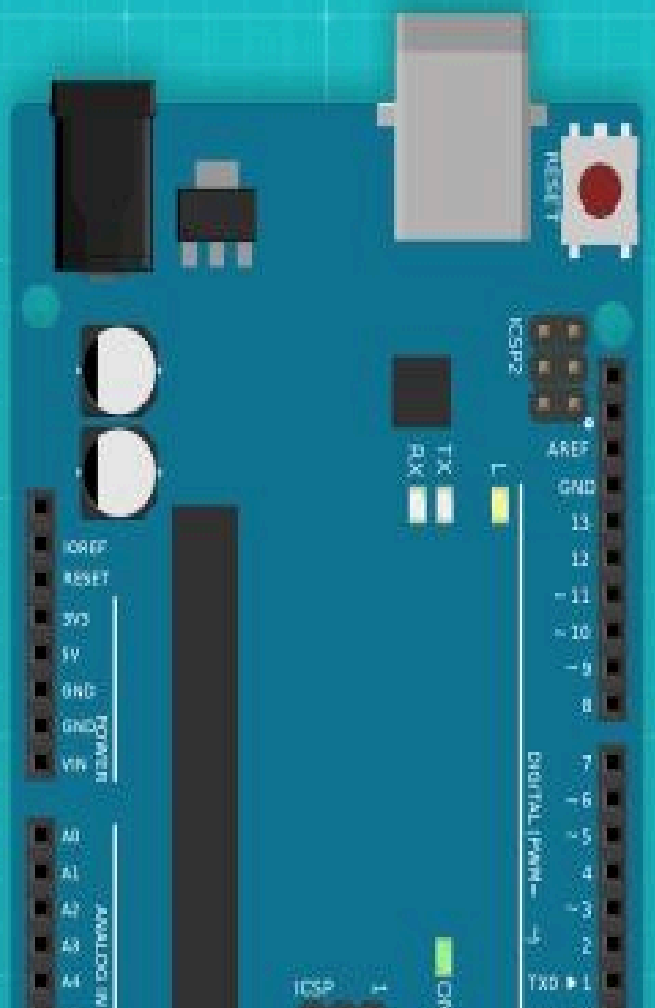
Arduino for STEM Teachers and Parents :

Teaching Electronics and Arduino to Kids in the Classroom and at Home

Book by P Barik
Graphics by Ashutosh D



Dear Parents and Educators,

I salute you for the hard work you do!

At the time of writing this book, there were countless resources available online teaching Arduino and electronics, yet not one focused on effectively teaching these concepts to kids and young students. Let me be clear: there's no shortage of resources for learning electronics. However, what's often lacking is guidance on how to teach these subjects in a way that keeps young minds engaged and eager to learn. Throughout this book, I've taken a different approach by applying inductive teaching methods. We start with practical, hands-on activities, allowing students to observe and explore before delving into the theory behind what they've experienced. This way, we aim to impart practical learning to young minds, avoiding the pitfall of bombarding them with dry theory before they've had a chance to truly engage with the material.

In the hustle and bustle of our fast-paced world, finding meaningful ways to engage with technology and foster curiosity in the younger generation can be challenging. I've had the privilege of meeting and guiding numerous teachers and parents through my content, and a common question that keeps popping up is how to make learning electronics engaging and playful. That's what inspired me to write this book – to clear the fog and provide practical guidance on effectively teaching these concepts.

As an enthusiast of electronics and a firm believer in the power of hands-on learning. through carefully crafted projects and clear instructions, "This book" offers a gateway to a realm of creativity and exploration. From the basics of circuitry to the wonders of coding with Arduino, each project is an opportunity for children—and the adults guiding them—to learn, experiment, and grow together. My hope is that this book will not only spark a love for electronics and technology but also foster critical thinking, problem-solving skills, and a lifelong passion for learning. So, whether you're embarking on this journey solo or with a group of eager learners, I invite you to dive in, get your hands dirty, and discover the joy of creating with electronics.

Happy tinkering!
Prathamesh Barik

Who is this book for?

I've written this book with the aim of providing a practical and enjoyable resource for anyone eager to introduce children to the exciting world of Arduino and electronics projects. Whether you're an educator, a mentor, or simply someone passionate about igniting curiosity in young minds, this book is designed to make your journey easier and more rewarding.

What You Will Need for This Book

There are two ways that we can teach practical experience to students:-

1. **Online Wowki Simulator:** This is a web-based platform where students can perform the activities outlined in this book. It offers a virtual environment for experimenting with electronics projects.

2. **Arduino IDE + Hardware (Recommended):** I highly recommend this method to parents. It involves using Arduino Integrated Development Environment (IDE) along with physical hardware components. This hands-on approach not only deepens understanding but it also inspires a sense of accomplishment. With Arduino IDE and hardware, students can physically interact with the components, observe how they function, and troubleshoot real-world issues. These are valuable skills in today's tech-driven world.

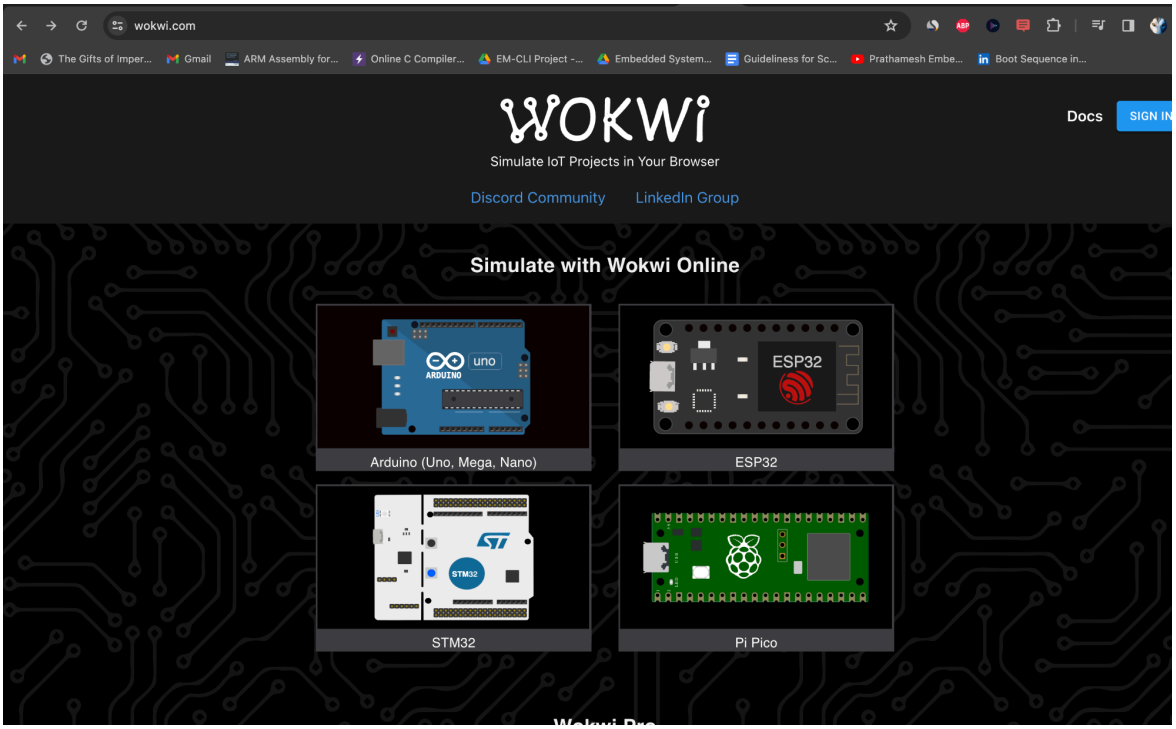
Note:- All the projects in this book will be done both ways- first through wowki simulator and then through hardware.

Table of Contents

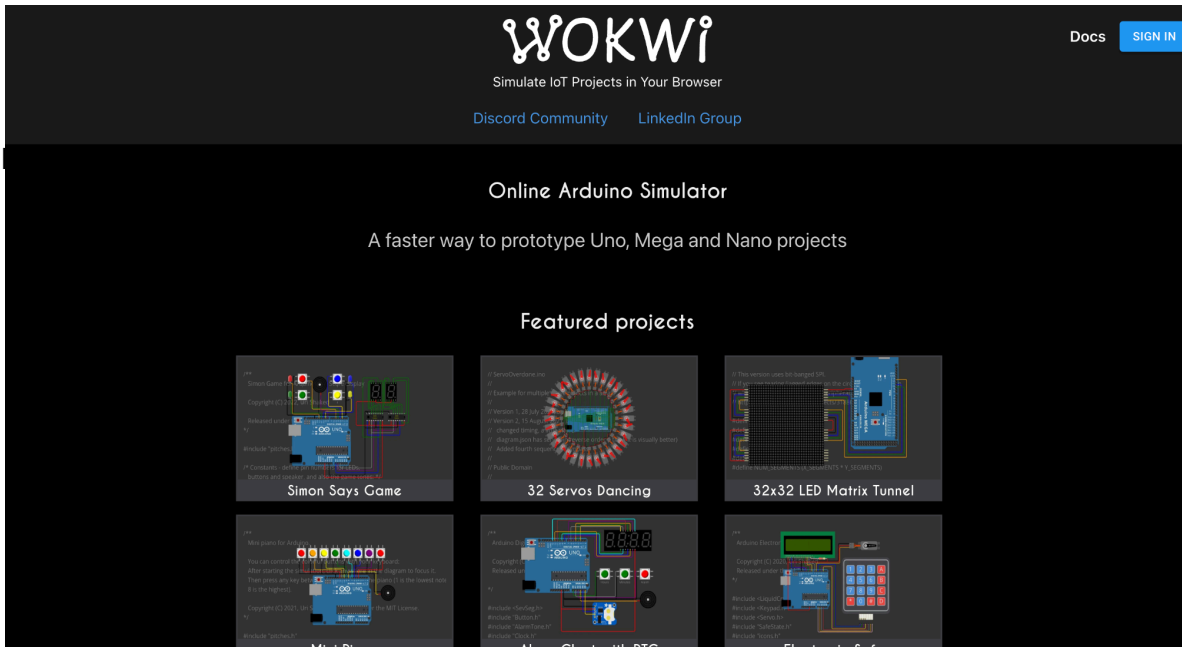
Lesson 1 :- Blinking an LED through Arduino

Mode 1:- Wowki Simulator

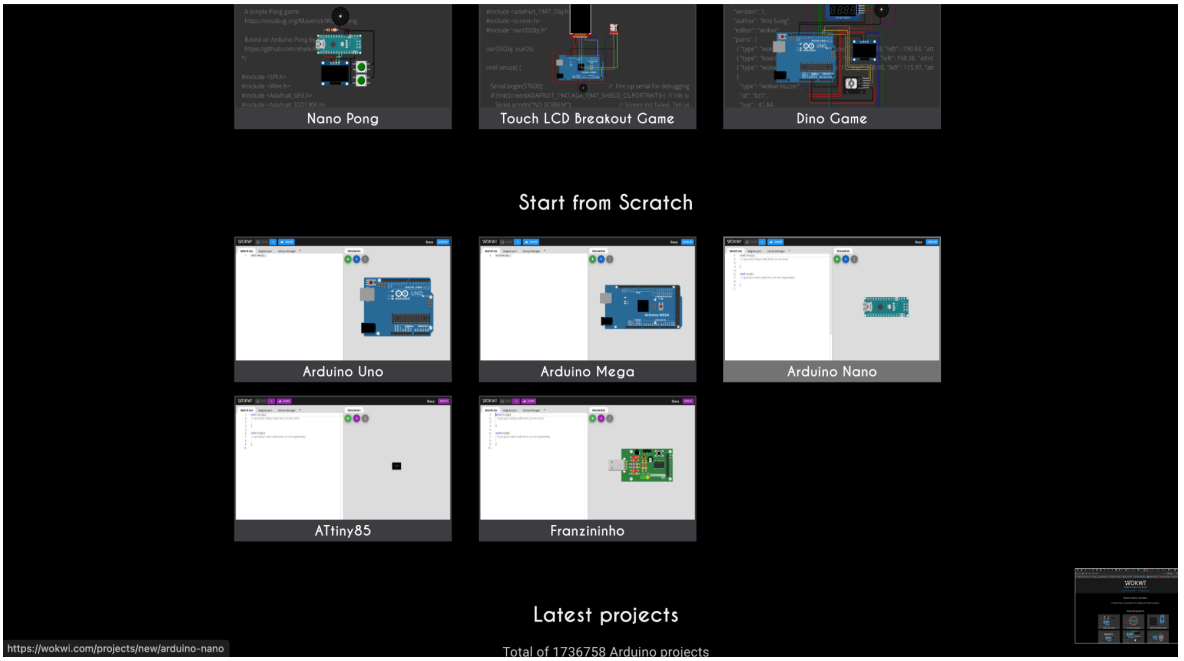
Step 1:- First, Go to the website:- www.wowki.com, you will see a website like this. Select the Arduino Uno, Mega, Nano board.



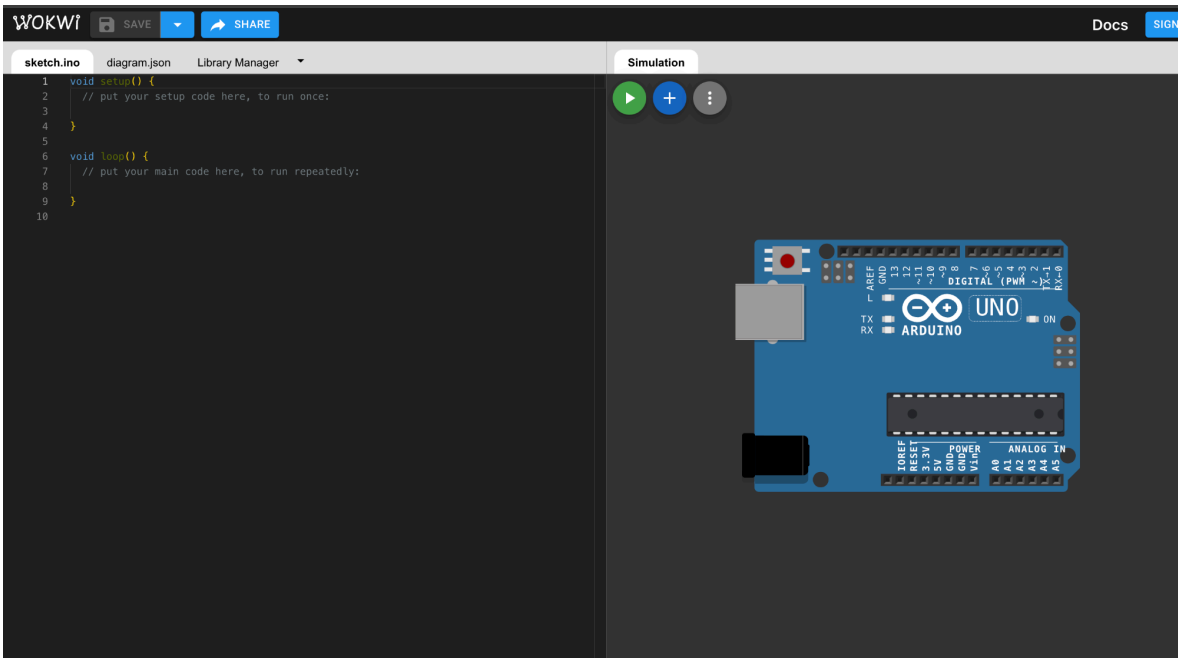
Step 2:- You will see a section like this, you need to scroll down using your mouse.



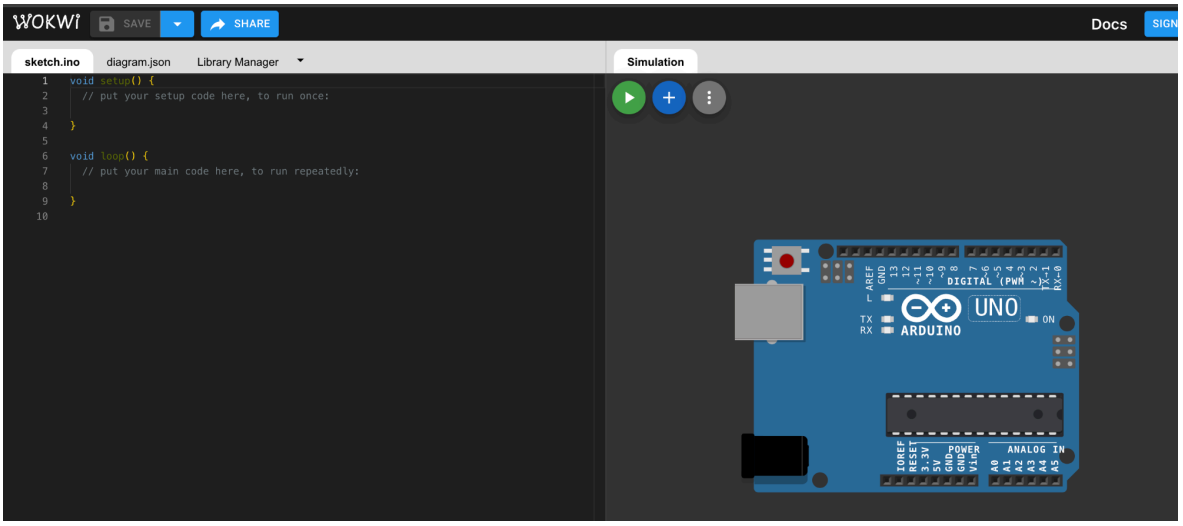
Step 3 :- Stop scrolling down when you see the “Start from Scratch” section like this. Click on the box with the name - “Arduino Uno”.



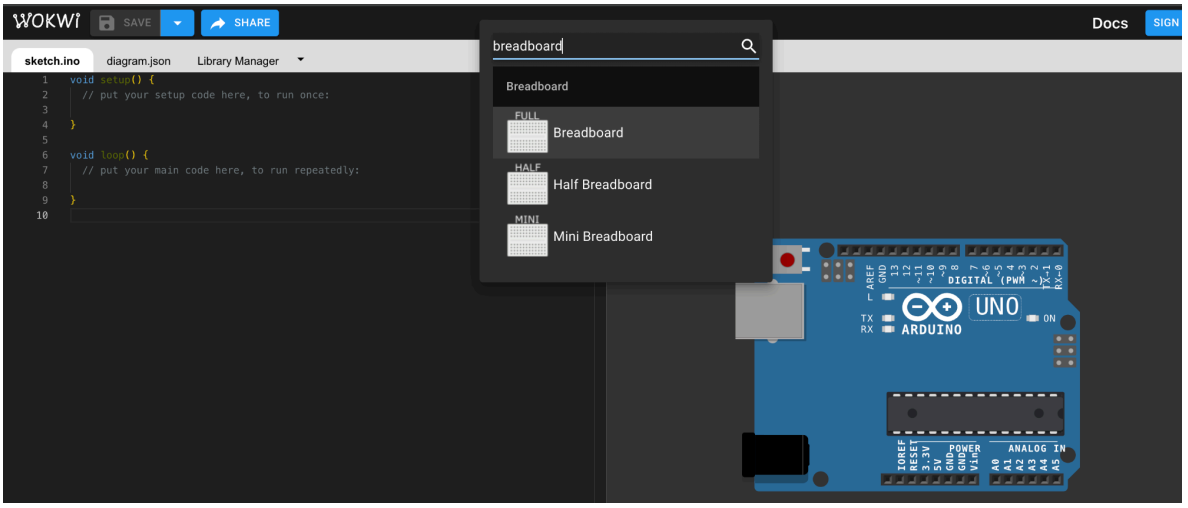
Step 4 :- Here’s how your screen will look after you have clicked.The left section is where you write code. The right section is where you will see the output.



Step 5 :- Click on the “+” button. This is for adding a new part to the project.



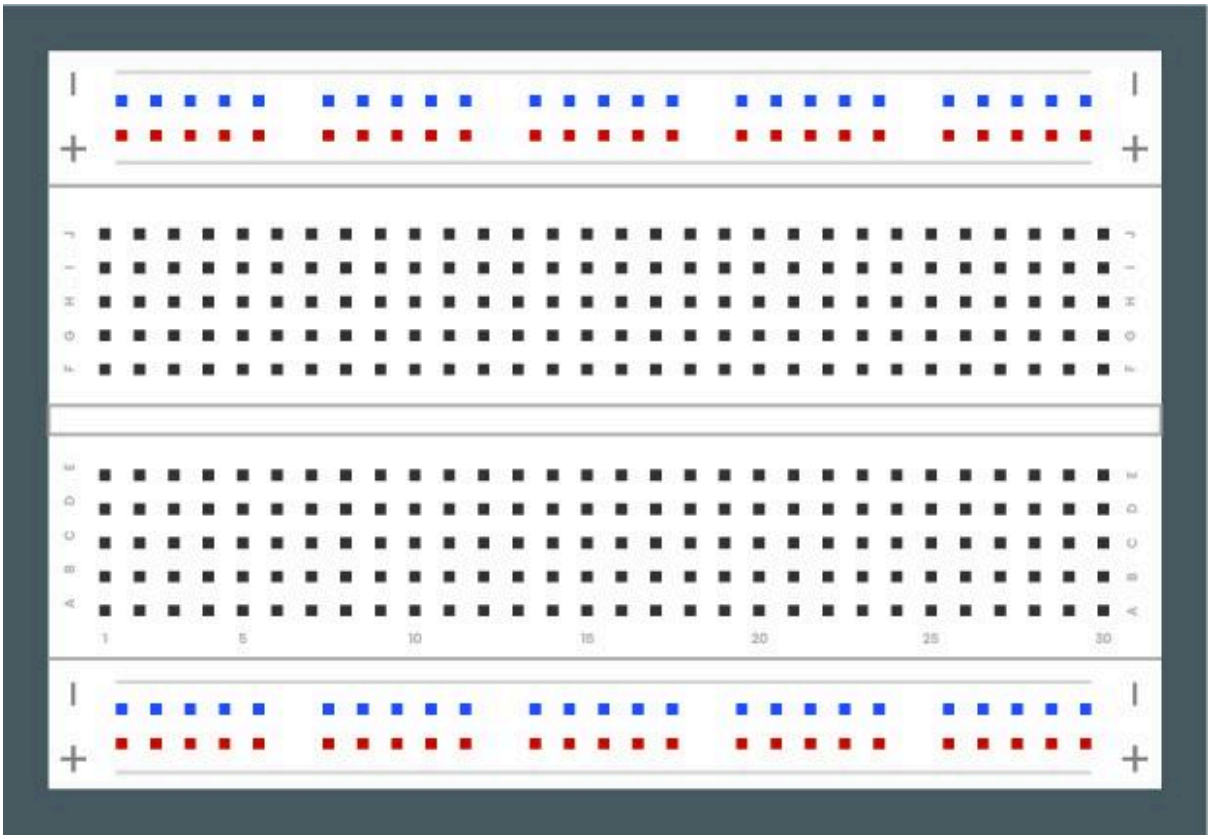
Step 6 :- When you click on the + button you will find different components there. Click on the search bar and type “breadboard” and then click on the FULL Breadboard option.



Let's Explore!

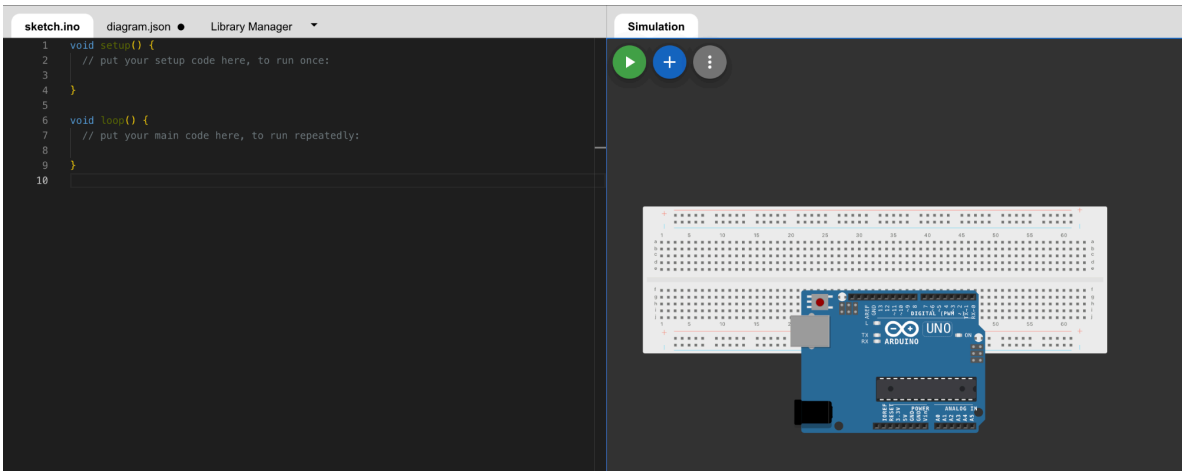
What is a Breadboard?

A breadboard is a tool used in electronics to create temporary circuits without soldering. It has rows and columns of small holes where you can insert and connect electronic components like resistors, LEDs, and wires. Breadboards allow you to quickly prototype and test circuit designs by easily rearranging components without damaging them.

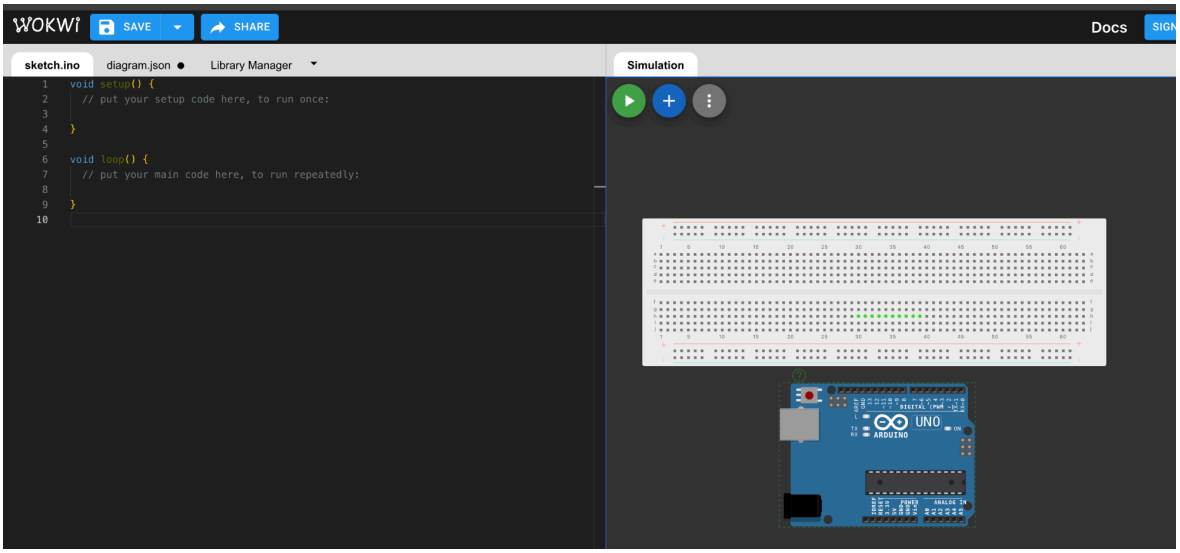


The side rails of the breadboard are usually used for power. The holes in these rails are connected vertically, meaning that all the holes in a particular rail are connected together. This makes it easy to provide power together. This allows you to easily connect components together in your circuit by inserting their leads into adjacent holes in the same row.

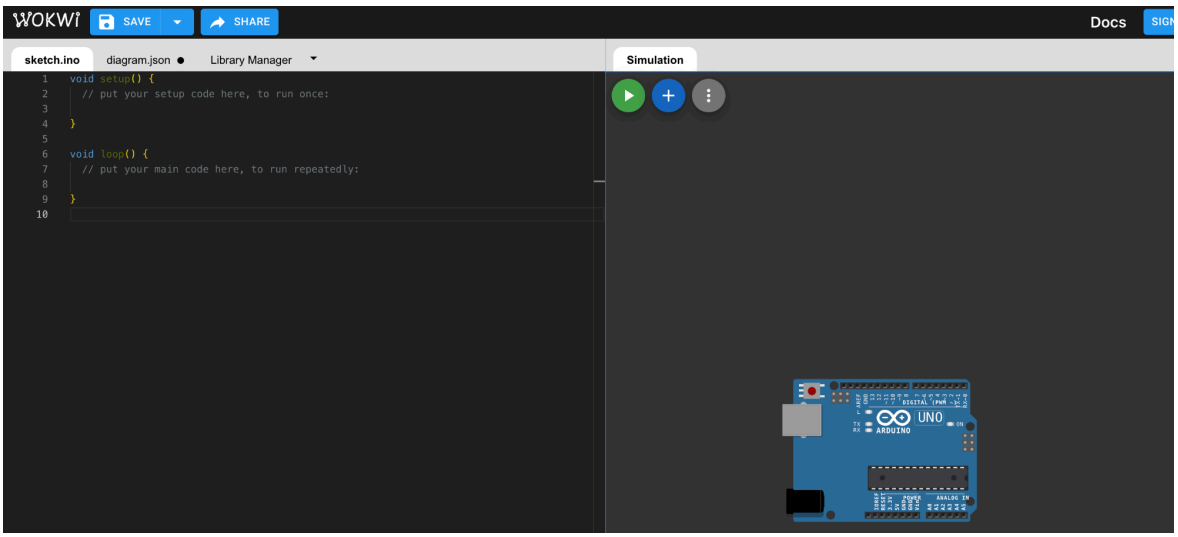
Step 6 :- After selecting the breadboard option, you may notice that the Arduino board overlaps with the breadboard. However, we don't need it this way.



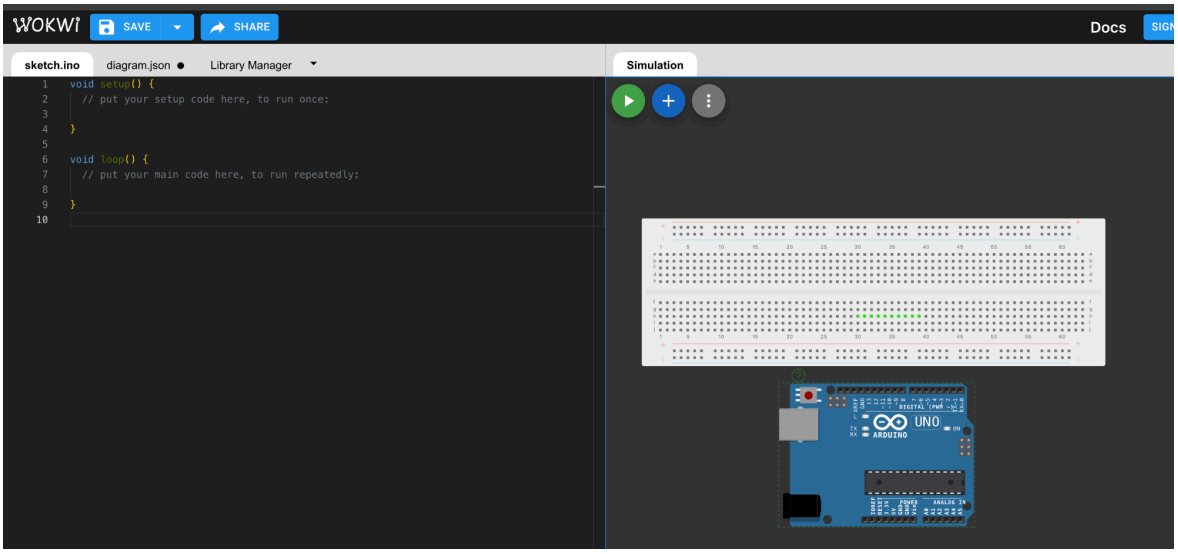
Step 7 :- You can hold the left click on your mouse, and then move it to drag any components. I have moved my arduino so it doesn't overlap now.



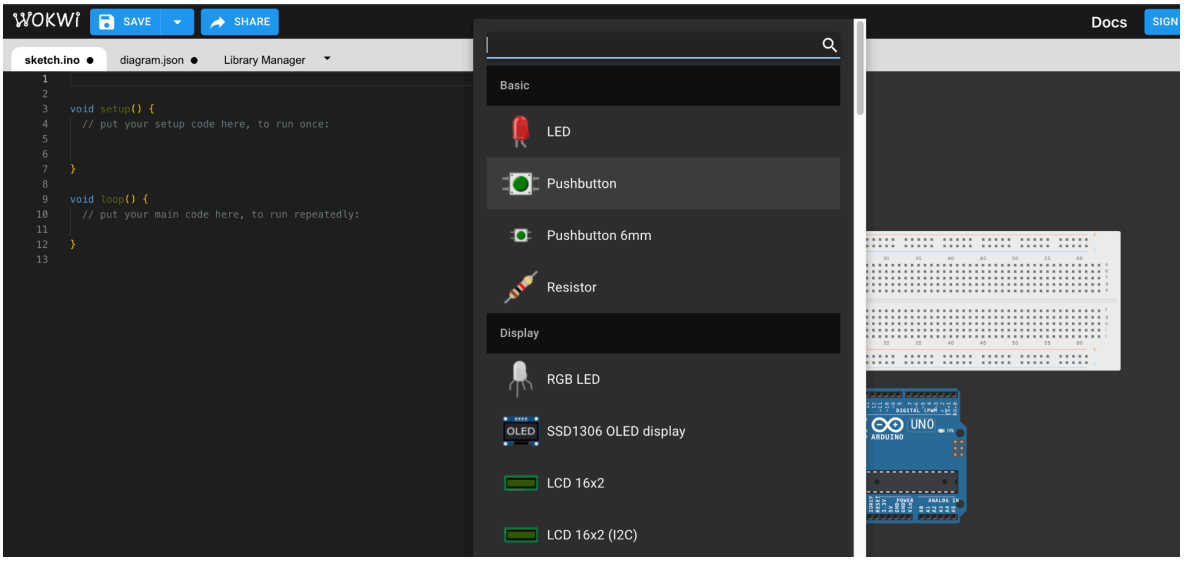
Step 8 :- You can also delete any components by left clicking on the mouse and then pressing the delete button on the mouse.



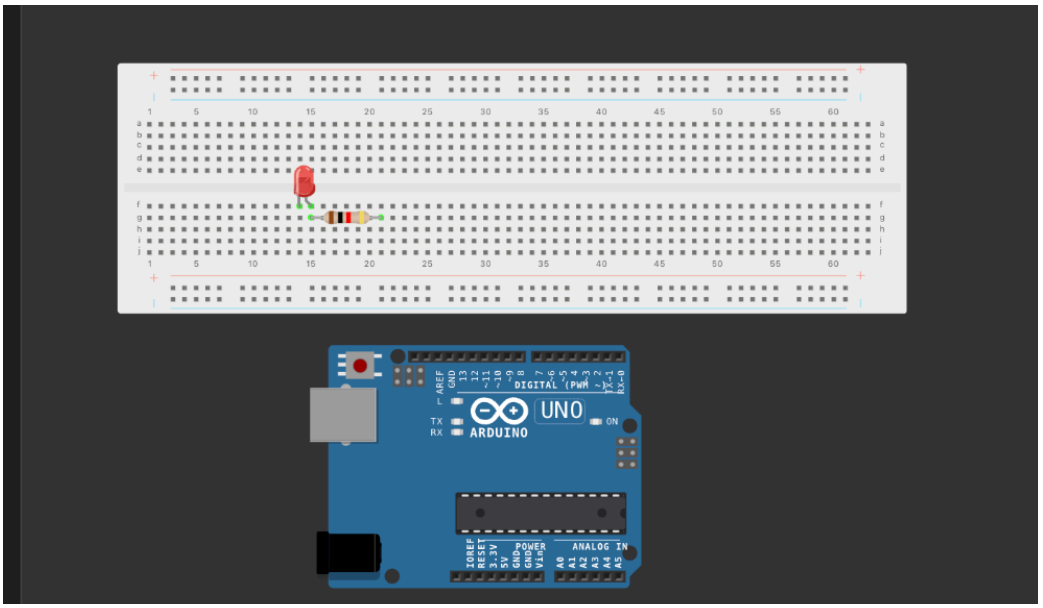
Step 9 :- Let’s bring back the breadboard again now by clicking the ”+” button.



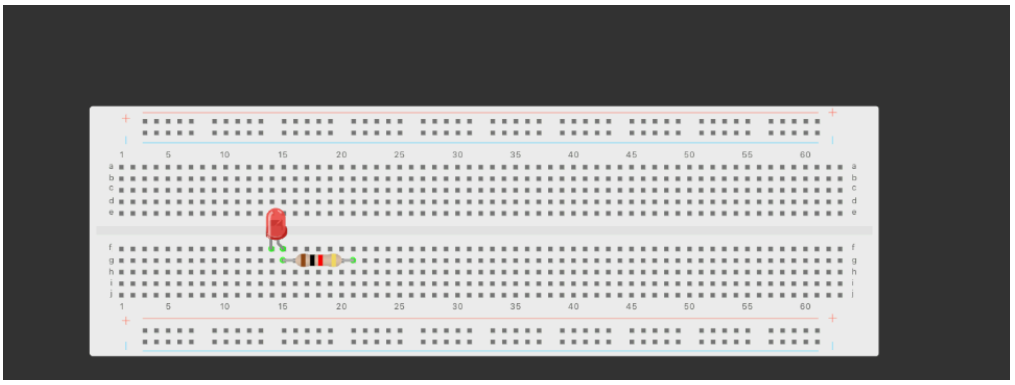
Step 10 :- Press the “+” button again and you will see the LED and the resistor in the Menu. Click on both of them.



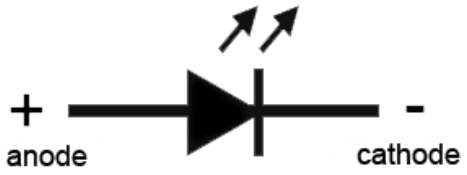
Step 11 :- You will see that both of the components are imported now. You can drag them at whatever position you need. Let's place them on the breadboard.

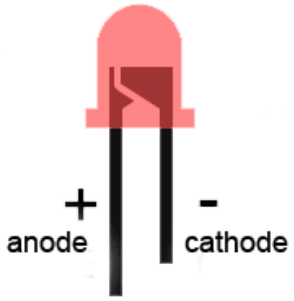


Remember:- The resistor and LED are connected together now because of the internal breadboard connection we learnt earlier. *mark illustration*



What is an LED?





What is a Resistor?

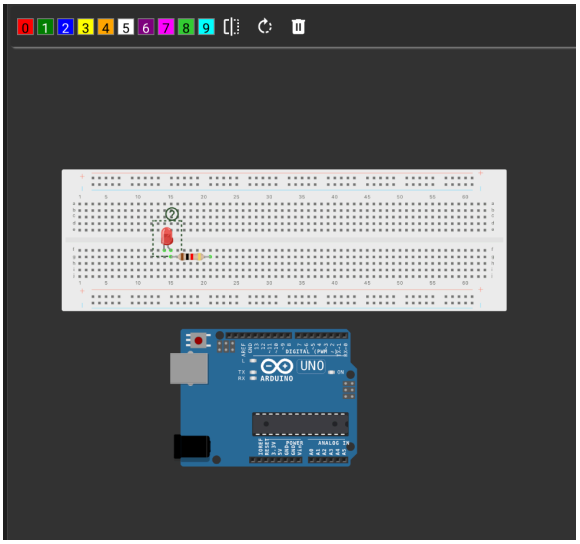
need illustration

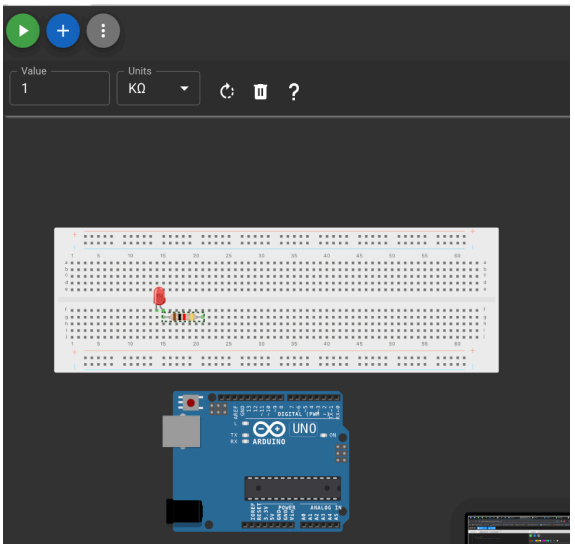
Step 12 :- When you click on any component, you'll notice a variety of options available for each one.

For instance, with the LED, you can select from different colours, change its appearance, rotate it, or delete it entirely.

Similarly, the resistor allows you to change its resistance value, rotate it, or delete it as well.

Feel free to experiment by clicking on these different options and observe the changes they make.





Let's Explore !

Understanding Electricity and Resistance:

Electricity involves the movement of tiny particles known as electrons through conductive mediums like wires.

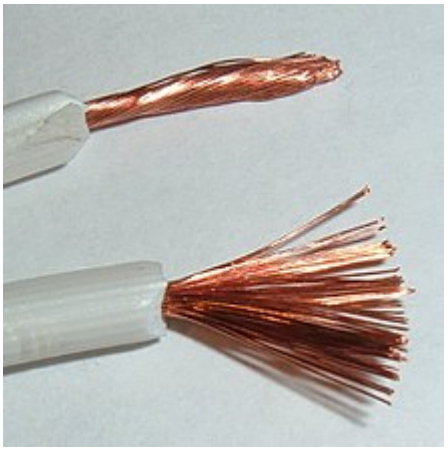
Resistance serves as a barrier to the flow of electricity. The resistance of a material effectively impedes the flow of electrons.

flowing electricity and resistance

Where do these things called electrons come from ?

Everything in this universe is made up of tiny building blocks called atoms - Even you and me. Each atom has even smaller particles inside it: protons, neutrons, and electrons. Protons have a positive charge, neutrons have no charge, and electrons have a negative charge. These electrons carry electrical energy from one place to another.

Wire zoomed atom



How do electrons carry electrical energy from one place to another ?

In an electrical circuit, we often refer to two points: the positive terminal and the negative terminal. These terms help us understand the flow of electricity. When we say something has a positive charge, it means it has an excess of positive particles called protons. Conversely, something with a negative charge has an excess of negative particles called **electrons.**

electric circuit

Consider a hill with water flowing from a higher point to a lower point. Due to gravity, water naturally moves downhill from where the (higher point) to the (lower point). This movement is driven by the force of gravity, which pulls the water downwards.

electric voltage

Now, let's relate this to electricity. Instead of water, think of tiny electric charges flowing from the positive to the negative terminal in a circuit. The positive terminal is like the top of the hill with lots of positive charges, and the negative terminal is like the bottom with lots of negative charges. This difference in "height," or potential, creates a force that pushes the electric charges through the circuit. We call this force **voltage.**

hill diagram

Now, let's think about how these electric charges move. Just like water flows downhill due to the force of gravity, electric charges move from the positive to the negative terminal in a circuit because of the force created by the voltage difference. This flow of electric charges is what we call **electric current.** Electric current is measured in units called amperes (amps), and it tells us how many electric charges are passing through a point in the circuit per second.

electric current

But what if there's something blocking the path, like a big rock on the hill? That's what we call **resistance** in electricity. It's like a barricade that slows down the flow of electric charges. Just like the rock stops the water, resistance limits the flow of electricity. So, when we connect the positive to the negative terminal, creating a pathway for the electric charges to flow, resistance can slow down this flow, just like a barricade on the hill slows down the water. Resistance is measured in units called Ohms similar to what we saw in wowki simulator.

blockage in river

Now, every material has its own unique way of allowing or resisting this flow of electrons. This property is called resistance. Imagine it like this: in some materials, such as metals like copper, the electrons can move freely, allowing electricity to flow easily. These materials have low resistance- so they are called conductors . But in other materials, like rubber or plastic, the electrons can't move as freely, so it's harder for electricity to pass through. These materials have high resistance and so they are called insulators.

conductors and insulators image

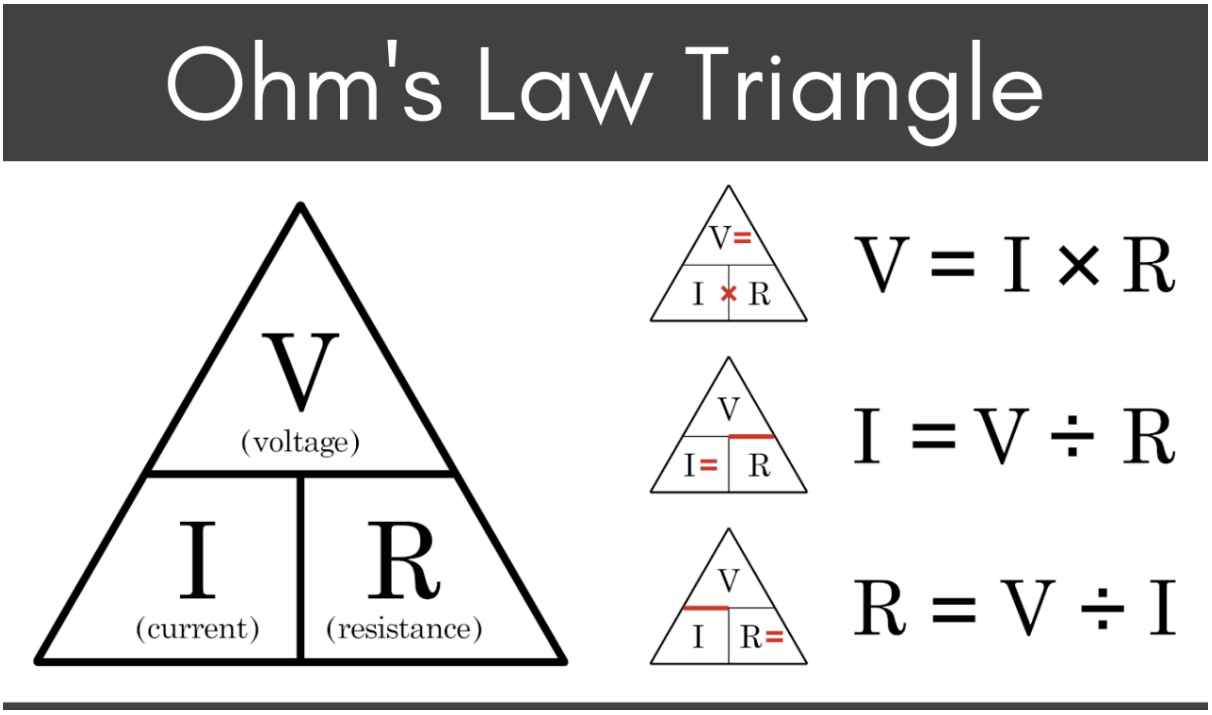
Did you know that there's a unique relationship between voltage, current and resistance?

This relationship between the voltage (V), current (I), and resistance (R) in an electrical circuit states that the current flowing through a conductor between two points is directly proportional to the voltage across the two points and inversely proportional to the resistance.

Mathematically, it is expressed as V = I * R,

where V is the voltage across the conductor,
I is the current flowing through the conductor,
and R is the resistance of the conductor.

You can also derive other formulas using the below triangle.



Now that we are done with the theory, let's jump to the practical side again and learn how to decide what will be the resistance value of our resistor.

.Since we know V= I x R

- "VLED" or "V" is the voltage across the LED (typically around 1.7 volts for a red LED).
- "I" is the desired current through the LED usually specified in milliamps, mA (This will be 15mA or 0.01A for our LED).

- “R” is the resistance value in ohms as we learnt before.

Note:- The supply voltage(Vsupply) coming from the arduino is 5V.

To find Voltage across resistor

VR = Vsupply − VLED = 5V−1.7V = 3.3V

Now, to find the value of resistance, let’s apply ohm’s law..

R = V ÷ I

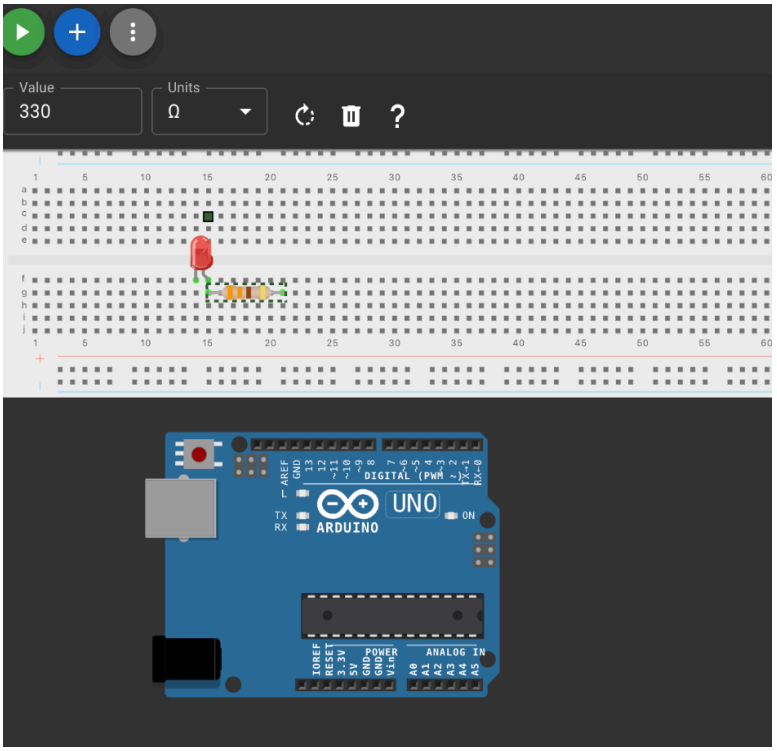
V here will be VR as we are calculating the value for the resistor.

R = VR ÷ I

R = 3.3 ÷ 0.01

R = 330 ohms

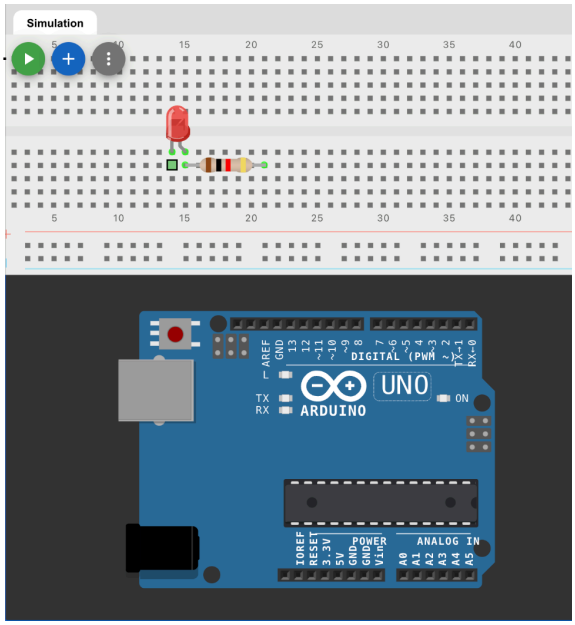
Step 13 :- Let’s change the value of resistance now to 330 and select units as ohms(Ω).



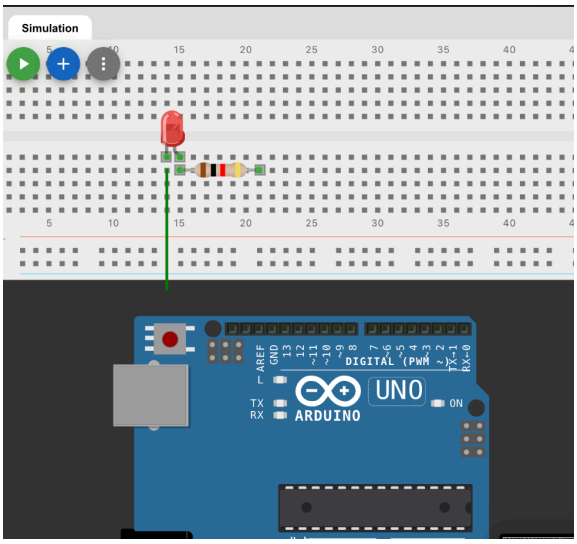
Step 14 :- Now that we are done with resistance, start with connecting the wires.

The first step is to make ground connections which means connecting LED’s ground to the Arduino's ground.

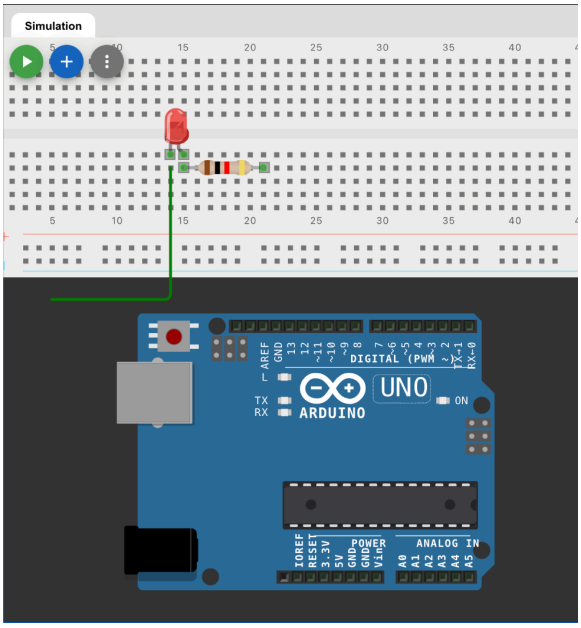
Just click on the hole below the LED, now you remember that the LED and the holes below it are connected to each other meaning if i can give ground to any of the holes below the LED, it will reach the LED.



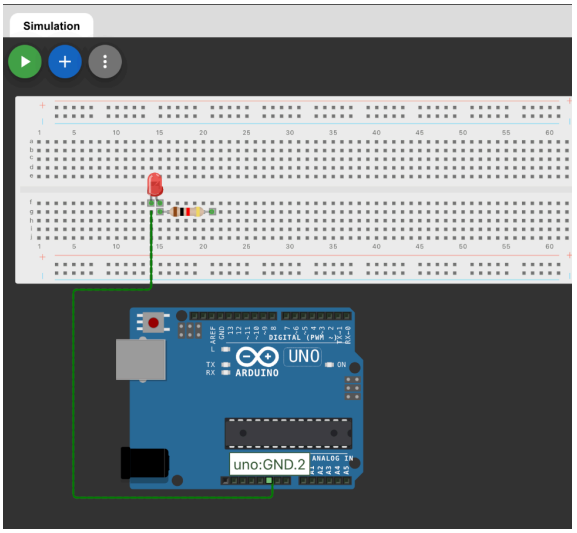
Step 15 :- After clicking, drag your mouse a little downwards and you will notice the wire extending.



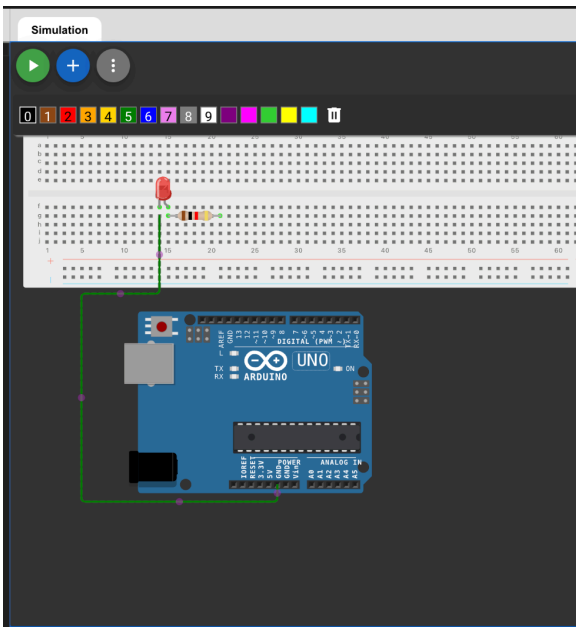
Step 16 :- Now click again and drag the wire to the left



Step 17 :- Elongate and connect wire to the GND pin.

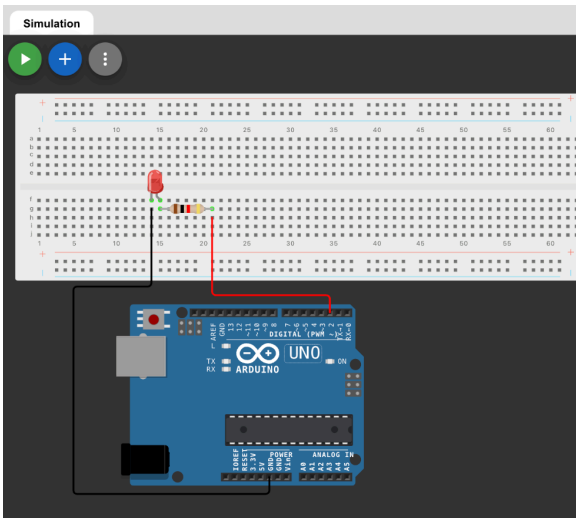


Step 18 :- Click on the wire and select the black box to change the wire colour to black.

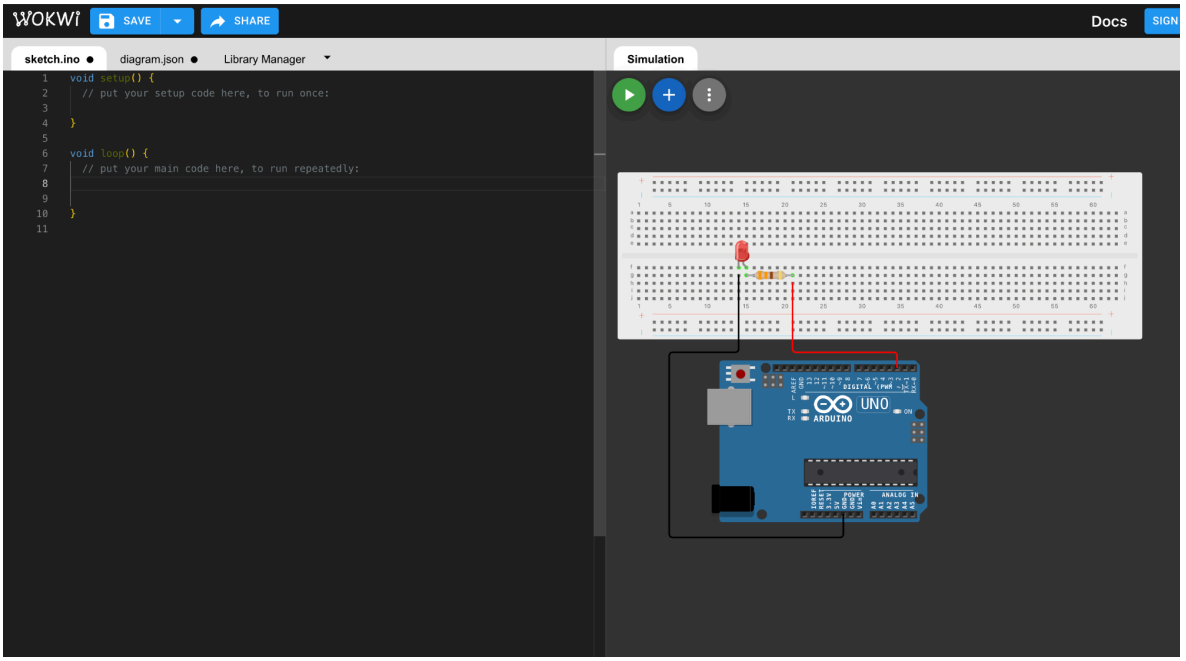


Step 19 :- Similarly, connect the wire from the resistor to pin 2.

Note:- Pin 1 to pin 13 are digital input/output pins which means that they can either take digital input or send digital output signals depending on how they are configured in code.



Step 20:- Now let's move on to the software part. You see the left section of the image is our Arduino sketch.



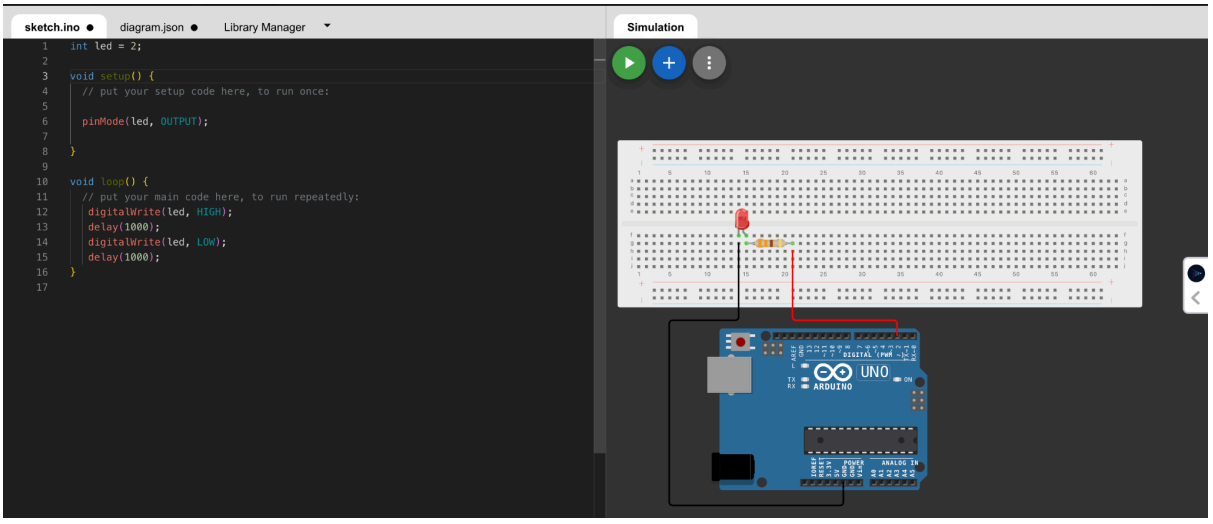
void setup():

- This part sets things up when the microcontroller starts or resets.
- We use it to get everything ready, like deciding what pins to use and any initial settings.
- It runs only once, and it goes from top to bottom, doing each thing one after the other.

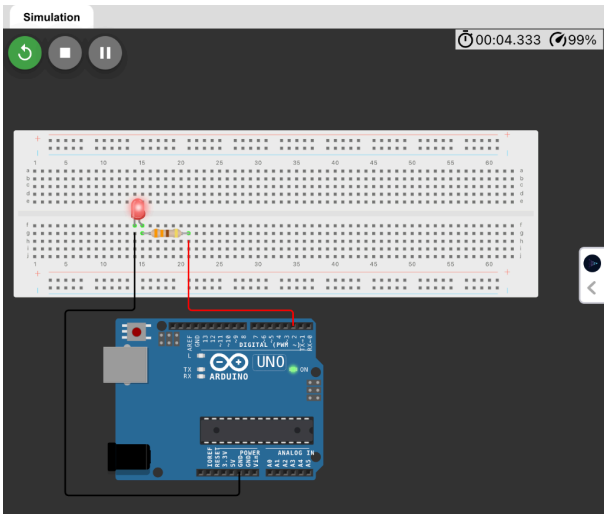
void loop():

- Once setup is done, this part keeps going over and over until we turn off or reset the microcontroller.
- Here, we put the main instructions or tasks we want the microcontroller to do repeatedly.
- It keeps doing whatever we put inside it, in a loop, until we stop it.

Step 21:- Write the below code as it is and click on the green coloured “start the simulation” button on the right side.



Step 22:- You should see the LED blink every one second. If not, you’ve probably made some mistake while writing the code. Check it again.



Now how is the code making the LED blink? Let's go through each line of the code and understand its purpose:

int led = 2;

We're saying that the pin connected to our LED is pin number 2.

void setup() {

This part is where we prepare things before we start doing our main job.

pinMode(led, OUTPUT);

Here, we're telling the Arduino that pin 2 will be used to send electricity out to control something, like our LED.

}

Remember to put the closing bracket. This tells Arduino that we're done setting up.

void loop() {

Now, we're going to start doing something over and over again.

digitalWrite(led, HIGH);

This turns on the LED connected to pin 2.

delay(1000);

We wait for 1000 milliseconds which is equal to 1 second before doing anything else.

digitalWrite(led, LOW);

This turns off the LED connected to pin 2.

delay(1000);

We wait for another 1 second before going back to the start of our loop.

}
Close this bracket to finish the loop function and start the loop again.