BE MAKER

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ELETTRONICA, ROBOTICA E CODING PER RAGAZZI... E NON SOLO !

COURSE OF ELECTRONICS, ROBOTICS AND CODING FOR CHILDREN... and not only!

BASIC COURSE – Lesson 1

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Warnings

With regard to the safety aspects, since the projects are based on a very low voltage power supply supplied by the USB port of the PC or by support batteries or power supplies with a maximum of 9V output,there are no particular risks of an electrical nature. It is however necessary to specify that any short circuits caused during the exercise phase could produce damage to the PC, to the furnishings and in extreme cases even to burns, for this reason every time a circuit is assembled, or changes are made on it, it will be necessary to do so in the absence of power and at the end of the exercise it will be necessary to provide for the disconnection of the circuit by removing both the USB cable connecting to the PC and any batteries from the appropriate compartments or external power connectors. In addition, always for safety reasons, it is strongly recommended to carry out projects on insulating and heat-resistant carpets that can be purchased in any electronics store or even on specialized websites.

At the end of the exercises it is advisable to wash your hands, as the electronic components could have processing residues that could cause damage if ingested or if in contact with eyes, mouth, skin, etc. Although the individual projects have been tested and safe, those who decide to follow what is reported in this document, assume full responsibility for what could happen in the execution of the exercises provided for in the same. For younger children and / or the first experiences in the field of Electronics, it is advisable to perform the exercises with the help and in the presence of an adult.

Note sul Copyright

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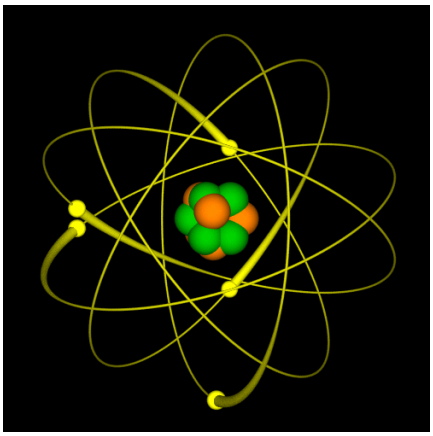
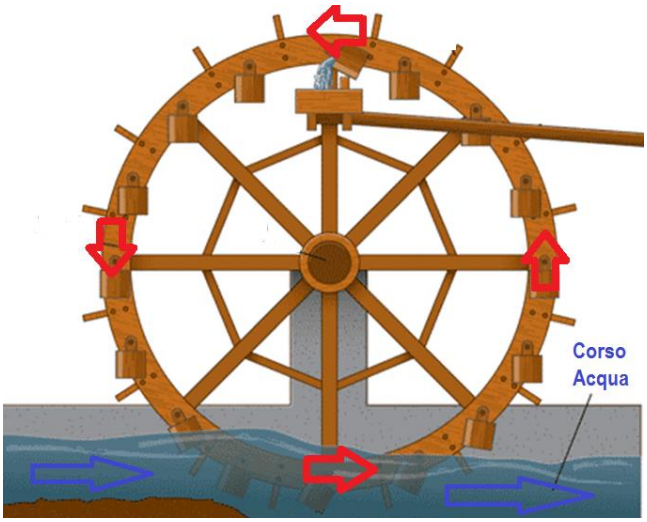
Roberto Francavilla

Current, Voltage and Electrical Resistance

Let's start with a bit of theory, but don't worry I won't bore you.

To give an intuitive explanation of what electric current and electrical voltage are and how it works, it is useful to think about water. In fact, the current flowing in the electrical wires is quite similar to a stream of water. The substantial difference between current and water is *that, while for water it is the molecules (of water) that flow in the pipes, in the electrical wires, it is the electrons (elements that make up the "atom"). Such an electron flow is calledor "electriccurrent".*





We can think of electrons as balls and just as water is able to operate water mills, electrons can also drive similar objects, the fate of electron mills. These mills, driven by electrons, can produce light, noise, sound or movement!

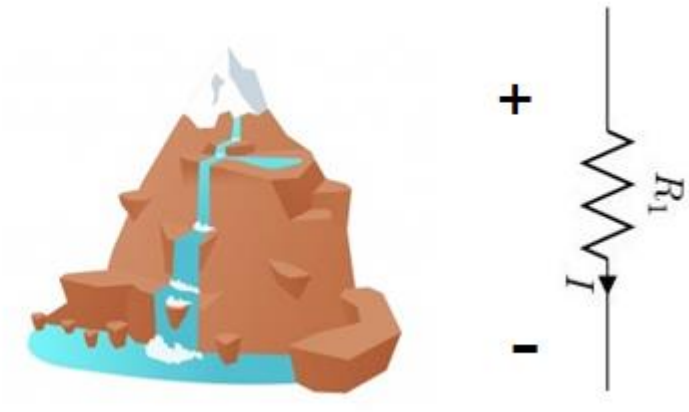
So: the current is made up of electrons that flow in a wire and can drive electrical components, which we can imagine as small mills. The electric current is measured in "A" that is in Ampere (it reads "amper" because it derives from the French).

Let's now make the analogy with water more specific, and think of a waterfall that derives from an artificial basin (that is, made by means of a man-made dam). In a waterfall the water descends from the highest point and falls to the lowest point (due to gravity), where it is collected, and *suppose there is a system of pumps that bringthe*no up into the artificial basin the water*just collected after falling from the waterfall. In this way the water is ready to make a new cycle of fall from the waterfall and ascent through pumps. The highest point of the waterfall is the one with a "higher potential" (conventionally it is indicated with the "+"), the lowest one is the one with "lower potential" (conventionally it is indicated with the "-"). So the water goes from + to the -, the same thing* ***conventionally*** does *the electric current, that is, it goes from the + (point with the highest potential) to the " – " (point with the lowest potential). This, in electrotechnical terms, is called potential difference (ddp),*or even electrical voltage and*is measured in "V" i.e. Volts.*

The water in its descent to the valley certainly meets rock, narrowing, becomes a river and finds loops ... these elements that oppose the intensity of the flow of water, in electrical engineering,

are called "resistances" and they oppose the flow of electric current. Resistance is measured in Ohms, or also denoted by "□".

Corrente Elettrica	**Ampere**	**A**
Tensione Elettrica	**Volt**	**V**
Resistenza Elettrica	**Ohm**	**Ω**



Ohm'slaw.

At this point we can already identify one of the first laws of electrical engineering, namely: with the same voltage (therefore the altitude jump of the water cascade), the higher the resistance (ie the more rocks and impediments to the flow of water) and the lower the electric current (ie there is a lower flow of water). This law of electrical engineering is called ***Ohm's law*** *and is represented as follows:*

V = R x I (cioè la tensione **V** è uguale alla **R**esistenza per la corrente **I**)

The inverse formulas are:

$$I = \frac{V}{R}$$

and

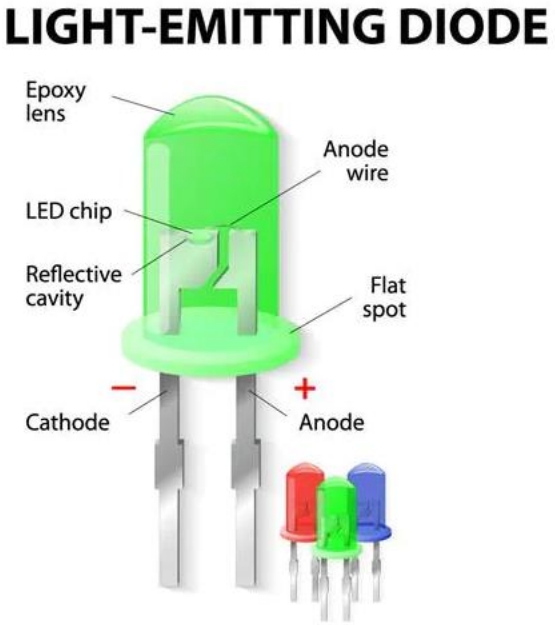
$$R = \frac{V}{I}$$

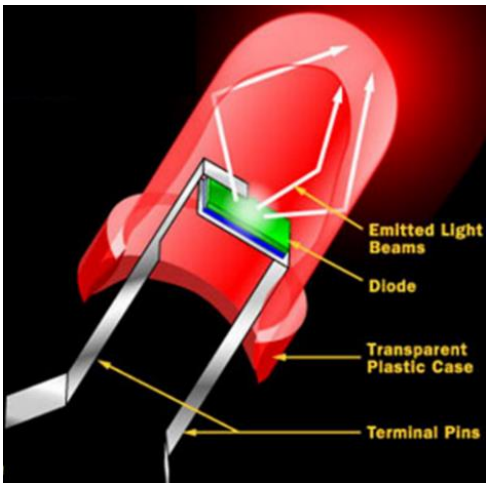
That thereis an LED.

Although the shape is very reminiscent of an incandescent bulb, its operation is completely different. In the incandescent bulb the current passes through a very thin filament of material with high electrical resistance and therefore becoming incandescent, because precisely the electrical resistance tries to prevent the passage ofcurrent, the incandescent generates light, but also so much heat that is *energy dispersed because* it is *not used* for the *purpose of better brightness.*

In an LED the current passes through a semiconductor (i.e. a conductor that can conduct current only in a predefined direction) and the material that makes up the semiconductor, crossed by the current, emits light (i.e. photons).
This method of producing light energy is much cheaper, in fact there is no waste of energy that turns into heat and the LED is also more reliable as a light source, because it is not subject to temperature changes that cause the breaking of incandescent filaments, as happens for normal light bulbs.

Remember that the LED is a semiconductor, so the polarity with which we feed it is important, the anode (ie the longest terminal) must be connected to the positive, otherwise it does not turn on and if a reverse voltage is applied to it (with exchanged poles), higher than the threshold allowed, we certainly burn the LED.
In reality, even by feeding the LED correctly you risk burning it, in fact you have to be careful not to exceed what is called "junction voltage", that's why in series to the LED in the previous project we put a resistance of 220 Ohms (later I will explain how to determine the correct value of the resistance as a function of the LEDs and the number of LEDs to be powered.

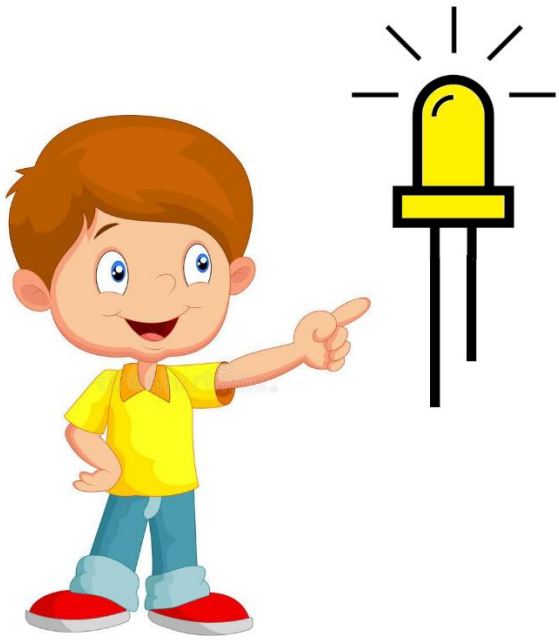




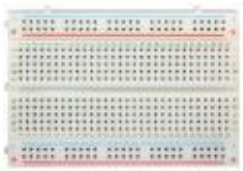
The LED, as you can see from the figures above, consists of two platelets between which there is the semiconductor that once excited (ie made to travel by an electric current) emits photons (ie light!). The platelets end with "terminals" one longer (the anode) and the other shorter (the cathode). So the positive voltage, the one indicated with the "+", must be connected to the anode, the negative one, indicated with the "-", must be connected to the cathode. The two plates, with the semiconductor, are then covered with a transparent plastic capsule in light that protects the components and directs the same light outwards.

Project 1 – *Turning on an LED*

The first project I want to introduce is the power supply of an LED.



For this project we need Arduino,the breadboard, an LED (of any color), a 220 Ohm resistance (the Ohm, also indicatedor with "□", is the unit of measurement of electrical resistance) and Dupont*jumper cables (male-male, that is, those that have the silver tip on both sides):*

			
Arduino Uno R3 or compatible	*Bread board*	*Resistance 220 Ohm*	*LED*
			
Dupont cables male - male	*USB connection cable*		

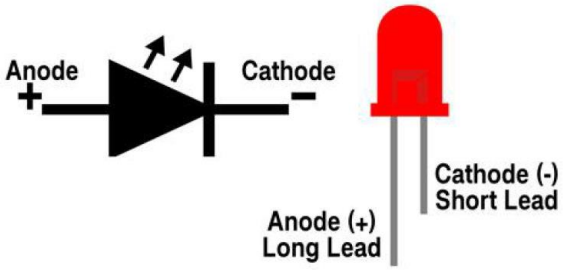
Be careful!

The 220 Ohm resistance is identified through the colored rings, in particular if the resistance has *5 colored rings, it* must have the rings so *colored: red-red-black-black-brown. If the resistance has 4 colored rings, then the colors of the rings must be: red-red-brown and then a silver or golden ring. In the next lesson we will learn how to read the values of the resistances through the use of the color table.*

Resistance to 5 colored rings

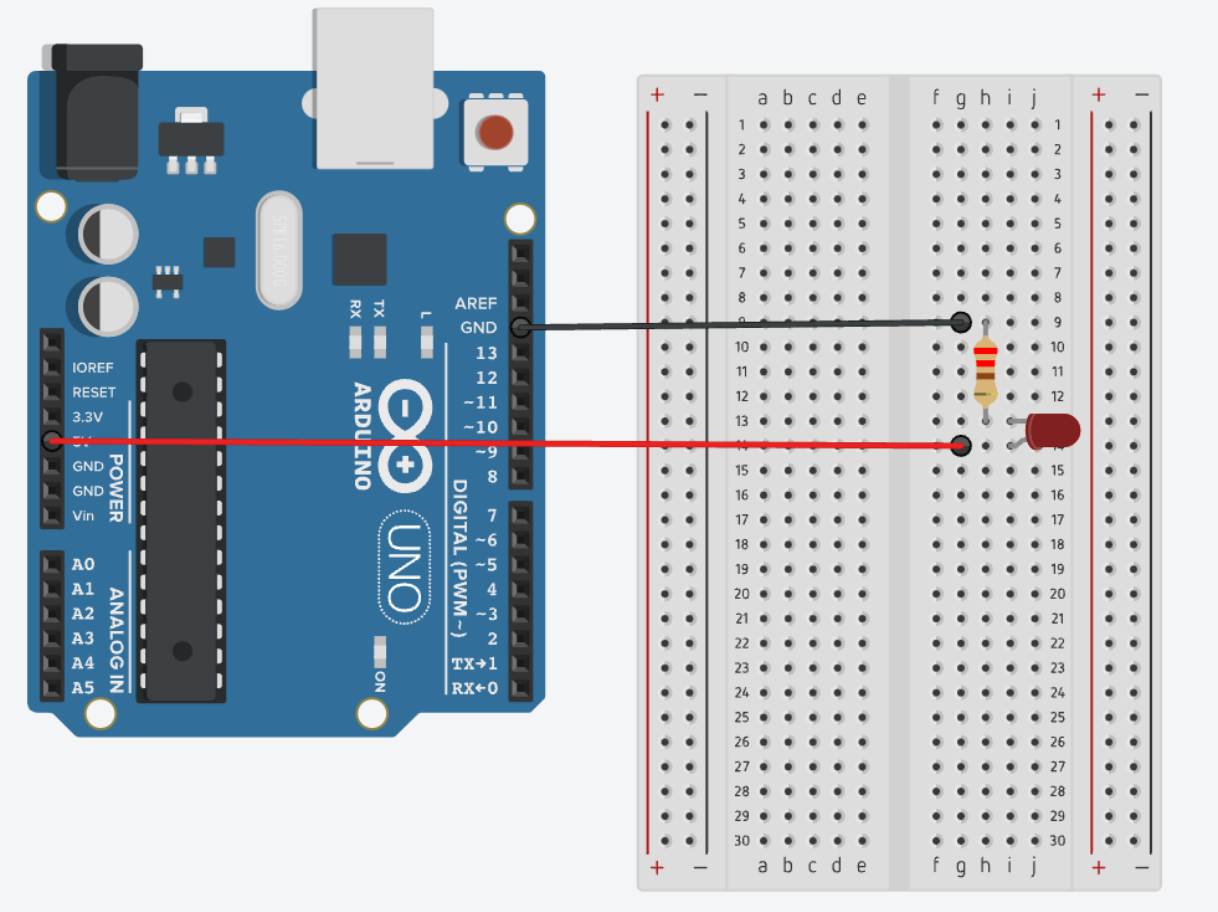
Resistance to 4 colored rings

For the LED, you need to pay attention to the end feet, one is longer and one is shorter:



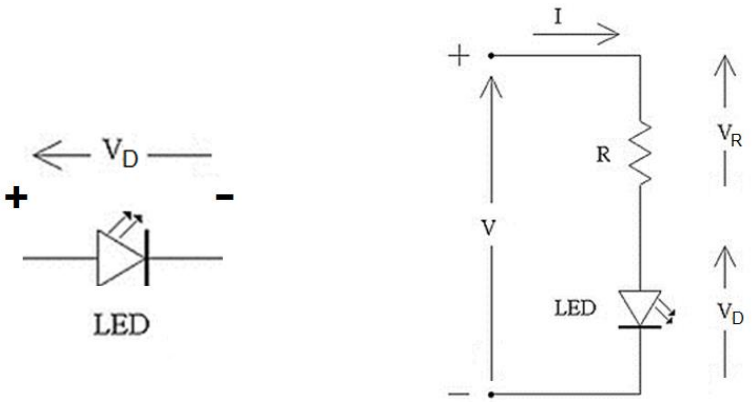
The longest terminal (anode), in the connection diagrams is represented "bent"

The connections to be made are:



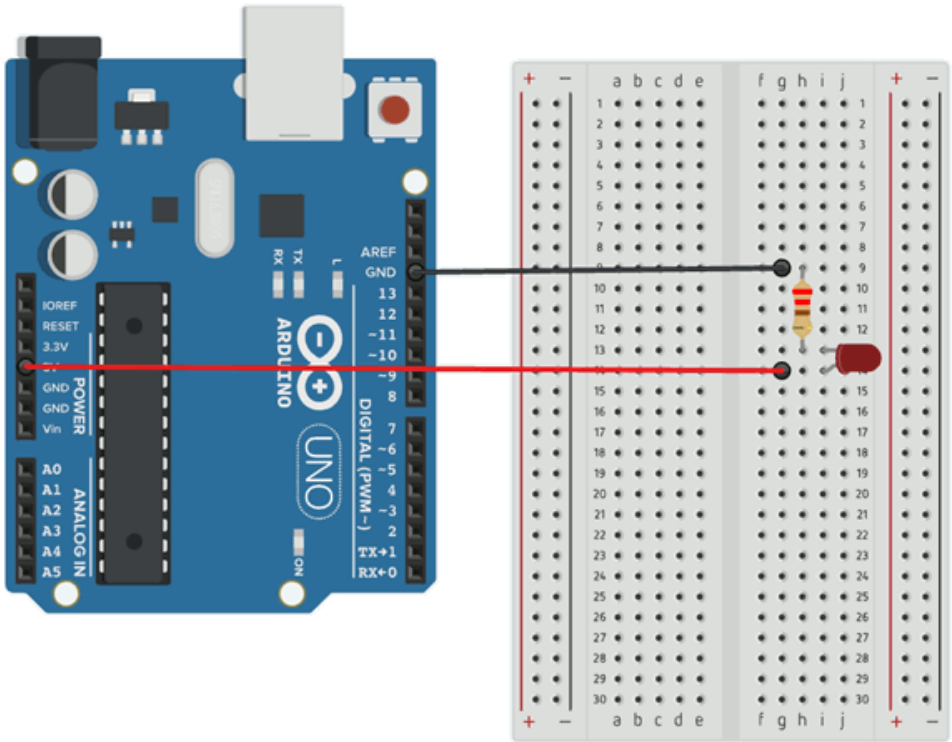
If everything has been connected well, when you insert one side of the USB cable *to the* USB port *of Arduino and the other side of the cable to the USB port of the PC, the LED should turn on, because it is powered.*

At the bottom there is the electrical symbol of the LED and the classic electrical connection circuit by resistance:



In the electrical circuit the resistance can be put before or after the LED, it does not matter because the two components are crossed by the same current "I" (they belong to the same electrical branch), the voltage drop on the resistance is identical. This mode of connection of the resistance to the LED is said, in electrotechnical terms, "in series", the meaning will be seen better later.

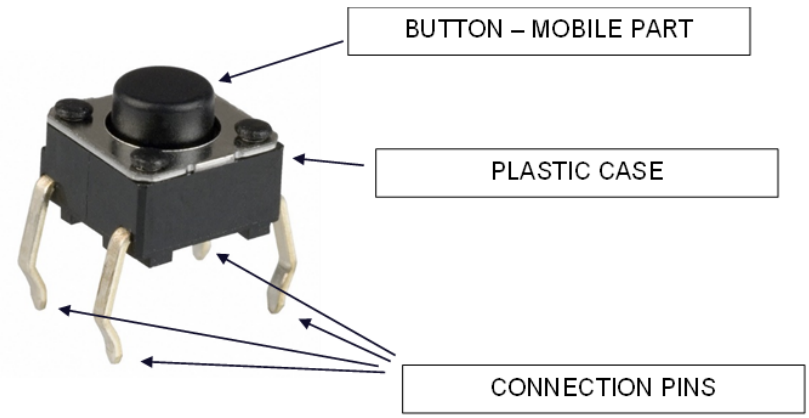
So, with this project, you are starting to have the first contacts with the world of electrical engineering and electronics, but let's see better what we have done.
In essence, to a passive element, such as the LED, ***[passive element*** *means that to work it needs electricity], we have applied an electrical voltage. The electric voltage is also called FEM (electromotive force), in fact it indicates how strongly we push the electrons to come out of their orbits and create that flow called electric current. The electric current, thus generated, through the semiconductor material that makes up the LED, transfers this energy to the same material that transforms it into "photons", that is, into light.*
So Arduino worked as a power supply, that is, energy supplier, the electrical wires made sure that this energy was transferred to what is called the user, that is, the LED



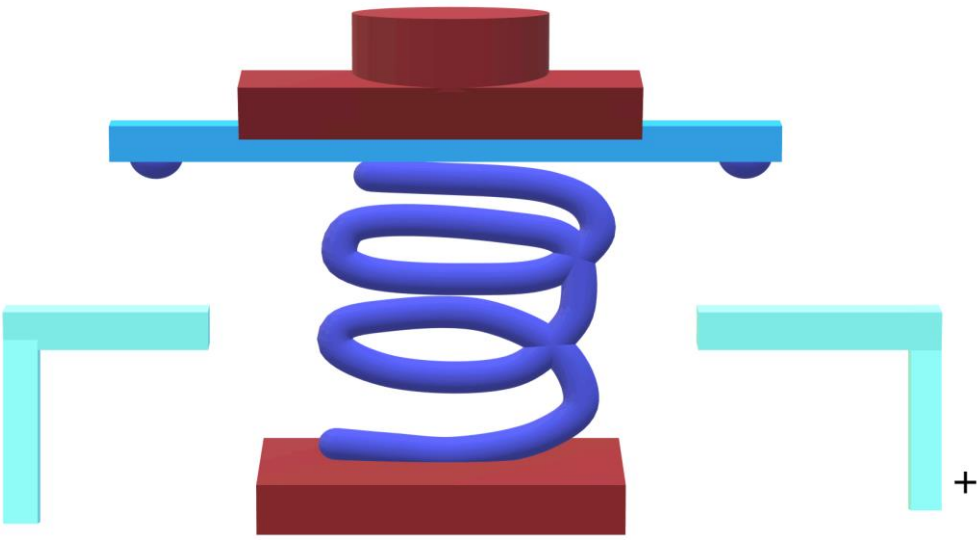
A part of this energy is dissipated in the resistance in series to the LED in the form of heat, this to reduce the amount *of energy otherwise it would be too high* and you would risk burning *the LED.*
[For the Video-project click ***here****]*

The Button: how it works and how to use it

Before moving on to the next project it is good to see how it works and how to use a very importantcomponent: the button.

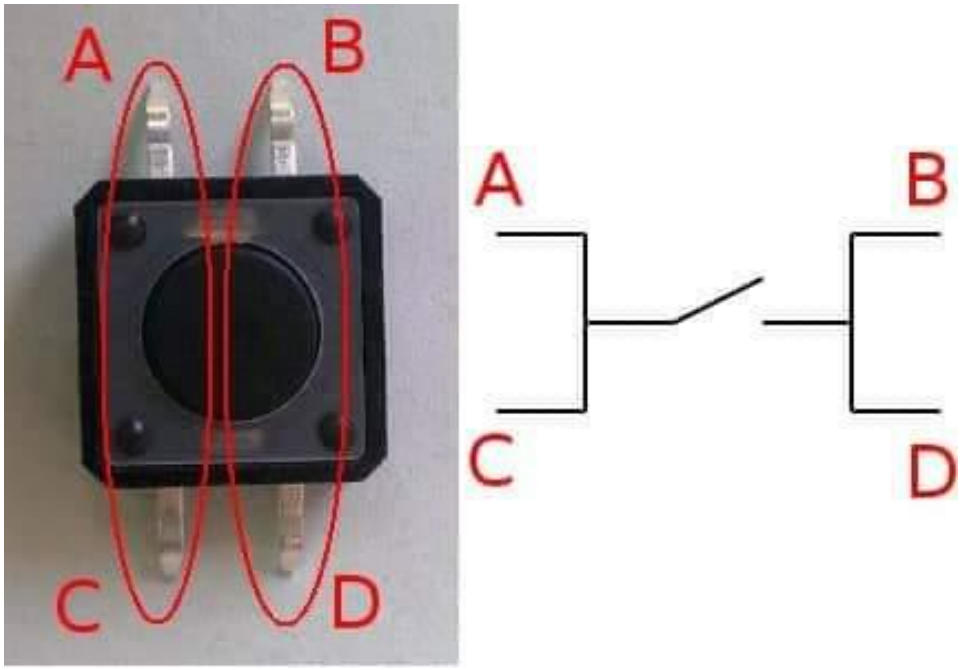


The principle of operation of a button is very *simple, and the animated gif* below *visually summarizes such operation.*
The button consists of a moving and a fixed part, the moving part consists of a metal blade fixed to a plastic support that is the button of the button that will *be pressed, below this blade there is a spring that holds the moving part pushed upwards.*
The fixed part instead consists of two separate blades that continue forming the feet of the button. The whole thing is enclosed in a plastic case.



When the button is pressed, the spring compresses and the moving blade puts the two fixed blades in contact. If an electrical voltage is applied to one of the two blades (indicated by the

"+") this voltage is also transferred to the other blade, so we have what in electrotechnical jargon is called "closing an electricalcircuit".
The buttons that we use are characterized by having 4 feet (or also called terminals) of which they are two by two connected metal to *each other.*

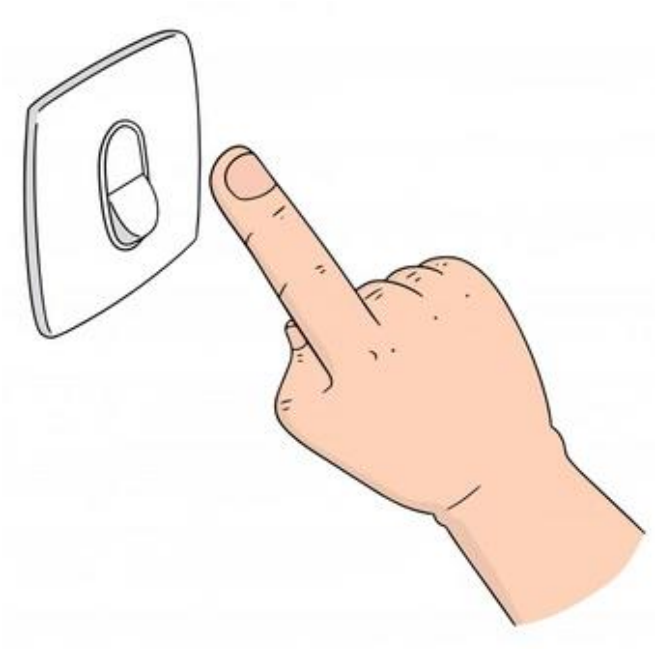


So connecting pin A or C is the same thing, as well as foot B with respect to D. The feet that are metal separated, as the figure above also shows, are the ones closest to each other, that is, foot A is separated from B, as C is separated from D.
Another type ofpush button,*but whose functionality is identical to the one seen above, is the two-terminal button:*

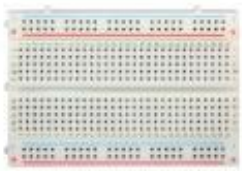
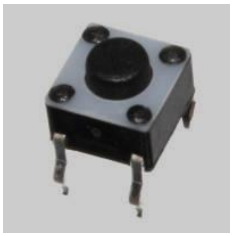
However, now we perform a project that better than anything else shows us how the button works.

Project 2 – *The use of a button for theaccesion of an LED*

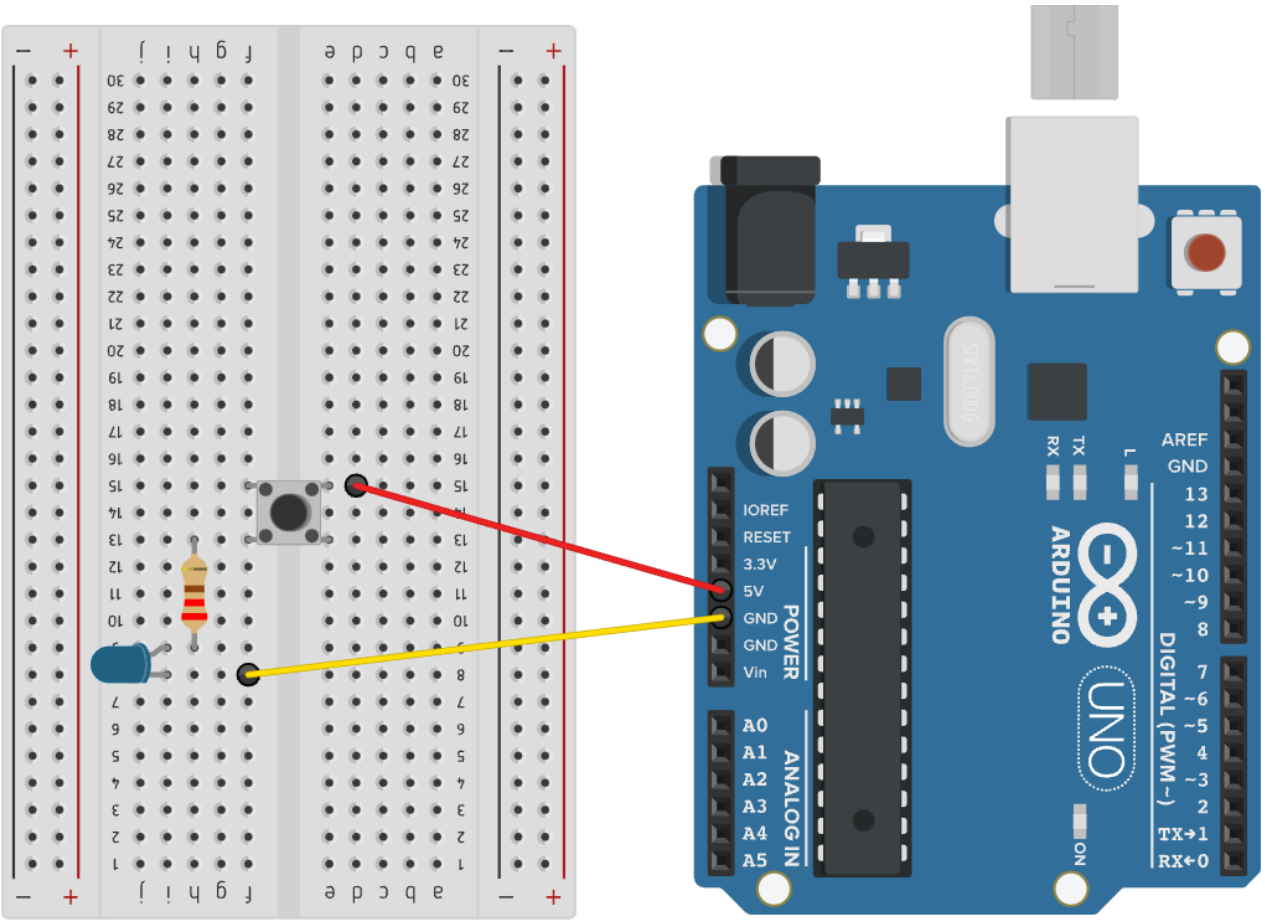
In this project I want to show you how to power an LED through the use of a Button that will allow us to turn the LED on and off to our liking.



*The material needed for this project is identical to the previous one, but in addition we need a micro*button.

			
Arduino Uno R3 or compatible	*Bread board*	*Resistance 220 Ohm*	*LED*
			
Dupont cables male - male	*USB connection cable*	*Button*	

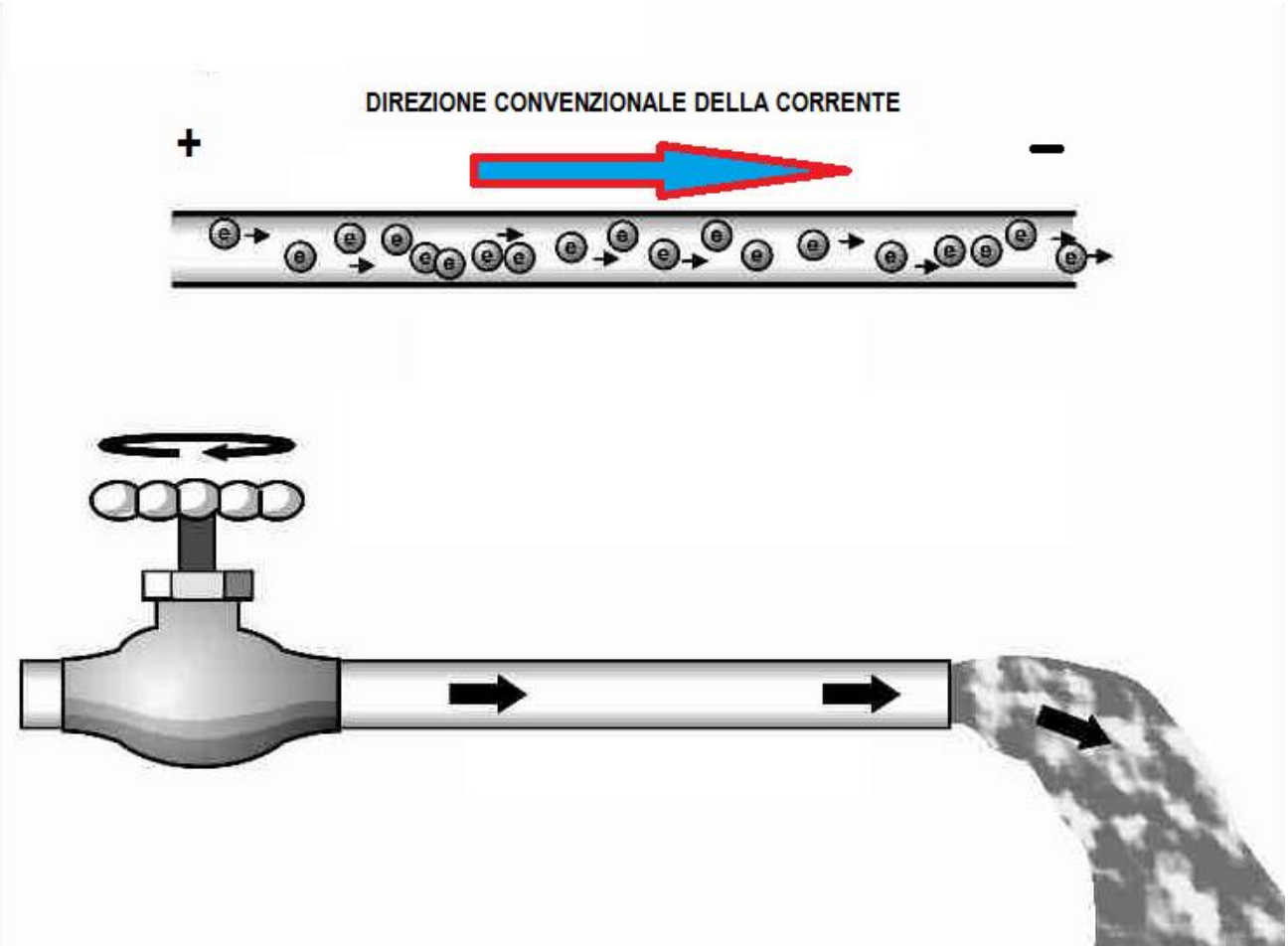
We proceed with the connections as per the diagram below keeping the USB cable disconnected from Arduino. In particular, attention must be paid to the longest terminal of the LED that must be connected in series to the *220 Ohm resistance. The resistance in turn is in series at the terminal of the button. The red dupont* cable *that carries the 5V, must be connected* to *the other terminal* of the button *and the* yellow *dupont cable* must be connected to the Arduino *GND and to the LED cathode.*



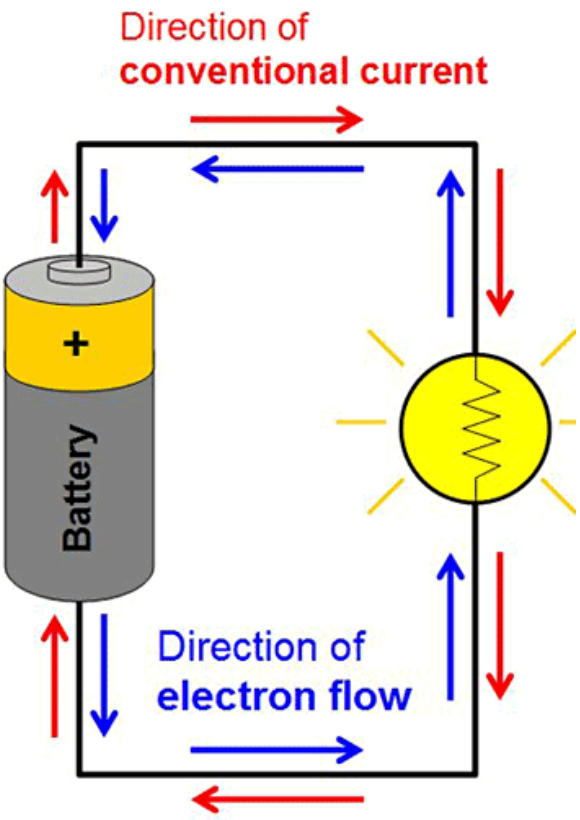
If everything has been connected well, when you insert the cable to the USB port of the PC, the LED should be turned off and pressing the button turns on, because only by pressing the button the LED is powered, that is, the button closes the circuit and gives electrical continuity.
*[For the Video-project click **here**]*

Now let's try to understand what we have done.
Itremindsus ofthe flow of water from a waterfall or a river.
Withthe insertion of the button we have done nothing but put a dam in the way, that is, an obstacle that cannot be overcome by water and only when the pipes are opened, the water flows through the waterfall. Then the button stops the current flow with a circuit break, only when it is pressed the circuit is reset and the current can flow into it.

Another example to understand the function of the button, is to imagine having a tap, only when you open the tap you create the difference in pressure such as to let out the water (and then circulate the current).



IMPORTANT*: I would like to point out that I used the term* conventional direction of the ***current***, this *is because at the time of the studies of this phenomenon it was thought that it* was the positive charges to move from + to the - *(because attracted by the opposite sign), in reality later it was discovered that it is the electrons that generate the flow of current and since they have a negative charge, they are attracted to the positive pole, so the current actually goes from the negative pole to the positive pole, but conventionally the convention* that *the* current goes from + to *the* -has continued to be*maintained.*



Curiosityà: A bit of scientific history

In 1799,the Italian scientist Alessandro ***Volta*** *(hence the name Volt to the*unit of measurement*of voltage),*for years a scholar of the then mysterious phenomena of*electromagnetism, managed to build a first, rudimentary but effective electric battery.*

Inthe early 1800s ***Charles Augustin de Coulomb*** *discovered thatelectrons, sub-atomic particles with a negative electric charge, were naturally attracted to areas where electric charges are of lesser intensity, and therefore can be seen as 'gaps', with positive valence.*

In the mid-1800s, around 1860, the unit of measurement of electric current was named after the physicist *French* ***André-Marie Ampère,****one of the leading scholars of electromagnetism.*

TheOhm (symbol: Ω) is the unit of measurement of electrical resistance, its name *derivesfrom that of the German physicist* Georg Simon ***Ohm*** *discoverer of the homonymous law of Ohm. In fact, in 1827, his main discovery was that the electric current passing through a conductor is directly proportional to the voltage applied to its heads. Of course I mentioned only a few physicists, actually between the beginning and the end of the 1800s, there were 100 years of exceptional scientific discoveries in the field of electrical engineering, electronics and electromagnetism.*

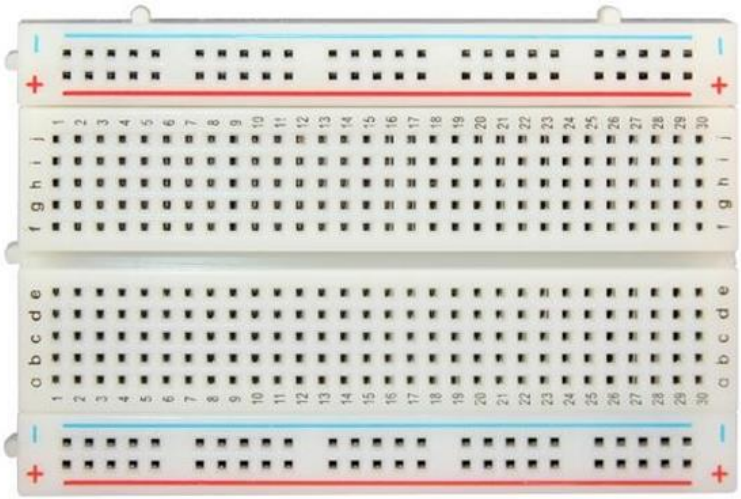
In 1889 the ***International System***was born in Paris, after the agreement of several states,*that is, they were attributed to fundamental physical quantities such as: length, mass and time the units of measurements "****meter [m]****", "****kilogram [kg]****" and "****second [s]****", then over time were added:* ***degrees kelvin [K]*** *for temperature,* ***amperes [A]*** *for the current,* ***candle [cd]*** *for brightness and* mole ***[mol]*** *for the amount of substance. These are the units of measurement that all scientists use to exchange information and scientific research in the world.*

That thereis a Breadboard.

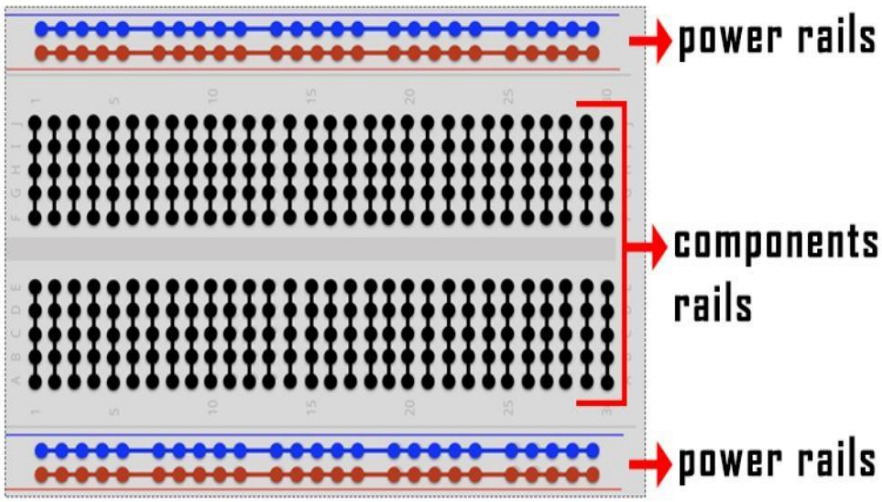
The Breadboard is for the maker like the blank canvas for a painter

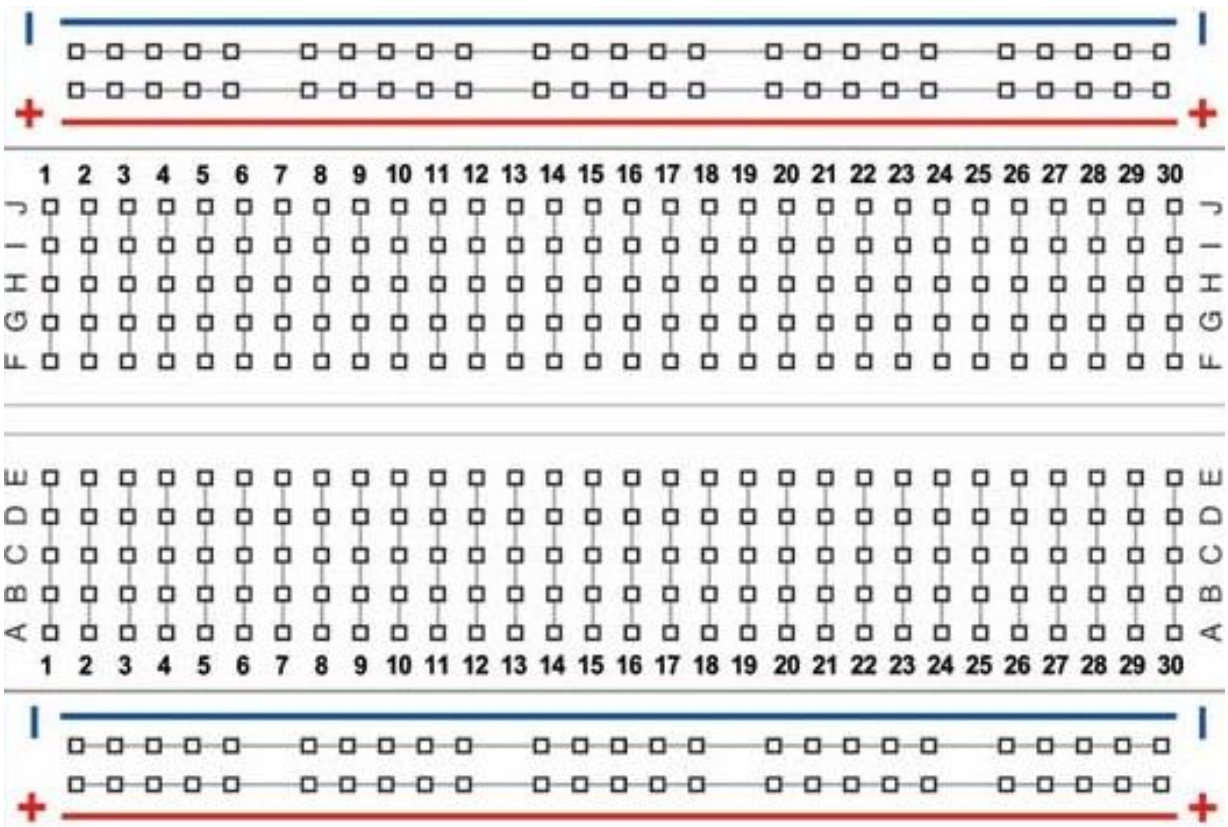
[Roberto Francavilla]

The Breadboard is a base in insulating material with many smallholes. There are different sizes on the *market, the most common is the 400-hole one. The various small holes are electrically connected to each other in a particular way that I show you later. In essence, in these holes the terminals of the various electronic components are inserted and without welding, therefore with considerable savings in time and above all in the reuse of the components, it allows the connection between the various electronic components.*



In fact, the Breadboard is used to experiment with the functionality of the circuits that the makers develop with the possibility of reusing the components and with the speed to modify and try different circuit solutions. As you can see from the photo,land*metal strips arranged horizontally and vertically allow connections between the holes of the same horizontal and vertical row.*





The columns of the Breadboard are identified by numbers, the rows by capital letters.
The only ***rows*** *whose holes are all electrically connected to each other are those identified with the "+" and the "-". The holes of the other rows (A, B, C, D, E, F, G, H, J), as seen from the photo above* and from the lines of *the figure*, are not connected to each*other horizontally,but they are vertically, that is, in* ***column****. This means that inserting a foot in column 6 to any line of the group between A and E, is the same thing. The Breadboard, as you can always see from the figure, is divided into two parts isolated from each other.*

Project 3 – *Hello World*

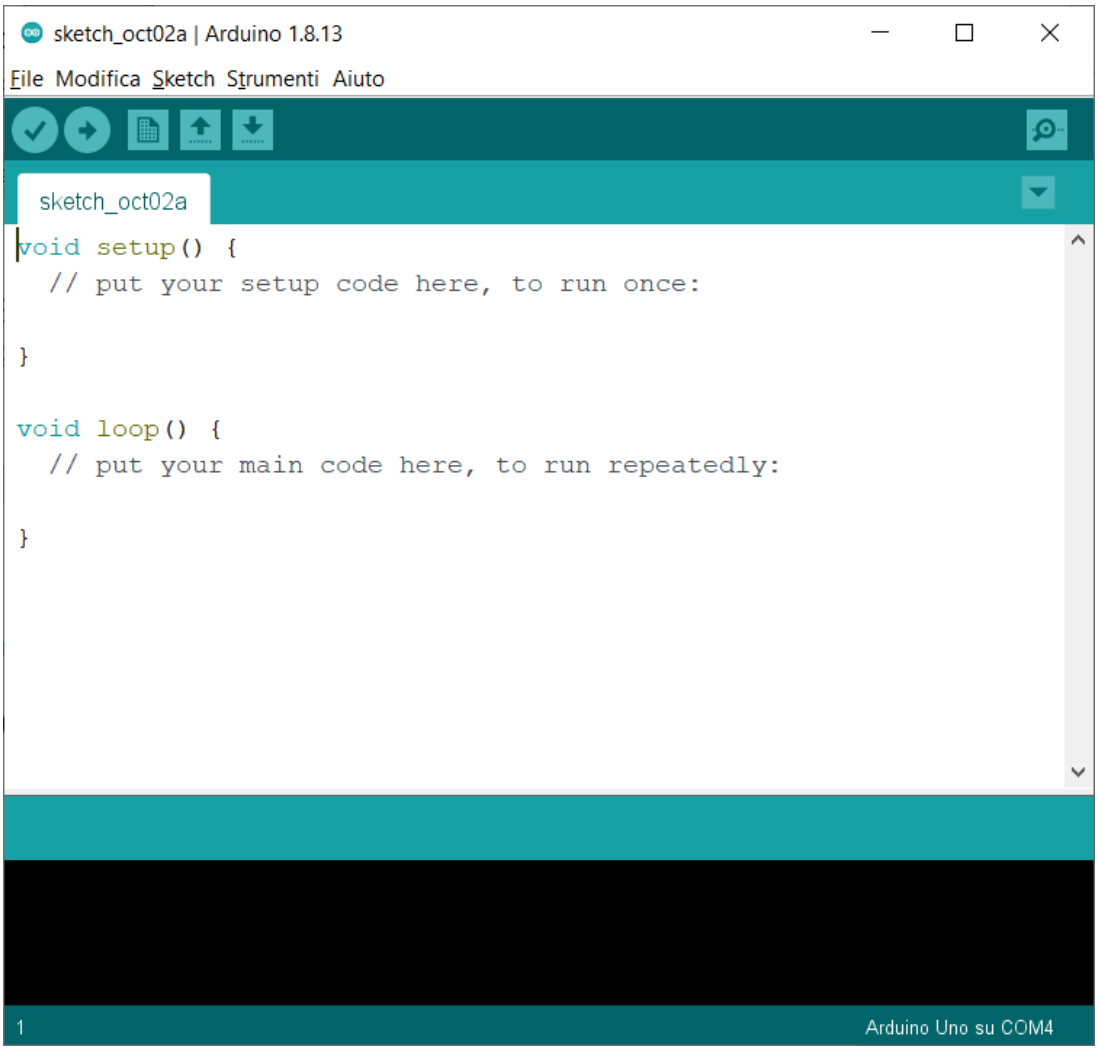
With this project we begin to use Arduino in its true *functionality, in fact in projects 1 and 2* our *board for Maker* has *been used* as a simple *battery (power supply), now la* we will use for *what*it *is, or* a development board *with* a powerful and *flexible microcontroller.*

For the project avremo only need an Arduino development board and a USB *cable. This projectis not only a communication test between our Arduino board and thePC, but also a basic project in the Arduino world* that introduces *programming.*

			
Arduino Uno R3 or compatible	*USB connection cable*		

And as usual, when you start learning a new programming language, one of the first things to learn and have the phrase "Hello Word" written to our system that we are programming.
Then we connect our development board to the PC via the USB cable and launch the ArduinoIDE application *by clicking twice on the relative icon.*

A blank window opens, or you need to open a new empty one:

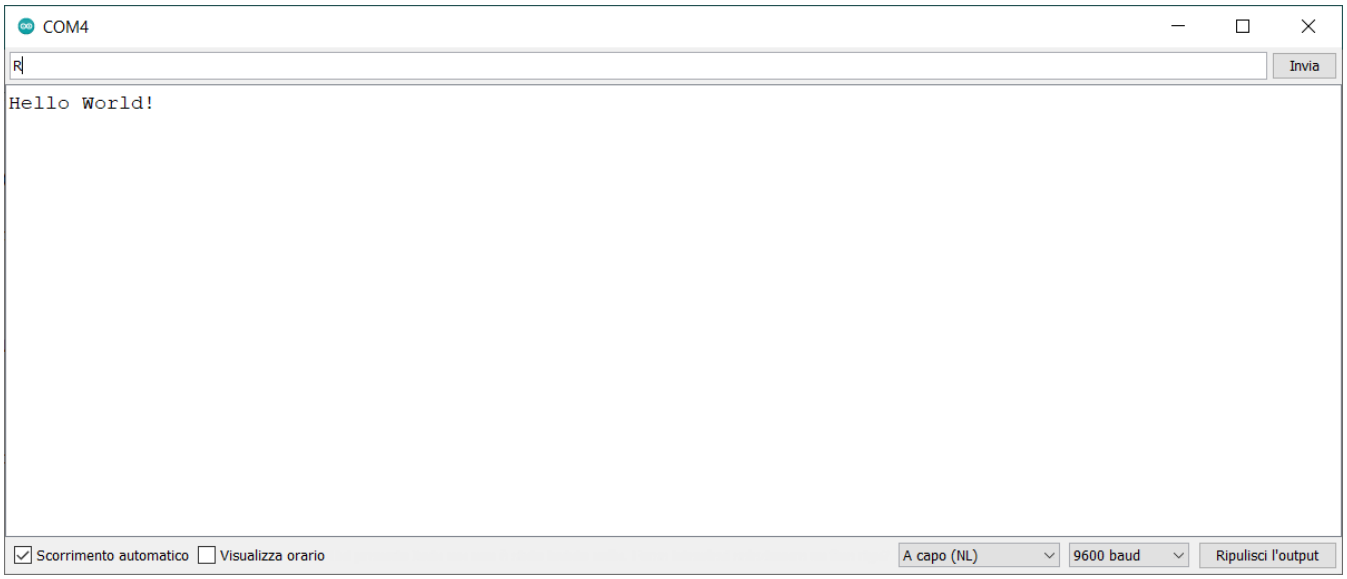


Typeiamo in the *sketch window below:*

```
/*
Be Maker School -  STEM -  Project 3  -  Hello World
*/
int val;//we define the variable named "val"
void setup()
{
Serial.begin(9600);// We initialize the port with a baud rate of 9600
}
void loop()
{
val = Serial.read();// Reads what is entered in the bar as input to the Serial Monitor and
                                assigns it to the variable val.
if(val=='R')// Check if what has been entered is equal to the letter "R"
  {// if it is "R",
Serial.println ("Hello World!");/ / Show the string message "Hello World!"
}}
```

*Once the sketch has been written, first proceed to click onthe "V" (check mark), if there are no errors**, then load it *on Arduino* by *clicking on "->" and finally, once loaded click on the lens (top right).*

The Serial Monitor window appears:



Every time we type the *R (capital letter) and then on Send (or Send), on the Serial Monitor comes out the inscription: Hello World ! .*

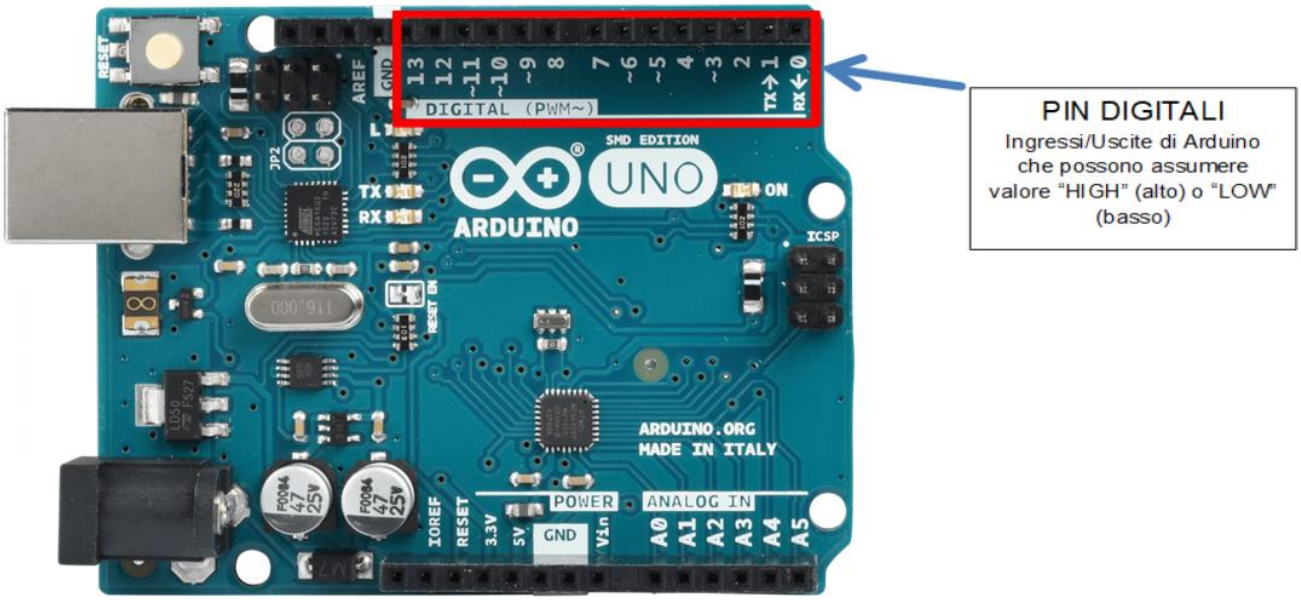
** In the event that clicking on the check mark should result in an error, then the possible causes* can *be three:*

1) *Incorrect typing of the sketch, so double check the individual lines paying attention to the ";" at the end of the instructions or the double lines for the comments... however, we will talk about this abundantly later.*
2) *Incorrect configuration of the serial port on the PC, in this regard I invite you to see the procedure provided in the initial activities of the Course*
3) *Incorrect installation of the driver of the development board, in fact some compatible Arduino install microcontrollers that require special drivers to be installed on your PC to be* seen from the serial *port. Also for this problem see the procedure provided in the initial activities of the Course.*

*[For the Video-project click **here**]*

Arduino's digital PINs

Before proceeding with the next project it is useful to know what digital PINs are and how they work on our development board. TheArduino board has 14 digital PINs.

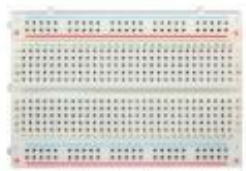


Digital PINs are particular PINs that can work as an input for Arduino or even as an output (the same PIN cannot work simultaneously as input and output) and *is characterized by the fact that it can only take two values: High – High state or 5 V and Low – Low state that is 0 V. Some digital PINs (to be exact 6) are indicated with a wave " **\u2012** ", these digital PINs are characterized by the fact that they can produce a PWM-type signal, but we will talk about this later.*

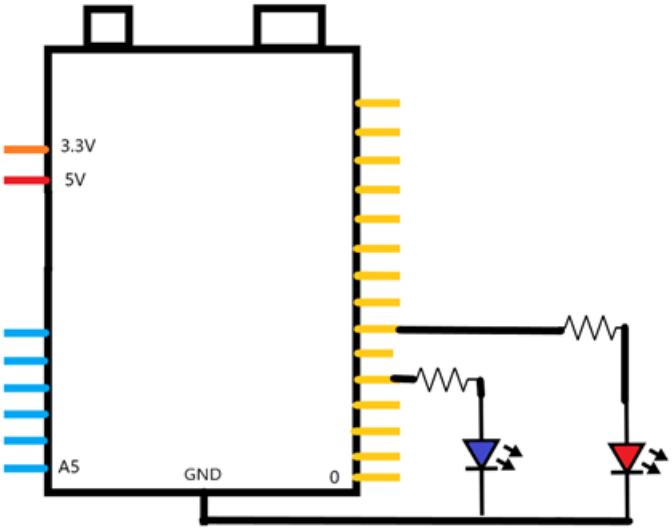
In the next project we begin to see the use of Digital *PINs .*

Project 4 – *Police Car with flashing light*

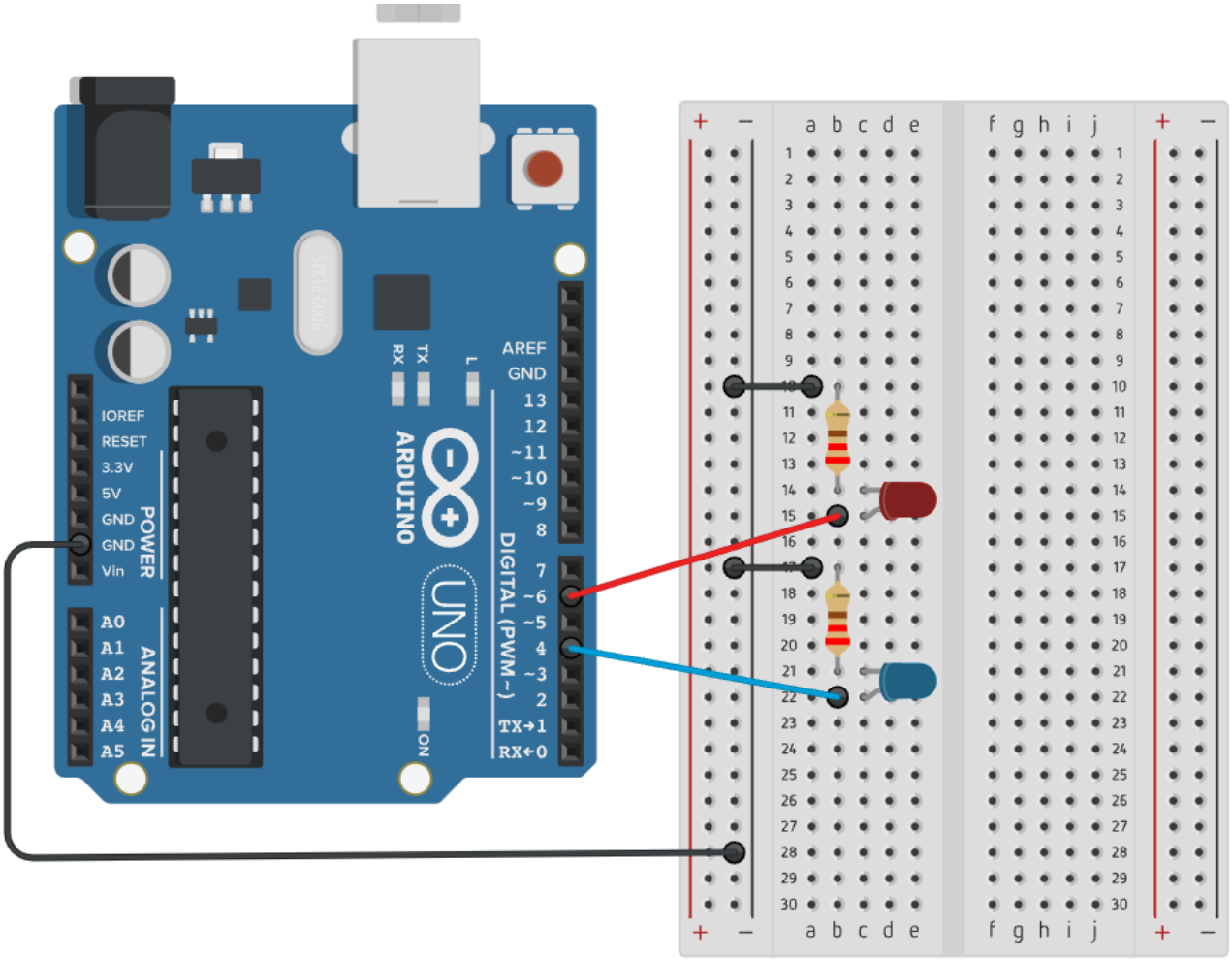
This is a simple project that shows the use of Arduino digitalPINs.

			
Arduino Uno R3 or compatible	*Bread board*	*2 x Resistance 220 Ohm*	*Red LED*
			
Blue LED	*USB connection cable*	*Dupont cables male - male*	*Printed cardboard*

With this project we also learn the use of wiring diagrams and symbols to be used to represent the various components. The wiring diagram to be made is as follows:

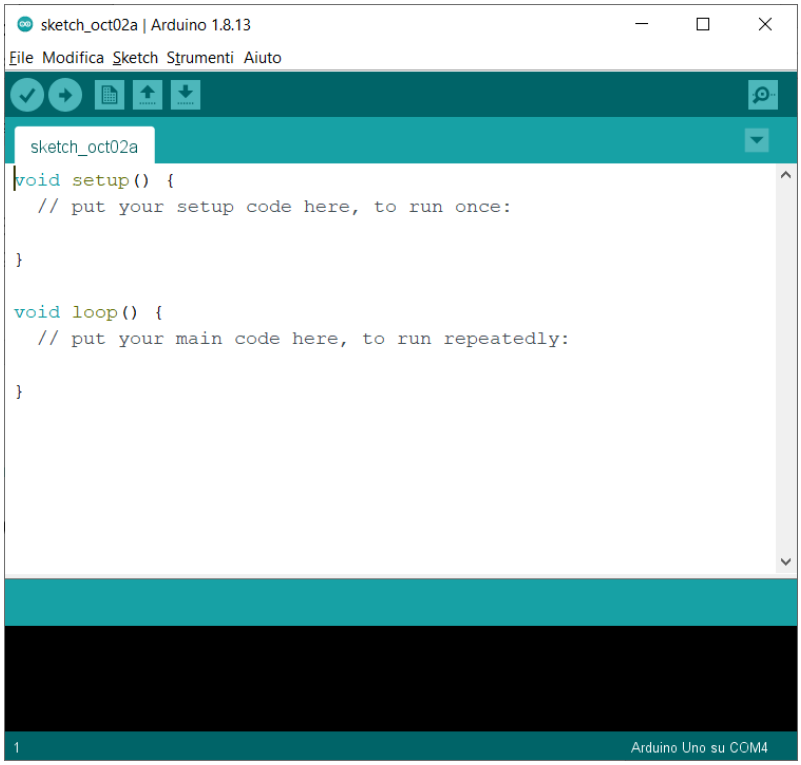


For connections instead refer to the assembly diagram below:



After the links we move on to write the sketch.
Connect Arduino to the PC via the USB cable and launch the Arduino IDE application by clicking twice on the relevant icon.

A blank window opens, or you need to open a new empty one:



Type the sketch below:

```
/*
Be Maker School - STEM - Project 4 - Police Cars
*/
void setup()
{
  pinMode(4, OUTPUT); we declare the digital PIN 4 outgoing
  pinMode(6, OUTPUT); we declare the digital PIN 6 outgoing
}

void loop()
{
  digitalWrite(4, HIGH);  We place the PIN 4 in a high state = at 5V i.e. on
  digitalWrite(6, LOW);   We put the PIN 6 in a low state = at 0V i.e. off
  delay(1000); we wait for 1000 milliseconds or 1 second
  digitalWrite(4, LOW);   We put the PIN 4 in a low state = at 0V i.e. off
  digitalWrite(6, HIGH);  We place the PIN 6 in high state = at 5V ie on
  delay(1000); we wait for 1000 milliseconds or 1 second
}
```

Once you have written the code launch the verification precompilation (check mark), it will ask you to save the sketch (you can change its name) and then click on the arrow for loading:

The result will be that the two LEDs of red and blue color, alternately, will turn on *and off* after every *second.*
If you place the police car, previously printed and cropped, in such a way that the two LEDs come out of the top flashing light of the car, drilling two holes at a suitable distance for how the LEDs are positioned, you will get a nice effect.
*[For the Video-project click **here**]*

(print and crop)