LECTURE 3
Arduino Fundamentals & Electronics

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Korea Advanced Institute of Science and Technology (KAIST)

Syllabus:

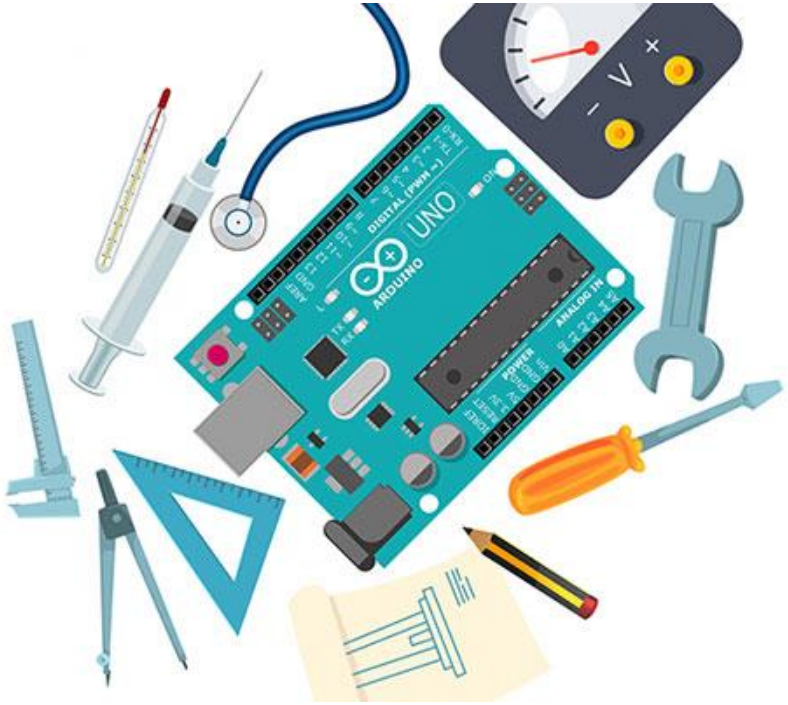
Week	Date& Time*	Content
1		No Class (Course Add/Drop Period)
2	March 6 (Mon) 20-22	Orientation and Course Overview
3	March 13 (Mon) 20-22	Sensor Fundamentals
4	March 20 (Mon) 20-22	Arduino Fundamentals
5	March 27 (Mon) 20-22	Arduino Programming and Applications
6	April 3 (Mon) 20-22	Force Sensor and Application: Control Multiple LEDs
7	April 10 (Mon) 20-22	Light Sensor and Application: Solar Tracker
8	April 17	No Class (Midterm)
9	April 24 (Mon) 20-22	Humidity and Temperature Sensor and Application: Temperature Controlled Fan
10	May 1 (Mon) 20-22	Gas Sensor and Application: Smoke Detector
11	May 8 (Mon) 20-22	Sound Sensor and Application: Control LED by Clapping
12	May 15 (Mon) 20-22	Accelerometer Sensor and Application: Ping Pong Game
13	May 22 (Mon) 20-22	Ultrasonic Sensor and Application: Flappy Bird Game
14	May 29 (Mon) 20-22	Course Wrap-up
15	June 5	No Class (Final)
16	June 12	No Class (Final)

What is Arduino?

https://robu.in/

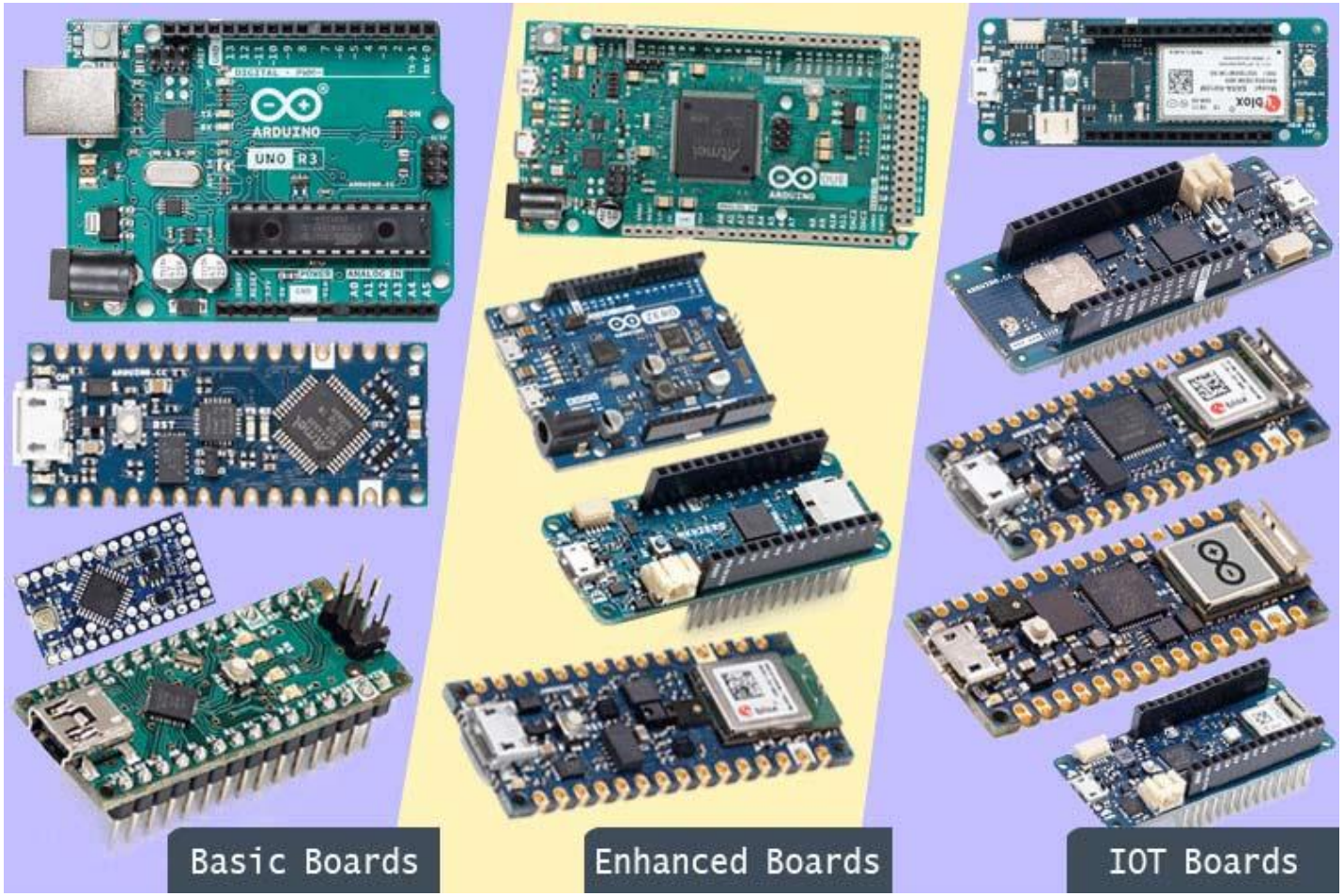
What is Arduino?

- Arduino is an **open-source** platform used for building electronics projects.
- Arduino consists of both a **physical programmable circuit board** (often referred to as a microcontroller) and **a piece of software**, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.
- Arduino is designed to make electronics more accessible to engineers, DIY people, artists, designers, hobbyists, and anyone interested in creating interactive objects or environments.
- Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators.
- The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing).

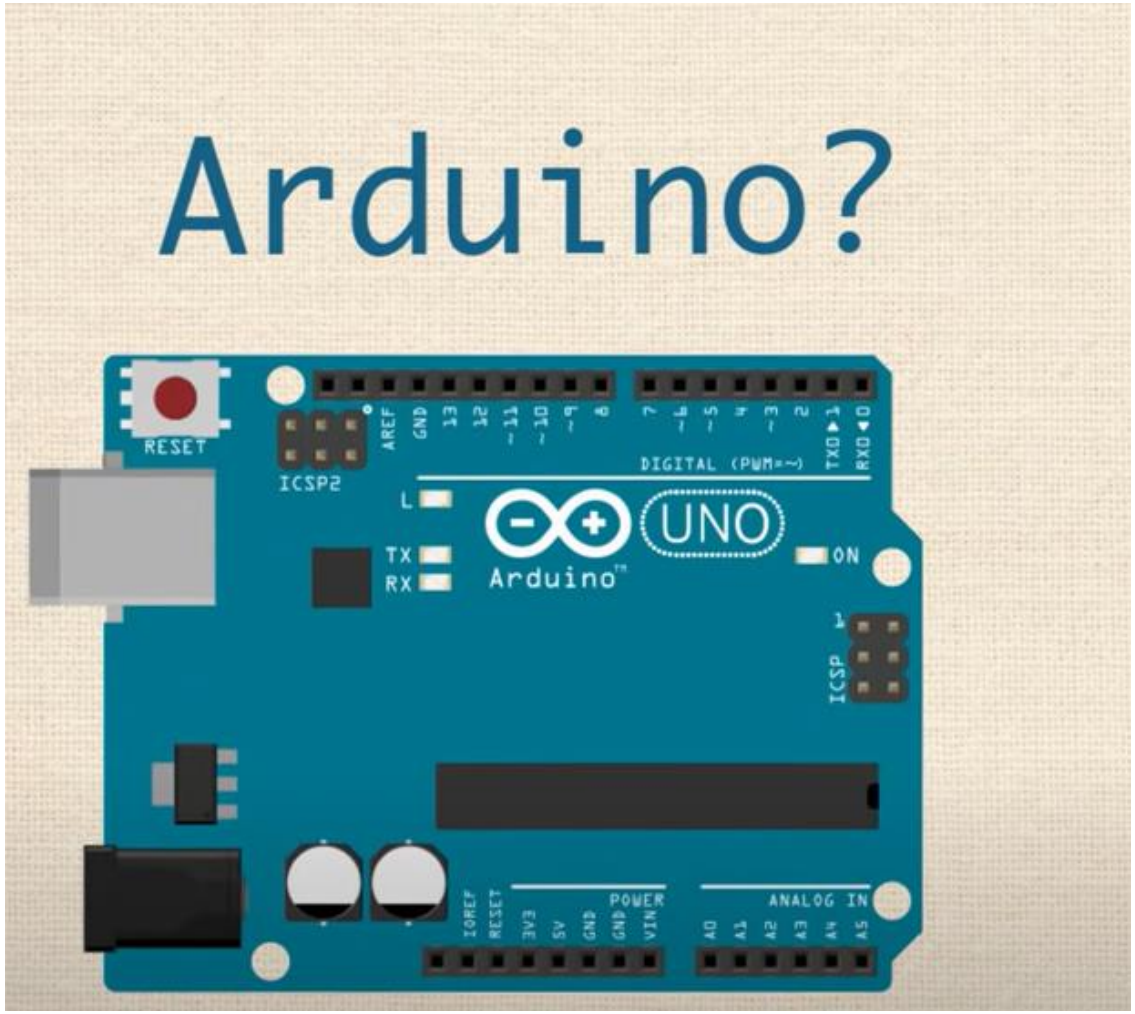


https://electropeak.com/

Arduino boards:



https://circuitdigest.com/



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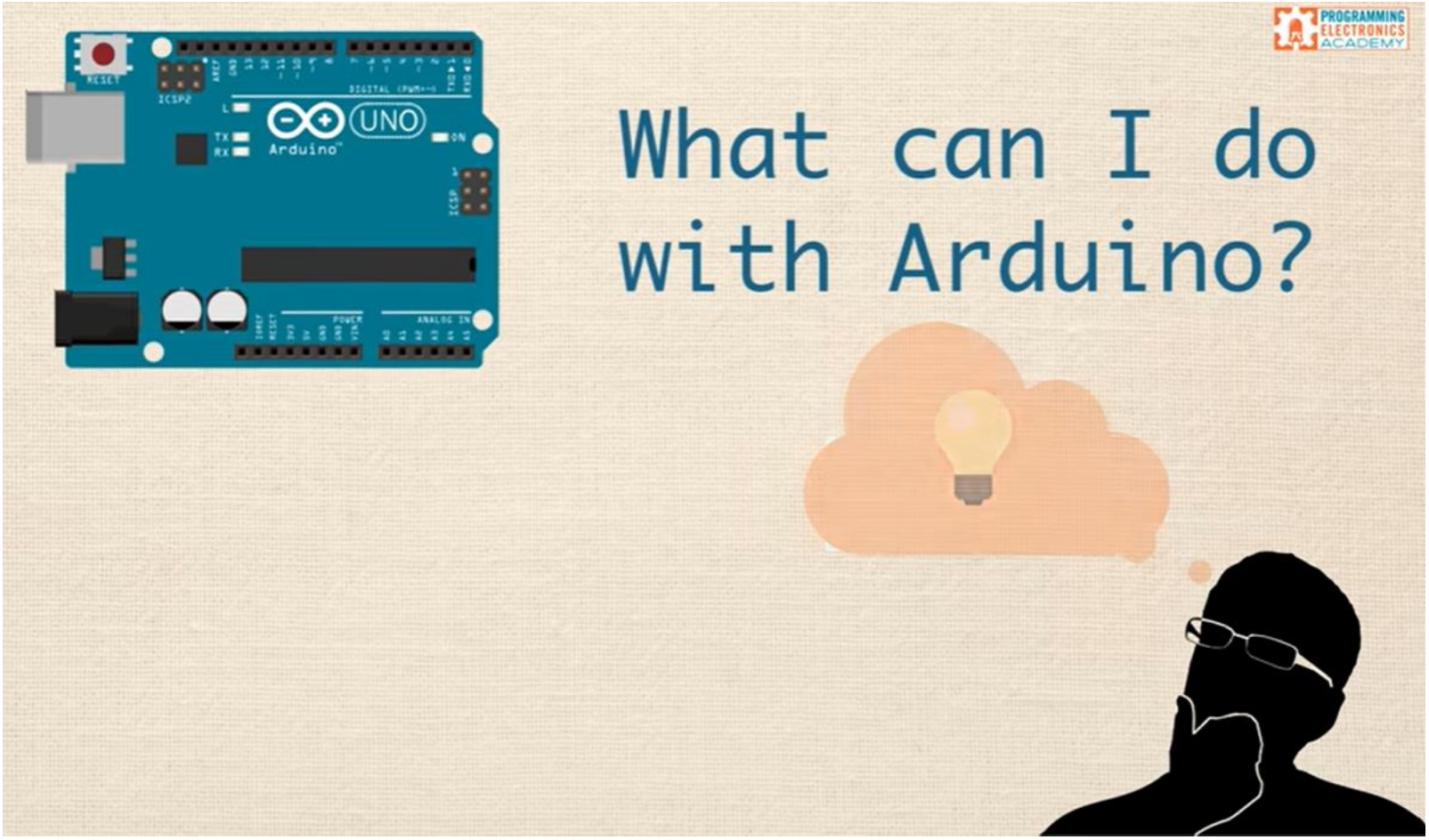

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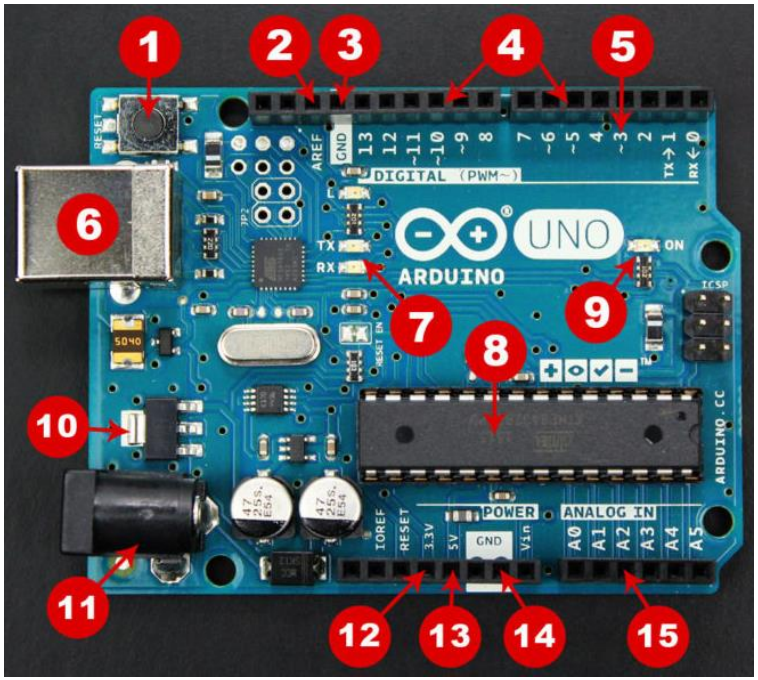
Arduino Uno:



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

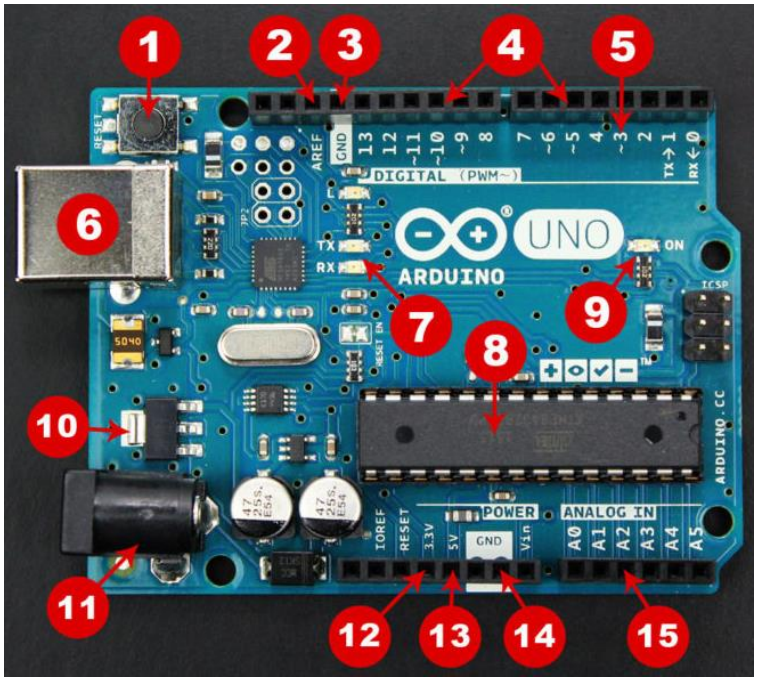
5.PWM – The pins marked with the (~) symbol can simulate analog output

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

Arduino Uno:



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

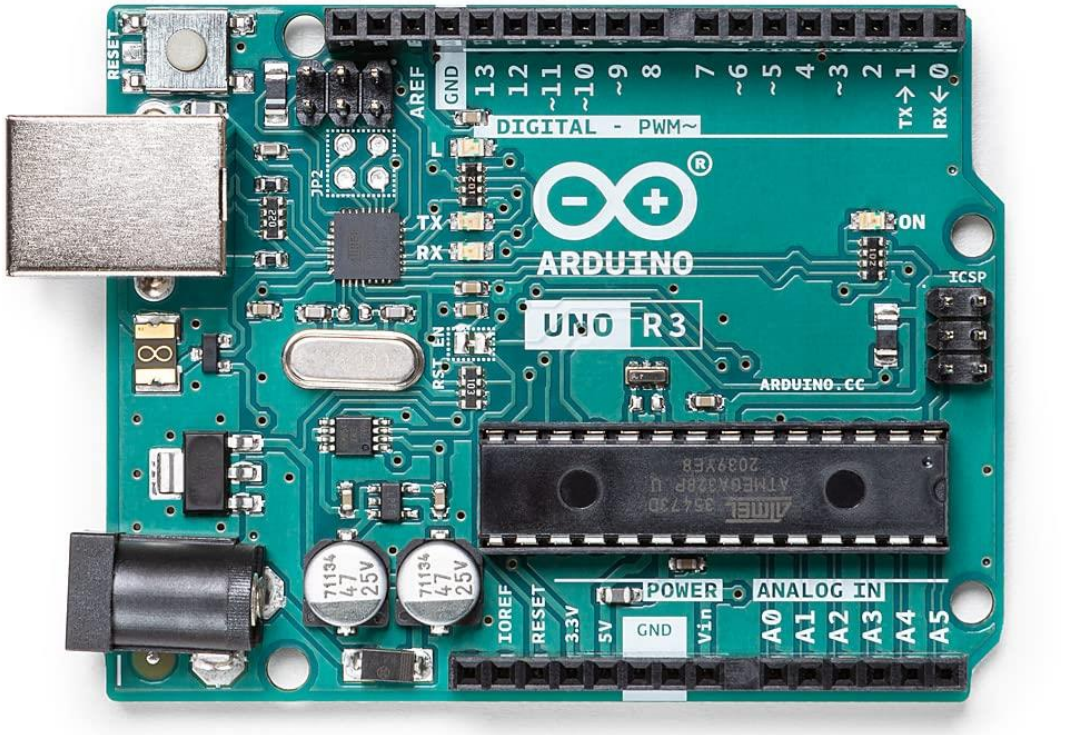
12. 3.3V Pin – This pin supplies 3.3 volts of power to your projects

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

Hardware Overview:



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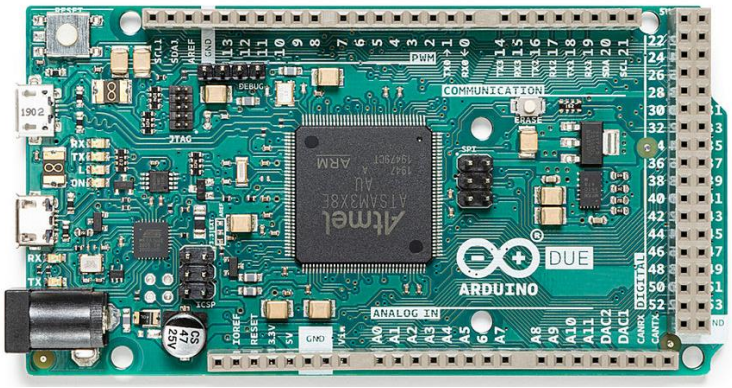
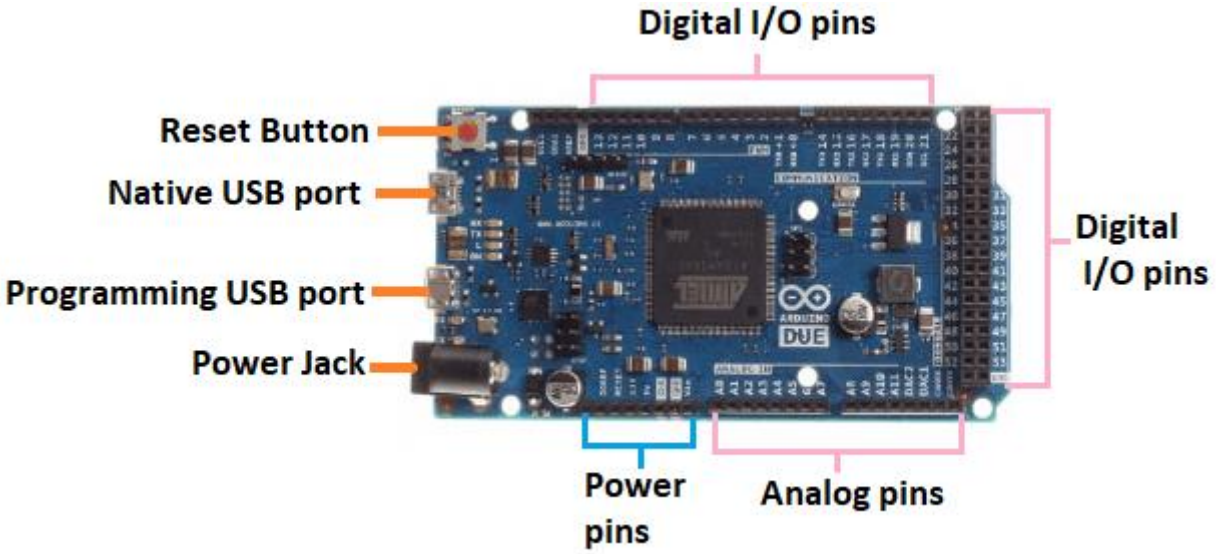
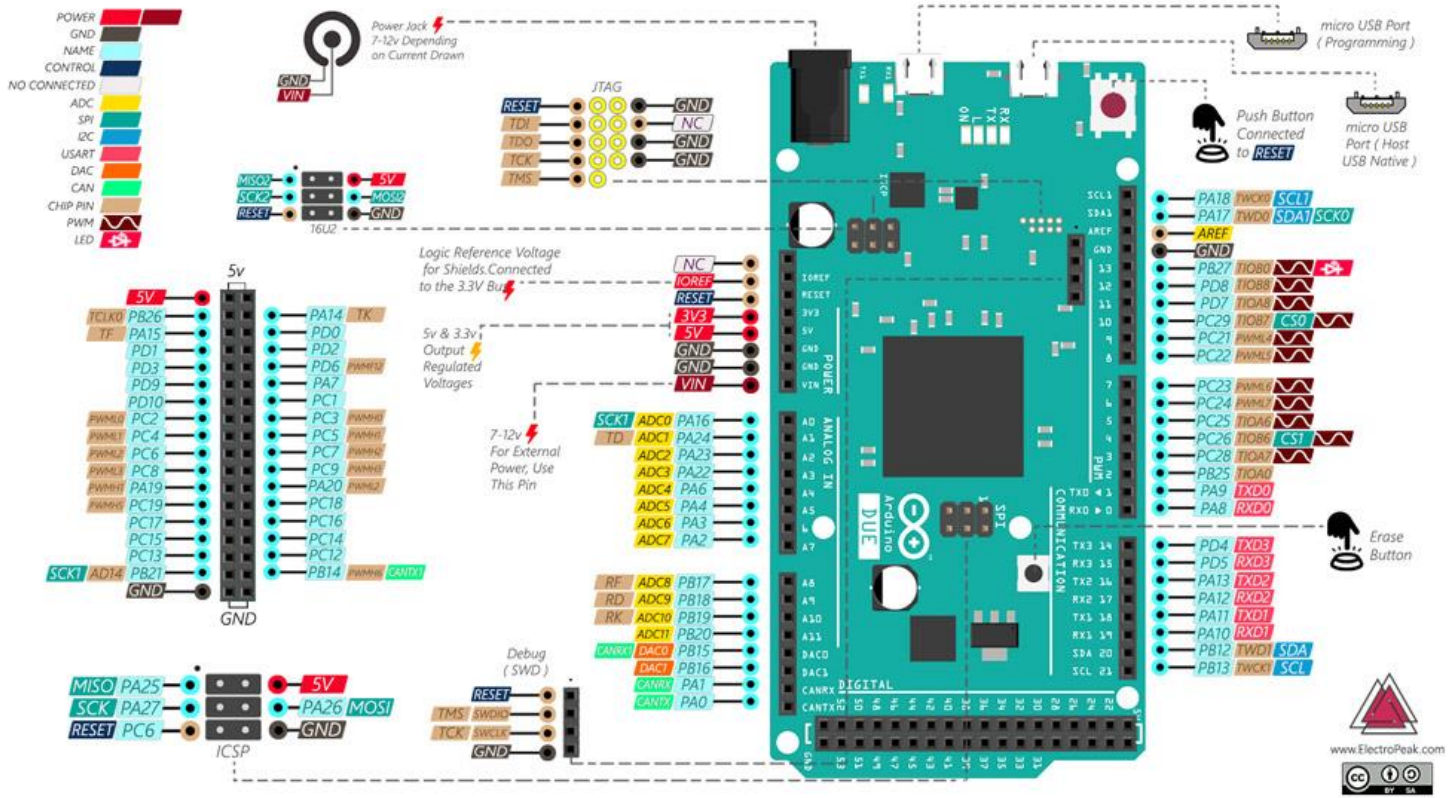
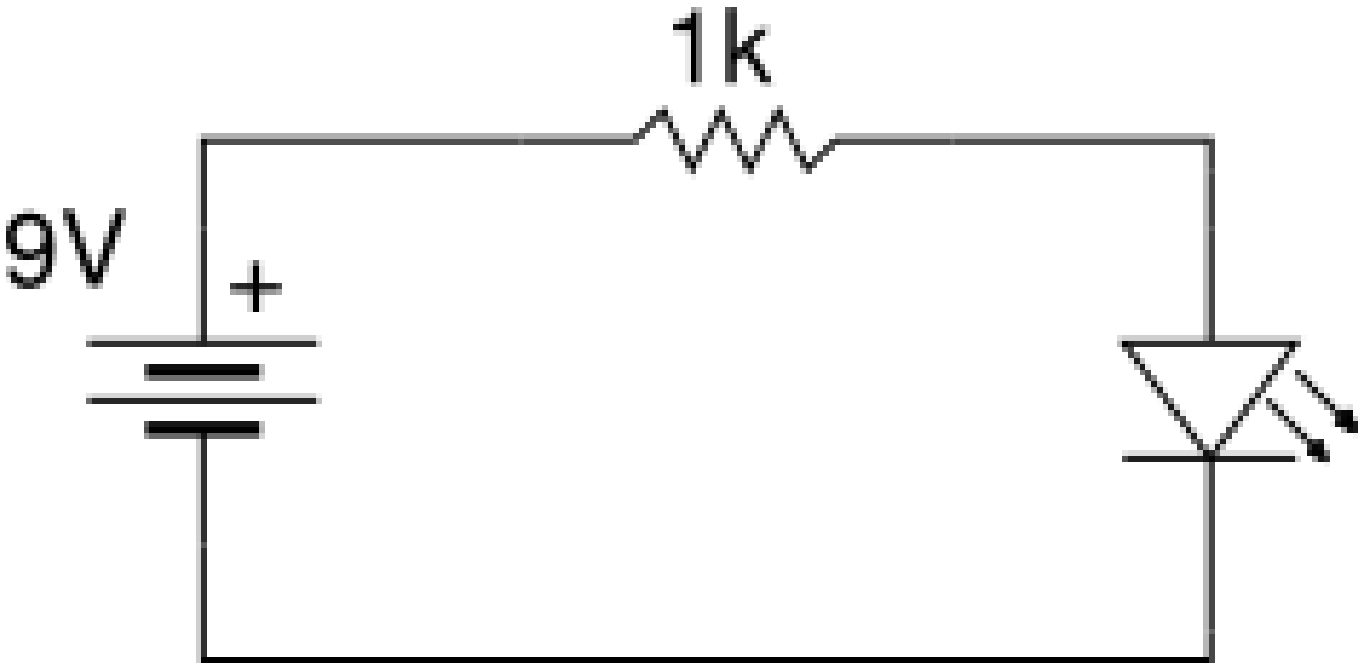
Arduino Due:


PWM
COMMUNICATION
DEBUG
ARDUINO
DUE
ANALOG IN

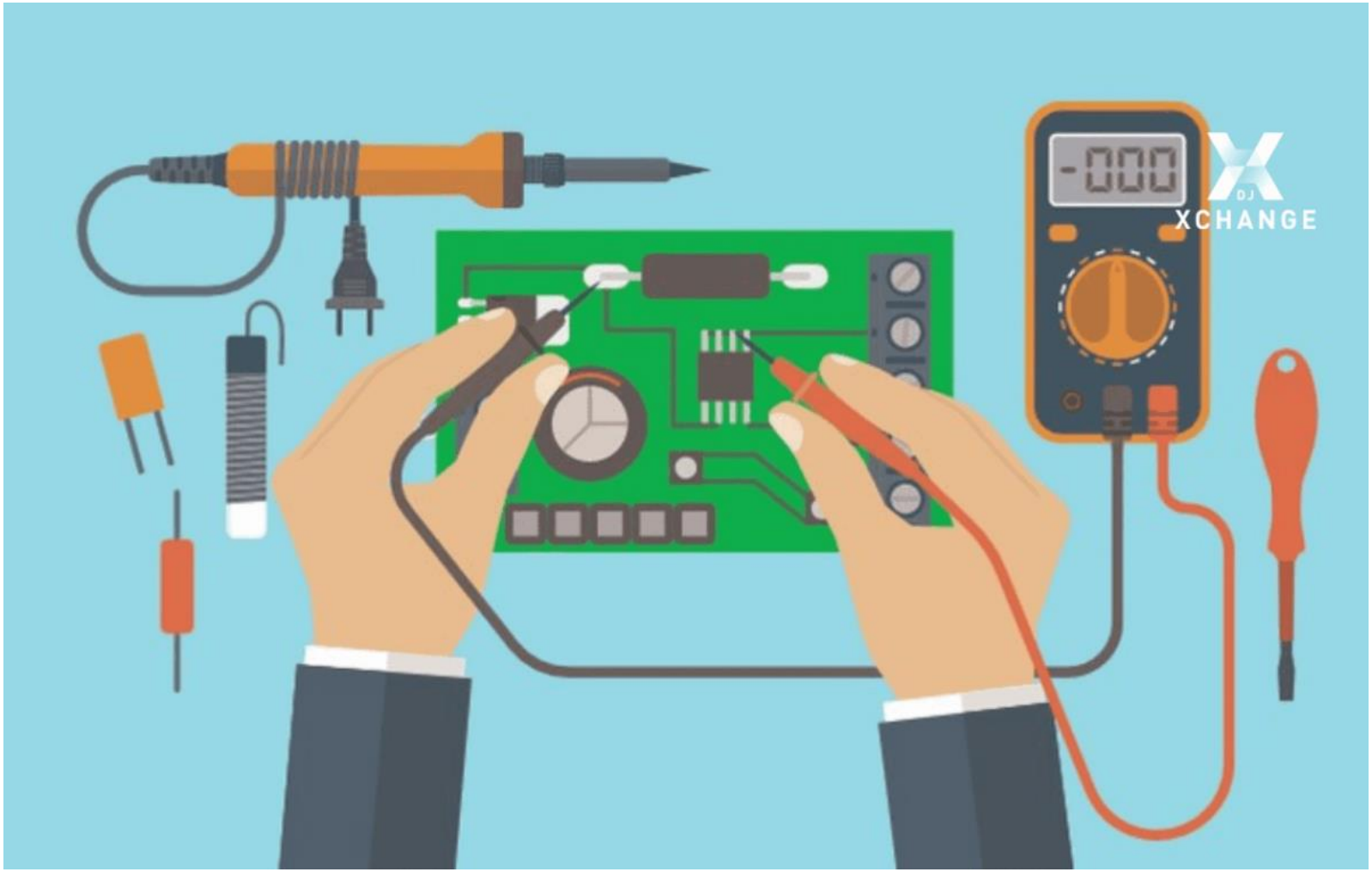

Digital I/O pins
Reset Button
Native USB port
Programming USB port
Power Jack
Digital
I/O pins
Power
pins
Analog pins

Arduino Due Schematic:





https://startingelectronics.org/



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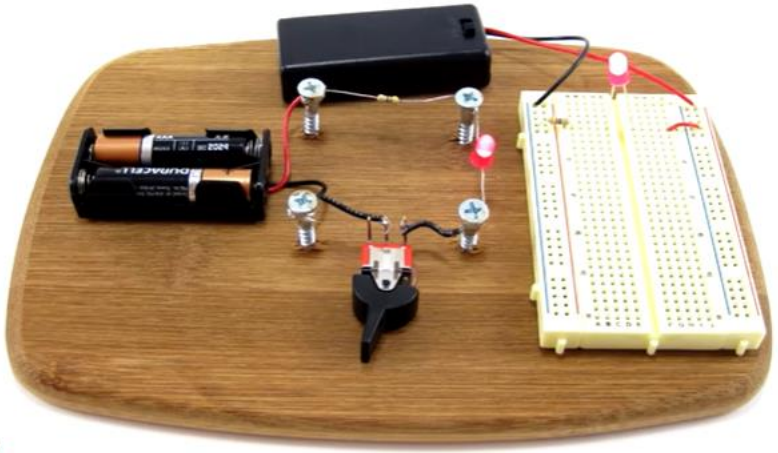
Introduction to Breadboards



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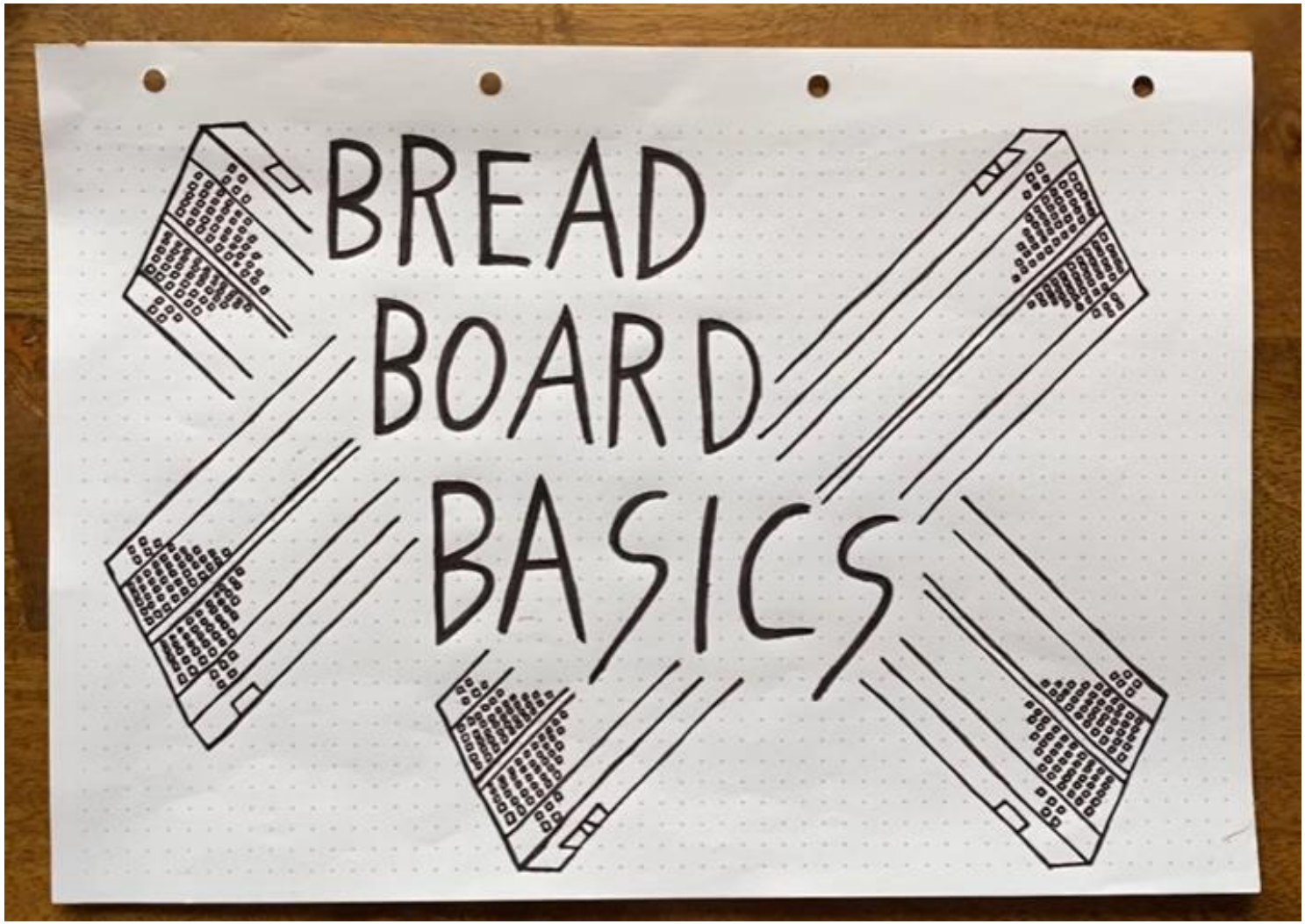

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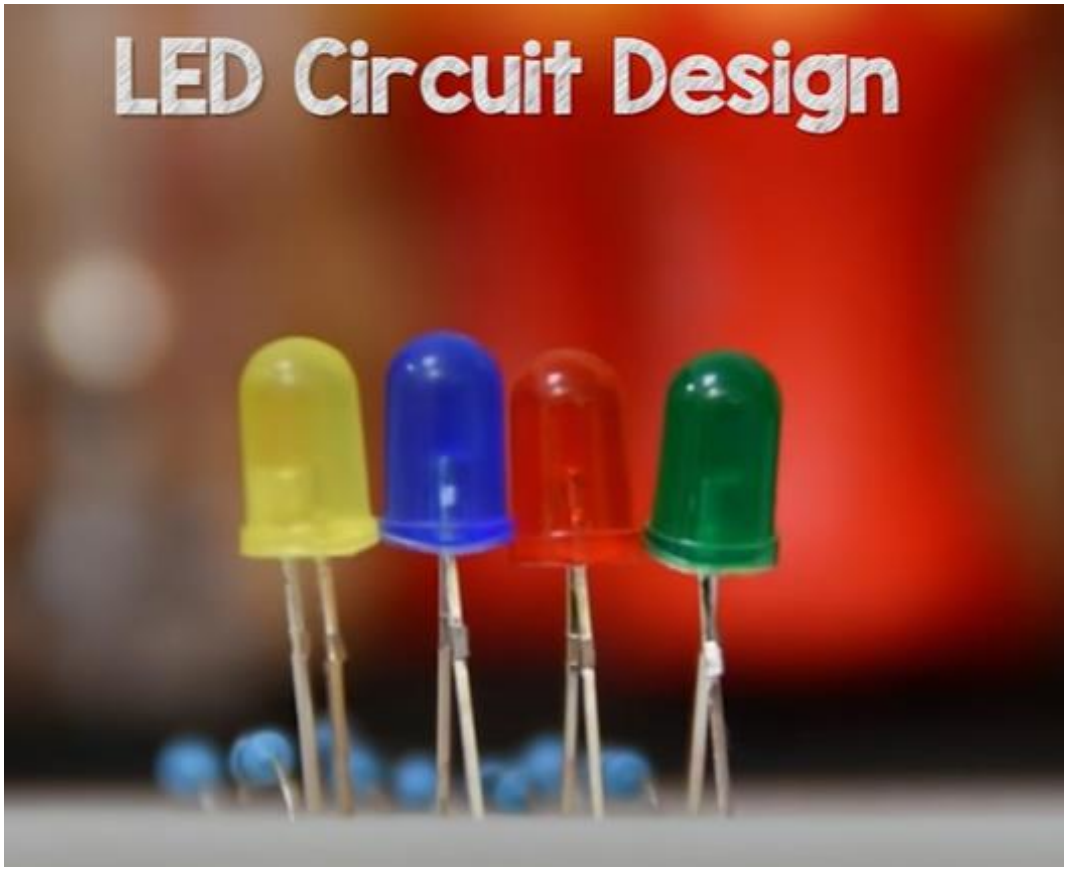

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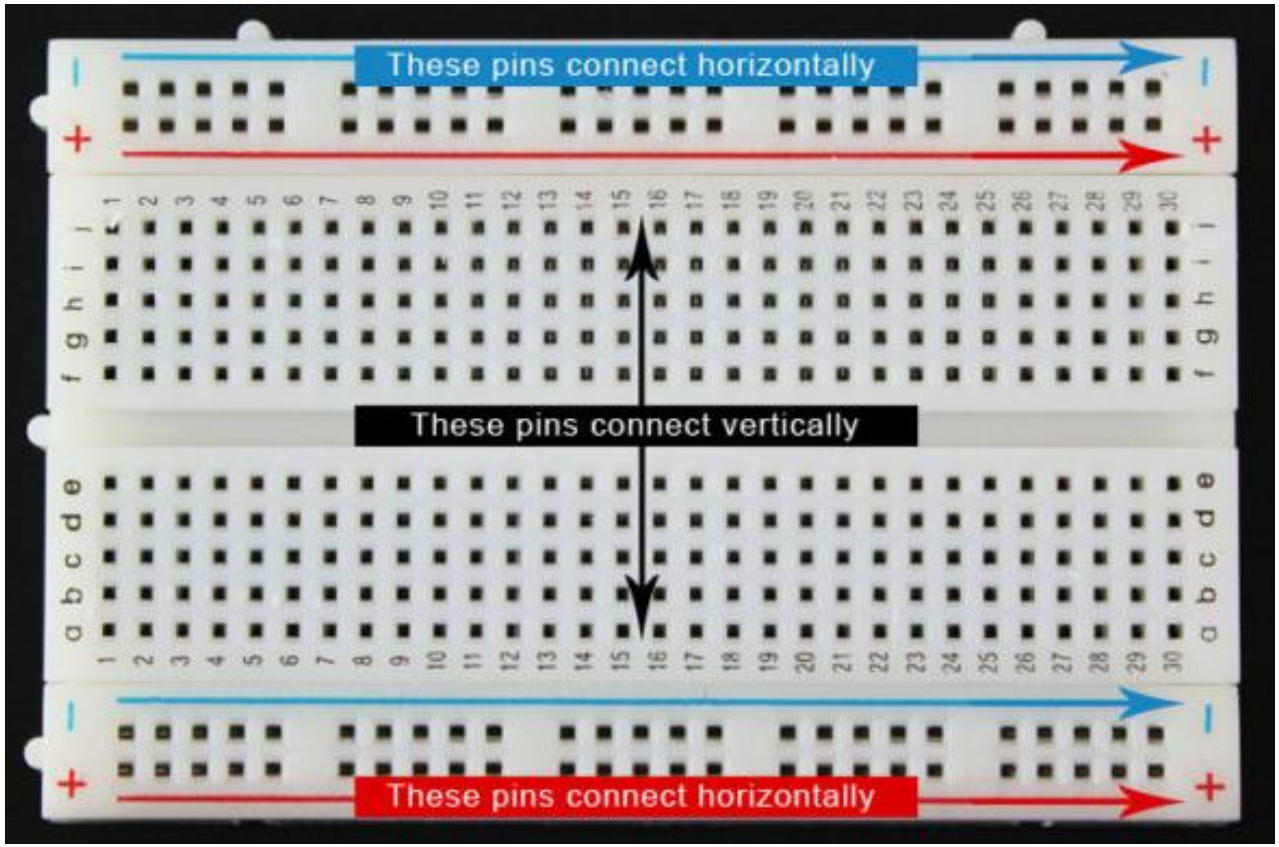
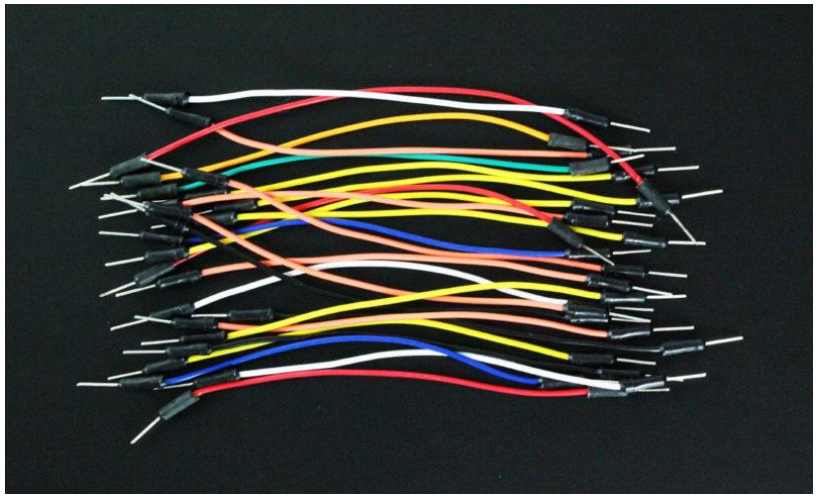
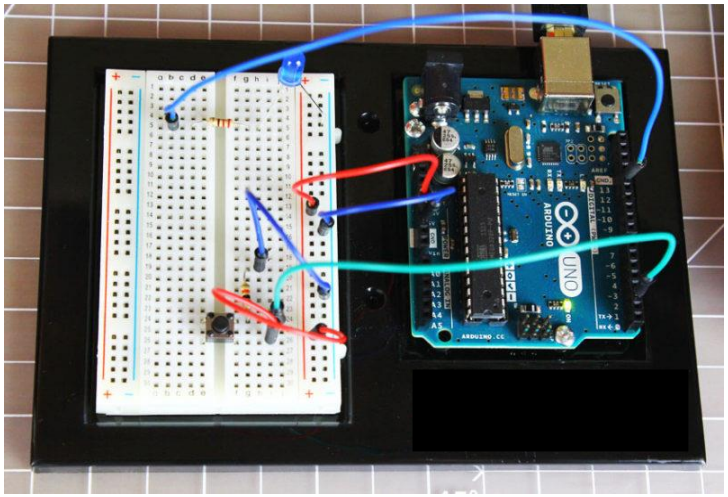
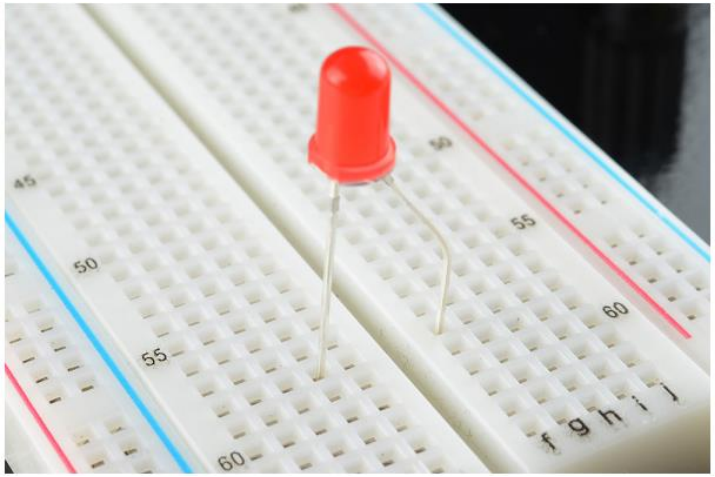
Breadboard:

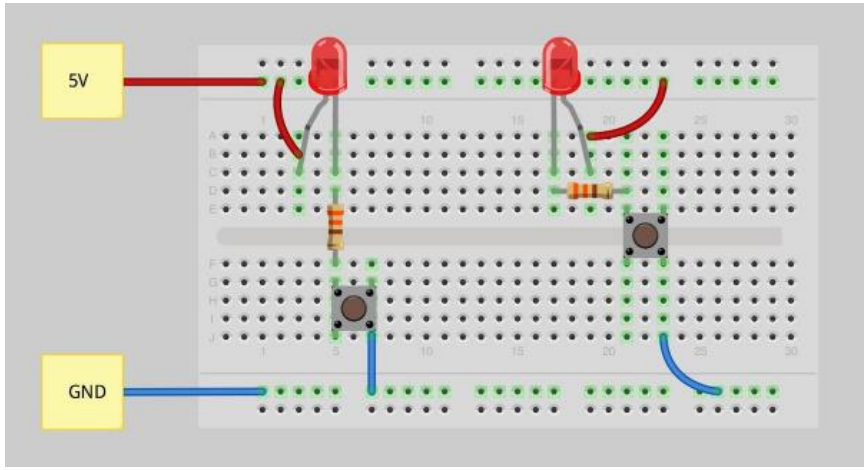


www.makerspaces.com









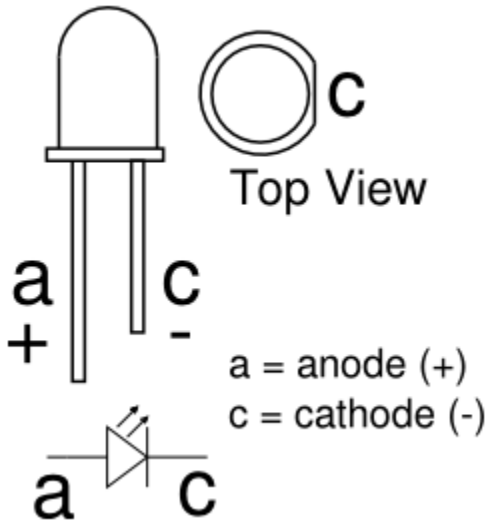
www.makerspaces.com

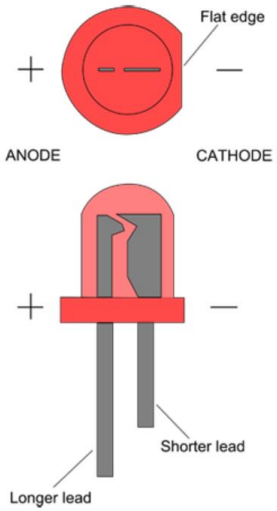
The LED (Light Emitting Diode) is exactly what it name suggests – a diode that emits light. LEDs are like small light bulbs and are available in different sizes and colors.

Examples of LEDs used in Electronics

The symbol for an LED used in circuit diagrams is shown here:

- ✓ An LED has **a positive lead know as the anode** and a **negative lead known as the cathode**. An LED must be connected in a circuit the right way around – observe the polarity of the LED.
- ✓ The way that the schematic symbol of the LED maps to the physical LED is shown in the diagram below:





- ✓ On the physical LED, the longer lead (or leg) of the LED is the anode. The cathode is marked on the rim of the LED body with a flat area shown in the diagram.

- ✓ Never connect an LED directly across a battery or other power source – it will burn out. LEDs must always be connected in series with a resistor.
- ✓ LEDs are diodes which means that current can only flow through an LED from the anode to the cathode and not the other way around.
- ✓ If an LED is connected the wrong way around in a circuit (anode to negative and cathode to positive) it is said to be "reverse biased" and will not emit light. When connected the right way around the LED is said to be "forward biased".
- ✓ LEDs, unlike other diodes, can not withstand large reverse bias voltages.

There are two schematic symbols for a resistor that are used in circuit diagrams as shown below. The symbol shown on the left is the American symbol for a resistor, while the resistor symbol on the right is the European symbol for a resistor.

Resistor Symbols used in Circuit Diagrams

When beginning electronics, we usually use quarter Watt five percent tolerance resistors (1/4W, 5%). These resistors look like this:

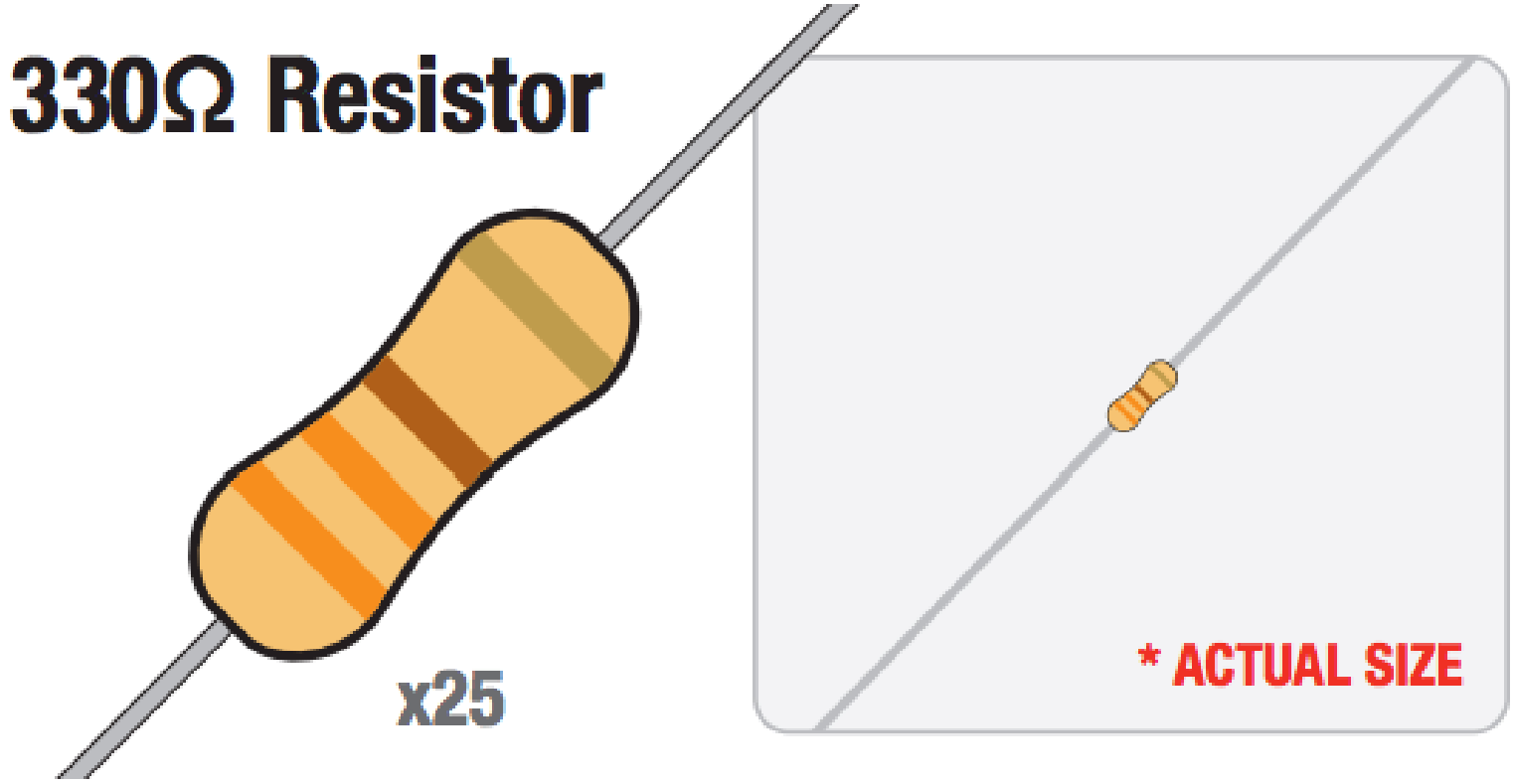
Example of a 1/4W 5% Tolerance Resistor of 1k Ohm Value

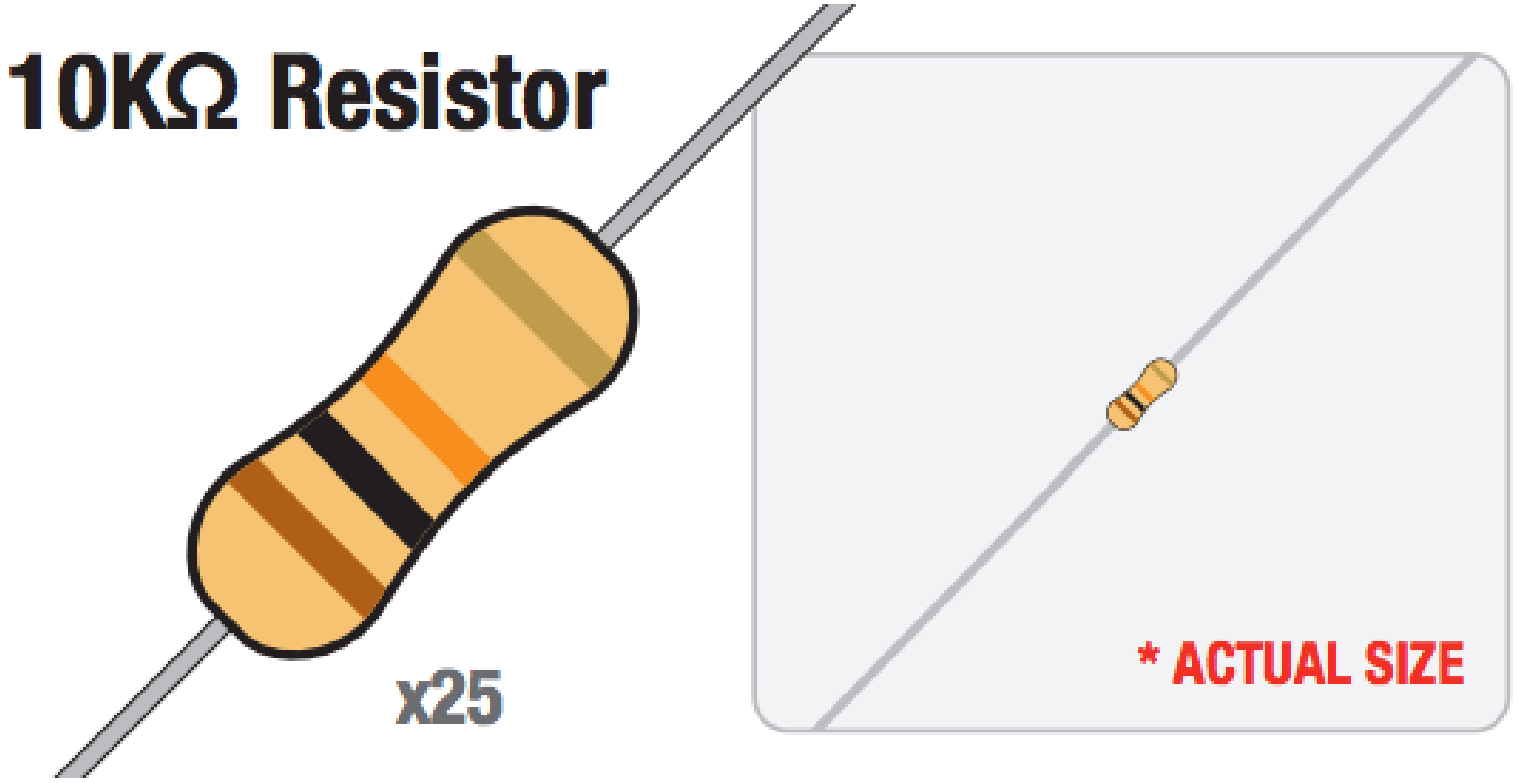
Resistors have a resistance that is given in Ohms (symbol Ω), e.g. 470 ohms (or 470Ω). The resistor above has a value of 1 kilo ohms which is written as 1kΩ or just 1k.

Resistors have a tolerance rating given as a percentage. The above resistor has a tolerance of 5%. This means that its ohm value could be 5% greater or 5% less than its quoted value. The above resistor has a value of 1k (1000 ohms) and a tolerance of 5% - this means that its value could be between 950 ohms and 1050 ohms (1000 - 5% to 1000 + 5%).

The colored bands that you see on the resistor tell us what its value is in ohms and what its tolerance is. The gold band tells us that its tolerance is 5%.

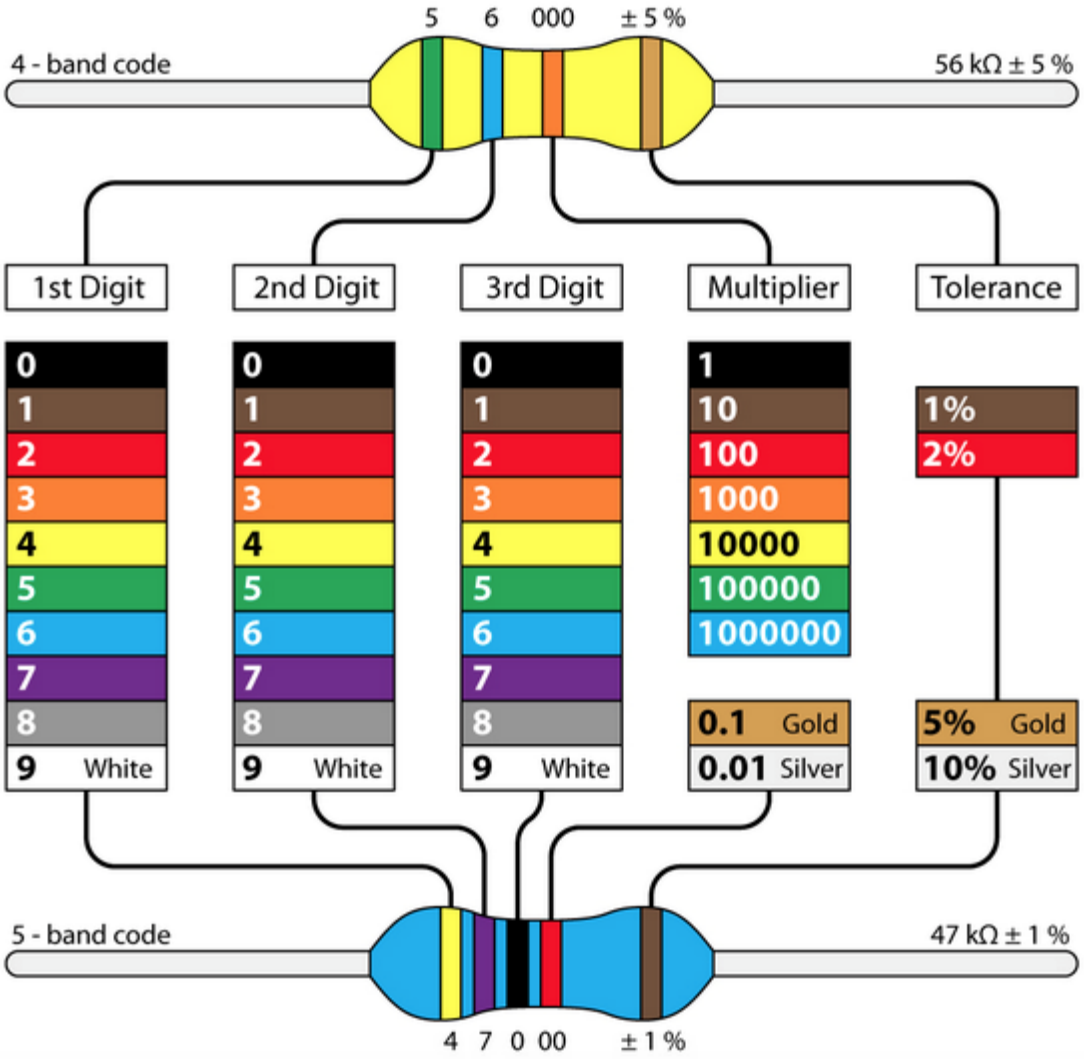
A resistor's value in ohms is worked out from the first three colored bands using the table below. Using the resistor above, its bands are brown, black and red. The first color, brown, has a value of 1. The second color, black, has a value of 0 (zero). The third color tells us how many zeros the value has - red = 2 zeros. Putting it all together we get: 1, 0, and two zeros (00) = 1000 ohms or 1k.

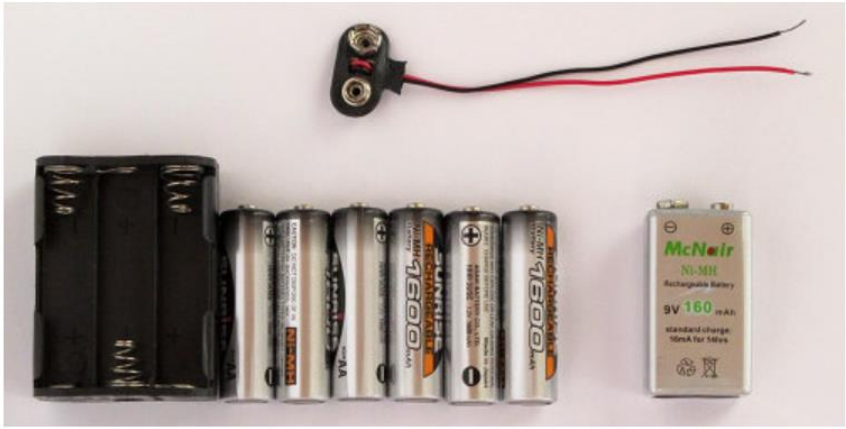

330Ω Resistor
x25
* ACTUAL SIZE


10KΩ Resistor
x25
* ACTUAL SIZE

More examples:
Resistor colors - Yellow, Violet, Brown = 4, 7, 1 (number of zeros is 1) = 47 and one zero = 470 ohms
Resistor colors - Red, Red, Red = 2, 2, 2 = 22 and 2 zeros = 2200 ohms = 2.2k, usually written as 2k2
Resistor colors - Yellow, Violet, Red = 4, 7, 2 = 4, 7, 00 = 4700 ohms or 4.7k = 4k7
Resistor colors - Brown, Black, Orange = 1, 0, 3 = 1, 0, 000 = 10000 = 10k
Resistor colors - Orange, Orange, Black = 3, 3, 0 (no zeros) = 33 ohms

	Color	Value
	Black	0
	Brown	1
	Red	2
	Orange	3
	Yellow	4
	Green	5
	Blue	6
	Violet	7
	Grey	8
	White	9


5 6 000 ± 5 %
4 - band code
56 kΩ ± 5 %
1st Digit
2nd Digit
3rd Digit
Multiplier
Tolerance
0 1 2 3 4 5 6 7 8 9 White
0 1 2 3 4 5 6 7 8 9 White
0 1 2 3 4 5 6 7 8 9 White
1 10 100 1000 10000 100000 1000000
0.1 Gold
0.01 Silver
1% 2%
5% Gold
10% Silver
5 - band code
47 kΩ ± 1 %
4 7 0 00 ± 1 %



Battery Holder, Rechargable Cells, 9V Battery and Battery Clip

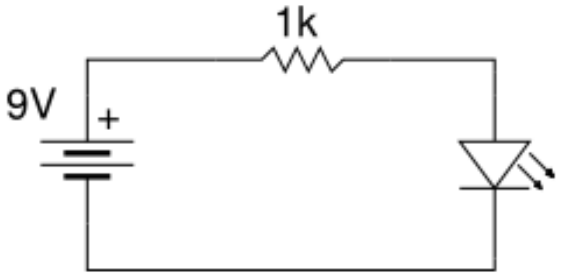
- ✓ The red wire of the battery clip is the positive lead and the black wire is the negative lead.
- ✓ The battery symbol shown below is used to represent a battery in circuit diagrams.

Battery Symbol used in Circuit Diagrams

- ✓ The longer vertical line of the battery symbol represents the positive terminal of the battery and is usually marked with a plus sign (+).

- ✓ Be sure to connect the battery the right way around in a circuit. This means that the positive terminal of the battery must be connected to the part of the circuit that is marked as positive in the circuit diagram. It will be marked with either the battery symbol or text – e.g. +9V

- ✓ The negative terminal of the battery must be connected to the part of the circuit that is marked negative with either the battery symbol, or 0V or GND.



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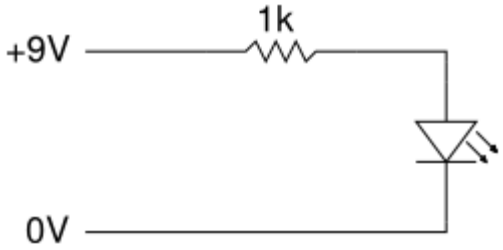
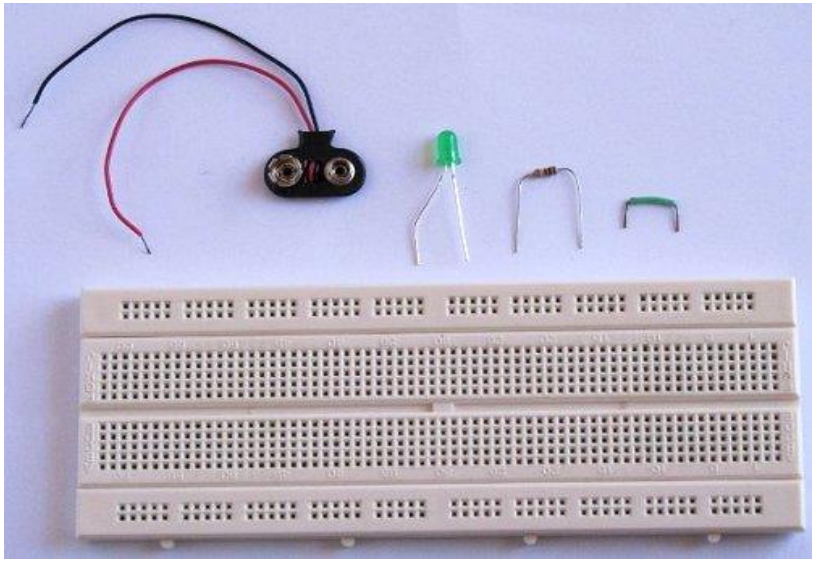


1. A breadboard
2. Breadboard wire links
3. 9V battery (nine volt battery)
4. Battery clip



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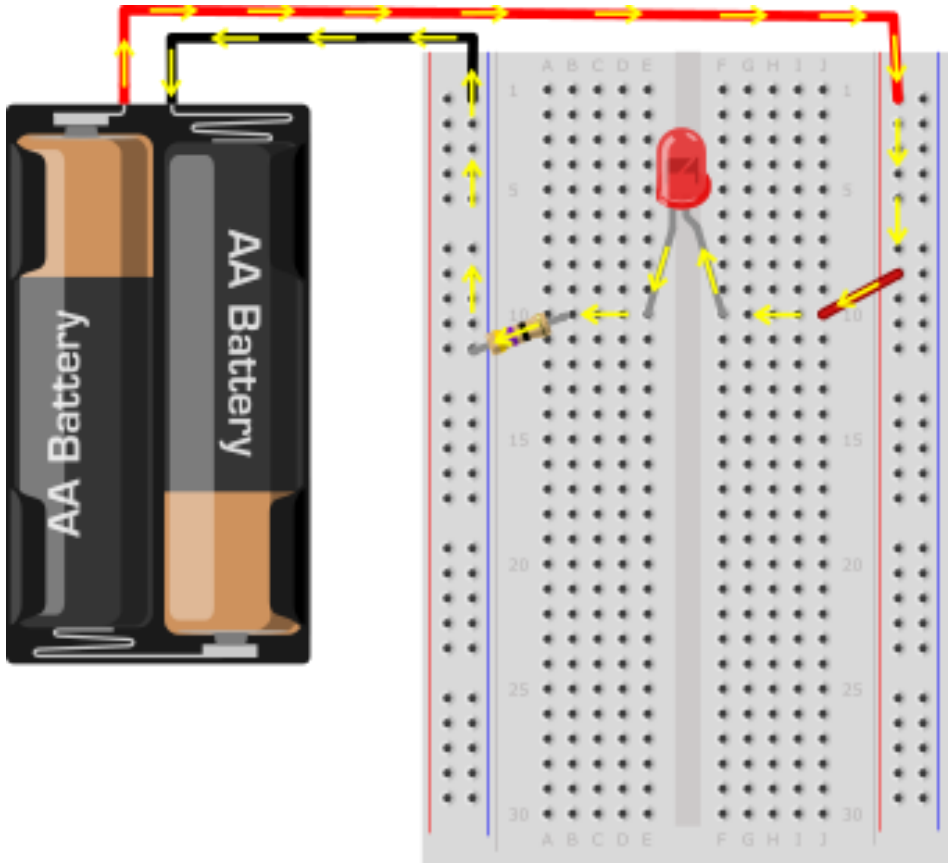
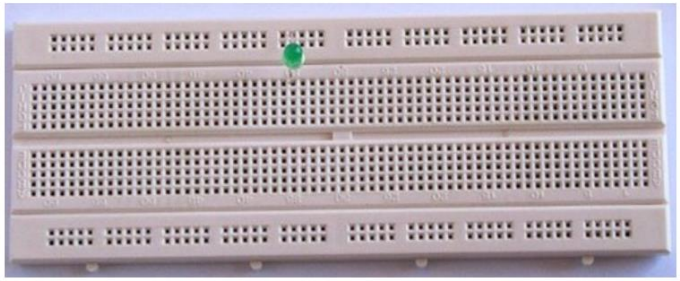
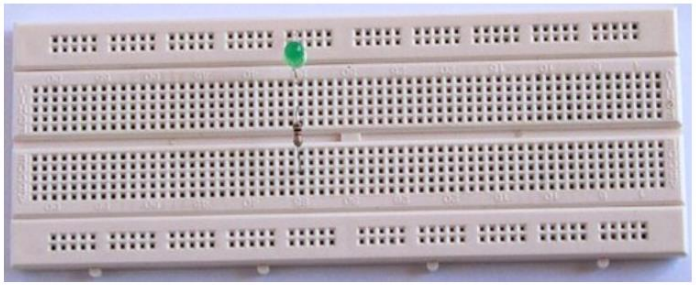
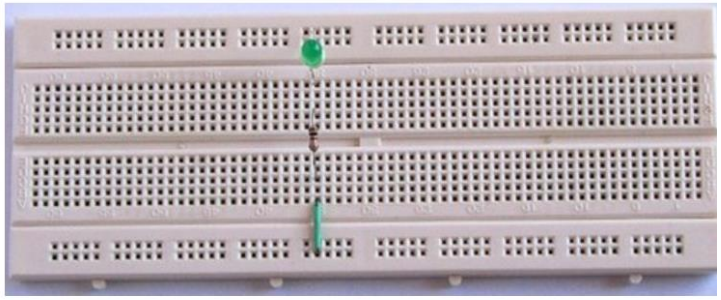

AA Battery
AA Battery



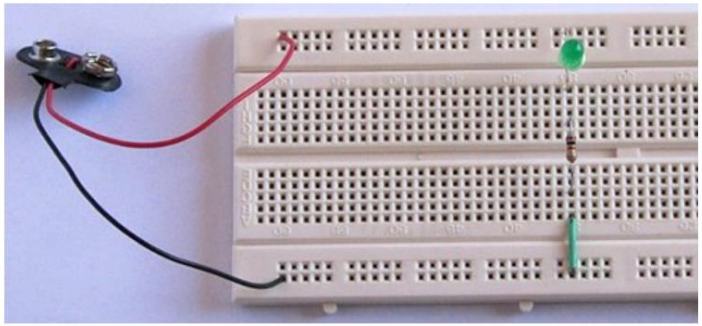
Step 1: Insert the LED into the Breadboard



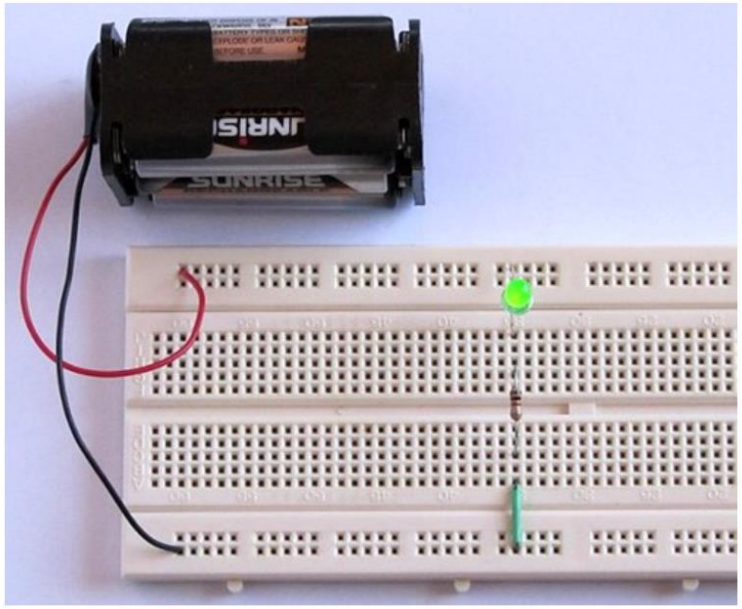
Step 2: Insert the 1kΩ Resistor into the Breadboard



Step 3: Insert the Wire Link



Step 4: Insert the Battery Clip into the Breadboard



Step 5: Connect the Battery to the Breadboard Circuit

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Q: What is the purpose of the resistor in the circuit?

A: The purpose of the resistor is to **limit** the current flowing through the LED so that the LED is **not burned out**. Limiting the current also limits the brightness of the LED.

Q: How do you choose the correct resistor for the circuit?

A: First subtract the LED forward voltage from the battery voltage. Different colored LEDs have different forward voltages, so check the LED datasheet for this value. If the LED forward voltage is 1.7V and the battery is 9V, we subtract 1.7 from 9: 9 – 1.7 = 7.3V. Now decide how much current must flow through the LED, for example 10mA (ten milliamps, which is 0.01A). Divide the calculated voltage by the desired LED current. 7.3 ÷ 0.01 = 730Ω. Choose a resistor value that is close to the calculated value.

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Why is the 1K resistor needed?

The resistor is needed in order to provide the correct current to the LED. Ohm's law states:

$V = IR$

where V = voltage in volts, I = current in amperes (amps), and R = resistance in Ohms. Adding in the values used in this circuit:

$(9V) = I(1000\Omega)$

Solve for I to get

$I = (9V) / (1000\Omega) = 9\ mA$

so the current in this circuit is 9 mA (0.009 amperes). 5mm LEDs are usually rated for a maximum of 20 mA, so this provides a current safely below the maximum.

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