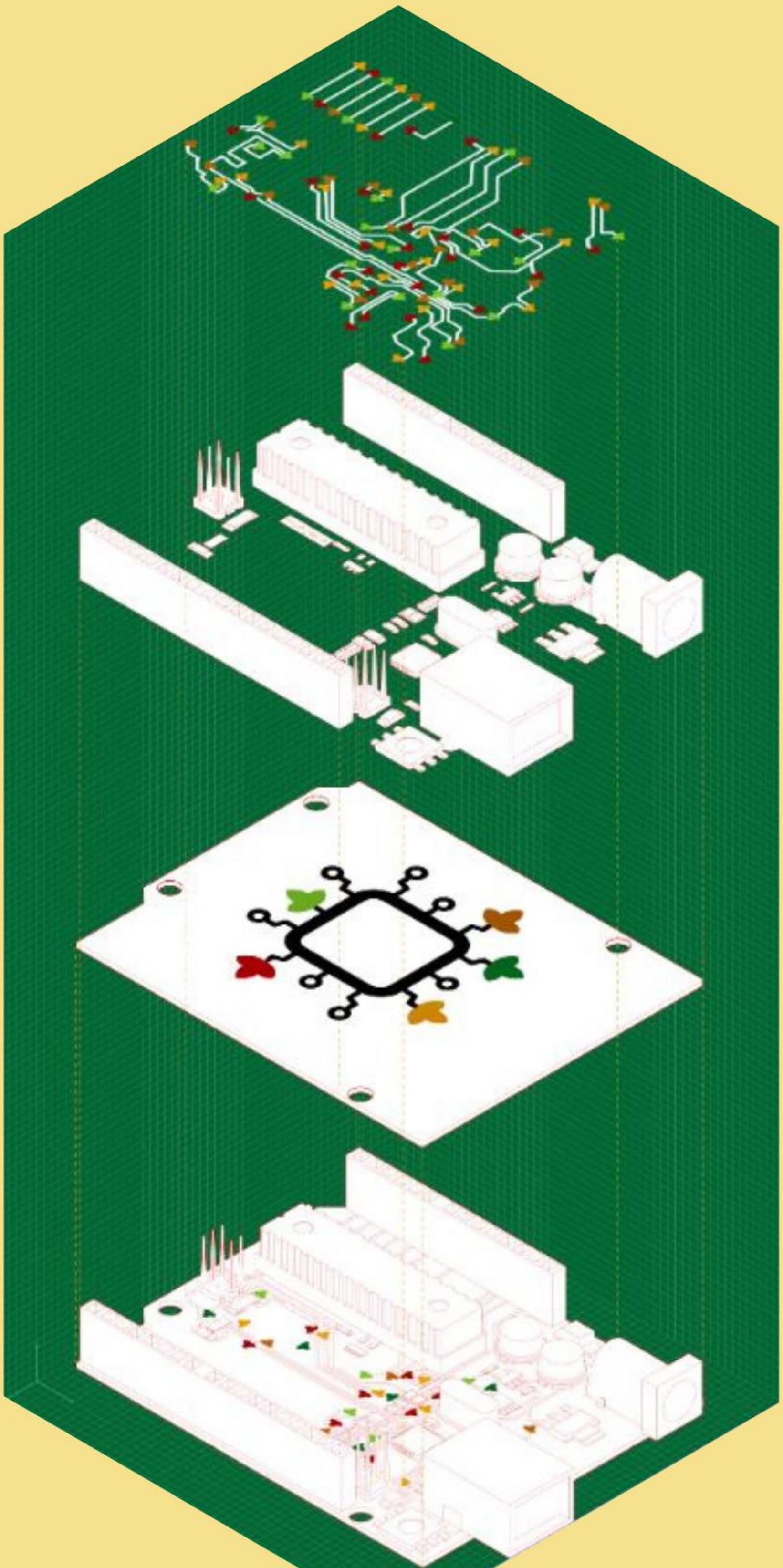
Green STEAM Incubator

# Module on Microcontrollers: 30 hours lessons



## Table of Contents

# INTRODUCTION

This module was written within Intellectual Output 3 of the Green STEAM Incubator project and contains chapters regarding microcontrollers and the various applications. The material was created in order to provide participants with STEAM-oriented knowledge, capacities and skills.

Every consortium partner worked on the different chapters that make up this module, from the research phase to the writing one. The objective was to devise learning material that focuses on microcontrollers and how they can be applied, considering the agricultural sector. In the end, this module is about how agriculture can benefit from technology and some of its components.

The module has three main chapters, and in each one, there is a subchapter that contains themes that serve as a lesson, and in total, there are 30 hours of lessons formulated in a logical order.

# INTRODUCTION TO MICROCONTROLLERS

## LESSON – WHAT IS A MICROCONTROLLER

- **Study section:** Introduction to microcontrollers
- **Lesson duration:** 1:00h
- **Educational objectives:**
    - Understand what a microcontroller is
    - Get to know different types of microcontrollers (e.g., Arduino, Scratch; Micro bits; Logic Gates, Raspberry PI)
- **Learning outcomes and acquired competencies:**

At the end of the unit, the student should be able to:

| Knowledge | Skills | Responsibility and Autonomy |
|---|---|---|
| • Understand what a microcontroller is<br>• Get to know different types of microcontrollers (e.g., Arduino, Scratch; Micro bits; Raspberry PI) | • Recognise the main elements and characteristics of a microcontroller | • Become able to identify microcontrollers available on the market. |

- **Main Keyword(s):**
    - Internet of Things (IoT)
    - Microcontroller
    - Arduino
    - Scratch
    - Micro bits
    - Raspberry PI
- **Required material and resources:**
    - Computer
    - Internet access

### Brief definition of Internet of Things

Internet of Things (IoT) describes the network of physical objects—"things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet.

### Brief definition of Micocontroller

A microcontroller is a compact integrated circuit designed to govern a specific operation in an embedded system. A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip.

**Microcontrollers**

As an introduction to this session, the facilitator trickers the participants' interest with the below introductory text:

Have you ever looked at some gadget and wondered how it really worked? Maybe it was a remote-control boat, the system that controls an elevator, a vending machine, or an electronic toy? Or have you wanted to create your own robot or electronic signals for a model railroad, or perhaps you would like to capture and analyze weather data over time? Where and how do you start?

Microcontrollers can help you find some of the answers to the mysteries of electronics in a hands-on way.

Then, the facilitator starts the lesson by explaining to the participants what microcontrollers are. The facilitator begins as follows:

A microcontroller is embedded inside of a system to control a singular function in a device. It does this by interpreting data it receives from its I/O peripherals using its central processor.

Microcontrollers are used in a wide array of systems and devices.

An example of the application of microcontrollers in vertical farming automation systems is provided.

The example: a soil moisture sensor measures the soil resistance at intervals, sends the information as a digital signal to the sensor; the microcontroller then decides whether or not the soil resistance is high or not (depending on the pre-set thresholds and soil type). If the soil moisture level is lower than the pre-set threshold, the microcontroller actuates the submersible water pump and solenoid valves which provide water to the soil via drip irrigation method (TE & COA, 2018).

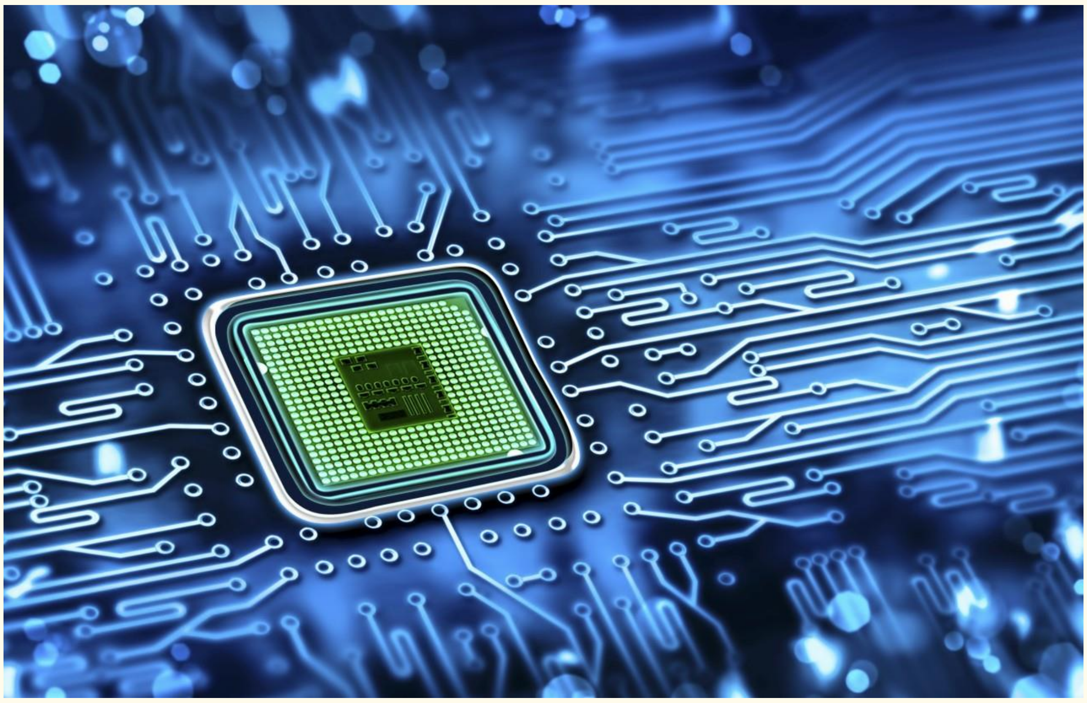


*Figure 1 A microcontroller, source: [https://predictabledesigns.com/microcontroller-or-microprocessor-which-is-right-for-your-new-product/](https://predictabledesigns.com/microcontroller-or-microprocessor-which-is-right-for-your-new-product/)*

Then, the facilitator will briefly present the core elements of a microcontroller, which are listed below:

- The processor (CPU): A processor processes and responds to various instructions that direct the microcontroller's function. This involves performing basic arithmetic, logic and I/O operations. It also performs data transfer operations, which communicate commands to other components in the larger embedded system.
- Memory: A microcontroller's memory is used to store the data that the processor receives and uses to respond to instructions that it's been programmed to carry out. A microcontroller has two main memory types:
    - Program memory, which stores long-term information about the instructions that the CPU carries out. Program memory is non-volatile memory, meaning it holds information over time without needing a power source.
    - Data memory, which is required for temporary data storage while the instructions are being executed. Data memory is volatile, meaning the data it holds is temporary and is only maintained if the device is connected to a power source.
- I/O peripherals: The input and output devices are the interface for the processor to the outside world. The input ports receive information and send it to the processor in the form of binary data. The processor receives that data and sends the necessary instructions to output devices that execute tasks external to the microcontroller.

**Examples of microcontrollers**

There are several microcontrollers available in the market. Brief information about some of those are given below. In the lessons to follow, the facilitator will focus on Arduino.

**Arduino**

Arduino is a prototype platform (open-source) based on an easy-to-use hardware and software. It consists of a circuit board, which can be programed (referred to as a microcontroller) and a ready-made software called Arduino IDE (Integrated Development Environment), which is used to write and upload the computer code to the physical board. Arduino is a great platform for prototyping projects and inventions. In the lessons to follow we will focus more on Arduino use and exploitation.

Also, for more information: https://www.arduino.cc/en/software

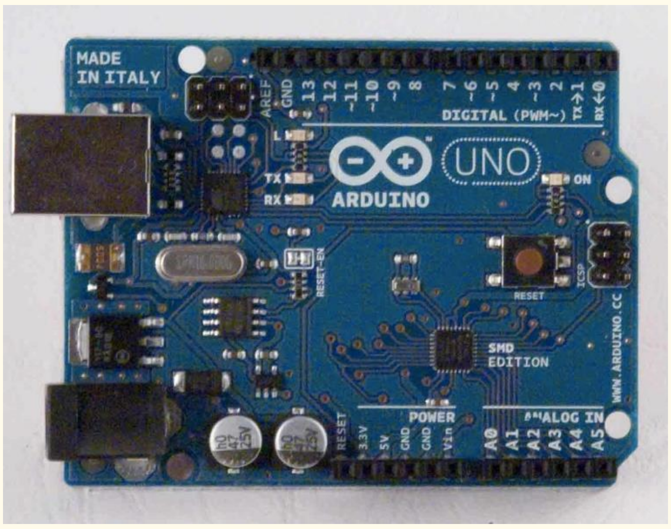


*Figure 2 Arduino, source: https://www.arduino.cc/en/Main/ArduinoBoardUnoSMD*

**Scratch**

Scratch is a free programming language and online community where users can create their own interactive stories, games, and animations, and share their creations with others in an online community. Scratch helps young people learn to think creatively, reason systematically, and work collaboratively — essential skills for life in the 21st century.

For more information: https://scratch.mit.edu/

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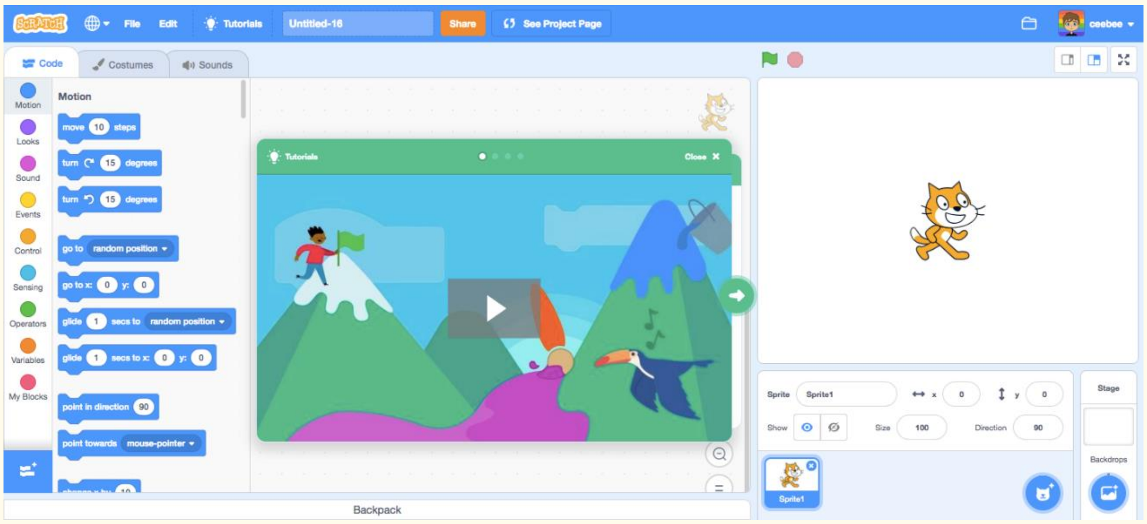

Figure 3 Scracth, source: https://scratch.mit.edu/discuss/topic/326861/

## Micro bits

The BBC micro:bit is a pocket-sized computer that can help young people learn basic programming knowledge. It is an open development board that allows the user to run code on it and have access to all of the hardware. For more information: https://microbit.org/

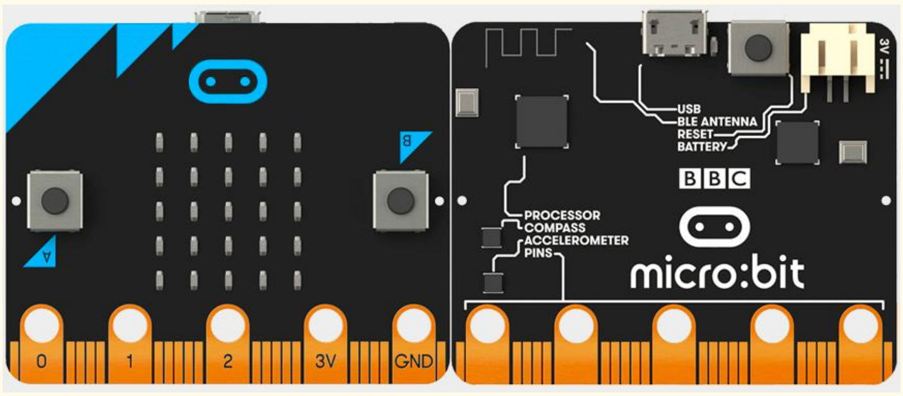

Figure 4 The BBC micro:bit, source: https://www.dfrobot.com/blog-734.html

## Raspberry PI

The Raspberry Pi is a tiny and affordable computer that the user can use to learn programming through fun, practical projects. Several generations of Raspberry Pis have been released. The first generation (Raspberry Pi Model B) was released in February 2012, while the latest generation (Raspberry Pi 400) was released in November 2020. It features a custom board that is derived from the existing Raspberry Pi 4 (previous release), specifically remodeled with a keyboard attached.

For more information: https://www.raspberrypi.org/

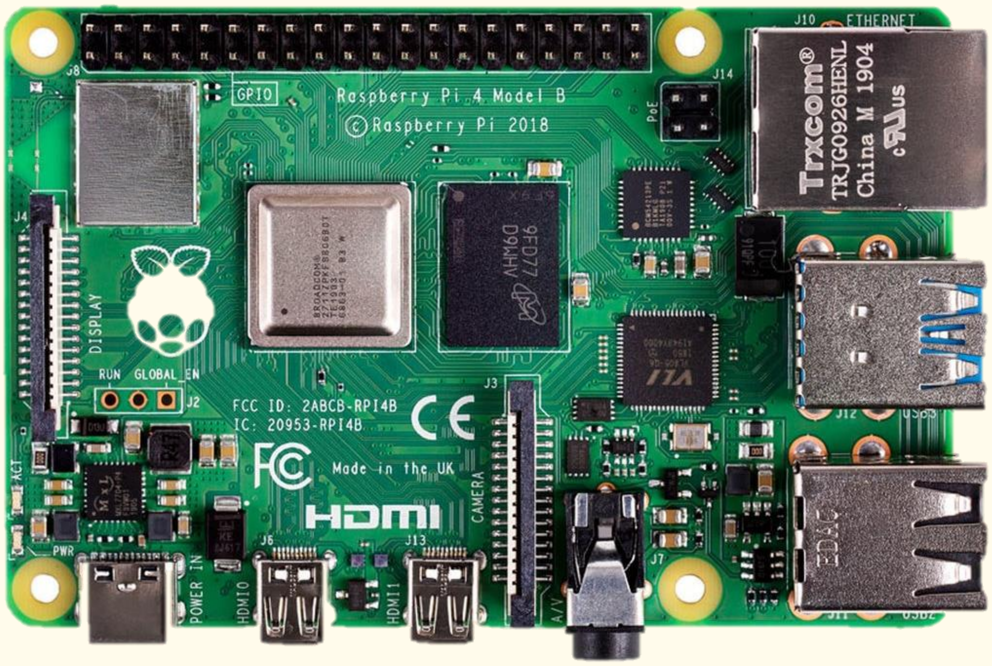

Figure 5 Raspberry PI, source: https://www.raspberrypi.org/

- **Bibliographic references:**

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## LESSON – WHAT IS ARDUINO (AND TYPES OF ARDUINO) AND HOW TO USE IT

- **Study section:** Introduction to microcontrollers
- **Lesson duration:** 1:00h
- **Educational objectives:**
    - Understand what an Arduino is
    - Learn about types of Arduino
    - Acquire basic knowledge on how to use Arduino IDE
- **Learning outcomes and acquired competences:**

At the end of the unit, the student should be able to:

| Knowledge | Skills | Responsibility and Autonomy |
|---|---|---|
| • Understand what Arduino is and how it can be used<br>• Acquire Basic knowledge on how to use Arduino UNO board and Arduino IDE | • Recognise the main parts of Arduino UNO board and explain their functionality<br>• Navigate to Arduino IDE and understand its main parts | • Use Arduino software autonomously |

- **Main Keyword(s):**
    - Arduino
    - Types of Arduino boards
    - Arduino UNO
    - Arduino IDE
- **Required material and resources:**
    - Computer
    - Internet Connection
    - Arduino UNO
    - Software Arduino IDE
    - Arduino USB cable

**Brief definition of Arduino**

Arduino is a prototype platform (open-source) based on an easy-to-use hardware and software. It consists of a circuit board, which can be programmed (referred to as a microcontroller) and a ready-made software called Arduino IDE.

**Brief definition of Arduino IDE**

Arduino IDE (Integrated Development Environment), which is used to write and upload the computer code to the physical board.

**What is Arduino**

The facilitator then introduces to the participants a particular type of microcontroller, Arduino, and the different types of Arduino. The facilitator begins a follows:

Arduino is a prototype platform (open-source) based on an easy-to-use hardware and software. It consists of a circuit board, which can be programed (referred to as a microcontroller) and a ready-made software called Arduino IDE (Integrated Development Environment), which is used to write and upload the computer code to the physical board. Arduino is a great platform for prototyping projects and inventions.

The Arduino board (shown in Figure 2) can help you find some of the answers to the mysteries of electronics in a hands-on way. The Arduino system was created by Massimo Banzi and David Cuartielles in 2005 and offers an inexpensive way to build interactive projects, such as remote-controlled robots, GPS tracking systems, and electronic games.

The main Arduino components are listed below:

- software - used to compose your programs and communicate with the hardware, called an integrated development environment (Arduino IDE). You can control your board functions by sending a set of instructions to the microcontroller on the board via Arduino IDE.
- hardware - refers to the boards themselves (e.g. Arduino Uno). Arduino boards are able to read analog or digital input signals from different sensors and turn it into an output such as activating a motor, turning LED on/off, connect to the cloud and many other actions.
- programming language - the Arduino programming language uses a simplified version of C++.

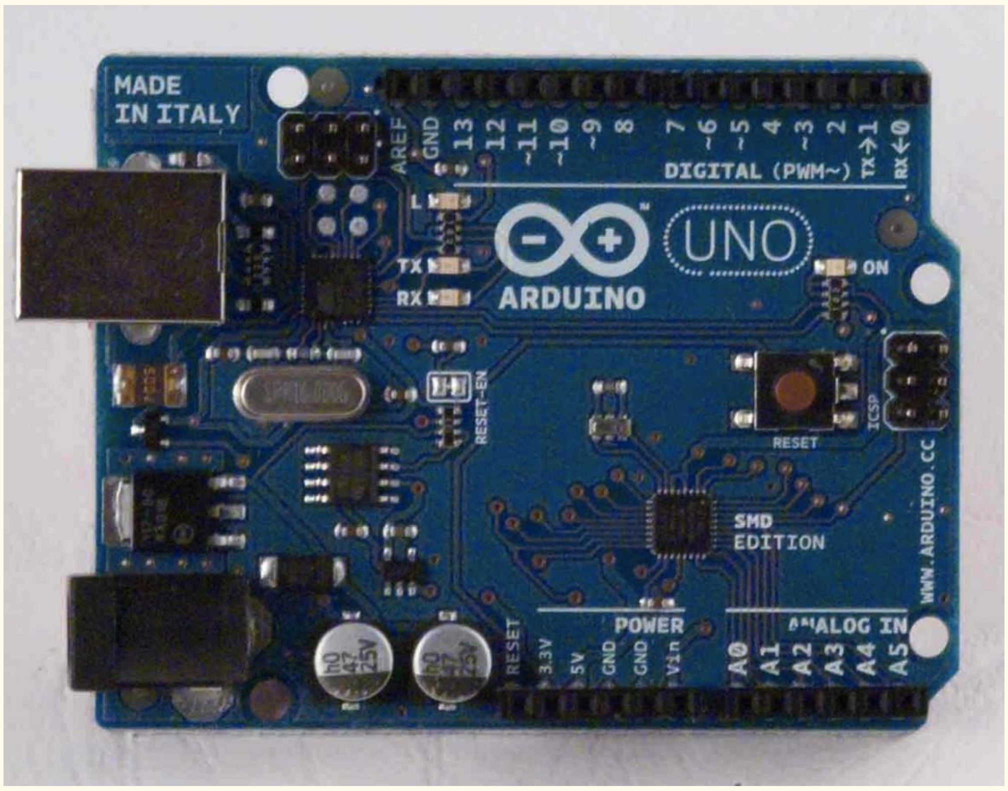

*Figure 1 Arduino, source: https://www.arduino.cc/en/Main/ArduinoBoardUnoSMD*

**Types of Arduino**

The facilitator will introduce the participants into different types of Arduino boards. If available, the facilitator can provide few differenty types of Arduino boards to the participants for them to obseve them. The following text is given:

Various kinds of Arduino boards are available depending on different microcontrollers used. The differences are based on the number of inputs and outputs (the number of sensors, LEDs, and buttons you can use on a single board), speed, operating voltage, form factor etc. Some boards are designed to be embedded and have no programming interface (hardware). Some can run directly from a 3.7V battery, others need at least 5V. Still, all Arduino boards have one thing in common: they are programed through the Arduino IDE.

Below are a few examples of the different types of Arduino boards.  A complete list of different Arduino boards is provided in the Appendix.

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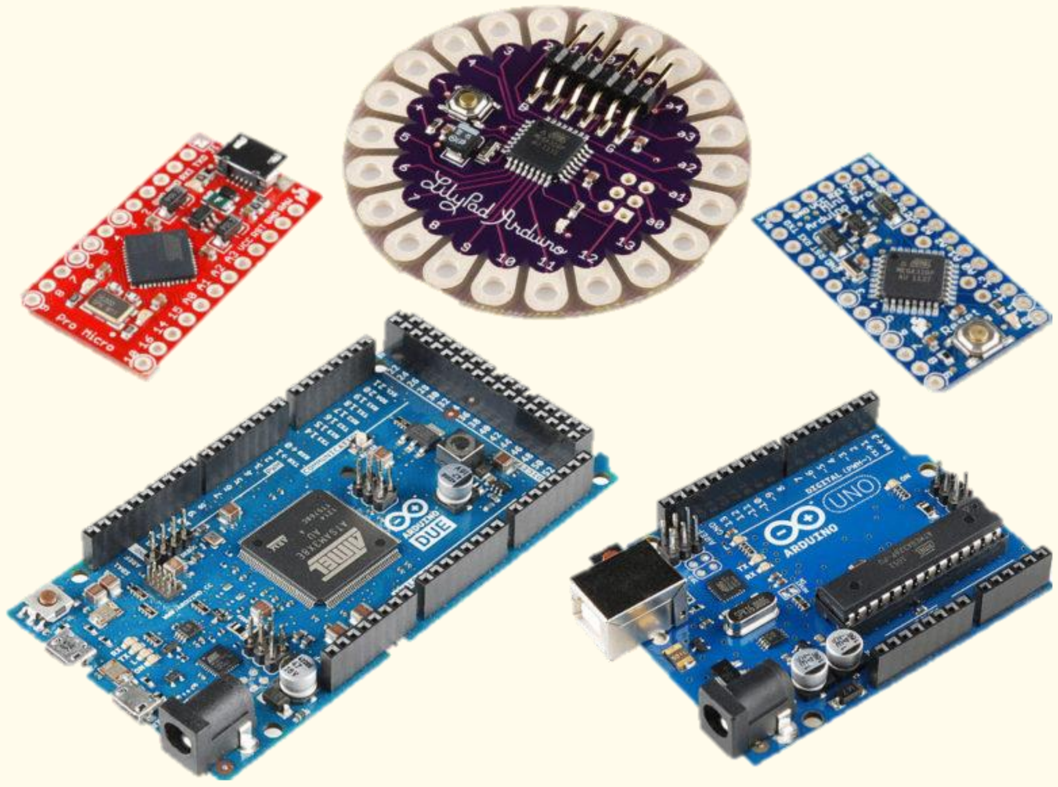


*Figure 2 Different types of Arduino boards, Image credit – Sparkfun.com*

One of the most popular Arduino boards is the Arduino Uno. While it was not actually the first board to be released, it remains to be the most actively used and most widely documented on the market.

The facilitator provides an Arduino Uno to the participants, and explains to them the various components of the board and their main functions.

Here are the components that make up an Arduino board and what each of their functions are (see figure 3).

1. Reset Button – This will restart any code that is loaded to the Arduino board
2. AREF – Stands for "Analog Reference" and is used to set an external reference voltage
3. Ground Pin – There are a few ground pins on the Arduino and they all work the same
4. Digital Input/Output – Pins 0-13 can be used for digital input or output
5. PWM – The pins marked with the (~) symbol can simulate analog output
6. USB Connection – Used for powering up your Arduino and uploading sketches
7. TX/RX – Transmit and receive data indication LEDs
8. ATmega Microcontroller – This is the brains and is where the programs are stored
9. Power LED Indicator – This LED lights up anytime the board is plugged in a power source
10. Voltage Regulator – This controls the amount of voltage going into the Arduino board
11. DC Power Barrel Jack – This is used for powering your Arduino with a power supply
12. 3.3V Pin – This pin supplies 3.3 volts of power to your projects
13. 5V Pin – This pin supplies 5 volts of power to your projects

14. Ground Pins – There are a few ground pins on the Arduino and they all work the same
15. Analog Pins – These pins can read the signal from an analog sensor and convert it to digital

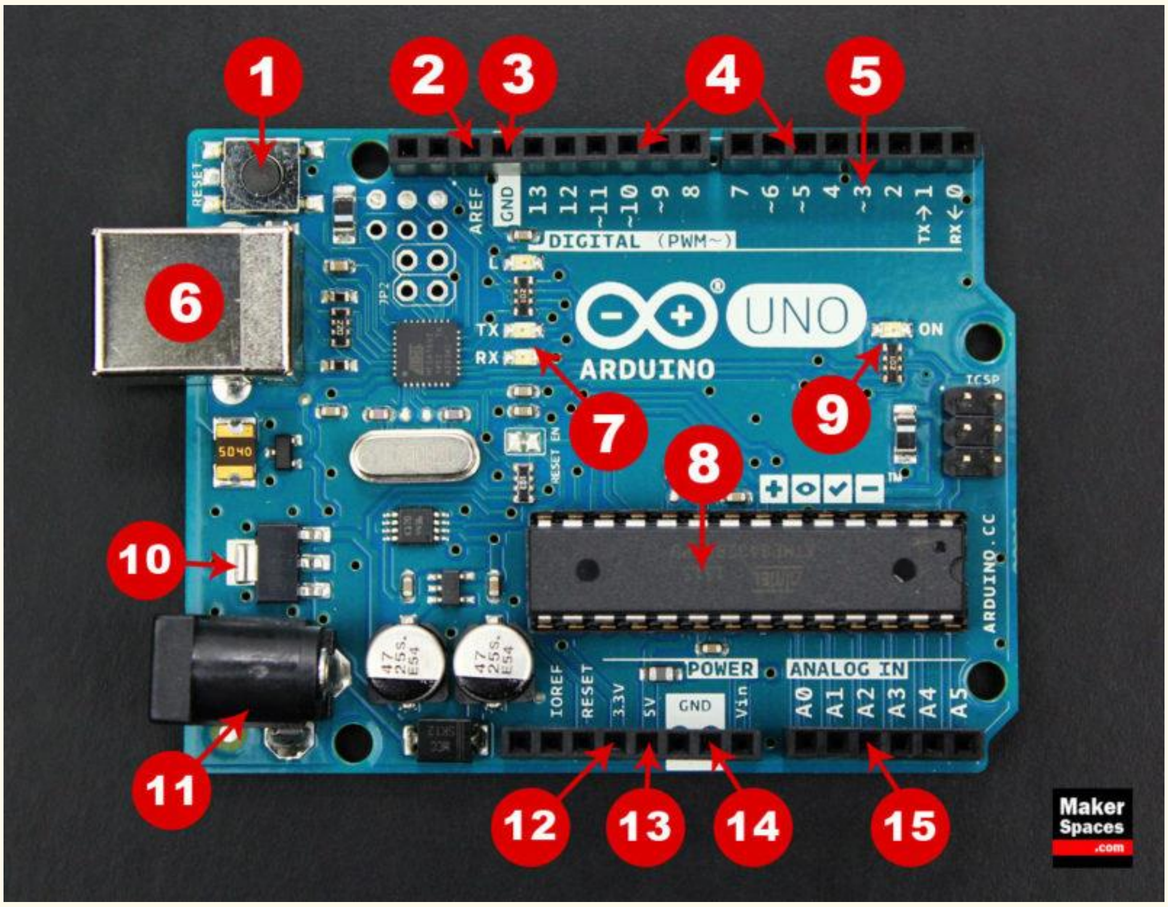


*Figure 3 Arduino UNO, source: [https://www.makerspaces.com/arduino-uno-tutorial-beginners/](https://www.makerspaces.com/arduino-uno-tutorial-beginners/)*

The Arduino Uno needs a power source in order for it to operate and can be powered in a variety of ways. The board can be connnected directly to a computer via a USB cable. In case of mobile projects, one can consider using a 9V battery pack. The last method would be to use a 9V AC power supply.

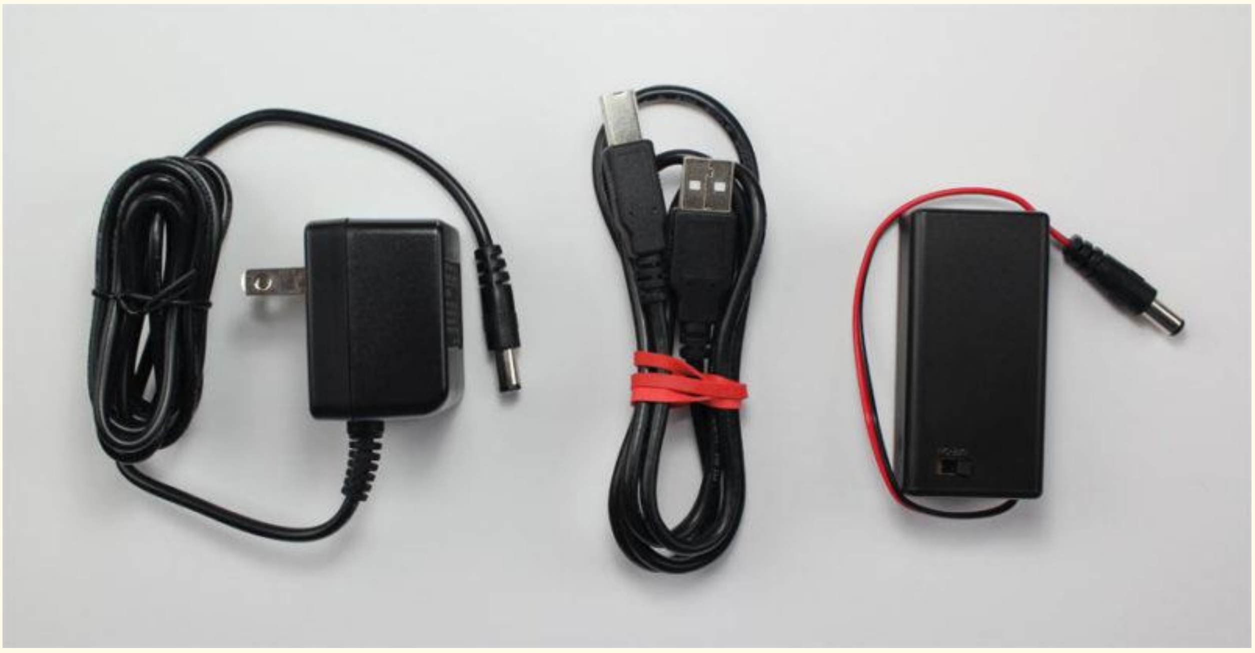
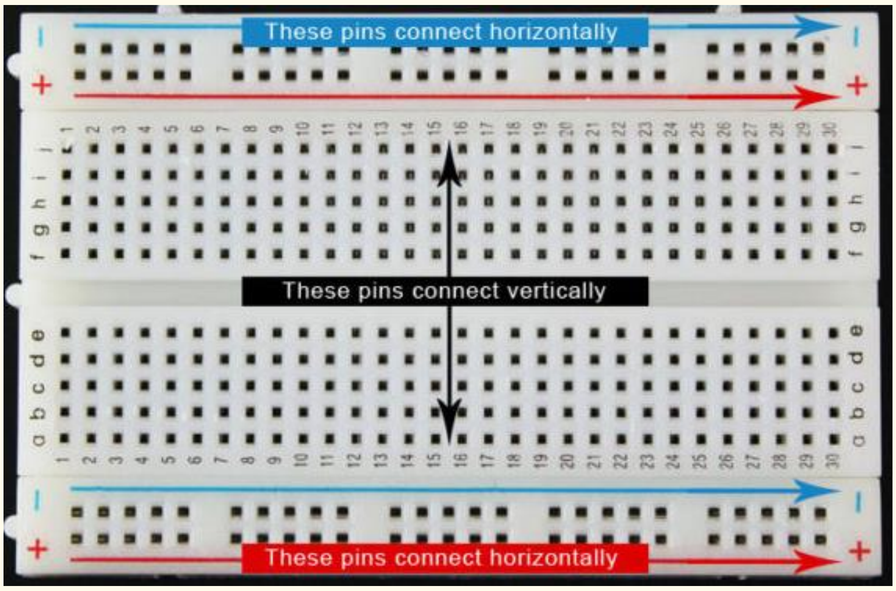


Figure 4 Arduino UNO power source, source: [https://www.makerspaces.com/arduino-uno-tutorial-beginners/](https://www.makerspaces.com/arduino-uno-tutorial-beginners/)

The facilitator also introduces another important item when working with Arduino, the breadboard. S/he explains to the participants that this device allows one prototype an Arduino project without having to permanently solder the circuit together. The following text is given:

Using a breadboard allows one to create temporary prototypes and experiment with different circuit designs. Inside the holes (tie points) of the plastic housing, are metal clips which are connected to each other by strips of conductive material. The breadboard is not powered on its own and needs power brought to it from the Arduino board using jumper wires. These wires are also used to form the circuit by connecting resistors, switches and other components together.


These pins connect horizontally
These pins connect vertically
These pins connect horizontally
Figure 5 Arduino Breadboard, source: [https://www.makerspaces.com/arduino-uno-tutorial-beginners/](https://www.makerspaces.com/arduino-uno-tutorial-beginners/)

The facilitator provides a visual of what a completed Arduino circuit looks like when connected to a breadboard.

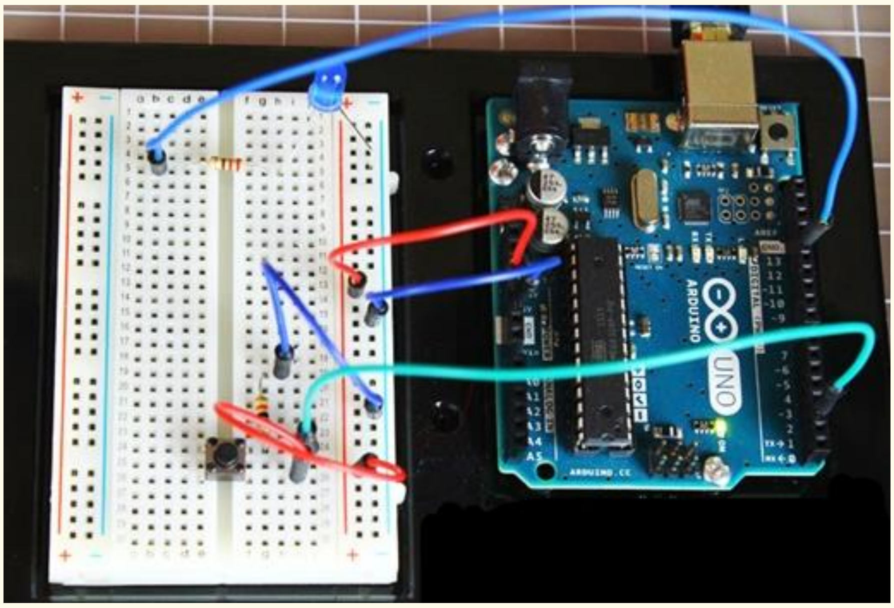


*Figure 6 A complete Arduino circuit, source:* [*https://www.makerspaces.com/arduino-uno-tutorial-beginners/*](https://www.makerspaces.com/arduino-uno-tutorial-beginners/)

**How to use Arduino IDE**

The facilitator introduces the Arduino IDE to the participants. As a first step, the facilitator guides the participants on how to download the software. The following instructions are provided:

Instructrions for downloading Arduino IDE

1. Go to [https://www.arduino.cc/](https://www.arduino.cc/)
2. Click on Software > Downloads > Arduino IDE 1.8.13 (see figure 7)
3. Click on the download option that suits to your operating system (see figure 8). If you have doubts, click on 'Getting Started' to read more information about installation of the software for your computer.

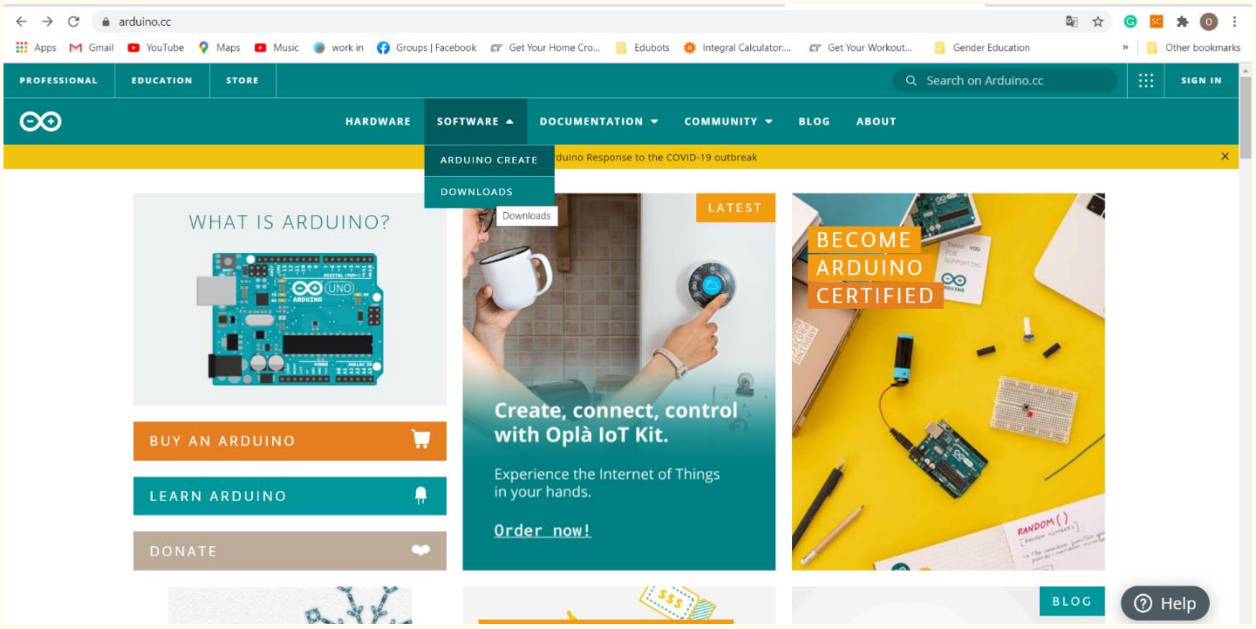
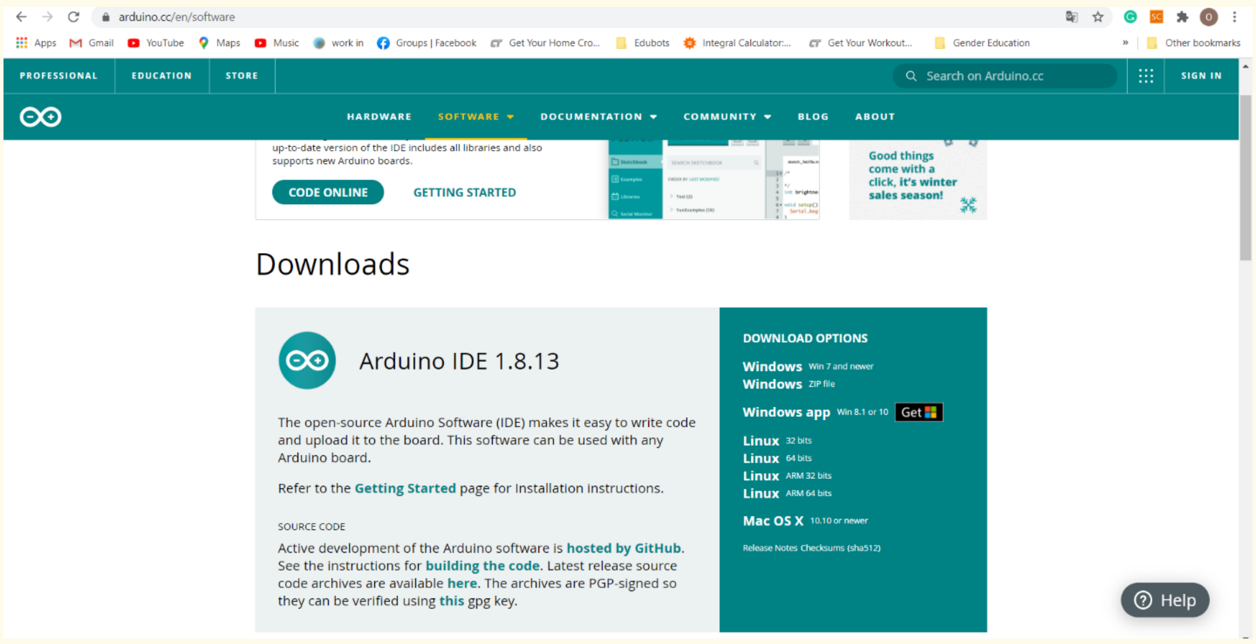


Figure 7 How to download Arduino IDE



up-to-date version of the IDE includes all libraries and also supports new Arduino boards.

Downloads

Arduino IDE 1.8.13

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. This software can be used with any Arduino board.

Refer to the **Getting Started** page for Installation instructions.

SOURCE CODE

Active development of the Arduino software is **hosted by GitHub**. See the instructions for **building the code**. Latest release source code archives are available **here**. The archives are PGP-signed so they can be verified using **this** gpg key.

DOWNLOAD OPTIONS

**Windows** Win 7 and newer
**Windows** ZIP file
**Windows app** Win 8.1 or 10 Get
**Linux** 32 bits
**Linux** 64 bits
**Linux** ARM 32 bits
**Linux** ARM 64 bits
**Mac OS X** 10.10 or newer

Release Notes Checksums (sha512)

Figure 8 How to download Arduino IDE

As soon as the participants have downloaded Arduino IDE, the facilitators first provides general information in Arduino IDE and then guides the participants in the main areas of IDE. The following text is provided.

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As already mentioned, the Arduino software is open-source. The source code for the Java environment is released under the GPL and the C/C++ microcontroller libraries are under the LGPL.

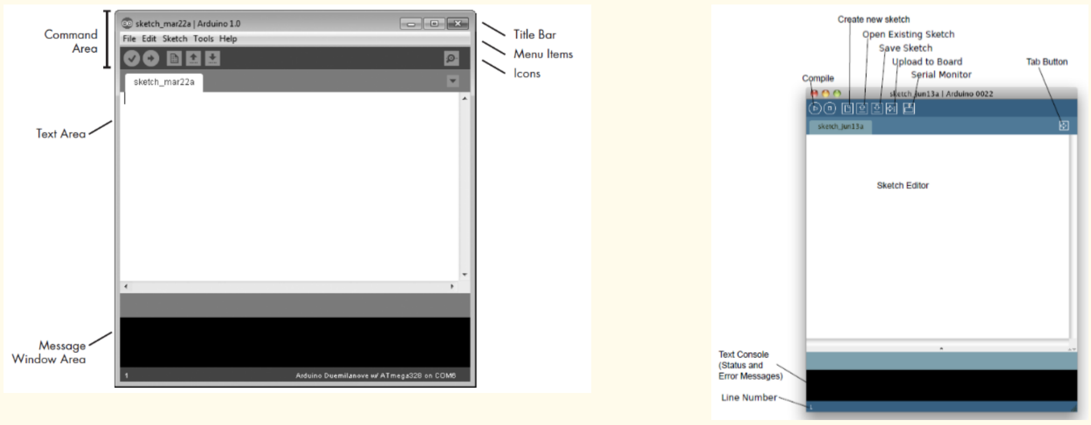


*Figure 9 The Arduino IDE on Windows (picture on the left, source: Boxall, 2013), and Mac (picture on the right, source: Smith, 2011).*

The software used to create Arduino sketches is called the IDE which stands for Integrated Development Environment. We can use Arduino IDE on the computer to create, open, and change sketches (the Arduino program is called "sketch"). Sketches define what the board will do. You can either use the buttons along the top of the IDE or the menu items.

As shown in Figure 9, the Arduino IDE resembles a simple word processor. The IDE is divided into three main areas: the command area, the text area, and the message window area.

**Menu items in Windows IDE**

Command area: The command area includes the title bar, menu items, and icons. The title bar displays the sketch's filename, as well as the version of the IDE. Below this is a series of menu items (File, Edit, Sketch, Tools, and Help) and icons, as described next.

As with any word processor or text editor, you can click one of the menu items to display its various options.

- File: contains options to save, load, and print sketches; a thorough set of example sketches to open; as well as the Preferences submenu
- Edit: contains the usual copy, paste, and search functions common to any word processor
- Sketch: contains the function to verify your sketch before uploading to a board, and some sketch folder and import options
- Tools: contains a variety of functions as well as the commands to select the Arduino board type and USB port
- Help: contains links to various topics of interest and the version of the IDE

The icons: Below the menu toolbar are six icons. Mouse over each icon to display its name. The icons, from left to right, are as follows:

- Verify: click this to check that the Arduino sketch is valid and does not contain any programming mistakes.
- Upload: click this to verify and then upload your sketch to the Arduino board.
- New: click this to open a new blank sketch in a new window.
- Open: click this to open a saved sketch.
- Save: click this to save the open sketch. If the sketch does not have a name, you will be asked to provide one.
- Serial monitor: click this to open a new window for use in sending and receiving data between your Arduino and the IDE.

**Menu items in MAC IDE**

Parts of the IDE (from left to right, top to bottom) as illustrated on the right side of Figure 8, are given below:

- Compile: before your program "code" can be sent to the board, it needs to be converted into instructions that the board understands. This process is called compiling.
- Stop: This stops the compilation process.
- Create new Sketch: This opens a new window to create a new sketch.
- Open Existing Sketch: This loads a sketch from a file on your computer.
- Save Sketch: This saves the changes to the sketch you are working on.
- Upload to Board: This compiles and then transmits over the USB cable to your board.

In addition:

- Tab Button: This lets you create multiple files in your sketch. This is for more advanced programming.
- Sketch Editor/ Text area: This is where you write or edit sketches. You will enter the contents of your sketch here as you would in any text editor.
- Text Console/ Message Window Area: This shows you what the IDE is currently doing and is also where error messages display if you make a mistake in typing your program (often called a syntax error).
- LineNumber: This shows you what line number your cursor is on. It is useful since the compiler gives error messages with a line number.

**How to change language**

The facilitator provides further instructions to the participants on how to change the language (optional).

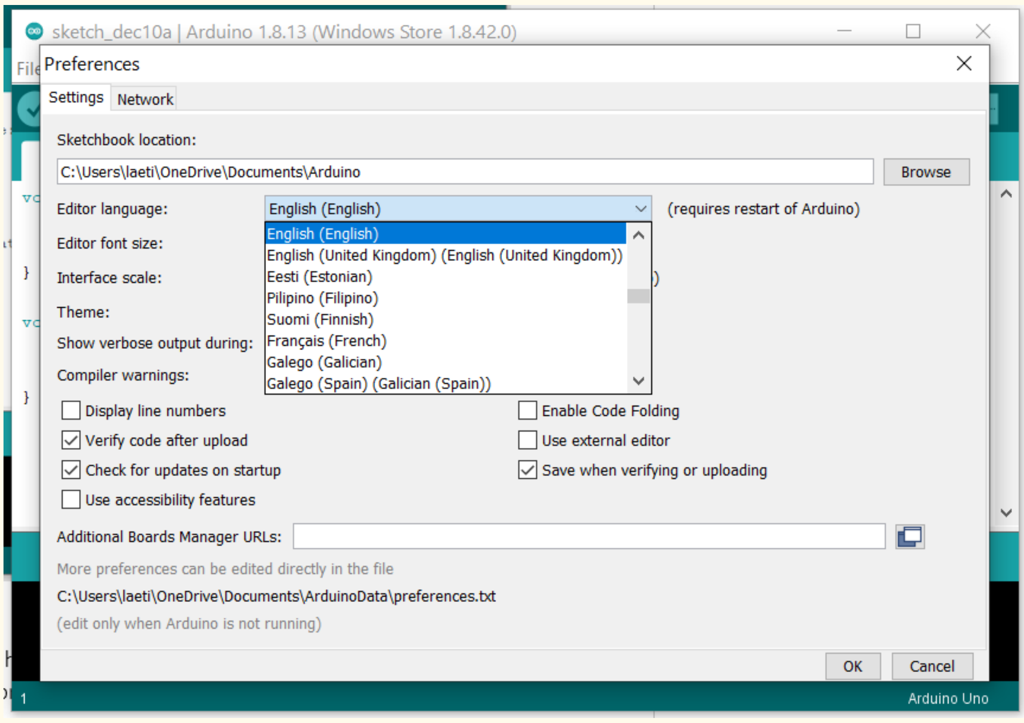
The instructions are given below:

1. Click on FILE and select PREFERENCES.

2. Next to the Editor Language there is a dropdown menu of currently supported languages.

3. Select your preferred language from the menu.

4. Restart the software to use the selected language.



sketch_dec10a | Arduino 1.8.13 (Windows Store 1.8.42.0)

Preferences

Settings | Network

Sketchbook location:
C:\Users\laeti\OneDrive\Documents\Arduino [Browse]

Editor language: English (English) (requires restart of Arduino)

- English (English)
- English (United Kingdom) (English (United Kingdom))
- Eesti (Estonian)
- Pilipino (Filipino)
- Suomi (Finnish)
- Français (French)
- Galego (Galician)
- Galego (Spain) (Galician (Spain))

Editor font size:
Interface scale:
Theme:
Show verbose output during:
Compiler warnings:

- [ ] Display line numbers
- [x] Verify code after upload
- [x] Check for updates on startup
- [ ] Use accessibility features
- [ ] Enable Code Folding
- [ ] Use external editor
- [x] Save when verifying or uploading

Additional Boards Manager URLs:

More preferences can be edited directly in the file
C:\Users\laeti\OneDrive\Documents\ArduinoData\preferences.txt
(edit only when Arduino is not running)

[OK] [Cancel]

Arduino Uno

Figure 10 How to change language

- **Bibliographic references:**

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## • Appendix

Table 1. Arduino boards based on ATMEGA328 microcontroller

| Board Name | Operating Volt | Clock Speed | Digital i/o | Analog Inputs | PWM | UART | Programming Interface |
|---|---|---|---|---|---|---|---|
| Arduino Uno R3 | 5V | 16MHz | 14 | 6 | 6 | 1 | USB via ATMega16U2 |
| Arduino Uno R3 SMD | 5V | 16MHz | 14 | 6 | 6 | 1 | USB via ATMega16U2 |
| Red Board | 5V | 16MHz | 14 | 6 | 6 | 1 | USB via FTDI |
| Arduino Pro 3.3v/8 MHz | 3.3V | 8MHz | 14 | 6 | 6 | 1 | FTDI-Compatible Header |
| Arduino Pro 5V/16MHz | 5V | 16MHz | 14 | 6 | 6 | 1 | FTDI-Compatible Header |
| Arduino mini 05 | 5V | 16MHz | 14 | 8 | 6 | 1 | FTDI-Compatible Header |
| Arduino Pro mini 3.3v/8mhz | 3.3V | 8MHz | 14 | 8 | 6 | 1 | FTDI-Compatible Header |
| Arduino Pro mini 5v/16mhz | 5V | 16MHz | 14 | 8 | 6 | 1 | FTDI-Compatible Header |
| Arduino Ethernet | 5V | 16MHz | 14 | 6 | 6 | 1 | FTDI-Compatible Header |
| Arduino Fio | 3.3V | 8MHz | 14 | 8 | 6 | 1 | FTDI-Compatible Header |
| LilyPad Arduino 328 main board | 3.3V | 8MHz | 14 | 6 | 6 | 1 | FTDI-Compatible Header |
| LilyPad Arduino simple board | 3.3V | 8MHz | 9 | 4 | 5 | 0 | FTDI-Compatible Header |

Table 2. Arduino boards based on ATMEGA32u4 microcontroller

| Board Name | Operating Volt | Clock Speed | Digital i/o | Analog Inputs | PWM | UART | Programming Interface |
|---|---|---|---|---|---|---|---|
| Arduino Leonardo | 5V | 16MHz | 20 | 12 | 7 | 1 | Native USB |
| Pro micro 5V/16MHz | 5V | 16MHz | 14 | 6 | 6 | 1 | Native USB |
| Pro micro 3.3V/8MHz | 5V | 16MHz | 14 | 6 | 6 | 1 | Native USB |
| LilyPad Arduino USB | 3.3V | 8MHz | 14 | 6 | 6 | 1 | Native USB |

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Table 3. Arduino boards based on ATMEGA2560 microcontroller

| **Board Name** | **Operating Volt** | **Clock Speed** | **Digital i/o** | **Analog Inputs** | **PWM** | **UART** | **Programming Interface** |
|---|---|---|---|---|---|---|---|
| Arduino Mega 2560 R3 | 5V | 16MHz | 54 | 16 | 14 | 4 | USB via ATMega16U2B |
| Mega Pro 3.3V | 3.3V | 8MHz | 54 | 16 | 14 | 4 | FTDI-Compatible Header |
| Mega Pro 5V | 5V | 16MHz | 54 | 16 | 14 | 4 | FTDI-Compatible Header |
| Mega Pro Mini 3.3V | 3.3V | 8MHz | 54 | 16 | 14 | 4 | FTDI-Compatible Header |

Table 4. Arduino boards based on AT91SAM3X8E microcontroller

| **Board Name** | **Operating Volt** | **Clock Speed** | **Digital i/o** | **Analog Inputs** | **PWM** | **UART** | **Programming Interface** |
|---|---|---|---|---|---|---|---|
| Arduino Mega 2560 R3 | 3.3V | 84MHz | 54 | 12 | 12 | 4 | USB native |

## LESSON – CONCEPTS: INPUT, OUTPUT, ANALOG, DIGITAL

- **Study section:** Microcontroller and Arduino Fundamentals
- **Lesson duration:** 1:00h
- **Educational objectives:**
  - Understand the concept of input and output (I/O)
  - Differentiate Analog and Digital I/O
  - Identify if an I/O is analog or digital on an Arduino
- **Learning outcomes and acquired competences:**

At the end of the unit, the student should be able to:

| Knowledge | Skills | Responsibility and Autonomy |
|---|---|---|
| • Recognize and identify inputs and outputs<br>• Identify if an I/O is digital or analog<br>• Be able to select the correct pins for any I/O | • Apprehend digital or analog pins<br>• Configure inputs and outputs | • Understand the very basics of circuit, analog and digital I/O |

- **Main Keyword(s):**
  - Digital
  - Analog
  - Input
  - Output

**Important definitions**

**Concept: Input/Output (I/O)**

Inputs: any signal or information going into / entering the board.
Most of the time inputs cannot be seen and they are processed by sensors.

Outputs: any signal or action exiting the board.
Most of the time outputs are visible results and are revealed by LED, motors, alarms, or any action.

**Brief definition of Analog and Digital I/O**

The analog signals are continuous. They are sent to a system when I/O have multiple states which refer to variables.
Most common analog signals: temperature, level, rate or flow.
Example: an analog signal will inform how bright the LED (output) is (intensity)

The digital signals are used in situations where I/O only have 2 states like ON/OFF, Open/Close, Start/Stop…
A digital signal will inform if the LED is making light or not (On/off)

All analog signals include digital signals: example about the LED intensity analog will signal will refer to 0%= LED Off and 100%= LED On in addition to other values like 25% On – 85% On…

**Inputs vs. Outputs**

The facilitator will start the lesson by explaining to the participants what inputs and outputs are and help them differentiate between Analog and Digital.
The facilitator begins as follow:

**What are Inputs or Outputs often written I/O in the programming language.**

I/Os are the results of robot/machine interaction with the real world.
In simple terms, we could say that inputs are invisible while outputs are visible results.

We, therefore, dissociate the inputs which are most of the time transmitted by sensors (switches, potentiometers, cameras, etc.) and the outputs which refer to the motors which will start, the LED which will light up, the alarm which will be triggered.

Examples:

When you type on the keys of your keyboard, you perform Inputs. In fact, you order information, but you do not see what happens when this information is recorded. The machine processes this information to translate it on the screen. What you see (the letters that appear on the screen) is, therefore, an Output.

Example with Adruino: if you program a button that, if activated, should light a led, your button will be an input (you do not see the information that enters and is processed), and the led that lights up or turns off will be output.

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There are two types of Inputs/Outputs: Analog or Digital I/O.

**Analog vs. Digital I/O**

The facilitator gives the definition and some examples of Analog and Digital signals and explains the points below:

There are two ways to differentiate if a signal is Analog or Digital: 1. By the type of sensor used
2. By the processing method:

1. Analog vs. digital sensors

Let's take an example of a fading LED. The state of the LED can be ON, OFF, or variable intensity: ON but low intensity or ON with high intensity.

- If the sensor is a switch placed on the LED, it will detect whether the LED is ON or OFF and will not detect anything else. This is a digital input.
- If the sensor is a LDR (light dependent resistor) it will convert the light of the LED and tell us if the LED is 0% (off), 100% (full brightness), and many other variables 20,23%, 86% related to the diming stages of the LED.

2. Analog vs. Digital Processing

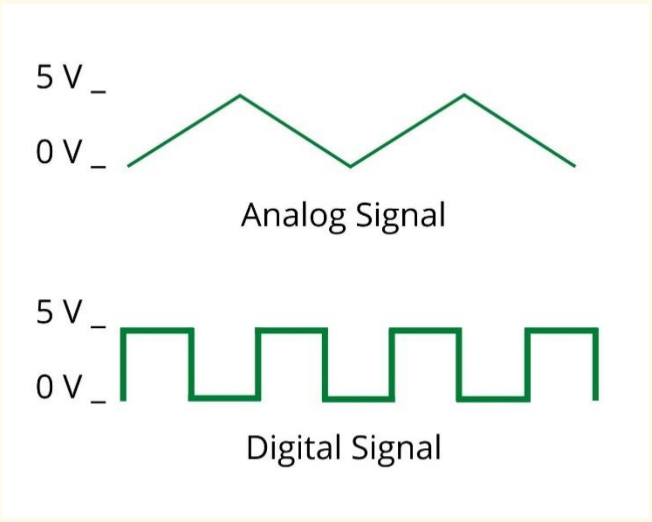
Another way to differentiate Analog and Digital is to check how both are processed.

- The time: Analog is continuously processing information, and whenever input is modified, the output is instantly changed according to the input. The update is immediate. For Digital, processing will have a short delay until the system registers the change. This delay is established by the "sampling frequency" and controlled by a clock.

- The resolution: As mentioned above, Analog processing has infinite resolutions because the signal never stops and values are different. Whereas for Digital processing, signals are either 0 or 1 (binary numbers), which means they need to be converted into only two values.

Example with the LED:
-> Switch it on/off with analog processing: when the dimer is activated, the circuit will immediately change the LED's intensity accordingly.
-> Switch it on/off with digital processing: with a set sampling frequency, every 5 seconds,

the system will read the switch and indicate if the light is on or off, no matter how intense and bright the light is. When you change the dimer within these 5 seconds, the LED's light will not change.



**Conclusion**

The real world is always about analog signals; however, digital signals and digital processing are more recommended for robotic purposes. First, because digital processing is cheaper and more flexible compared to analog processing. Second, because programs work with digital signals (binary system). And third, because analog signals are more likely to be affected by electrical circuit noise. For this reason, most of the time, even analog signals are converted into digital signals.

Finally, we must keep in mind that all analog signals from inputs and outputs can be converted into digital signals while the contrary does not apply.

- **Bibliographic references:**

https://blog.robotiq.com/whats-the-difference-between-digital-and-analog-i/o

https://www.mines.edu/epics/wp-content/uploads/sites/99/2018/01/John-Steele-Basics-of-Arduino-Presentation.pdf

## LESSON – ARDUINO SOFTWARE

- **Study section:** Microcontroller and Arduino Fundamentals

- **Lesson duration:** 1:00h

- **Educational objectives:**

  - Download Arduino software (IDE)
  - Learn the basics of the software
  - First steps with Arduino software

- **Learning outcomes and acquired competencies:**

At the end of the unit, the student should be able to:

| Knowledge | Skills | Responsibility and Autonomy |
|---|---|---|
| • Arduino software<br>• Create a new project<br>• Check/export…<br>• | • Download, run and use Arduino software | • Use Arduino software autonomously |

- **Main Keyword(s):**

  - Arduino software
  - Arduino IDE 1.8.13

- **Required material and resources:**

  - Arduino UNO
  - Computer
  - Arduino USB cable
  - Software Arduino IDE
  - Internet Connection

## What is Arduino?

Arduino is an **open-source electronics platform** based on easy-to-use hardware and software. The Arduino boards can read **inputs** (like light on a sensor, a finger on a button…) and turn them into **outputs** (activating a motor, turning on an LED.)

To program an Arduino board (give instructions to microcontrollers on the board) you need to use what **Arduino programming language** (based on **Wiring**), and the **Arduino Software** (IDE), based on **Processing**.

It is intended for anyone who want to make interactive projects

Definition from: https://www.arduino.cc/en/Guide/Introduction

## Arduino Software (IDE)

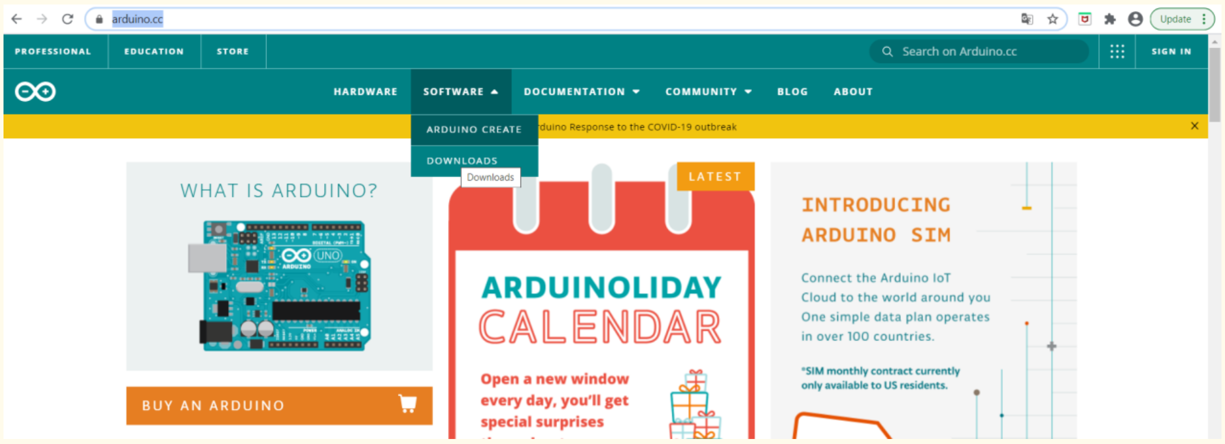
IDE stands for Integrated Development Environment.
Thanks to the Arduino software, it is possible to write programs and codes and upload the corresponding sketches to any Arduino board.

**Download Arduino IDE**

The facilitator will start the lesson by explaining what Arduino is, what it can be used for, and how to use it. The facilitator begins with the following steps:

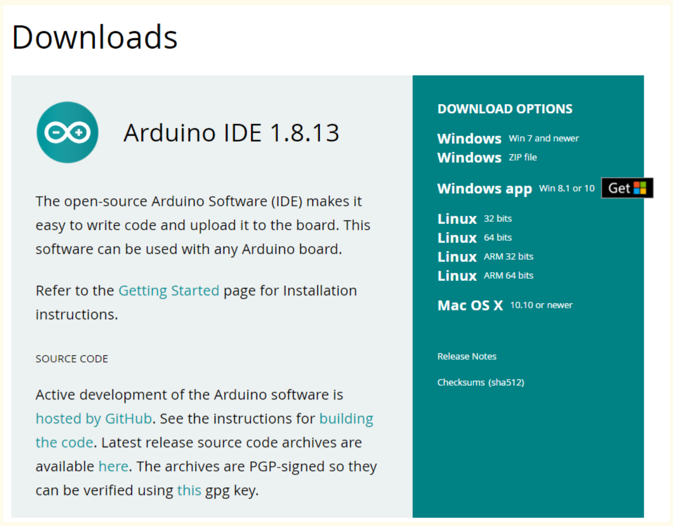
**To download the software**, go on: https://www.arduino.cc/

Click on SOFTWARE -> DOWNLOADS


arduino.cc
Update
PROFESSIONAL
EDUCATION
STORE
Search on Arduino.cc
SIGN IN
HARDWARE
SOFTWARE
DOCUMENTATION
COMMUNITY
BLOG
ABOUT
ARDUINO CREATE
DOWNLOADS
Downloads
rduino Response to the COVID-19 outbreak
WHAT IS ARDUINO?
BUY AN ARDUINO
LATEST
ARDUINOLIDAY
CALENDAR
Open a new window every day, you'll get special surprises
INTRODUCING ARDUINO SIM
Connect the Arduino IoT Cloud to the world around you One simple data plan operates in over 100 countries.
*SIM monthly contract currently only available to US residents.

## The version ARDUINO IDE 1.8.13

Click on the Download option that corresponds to your computer. If you have doubts, click on **Getting Started** to read more information about the installation of the software for your computer.



Downloads

Arduino IDE 1.8.13

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. This software can be used with any Arduino board.

Refer to the Getting Started page for Installation instructions.

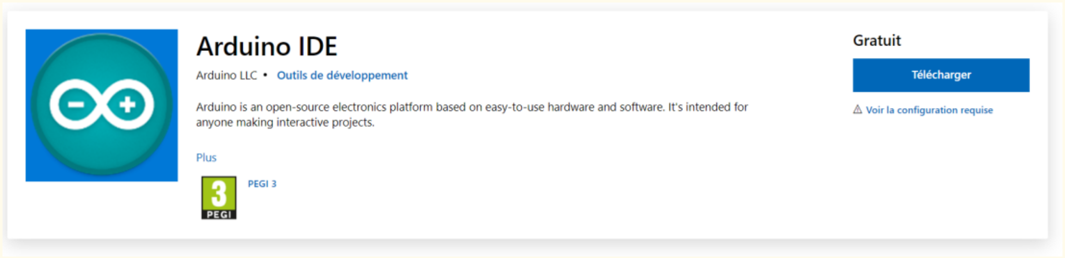
SOURCE CODE

Active development of the Arduino software is hosted by GitHub. See the instructions for building the code. Latest release source code archives are available here. The archives are PGP-signed so they can be verified using this gpg key.

DOWNLOAD OPTIONS

Windows Win 7 and newer
Windows ZIP file
Windows app Win 8.1 or 10 Get
Linux 32 bits
Linux 64 bits
Linux ARM 32 bits
Linux ARM 64 bits
Mac OS X 10.10 or newer

Release Notes
Checksums (sha512)



Arduino IDE

Arduino LLC • Outils de développement

Arduino is an open-source electronics platform based on easy-to-use hardware and software. It's intended for anyone making interactive projects.

Plus

PEGI 3

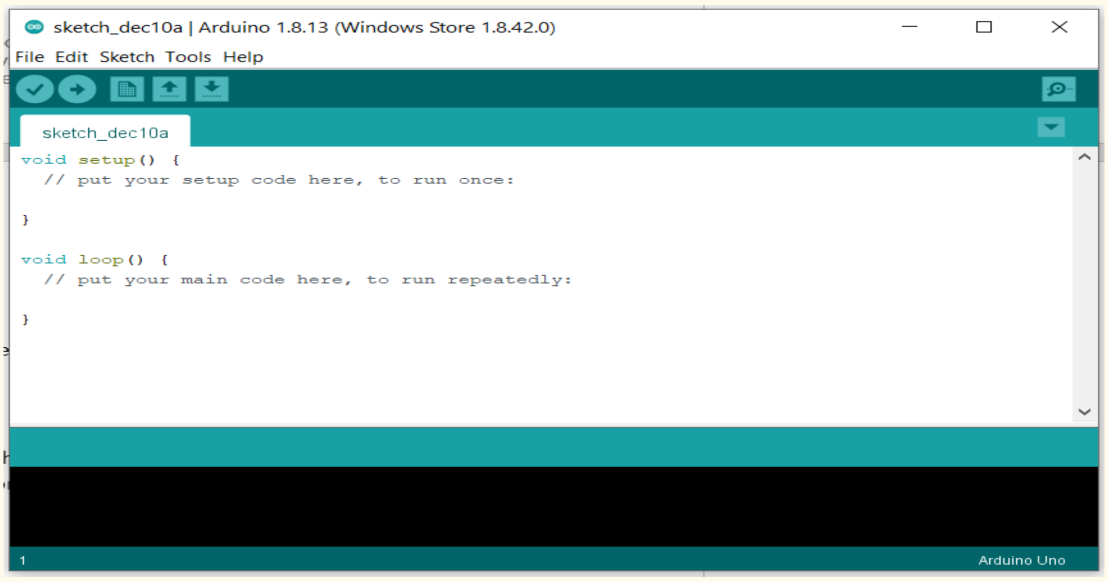
Gratuit

Télécharger

⚠ Voir la configuration requise

## Quick overview of Arduino software

When the download is over, the below page will automatically open:



sketch_dec10a | Arduino 1.8.13 (Windows Store 1.8.42.0)

File Edit Sketch Tools Help

sketch_dec10a

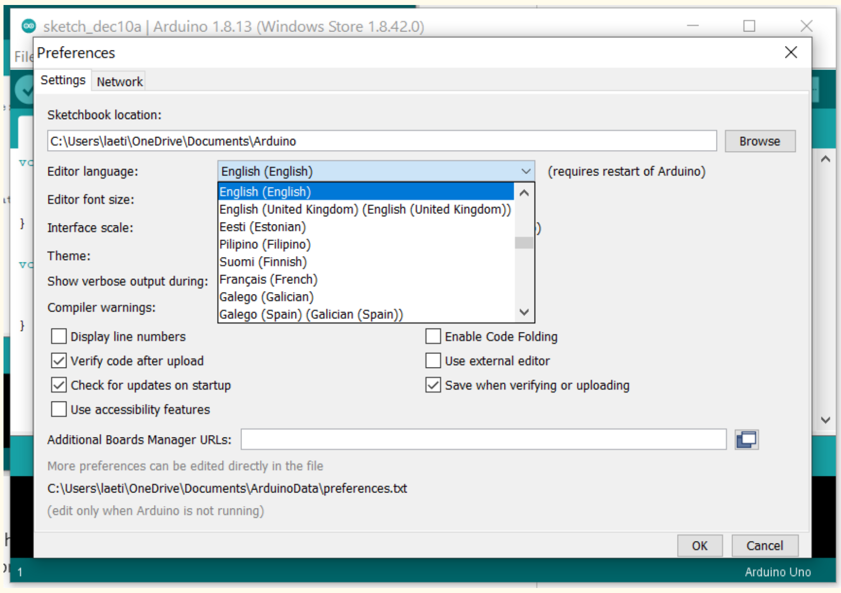
```
void setup() {
  // put your setup code here, to run once:

}

void loop() {
  // put your main code here, to run repeatedly:

}
```

1 Arduino Uno

The facilitator will guide the participants with step-by-step instructions on understanding how the software works and how to create projects.

**To change the language:**

1. Click on FILE and select PREFERENCES.
2. Next to the Editor Language, there is a dropdown menu of currently supported languages.
3. Select your preferred language from the menu.
4. Restart the software to use the selected language.


sketch_dec10a | Arduino 1.8.13 (Windows Store 1.8.42.0)

Preferences

Settings Network

Sketchbook location:
C:\Users\laeti\OneDrive\Documents\Arduino   Browse

Editor language: English (English)   (requires restart of Arduino)

English (English)
English (United Kingdom) (English (United Kingdom))
Eesti (Estonian)
Pilipino (Filipino)
Suomi (Finnish)
Français (French)
Galego (Galician)
Galego (Spain) (Galician (Spain))

Editor font size:
Interface scale:
Theme:
Show verbose output during:
Compiler warnings:

☐ Display line numbers
☑ Verify code after upload
☑ Check for updates on startup
☐ Use accessibility features
☐ Enable Code Folding
☐ Use external editor
☑ Save when verifying or uploading

Additional Boards Manager URLs:

More preferences can be edited directly in the file
C:\Users\laeti\OneDrive\Documents\ArduinoData\preferences.txt
(edit only when Arduino is not running)

OK   Cancel

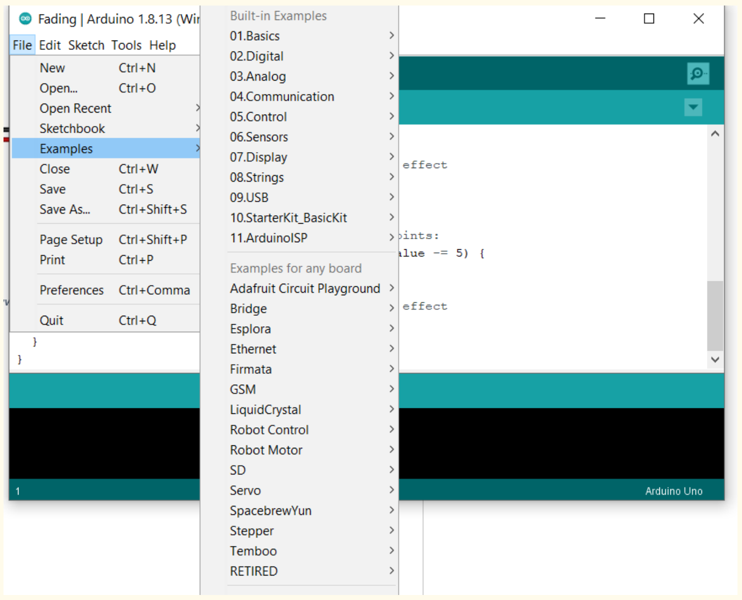
Arduino Uno

**To create a new project:**

File -> New

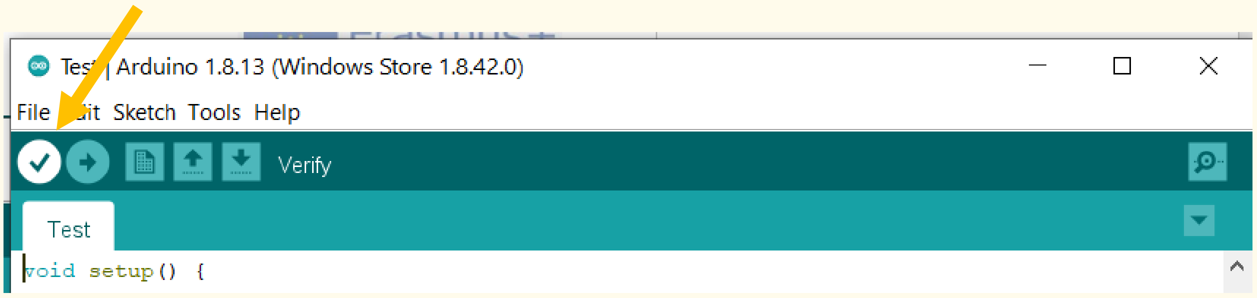
It is also possible to use already developed examples to have some inspiration or to reproduce them:

File -> Examples



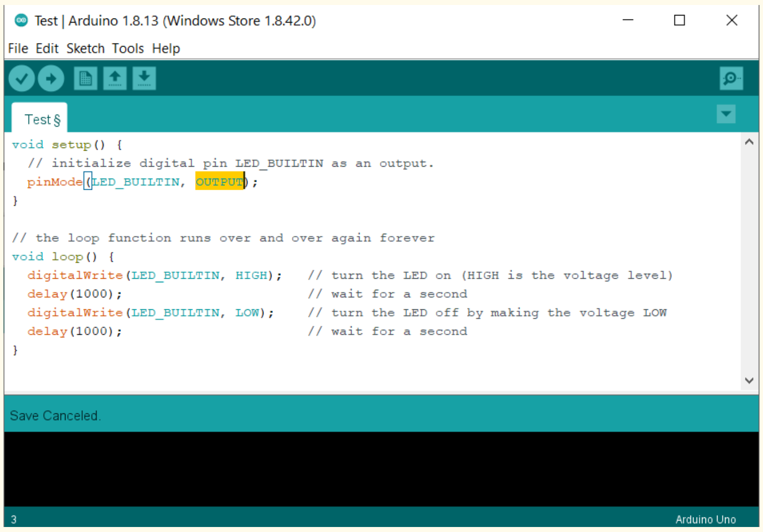
**To verify the project:**

Click on the TICK on the left below the Tab FILE.
It will turn orange while it is compiling information. Wait until it comes back to its initial color.


Test | Arduino 1.8.13 (Windows Store 1.8.42.0)
File Edit Sketch Tools Help
Verify
Test

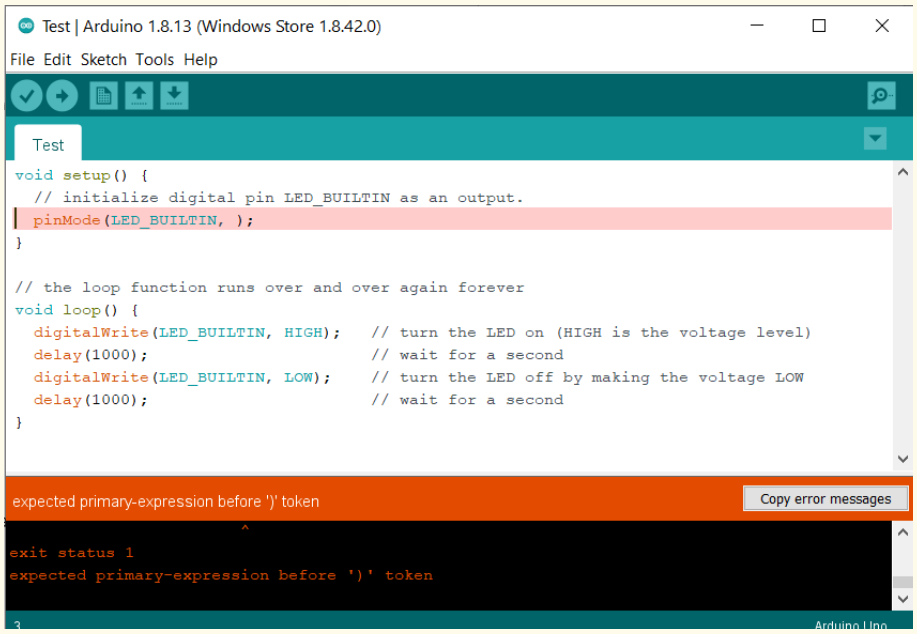
```
void setup() {
```

For this example, we have selected a sketch about blinking LED, and we have removed the information about "output" so the "verify function" will display the error:


Test | Arduino 1.8.13 (Windows Store 1.8.42.0)
File Edit Sketch Tools Help
Test §

```
void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(LED_BUILTIN, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(LED_BUILTIN, HIGH);   // turn the LED on (HIGH is the voltage level)
  delay(1000);                       // wait for a second
  digitalWrite(LED_BUILTIN, LOW);    // turn the LED off by making the voltage LOW
  delay(1000);                       // wait for a second
}
```

```
Save Canceled.
```



Test | Arduino 1.8.13 (Windows Store 1.8.42.0)

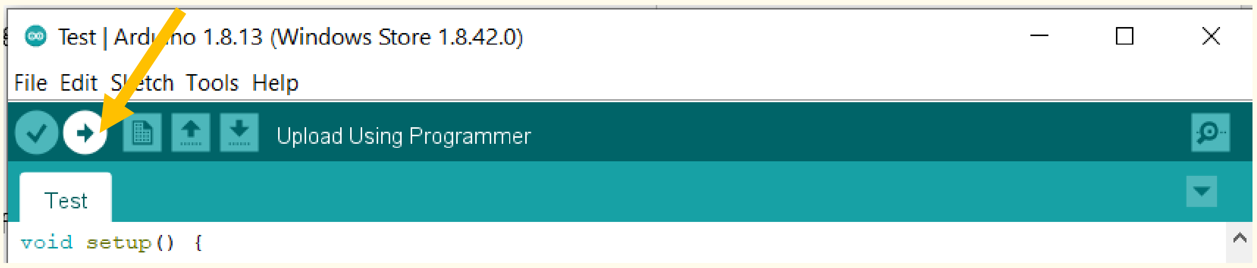
File Edit Sketch Tools Help

```
void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(LED_BUILTIN, );
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(LED_BUILTIN, HIGH);   // turn the LED on (HIGH is the voltage level)
  delay(1000);                       // wait for a second
  digitalWrite(LED_BUILTIN, LOW);    // turn the LED off by making the voltage LOW
  delay(1000);                       // wait for a second
}
```

```
expected primary-expression before ')' token

exit status 1
expected primary-expression before ')' token
```

**To upload the program:**

To upload the program, the Arduino board should be plugged into your computer with a USB cable. To upload the program, you should click on the horizontal arrow:



Test | Arduino 1.8.13 (Windows Store 1.8.42.0)

File Edit Sketch Tools Help

```
void setup() {
```

When the program is uploaded, the arrow will come back to its initial color.

If you have plugged and set up your Arduino board according to what you have programmed, you will be able to watch your program in action.

- **Bibliographic references:**

https://www.arduino.cc/en/Guide

https://create.arduino.cc/projecthub/Arduino_Genuino/getting-started-with-arduino-web-editor-on-various-platforms-4b3e4a

# MICROCONTROLLER AND ARDUINO FUNDAMENTALS

## LESSON – HOW TO PROGRAM IN ARDUINO, AND UPLOAD PROGRAMS TO THE BOARD

- **Study section:** Introduction to microcontrollers
- **Lesson duration:** 1:00h + 1:h00
- **Educational objectives:**
  - Learn the basics on how to program Arduino
  - Learn how to upload programs to Arduino board
- **Learning outcomes and acquired competencies:**

At the end of the unit, the student should be able to:

| Knowledge | Skills | Responsibility and Autonomy |
|---|---|---|
| • How to program Arduino<br>• How to upload programs (sketches) to Arduino board | • Program Arduino and create a simple sketch<br>• Upload a sketch to Arduino board | • Be capable of creating and uploading a simple sketch |

- **Main Keyword(s):**
  - Arduino UNO board
  - Arduino IDE
  - Program / Sketch
- **Required material and resources:**
  - Arduino UNO
  - Software Arduino IDE
  - Computer
  - Arduino USB cable

## Brief definition of Skecthes

Arduino calls programs are called “sketches”. An Arduino sketch is a set of instructions that you create to accomplish a particular task; in other words, a sketch is a program.

**How to program Arduino**

The facilitator first provides essential information on Arduino programs structures and then guides the participants in creating their first sketch in the IDE. The following text is provided:

Arduino programs can be divided into three main parts: ***Structure, Values (variables and constants), and Functions***. In this session, we will learn about the Arduino software program, step by step, and how we can write the program without any syntax or compilation error.

**Arduino – Programme Structure**

Let us start with the Structure. Software structure consist of two main functions:

Setup( ) function

Loop( ) function

```
Void setup ( ) {

}
```

PURPOSE − The setup() function is called when a sketch starts. Use it to initialize the variables, pin modes, start using libraries, etc. The setup function will only run once after each power-up or reset of the Arduino board.

INPUT − -

OUTPUT − -

RETURN − -

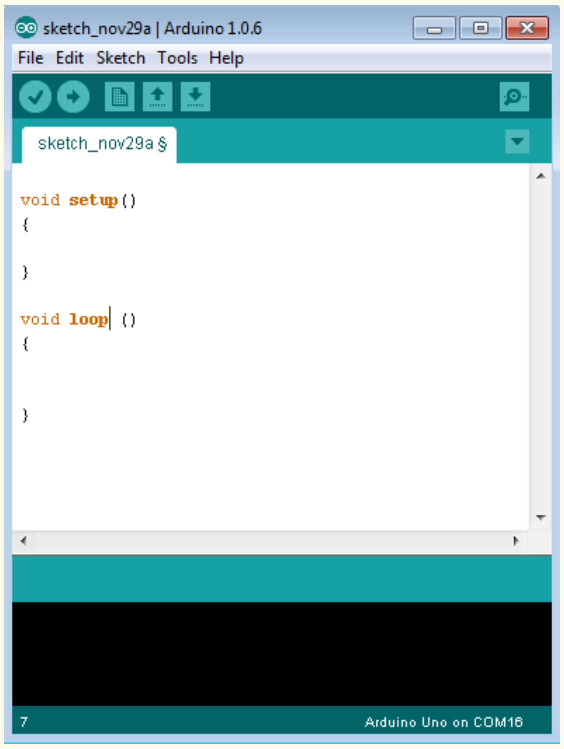
```
Void Loop ( ) {

}
```

PURPOSE − After creating a setup() function, which initializes and sets the initial values, the loop() function does precisely what its name suggests and loops consecutively, allowing your program to change and respond. Use it to actively control the Arduino board.

INPUT − -

OUTPUT – -

RETURN – -



```
void setup()
{

}

void loop ()
{


}
```

*Figure 1 Programme structure, source:* https://www.tutorialspoint.com/arduino/arduino_program_structure.htm

**Arduino – Data Types**

Data types in C refers to an extensive system used for declaring variables or functions of different types. The type of a variable determines how much space it occupies in the storage and how the bit pattern stored is interpreted.

The data types that you can use during Arduino programming are listed below.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| void | Boolean | char | Unsigned char | byte | int | Unsigned int | word |
| long | Unsigned long | short | float | double | array | String-char array | String-object |

**Arduino – Variables**

Variables in the C programming language, which Arduino uses, have a property called scope. A scope is a region of the program, and there are three places where variables can be declared. They are:

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- Inside a function or a block, which is called local variables.
- In the definition of function parameters, which are called formal parameters.
- Outside of all functions, which are called global variables.

Example of local variables:

```
Void setup () {

}

Void loop () {
   int x , y ;
   int z ; Local variable declaration
   x = 0;
   y = 0; actual initialization
   z = 10;
```

Example of global variables:

```
Int T , S ;
float c = 0 ; Global variable declaration

Void setup () {

}

Void loop () {
   int x , y ;
   int z ; Local variable declaration
   x = 0;
   y = 0; actual initialization
   z = 10;
}
```

An operator is a symbol that tells the compiler to perform specific mathematical or logical functions. C language is rich in built-in operators and provides the following types of operators:

- Arithmetic Operators
- Comparison Operators
- Boolean Operators
- Bitwise Operators
- Compound Operators

More details about each type of operator can be retrieved from here: https://www.tutorialspoint.com/arduino/arduino_operators.htm

**Arduino – Control statements**

Decision-making structures require that the programmer specify one or more conditions to be evaluated or tested by the program. It should be along with a statement or statements to be executed if the condition is determined to be true, and optionally, other statements to be executed if the condition is determined to be false.

Following is the general form of a typical decision-making structure found in most of the programming languages:

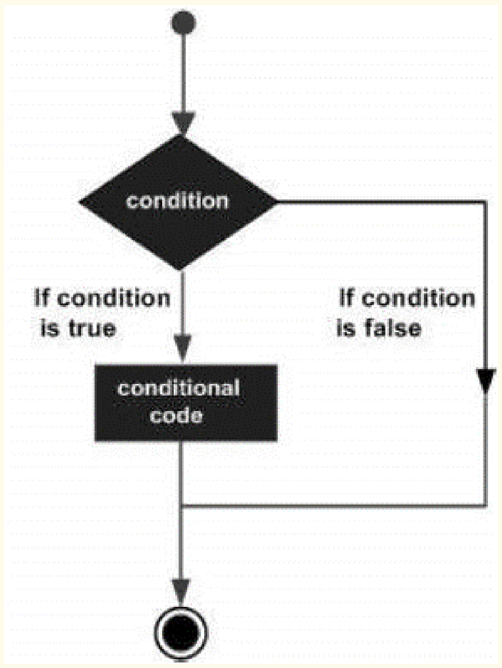

*Figure 2 The general form of a typical decision-making structure found in programming languages*

Control Statements are elements in the Source Code that control the flow of program execution. Those are listed below.

| No | Control Statement & Description |
|---|---|
| 1 | If statement<br>It takes an expression in parenthesis and a statement or block of statements. If the expression is true then the statement or block of statements gets executed otherwise these statements are skipped. |
| 2 | If ...else statement<br>An if statement can be followed by an optional else statement, which executes when the expression is false. |
| 3 | If...else if ...else statement<br>The if statement can be followed by an optional else if...else statement, which is very useful to test various conditions using single if...else if statement. |
| 4 | switch case statement<br>Similar to the if statements, switch...case controls the flow of programs by allowing the programmers to specify different codes that should be executed in various conditions. |

| | |
|---|---|
| 5 | Conditional Operator? :<br><br>The conditional operator?: is the only ternary operator in C. |

**Arduino – Loops**

A loop statement allows us to execute a statement or group of statements multiple times, and the following is the general form of a loop statement in most programming languages.

C programming language provides the following types of loops to handle looping requirements.

| No. | Loop & Description |
|---|---|
| 1 | while loop<br><br>while loops will loop continuously and infinitely until the expression inside the parenthesis, () becomes false. Something must change the tested variable, or the while loop will never exit. |
| 2 | do…while loop<br><br>The do…while loop is similar to the while loop. In the while loop, the loop-continuation condition is tested at the beginning of the loop before performing the loop's body. |
| 3 | for loop<br><br>A for loop executes statements a predetermined number of times. The control expression for the loop is initialized, tested, and manipulated entirely within the for loop parentheses. |
| 4 | Nested Loop<br><br>C language allows you to use one loop inside another loop. The following example illustrates the concept. |
| 5 | Infinite loop<br><br>It is the loop having no terminating condition, so the loop becomes infinite. |

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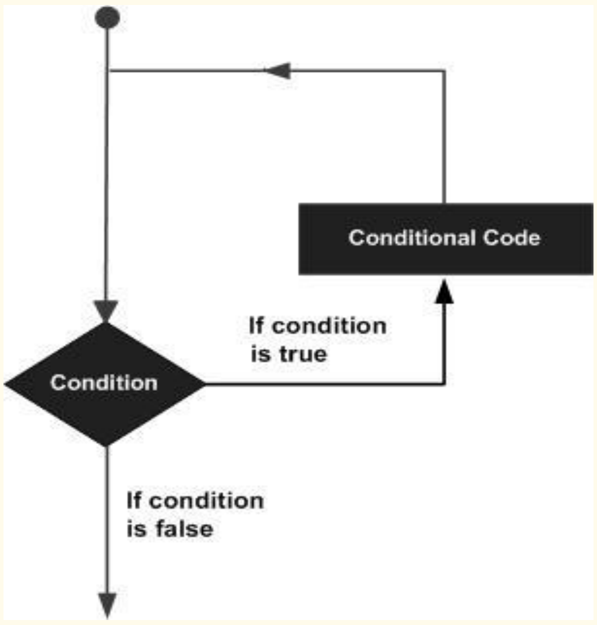

*Figure 3 The general form of a loop statement in most of the programming languages*

**Creating your first sketch in the Arduino IDE**

The facilitator guides the participants to create and upload a simple sketch. The following text can be used:

In this part of the session, you will create and upload a simple sketch that will cause the Arduino's LED to blink repeatedly by turning it on and then off for 1-second intervals.

To begin, connect your Arduino to the computer with the USB cable. Then open the IDE, choose Tools4Serial Port, and make sure the USB port is selected. This ensures that the Arduino board is properly connected.

The first stage in creating any sketch is to add the void setup() function. This function contains instructions for the Arduino to execute once only, each time it is reset or turned on. To create the setup function, add the following lines to your sketch:

```
void setup()
{
}
```

Our program will blink the user LED on the Arduino. The user LED is connected to the Arduino's digital pin 13. A digital pin can either detect an electrical signal or generate one on command. In this small project, we will generate an electrical signal that will light the LED. Enter the following into your sketch between the braces ({ and }):

```
pinMode(13, OUTPUT); // set digital pin 13 to output
```

The number 13 in the listing represents the digital pin you're addressing. You are setting this pin to OUTPUT, which will generate (output) an electrical signal. If you wanted it to detect an incoming electrical signal, then you would use INPUT instead. Notice that the function pinMode() ends with a semicolon (;). Every function in your Arduino sketches will end with a semicolon. Save your sketch again to ensure that you don't lose any of your work by choosing File > Save As. Enter a short name for your sketch, and then click OK.

Remember that our goal is to make the LED blink repeatedly. To do this, we will create a loop function to tell the Arduino to execute an instruction repeatedly until the power is shut off or someone presses the RESET button.

Enter the code shown in boldface after the void setup() section in the following listing to create an empty loop function. Be sure to end this new section with another brace (}), and then save your sketch again.

```
/*
Arduino Blink LED Sketch
by Mary Smith, created 09/09/12
*/
void setup()
{
pinMode(13, OUTPUT); // set digital pin 13 to output
}
void loop()
{
// place your main loop code here:
}
```

Next, enter the actual functions into the void loop() for the Arduino to execute.

Enter the following between the loop function's braces, and then click Verify to make sure that you have entered everything correctly:

```
digitalWrite(13, HIGH); // turn on digital pin 13
delay(1000); // pause for one second
digitalWrite(13, LOW); // turn off digital pin 13
delay(1000); // pause for one second
```

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The digitalWrite() function controls the voltage that is output from a digital pin: in this case, pin 13 to the LED. By setting the second parameter of this function to HIGH, a "high" digital voltage is output; then current will flow from the pin, and the LED will turn on.

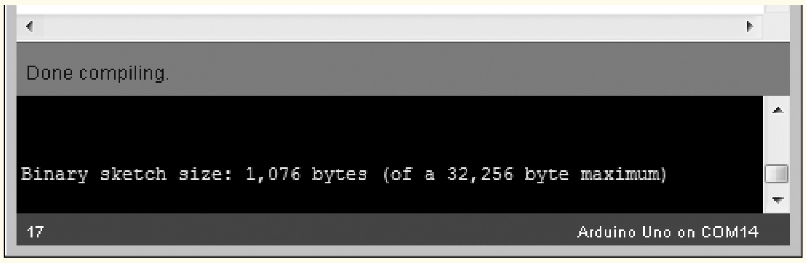
With the LED turned on, the light pauses for 1 second with delay(1000). The delay() function causes the sketch to do nothing for a period of time— in this case, 1,000 milliseconds, or 1 second.

Next, we turn off the voltage to the LED with digitalWrite(13, LOW);. Finally, we pause again for 1 second while the LED is off, with delay(1000);. The completed sketch should look like this:

```
/*
Arduino Blink LED Sketch
by nickname, created 28/12/20
*/
void setup()
{
pinMode(13, OUTPUT); // set digital pin 13 to output
}
void loop()
{
digitalWrite(13, HIGH); // turn on digital pin 13
delay(1000); // pause for one second
digitalWrite(13, LOW); // turn off digital pin 13
delay(1000); // pause for one second
}
```

Before you do anything further, save your sketch.

Next, you should verify your sketch. When doing so, you ensure that it has been written correctly so that the Arduino can understand. To verify your complete sketch, click Verify in the IDE and wait a moment. Once the sketch has been verified, a note should appear in the message window, as shown in Figure 4.



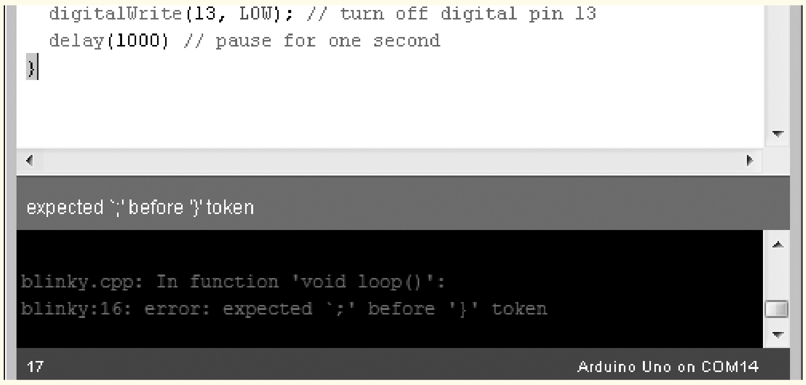
```
Done compiling.

Binary sketch size: 1,076 bytes (of a 32,256 byte maximum)
17                                          Arduino Uno on COM14
```

Figure 4 The sketch has been verified.

This "Done compiling" message tells you that the sketch is OK to upload to your Arduino. It also shows how much memory it will use (1,076 bytes in this case) of the total available on the Arduino (32,256 bytes).

In case that your sketch is not OK, e.g., you forgot to add a semicolon at the end of the second delay(1000) function, then when you click Verify, the message window should display a verification error message similar to the one shown in Figure 5.



```
  digitalWrite(13, LOW); // turn off digital pin 13
  delay(1000) // pause for one second
}

expected `;' before '}' token

blinky.cpp: In function 'void loop()':
blinky:16: error: expected `;' before '}' token
17                                          Arduino Uno on COM14
```

Figure 5 The message window with a verification error.

The message tells you that the error occurs in the void loop function, lists the line number of the sketch where the IDE thinks the error is located (blinky:16, or line 16 of your blinky sketch), and displays the error itself (the missing semicolon, error: expected ';' before '}' token). Furthermore, the IDE should also highlight in yellow the location of the error or a spot just after it. This helps you easily locate and rectify the mistake.

## Uploading and Running Your Sketch

Once having saved your sketch, ensure that your Arduino board is connected, and click Upload in the IDE. The IDE may verify your sketch again and then upload it to your Arduino board. The TX/RX LEDs on your board should blink during this process, indicating your program functions properly.

- **Bibliographic references:**

Arduino (2020). Arduino Tutorial. Retrieved from: https://www.tutorialspoint.com/arduino/index.htm

Boxall, J. (2013). *Arduino workshop: A Hands-On introduction with 65 projects*. No starch press.

Smith, A. G. (2011). *Introduction to Arduino*. Alan G. Smith.

## LESSON – BREADBOARD ASSEMBLIES

- **Study section:** Microcontroller and Arduino Fundamentals

- **Lesson duration:** 2:00h

- **Educational objectives:**

  - Discovering the breadboard assemblies
  - Understand the basics of breadboard assemblies
  - Discover the parts to create a circuit

- **Learning outcomes and acquired competencies:**

At the end of the unit, the student should be able to:

| Knowledge | Skills | Responsibility and Autonomy |
|---|---|---|
| • What are Breadboard assemblies<br>• How to use it<br>• How does it work<br>• The different parts | • Power a breadboard assemblies<br>• Build a circuit<br>• Recognize the parts | • Be capable of building a simple circuit on a breadboard |

- **Main Keyword(s):**

  - Breadboard
  - Parts: jumper, pushbuttons, resistors, LED

- **Required material and resources:**

  - Breadboard Arduino Compatible (BBAC)
  - A 9V battery
  - A battery clip
  - A LEDs
  - Jumpers

## What is a Breadboard?

A **breadboard** is a thin plastic board used to hold electronic components (transistors, resistors, chips, etc.) that are wired together to create a circuit. It is used to develop prototypes of electronic circuits.
Breadboards can be used to create one-of-a-kind systems but rarely become commercial products. A breadboard can be reused for several different projects.

Definition from: ttps://www.pcmag.com/encyclopedia/term/breadboard

**Present the breadboard**

The facilitator will start the lesson by showing a different type of breadboard and explaining what it is used for and how to use it. The facilitator begins with the following steps:

**THE BREADBOARD, also called SOLDERLESS BREADBOARD**

There are several kinds of breadboards, also called Solderless Breadboard, with different sizes, shapes, and purposes. The one we will focus on for this lesson is the breadboard Arduino compatible that looks like the image below:

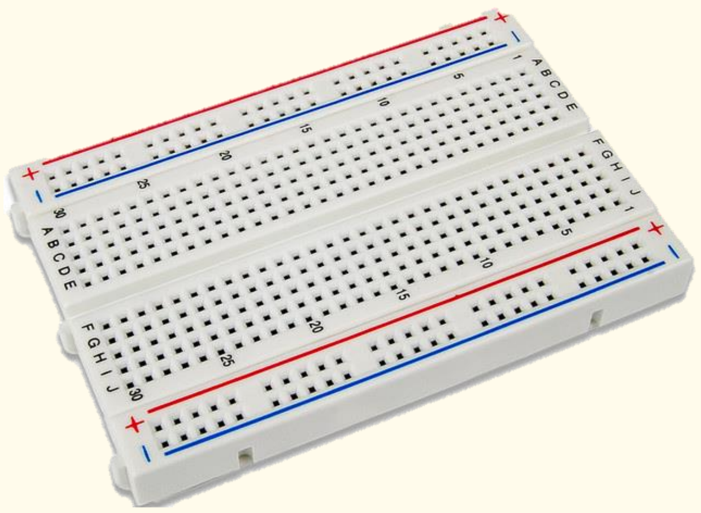
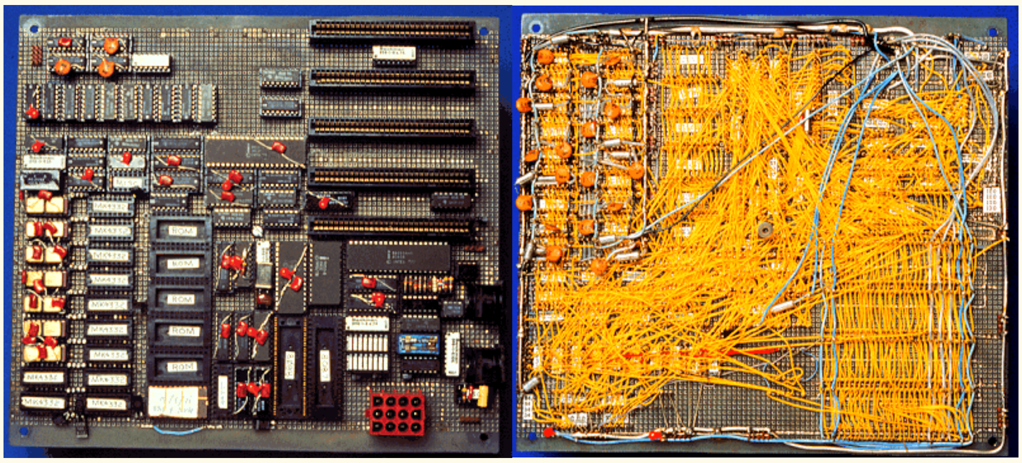


Image: https://blog.digilentinc.com/a-breadboard-for-every-circuit/

More complex breadboards:


Source: https://www.pcmag.com/encyclopedia/term/breadboard

## WHAT IS THE BREADBOARD USED FOR?

A breadboard is used to construct simple electronic circuits that do not require a soldering iron. Components like pins, microcontrollers, LEDs, jumpers… are pushed/ plugged into the holes (sockets) of the breadboard. Wires called jumpers enable the connection (power) within the different elements.

### How does the breadboard work?

The most common breadboard is composed of rows and columns that are electrically connected. You have two types of rails:

The vertical rails or columns:

The vertical lines (red and blue) with + and – run the board's length. They are traditionally used for power and Ground.

The horizontal rails or lines:

- 1,2,3…up to 30 in our below example.
- a-b-c-d-e of each line are connected together.
- But 1 – 2 – 3 …30 are separated by a gap, so they are not connected.

To better understand, it is worth looking at the back of a breadboard with metal connections. **Caution**: do not rip the back off your breadboard; it will ruin the breadboard.

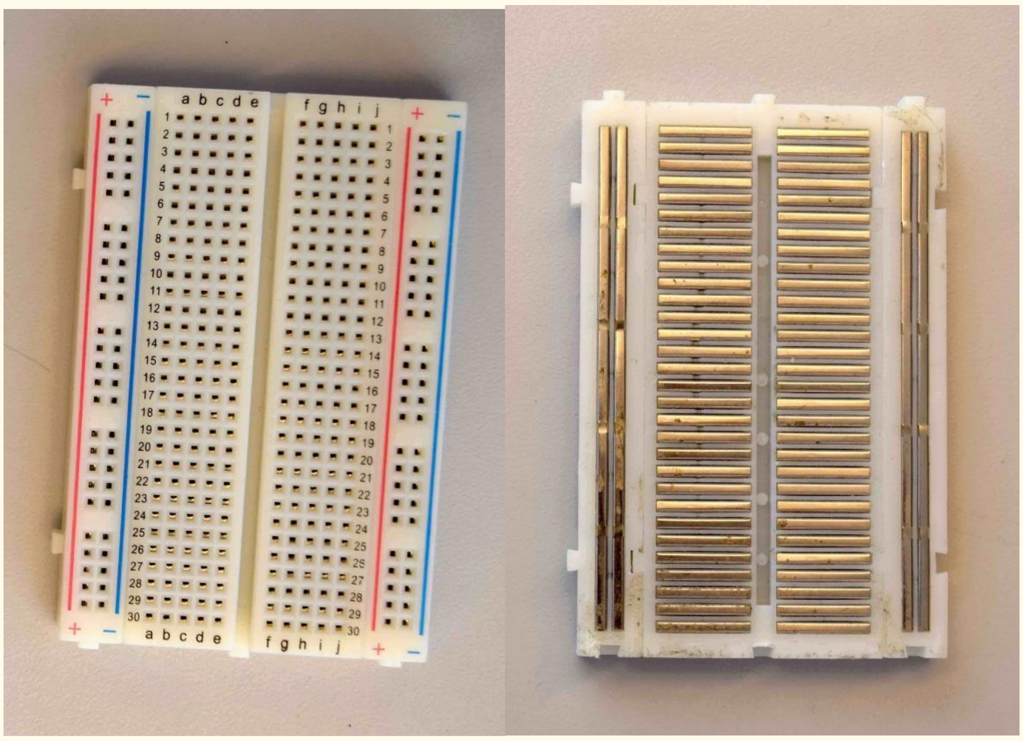


Image source: https://hcie.csail.mit.edu/classes/2018-fall-6810/6810-electronics.html

## TO HAVE A WORKING CIRCUIT

To develop a working circuit, your breadboard needs to be alimented with power. In the next lessons, we will have power through an USB cable connected to Arduino, but we will have a look at a classic 9V battery for this lesson.

The components:

| | | |
|---|---|---|
| A battery clip | A 9V battery | A breadboard |
| | | |

To connect the breadboard to power, jumpers (wires) from the battery should be plugged in the vertical lines. The red jumper in the red line (the +) and the black jumper in the Ground (the -).

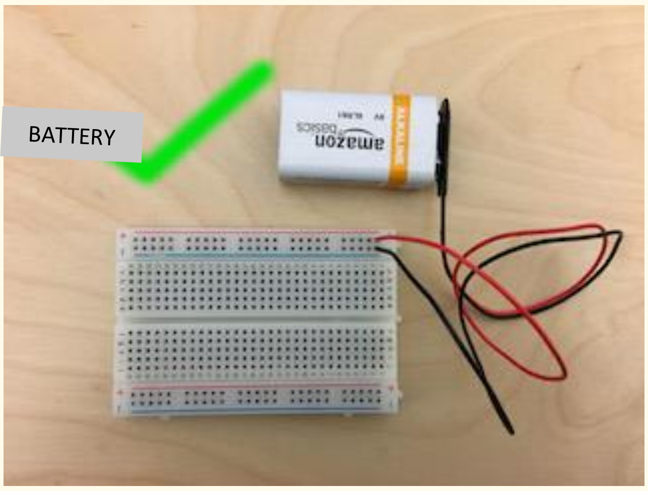


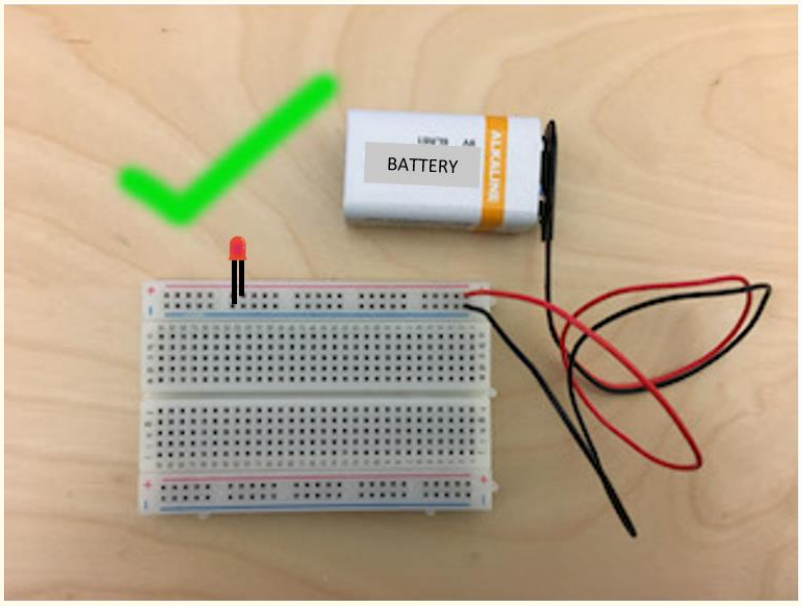
image: https://hcie.csail.mit.edu/classes/2018-fall-6810/6810-electronics.html

**Example**

At this stage, the facilitator should display what the bad practices are and what should not be done:

- Plugging the red jumper in the minus (Ground) and the black jumper in the plus.
- Plugging the jumpers in different locations than the vertical lines (1-A and 5-B or 4-A and 4-C)

Then facilitator could show how a LED can be switched on thanks to breadboard connections:



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- **Bibliographic references:**

https://www.seeedstudio.com/blog/2020/01/06/how-to-use-a-breadboard-wiring-circuit-and-arduino-interfacing/

https://learn.adafruit.com/lesson-0-getting-started/breadboard

https://hcie.csail.mit.edu/classes/2018-fall-6810/6810-electronics.html

https://www.arduino.cc/en/main/standalone

https://www.digikey.si/en/maker/projects/learn-to-breadboard/43bde9f32dad493182278f0441466a6e

Images sources (components):
https://core-electronics.com.au/solderless-breadboard-300-tie-points-zy-60.html

https://www.allekabels.be/blok-batterij/7289/1217862/blok-batterij-alkaline.html?gclid=Cj0KCQiAzsz-BRCCARIsANotFgM9Sxa3miWc_qzn_BUEsmQscHz6gp0mDBfN4itGROwA4fGiv99eo2IaAkViEALw_wcB

https://www.parts-express.com/snap-type-battery-clip-with-wire-leads-for-9v-batteries-battery-holders--090-805

## LESSON- DIGITAL OUTPUT: BLINKING LED WITH ARDUINO

- **Study section:** Microcontroller and Arduino Fundamentals
- **Lesson duration:** 2:00h
- **Educational objectives:**
    - Build a circuit to have a blinking LED (breadboard & Arduino)
    - Program Arduino to trigger the blinking LED
    - The components
- **Learning outcomes and acquired competencies:**

At the end of the unit, the student should be able to:

| Knowledge | Skills | Responsibility and Autonomy |
|---|---|---|
| • How to install a circuit<br>• The digital outputs<br>• How to program the Arduino to have a blinking LED | • Know the components needed<br>• Program/code the outputs<br>• Build a circuit | • Be capable of building a blinking LED circuit on a breadboard using an Arduino |

- **Main Keyword(s):**
    - Breadboard
    - Components: jumpers, LED, resistors, LEDs…
    - Arduino
    - Digital output
- **Required material and resources:**
    - Arduino Uno R3
    - Arduino IDE software
    - Computer/Laptop
    - Connection cable to connect Arduino and Laptop
    - Breadboard Arduino Compatible (BBAC)
    - A LED
    - 1 Resistor (220ohm)
    - 2 Jumpers

**The objective of the exercise**

The facilitator will start the lesson by explaining what the objective of the lesson is:

In this lesson we want to develop something simple that can be developed with an Arduino; that is to say, we want to build a circuit and program the Arduino to obtain a blinking LED every 1 second. The signal we will receive is a digital output: a LED switching from on and off every 1 second. We will therefore use the DIGITAL PINS of the Arduino.¨If necessary, the facilitator can briefly present the concepts of I/O and the Arduino Uno and its functionalities.

**Present the components and circuit**

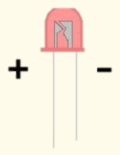
Then, the facilitator will present the different components that will be used during the lesson and show them how components must be manipulated to build this circuit. The facilitator begins with the following steps:

- **THE LED and the RESISTOR**

**LEDs** are small, powerful lights that can be used for many different applications.
The LED has two legs, one + and one +.

In our example, the legs of the LED can be either plugged in the pin of the Arduino board or on the breadboard.

To determine the positive and the negative leg you have to remember that:

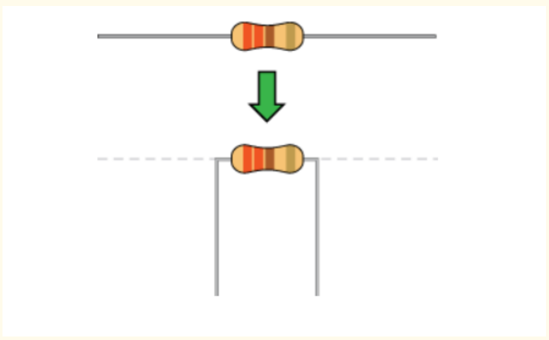


LONG LEG = POSITIVE (+)

SHORT LEG = NEGATIVE (-)

Most of the time, the LED is used with a RESISTOR

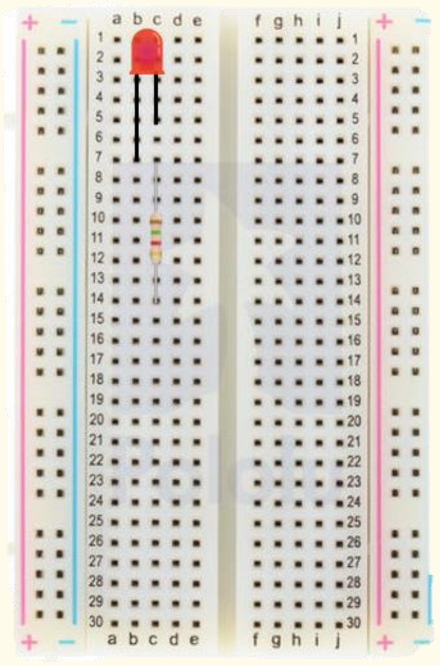
A **RESISTOR** is a component that allows reducing the supply voltage (like a transformer delivering 12V DC) to obtain the necessary voltage to illuminate a led (for example, 2.3V). Attention, the value of a resistor is calculated concerning what you want to supply.



To plug the resistor in the breadboard, you need to bend the terminals (legs) of the resistor into 90° angles, so it fits the sockets.

Remember that you can also cut the legs to obtain the appropriate length for your circuit.

Let's plug our LED and RESISTOR on the BREADBOARD:



- LED: The long leg (+) of the LED is in 7B. The short leg of the LED is in 5C
- RESISTOR: Terminals in 7C and 14C

- **ARDUINO BOARD – BREADBOARD AND JUMPERS**

To build your circuit, you will first need to plug the jumpers: red and black wires into the pin of the Arduino and make the connections with the breadboard.

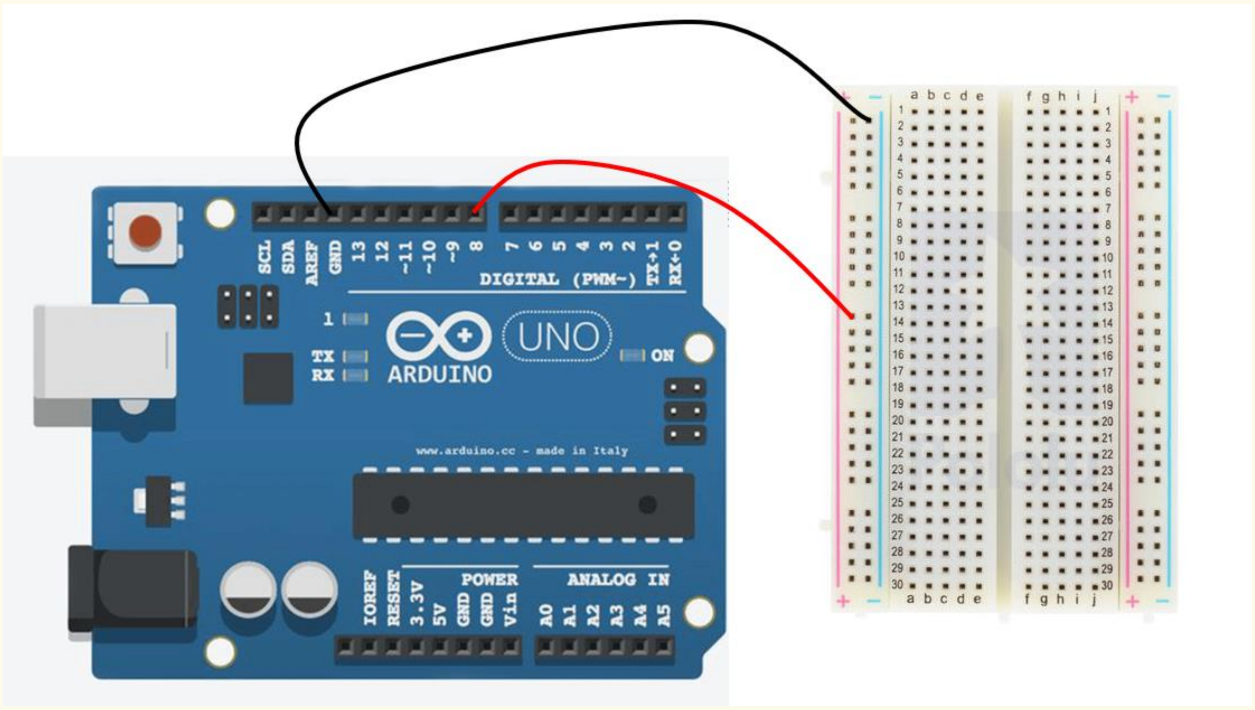
**IMPORTANT NOTE**: The BLACK jumper is the GROUND (-), so it is ALWAYS plugged in the GDN PIN of the Arduino board, and the RED jumper is (+). You need to determine whether you are in the presence of Digital or Analog I/O, so you place your jumpers in the correct pin.

In our example, we will plug the Black jumper in the PIN GDN of the Digital

And the Red jumper in the PIN 9 of Digital.

Jumpers on the breadboard: The Black (-) jumper going from the GDN pin to the Minus (Blue) column. The Red (+) jumper going from 8 Digital PIN to the Plus (Red) column

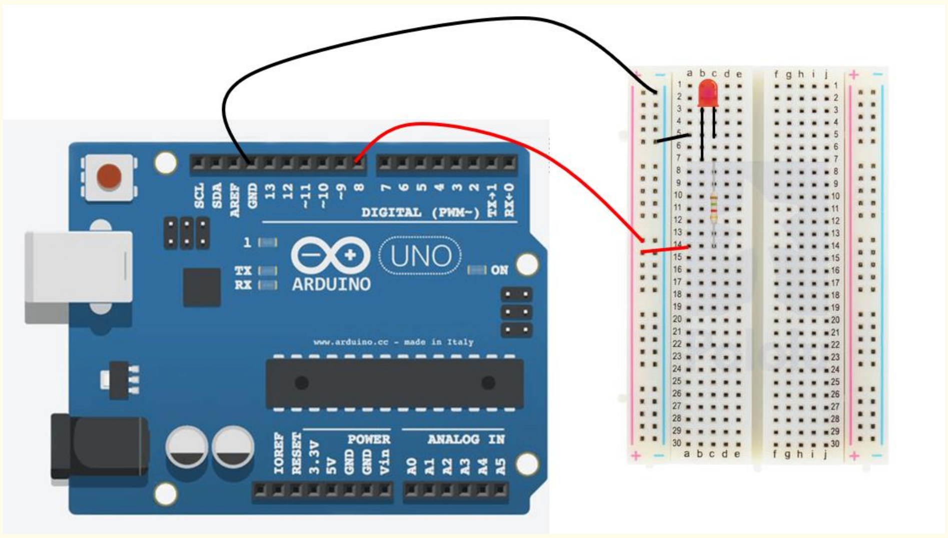
See below:



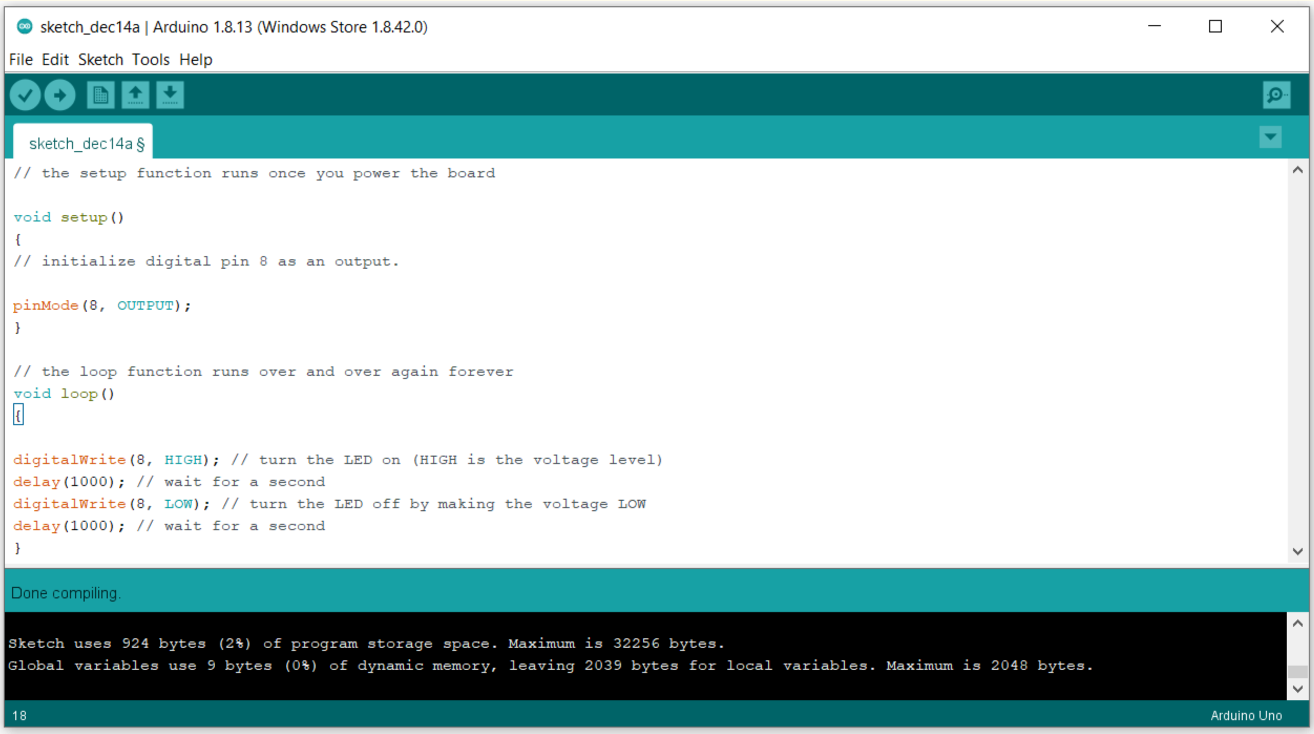
**IMPORTANT NOTE:**

To have power running in your circuit and to be able to set up the program, your Arduino board should be plugged with the USB cable to your laptop/computer.

- **ARDUINO BREADBOARD CONNECTIONS**



**Arduino code:**


sketch_dec14a | Arduino 1.8.13 (Windows Store 1.8.42.0)
File Edit Sketch Tools Help
sketch_dec14a §
Done compiling.
18
Arduino Uno

```
// the setup function runs once you power the board

void setup()
{
// initialize digital pin 8 as an output.

pinMode(8, OUTPUT);
}

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

digitalWrite(8, HIGH); // turn the LED on (HIGH is the voltage level)
delay(1000); // wait for a second
digitalWrite(8, LOW); // turn the LED off by making the voltage LOW
delay(1000); // wait for a second
}
```

```
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.
```

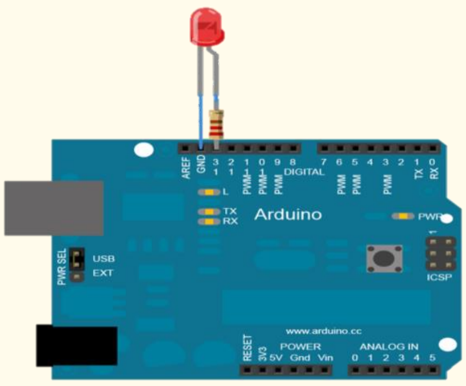
**Additional notes:**

**pinMode(2, OUTPUT)** – Before using one of Arduino's pins, you need to tell Arduino Uno R3 whether it is an INPUT or OUTPUT. We use a built-in "function" called pinMode() to do this.

**digitalWrite(2, HIGH)** – When you are using a pin as an OUTPUT, you can command it to be HIGH (output 5 volts), or LOW (output 0 volts).

**To have a blinking LED, we could also have attached the LED to the PIN of the Arduino without using a breadboard.**

See example below:



source: https://www.instructables.com/How-to-Blink-LED-Using-Arduino/

- **Bibliographic references:**

https://www.instructables.com/How-to-Blink-LED-Using-Arduino/

https://www.tutorialspoint.com/arduino/arduino_blinking_led.htm

https://www.arduino.cc/en/Tutorial/BuiltInExamples/Blink

https://www.hackerearth.com/blog/developers/a-tour-of-the-arduino-uno-board/

https://docs.allthingstalk.com/examples/kits/arduino-rdk/

## LESSON – ANALOG OUTPUT: FADING LED WITH ARDUINO

- **Study section:** Microcontroller and Arduino Fundamentals
- **Lesson duration:** 2:00h
- **Educational objectives:**
  - Build a circuit to have a fading LED (breadboard & Arduino)
  - Program Arduino to change the intensity of the LED
  - The components
- **Learning outcomes and acquired competencies:**

At the end of the unit, the student should be able to:

| Knowledge | Skills | Responsibility and Autonomy |
|---|---|---|
| • How to install the circuit<br>• How to program the Arduino<br>• The analogWrite() function<br>• The concept of PWM<br>• Program a fading LED on an Arduino | • Know the components needed<br>• Program/code the outputs<br>• Learn about how to use PWM | • Be capable of building a fading LED circuit on a breadboard<br>• Code a fading LED program |

- **Main Keyword(s):**
  - Breadboard
  - Components: jumpers, LED, resistors, LEDs…
  - analogWrite() function
  - Pulse Width Modulation (PWM)
  - Digital output
- **Required material and resources:**
  - Arduino Uno R3
  - Arduino IDE software
  - Computer/Laptop
  - Connection cable to connect Arduino and Laptop
  - Breadboard Arduino Compatible (BBAC)
  - A LED
  - 1 Resistor (220ohm)
  - 2 Jumpers

**Definition: Pulse Width Modulation (PWM)**

Pulse Width Modulation, or PWM, is a technique for getting analog results with digital means.

The Fading example demonstrates the use of analog output (PWM)

AnalogWrite uses pulse width modulation (PWM), turning a digital pin on and off very quickly with different ratio between on and off, to create a fading effect.

## The objective of the exercise

The facilitator will start the lesson by explaining what the objective of the lesson is:

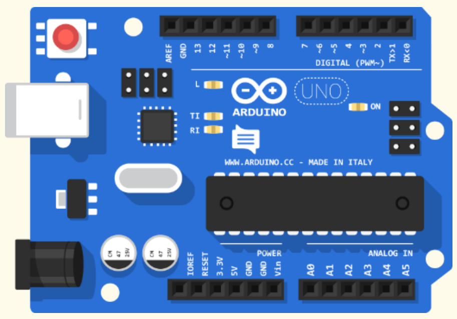
In this lesson, we will see how to make an LED fade. For an LED to fade, it has to change from 0% OFF (0 Volt) to 100% ON (5 Volt) very quickly, so the human eye sees a nuance of intensity.

To do this, we will use the analogWrite() function. AnalogWrite uses pulse width modulation (PWM).

**Pulse Width Modulation**, or PWM, is a technique for getting analog results with digital means.

## The PWM pins

The Arduino board is composed of several pins.
There are Analog and Digital Pins, and among the digital pins, some are what we call PWM, that is to say, PULSE WIDTH MODULATION.
The pins with PWM can be identified with the "~" sign like ~3, ~5, ~6, ~9, ~10, and ~11.
See the image below:



Source: https://docs.allthingstalk.com/examples/kits/arduino-rdk/

To know more about the PINS and Arduino board, check the lessons about "Introduction to microcontrollers."

**Present the components and circuit**

The components used for fading a LED are the same as for blinking a LED. Please refer to the previous lesson to have more details about the components.

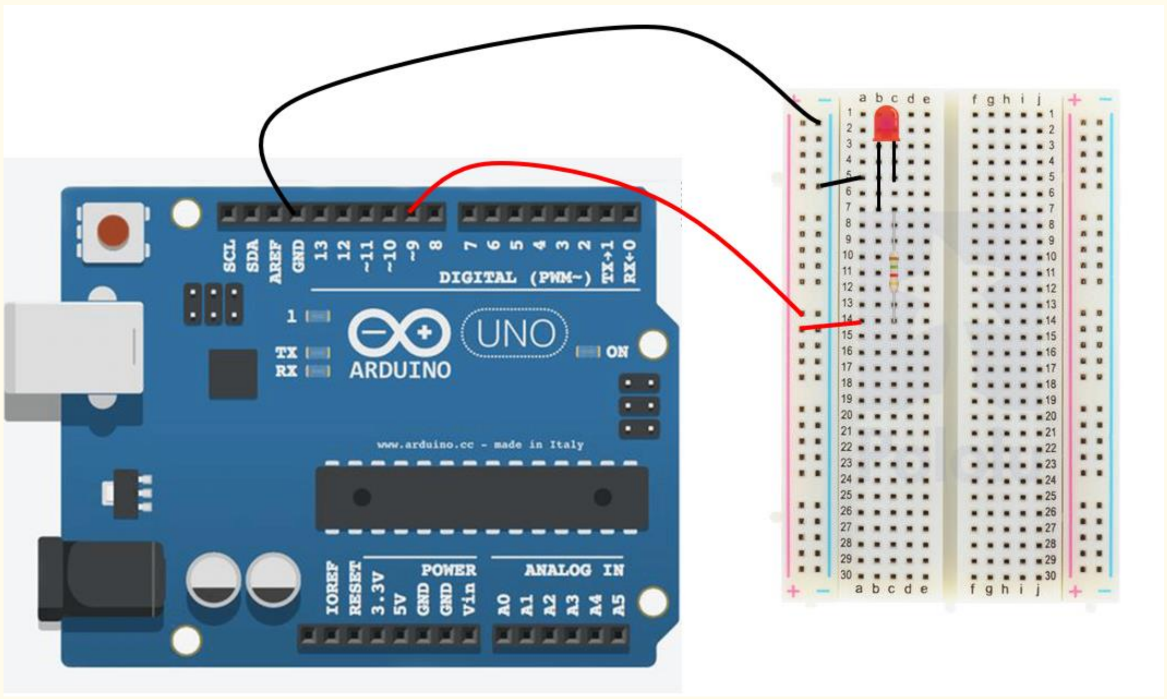
- **THE LED and the RESISTOR (see the lesson about Blinking LED)**
- **ARDUINO BOARD – BREADBOARD AND JUMPERS (see the lesson about Blinking LED)**

- **ARDUINO BREADBOARD CONNECTIONS**

Unlike the circuit for blinking LED, for the fading LED, the output will be in PIN 9 because it is with PWM.

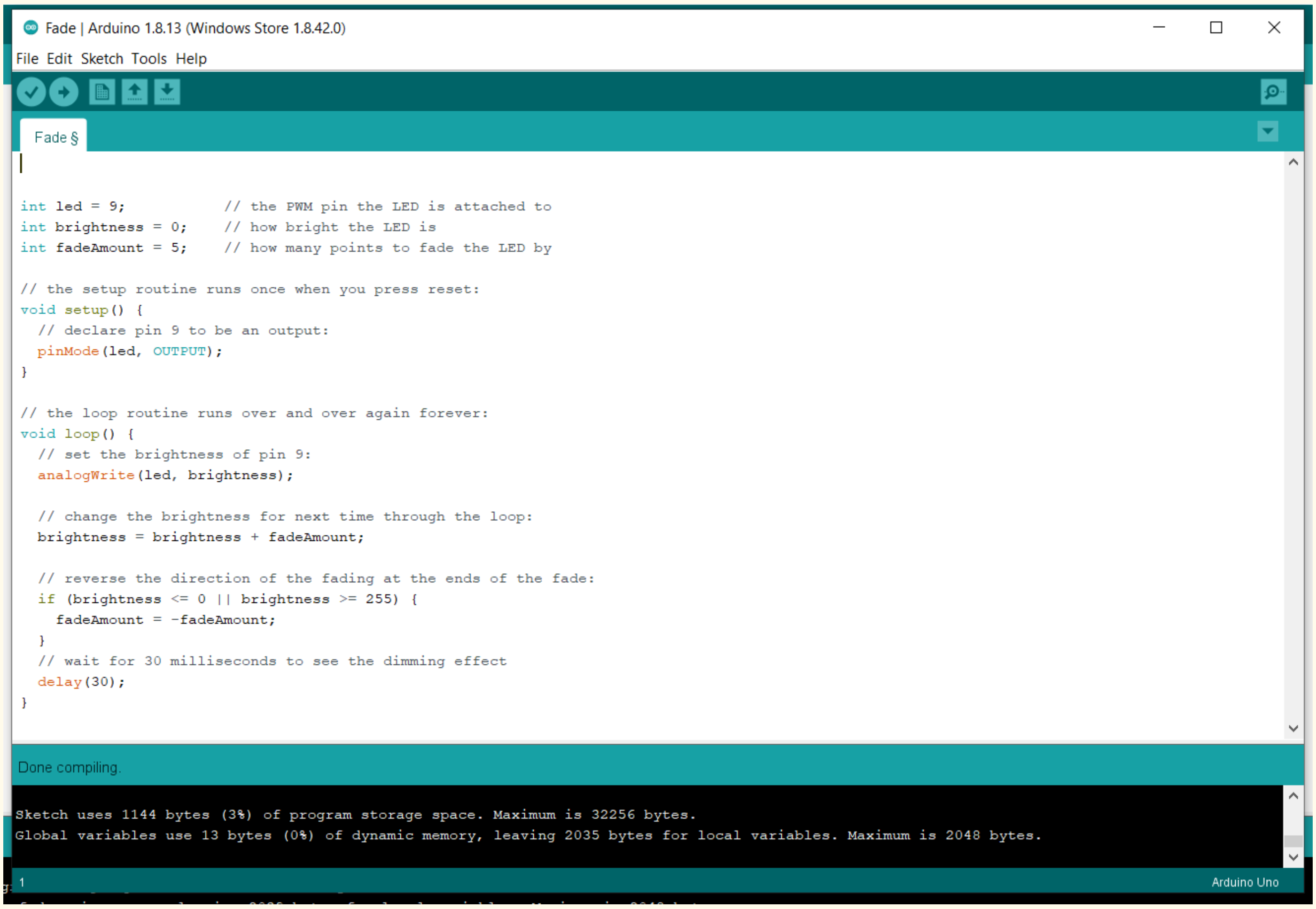
Connect the LED's positive leg (the long one) to digital output pin 9 on your board through a 220-ohm resistor. Connect the negative leg (the shorter) directly to Ground.

+LEG of the LED in 7B with a resistor in 7C connected to the ~9 PIN – LEG of the LED in 5C connected to the Ground. See the circuit below:



**Arduino code:**

This example shows how to fade an LED on pin 9 using the analogWrite() function. The analogWrite() function uses PWM, so if you want to change the pin you're using, be sure to use another PWM-capable pin. On most Arduino, the PWM pins are identified with a "~" sign, like ~3, ~5, ~6, ~9, ~10 and ~11. This example code is in the public domain: http://www.arduino.cc/en/Tutorial/Fade


Fade | Arduino 1.8.13 (Windows Store 1.8.42.0)
File Edit Sketch Tools Help
Fade §

```
int led = 9;           // the PWM pin the LED is attached to
int brightness = 0;    // how bright the LED is
int fadeAmount = 5;    // how many points to fade the LED by

// the setup routine runs once when you press reset:
void setup() {
  // declare pin 9 to be an output:
  pinMode(led, OUTPUT);
}

// the loop routine runs over and over again forever:
void loop() {
  // set the brightness of pin 9:
  analogWrite(led, brightness);

  // change the brightness for next time through the loop:
  brightness = brightness + fadeAmount;

  // reverse the direction of the fading at the ends of the fade:
  if (brightness <= 0 || brightness >= 255) {
    fadeAmount = -fadeAmount;
  }
  // wait for 30 milliseconds to see the dimming effect
  delay(30);
}
```

```
Done compiling.

Sketch uses 1144 bytes (3%) of program storage space. Maximum is 32256 bytes.
Global variables use 13 bytes (0%) of dynamic memory, leaving 2035 bytes for local variables. Maximum is 2048 bytes.
```

- **Bibliographic references:**

https://www.arduino.cc/en/Tutorial/Foundations/PWM

https://www.arduino.cc/en/Tutorial/BuiltInExamples/Fade

https://create.arduino.cc/projecthub/glowascii/fade-an-led-arduino-basics-eebff7

https://www.instructables.com/How-to-Fade-an-LED-Arduino-Tutorial/

## LESSON – DIGITAL INPUT: READING BUTTONS

- **Study section:** Microcontroller and Arduino Fundamentals
- **Lesson duration:** 2:00h
- **Educational objectives:**
  - Describe inputs in Arduino
  - Understand Digital Inputs
  - Program Arduino to read a button's value
- **Learning outcomes and acquired competencies:**

At the end of the unit, the student should be able to:

| Knowledge | Skills | Responsibility and Autonomy |
|---|---|---|
| • Recognize a Digital Input<br>• Read a switch's on/off state<br>• Use digitalRead function | • Program and configure digital pins<br>• Blink an LED by closing a switch | • Solve problems autonomously |

- **Main Keyword(s):**
  - Digital Inputs
  - Arduino Programming
  - LED and Buttons
- **Required material and resources:**
  - Arduino UNO
  - LED Red
  - Resistor 1K and 10K
  - A momentary switch, button, or toggle switch
  - Hook-up wires
  - Breadboard
  - Computer
  - Arduino USB cable
  - Software Arduino IDE
  - Internet Connection

**Brief definition of Digital Input**

The digital inputs are signals or external values sent to a system having two states: HIGH or LOW.

Digital signals are used in situations where the input or output will have one of those two values. For example, a digital signal is used to turn an LED on or off by reading a button's value.

**Digital Inputs**

The facilitator will start the lesson by explaining what inputs are in Arduino and, more precisely, digital information. The facilitator begins a follow:

Inputs can be signals or external values sent to a system. For instance, the keyboard is an input for the computer because it sends data to the system. Another example of an input is the microphone that captures audio and sends it to a computer. On Arduino, by default, all the pins are already pre-configured as input. Unlike analog inputs, which may take on any value within a range of values, digital signals have two states: 0 or 1.

Digital signals are used in situations where the input or output will have one of those two values. For example, a digital signal is used to turn an LED on or off by reading a button's value. Buttons connect two points in a circuit when you press them, as shown in Figure 1. When the button/switch is unpressed, there is no connection between the button's two legs, so the pin is connected to 5 volts (through the pull-up resistor), and we read a HIGH. When the button/switch is closed/pressed, it makes a connection between its two legs, connecting the pin to the Ground so that we read a LOW.

In Arduino programming, the function digitalRead() is used to read a value from a digital pin, which can only be either HIGH (1) or LOW (2).

Syntax:

digitalRead(pin), where "pin" is the number of the digital pin you want to read (int)

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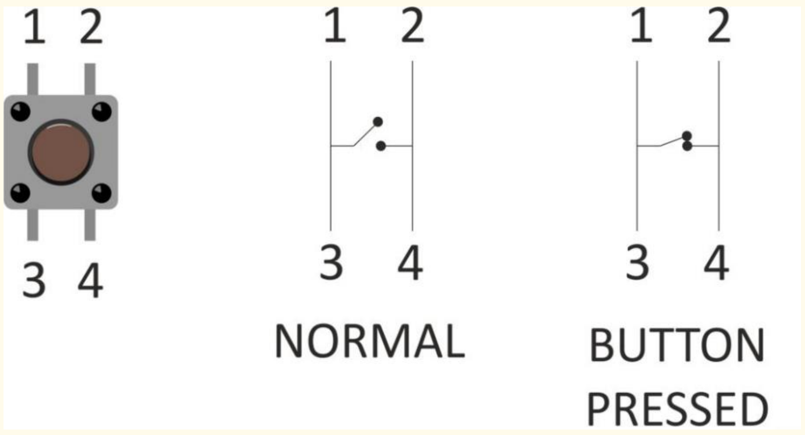


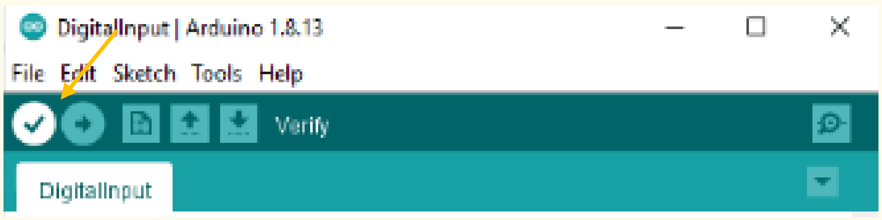
*Figure 1 Buttons Diagram (Source: [https://roboindia.com/](https://roboindia.com/))*

**Program Arduino to turn On and Off a LED using a button**

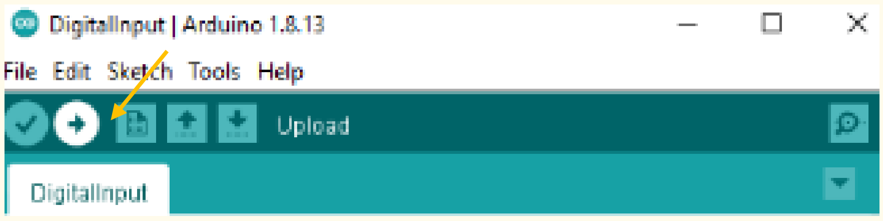
The facilitator will guide the participants with step-by-step instructions on making the connections on the breadboard and then explaining the Arduino code to them.

Step-by-step Instructions:

- Connect an Arduino GND pin to one of the long power rails on the breadboard
- Connect the short leg of the LED to the same ground rail on the breadboard and connect the long leg to a different row on the breadboard.
- Connect the 1K resistor, as shown in Figure 2, in the same row where the LED's long leg is attached.
- Place the pushbutton on the breadboard.
- Connect a jumper wire from the 5-volt pin to one side of the pushbutton and a jumper wire from pin 9 to the other side of the pushbutton.
- Connect one side of the 10k ohm resistor to the ground rail on the breadboard and the other side to the pushbutton in row 24 (as shown in Figure 2).
- Plug the Arduino board into your computer with a USB cable.
- Open the Arduino IDE.
- The code can be found in Figure 3.
- Click the Verify button on the top left. It should turn orange and then back to blue.



- Click the Upload button. Once the uploading has finished, it will turn blue.



- Press the button and watch how the LED reacts.

- **Arduino breadboard connections:**

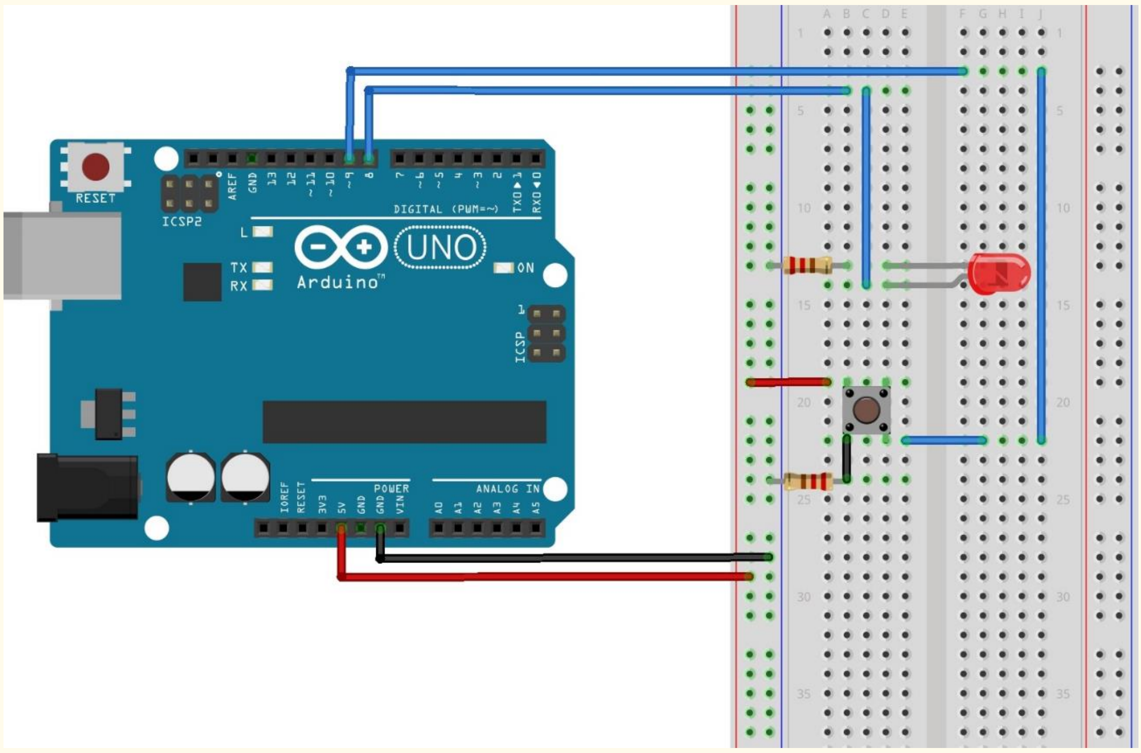
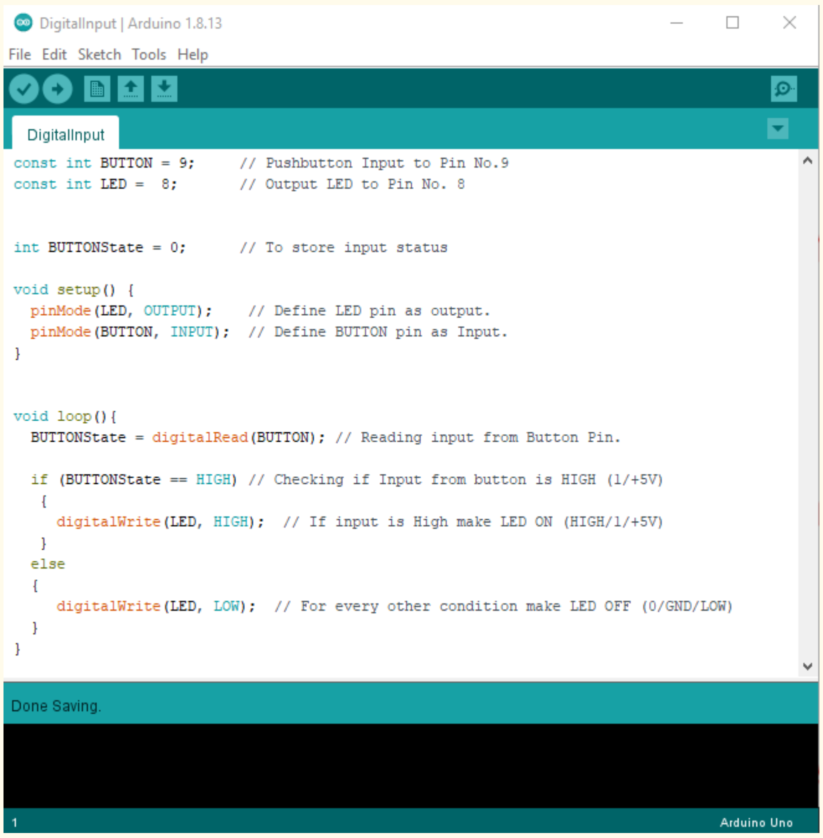


*Figure 2 Turn On and Off a LED using a button (Source: https://www.allaboutcircuits.com/)*

- **Arduino Code:**



```
const int BUTTON = 9;     // Pushbutton Input to Pin No.9
const int LED =  8;       // Output LED to Pin No. 8


int BUTTONState = 0;      // To store input status

void setup() {
  pinMode(LED, OUTPUT);    // Define LED pin as output.
  pinMode(BUTTON, INPUT);  // Define BUTTON pin as Input.
}


void loop(){
  BUTTONState = digitalRead(BUTTON); // Reading input from Button Pin.

  if (BUTTONState == HIGH) // Checking if Input from button is HIGH (1/+5V)
   {
     digitalWrite(LED, HIGH);  // If input is High make LED ON (HIGH/1/+5V)
   }
  else
  {
     digitalWrite(LED, LOW);  // For every other condition make LED OFF (0/GND/LOW)
  }
}
```

```
Done Saving.
```

*Figure 3 Arduino code to turn off and on an LED using push button*

- **Bibliographic references:**

https://roboindia.com/tutorials/digital-input-how-to-use-the-button-with-arduino/

https://www.arduino.cc/en/Tutorial/BuiltInExamples/DigitalReadSerial

https://www.tutorialspoint.com/arduino/index.htm

Setting up a circuit with a push button and a LED: https://www.youtube.com/watch?v=SYMe1wWthlw

Circuits with multiple push buttons: https://www.youtube.com/watch?v=kzlmojF3tBo

https://www.youtube.com/watch?v=OCJabRA3m4U

Timed LED with a button: https://www.youtube.com/watch?v=oPDcVnPfjdk

## LESSON – ANALOG INPUT: POTENTIOMETER

- **Study section:** Microcontroller and Arduino Fundamentals
- **Lesson duration:** 2:00h
- **Educational objectives:**
  - Describe inputs in Arduino
  - Understand Analog Inputs
  - Program Arduino to read a potentiometer's values
- **Learning outcomes and acquired competencies:**

At the end of the unit, the student should be able to:

| Knowledge | Skills | Responsibility and Autonomy |
|---|---|---|
| • Recognize an Analog Input<br>• Read the value of a potentiometer<br>• Use pinMode(), delay(), map(), digitalWrite(), analogWrite() and analogRead() functions | • Program and configure analog pins<br>• Change a LED brightness using the potentiometer | • Solve problems autonomously |

- **Main Keyword(s):**
  - Analog Inputs
  - Arduino Programming
  - LED and Potentiometer
- **Required material and resources:**
  - Arduino UNO
  - LED Red
  - Resistor 220 ohm
  - Potentiometer
  - Hook-up wires
  - BreadBoard
  - Computer
  - Arduino USB cable
  - Software Arduino IDE

**Brief definition of Analog Input**

Analog inputs are signals or external values that convert a voltage level into a digital value that can be stored and processed in a computer.

**Analog Inputs**

The facilitator will start the lesson by explaining to the participants what analog inputs are. The facilitator begins a follows:

An analog input converts a voltage level into a digital value stored and processed in a computer. In Arduino, the function analogRead() is used to read a value from the specified analog pin. Arduino boards contain a multichannel, 10-bit analog to digital converter. That means that it will map input voltages between 0 and 5 Volts into integer values between 0 and 1023.

A potentiometer is an example of analog input (Figure 1). It consists of a simple knob that provides a variable resistance, which it can be read into the Arduino board as an analog value. If we use the LED example, the analog value coming from the potentiometer controls the level of the LED's brightness.

By turning the potentiometer's shaft, we change the amount of resistance on either side of the wiper connected to the potentiometer's center pin. This changes the relative "closeness" of that pin to 5 volts and Ground, giving us a different analog input. When the shaft is turned in one direction, 0 volts go to the pin, and we read 0. When the shaft is rotated in the other direction, 5 volts go to the pin, and we read 1023. In between, analogRead() returns a number between 0 and 1023 that is proportional to the amount of voltage being applied to the pin.

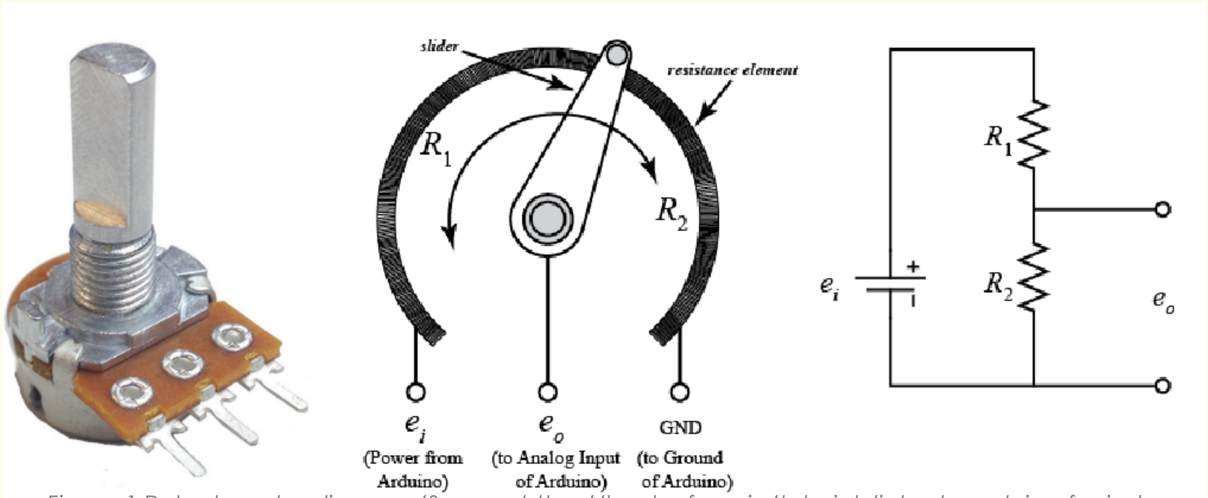


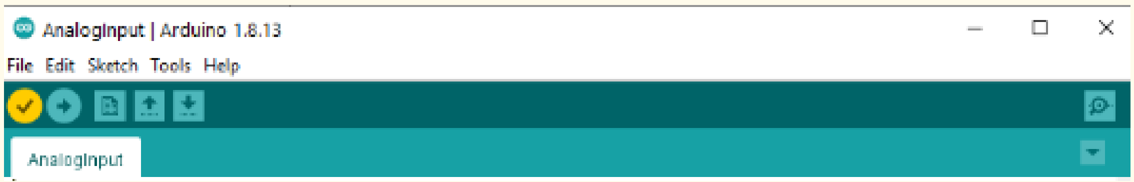
Figure 1 Potentometer diagram (Source: https://hackerfarm.jp/tutorials/intro-to-arduino-for-indoor-grow-lights/)

**Use a potentiometer to change the LED's brightness**

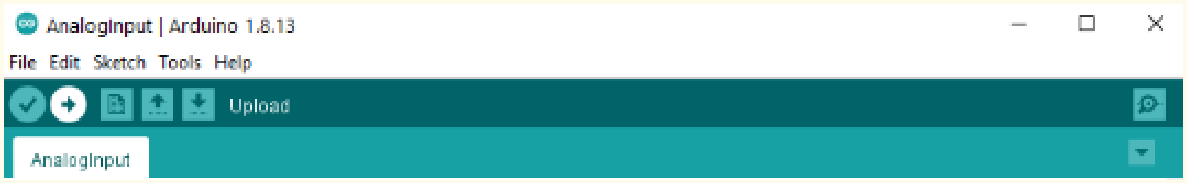
The facilitator will guide the participants with step-by-step instructions on making the connections on the breadboard and then explaining the Arduino code to them.

Step-by-step Instructions:

- The potentiometer has three terminals. Connect terminal 1 to the Ground and terminal 2 to the 5V of the Arduino card, as shown in Figure 2.
- Connect terminal 3 (the one in the middle) to the Analog Input (A0) in the Arduino card. This is where we get a value between 0 and 5 Volts.
- Place the one end of the 220-ohm resistor into pin 9 and the LED's short leg into the ground pin (GND).
- Connect the long leg of the LED to the other end of the resistor.
- 
- Use the USB cable to plug the Arduino into your computer.
- Open the Arduino IDE and copy the code given in Figure 4.
- Click the Verify button on the top left side of the screen.



- Then click the Upload button. It will turn orange and then back to blue once it has finished.



- As you adjust the knob of the potentiometer, the brightness of the LED should vary.

- **Arduino breadboard connections:**

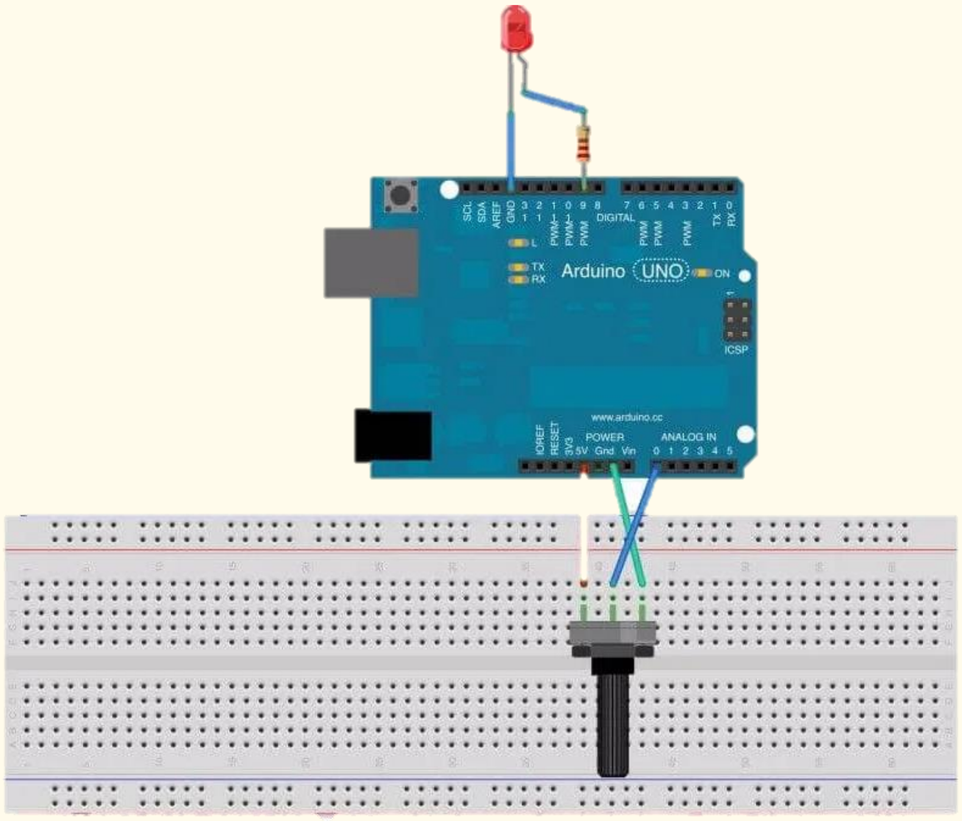


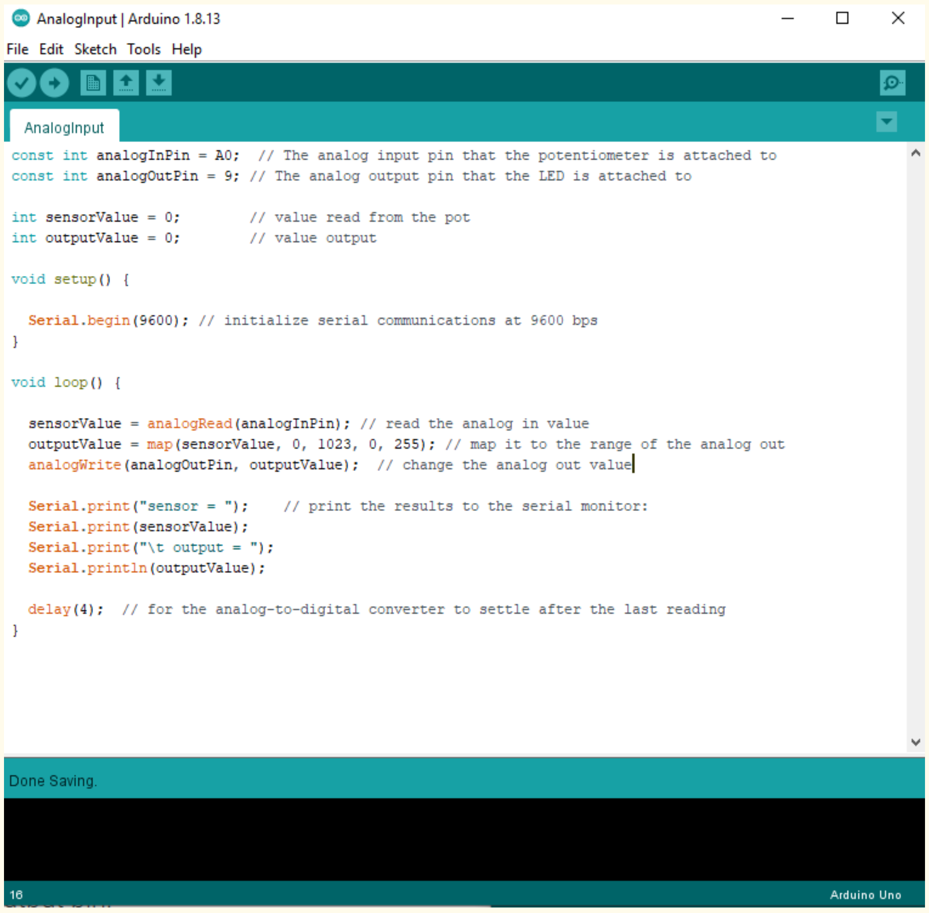
*Figure 2 Reading Analog inputs in Arduino using a Potentiometer (Source:https://www.arduino.cc/)*

- **Arduino Code:**

At the end the facilitator will explain the code in brief:

- Read analog value from potentiometer
  sensorValue=analogRead(analogInPin)
- Map analog values 0-1024 to pwm values 0-255
  outputValue = map(sensorValue, 0, 1023, 0, 255);

- Change the analog out value analogWrite(analogOutPin, outputValue);



```
const int analogInPin = A0;  // The analog input pin that the potentiometer is attached to
const int analogOutPin = 9; // The analog output pin that the LED is attached to

int sensorValue = 0;        // value read from the pot
int outputValue = 0;        // value output

void setup() {

  Serial.begin(9600); // initialize serial communications at 9600 bps
}

void loop() {

  sensorValue = analogRead(analogInPin); // read the analog in value
  outputValue = map(sensorValue, 0, 1023, 0, 255); // map it to the range of the analog out
  analogWrite(analogOutPin, outputValue);  // change the analog out value

  Serial.print("sensor = ");    // print the results to the serial monitor:
  Serial.print(sensorValue);
  Serial.print("\t output = ");
  Serial.println(outputValue);

  delay(4);  // for the analog-to-digital converter to settle after the last reading
}
```

*Figure 2 Arduino code that change the brightness of a LED using a potentiometer*

- **Bibliographic references:**

https://www.programmingelectronics.com/tutorial-21-analog-input-old-version/

https://www.arduino.cc/en/Tutorial/BuiltInExamples/AnalogInput

https://www.instructables.com/How-to-use-Potentiometer-Arduino-Tutorial/

Schwartz, M. (2014). Arduino Networking

# WIFI FUNDAMENTALS AND IOT

## LESSON – WIRING THE ESP8266

- **Study section:** WiFi Fundamentals and IoT
- **Lesson duration:** 2:00h
- **Educational objectives:**
    - Describe ESP8266
    - Understand ESP8266 wiring
- **Learning outcomes and acquired competencies:**

At the end of the unit, the student should be able to:

| Knowledge | Skills | Responsibility and Autonomy |
|---|---|---|
| • **Recognize an ESP8266**<br>• **Wire an ESP8266** | • Wiring different modules to Arduino UNO | • Solve problems autonomously |

- **Main Keyword(s):**
    - ESP8266
    - WiFi network
    - Microcontroller units (MCUs)
- **Required material and resources:**
    - An ESP8266 board
    - Arduino UNO
    - A computer that can run the Arduino IDE
    - A USB-to-Serial converter (it is essential to use a 3.3V model)
    - A USB cable
    - A 3.3V power supply or voltage regulator
    - A WiFi network
    - Breadboard
    - Computer
    - Arduino USB cable
    - Software Arduino IDE
    - Internet Connection

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**Brief definition of ESP8266**

The ESP8266 module is a low-cost Wi-Fi microchip that enables microcontrollers to connect to Wi-Fi, using the IEEE 802.11 protocol.

**ESP8266**

The facilitator will start the lesson by explaining to the participants what the ESP8266 module is and connecting it to Arduino. The facilitator begins as follow:

The ESP8266 module is a low-cost WiFi microchip that enables microcontrollers to connect to WiFi, using the IEEE 802.11 protocol. It can provide WiFi connectivity to external host microcontroller units (MCUs) or be used as a self-sufficient MCU. The module has a full TCP/IP stack and provides data processing, reads, and controls of General Purpose Input/OGPIOs. ESP8266 Arduino core comes with libraries to communicate over WiFi using TCP and UDP, use a file system in flash memory, work with SD cards, and I2C peripherals. It can be used in several applications such as smart power plugs, home automation, industrial wireless control, IP Cameras, sensor networks, wearable electronics, WiFi location-aware devices, and security ID tags.

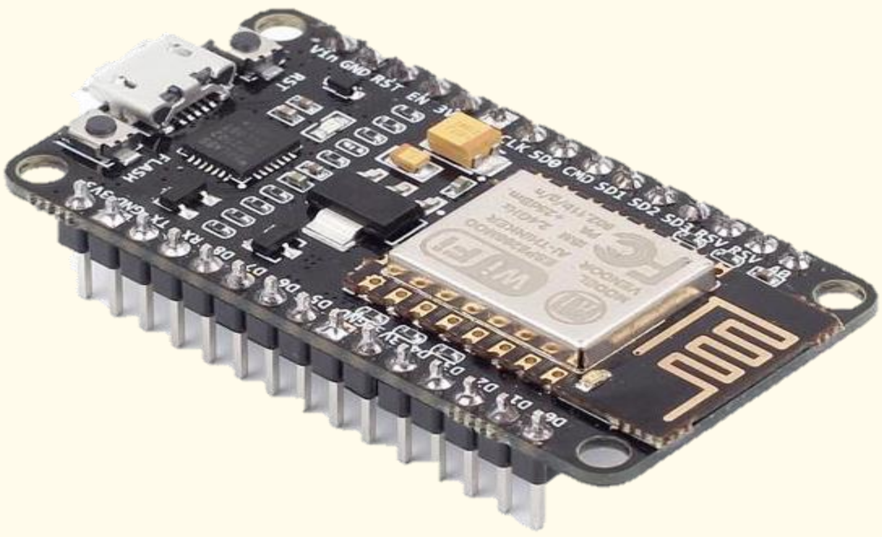

*Figure 1 ESP8266 WiFi based microcontroller board (Source: www.antratek.com)*

## Connect ESP8266 with Arduino

The facilitator will guide the participants with step-by-step instructions on connecting the ESP8266 module with Arduino Uno.

- **Requirements to program ESP8266 with Arduino IDE:**
    - An ESP8266 board
    - A computer that can run the Arduino IDE
    - A USB-to-Serial converter (it is essential to use a 3.3V model)
    - A USB cable
    - A 3.3V power supply or voltage regulator
    - A WiFi network

- **Steps to connect the ESP8266 to Arduino:**
    - Power the ESP8266 with the 3.3V power supply. You can also power ESP8266 using two AA batteries as shown in Figure 2. Positive from batteries to VCC of ESP and GND to GND of ESP 8266.

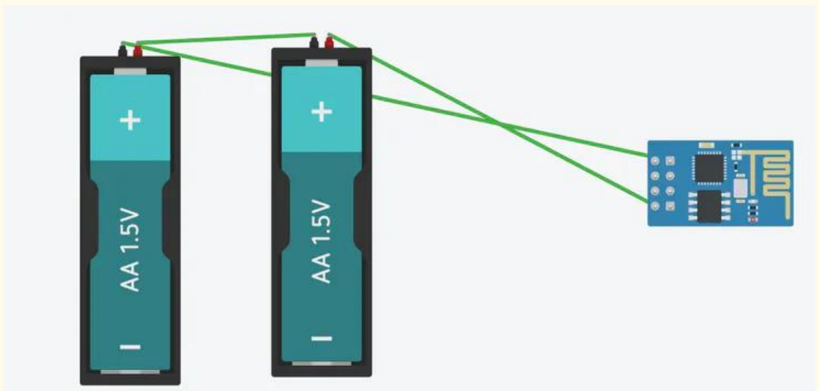

*Figure 23 Powering ESP8266 with 2 AA batteries (Source https://www.hackster.io/PatelDarshil/things-you-should-know-before-using-esp8266-wifi-module-784001 ).*

    - Connect the Arduino to a breadboard.
    - Connect the Arduino's 3.3V output to the red line of a breadboard (The ESP8266 needs 3.3V. If you connect it to a 5V power supply, you'll destroy it).
    - Connect the Ground (GND) to the blue line.
    - Connect the RES or RESET pin to the blue line. When you ground the reset pin, the Arduino works as a USB to a serial connector, which we want to talk to the ESP8266.
    - Connect the RXD pin of the Arduino to the RX pin of the ESP8266.
    - Connect the TXD pin of the Arduino to the TX pin of the ESP8266.
    - Connect the GND pin of the ESP to the blue line and the VCC pin to the red line.
    - Connect the CH_PD to the red line.

- **Arduino breadboard connections:**

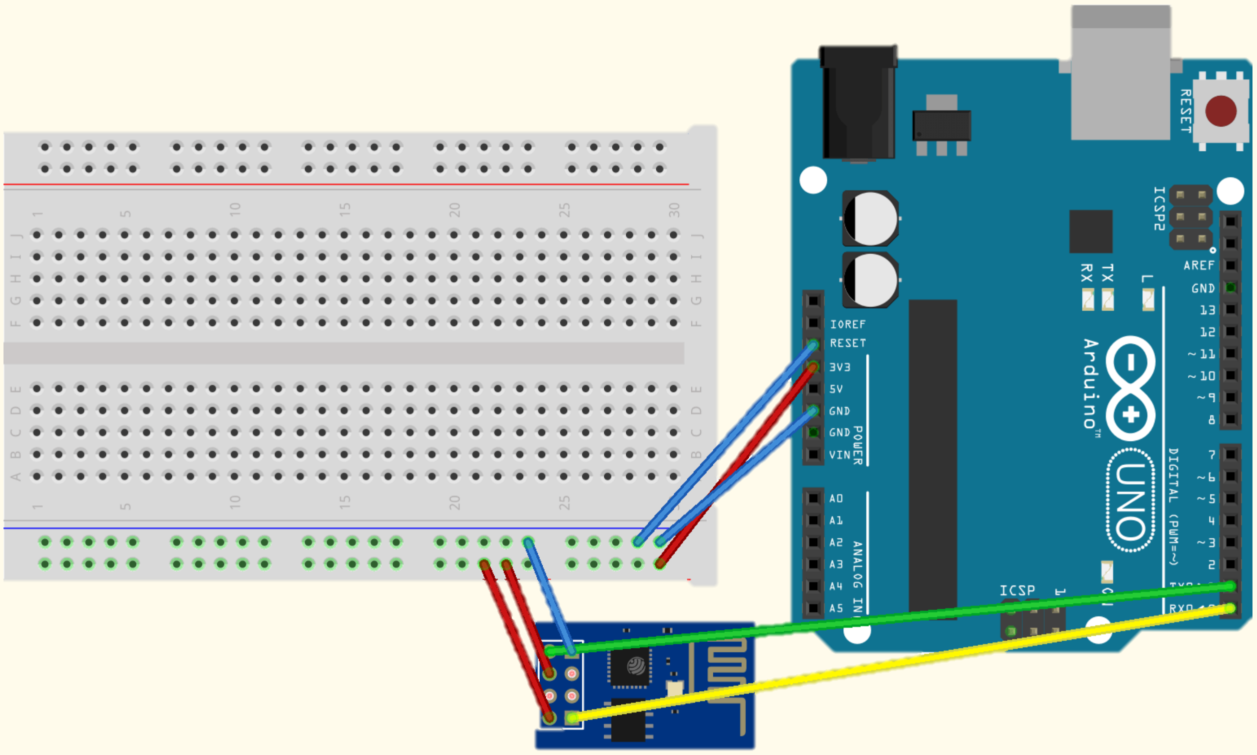

*Figure 34 Wiring ESP8266 to Arduino UNO (Source: http://www.teomaragakis.com/hardware/electronics/how-to-connect-an-esp8266-to-an-arduino-uno/)*

- **Bibliographic references:**

**http://www.teomaragakis.com/hardware/electronics/how-to-connect-an-esp8266-to-an-arduino-uno/**

**http://dexterous-programmer.blogspot.com/2018/09/arduino-uno-wifi-module-esp8266.html**

**https://la.mathworks.com/help/supportpkg/arduino/ug/connect-esp8266-to-arduino-hardware.html#mw_d1735291-00d0-410d-a9a5-3beb76a24286**

**https://create.arduino.cc/projecthub/turaib/esp8266-arduino-communication-1fdd40**

## LESSON – WIFI OVERVIEW: ESP8266 CAPABILITIES

- **Study section:** WiFi Fundamentals and IoT
- **Lesson duration:** 2:00h
- **Educational objectives:**
  - Describe TCP/IP stack
  - Understand layers and protocols
  - Understand ESP8266 capabilities
- **Learning outcomes and acquired competencies:**

At the end of the unit, the student should be able to:

| Knowledge | Skills | Responsibility and Autonomy |
|---|---|---|
| • **Understand the difference between layer and protocol**<br>• **Understand the difference between an access point and a station and between a client and a server.**<br>• **Explain the ESP8266 capabilities** | • Determine the capabilities of an ESP8266 | • Communicate concepts and ideas clearly |

- **Main Keyword(s):**
  - ESP8266
  - WiFi network
  - TCP/IP
  - Layers and protocols
  - Access point and station
  - Client and server
- **Required material and resources:**
  - An ESP8266 board

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**Brief definition of ESP8266 capabilities**

ESP8266 works in two modes: Station and Access Point (AP). AP mode allows it to create its own network and have other devices connect to it. Station mode allows the ESP8266 to connect to a Wi-Fi network .

ESP8266 can function as a client, as an access point or both.

**ESP8266**

The facilitator will start the lesson by explaining to the participants what the ESP8266 module is and connecting it to Arduino. The facilitator begins as follow:

As previously mentioned, the reason why most people use ESP8266 is its WiFi capabilities. To understand how ESP8266 communicates with other devices on the network, we need to understand the different layers and protocols (Table 1).

| **Layer** | **Protocol** |
|---|---|
| **Application** | HTTP,FTP, etc. |
| **Transport** | TCP, UDP |
| **Internet** | IP |
| **Link** | Ethernet, Wi-Fi |

Table 1 The TCP/IP stack

The link layer is the physical link between two devices, an Ethernet cable or a WiFi connection. To connect an ESP8266 to the network, you have to physically connect the ESP8266 to other devices through actual wires (Ethernet) or WiFi. The Internet Protocol (IP) involves giving each device an IP address to make it possible that the devices can send messages and "talk" to each other. Nevertheless, IP can't guarantee that the messages (packets) arrive in the same order they were sent in. This means that we can't reliably send messages by only using the link and the Internet layer. So the Transport layer is needed.

The Transmission Control Protocol (TCP) makes sure that all packets are received, that the packets are in order, and corrupted packets are re-sent, and the User Datagram Protocol (UDP) only checks for errors (faster with lower latency).

The application layer of protocols is the one that "translates" the messages for two programs to understand each other.

- **ESP8266 Capabilities:**
    - Station mode: Station mode is used to get the ESP8266 module connected to a WiFi network established by an access point (router). As shown in Figure 1,

the router acts as an access point, and the ESP8266 is set as a station. To control the ESP8266, we need to be connected to the router.

- An access point (AP) is a device that provides access to a WiFi network to other devices (stations) and connects them further to a wired network. ESP8266 can provide similar functionality, except it does not have an interface to a wired network.

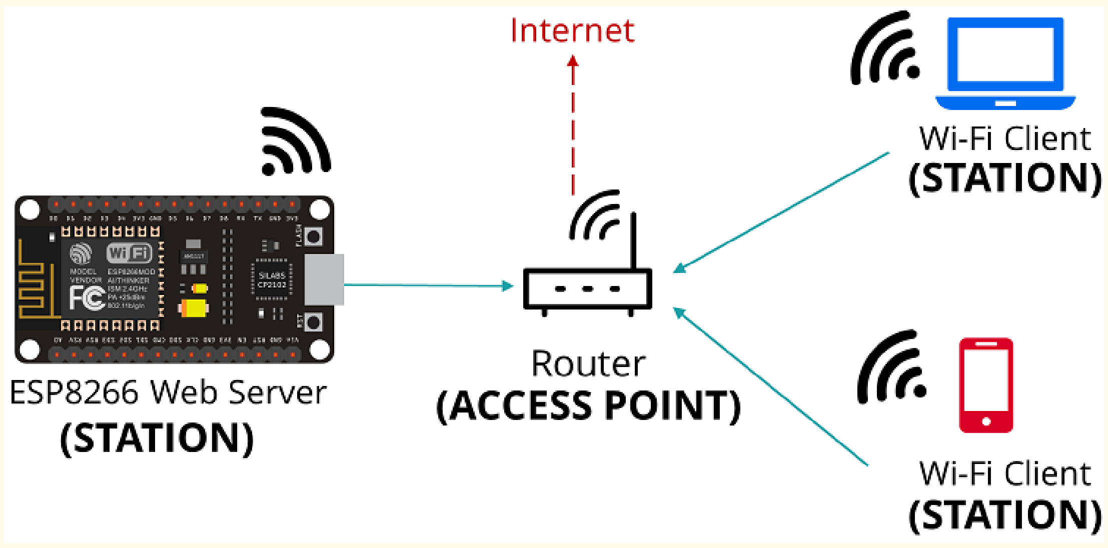

*Figure 5 ESP8266 as a Station (Source: https://randomnerdtutorials.com/esp8266-nodemcu-access-point-ap-web-server/)*

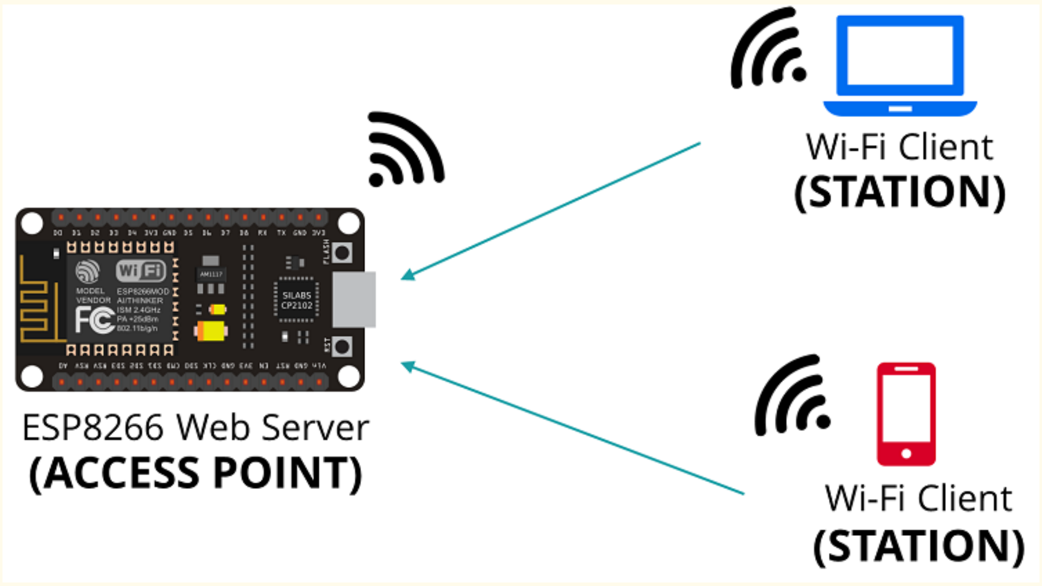

*Figure 6 ESP8266 as an Access Point (Source: https://randomnerdtutorials.com/esp8266-nodemcu-access-point-ap-web-server/)*

- **Bibliographic references:**

http://onlineshouter.com/use-esp8266-wifi-modes-station-access point/#:~:text=An%20access%20point%20(AP)%20is,interface%20to%20a%20wired%20network.&text=The%20maximum%20number%20of%20stations,the%20soft%2DAP%20is%20five.

https://medium.com/concepts-for-dummies/client-vs-server-terminology-b18355d1f9ff

http://www.teomaragakis.com/hardware/electronics/how-to-connect-an-esp8266-to-an-arduino-uno/

http://dexterous-programmer.blogspot.com/2018/09/arduino-uno-wifi-module-esp8266.html

https://la.mathworks.com/help/supportpkg/arduino/ug/connect-esp8266-to-arduino-hardware.html#mw_d1735291-00d0-410d-a9a5-3beb76a24286

https://create.arduino.cc/projecthub/turaib/esp8266-arduino-communication-1fdd40

## LESSON – WIFI CONNECTION WITH ESP8266

- **Study section:** WiFi Fundamentals and IoT
- **Lesson duration:** 3:00h
- **Educational objectives:**
    - Describe the usefulness of ESP8266
    - Configure the ESP8266 to access to internet
    - Build the Web Server with ESP8266
- **Main Keyword(s):**
    - ESP8266
    - WiFi
    - Web Server
- **Learning outcomes and acquired competencies:**

At the end of the unit, the student should be able to:

| Knowledge | Skills | Responsibility and Autonomy |
|---|---|---|
| • **Characterize ESP 8266**<br>• **Recognize the hardware needed to build a web server using ESP8266** | • Determine the hardware to be used in different configurations with the ESP8266<br>• Program and configure Internet access using ESP8266 | • Plan and structure tasks<br>• Communicate concepts and ideas clearly<br>• Act with initiative and demonstrate the analytical capacity<br>• Recommend solutions for problem-solving<br>• Demonstrate creativity, autonomy, and innovative spirit |

- **Required material and resources:**
    - ESP8266
    - Cable USB to microUSB
    - LED Green
    - LED Red
    - BreadBoard

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- Computer
- Software Arduino IDE
- Internet Connection

**Brief definition of ESP8266**

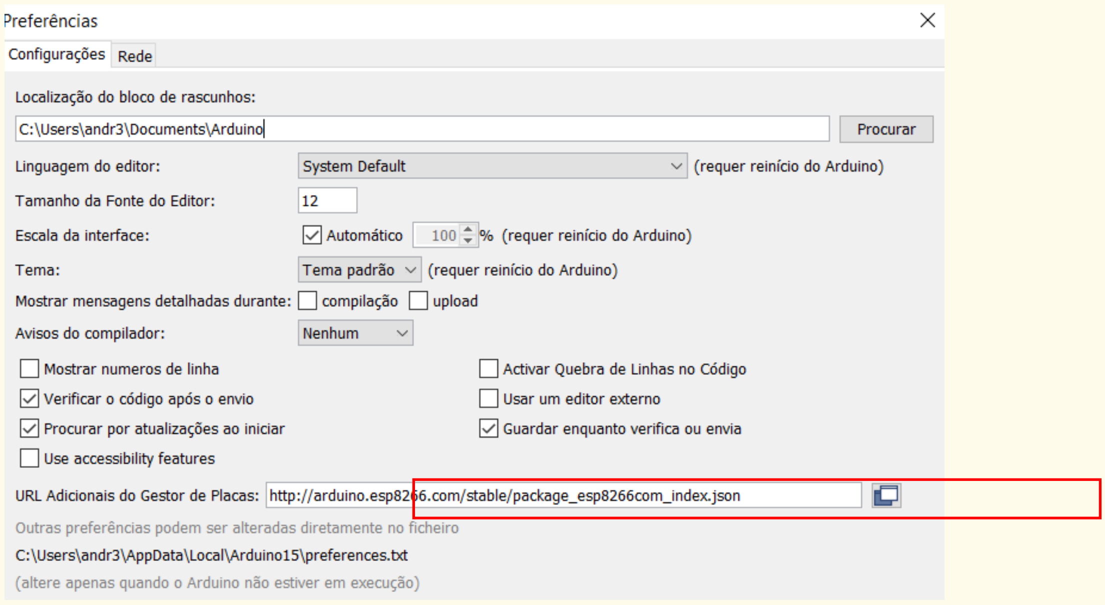
The ESP8266 is a low-cost Wi-Fi chip.

This chip revolutionized wifi connections in the development of small circuits due to its low cost, allowing for a quick dissemination. What caught our attention is that it has WiFi enabling the connection of several devices to the internet, so it can be easily configured to work as for example a wireless switch, among many other things.

**Programming ESP8266**

Regarding the installation of nodemcu board, you must follow the following steps:

1. Access the Arduino IDE and add the URL indicated above.



Preferências

Configurações | Rede

Localização do bloco de rascunhos: C:\Users\andr3\Documents\Arduino [Procurar]

Linguagem do editor: System Default (requer reinício do Arduino)

Tamanho da Fonte do Editor: 12

Escala da interface: ☑ Automático 100 % (requer reinício do Arduino)

Tema: Tema padrão (requer reinício do Arduino)

Mostrar mensagens detalhadas durante: ☐ compilação ☐ upload

Avisos do compilador: Nenhum

☐ Mostrar numeros de linha
☑ Verificar o código após o envio
☑ Procurar por atualizações ao iniciar
☐ Use accessibility features
☐ Activar Quebra de Linhas no Código
☐ Usar um editor externo
☑ Guardar enquanto verifica ou envia

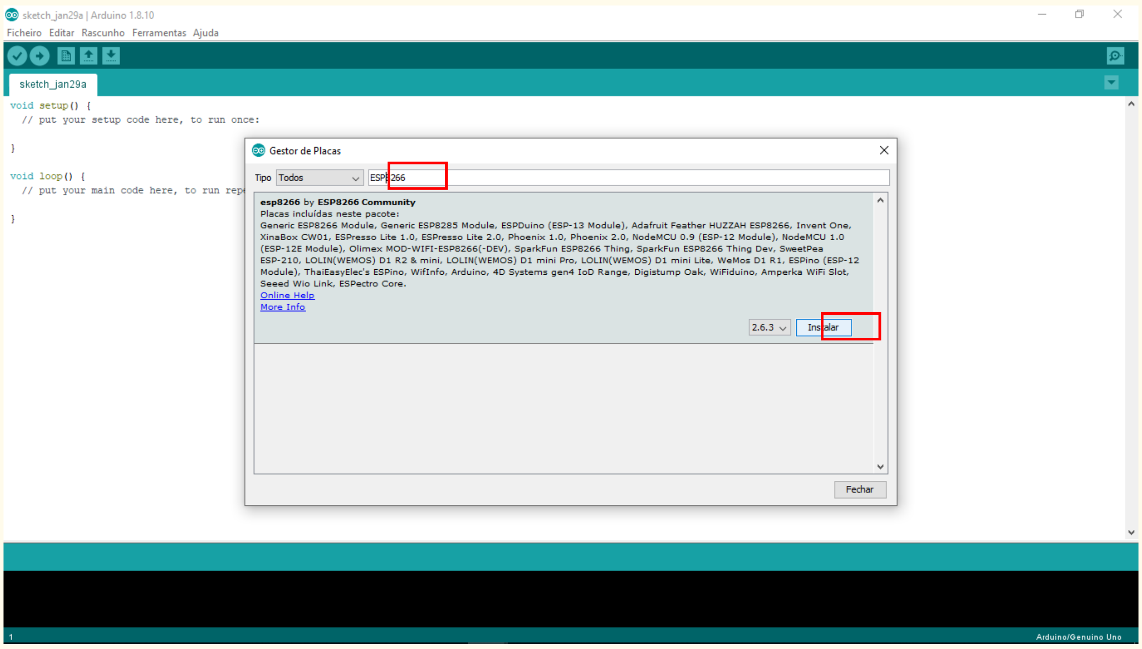
URL Adicionais do Gestor de Placas: http://arduino.esp8266.com/stable/package_esp8266com_index.json

Outras preferências podem ser alteradas diretamente no ficheiro

C:\Users\andr3\AppData\Local\Arduino15\preferences.txt

(altere apenas quando o Arduino não estiver em execução)

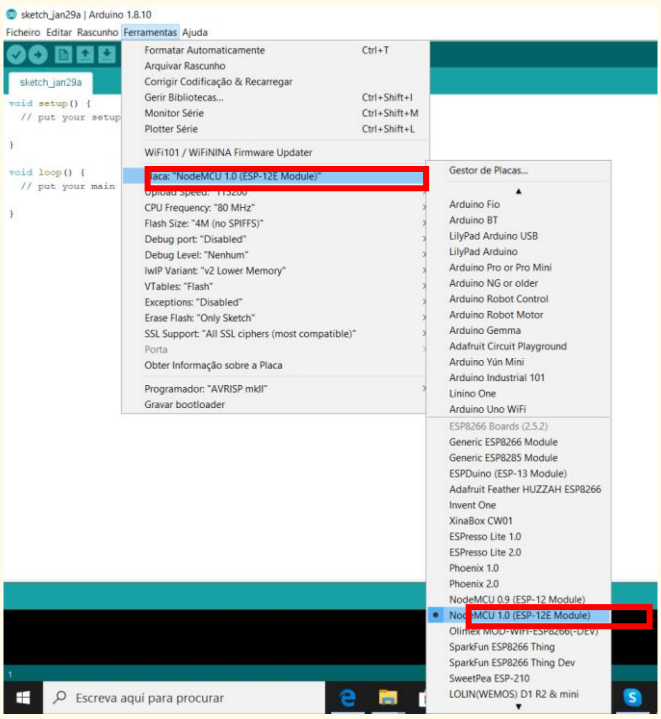
2. In plate manager add the ESP8266



```
void setup() {
  // put your setup code here, to run once:

}

void loop() {
  // put your main code here, to run repe
}
```

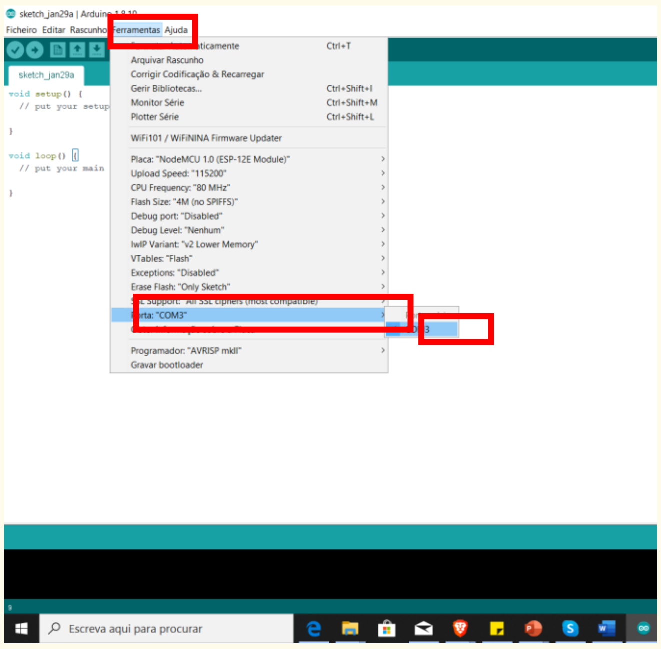
**esp8266** by **ESP8266 Community**
Placas incluídas neste pacote:
Generic ESP8266 Module, Generic ESP8285 Module, ESPDuino (ESP-13 Module), Adafruit Feather HUZZAH ESP8266, Invent One, XinaBox CW01, ESPresso Lite 1.0, ESPresso Lite 2.0, Phoenix 1.0, Phoenix 2.0, NodeMCU 0.9 (ESP-12 Module), NodeMCU 1.0 (ESP-12E Module), Olimex MOD-WIFI-ESP8266(-DEV), SparkFun ESP8266 Thing, SparkFun ESP8266 Thing Dev, SweetPea ESP-210, LOLIN(WEMOS) D1 R2 & mini, LOLIN(WEMOS) D1 mini Pro, LOLIN(WEMOS) D1 mini Lite, WeMos D1 R1, ESPino (ESP-12 Module), ThaiEasyElec's ESPino, WifInfo, Arduino, 4D Systems gen4 IoD Range, Digistump Oak, WiFiduino, Amperka WiFi Slot, Seeed Wio Link, ESPectro Core.
Online Help
More Info

3. Select the NodeMCU 1.0


sketch_jan29a | Arduino 1.8.10
Ficheiro Editar Rascunho Ferramentas Ajuda
sketch_jan29a
Formatar Automaticamente Ctrl+T
Arquivar Rascunho
Corrigir Codificação & Recarregar
Gerir Bibliotecas... Ctrl+Shift+I
Monitor Série Ctrl+Shift+M
Plotter Série Ctrl+Shift+L
WiFi101 / WiFiNINA Firmware Updater
Placa: "NodeMCU 1.0 (ESP-12E Module)"
Upload Speed: "115200"
CPU Frequency: "80 MHz"
Flash Size: "4M (no SPIFFS)"
Debug port: "Disabled"
Debug Level: "Nenhum"
IwIP Variant: "v2 Lower Memory"
VTables: "Flash"
Exceptions: "Disabled"
Erase Flash: "Only Sketch"
SSL Support: "All SSL ciphers (most compatible)"
Porta
Obter Informação sobre a Placa
Programador: "AVRISP mkII"
Gravar bootloader
Gestor de Placas...
Arduino Fio
Arduino BT
LilyPad Arduino USB
LilyPad Arduino
Arduino Pro or Pro Mini
Arduino NG or older
Arduino Robot Control
Arduino Robot Motor
Arduino Gemma
Adafruit Circuit Playground
Arduino Yún Mini
Arduino Industrial 101
Linino One
Arduino Uno WiFi
ESP8266 Boards (2.5.2)
Generic ESP8266 Module
Generic ESP8285 Module
ESPDuino (ESP-13 Module)
Adafruit Feather HUZZAH ESP8266
Invent One
XinaBox CW01
ESPresso Lite 1.0
ESPresso Lite 2.0
Phoenix 1.0
Phoenix 2.0
NodeMCU 0.9 (ESP-12 Module)
● NodeMCU 1.0 (ESP-12E Module)
Olimex MOD-WIFI-ESP8266(-DEV)
SparkFun ESP8266 Thing
SparkFun ESP8266 Thing Dev
SweetPea ESP-210
LOLIN(WEMOS) D1 R2 & mini
Escreva aqui para procurar

```
void setup() {
  // put your setup

}

void loop() {
  // put your main

}
```

4. Conect the ESP8266 and Select the COM

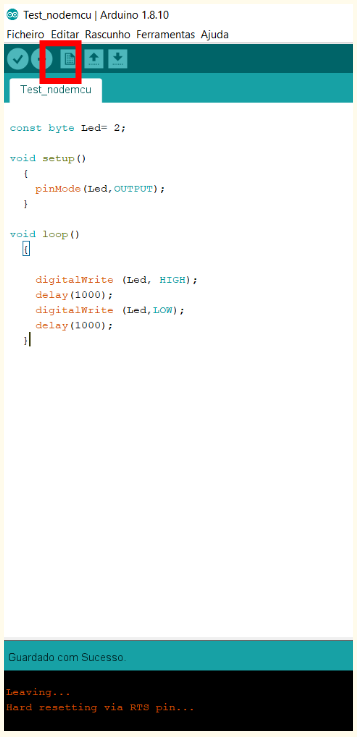

sketch_jan29a | Arduino 1.8.10

Ficheiro Editar Rascunho Ferramentas Ajuda

```
void setup() {
  // put your setup

}

void loop() {
  // put your main

}
```

```
Arquivar Rascunho
Corrigir Codificação & Recarregar
Gerir Bibliotecas...                      Ctrl+Shift+I
Monitor Série                             Ctrl+Shift+M
Plotter Série                             Ctrl+Shift+L
WiFi101 / WiFiNINA Firmware Updater
Placa: "NodeMCU 1.0 (ESP-12E Module)"
Upload Speed: "115200"
CPU Frequency: "80 MHz"
Flash Size: "4M (no SPIFFS)"
Debug port: "Disabled"
Debug Level: "Nenhum"
IwIP Variant: "v2 Lower Memory"
VTables: "Flash"
Exceptions: "Disabled"
Erase Flash: "Only Sketch"
SSL Support: "All SSL ciphers (most compatible)"
Porta: "COM3"
Programador: "AVRISP mkII"
Gravar bootloader
```

In order to verify that the installation was performed correctly, proceed to insert the following code and select the upload to board.


Test_nodemcu | Arduino 1.8.10

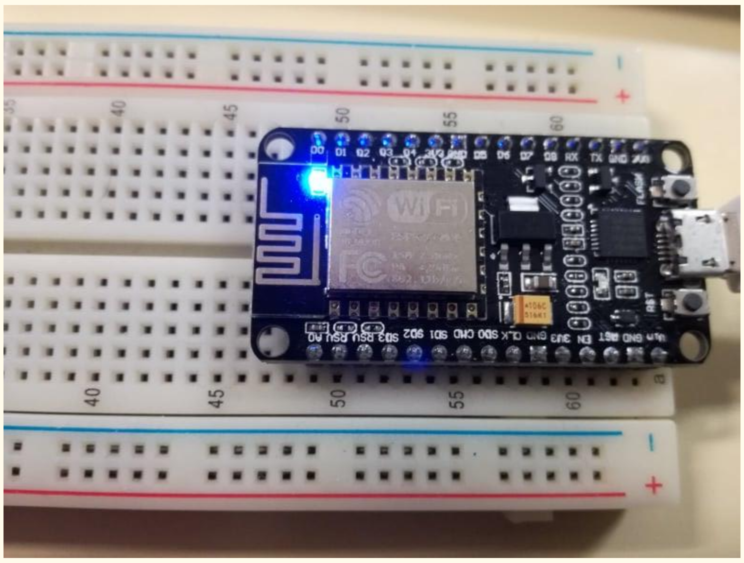
Ficheiro Editar Rascunho Ferramentas Ajuda

```
const byte Led= 2;

void setup()
  {
    pinMode(Led,OUTPUT);
  }

void loop()
  {

    digitalWrite (Led, HIGH);
    delay(1000);
    digitalWrite (Led,LOW);
    delay(1000);
  }
```

Guardado com Sucesso.

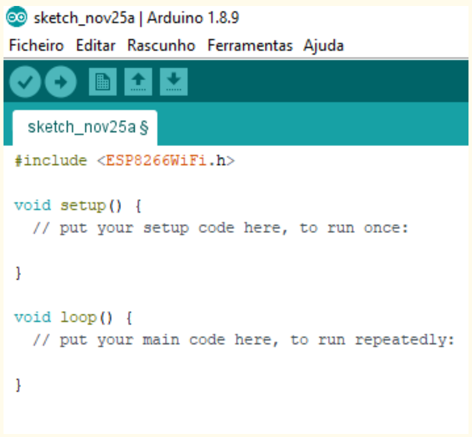
```
Leaving...
Hard resetting via RTS pin...
```

After the upload, we can observe the internal LED flash ESP8266 1 second in 1 second.



**WiFi Connection –"Green Steam"   Web Server**

Include the WiFi library for the Esp8266: ESP8266WiFi.h.


sketch_nov25a | Arduino 1.8.9
Ficheiro Editar Rascunho Ferramentas Ajuda
sketch_nov25a §

```
#include <ESP8266WiFi.h>

void setup() {
  // put your setup code here, to run once:

}

void loop() {
  // put your main code here, to run repeatedly:

}
```

Define a variable with your WiFi SSID and other one with your WiFi password. Begin the WiFi library with the ssid and password variables. The command is: WiFi.begin(ssid,pass).

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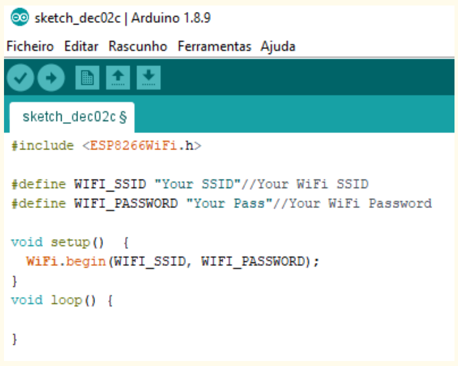

sketch_dec02c | Arduino 1.8.9
Ficheiro Editar Rascunho Ferramentas Ajuda
sketch_dec02c §

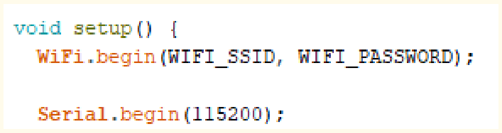
```
#include <ESP8266WiFi.h>

#define WIFI_SSID "Your SSID"//Your WiFi SSID
#define WIFI_PASSWORD "Your Pass"//Your WiFi Password

void setup()  {
  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
}
void loop() {

}
```

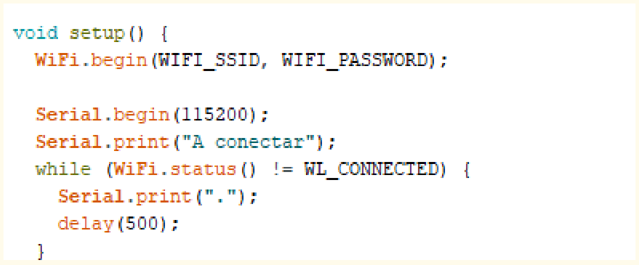
Initialize the Serial to a 115200 baud rate. The command is Serial.begin (115200). With that, it is possible to print values on the Serial Monitor with the specific baud rate (115200).



```
void setup() {
  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);

  Serial.begin(115200);
```

While not connected, the code will be in a loop. The ESP8266 will try to connect to the specified WiFi network and print dots "." on the Serial Monitor.

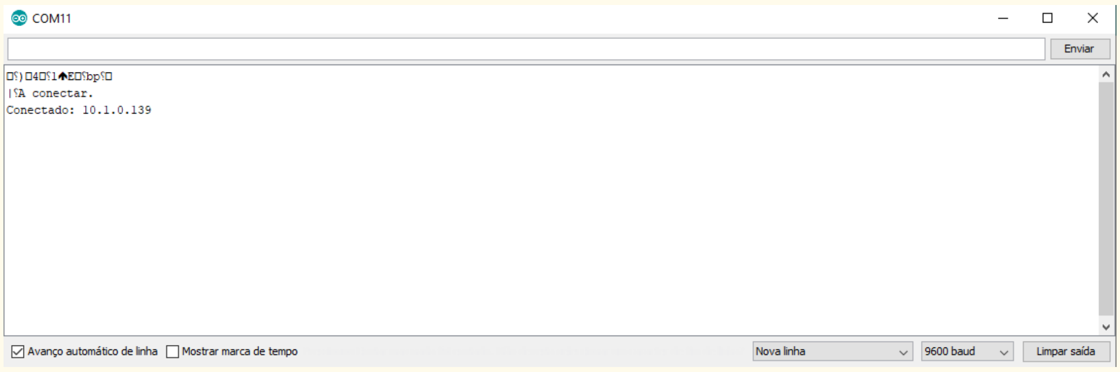


```
void setup() {
  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);

  Serial.begin(115200);
  Serial.print("A conectar");
  while (WiFi.status() != WL_CONNECTED) {
    Serial.print(".");
    delay(500);
  }
```

When the ESP8266 connects to the WiFi, the code will exit the loop and run forward, printing that the ESP8266 is connected, its IP and will continue running to the void loop.

The result is the following:



```
□⸮)□4□⸮1⬆E□⸮bp⸮□
|⸮A conectar.
Conectado: 10.1.0.139
```

**Creating a web server using the ESP8266**

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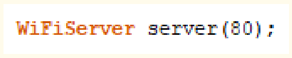
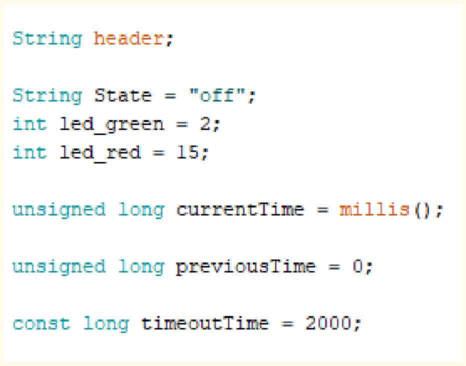
Using the previous code that was used to connect the ESP8266 to an WiFi network define the WiFi server to port 80. The command is: WiFiServer server(port).



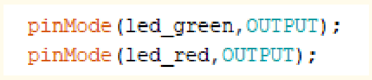
```
WiFiServer server(80);
```

Define the following variables plus the led pin that will be used. Here it will going to be used the internal LED of the ESP8266 on the GPIO 2.



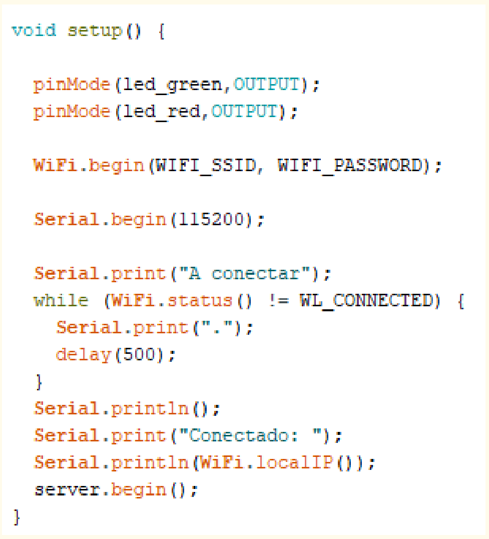
```
String header;

String State = "off";
int led_green = 2;
int led_red = 15;

unsigned long currentTime = millis();

unsigned long previousTime = 0;

const long timeoutTime = 2000;
```

Then, on the void setup, define the green and red LEDs pins as OUTPUT since signals will be emitted.



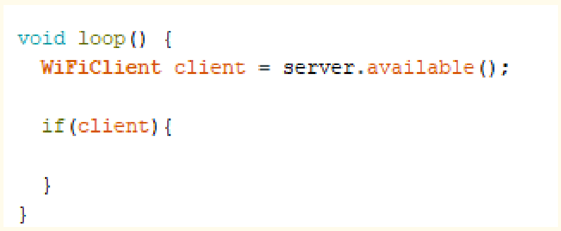
```
 pinMode(led_green,OUTPUT);
 pinMode(led_red,OUTPUT);
```

After the ESP8266 being connected, the server must begin:



```
void setup() {

  pinMode(led_green,OUTPUT);
  pinMode(led_red,OUTPUT);

  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);

  Serial.begin(115200);

  Serial.print("A conectar");
  while (WiFi.status() != WL_CONNECTED) {
    Serial.print(".");
    delay(500);
  }
  Serial.println();
  Serial.print("Conectado: ");
  Serial.println(WiFi.localIP());
  server.begin();
}
```

By now, when the ESP8266 conects to the WiFi the code will exit the while loop and run forward-printing that the ESP8266 is connected, its WiFi, beginning the WiFi server to port 80 and jumps to the void loop.  Read if the ESP8266 has a connected client. If there is a new client connected the code will do a procedure.

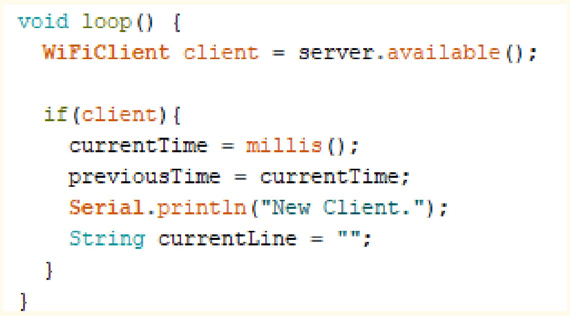


```
void loop() {
  WiFiClient client = server.available();

  if(client){

  }
}
```

All the following code will be inside the if client condition.

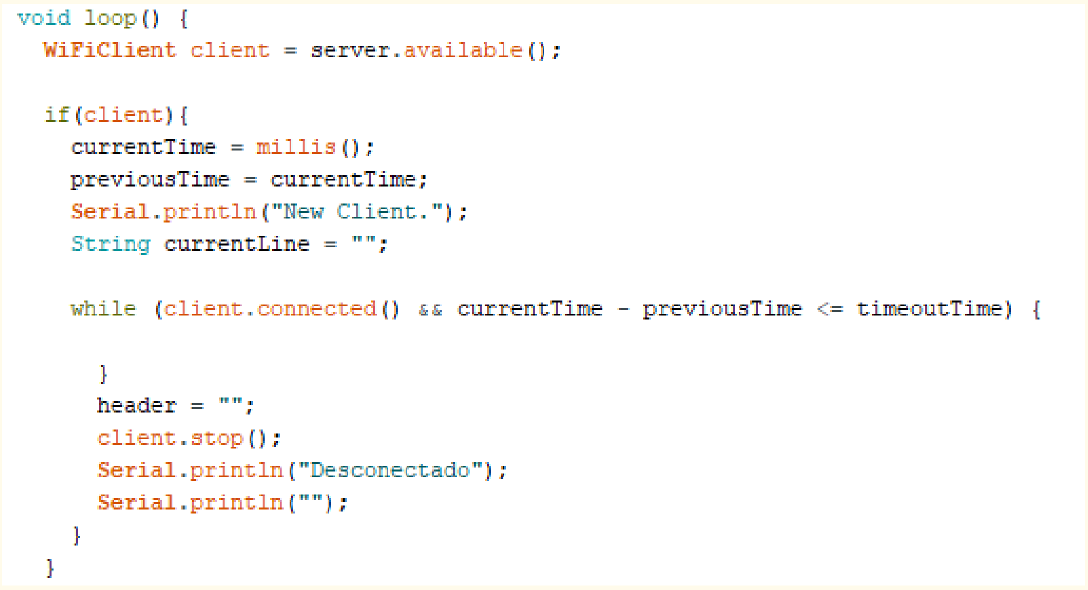
Set the defined variables "currentTime" to millis(), to get every passed millisecond and "previousTime" to "currentTime".

Create a new string and call it, for example, currentLine, setting it to an empty string ("").



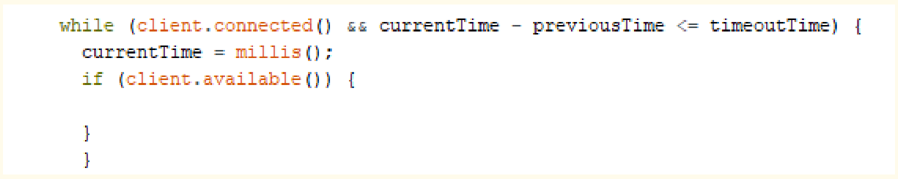
```
void loop() {
  WiFiClient client = server.available();

  if(client){
    currentTime = millis();
    previousTime = currentTime;
    Serial.println("New Client.");
    String currentLine = "";
  }
}
```

Create a loop while to make the code running continuously there while the ESP8266 is connected. Then, when the ESP8266 will be disconnected or timeout the header string, used to store every character received from the web, must be set to an empty string, the client must stop and it will printed on the Serial Monitor that the ESP8266 is disconnected.



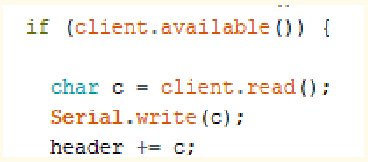
```
void loop() {
  WiFiClient client = server.available();

  if(client){
    currentTime = millis();
    previousTime = currentTime;
    Serial.println("New Client.");
    String currentLine = "";

    while (client.connected() && currentTime - previousTime <= timeoutTime) {

      }
      header = "";
      client.stop();
      Serial.println("Desconectado");
      Serial.println("");
    }
  }
```

While the ESP8266 is connected the variable currentTime is set to millis() and then ask if the ESP8266 receives data.



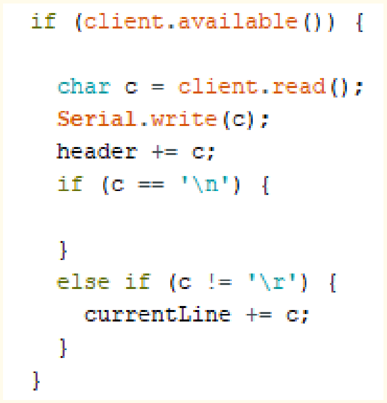
```
while (client.connected() && currentTime - previousTime <= timeoutTime) {
  currentTime = millis();
  if (client.available()) {

  }
  }
```

If the ESP8266 receives data, it will read every character received and store it on a variable called c. Then the ESP8266 prints on the Serial Monitor the read character. All the characters that will be received will be added to the variable header, making a String.



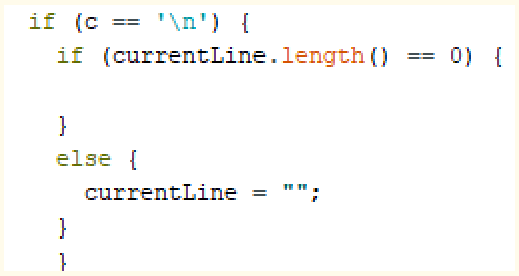
```
if (client.available()) {

  char c = client.read();
  Serial.write(c);
  header += c;
```

If the client reads a new line character, it will do a procedure. If is not a new line character but a carriage return character add it to the currentLine String



```
if (client.available()) {

  char c = client.read();
  Serial.write(c);
  header += c;
  if (c == '\n') {

  }
  else if (c != '\r') {
    currentLine += c;
  }
}
```

If the client reads a new line character, then ask if the length of the currentLine equals to 0. If so it will do a certain procedure, if not set the currentLine variable to an empty string.



```
if (c == '\n') {
  if (currentLine.length() == 0) {

  }
  else {
    currentLine = "";
  }
  }
```

If the length of the current line equals to 0, meaning it is the end of the http request, the client will send a response. That response starts with a response code such as HTTP/1.1 200 OK and a content-type to make the client knowing what is coming. And then a send a blank line.

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```
if (currentLine.length() == 0) {
  client.println("HTTP/1.1 200 OK");
  client.println("Content-type:text/html");
  client.println("Connection: close");
  client.println();
```

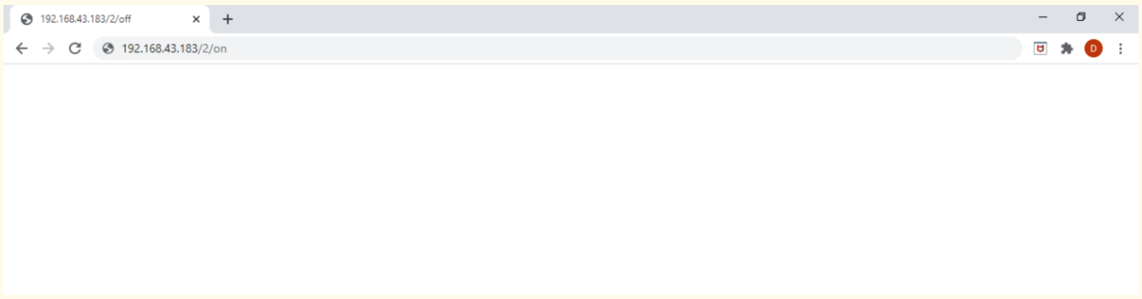
After sending the response ask if the header contains GET/2/on, turn the green LED on and the red LED off, store "on" in the State variable

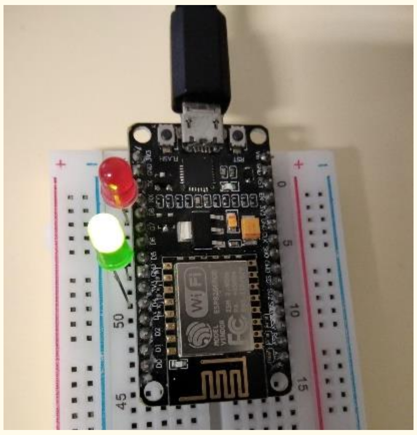
```
if (header.indexOf("GET /2/on") >= 0) {
  State = "on";
  digitalWrite(led_green, HIGH);
  digitalWrite(led_red, LOW);
}
```

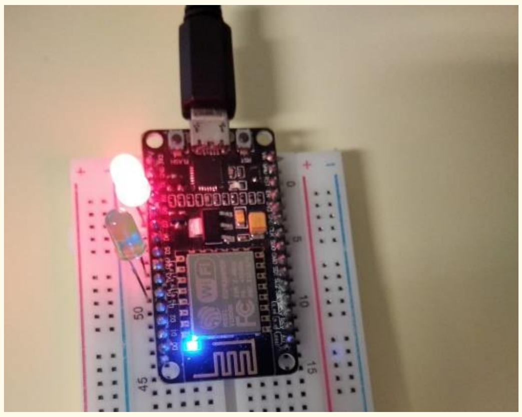
Otherwise, if the header contains GET/2/off, turn the LED off, store "off" in the State variable and optionally print on the Serial that the GPIO 2 is LOW as an indication.

```
else if (header.indexOf("GET /2/off") >= 0) {
  State = "off";
  digitalWrite(led_green, LOW);
  digitalWrite(led_red, HIGH);
}
```

After those conditions, it is possible to control the LED changing the values on the header, but the page is blank.







The page is build using the client to print http commands to define all the specifications required such as the buttons, their background colour, text colour, font etc…

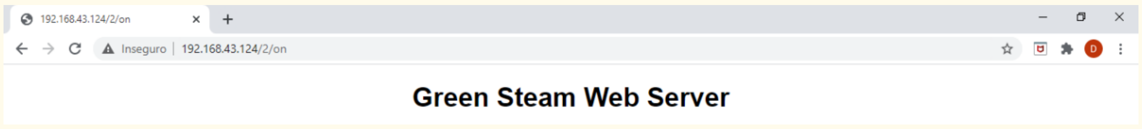
The resulting peace of code is the following:

```
// Display the HTML web page
client.println("<!DOCTYPE html><html>");
client.println("<head><meta name=\"viewport\" content=\"width=device-width, initial-scale=1\">");
client.println("<link rel=\"icon\" href=\"data:,\">");
// CSS to style the on/off buttons
// Feel free to change the background-color and font-size attributes to fit your preferences
client.println("<style>html { font-family: Helvetica; display: inline-block; margin: 0px auto; text-align: center;}");
client.println(".button { background-color: #4CAF50; border: none; color: white; padding: 16px 40px;");
client.println("text-decoration: none; font-size: 30px; margin: 2px; cursor: pointer;}");
client.println(".button2 {background-color: #AF4C50;}</style></head>");
```

After that write the title of the page:

```
client.println("<body><h1>Green Steam Web Server</h1>");
```

Look! The "Green Steam Web Server" is written on the web page.


192.168.43.124/2/on

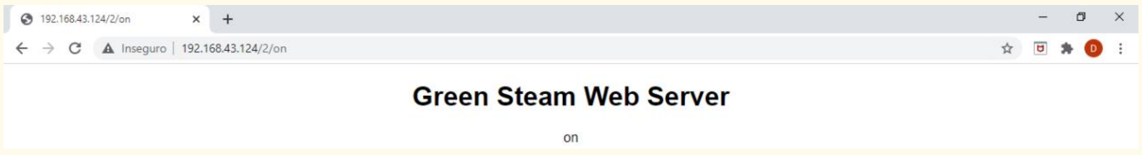
Inseguro | 192.168.43.124/2/on

Green Steam Web Server

After that, write the state of the LED:

```
client.println("<p>" + State + "</p>");
```

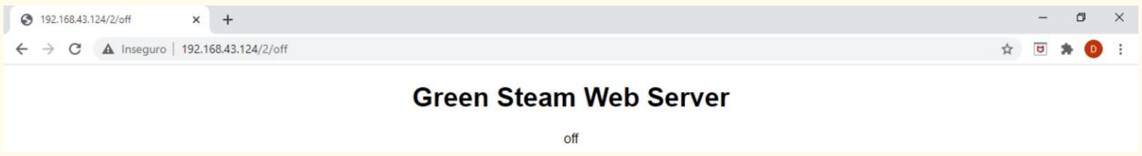
With that, the page will have a visible title and a real time indication of the led state either on or off.


192.168.43.124/2/on

Inseguro | 192.168.43.124/2/on

Green Steam Web Server

on


192.168.43.124/2/off

Inseguro | 192.168.43.124/2/off

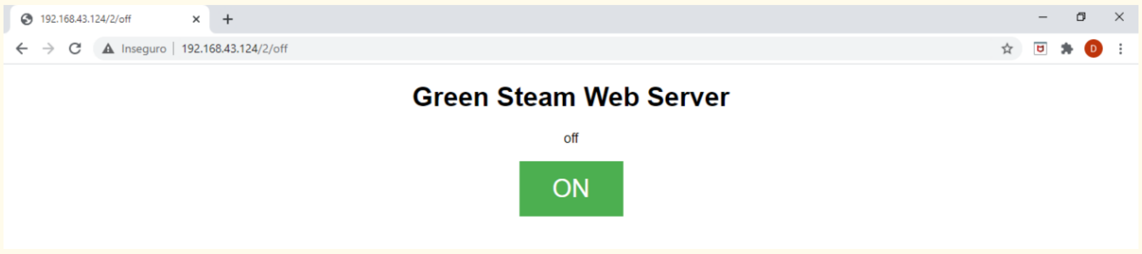
Green Steam Web Server

off

Then, if the State equals to "off" the client must print a green button with "ON" written on it. Otherwise, the client will print a red button with "OFF" written on it.

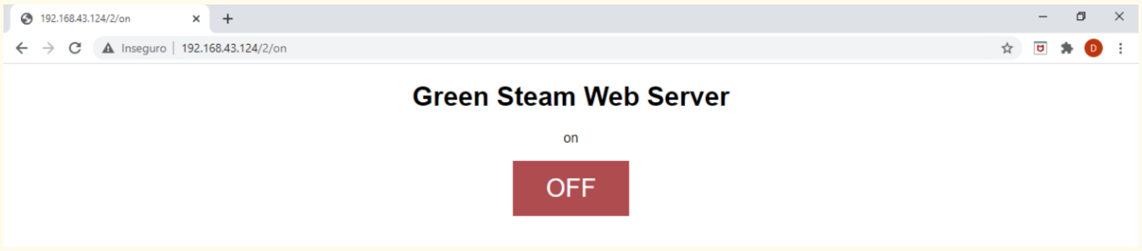
The result is the following:

```
if (State=="off") {
  client.println("<p><a href=\"/2/on\"><button class=\"button\">ON</button></a></p>");
} else {
  client.println("<p><a href=\"/2/off\"><button class=\"button button2\">OFF</button></a></p>");
}
```



Green Steam Web Server

off



Green Steam Web Server

on

Finally, it is necessary to add this piece of code to finish the html code and break the while loop.

```
client.println("</body></html>");

client.println();
break;
```

- **Bibliographic references:**

http://www.electronicwings.com/. (n.d.). Retrieved from http://www.electronicwings.com/public/images/user_images/images/NodeMCU/NodeMCU%20Basics%20using%20ESPlorer%20IDE/NodeMCU%20MQTT%20Client/MQTT%20Broker%20nw.png.
https://diygeeks.org/learn/intro-to-blynk/. (n.d.). Retrieved from https://diygeeks.org.
https://esp8266-shop.com/esp8266-guide/esp8266-nodemcu-pinout/. (n.d.). Retrieved from https://esp8266-shop.com/.
https://realbusiness.co.uk/from-1982-coca-cola-vending-machine-to-latest-trend-what-the-internet-of-things-means-for-business/. (n.d.).
https://www.embarcados.com.br/introducao-ao-blynk-app/. (n.d.). Retrieved from https://www.embarcados.com.br/.
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Santos, R. (n.d.). https://randomnerdtutorials.com/. Retrieved from https://randomnerdtutorials.com/.
Souza, F. (n.d.). Controle de dispostivos remotamento com o ESP8266.

## LESSON – CONNECTING ESP8266 WITH TELEGRAM

- **Study section:** WiFi Fundamentals and IoT
- **Lesson duration:** 3:00h
- **Educational objectives:**
  - Configure the ESP8266 to communicate with the Telegram
  - Configure the Telegram to communication with the ESP8266
  - Communication between Telegram and ESP8266
- **Main Keyword(s):**
  - ESP8266
  - WiFi
  - Telegram
- **Learning outcomes and acquired competencies:**

At the end of the unit, the student should be able to:

| Knowledge | Skills | Responsibility and Autonomy |
|---|---|---|
| • Characterize ESP 8266<br>• Recognize the hardware needed to connect ESP8266 with Telegram<br>• Recognize the importance and benefits the Telegram | • Determine the hardware to be used in different configurations with the ESP8266<br>• Program and configure communication between the Telegram and ESP8266 | • Plan and structure tasks<br>• Communicate concepts and ideas clearly<br>• Act with initiative and demonstrate analytical capacity<br>• Recommend solutions for problem-solving<br>• Demonstrate creativity, autonomy and innovative spirit |

- **Required material and resources:**
  - ESP8266
  - Cable USB to microUSB
  - LED Red
  - BreadBoard
  - Computer
  - Software Arduino IDE
  - Internet Connection

Co-funded by the Erasmus+ Programme of the European Union

- Smartphone with the Telegram app

**Brief definition of Telegram**

Telegram is a free application that is used similarly to Whatsapp, where you can share text, photos, videos, files, etc.

**Connecting ESP8266 with Telegram**

Telegram can be used for more specific purposes and with professional interest; that is, it can be used in IoT systems, to control / monitor intelligent devices, which will be our main objective. In 2015 a new API was presented, which allowed the creation of bots in the telegram for ESP32 / ESP8266, where it is possible to exchange messages as if they were a person. With this functionality, it is possible to send instructions, thus controlling smart devices. This chapter will present how we can configure ESP32 / ESP8266 and Telegram so that there is a bidirectional communication between both.

To demonstrate the potential of this relationship, the control of an LED will be presented through a message by the Telegram Bot.

**Programming nodemcu plate**

Regarding the installation of node MCU board, you must follow the following steps similar in the topic Programming ESP8266.

After checking the steps in this topic, we can proceed to Telegram programming.

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**Programming Arduino IDE to communication with Telegram**

```
/*
  Project created using Brian Lough's Universal Telegram Bot Library:
https://github.com/witnessmenow/Universal-Arduino-Telegram-Bot
  Example based on the Universal Arduino Telegram Bot Library:
https://github.com/witnessmenow/Universal-Arduino-Telegram-
Bot/blob/master/examples/ESP8266/FlashLED/FlashLED.ino
*/

#ifdef ESP32
  #include <WiFi.h>
#else
  #include <ESP8266WiFi.h>
#endif
#include <WiFiClientSecure.h>
#include <UniversalTelegramBot.h>   // Universal Telegram Bot Library written by Brian Lough:
https://github.com/witnessmenow/Universal-Arduino-Telegram-Bot
#include <ArduinoJson.h>

// Your network credentials
const char* ssid = "YOUR_SSID";
const char* password = "YOUR_PASSWORD";

// Initialize Telegram BOT
#define BOTtoken "XXXXXXXXXX:XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX" //Your Bot Token
(Get from Botfather)

// Use @myidbot to find out the chat ID of an individual or a group
// Also note that you need to click "start" on a bot before it can
// message you
#define CHAT_ID "XXXXXXXXXX"

WiFiClientSecure client;
UniversalTelegramBot bot(BOTtoken, client);

// Checks for new messages every 1 second.
int botRequestDelay = 1000;
unsigned long lastTimeBotRan;

const int ledPin = 2;
bool ledState = LOW;

// Handle what happens when you receive new messages
void handleNewMessages(int numNewMessages) {
  Serial.println("handleNewMessages");
  Serial.println(String(numNewMessages));
```

```
 for (int i=0; i<numNewMessages; i++) {
   // Chat id of the requester
   String chat_id = String(bot.messages[i].chat_id);
   if (chat_id != CHAT_ID){
     bot.sendMessage(chat_id, "Unauthorized user", "");
     continue;
   }

   // Print the received message
   String text = bot.messages[i].text;
   Serial.println(text);

   String from_name = bot.messages[i].from_name;

   if (text == "/start") {
     String welcome = "Welcome, " + from_name + ".\n";
     welcome += "Use the following commands to control your outputs.\n\n";
     welcome += "/led_on to turn GPIO ON \n";
     welcome += "/led_off to turn GPIO OFF \n";
     welcome += "/state to request current GPIO state \n";
     bot.sendMessage(chat_id, welcome, "");
   }

   if (text == "/led_on") {
     bot.sendMessage(chat_id, "LED state set to ON", "");
     ledState = HIGH;
     digitalWrite(ledPin, ledState);
   }

   if (text == "/led_off") {
     bot.sendMessage(chat_id, "LED state set to OFF", "");
     ledState = LOW;
     digitalWrite(ledPin, ledState);
   }

   if (text == "/state") {
     if (digitalRead(ledPin)){
       bot.sendMessage(chat_id, "LED is ON", "");
     }
     else{
       bot.sendMessage(chat_id, "LED is OFF", "");
     }
   }
  }
}

void setup() {
  Serial.begin(115200);

  #ifdef ESP8266
    client.setInsecure();
  #endif

  pinMode(ledPin, OUTPUT);
  digitalWrite(ledPin, ledState);

  // Connect to Wi-Fi
  WiFi.mode(WIFI_STA);
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
    Serial.println("Connecting to WiFi..");
  }
  // Print ESP32 Local IP Address
  Serial.println(WiFi.localIP());
}

void loop() {
  if (millis() > lastTimeBotRan + botRequestDelay)  {
    int numNewMessages = bot.getUpdates(bot.last_message_received + 1);

    while(numNewMessages) {
      Serial.println("got response");
      handleNewMessages(numNewMessages);
      numNewMessages = bot.getUpdates(bot.last_message_received + 1);
    }
    lastTimeBotRan = millis();
  }
}
```

After copying the code to Arduino IDE, you need to verify:

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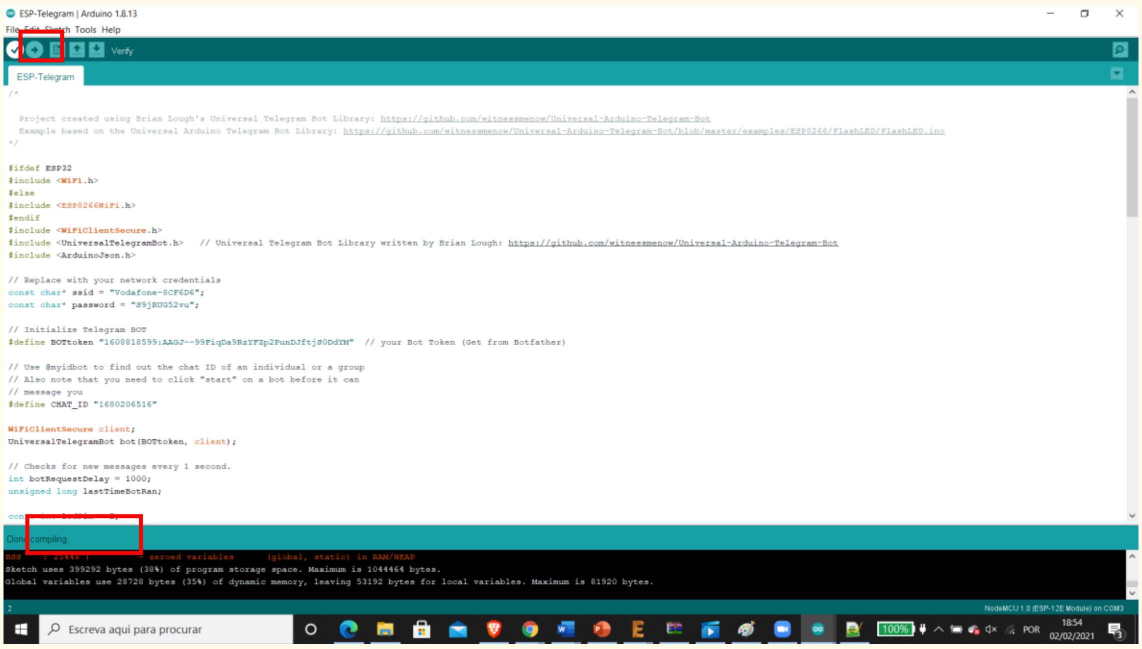
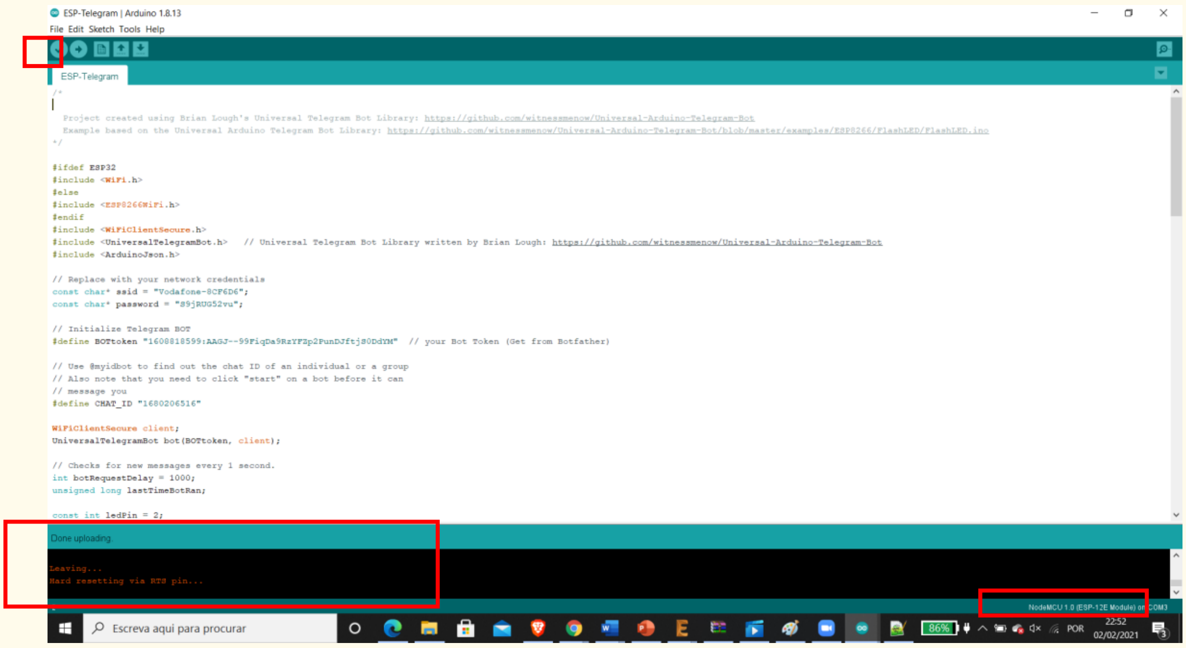

ESP-Telegram | Arduino 1.8.13
File Edit Sketch Tools Help
Verify
ESP-Telegram
NodeMCU 1.0 (ESP-12E Module) on COM3
Escreva aqui para procurar
18:54
02/02/2021

```
/*

  Project created using Brian Lough's Universal Telegram Bot Library: https://github.com/witnessmenow/Universal-Arduino-Telegram-Bot
  Example based on the Universal Arduino Telegram Bot Library: https://github.com/witnessmenow/Universal-Arduino-Telegram-Bot/blob/master/examples/ESP8266/FlashLED/FlashLED.ino
*/

#ifdef ESP32
#include <WiFi.h>
#else
#include <ESP8266WiFi.h>
#endif
#include <WiFiClientSecure.h>
#include <UniversalTelegramBot.h>   // Universal Telegram Bot Library written by Brian Lough: https://github.com/witnessmenow/Universal-Arduino-Telegram-Bot
#include <ArduinoJson.h>

// Replace with your network credentials
const char* ssid = "Vodafone-8CF6D6";
const char* password = "S9jRUG52vu";

// Initialize Telegram BOT
#define BOTtoken "1608818599:AAGJ--99FiqDa9RzYFZp2PunDJftjS0DdYM"  // your Bot Token (Get from Botfather)

// Use @myidbot to find out the chat ID of an individual or a group
// Also note that you need to click "start" on a bot before it can
// message you
#define CHAT_ID "1680206516"

WiFiClientSecure client;
UniversalTelegramBot bot(BOTtoken, client);

// Checks for new messages every 1 second.
int botRequestDelay = 1000;
unsigned long lastTimeBotRan;
```

```
Done compiling.
BSS    : 25448 )         - zeroed variables      (global, static) in RAM/HEAP
Sketch uses 399292 bytes (38%) of program storage space. Maximum is 1044464 bytes.
Global variables use 28728 bytes (35%) of dynamic memory, leaving 53192 bytes for local variables. Maximum is 81920 bytes.
```

If compiling is correct below the image show the message: Done Compiling

The next step is the transfer the code to Board ESP8266. You should not forget to select the correct board and port COM. We can see this correct operation below:

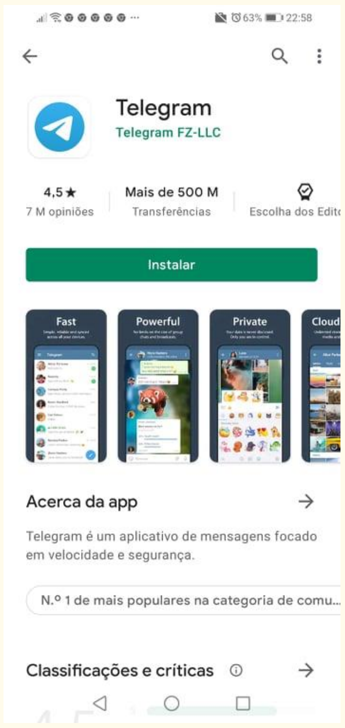

ESP-Telegram | Arduino 1.8.13
File Edit Sketch Tools Help
ESP-Telegram
NodeMCU 1.0 (ESP-12E Module) on COM3
Escreva aqui para procurar
22:52
02/02/2021

```
/*

  Project created using Brian Lough's Universal Telegram Bot Library: https://github.com/witnessmenow/Universal-Arduino-Telegram-Bot
  Example based on the Universal Arduino Telegram Bot Library: https://github.com/witnessmenow/Universal-Arduino-Telegram-Bot/blob/master/examples/ESP8266/FlashLED/FlashLED.ino
*/

#ifdef ESP32
#include <WiFi.h>
#else
#include <ESP8266WiFi.h>
#endif
#include <WiFiClientSecure.h>
#include <UniversalTelegramBot.h>   // Universal Telegram Bot Library written by Brian Lough: https://github.com/witnessmenow/Universal-Arduino-Telegram-Bot
#include <ArduinoJson.h>

// Replace with your network credentials
const char* ssid = "Vodafone-8CF6D6";
const char* password = "S9jRUG52vu";

// Initialize Telegram BOT
#define BOTtoken "1608818599:AAGJ--99FiqDa9RzYFZp2PunDJftjS0DdYM"  // your Bot Token (Get from Botfather)

// Use @myidbot to find out the chat ID of an individual or a group
// Also note that you need to click "start" on a bot before it can
// message you
#define CHAT_ID "1680206516"

WiFiClientSecure client;
UniversalTelegramBot bot(BOTtoken, client);

// Checks for new messages every 1 second.
int botRequestDelay = 1000;
unsigned long lastTimeBotRan;

const int ledPin = 2;
```

```
Done uploading.

Leaving...
Hard resetting via RTS pin...
```

### Telegram Configuration

After configuring the ESP8266, we will move to Telegram, creating the necessary steps for the communication between the devices. For this, we must proceed with the installation of the Telegram application as shown in the figure below:

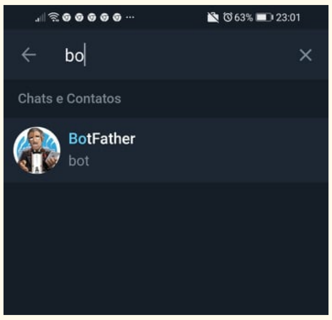


Telegram é um aplicativo de mensagens focado em velocidade e segurança.

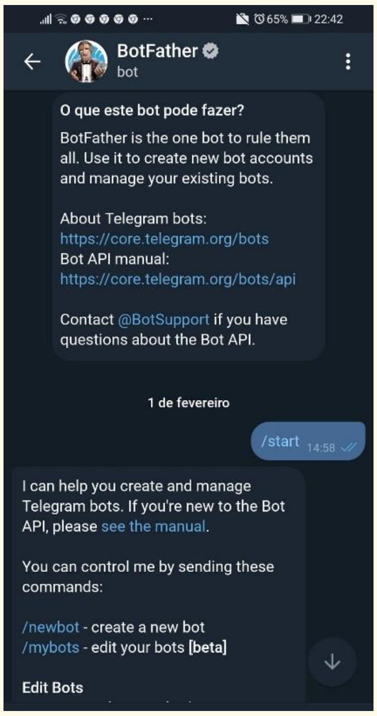
N.º 1 de mais populares na categoria de comu...
Classificações e críticas

After installing the application and creating your account, we will create a bot. This bot is a system that allows you to respond to messages; however, it has to be configured for that to happen. To better understand what it is about, let's follow the tutorial step by step to observe the final result.

Let's start by looking for "botfather" as shown in the figure below:



The "botfather" is a bot that is already built and allows us to manage our bots. To do this, we click on the botfather and type */start*, observing some available codes.



BotFather
bot

**O que este bot pode fazer?**

BotFather is the one bot to rule them all. Use it to create new bot accounts and manage your existing bots.

About Telegram bots:
https://core.telegram.org/bots
Bot API manual:
https://core.telegram.org/bots/api

Contact @BotSupport if you have questions about the Bot API.

1 de fevereiro

/start 14:58

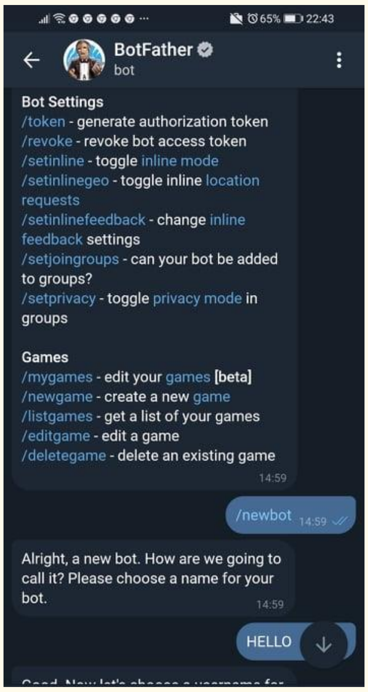
I can help you create and manage Telegram bots. If you're new to the Bot API, please see the manual.

You can control me by sending these commands:

/newbot - create a new bot
/mybots - edit your bots **[beta]**

**Edit Bots**

We wrote the code */newbot* as shown in the figure below:



BotFather
bot

**Bot Settings**
/token - generate authorization token
/revoke - revoke bot access token
/setinline - toggle inline mode
/setinlinegeo - toggle inline location requests
/setinlinefeedback - change inline feedback settings
/setjoingroups - can your bot be added to groups?
/setprivacy - toggle privacy mode in groups

**Games**
/mygames - edit your games **[beta]**
/newgame - create a new game
/listgames - get a list of your games
/editgame - edit a game
/deletegame - delete an existing game
14:59

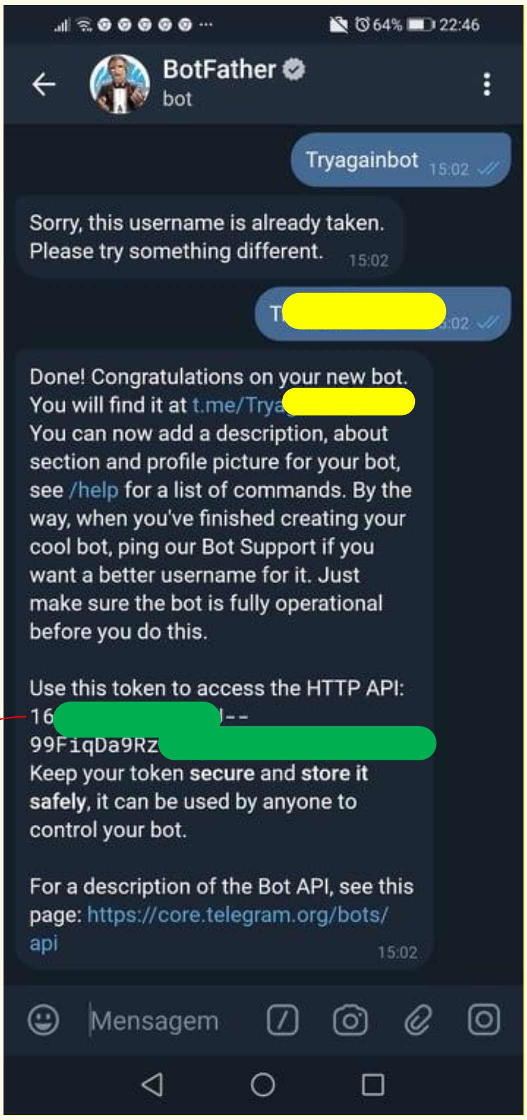
/newbot 14:59

Alright, a new bot. How are we going to call it? Please choose a name for your bot.
14:59

HELLO

In response to the question asked, I put the name HELLO, thus defining the name for my bot.

(Continues on the next page)


BotFather
bot

Tryagainbot 15:02

Sorry, this username is already taken. Please try something different. 15:02

T[redacted]:02

Done! Congratulations on your new bot. You will find it at t.me/Trya[redacted] You can now add a description, about section and profile picture for your bot, see /help for a list of commands. By the way, when you've finished creating your cool bot, ping our Bot Support if you want a better username for it. Just make sure the bot is fully operational before you do this.

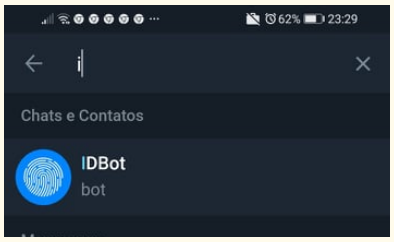
Use this token to access the HTTP API:
16[redacted]--
99F1qDa9Rz[redacted]
Keep your token **secure** and **store it safely**, it can be used by anyone to control your bot.

For a description of the Bot API, see this page: https://core.telegram.org/bots/api 15:02

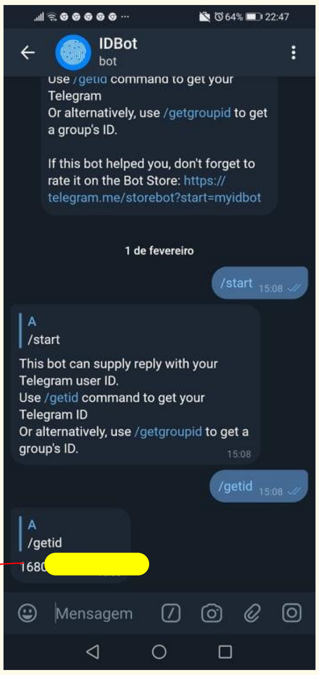
```
// Initialize Telegram BOT
#define BOTtoken "XXXXXXXXXX:XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX" //Your Bot Token (Get from Botfather)
```

In the place shown in yellow, the username for the Bot is defined. If the bot is successfully created, you will receive a message similar to the one above, where a green ID is displayed that will be used to communicate with the bot's token. We copied this ID and put it in the ESP programming in the Arduino IDE as shown in the figure above.

The next step is to obtain our ID, so that in this way it is identified who is communicating with the bot. For this I will search for "idbot" as shown in the figure below:



I select IDBot and send first */start* and then */get* id thus obtaining my ID.


IDBot
bot

Use /getid command to get your Telegram
Or alternatively, use /getgroupid to get a group's ID.

If this bot helped you, don't forget to rate it on the Bot Store: https://telegram.me/storebot?start=myidbot

1 de fevereiro

/start 15:08

A
/start
This bot can supply reply with your Telegram user ID.
Use /getid command to get your Telegram ID
Or alternatively, use /getgroupid to get a group's ID. 15:08

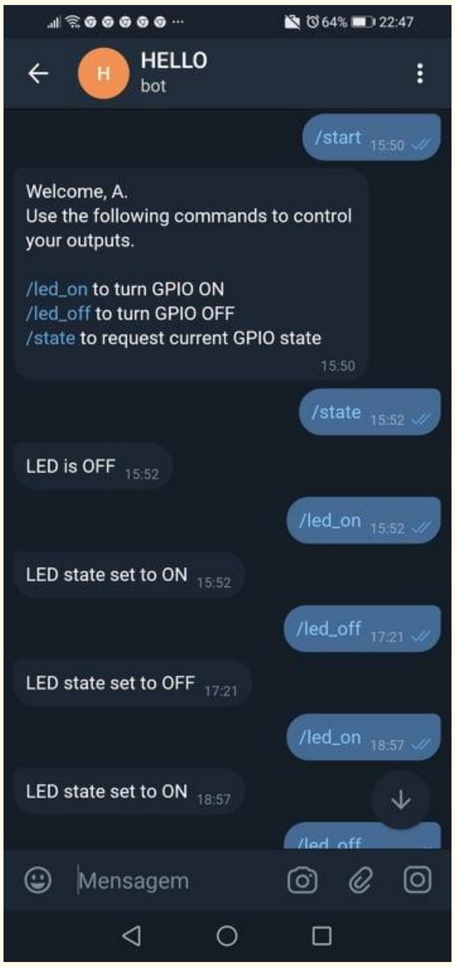
/getid 15:08

A
/getid
168[redacted]

Mensagem

```
// message you
#define CHAT_ID "XXXXXXXXXX"

// message you
#define CHAT_ID "XXXXXXXXXX"

WiFiClientSecure client;
UniversalTelegramBot bot(BOTtoken, client);
```

We look for our created bot, and we can start the conversation with him. In this case, to turn on and turn off an LED.



HELLO
bot

/start 15:50

Welcome, A.
Use the following commands to control your outputs.

/led_on to turn GPIO ON
/led_off to turn GPIO OFF
/state to request current GPIO state
15:50

/state 15:52

LED is OFF 15:52

/led_on 15:52

LED state set to ON 15:52

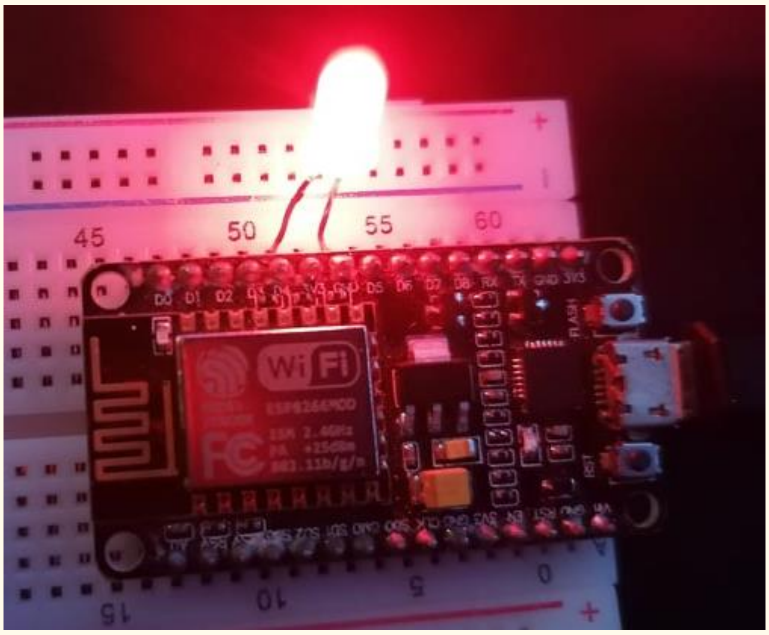
/led_off 17:21

LED state set to OFF 17:21

/led_on 18:57

LED state set to ON 18:57

To observe the final result, an LED was placed between PIN D4 and GND, obtaining the result below:



- **Bibliographic references:**

*http://www.electronicwings.com/*. (n.d.). Retrieved from http://www.electronicwings.com/public/images/user_images/images/NodeMCU/NodeMCU%20Basics%20using%20ESPlorer%20IDE/NodeMCU%20MQTT%20Client/MQTT%20Broker%20nw.png.

*https://diygeeks.org/learn/intro-to-blynk/*. (n.d.). Retrieved from https://diygeeks.org.

*https://esp8266-shop.com/esp8266-guide/esp8266-nodemcu-pinout/*. (n.d.). Retrieved from https://esp8266-shop.com/.

https://realbusiness.co.uk/from-1982-coca-cola-vending-machine-to-latest-trend-what-the-internet-of-things-means-for-business/. (n.d.).

*https://www.embarcados.com.br/introducao-ao-blynk-app/*. (n.d.). Retrieved from https://www.embarcados.com.br/.

Oliveira, S. d. (2017). *Internet das coisas .* novatec.

Santos, R. (n.d.). *https://randomnerdtutorials.com/*. Retrieved from https://randomnerdtutorials.com/.

Souza, F. (n.d.). *Controle de dispostivos remotamento com o ESP8266.*

## LESSON – CONNECTING ESP8266 WITH FIREBASE

- **Study section:** WiFi Fundamentals and IoT
- **Lesson duration:** 4:00h
- **Educational objectives:**
    - Configure the ESP32 to Firebase access
    - Configure the Firebase to communicate with ESP32
    - Communication between Firebase and ESP32
- **Main Keyword(s):**
    - ESP32
    - WiFi
    - Firebase
- **Learning outcomes and acquired competencies:**

At the end of the unit, the student should be able to:

| Knowledge | Skills | Responsibility and Autonomy |
|---|---|---|
| • Characterize ESP 8266<br>• Recognize the hardware needed to connect ESP32 with Firebase<br>• Recognize the importance and benefits the Firebase | • Determine the hardware to be used in different configurations with the ESP32<br>• Program and configure communication between the Firebase and ESP32 | • Plan and structure tasks<br>• Communicate concepts and ideas clearly<br>• Act with initiative and demonstrate the analytical capacity<br>• Recommend solutions for problem-solving<br>• Demonstrate creativity, autonomy, and innovative spirit |

- **Required material and resources:**
    - ESP32
    - Cable USB to micro-USB
    - BreadBoard
    - Computer
    - Software Arduino IDE

- Internet Connection
- Google Account

**Brief definition of Firebase**

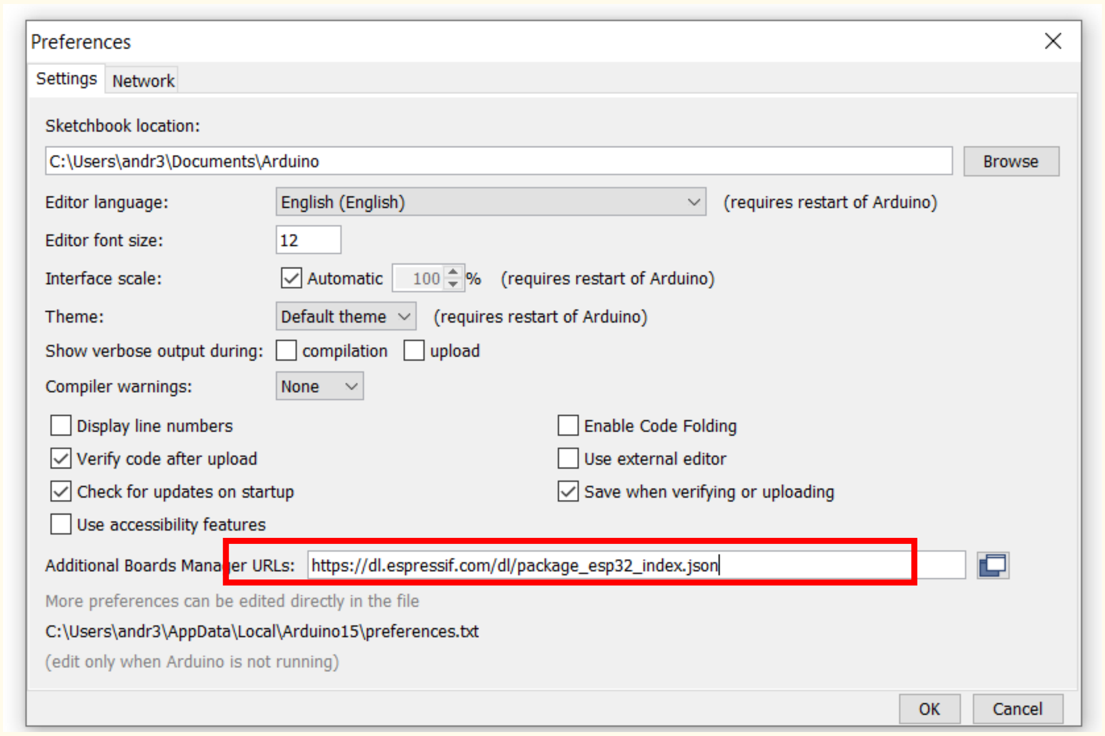
The Firebase provides developers with a variety of tools and services to help them develop quality applications, grow their user base and make a profit. It is built on Google's infrastructure.

**Connecting Firebase – ESP32**

In our project will be working on the Firebase Real-Time Database. The Realtime Database is cloud-hosted. Data is synced across all clients in real-time and remains available when your app goes offline.

**Programming ESP32**

Access the Arduino IDE and add the URL indicated above.



Preferences

Settings | Network

Sketchbook location: C:\Users\andr3\Documents\Arduino

Editor language: English (English) (requires restart of Arduino)

Editor font size: 12

Interface scale: ✓ Automatic 100 % (requires restart of Arduino)

Theme: Default theme (requires restart of Arduino)

Show verbose output during: ☐ compilation ☐ upload

Compiler warnings: None

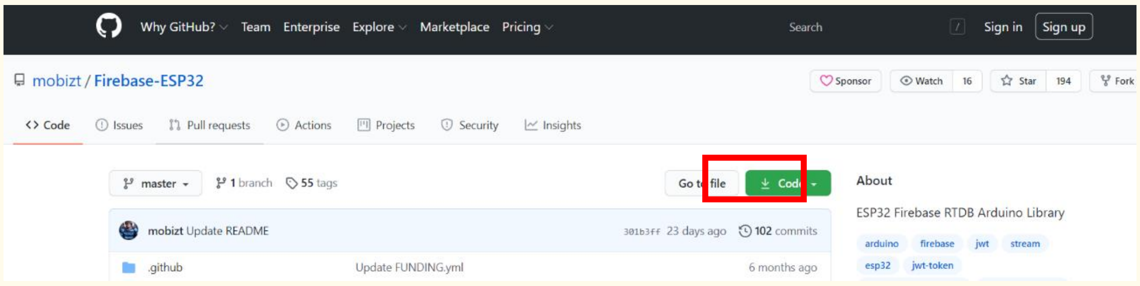
☐ Display line numbers
✓ Verify code after upload
✓ Check for updates on startup
☐ Use accessibility features
☐ Enable Code Folding
☐ Use external editor
✓ Save when verifying or uploading

Additional Boards Manager URLs: https://dl.espressif.com/dl/package_esp32_index.json

More preferences can be edited directly in the file
C:\Users\andr3\AppData\Local\Arduino15\preferences.txt
(edit only when Arduino is not running)

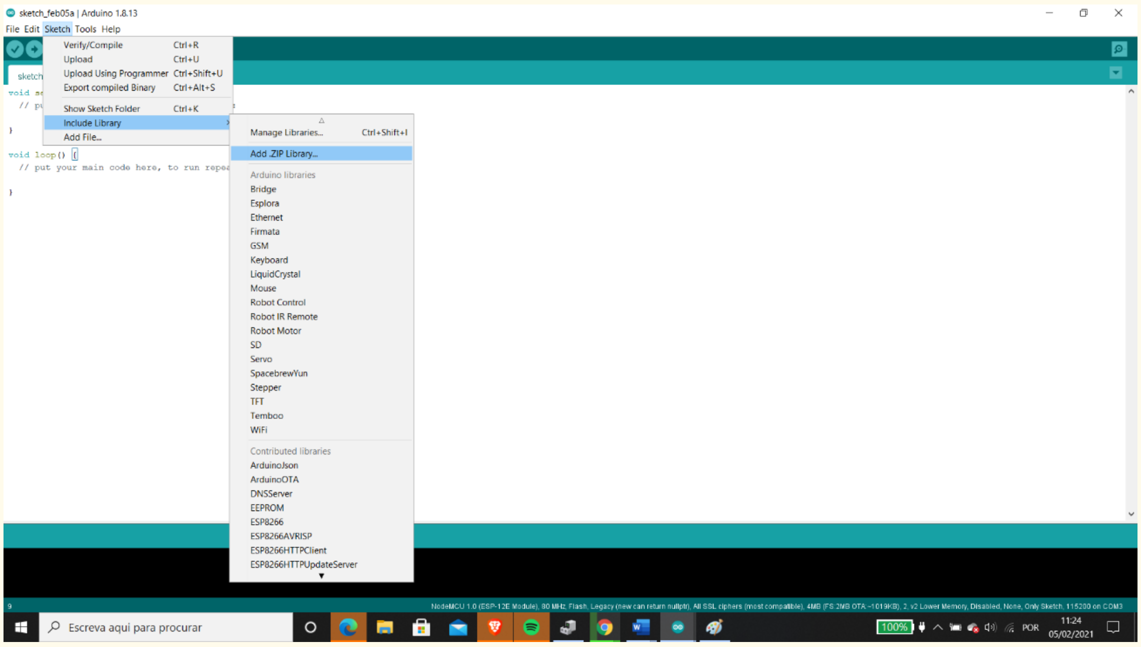
For work with ESP32 and Firebase we need download the library FirebaseESP32.H. For this we can download in the page indicated below:

https://github.com/mobizt/Firebase-ESP32

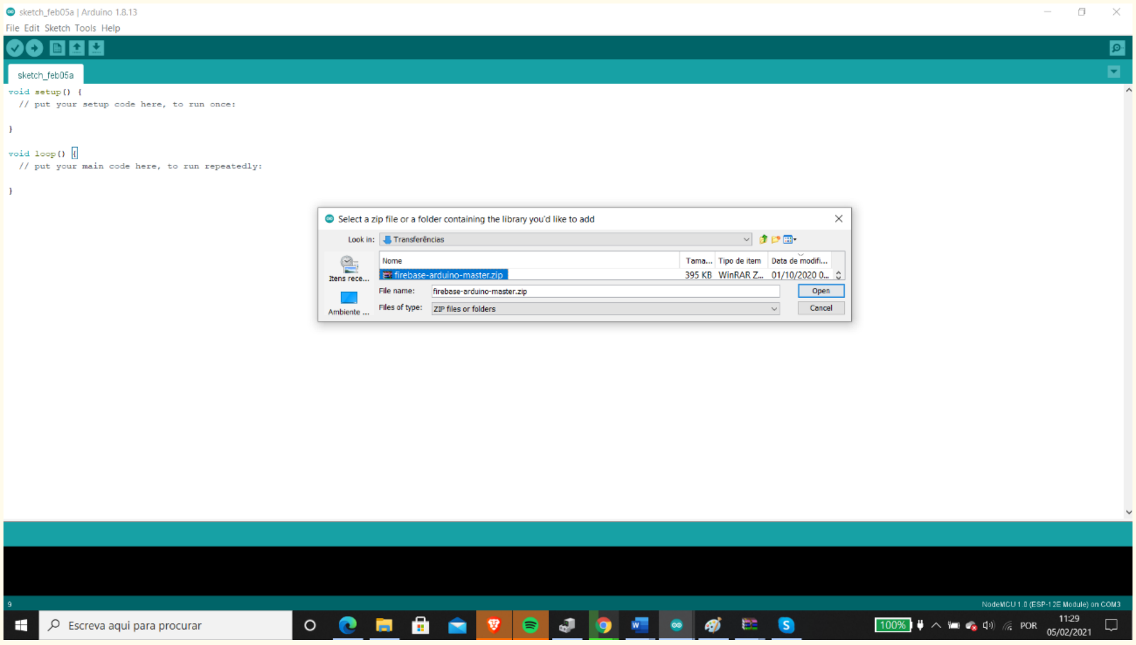


After download, we need to install the library. We can see the step in the images below:

Add the library.



Select the library "firebase-arduino-master" .zip


sketch_feb05a | Arduino 1.8.13
File Edit Sketch Tools Help
sketch_feb05a
Select a zip file or a folder containing the library you'd like to add
Look in: Transferências
Nome
Tama...
Tipo de item
Data de modifi...
firebase-arduino-master.zip
395 KB
WinRAR Z...
01/10/2020 0...
File name: firebase-arduino-master.zip
Files of type: ZIP files or folders
Open
Cancel
Escreva aqui para procurar

```
void setup() {
  // put your setup code here, to run once:

}

void loop() {
  // put your main code here, to run repeatedly:

}
```

In the last step for programming the ESP32, we select the correct board:

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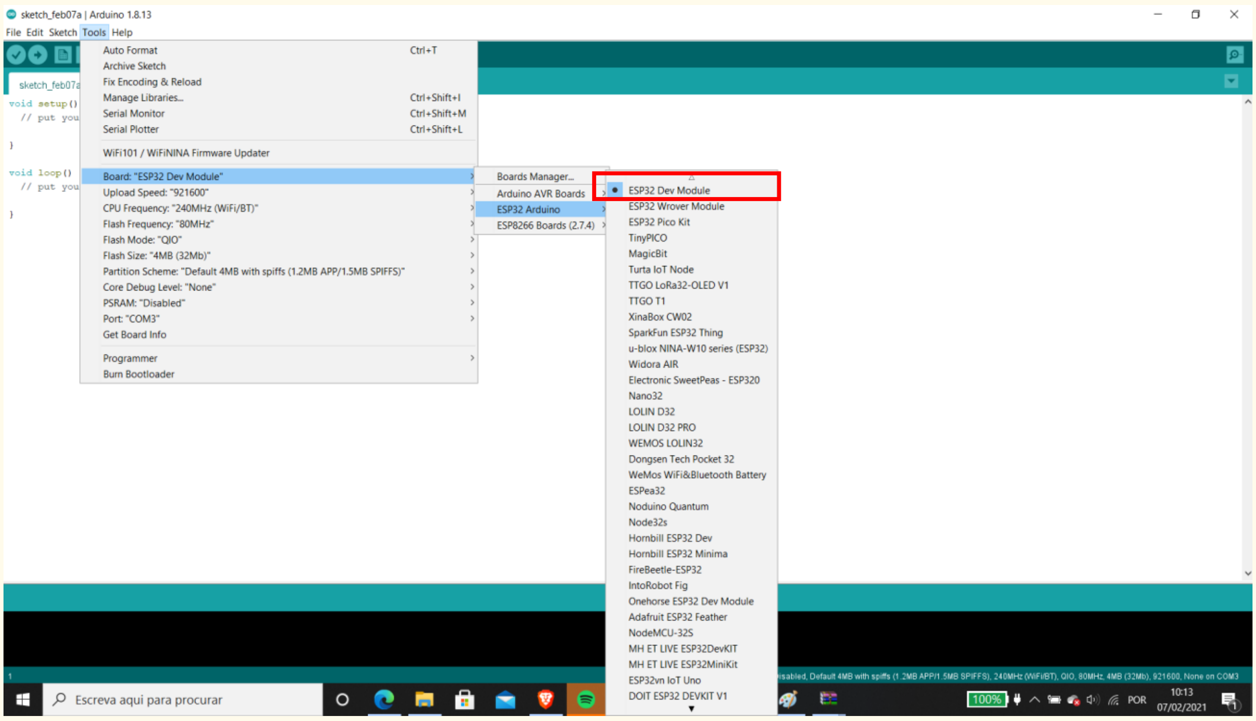
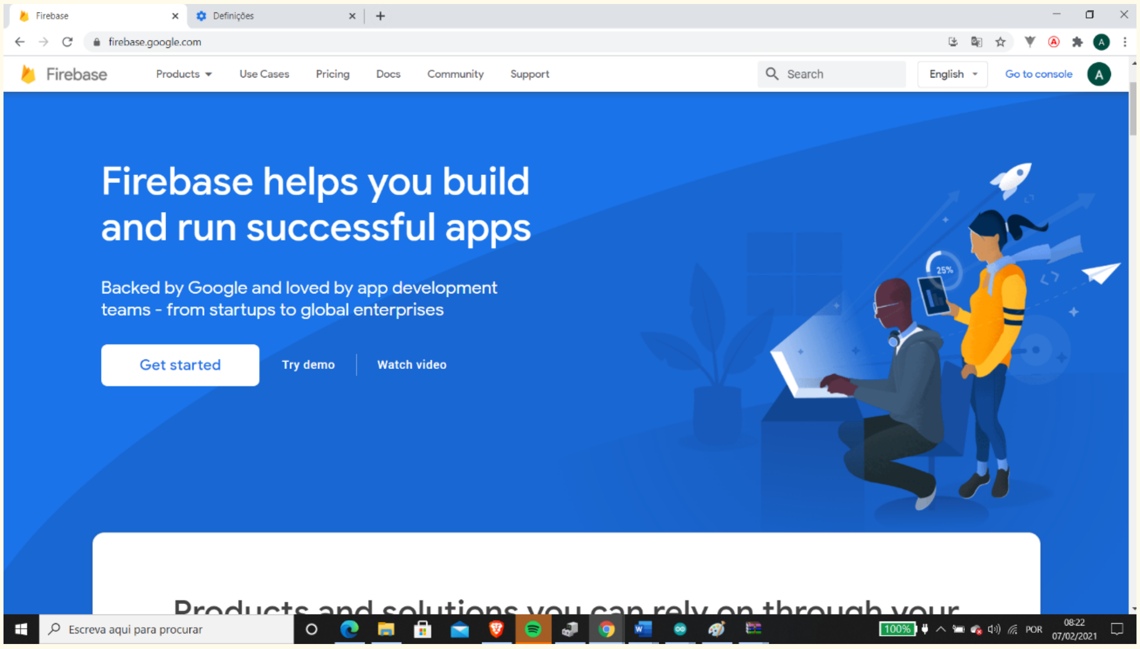


Board: "ESP32 Dev Module"
Upload Speed: "921600"
CPU Frequency: "240MHz (WiFi/BT)"
Flash Frequency: "80MHz"
Flash Mode: "QIO"
Flash Size: "4MB (32Mb)"
Partition Scheme: "Default 4MB with spiffs (1.2MB APP/1.5MB SPIFFS)"
Core Debug Level: "None"
PSRAM: "Disabled"
Port: "COM3"

## Configuration Firebase

For configuration Firebase you must follow the following steps:

1. Go to the site *firebase.google.com*



Firebase
Definições
firebase.google.com
Products
Use Cases
Pricing
Docs
Community
Support
Search
English
Go to console
Firebase helps you build and run successful apps
Backed by Google and loved by app development teams - from startups to global enterprises
Get started
Try demo
Watch video
Products and solutions you can rely on through your
Escreva aqui para procurar

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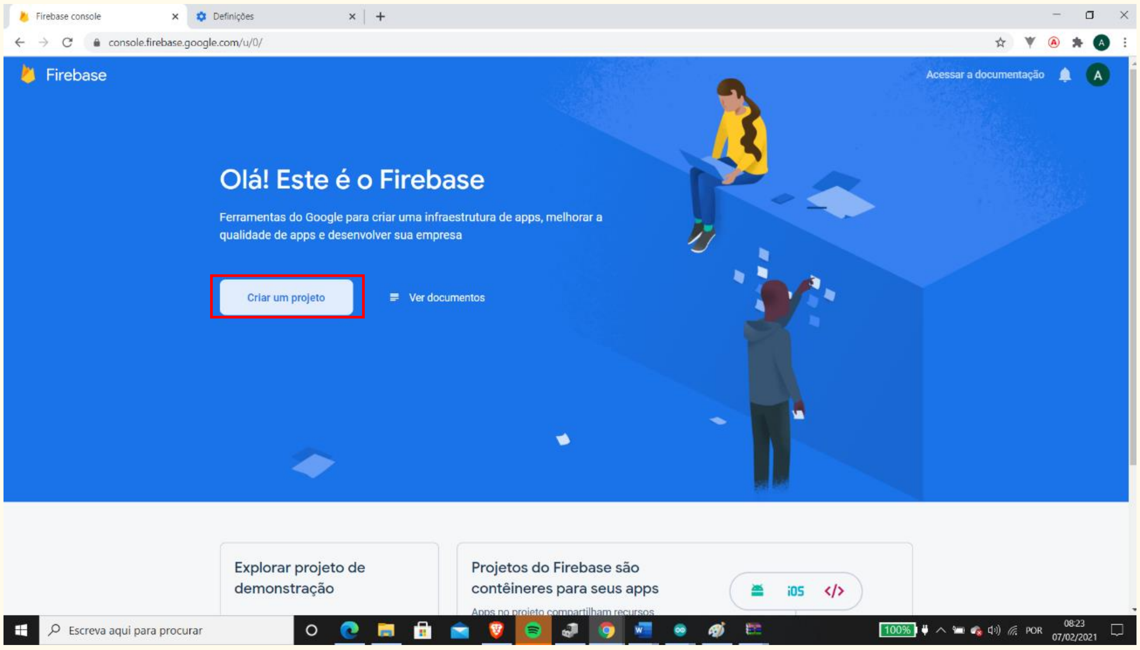
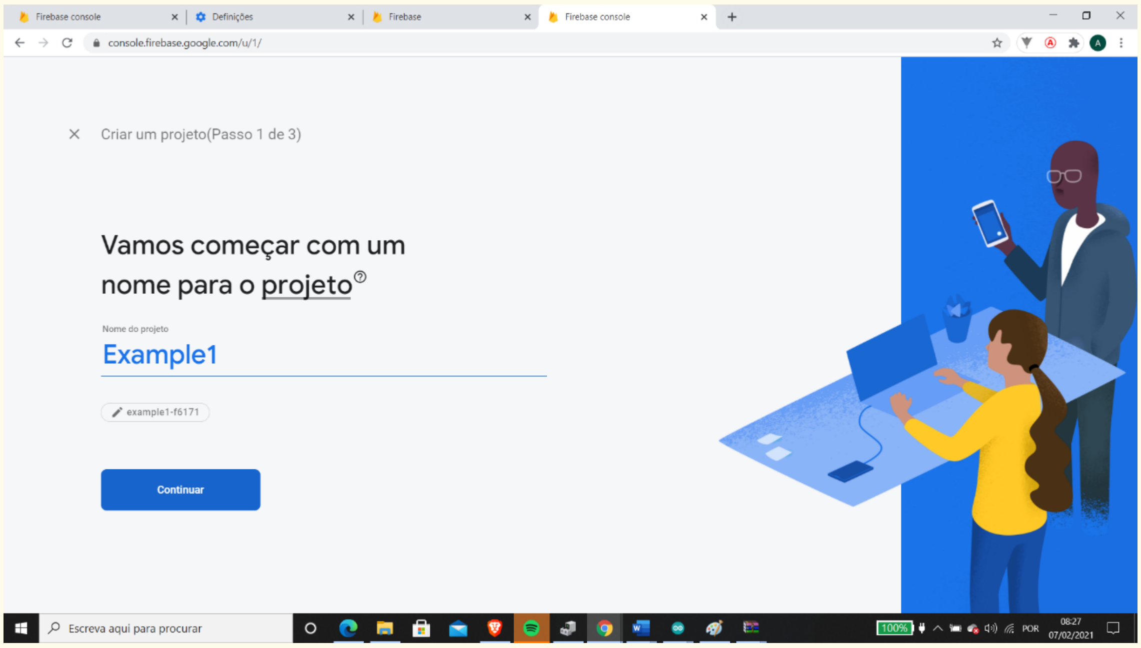
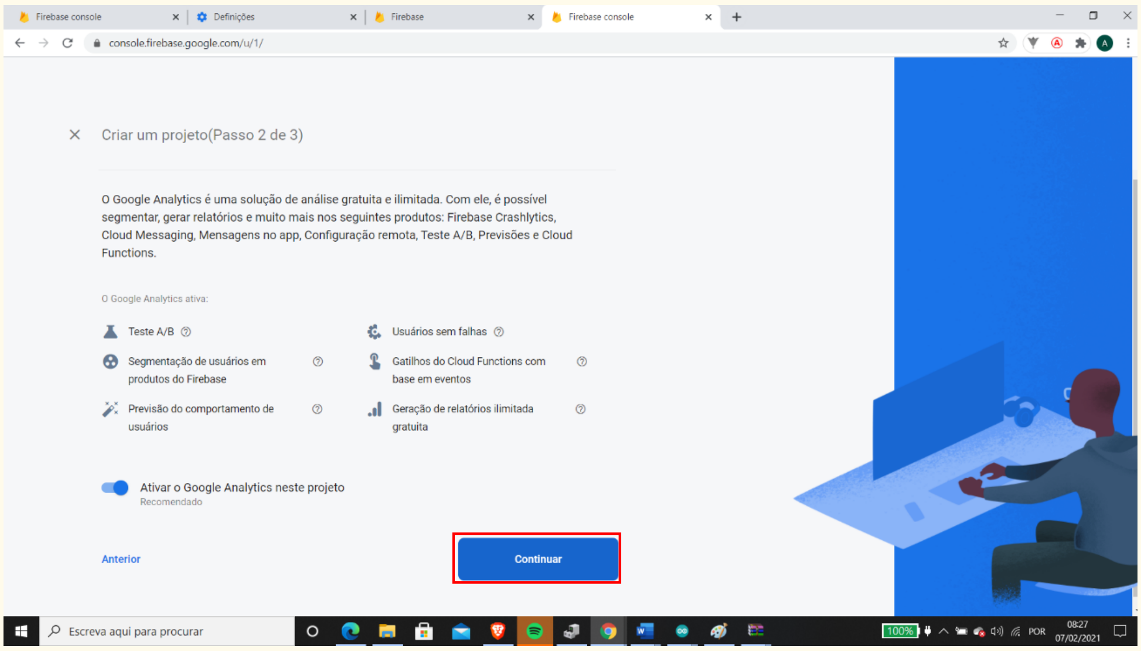
2. Select *Add new project*


Firebase
Olá! Este é o Firebase
Ferramentas do Google para criar uma infraestrutura de apps, melhorar a qualidade de apps e desenvolver sua empresa
Criar um projeto
Ver documentos
Explorar projeto de demonstração
Projetos do Firebase são contêineres para seus apps

3. Choose the name for your project. In the example below, the chosen name was the "*Example1*"


Criar um projeto(Passo 1 de 3)
Vamos começar com um nome para o projeto
Nome do projeto
Example1
example1-f6171
Continuar

4. Confirm the creation of the project.



Criar um projeto(Passo 2 de 3)

O Google Analytics é uma solução de análise gratuita e ilimitada. Com ele, é possível segmentar, gerar relatórios e muito mais nos seguintes produtos: Firebase Crashlytics, Cloud Messaging, Mensagens no app, Configuração remota, Teste A/B, Previsões e Cloud Functions.

O Google Analytics ativa:

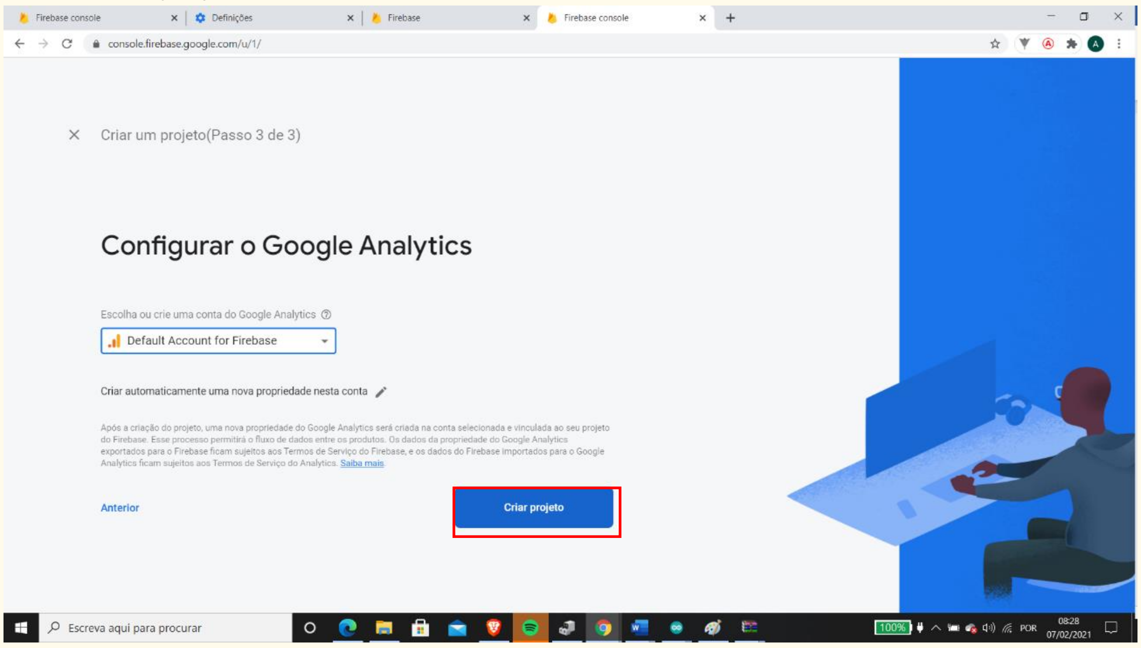
- Teste A/B
- Usuários sem falhas
- Segmentação de usuários em produtos do Firebase
- Gatilhos do Cloud Functions com base em eventos
- Previsão do comportamento de usuários
- Geração de relatórios ilimitada gratuita

Ativar o Google Analytics neste projeto
Recomendado

Anterior

Continuar

5. Finalize the project.



Criar um projeto(Passo 3 de 3)

Configurar o Google Analytics

Escolha ou crie uma conta do Google Analytics

Default Account for Firebase

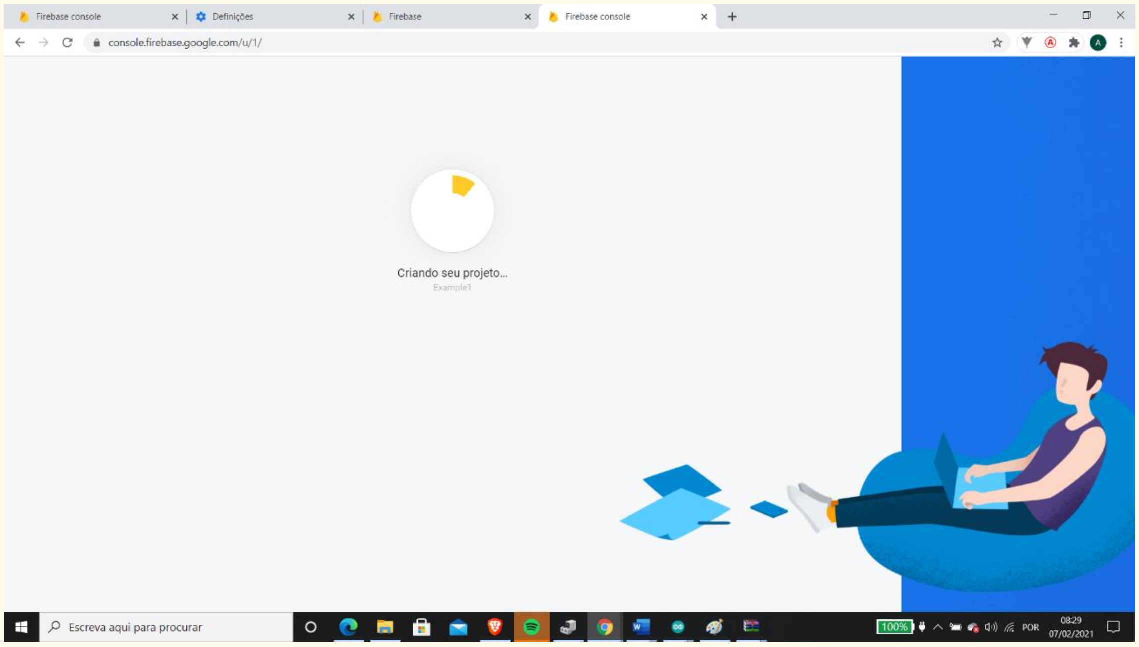
Criar automaticamente uma nova propriedade nesta conta

Após a criação do projeto, uma nova propriedade do Google Analytics será criada na conta selecionada e vinculada ao seu projeto do Firebase. Esse processo permitirá o fluxo de dados entre os produtos. Os dados da propriedade do Google Analytics exportados para o Firebase ficam sujeitos aos Termos de Serviço do Firebase, e os dados do Firebase importados para o Google Analytics ficam sujeitos aos Termos de Serviço do Analytics. Saiba mais.

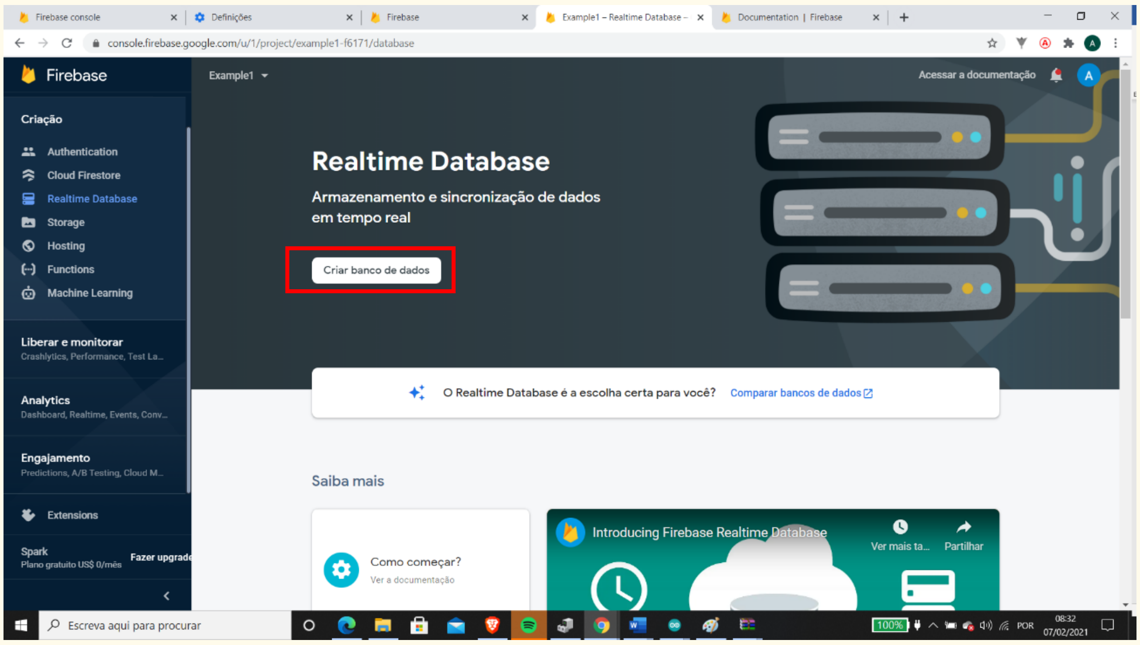
Anterior

Criar projeto

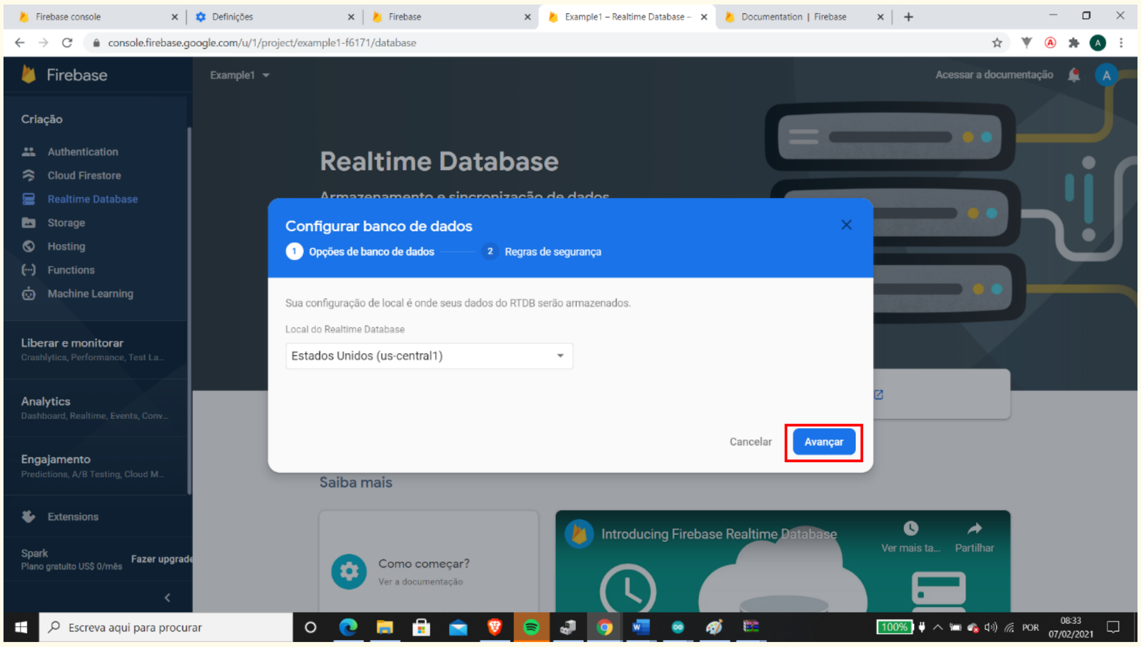
6. Wait while the project is created.



7. Configure the Real-Time Database to operating with your system:



8. Select the "*Configuration Database.*"

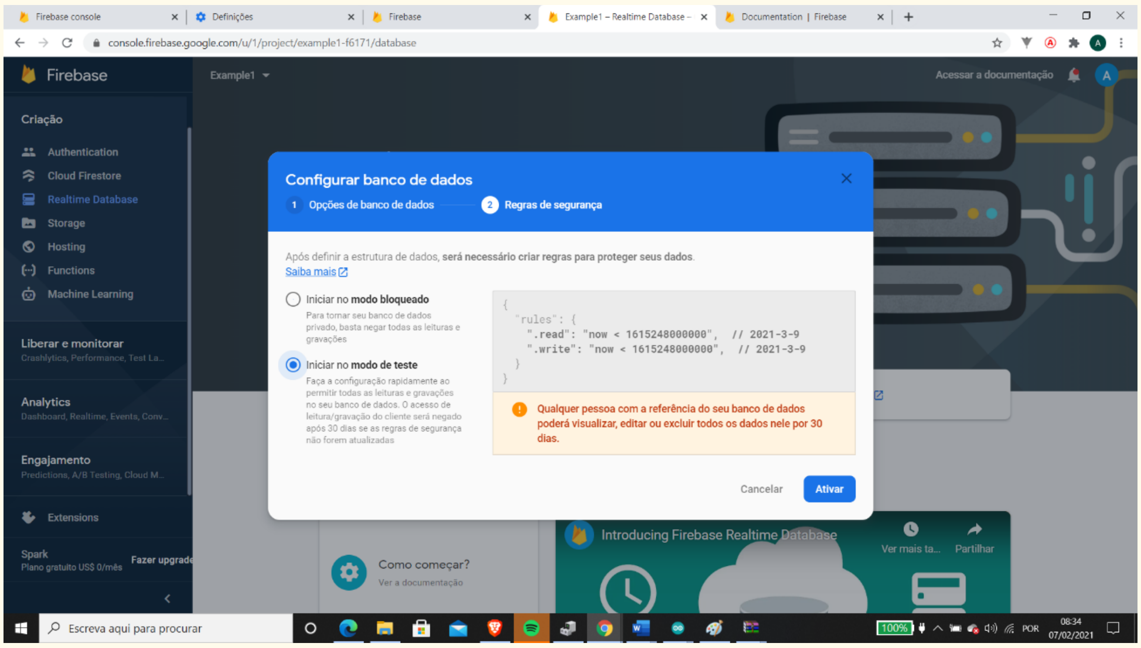

Configurar banco de dados

1 Opções de banco de dados — 2 Regras de segurança

Sua configuração de local é onde seus dados do RTDB serão armazenados.

Local do Realtime Database: Estados Unidos (us-central1)

9. Select the "Test Mode."


Configurar banco de dados

1 Opções de banco de dados — 2 Regras de segurança

Após definir a estrutura de dados, **será necessário criar regras para proteger seus dados.**
Saiba mais

Iniciar no **modo bloqueado**
Para tornar seu banco de dados privado, basta negar todas as leituras e gravações

[✓ Iniciar no **modo de teste**]
Faça a configuração rapidamente ao permitir todas as leituras e gravações no seu banco de dados. O acesso de leitura/gravação do cliente será negado após 30 dias se as regras de segurança não forem atualizadas

```
{
  "rules": {
    ".read": "now < 1615248000000",  // 2021-3-9
    ".write": "now < 1615248000000",  // 2021-3-9
  }
}
```

Qualquer pessoa com a referência do seu banco de dados poderá visualizar, editar ou excluir todos os dados nele por 30 dias.

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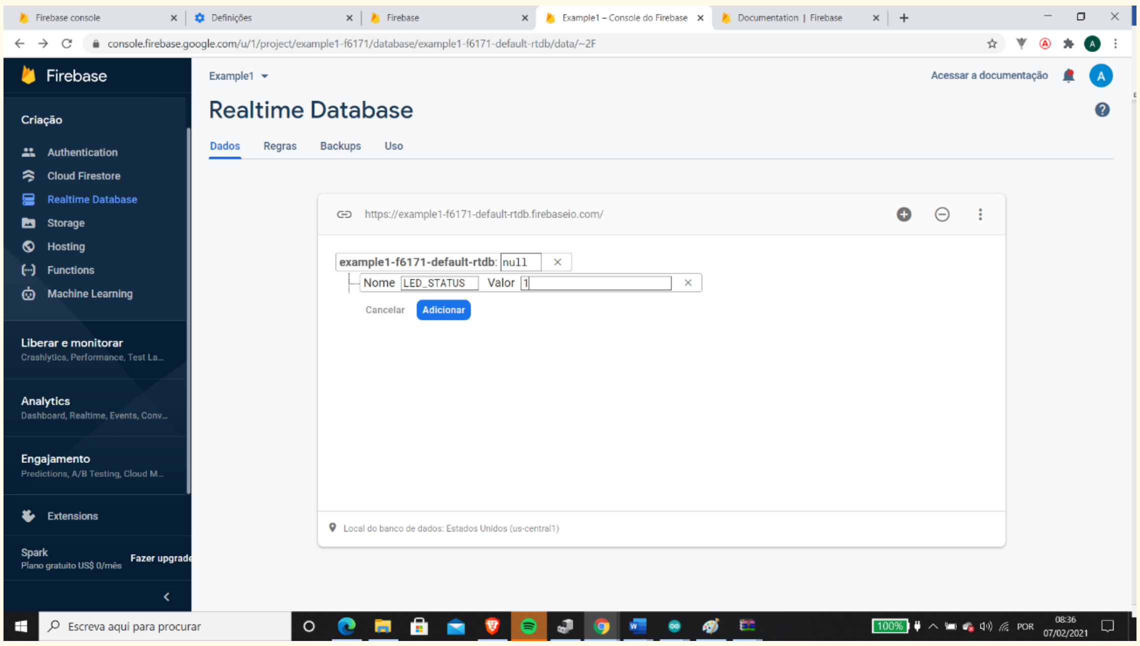
10. Select the Data and your example. To fill in this field, you must put the name STATUS LED and assign a value of 1, as shown in the image below.


console.firebase.google.com/u/1/project/example1-f6171/database/example1-f6171-default-rtdb/data/~2F

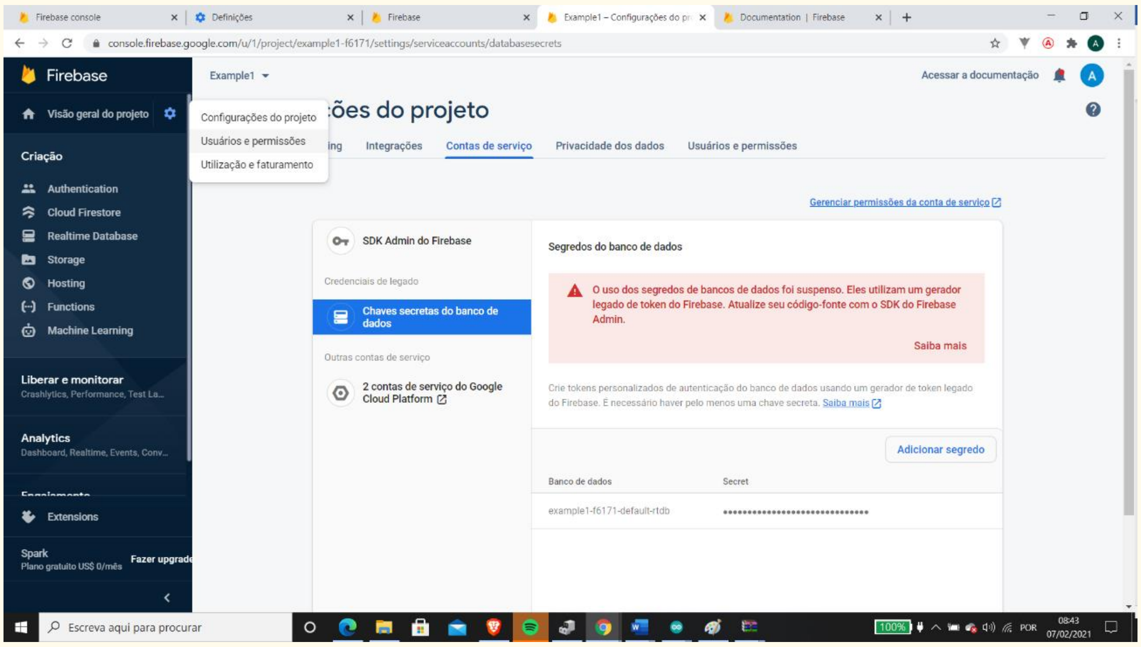
https://example1-f6171-default-rtdb.firebaseio.com/

example1-f6171-default-rtdb: null

Nome LED_STATUS Valor 1

Local do banco de dados: Estados Unidos (us-central1)

11. In the *project overview* select the *user and permissions* and copy the secret token. This token will be used in the programming ESP32 to communication with the firebase.


console.firebase.google.com/u/1/project/example1-f6171/settings/serviceaccounts/databasesecrets

Segredos do banco de dados

O uso dos segredos de bancos de dados foi suspenso. Eles utilizam um gerador legado de token do Firebase. Atualize seu código-fonte com o SDK do Firebase Admin.

Crie tokens personalizados de autenticação do banco de dados usando um gerador de token legado do Firebase. É necessário haver pelo menos uma chave secreta. Saiba mais

| Banco de dados | Secret |
|---|---|
| example1-f6171-default-rtdb | •••••••••••••••••••••••••••••••• |

## The Programming ESP32 to connection with Firebase

```
#include <WiFi.h>
#include <FirebaseESP32.h>
```

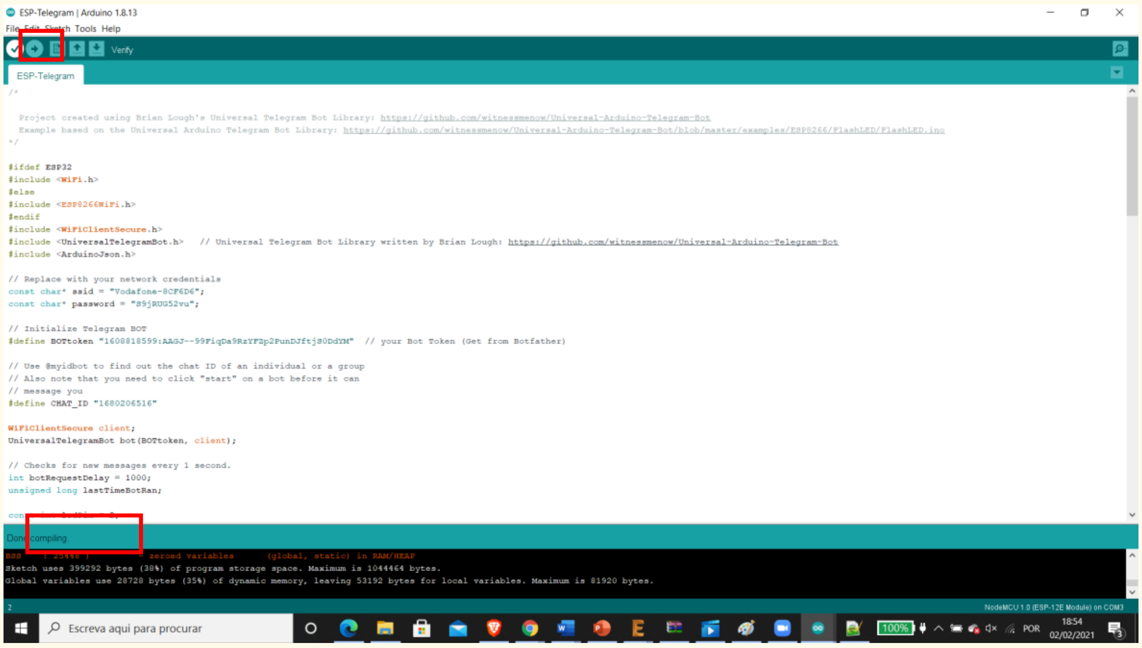
```
#define FIREBASE_HOST "Your Firebase Host"
#define FIREBASE_AUTH "Your Firebase Auth"
```

Now we can copy the code below to Arduino IDE:

```
#include <WiFi.h>
#include <FirebaseESP32.h>

#define FIREBASE_HOST "Your Firebase Host"
#define FIREBASE_AUTH "Your Firebase Auth"

#define WIFI_SSID "Vodafone-8CF6D6"
#define WIFI_PASSWORD "S9jRUG52vu"

FirebaseData firebaseData;
FirebaseJson json;
int led =2;

void setup() {
 Serial.begin(115200);
 pinMode(led, OUTPUT);
 WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
 Serial.print("Connecting to Wi-Fi");
 while (WiFi.status() != WL_CONNECTED)
 {
  Serial.print(".");
  delay(500);
 }
 Serial.println();
 Serial.print("Connected with IP: ");
 Serial.println(WiFi.localIP());
 Serial.println();

 Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);
 Firebase.reconnectWiFi(true);

}

void loop() {

 Firebase.getInt(firebaseData, "LED_STATUS");
 Serial.println(firebaseData.intData());

 if (firebaseData.intData() == 1) {    // compare the input of led status received from firebase
  Serial.println("Led Turned ON");
  digitalWrite(led, HIGH);
 }
 if (firebaseData.intData() == 2) {   // compare the input of led status received from firebase
  Serial.println("Led Turned OFF");
```

```
    digitalWrite(led, LOW);
  }
}
```

After copying the code to Arduino IDE, you need to verify:

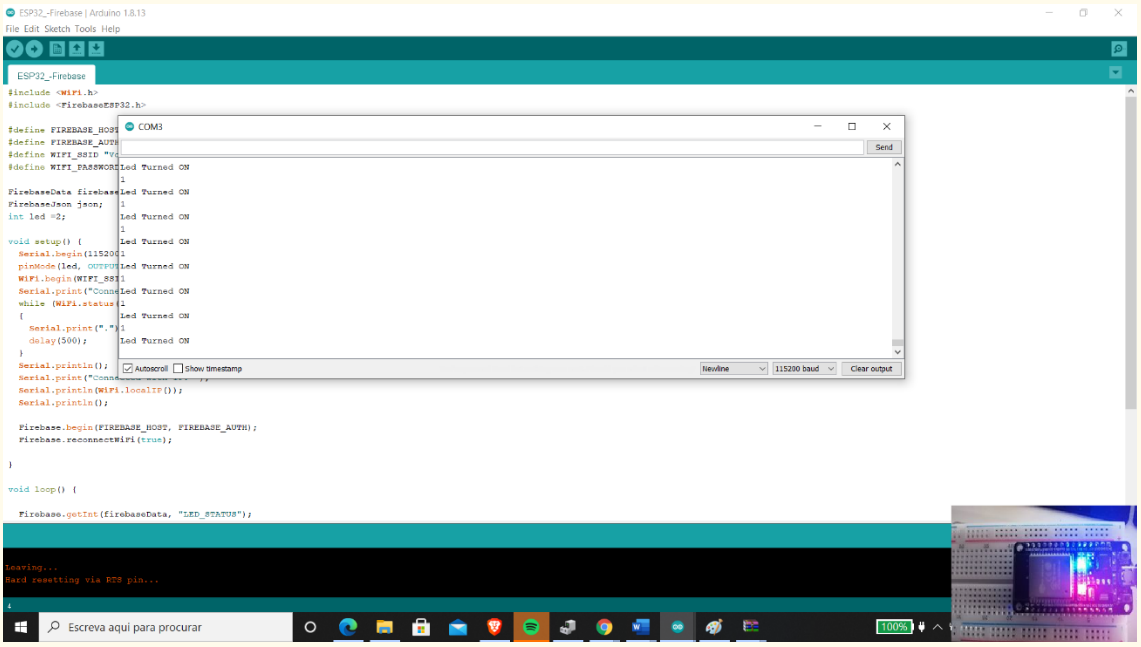


```
/*

  Project created using Brian Lough's Universal Telegram Bot Library: https://github.com/witnessmenow/Universal-Arduino-Telegram-Bot
  Example based on the Universal Arduino Telegram Bot Library: https://github.com/witnessmenow/Universal-Arduino-Telegram-Bot/blob/master/examples/ESP8266/FlashLED/FlashLED.ino
*/

#ifdef ESP32
#include <WiFi.h>
#else
#include <ESP8266WiFi.h>
#endif
#include <WiFiClientSecure.h>
#include <UniversalTelegramBot.h>   // Universal Telegram Bot Library written by Brian Lough: https://github.com/witnessmenow/Universal-Arduino-Telegram-Bot
#include <ArduinoJson.h>

// Replace with your network credentials
const char* ssid = "Vodafone-8CF6D6";
const char* password = "S9jRUG52vu";

// Initialize Telegram BOT
#define BOTtoken "1608818599:AAGJ--99FiqDa9RzYFZp2PunDJftjS0DdYM"  // your Bot Token (Get from Botfather)

// Use @myidbot to find out the chat ID of an individual or a group
// Also note that you need to click "start" on a bot before it can
// message you
#define CHAT_ID "1680206516"

WiFiClientSecure client;
UniversalTelegramBot bot(BOTtoken, client);

// Checks for new messages every 1 second.
int botRequestDelay = 1000;
unsigned long lastTimeBotRan;
```

```
Done compiling.
Sketch uses 399292 bytes (38%) of program storage space. Maximum is 1044464 bytes.
Global variables use 28728 bytes (35%) of dynamic memory, leaving 53192 bytes for local variables. Maximum is 81920 bytes.
```

If compiling is correct, below the image show the message: Done Compiling

The next step is the transfer the code to Board ESP32. You should not forget to verify the correct board and port COM. We can see this correct operation below:

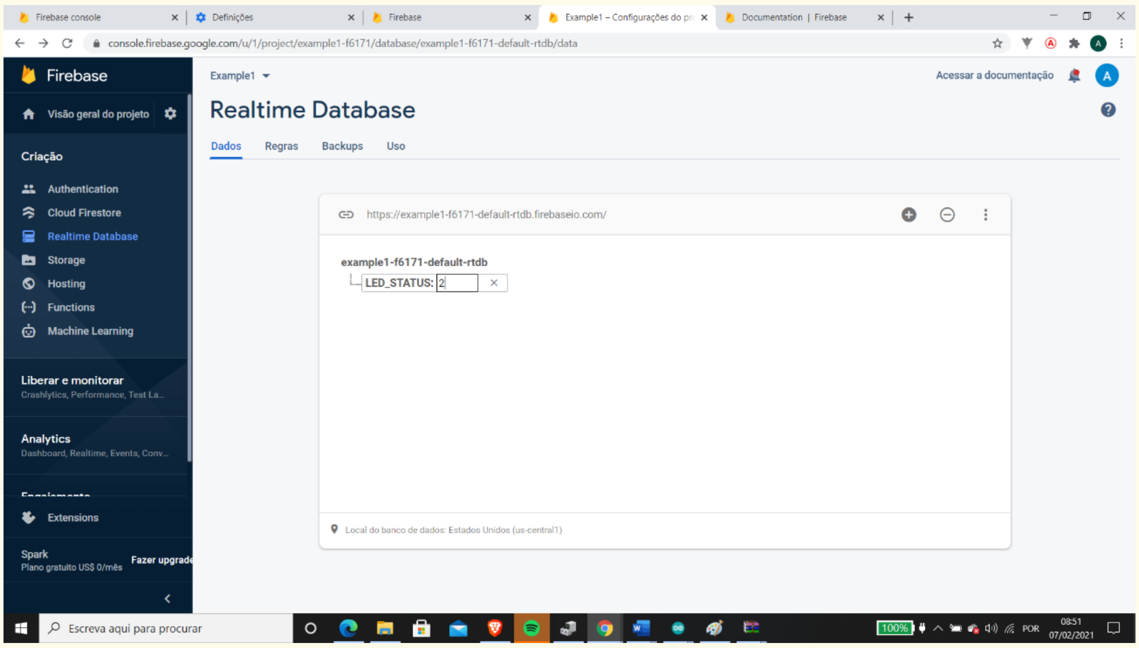


```
#include <WiFi.h>
#include <FirebaseESP32.h>

#define FIREBASE_HOST
#define FIREBASE_AUTH
#define WIFI_SSID "V
#define WIFI_PASSWORD

FirebaseData firebase
FirebaseJson json;
int led =2;

void setup() {
  Serial.begin(115200
  pinMode(led, OUTPUT
  WiFi.begin(WIFI_SSI
  Serial.print("Conne
  while (WiFi.status(
  {
    Serial.print(".")
    delay(500);
  }
  Serial.println();
  Serial.print("Conne
  Serial.println(WiFi.localIP());
  Serial.println();

  Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);
  Firebase.reconnectWiFi(true);

}

void loop() {

  Firebase.getInt(firebaseData, "LED_STATUS");
```

```
Led Turned ON
1
Led Turned ON
1
Led Turned ON
1
Led Turned ON
1
Led Turned ON
1
Led Turned ON
1
Led Turned ON
1
Led Turned ON
```

```
Leaving...
Hard resetting via RTS pin...
```

The LED blue turns on. If changes the value 1 in LED_SATATUS for 2, the LED blue turns off.



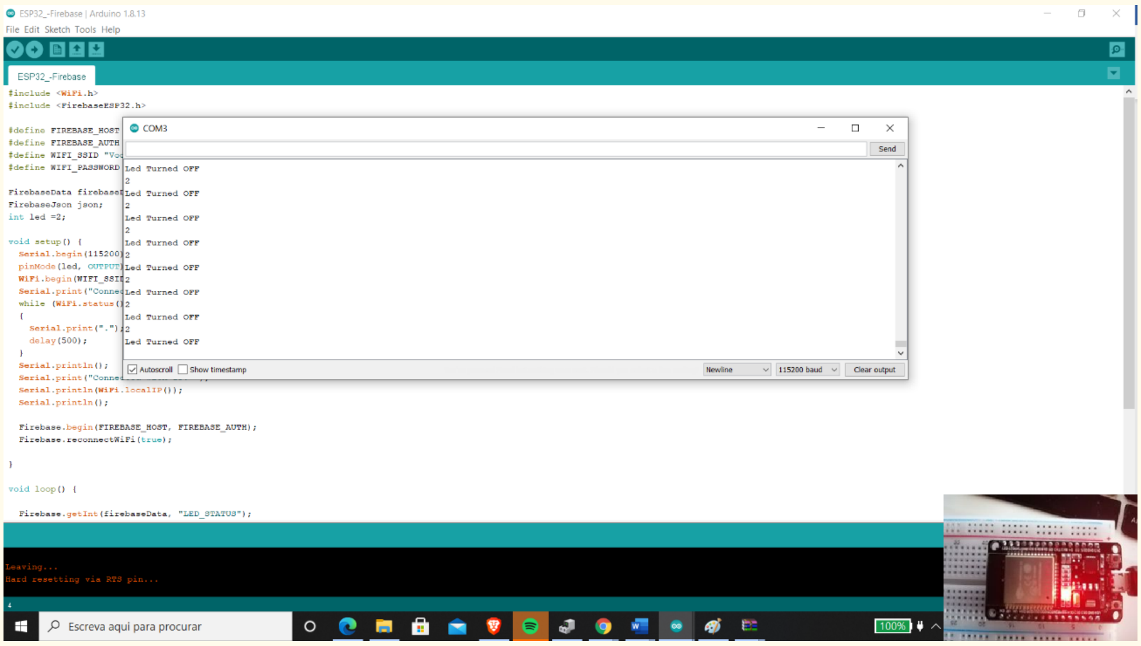
console.firebase.google.com/u/1/project/example1-f6171/database/example1-f6171-default-rtdb/data

Realtime Database

https://example1-f6171-default-rtdb.firebaseio.com/

example1-f6171-default-rtdb
LED_STATUS: 2

Local do banco de dados: Estados Unidos (us-central1)



```
#include <WiFi.h>
#include <FirebaseESP32.h>

#define FIREBASE_HOST
#define FIREBASE_AUTH
#define WIFI_SSID "Vo
#define WIFI_PASSWORD

FirebaseData firebase
FirebaseJson json;
int led =2;

void setup() {
  Serial.begin(115200)
  pinMode(led, OUTPUT)
  WiFi.begin(WIFI_SSI
  Serial.print("Conne
  while (WiFi.status()
  {
    Serial.print(".");
    delay(500);
  }
  Serial.println();
  Serial.print("Conne
  Serial.println(WiFi.localIP());
  Serial.println();

  Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);
  Firebase.reconnectWiFi(true);

}

void loop() {

  Firebase.getInt(firebaseData, "LED_STATUS");
```

```
Led Turned OFF
2
Led Turned OFF
2
Led Turned OFF
2
Led Turned OFF
2
Led Turned OFF
2
Led Turned OFF
2
Led Turned OFF
2
Led Turned OFF
```

```
Leaving...
Hard resetting via RTS pin...
```

- **Bibliographic references:**

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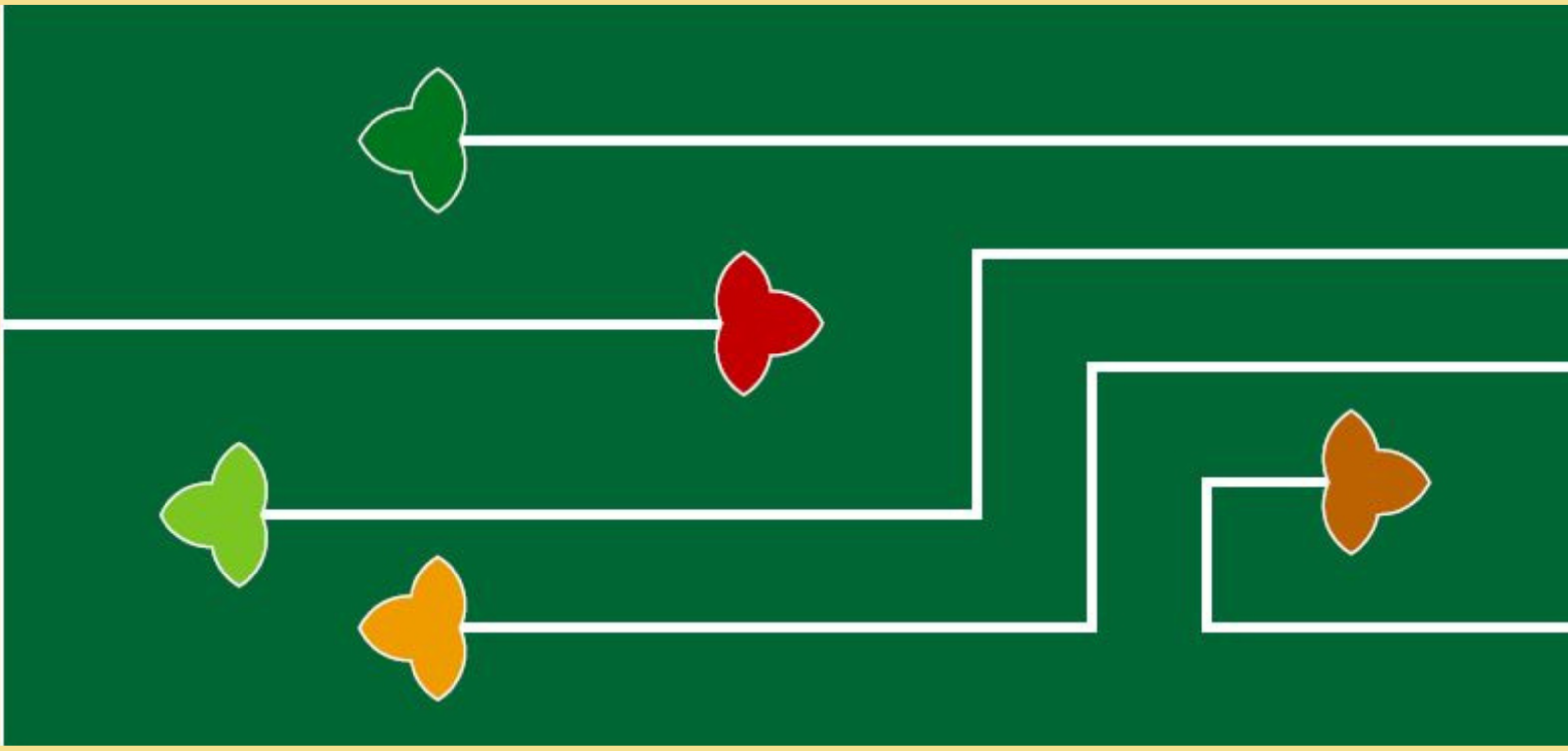

Erasmus+

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Project number: 2019-3-CY02-KA205-001692

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