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# SunFounder 3in1 Kit

[www.sunfounder.com](http://www.sunfounder.com)

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# CONTENTS

<b>1</b>	<b>Learn about the Components in Your Kit</b>	<b>3</b>
1.1	SunFounder R3 Board . . . . .	4
1.2	ESP8266 Module . . . . .	6
1.3	Breadboard . . . . .	9
1.4	Resistor . . . . .	10
1.5	Capacitor . . . . .	13
1.6	Jumper Wires . . . . .	15
1.7	74HC595 . . . . .	15
1.8	LED . . . . .	17
1.9	RGB LED . . . . .	18
1.10	7-segment Display . . . . .	20
1.11	I2C LCD1602 . . . . .	23
1.12	Buzzer . . . . .	25
1.13	TT Motor . . . . .	26
1.14	Servo . . . . .	27
1.15	Centrifugal Pump . . . . .	30
1.16	L298N Module . . . . .	31
1.17	Button . . . . .	34
1.18	Reed Switch . . . . .	35
1.19	Potentiometer . . . . .	36
1.20	Joystick Module . . . . .	38
1.21	IR Receiver . . . . .	40
1.22	Photoresistor . . . . .	42
1.23	Thermistor . . . . .	43
1.24	DHT11 Humiture Sensor . . . . .	44
1.25	Line Tracking Module . . . . .	46
1.26	Soil Moisture Module . . . . .	47
1.27	Obstacle Avoidance Module . . . . .	49
1.28	Ultrasonic Module . . . . .	50
<b>2</b>	<b>Get Started with Arduino</b>	<b>53</b>
2.1	What is Arduino? . . . . .	53
2.2	What can Arduino do? . . . . .	53
2.3	How to build an Arduino Project . . . . .	54
<b>3</b>	<b>Download the Code</b>	<b>85</b>
<b>4</b>	<b>Basic Projects</b>	<b>87</b>
4.1	1. Digital Write . . . . .	87
4.2	2. Analog Write . . . . .	98

4.3	3. Digital Read . . . . .	106
4.4	4. Analog Read . . . . .	119
4.5	5. More Syntax . . . . .	134
4.6	6. Funny Project . . . . .	197
<b>5</b>	<b>Car Projects</b>	<b>221</b>
5.1	Assemble the Car . . . . .	221
5.2	1. Move . . . . .	236
5.3	2. Move by Code . . . . .	242
5.4	3. Speed Up . . . . .	246
5.5	4. Follow the line . . . . .	247
5.6	5. Play with Obstacle Avoidance Module . . . . .	251
5.7	6. Play with Ultrasonic Module . . . . .	255
5.8	7. Follow Your Hand . . . . .	258
5.9	8. Self-Driving Car . . . . .	260
5.10	9. Remote Control . . . . .	263
5.11	10. One Touch Start . . . . .	267
5.12	11. Speed Calibration . . . . .	269
<b>6</b>	<b>IoT Projects</b>	<b>273</b>
6.1	1. Get Started with Blynk . . . . .	274
6.2	2. Get Data from Blynk . . . . .	287
6.3	3. Push Data to Blynk . . . . .	296
6.4	4. Cloud Music Player . . . . .	301
6.5	5. Home Environment Monitoring . . . . .	307
6.6	6. Plant Monitor . . . . .	315
6.7	7. Current Limiting Gate . . . . .	322
6.8	8. IoT Car . . . . .	328
<b>7</b>	<b>Play with Scratch</b>	<b>337</b>
7.1	1.1 Install PictoBlox . . . . .	338
7.2	1.2 Interface Introduction . . . . .	339
7.3	1.3 Quick Guide on PictoBlox . . . . .	340
7.4	2.1 Table Lamp . . . . .	357
7.5	2.2 Breathing LED . . . . .	362
7.6	2.3 Colorful Balls . . . . .	370
7.7	2.4 LCD1602 . . . . .	378
7.8	2.5 Moving Mouse . . . . .	387
7.9	2.6 Doorbell . . . . .	394
7.10	2.7 Low Temperature Alarm . . . . .	401
7.11	2.8 Light Alarm Clock . . . . .	408
7.12	2.9 Read Temperature and Humidity . . . . .	415
7.13	2.10 Pendulum . . . . .	421
7.14	2.11 Rotating Fan . . . . .	430
7.15	2.12 Light Sensitive Ball . . . . .	437
7.16	2.13 GAME - Shooting . . . . .	450
7.17	2.14 GAME - Inflating the Balloon . . . . .	464
7.18	2.15 GAME - Star-Crossed . . . . .	473
7.19	2.16 GAME - Eat Apple . . . . .	482
7.20	2.17 GAME - Flappy Parrot . . . . .	493
7.21	2.18 GAME - Breakout Clone . . . . .	502
7.22	2.19 GAME - Fishing . . . . .	514
7.23	2.20 GAME - Don't Tap on The White Tile . . . . .	523
7.24	2.21 GAME - Protect Your Heart . . . . .	544

7.25	2.22 GAME - Kill Dragon . . . . .	561
7.26	3.1 Test the Car . . . . .	585
7.27	3.2 Movement . . . . .	590
7.28	3.3 Follow the line . . . . .	597
7.29	3.4 Follow Your Hand . . . . .	601
7.30	3.5 Obstacle avoidance . . . . .	605
7.31	3.6 Follow Your Hand 2 . . . . .	613
7.32	3.7 Obstacle avoidance 2 . . . . .	617
<b>8</b>	<b>Video Courses</b>	<b>623</b>
<b>9</b>	<b>FAQ</b>	<b>625</b>
9.1	How to use Blynk on mobile device? . . . . .	625
9.2	How to re-burn the firmware for ESP8266 module? . . . . .	627
<b>10</b>	<b>Thank You</b>	<b>637</b>
<b>11</b>	<b>Copyright Notice</b>	<b>639</b>



Thanks for choosing our 3 in 1 starter kit.

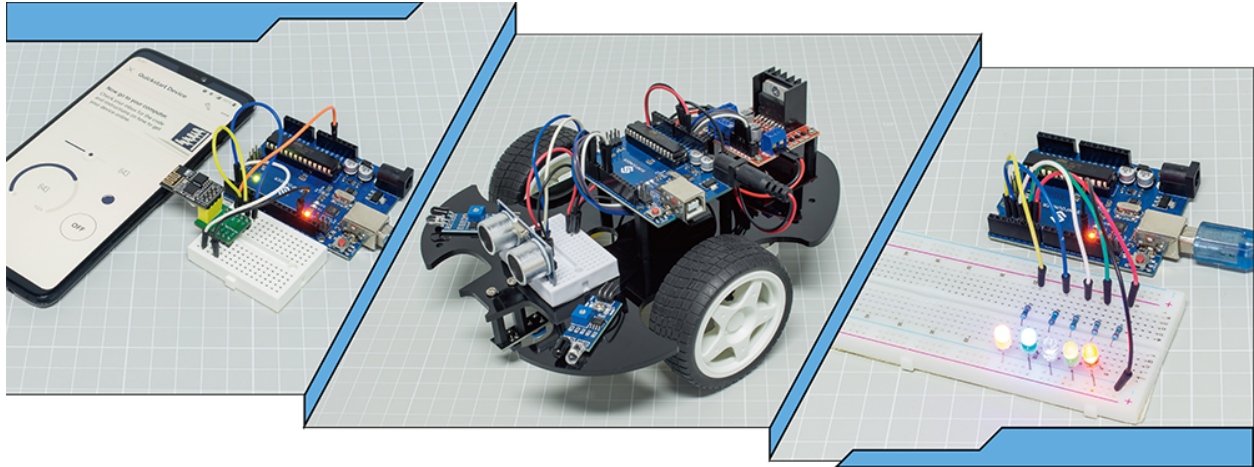
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**Note:** This document is available in the following languages.

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Please click on the respective links to access the document in your preferred language.

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When you bought a learning kit online, did it come with a simple PDF or booklet with only the steps to build the project?

Or maybe you want to build your own smart car, but the ones you find online are pricey and complicated

Or have you seen useful and interesting IoT projects made by others, but have no idea where to start?

All these problems can be solved with our 3 in 1 starter kit.

In the 3-in-1 starter kit, you will find a complete Arduino course to help beginners learn Arduino, as well as a wide variety of interesting projects that other learning kits do not offer, such as smart car projects and IoT projects. You will master Arduino as long as you follow the kit's course step by step, instead of just copying and pasting code, you will write your own code and implement your Arduino project however you like.

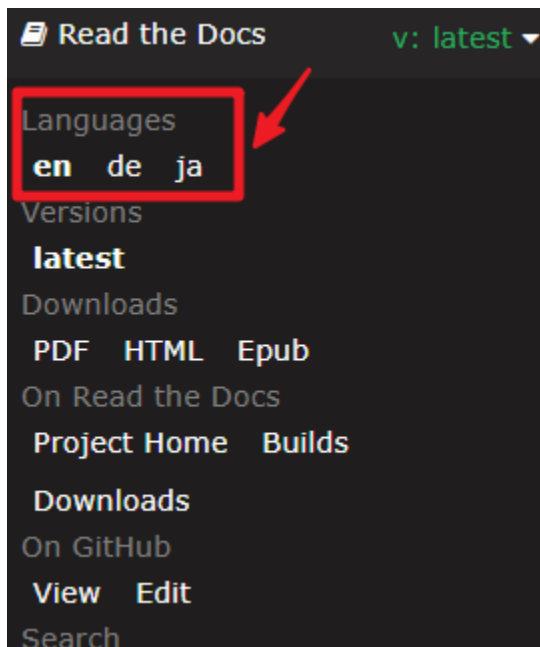
In addition, the kit also provides 30+ Scratch programming projects for younger students and enthusiasts, so beginners don't need any programming experience to write and make their own creations!

Come on! Start programing Arduino with confidence from zero to hero!

If you have any questions, please send an email to [service@sunfounder.com](mailto:service@sunfounder.com) and we will respond as soon as possible.

### **About the display language**

This document is available in other languages as well. To switch the display language, kindly click on the **Read the Docs** icon located in the lower left corner of the page.



Contents

## **LEARN ABOUT THE COMPONENTS IN YOUR KIT**

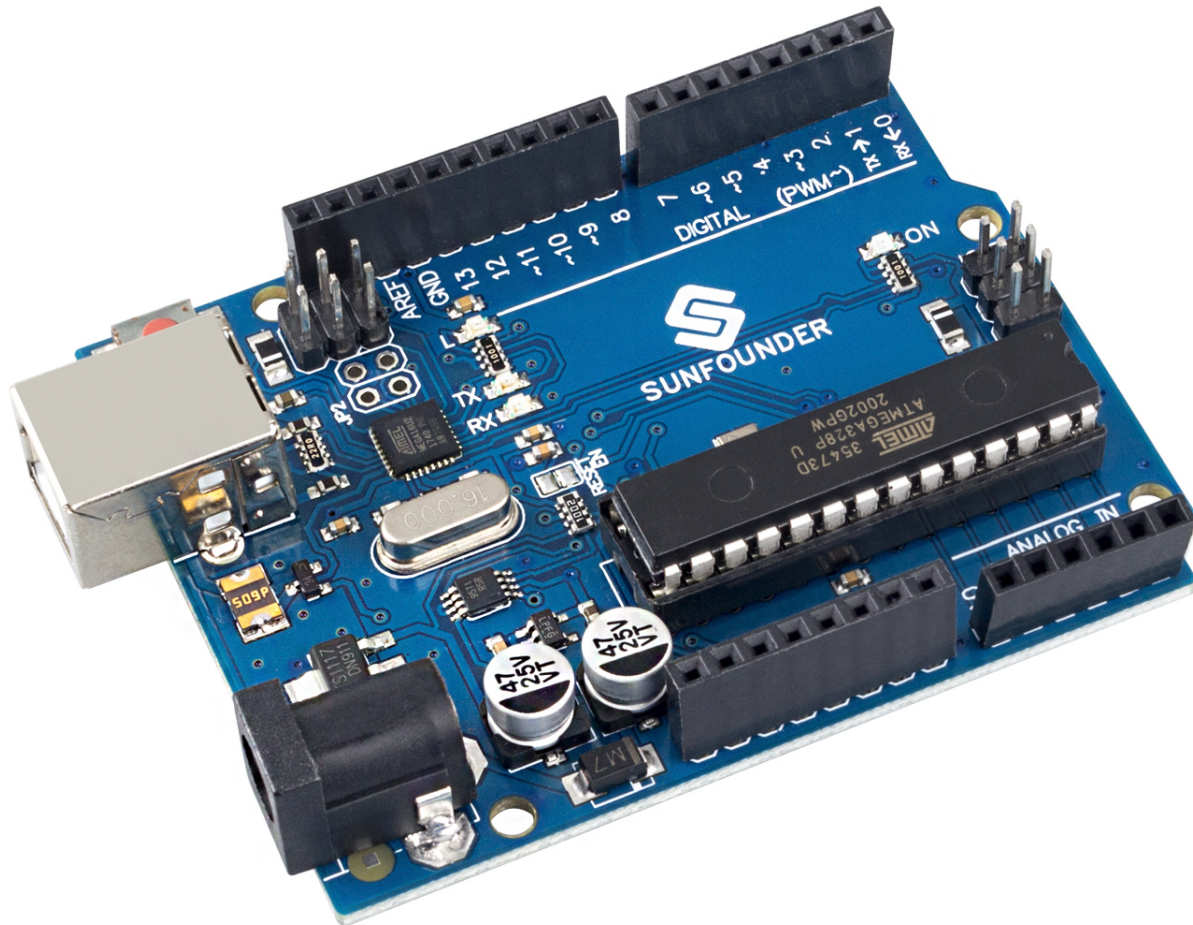
After opening the package, please check whether the quantity of components is compliance with product description and whether all components are in good condition.

- **3 in 1 Kit Components List**

Below is the introduction to each component, which contains the operating principle of the component and the corresponding projects.

### **Control Board**

## 1.1 SunFounder R3 Board



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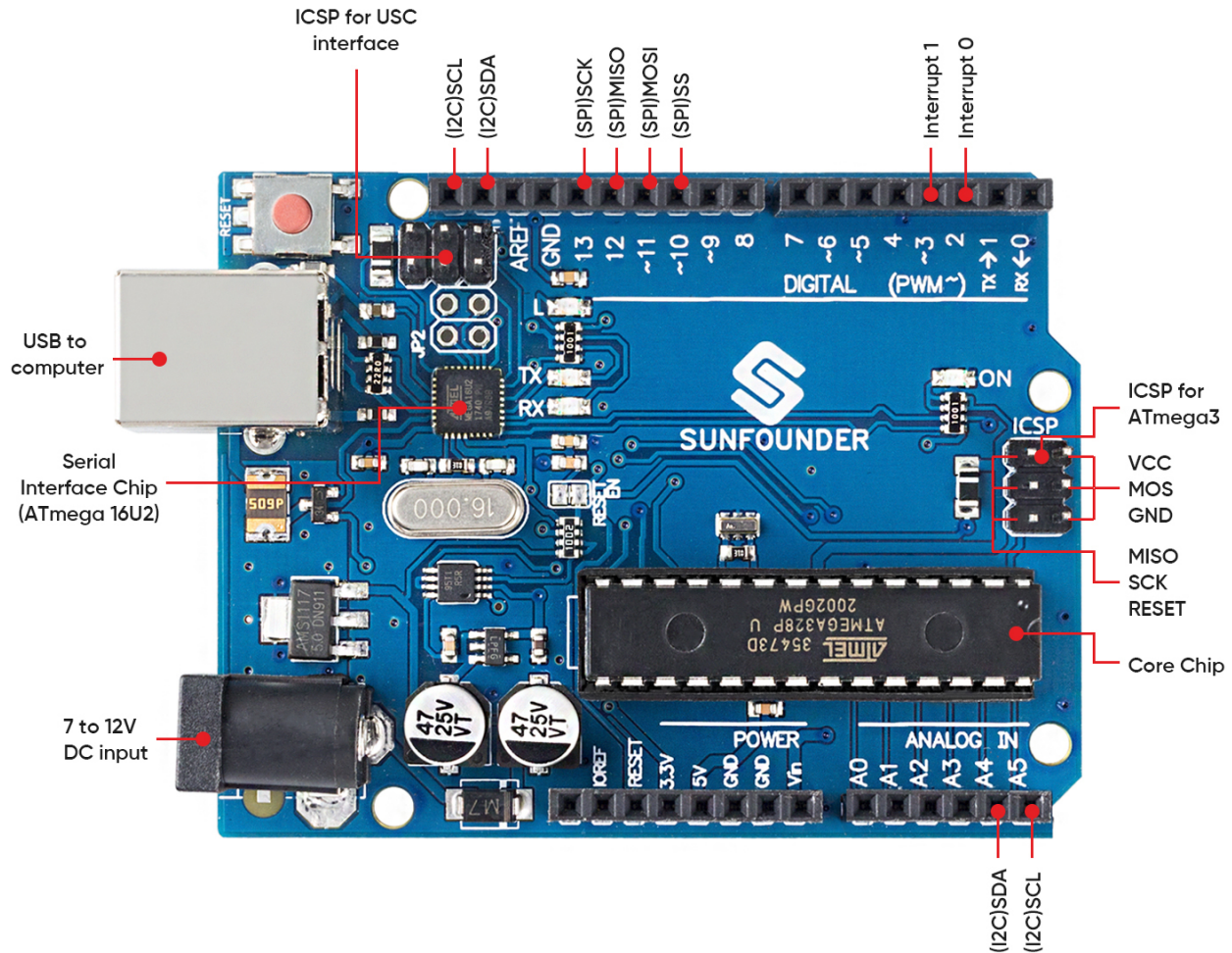
**Note:** The SunFounder R3 board is a mainboard with almost the same functions as the [Arduino Uno](#), and the two boards can be used interchangeably.

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SunFounder R3 board is a microcontroller board based on the ATmega328P ([datasheet](#)). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

### Technical Parameters





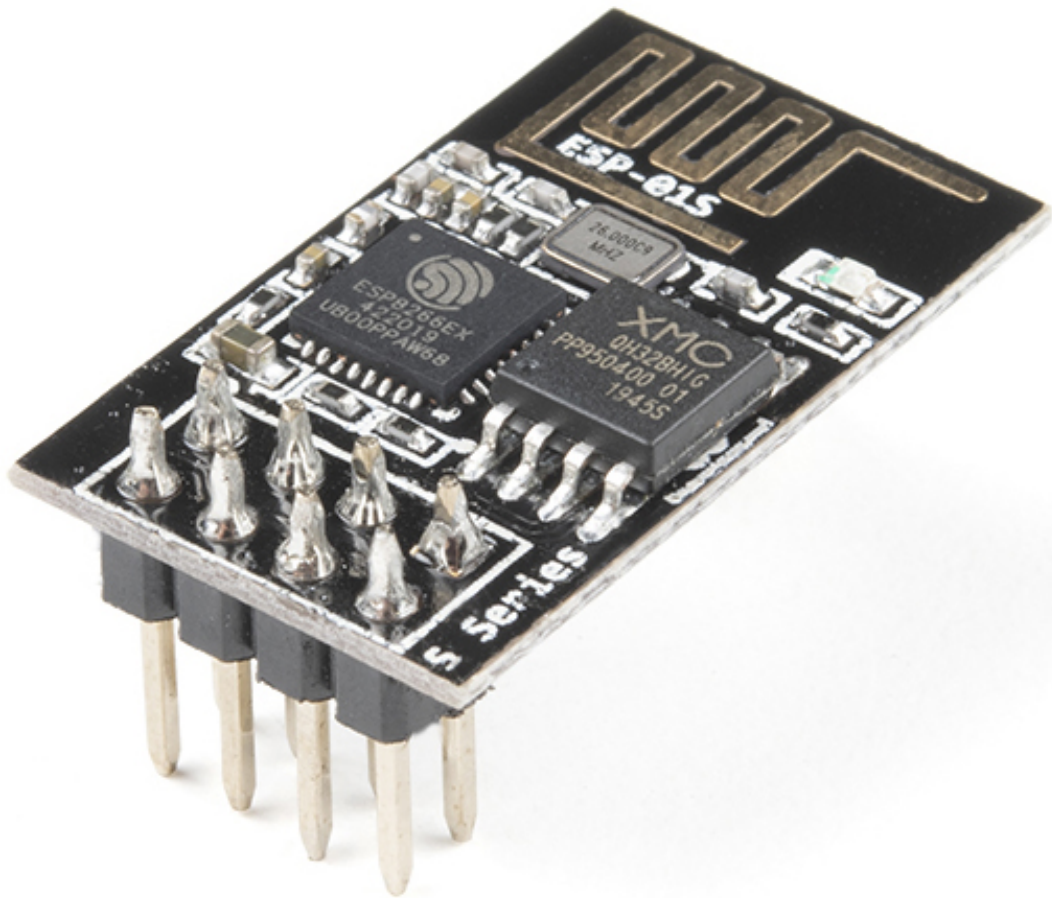
- MICROCONTROLLER: ATmega328P
- OPERATING VOLTAGE: 5V
- INPUT VOLTAGE (RECOMMENDED): 7-12V
- INPUT VOLTAGE (LIMIT): 6-20V
- DIGITAL I/O PINS: 14 (0-13, of which 6 provide PWM output(3, 5, 6, 9-11))
- PWM DIGITAL I/O PINS: 6 (3, 5, 6, 9-11)
- ANALOG INPUT PINS: 6 (A0-A5)
- DC CURRENT PER I/O PIN: 20 mA
- DC CURRENT FOR 3.3V PIN: 50 mA
- FLASH MEMORY: 32 KB (ATmega328P) of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328P)
- EEPROM: 1 KB (ATmega328P)
- CLOCK SPEED: 16 MHz
- LED\_BUILTIN: 13
- LENGTH: 68.6 mm

- WIDTH: 53.4 mm
- WEIGHT: 25 g
- I2C Port: A4(SDA), A5(SCL)

### What's More

- [Arduino IDE](#)
- [Arduino Programming Language Reference](#)
- [Download and Install Arduino IDE 2.0](#)
- [ATmega328P Datasheet](#)

## 1.2 ESP8266 Module



The ESP8266 is a low-cost Wi-Fi microchip, with built-in TCP/IP networking software, and microcontroller capability, produced by Espressif Systems in Shanghai, China.

The chip first came to the attention of Western makers in August 2014 with the ESP-01 module, made by a third-party manufacturer Ai-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. However, at first, there was almost no English-language documentation on the chip and the commands it accepted. The very low price and the fact that there were very few external components on the module, which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, the chip, and the software on it, as well as to translate the Chinese documentation.

Pins of ESP8266 and their functions:

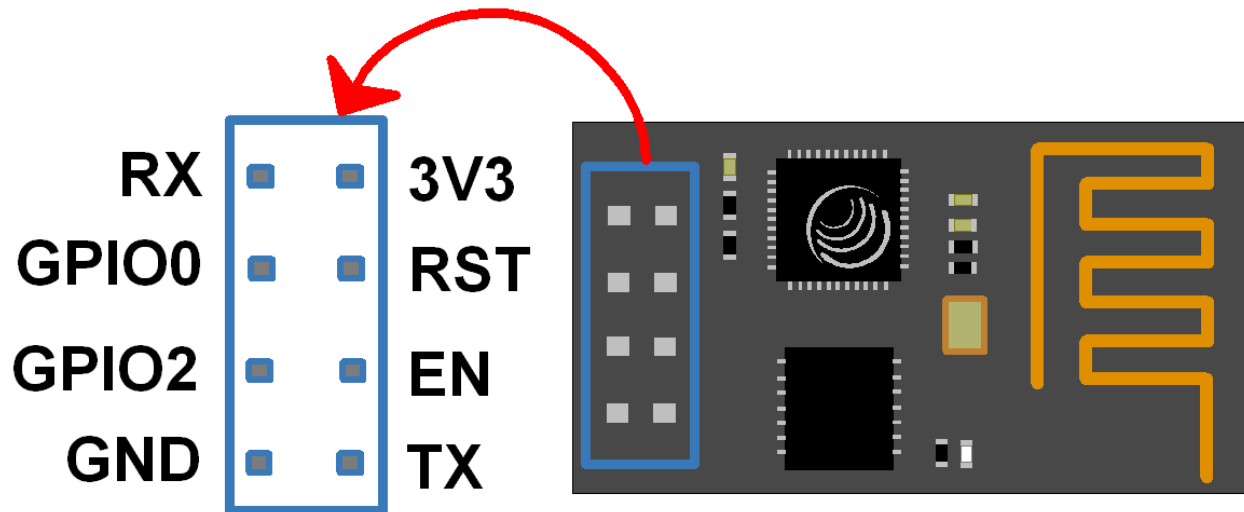
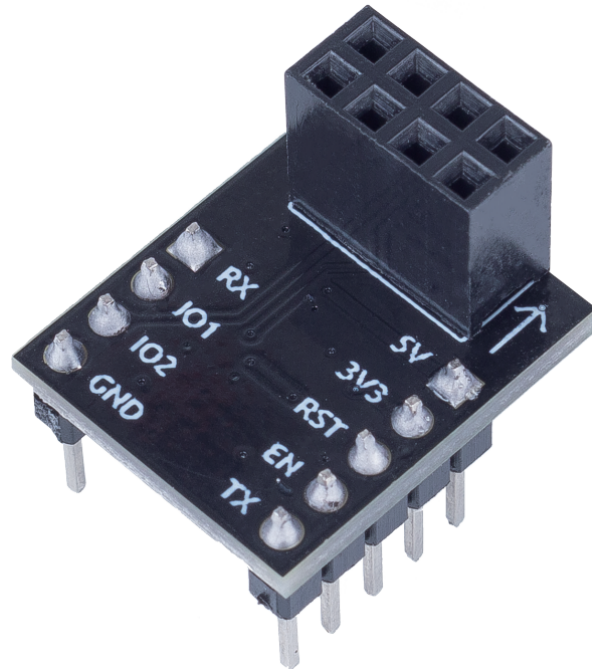


Table 1: ESP8266-01 Pins

Pin	Name	Description
1	TXD	UART_TXD, sending; General Purpose Input/Output: GPIO1; Pull-down is not allowed when startup.
2	GND	GND
3	CU_PD	Working at high level; Power off when low level is supplied.
4	GPIO2	It should be high level when power on, hardware pull-down is not allowed; Pull-up by default;
5	RST	External Reset signal, reset when low level is supplied; work when high level is supplied (high level by default);
6	GPIO0	WiFi Status indicator; Operation mode selection: Pull-up: Flash Boot, operation mode; Pull-down: UART Download, download mode
7	VCC	Power Supply(3.3V)
8	RXD	UART_RXDReceiving; General Purpose Input/Output: GPIO3;

- [ESP8266 - Espressif](#)
- [ESP8266 AT Instruction Set](#)

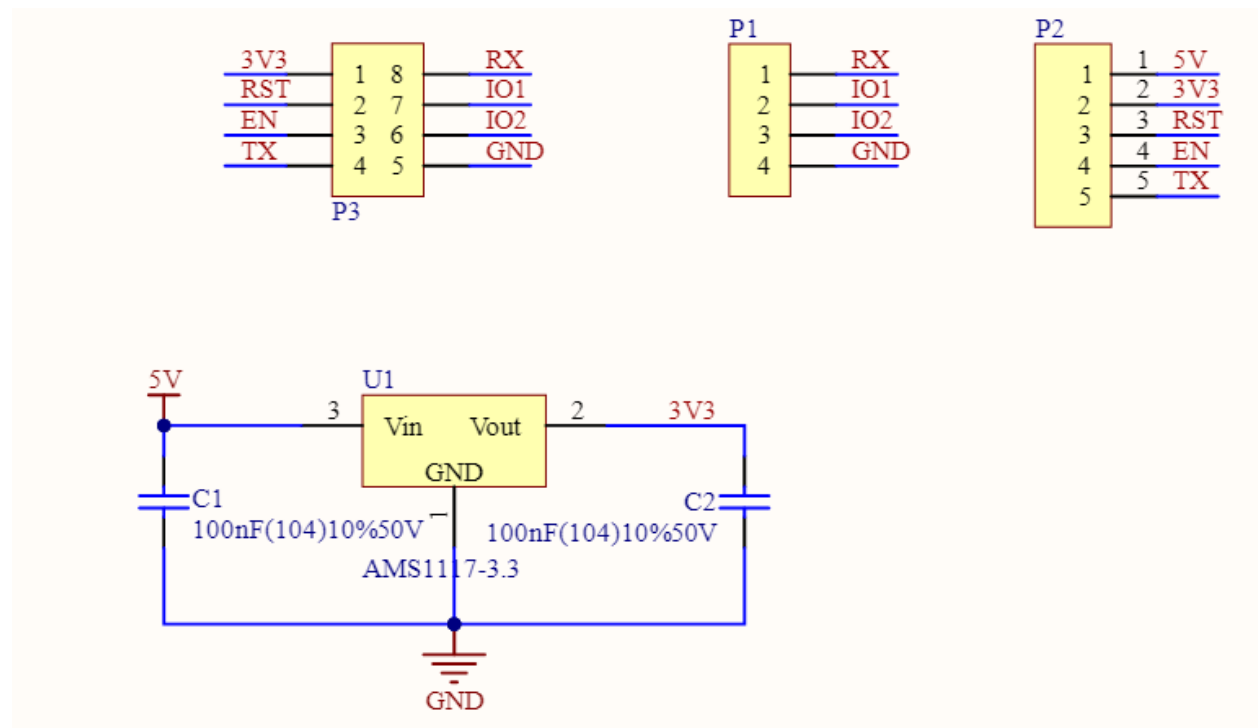
### 1.2.1 ESP8266 Adapter



The ESP8266 adapter is an expansion board that allows the ESP8266 module to be used on a breadboard.

It perfectly matches the pins of the ESP8266 itself, and also adds a 5V pin to receive the voltage from the Arduino board. The integrated AMS1117 chip is used to drive the ESP8266 module after dropping the voltage to 3.3V.

The schematic diagram is as follows:

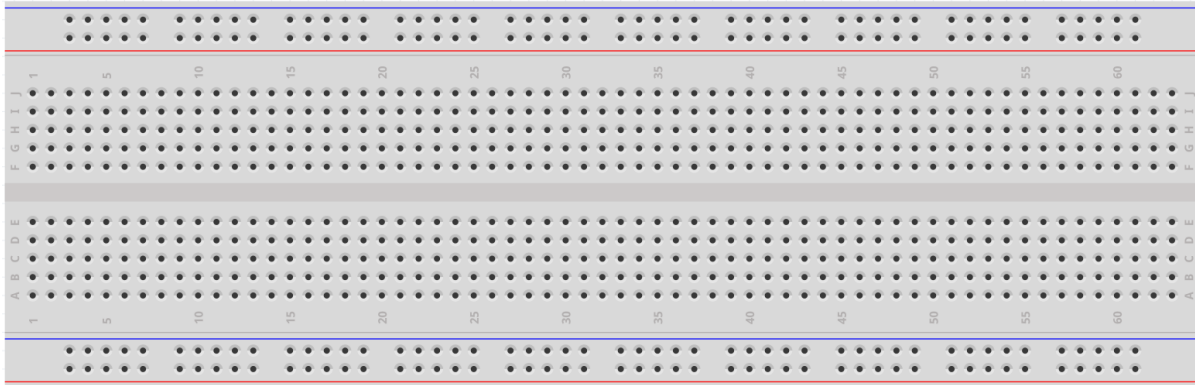


**Example**

- *IoT Projects* (IoT Project)

## Basic

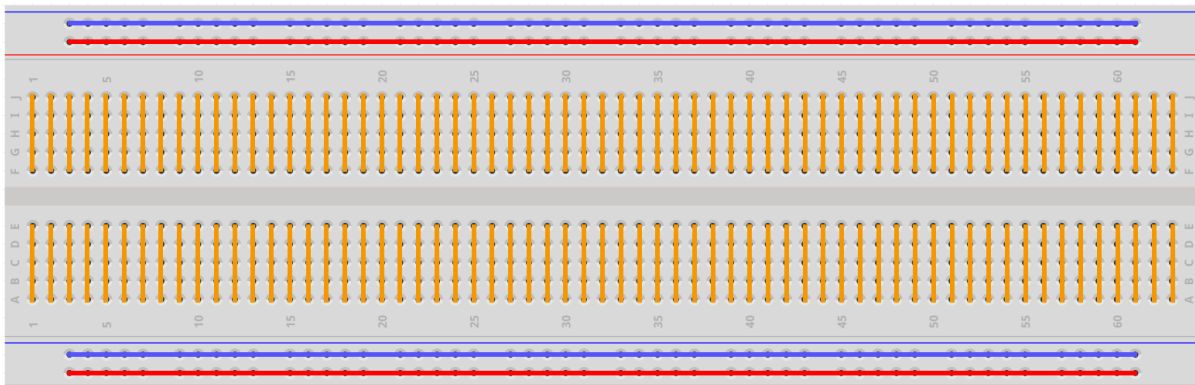
### 1.3 Breadboard



A breadboard is a construction base for prototyping of electronics. Originally the word referred to a literal bread board, a polished piece of wood used for slicing bread.[1] In the 1970s the solderless breadboard (a.k.a. plugboard, a terminal array board) became available and nowadays the term “breadboard” is commonly used to refer to these.

It is used to build and test circuits quickly before finishing any circuit design. And it has many holes into which components mentioned above can be inserted like ICs and resistors as well as jumper wires. The breadboard allows you to plug in and remove components easily.

The picture shows the internal structure of a breadboard. Although these holes on the breadboard appear to be independent of each other, they are actually connected to each other through metal strips internally.



If you want to know more about breadboard, refer to: [How to Use a Breadboard - Science Buddies](#)

## 1.4 Resistor



Resistor is an electronic element that can limit the branch current. A fixed resistor is a kind of resistor whose resistance cannot be changed, while that of a potentiometer or a variable resistor can be adjusted.

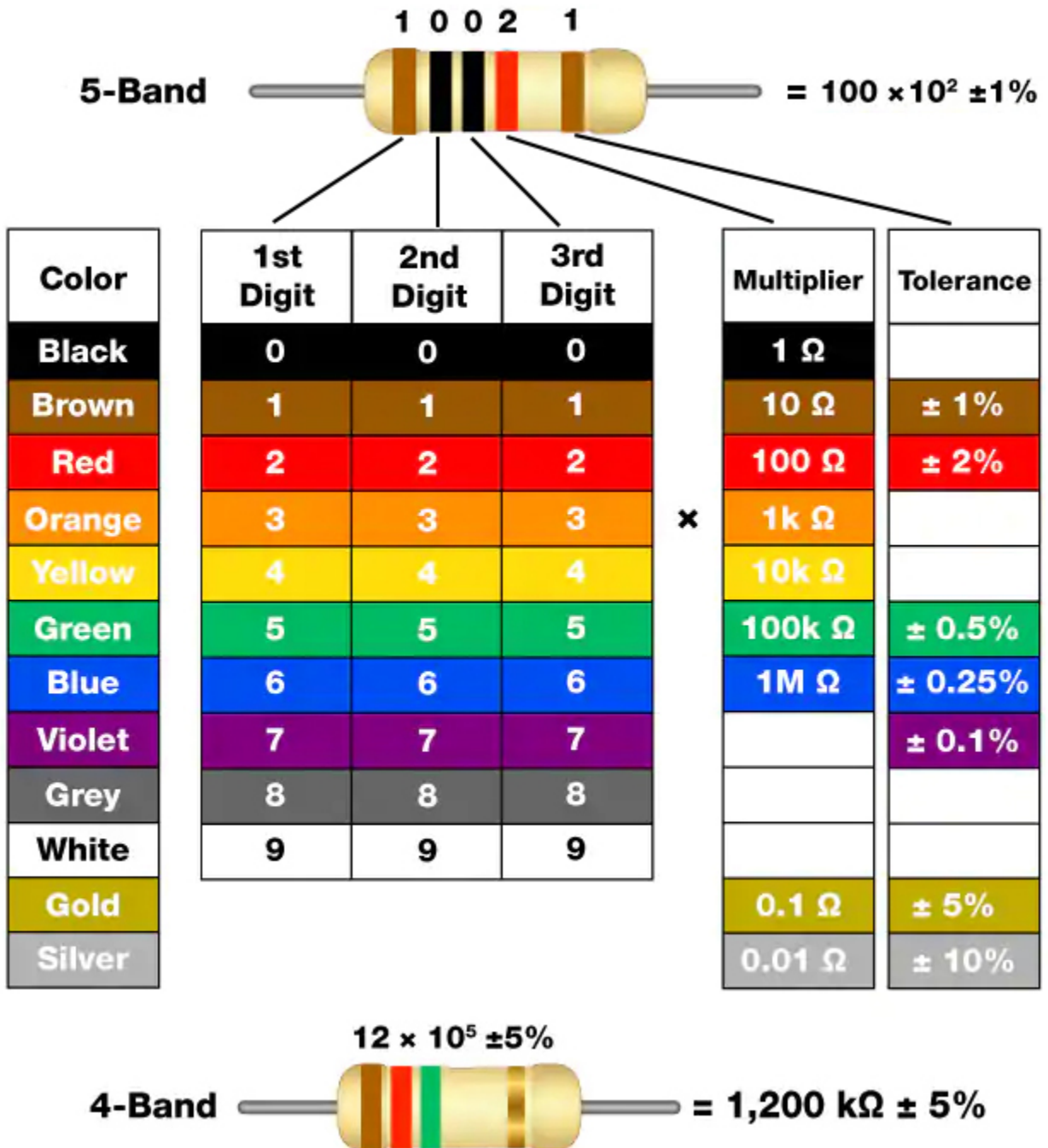
Two generally used circuit symbols for resistor. Normally, the resistance is marked on it. So if you see these symbols in a circuit, it stands for a resistor.



$\Omega$  is the unit of resistance and the larger units include K, M, etc. Their relationship can be shown as follows: 1 M=1000 K, 1 K = 1000  $\Omega$ . Normally, the value of resistance is marked on it.

When using a resistor, we need to know its resistance first. Here are two methods: you can observe the bands on the resistor, or use a multimeter to measure the resistance. You are recommended to use the first method as it is more convenient and faster.





As shown in the card, each color stands for a number.

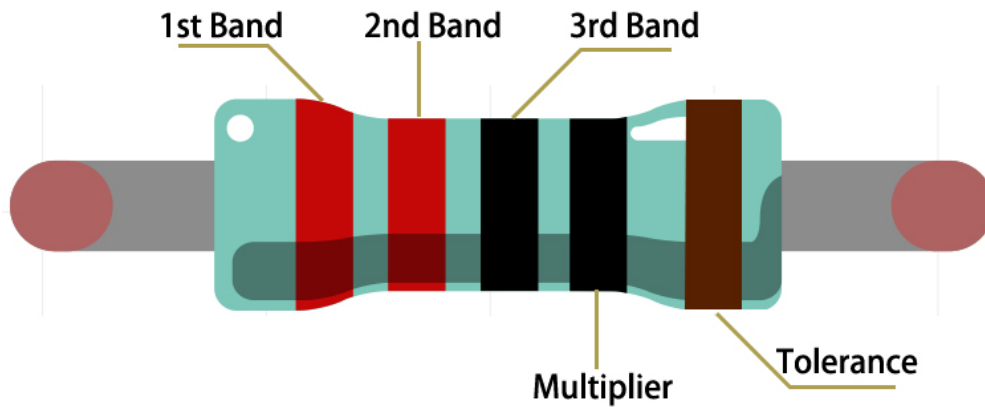
Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Grey	White	Gold	Silver
0	1	2	3	4	5	6	7	8	9	0.1	0.01

The 4- and 5-band resistors are frequently used, on which there are 4 and 5 chromatic bands.

Normally, when you get a resistor, you may find it hard to decide which end to start for reading the color. The tip is that the gap between the 4th and 5th band will be comparatively larger.

Therefore, you can observe the gap between the two chromatic bands at one end of the resistor; if it's larger than any other band gaps, then you can read from the opposite side.

Let's see how to read the resistance value of a 5-band resistor as shown below.



So for this resistor, the resistance should be read from left to right. The value should be in this format: 1st Band 2nd Band 3rd Band  $\times 10^{\text{Multiplier}}$  and the permissible error is  $\pm \text{Tolerance}\%$ . So the resistance value of this resistor is 2(red) 2(red) 0(black)  $\times 10^0(\text{black}) = 220$ , and the permissible error is  $\pm 1\%$  (brown).

You can learn more about resistor from Wiki: [Resistor - Wikipedia](#).



## 1.5 Capacitor





Capacitor, refers to the amount of charge storage under a given potential difference, denoted as  $C$ , and the international unit is farad (F). Generally speaking, electric charges move under force in an electric field. When there is a medium between conductors, the movement of electric charges is hindered and the electric charges accumulate on the conductors, resulting in accumulation of electric charges.

The amount of stored electric charges is called capacitance. Because capacitors are one of the most widely used electronic components in electronic equipment, they are widely used in direct current isolation, coupling, bypass, filtering, tuning loops, energy conversion, and control circuits. Capacitors are divided into electrolytic capacitors, solid capacitors, etc.

According to material characteristics, capacitors can be divided into: aluminum electrolytic capacitors, film capacitors, tantalum capacitors, ceramic capacitors, super capacitors, etc.

In this kit, ceramic capacitors and electrolytic capacitors are used.

- [Ceramic Capacitor - Wikipedia](#)
- [Electrolytic Capacitor - Wikipedia](#)

There are 103 or 104 label on the ceramic capacitors, which represent the capacitance value, 103= $10 \times 10^3 \text{pF}$ , 104= $10 \times 10^4 \text{pF}$

#### **Unit Conversion**

$$1\text{F}=10^3\text{mF}=10^6\mu\text{F}=10^9\text{nF}=10^{12}\text{pF}$$

#### **Example**

- [2.6 Doorbell](#) (Scratch Project)
- [2.16 GAME - Eat Apple](#) (Scratch Project)
- [2.19 GAME - Fishing](#) (Scratch Project)

## 1.6 Jumper Wires

Wires that connect two terminals are called jumper wires. There are various kinds of jumper wires. Here we focus on those used in breadboard. Among others, they are used to transfer electrical signals from anywhere on the breadboard to the input/output pins of a microcontroller.

Jump wires are fitted by inserting their “end connectors” into the slots provided in the breadboard, beneath whose surface there are a few sets of parallel plates that connect the slots in groups of rows or columns depending on the area. The “end connectors” are inserted into the breadboard, without soldering, in the particular slots that need to be connected in the specific prototype.

There are three types of jumper wire: Female-to-Female, Male-to-Male, and Male-to-Female. The reason we call it Male-to-Female is because it has the outstanding tip in one end as well as a sunk female end. Male-to-Male means both side are male and Female-to-Female means both ends are female.

Male-to-Female



Male-to-Male



Female-to-Female



More than one type of them may be used in a project. The color of the jump wires is different but it doesn't mean their function is different accordingly; it's just designed so to better identify the connection between each circuit.

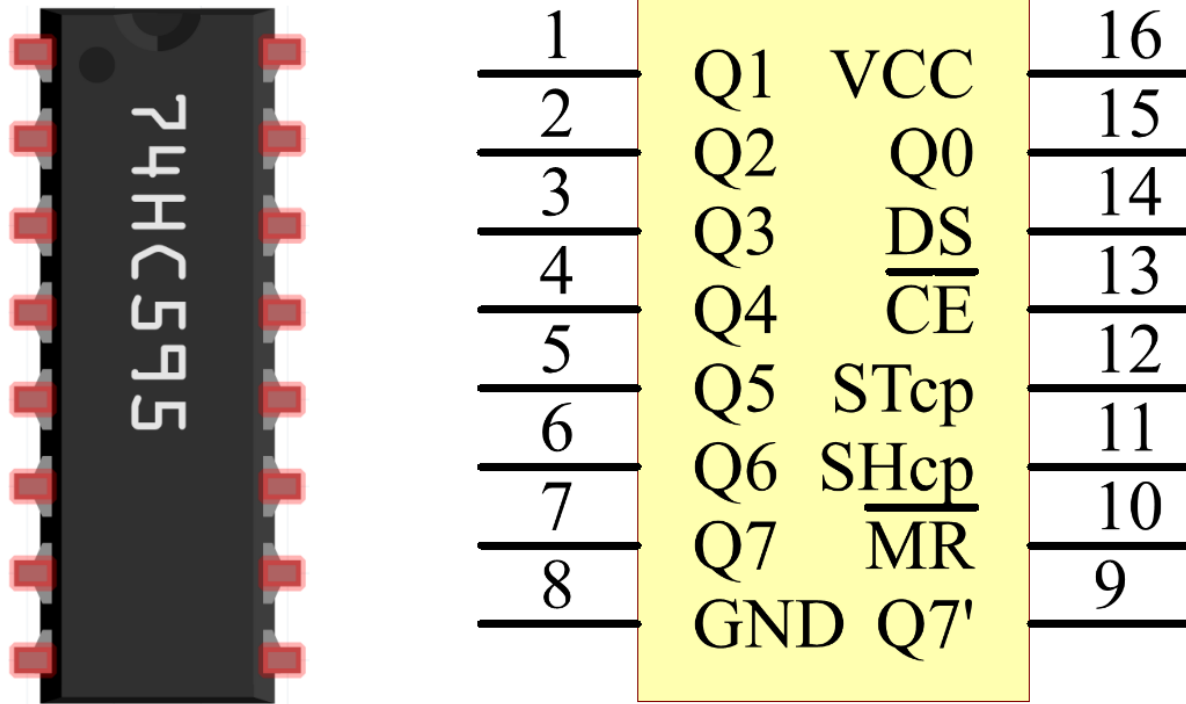
### Chip

## 1.7 74HC595



The 74HC595 consists of an 8bit shift register and a storage register with threestate parallel outputs. It converts serial input into parallel output so you can save IO ports of an MCU. When MR (pin10) is high level and OE (pin13) is low level, data is input in the rising edge of SHcp and goes to the memory register through the rising edge of SHcp. If the two clocks are connected together, the shift register is always one pulse earlier than the memory register. There is a serial shift input pin (Ds), a serial output pin (Q) and an asynchronous reset button (low level) in the memory register. The memory register outputs a Bus with a parallel 8-bit and in three states. When OE is enabled (low level), the data in memory register is output to the bus.

- [74HC595 Datasheet](#)



Pins of 74HC595 and their functions:

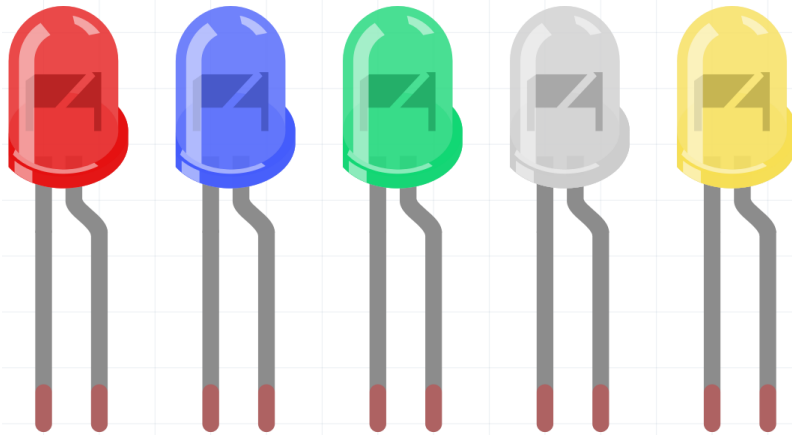
- **Q0-Q7**: 8-bit parallel data output pins, able to control 8 LEDs or 8 pins of 7-segment display directly.
- **Q7'**: Series output pin, connected to DS of another 74HC595 to connect multiple 74HC595s in series
- **MR**: Reset pin, active at low level;
- **SHcp**: Time sequence input of shift register. On the rising edge, the data in shift register moves successively one bit, i.e. data in Q1 moves to Q2, and so forth. While on the falling edge, the data in shift register remain unchanged.
- **STcp**: Time sequence input of storage register. On the rising edge, data in the shift register moves into memory register.
- **CE**: Output enable pin, active at low level.
- **DS**: Serial data input pin
- **VCC**: Positive supply voltage.
- **GND**: Ground.

#### Example

- [5.9 ShiftOut\(LED\)](#) (Basic Project)
- [5.10 ShiftOut\(Segment Display\)](#) (Basic Project)
- [7. Current Limiting Gate](#) (IoT Project)

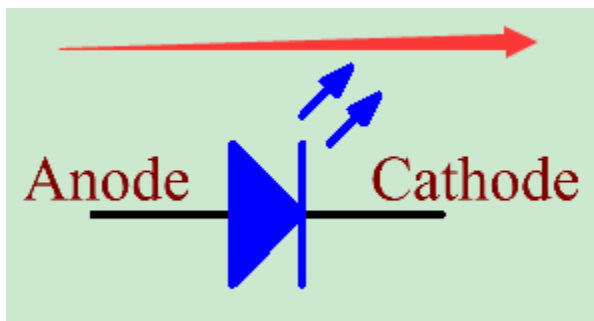
#### Display

## 1.8 LED



Semiconductor light-emitting diode is a type of component which can turn electric energy into light energy via PN junctions. By wavelength, it can be categorized into laser diode, infrared light-emitting diode and visible light-emitting diode which is usually known as light-emitting diode (LED).

Diode has unidirectional conductivity, so the current flow will be as the arrow indicates in figure circuit symbol. You can only provide the anode with a positive power and the cathode with a negative. Thus the LED will light up.



An LED has two pins. The longer one is the anode, and shorter one, the cathode. Pay attention not to connect them inversely. There is fixed forward voltage drop in the LED, so it cannot be connected with the circuit directly because the supply voltage can outweigh this drop and cause the LED to be burnt. The forward voltage of the red, yellow, and green LED is 1.8 V and that of the white one is 2.6 V. Most LEDs can withstand a maximum current of 20 mA, so we need to connect a current limiting resistor in series.

The formula of the resistance value is as follows:

$$R = (V_{\text{supply}} - V_D) / I$$

**R** stands for the resistance value of the current limiting resistor, **V<sub>supply</sub>** for voltage supply, **V<sub>D</sub>** for voltage drop and **I** for the working current of the LED.

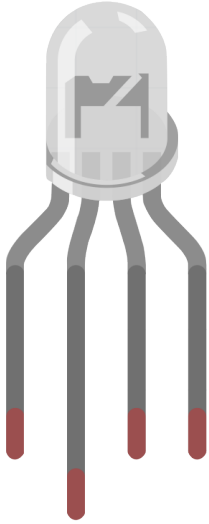
Here is the detailed introduction for the LED: [LED - Wikipedia](#).

### Example

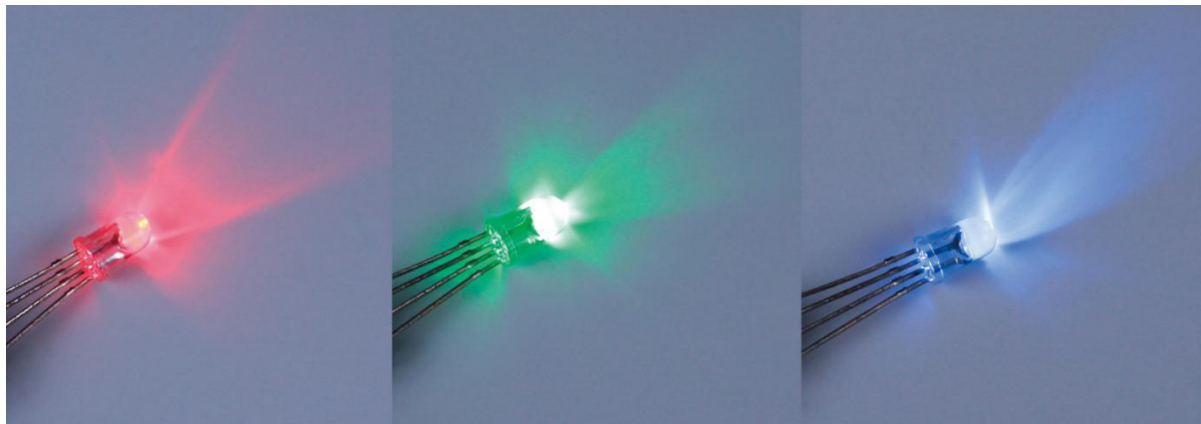
- [1.1 Hello, LED!](#) (Basic Project)
- [2.1 Fading](#) (Basic Project)
- [2. Get Data from Blynk](#) (IoT Project)
- [2.2 Breathing LED](#) (Scratch Project)

- 2.1 *Table Lamp* (Scratch Project)

### 1.9 RGB LED

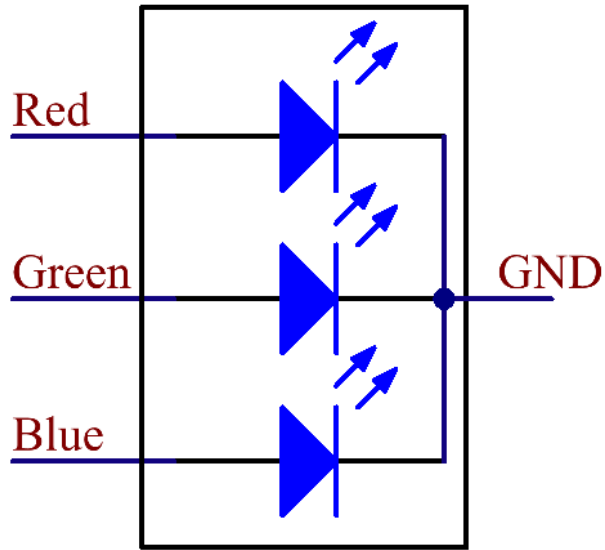


RGB LEDs emit light in various colors. An RGB LED packages three LEDs of red, green, and blue into a transparent or semitransparent plastic shell. It can display various colors by changing the input voltage of the three pins and superimpose them, which, according to statistics, can create 16,777,216 different colors.

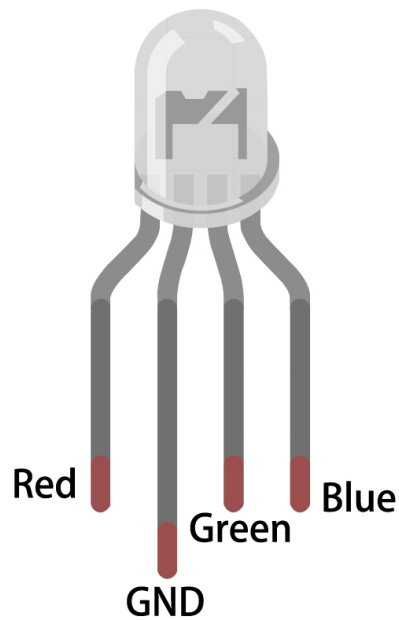


RGB LEDs can be categorized into common anode and common cathode ones. In this kit, the latter is used. The **common cathode**, or CC, means to connect the cathodes of the three LEDs. After you connect it with GND and plug in the three pins, the LED will flash the corresponding color.

Its circuit symbol is shown as figure.



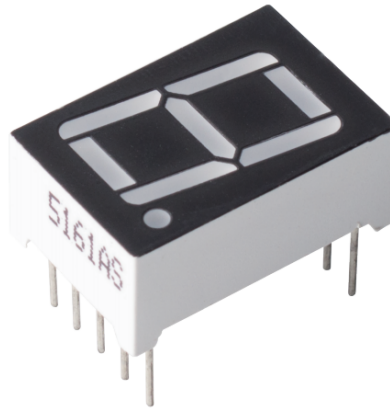
An RGB LED has 4 pins: the longest one is GND; the others are Red, Green and Blue. Touch its plastic shell and you will find a cut. The pin closest to the cut is the first pin, marked as Red, then GND, Green and Blue in turn.



#### Example

- [2.2 Colorful Light](#) (Basic Project)
- [5.2 Threshold](#) (Basic Project)
- [2.3 Colorful Balls](#) (Scratch Project)

## 1.10 7-segment Display

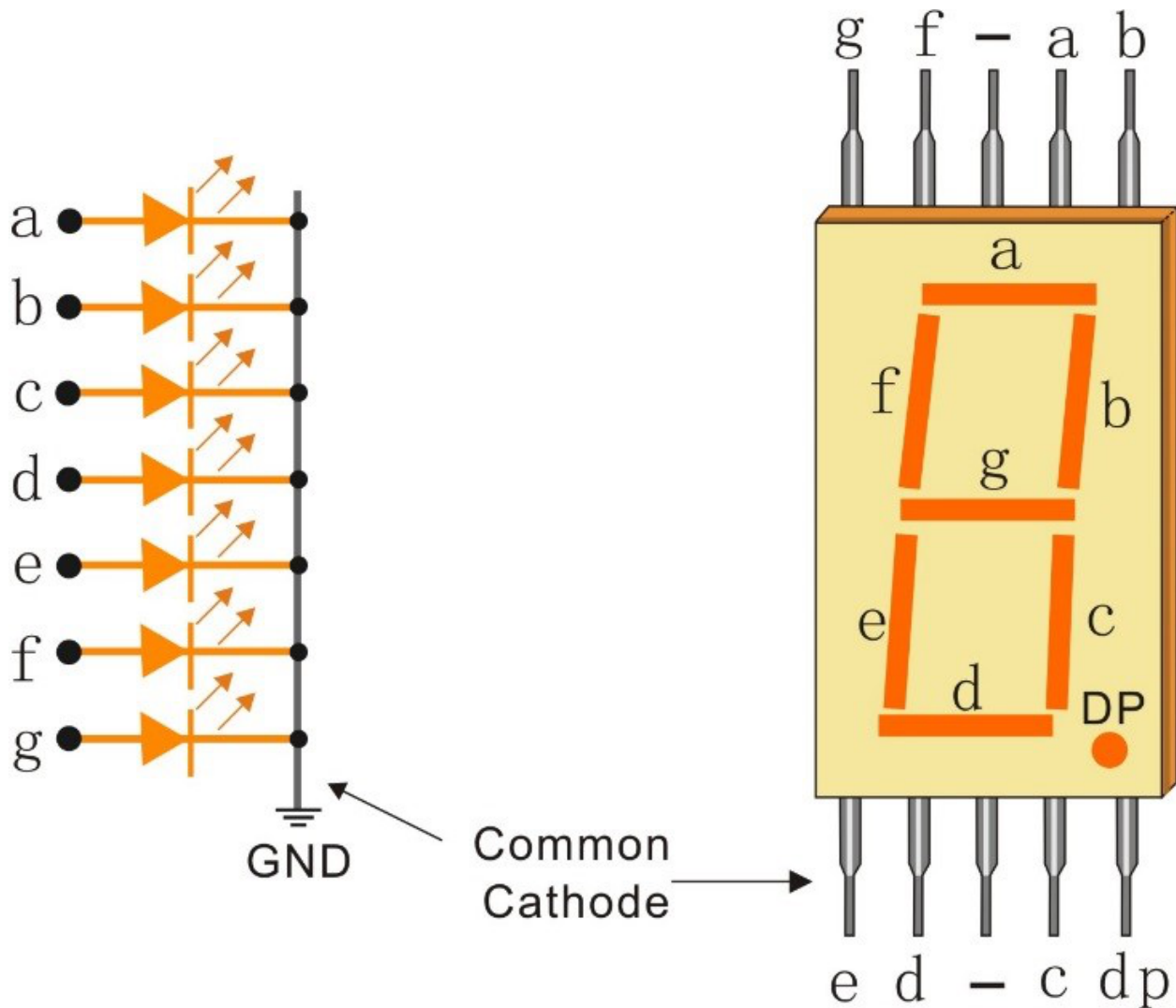


A 7-segment display is an 8-shaped component which packages 7 LEDs. Each LED is called a segment - when energized, one segment forms part of a numeral to be displayed.

There are two types of pin connection: Common Cathode (CC) and Common Anode (CA). As the name suggests, a CC display has all the cathodes of the 7 LEDs connected when a CA display has all the anodes of the 7 segments connected.

In this kit, we use the Common Cathode 7-segment display, here is the electronic symbol.





Each of the LEDs in the display is given a positional segment with one of its connection pins led out from the rectangular plastic package. These LED pins are labeled from “a” through to “g” representing each individual LED. The other LED pins are connected together forming a common pin. So by forward biasing the appropriate pins of the LED segments in a particular order, some segments will brighten and others stay dim, thus showing the corresponding character on the display.

#### Display Codes

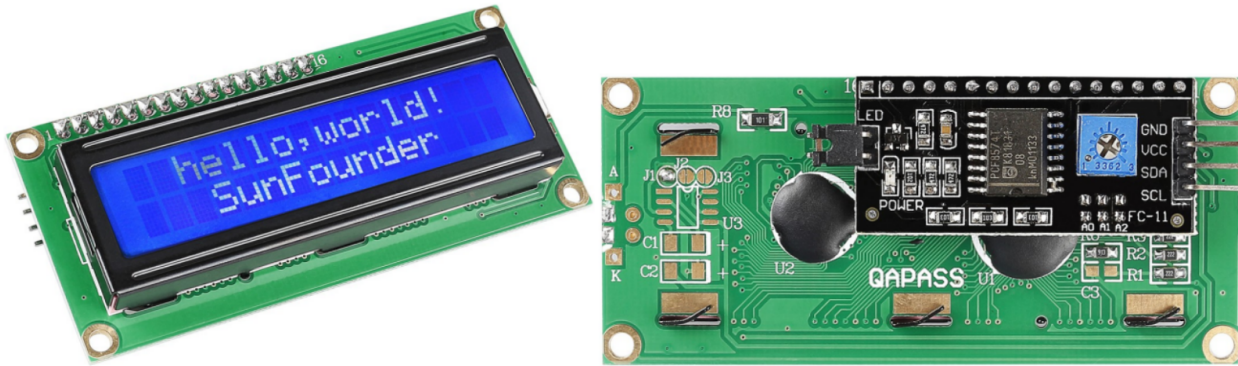
To help you get to know how 7-segment displays(Common Cathode) display Numbers, we have drawn the following table. Numbers are the number 0-F displayed on the 7-segment display; (DP) GFEDCBA refers to the corresponding LED set to 0 or 1, For example, 00111111 means that DP and G are set to 0, while others are set to 1. Therefore, the number 0 is displayed on the 7-segment display, while HEX Code corresponds to hexadecimal number.

Numbers	Common Cathode		Numbers	Common Cathode	
	(DP)GFEDCBA	Hex Code		(DP)GFEDCBA A	Hex Code
0	00111111	0x3f	A	01110111	0x77
1	00000110	0x06	B	01111100	0x7c
2	01011011	0x5b	C	00111001	0x39
3	01001111	0x4f	D	01011110	0x5e
4	01100110	0x66	E	01111001	0x79
5	01101101	0x6d	F	01110001	0x71
6	01111101	0x7d			
7	00000111	0x07			
8	01111111	0x7f			
9	01101111	0x6f			

**Example**

- *5.15 EEPROM* (Basic Project)
- *7. Current Limiting Gate* (IoT Project)

## 1.11 I2C LCD1602



- **GND:** Ground
- **VCC:** Voltage supply, 5V.
- **SDA:** Serial data line. Connect to VCC through a pullup resistor.
- **SCL:** Serial clock line. Connect to VCC through a pullup resistor.

As we all know, though LCD and some other displays greatly enrich the man-machine interaction, they share a common weakness. When they are connected to a controller, multiple IOs will be occupied of the controller which has no so many outer ports. Also it restricts other functions of the controller.

Therefore, LCD1602 with an I2C module is developed to solve the problem. The I2C module has a built-in PCF8574 I2C chip that converts I2C serial data to parallel data for the LCD display.

- [PCF8574 Datasheet](#)

### I2C Address

The default address is basically 0x27, in a few cases it may be 0x3F.

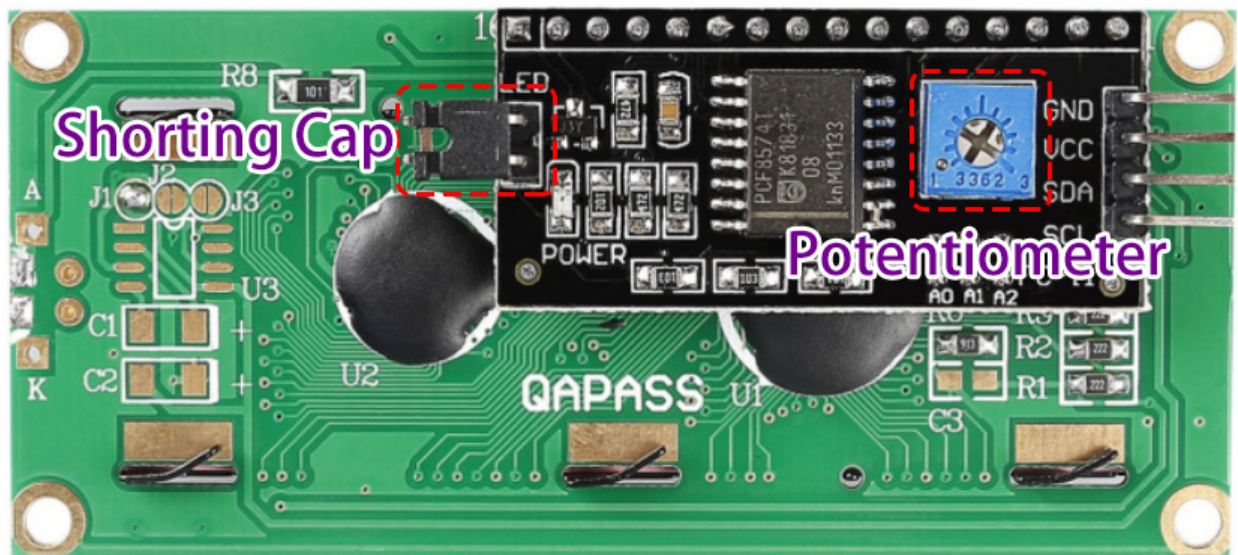
Taking the default address of 0x27 as an example, the device address can be modified by shorting the A0/A1/A2 pads; in the default state, A0/A1/A2 is 1, and if the pad is shorted, A0/A1/A2 is 0.

## Slave Address

Slave Address								
0	0	1	0	0	A2	A1	A0	
0	0	1	0	0	1	1	1	0x27
0	0	1	0	0	1	1	0	0x26
0	0	1	0	0	1	0	1	0x25
0	0	1	0	0	0	1	1	0x23
.....								
0	0	1	0	0	0	0	0	0x20

### Backlight/Contrast

Backlight can be enabled by jumper cap, unplug the jumper cap to disable the backlight. The blue potentiometer on the back is used to adjust the contrast (the ratio of brightness between the brightest white and the darkest black).



- **Shorting Cap:** Backlight can be enabled by this cap, unplug this cap to disable the backlight.
- **Potentiometer:** It is used to adjust the contrast (the clarity of the displayed text), which is increased in the clockwise direction and decreased in the counterclockwise direction.

**Example**

- *5.11.1 Liquid Crystal Display* (Basic Project)
- *5.12 Serial Read* (Basic Project)

**Sound****1.12 Buzzer**

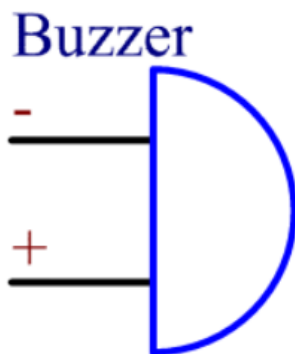
As a type of electronic buzzer with an integrated structure, buzzers, which are supplied by DC power, are widely used in computers, printers, photocopiers, alarms, electronic toys, automotive electronic devices, telephones, timers and other electronic products or voice devices.

Buzzers can be categorized as active and passive ones (see the following picture). Turn the buzzer so that its pins are facing up, and the buzzer with a green circuit board is a passive buzzer, while the one enclosed with a black tape is an active one.

The difference between an active buzzer and a passive buzzer:

An active buzzer has a built-in oscillating source, so it will make sounds when electrified. But a passive buzzer does not have such source, so it will not beep if DC signals are used; instead, you need to use square waves whose frequency is between 2K and 5K to drive it. The active buzzer is often more expensive than the passive one because of multiple built-in oscillating circuits.

The following is the electrical symbol of a buzzer. It has two pins with positive and negative poles. With a + in the surface represents the anode and the other is the cathode.



You can check the pins of the buzzer, the longer one is the anode and the shorter one is the cathode. Please don't mix them up when connecting, otherwise the buzzer will not make sound.

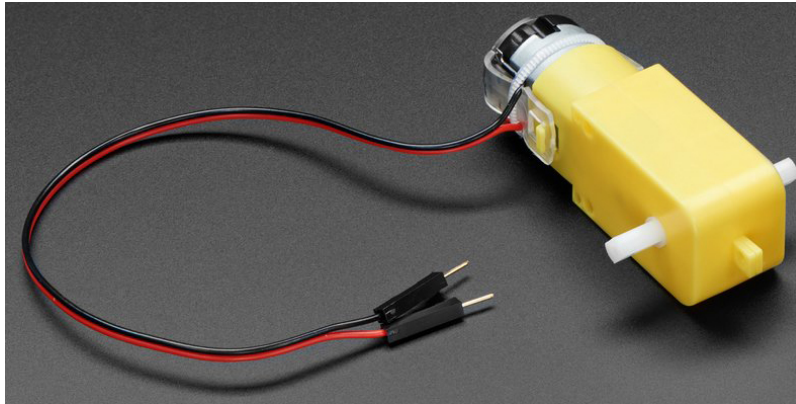
Buzzer - Wikipedia

### Example

- [1.2 Beep](#) (Basic Project)
- [5.7 Tone\(\) or noTone\(\)](#) (Basic Project)
- [4. Cloud Music Player](#) (IoT Project)

### Driver

## 1.13 TT Motor



This is a TT DC gearbox motor with a gear ratio of 1:48, it comes with 2 x 200mm wires with 0.1" male connectors that fit into a breadboard. Perfect for plugging into a breadboard or terminal block.

You can power these motors with 3 ~ 6VDC, but of course, they will go a little faster at higher voltages.

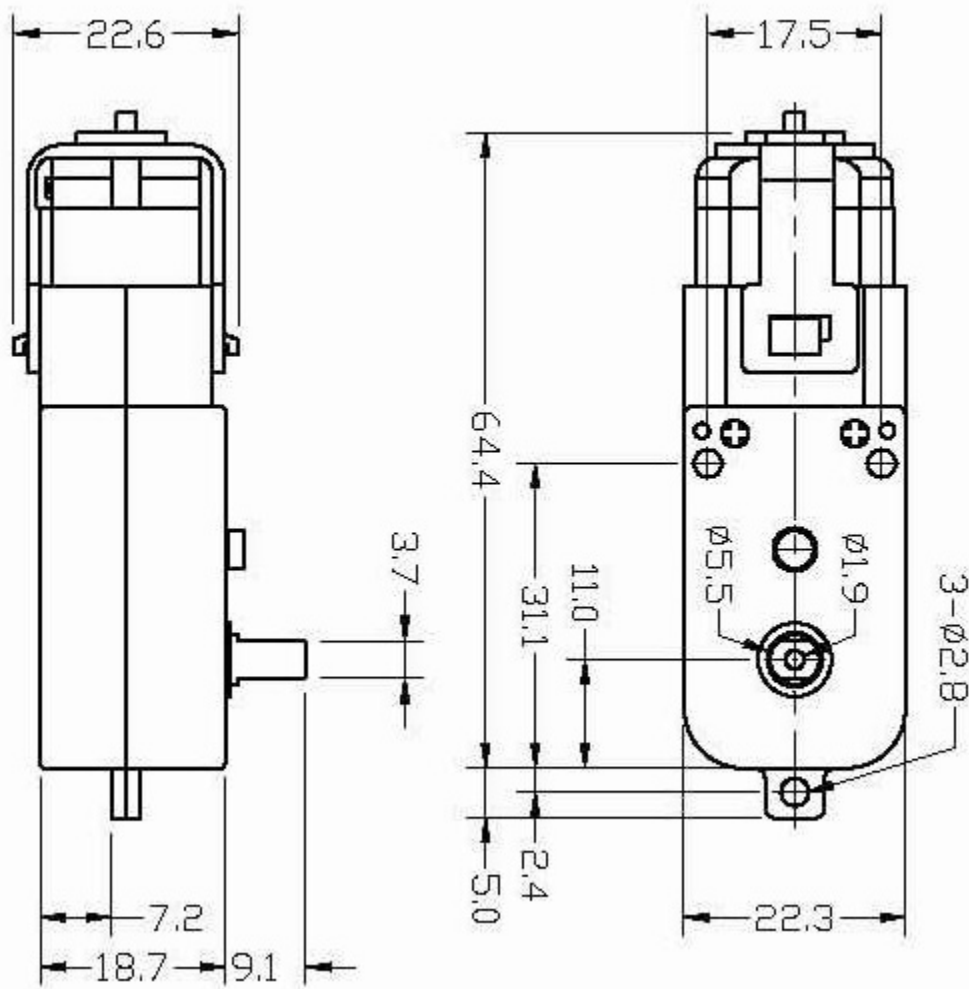
Note that these are very basic motors with no built-in encoder, speed control or position feedback. The voltage goes in and the spin comes out. There will be variation from motor to motor, so if you need precise motion, you'll need a separate feedback system.

### Technical Details

- Rated Voltage: 3~6V
- Continuous No-Load Current: 150mA +/- 10%
- Min. Operating Speed (3V): 90+/- 10% RPM
- Min. Operating Speed (6V): 200+/- 10% RPM
- Stall Torque (3V): 0.4kg.cm
- Stall Torque (6V): 0.8kg.cm
- Gear Ratio: 1:48
- Body Dimensions: 70 x 22 x 18mm
- Wires Length: 200mm & 28 AWG
- Weight: 30.6g

### Dimensional Drawing





### Example

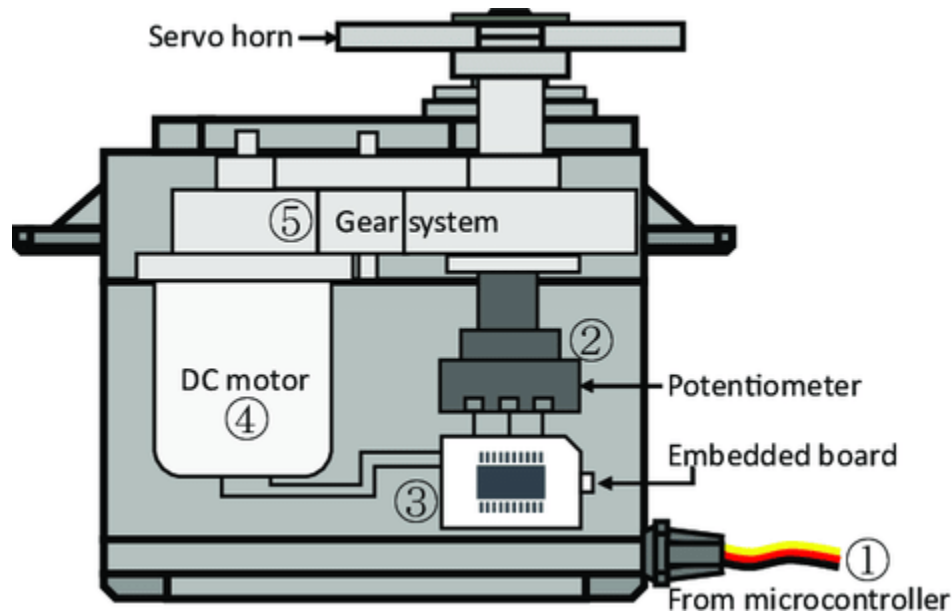
- *1.3 Turn the Wheel* (Basic Project)
- *1. Move* (Car Project)
- *3. Speed Up* (Car Project)
- *8. IoT Car* (IoT Project)
- *3.1 Test the Car* (Scratch Project)

## 1.14 Servo



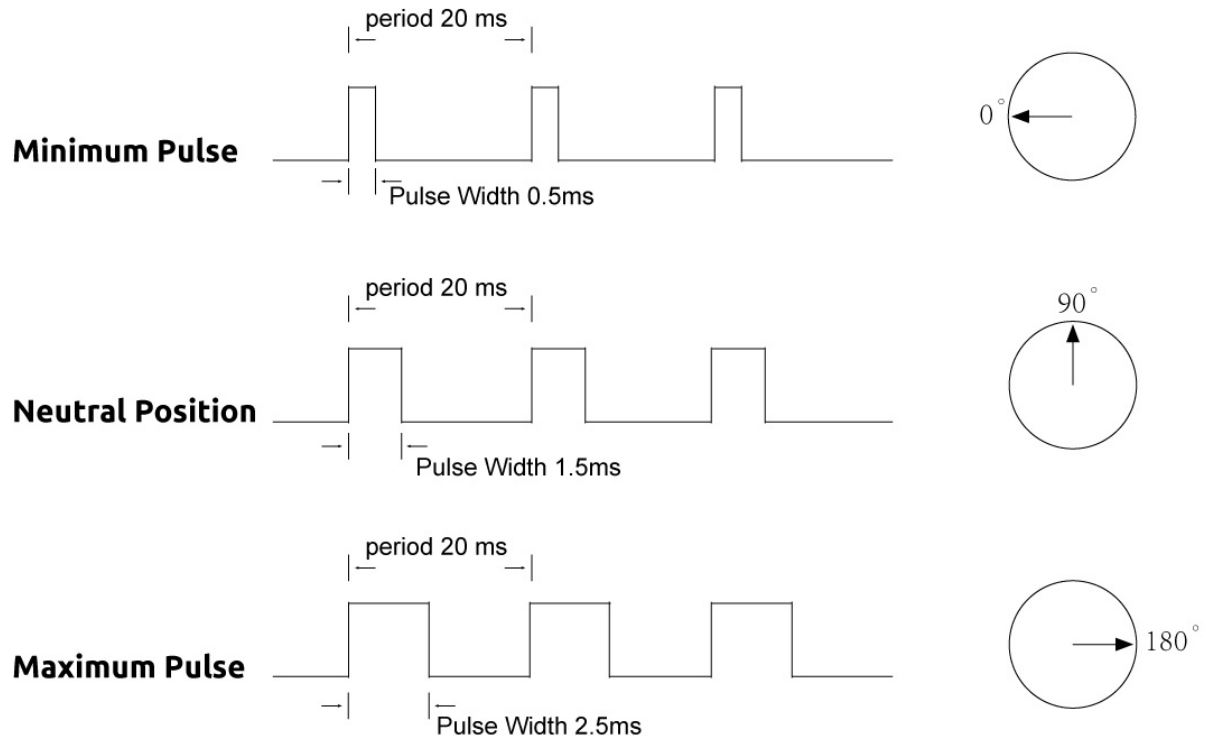
A servo is generally composed of the following parts: case, shaft, gear system, potentiometer, DC motor, and embedded board.

It works like this: The microcontroller sends out PWM signals to the servo, and then the embedded board in the servo receives the signals through the signal pin and controls the motor inside to turn. As a result, the motor drives the gear system and then motivates the shaft after deceleration. The shaft and potentiometer of the servo are connected together. When the shaft rotates, it drives the potentiometer, so the potentiometer outputs a voltage signal to the embedded board. Then the board determines the direction and speed of rotation based on the current position, so it can stop exactly at the right position as defined and hold there.



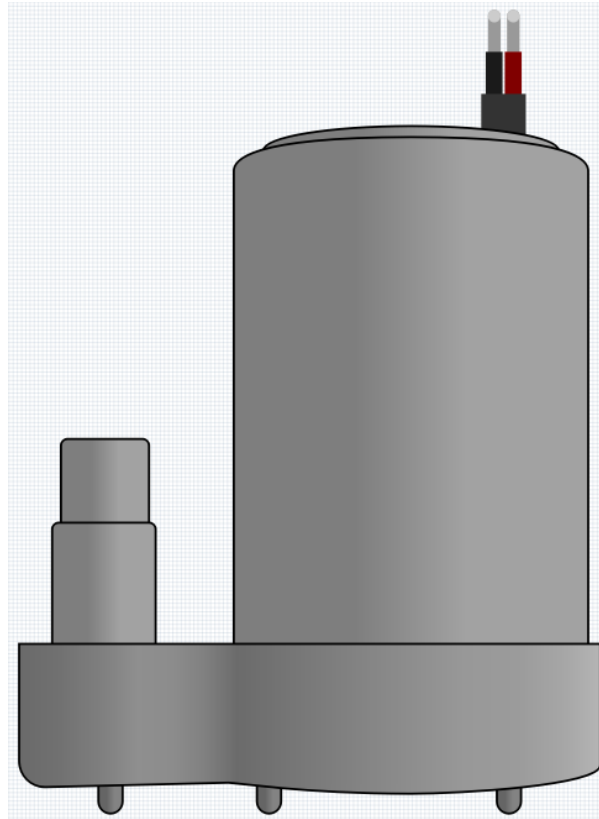
The angle is determined by the duration of a pulse that is applied to the control wire. This is called Pulse width Modulation. The servo expects to see a pulse every 20 ms. The length of the pulse will determine how far the motor turns. For example, a 1.5ms pulse will make the motor turn to the 90 degree position (neutral position). When a pulse is sent to a servo that is less than 1.5 ms, the servo rotates to a position and holds its output shaft some number of degrees counterclockwise from the neutral point. When the pulse is wider than 1.5 ms the opposite occurs. The minimal width and the maximum width of pulse that will command the servo to turn to a valid position are functions of each servo. Generally the minimum pulse will be about 0.5 ms wide and the maximum pulse will be 2.5 ms wide.



**Example**

- [5.5 Use Internal Library](#) (Basic Project)
- [7. Current Limiting Gate](#) (IoT Project)
- [2.10 Pendulum](#) (Scratch Project)

## 1.15 Centrifugal Pump



The centrifugal pump converts rotational kinetic energy into hydrodynamic energy to transport fluid. The rotation energy comes from the electric motor. The fluid enters the pump impeller along or near the rotating shaft, is accelerated by the impeller, flows radially outward into the diffuser or volute chamber, and then flows out from there.

Common uses of centrifugal pumps include water, sewage, agricultural, petroleum, and petrochemical pumping.

- [Centrifugal Pump - Wikipedia](#)

### Features

- **Voltage Scope:** DC 3 ~ 4.5V
- **Operating Current:** 120 ~ 180mA
- **Power:** 0.36 ~ 0.91W
- **Max Water Head:** 0.35 ~ 0.55M
- **Max Flow Rate:** 80 ~ 100 L/H
- **Continuous Working Life:** 100 hours
- **Water Fing Grade:** IP68
- **Driving Mode:** DC, Magnetic Driving
- **Material:** Engineering Plastic
- **Outlet Outside Diameter:** 7.8 mm
- **Outlet Inside Diameter:** 6.5 mm

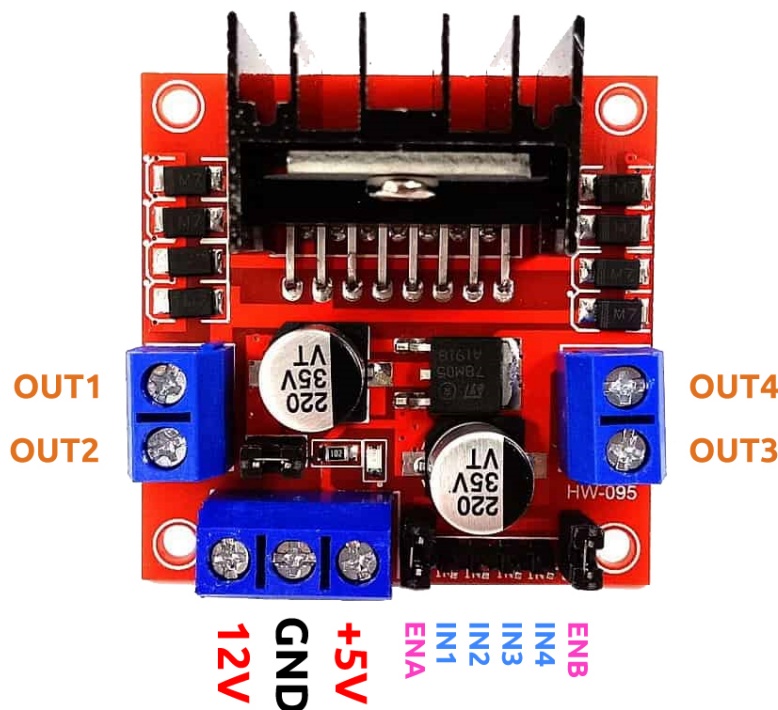
- It is a submersible pump and should be used that way. It tends to heat too much that there's a risk of overheating if you turn it on unsubmerged.

### Example

- *1.4 Pumping* (Basic Project)
- *6. Plant Monitor* (IoT Project)

## 1.16 L298N Module

This L298N Motor Driver Module is a high power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control.



- **IN1 & IN2:** Motor A input pins. Used to control the spinning direction of Motor A
- **IN3 & IN4:** Motor B input pins. Used to control the spinning direction of Motor B
- **ENA:** Enables PWM signal for Motor A. Here it has been connected to 5V with a jumper cap.
- **ENB:** Enables PWM signal for Motor B. Here it has been connected to 5V with a jumper cap.
- **OUT1 & OUT2:** Output pins of Motor A
- **OUT3 & OUT4:** Output pins of Motor B
- **12V:** 12V input from DC power Source
- **5V:** Supplies power for the switching logic circuitry inside L298N IC
- **GND:** Ground pin

### Features

- Driver Model: L298N 2A

- Driver Chip: Double H Bridge L298N
- Motor Supply Voltage (Maximum): 46V
- Motor Supply Current (Maximum): 2A
- Logic Voltage: 5V
- Driver Voltage: 5-35V
- Driver Current: 2A
- Logical Current: 0-36mA
- Maximum Power (W): 25W
- Current Sense for each motor
- Heatsink for better performance
- Power-On LED indicator

### Operating Principle

The driver module can drive two motors. The enabled terminals ENA and ENB are effective at high level.

The working relationship between ENA and IN1, IN2 is as follows

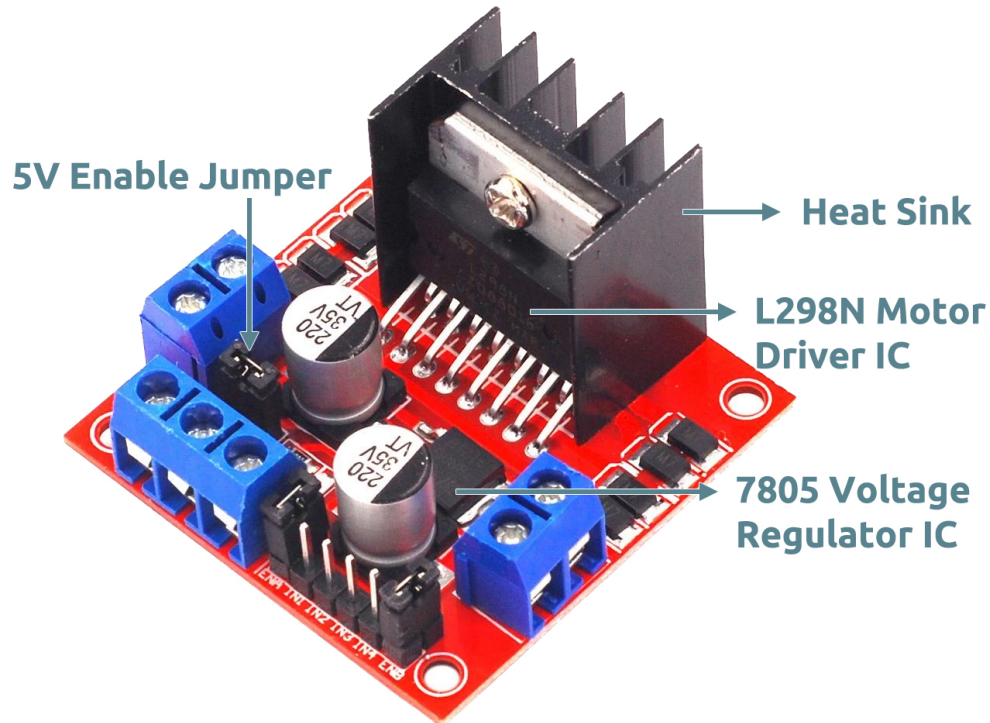
ENA	IN1	IN2	The state of Motor A
0	X	X	Stop
1	0	0	Brake
1	0	1	Rotate clockwise
1	1	0	Rotate counterclockwise
1	1	1	Brake

The working relationship between ENB and IN3, IN4 is as follows.

ENB	IN3	IN4	The state of Motor B
0	X	X	Stop
1	0	0	Brake
1	0	1	Rotate clockwise
1	1	0	Rotate counterclockwise
1	1	1	Brake

### About 5V Enable Cap

The L298N Motor Driver module consists of an L298 Motor Driver IC, 78M05 Voltage Regulator, resistors, capacitor, Power LED, 5V jumper in an integrated circuit.



78M05 Voltage regulator will be enabled only when the jumper is placed. When the power supply is less than or equal to 12V, then the internal circuitry will be powered by the voltage regulator and the 5V pin can be used as an output pin to power the microcontroller.

The jumper should not be placed when the power supply is greater than 12V and separate 5V should be given through 5V terminal to power the internal circuitry.

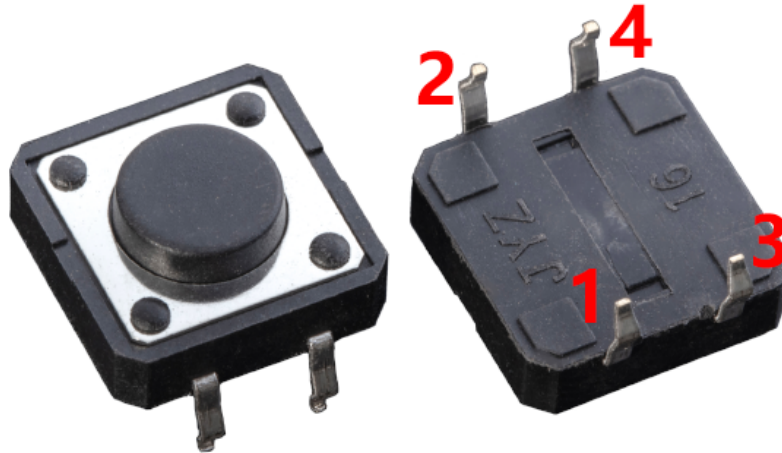
- [L298N datasheet](#)

### Example

- *1.3 Turn the Wheel* (Basic Project)
- *1. Move* (Car Project)
- *3. Speed Up* (Car Project)
- *8. IoT Car* (IoT Project)
- *3.1 Test the Car* (Scratch Project)

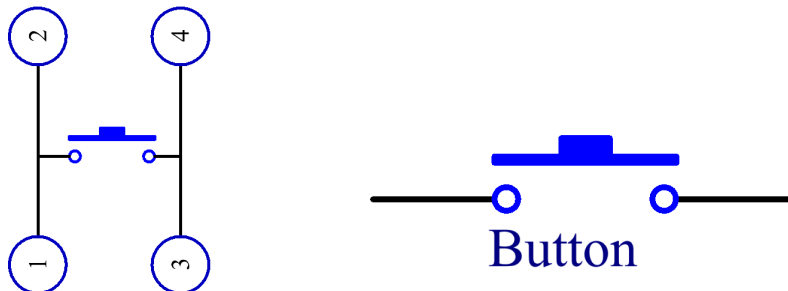
### Controller

## 1.17 Button

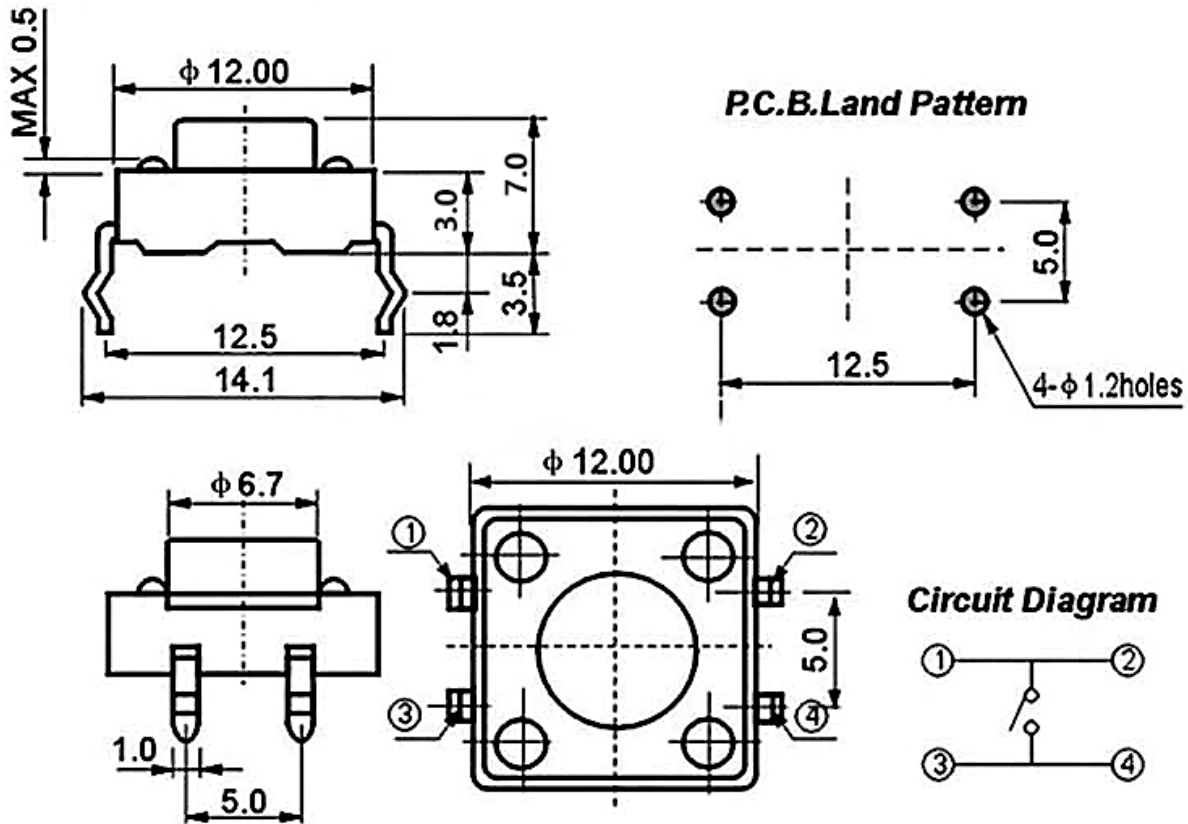


Buttons are a common component used to control electronic devices. They are usually used as switches to connect or break circuits. Although buttons come in a variety of sizes and shapes, the one used here is a 6mm mini-button as shown in the following pictures. Pin 1 is connected to pin 2 and pin 3 to pin 4. So you just need to connect either of pin 1 and pin 2 to pin 3 or pin 4.

The following is the internal structure of a button. The symbol on the right below is usually used to represent a button in circuits.



Since the pin 1 is connected to pin 2, and pin 3 to pin 4, when the button is pressed, the 4 pins are connected, thus closing the circuit.



### Example

- [3.1 Reading Button Value](#) (Basic Project)
- [2.6 Doorbell](#) (Scratch Project)
- [2.16 GAME - Eat Apple](#) (Scratch Project)
- [2.19 GAME - Fishing](#) (Scratch Project)

## 1.18 Reed Switch



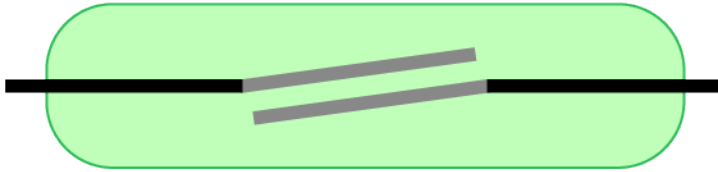
The Reed Switch is an electrical switch that operates by means of an applied magnetic field. It was invented by Walter B. Ellwood of Bell Telephone Laboratories in 1936 and patented in the United States on June 27, 1940, under patent number 2264746.

The principle of operation of a reed switch is very simple. Two reeds (usually made of iron and nickel, two metals) that overlap at the end points are sealed in a glass tube, with the two reeds overlapping and separated by a small gap (only about a few microns). The glass tube is filled with a high purity inert gas (such as nitrogen), and some reed switches are made to have a vacuum inside to enhance their high voltage performance.

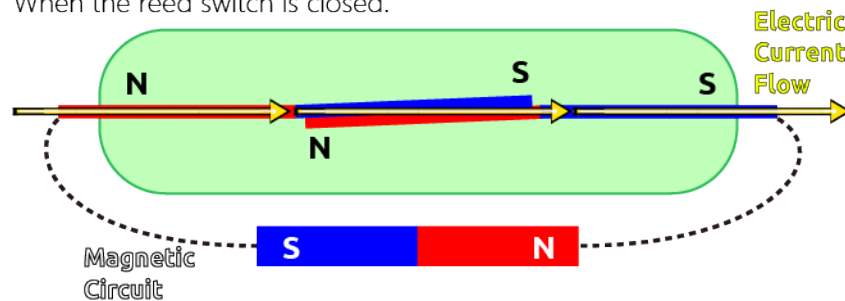
The reed acts as a magnetic flux conductor. The two reeds are not in contact when not yet in operation; when passing through a magnetic field generated by a permanent magnet or electromagnetic coil, the applied magnetic field causes the two reeds to have different polarities near their endpoints, and when the magnetic force exceeds the spring force of

the reeds themselves, the two reeds will be drawn together to conduct the circuit; when the magnetic field weakens or disappears, the reeds are released due to their own elasticity, and the contact surfaces will separate to open the circuit.

When the reed switch is open.



When the reed switch is closed.

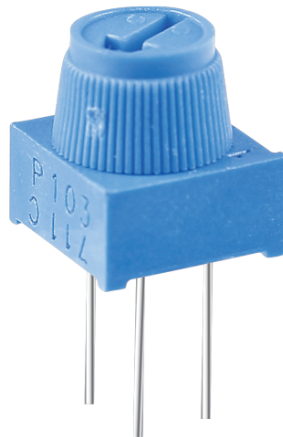


- [Reed Switch - Wikipedia](#)

### Example

- [3.2 Feel the Magnetism](#) (Basic Project)
- [7. Current Limiting Gate](#) (IoT Project)

## 1.19 Potentiometer



Potentiometer is also a resistance component with 3 terminals and its resistance value can be adjusted according to some regular variation.

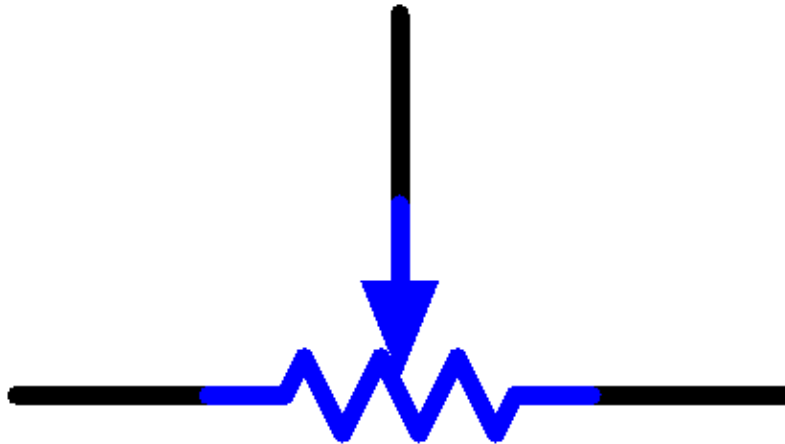
Potentiometers come in various shapes, sizes, and values, but they all have the following things in common:

- They have three terminals (or connection points).



- They have a knob, screw, or slider that can be moved to vary the resistance between the middle terminal and either one of the outer terminals.
- The resistance between the middle terminal and either one of the outer terminals varies from 0 to the maximum resistance of the pot as the knob, screw, or slider is moved.

Here is the circuit symbol of potentiometer.



The functions of the potentiometer in the circuit are as follows:

1. Serving as a voltage divider

Potentiometer is a continuously adjustable resistor. When you adjust the shaft or sliding handle of the potentiometer, the movable contact will slide on the resistor. At this point, a voltage can be output depending on the voltage applied onto the potentiometer and the angle the movable arm has rotated to or the travel it has made.

2. Serving as a rheostat

When the potentiometer is used as a rheostat, connect the middle pin and one of the other 2 pins in the circuit. Thus you can get a smoothly and continuously changed resistance value within the travel of the moving contact.

3. Serving as a current controller

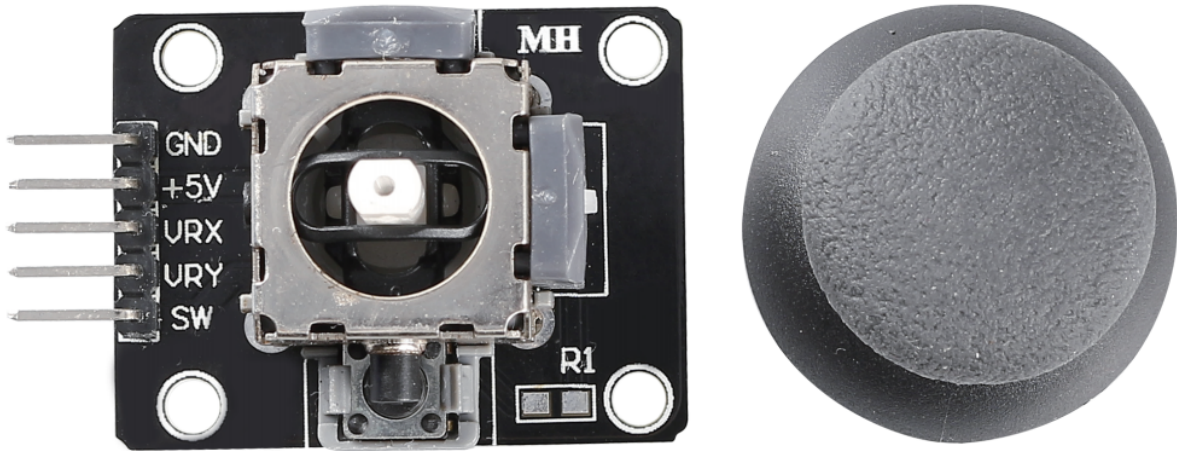
When the potentiometer acts as a current controller, the sliding contact terminal must be connected as one of the output terminals.

If you want to know more about potentiometer, refer to: [Potentiometer - Wikipedia](#)

### Example

- [4.1 Turn the Knob](#) (Basic Project)
- [2.5 Moving Mouse](#) (Scratch Project)
- [2.18 GAME - Breakout Clone](#) (Scratch Project)

## 1.20 Joystick Module

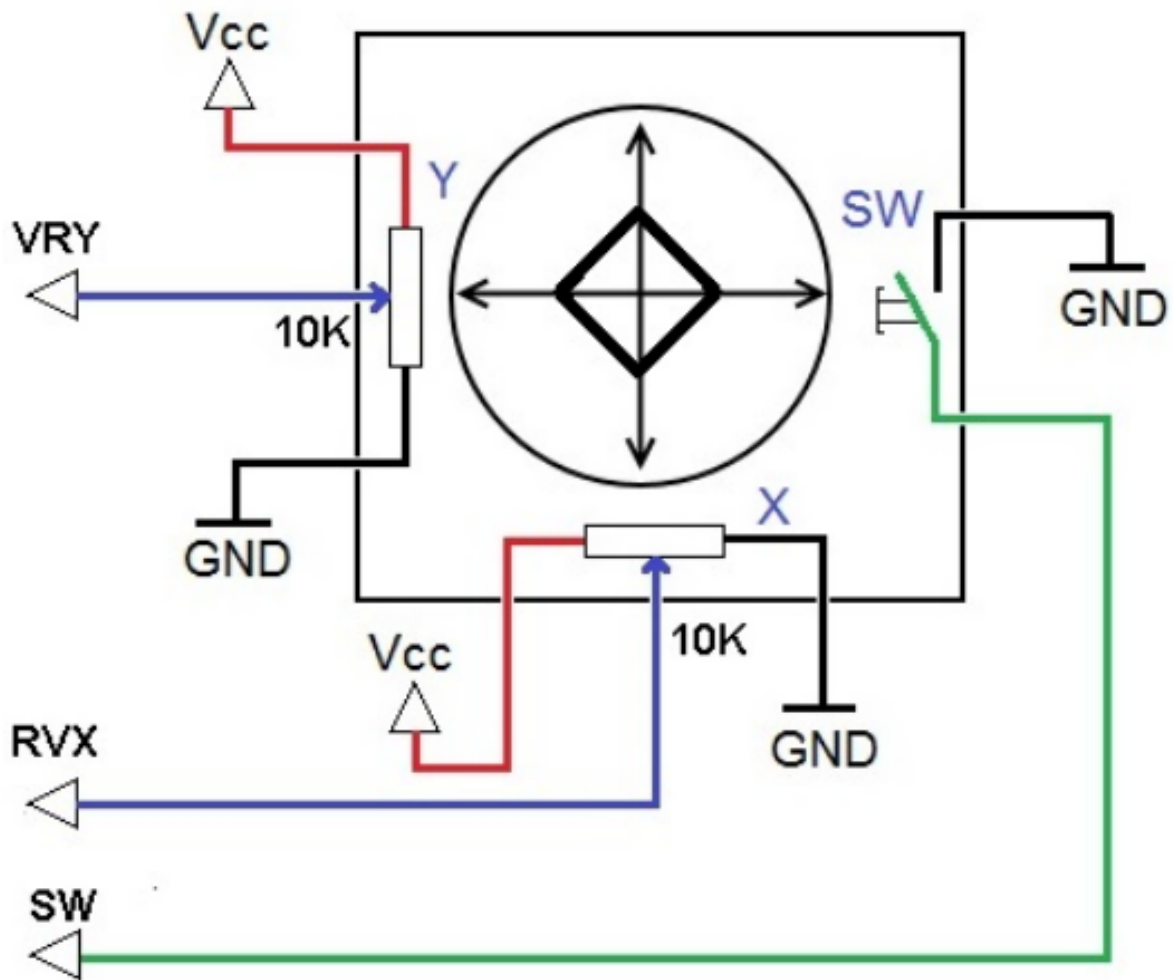


The basic idea of a joystick is to translate the movement of a stick into electronic information that a computer can process.

In order to communicate a full range of motion to the computer, a joystick needs to measure the stick's position on two axes – the X-axis (left to right) and the Y-axis (up and down). Just as in basic geometry, the X-Y coordinates pinpoint the stick's position exactly.

To determine the location of the stick, the joystick control system simply monitors the position of each shaft. The conventional analog joystick design does this with two potentiometers, or variable resistors.

The joystick also has a digital input that is actuated when the joystick is pressed down.

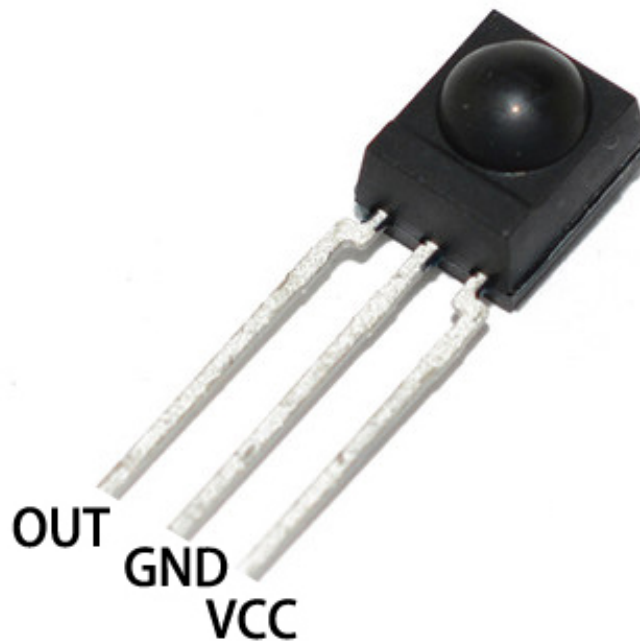


#### Example

- [4.3 Toggle the Joystick](#) (Basic Project)
- [2.15 GAME - Star-Crossed](#) (Scratch Project)
- [2.22 GAME - Kill Dragon](#) (Scratch Project)

## 1.21 IR Receiver

### IR Receiver



- OUT: Signal output
- GND: GND
- VCC: power supply, 3.3v~5V

An infrared-receiver is a component which receives infrared signals and can independently receive infrared rays and output signals compatible with TTL level. It is similar with a normal plastic-packaged transistor in size and is suitable for all kinds of infrared remote control and infrared transmission.

Infrared, or IR, communication is a popular, low-cost, easy-to-use wireless communication technology. Infrared light has a slightly longer wavelength than visible light, so it is imperceptible to the human eye - ideal for wireless communication. A common modulation scheme for infrared communication is 38KHz modulation.

- Adopted [HS0038B](#) IR Receiver Sensor, high sensitivity
- Can be used for remote control
- Power Supply: 5V
- Interface: Digital
- Modulate Frequency: 38Khz
- Pin Definitions: (1) Output (2) Vcc (3) GND
- Size: 23.5mm x 21.5mm

### Remote Control



This is a Mini thin infrared wireless remote control with 21 function buttons and a transmitting distance of up to 8 meters, which is suitable for operating a wide range of devices in a kid's room.

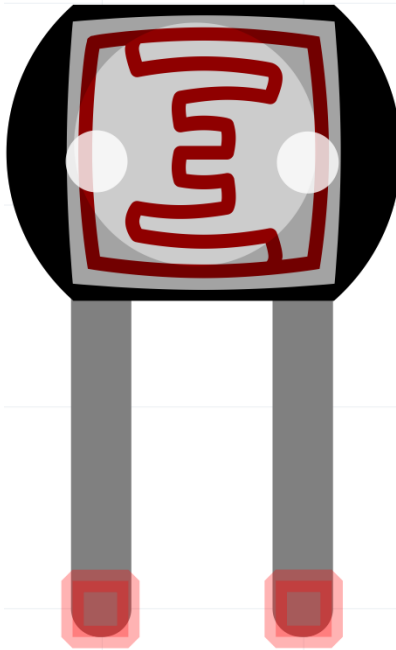
- Size: 85x39x6mm
- Remote control range: 8-10m
- Battery: 3V button type lithium manganese battery
- Infrared carrier frequency: 38KHz
- Surface paste material: 0.125mm PET
- Effective life: more than 20,000 times

#### Example

- [5.11.2 IR Receiver](#) (Basic Project)
- [9. Remote Control](#) (Car Project)
- [10. One Touch Start](#) (Car Project)

#### Sensor

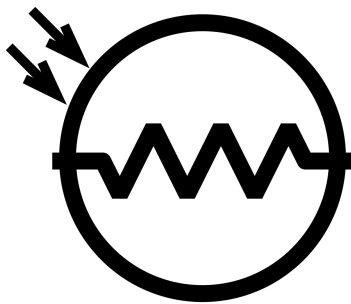
## 1.22 Photoresistor



A photoresistor or photocell is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity; in other words, it exhibits photo conductivity.

A photoresistor can be applied in light-sensitive detector circuits and light-activated and dark-activated switching circuits acting as a resistance semiconductor. In the dark, a photoresistor can have a resistance as high as several megaohms (M), while in the light, a photoresistor can have a resistance as low as a few hundred ohms.

Here is the electronic symbol of photoresistor.

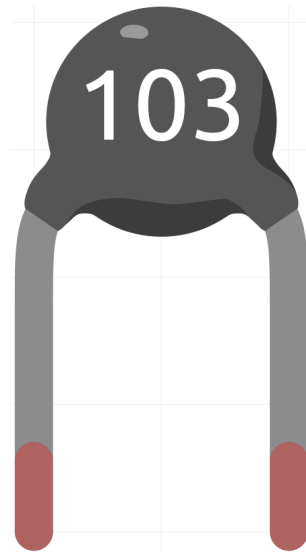


- [Photoresistor - Wikipedia](#)

### Example

- [4.2 Feel the Light](#) (Basic Project)
- [5. Home Environment Monitoring](#) (IoT Project)
- [6. Plant Monitor](#) (IoT Project)

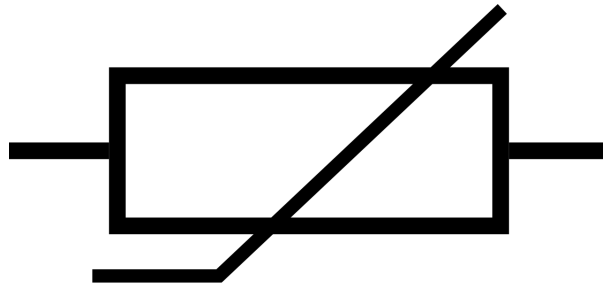
## 1.23 Thermistor



A thermistor is a type of resistor whose resistance is strongly dependent on temperature, more so than in standard resistors. The word is a combination of thermal and resistor. Thermistors are widely used as inrush current limiters, temperature sensors (negative temperature coefficient or NTC type typically), self-resetting overcurrent protectors, and self-regulating heating elements (positive temperature coefficient or PTC type typically).

- [Thermistor - Wikipedia](#)

Here is the electronic symbol of thermistor.



Thermistors are of two opposite fundamental types:

- With NTC thermistors, resistance decreases as temperature rises usually due to an increase in conduction electrons bumped up by thermal agitation from valency band. An NTC is commonly used as a temperature sensor, or in series with a circuit as an inrush current limiter.
- With PTC thermistors, resistance increases as temperature rises usually due to increased thermal lattice agitations particularly those of impurities and imperfections. PTC thermistors are commonly installed in series with a circuit, and used to protect against overcurrent conditions, as resettable fuses.

In this kit we use an NTC one. Each thermistor has a normal resistance. Here it is 10k ohm, which is measured under 25 degree Celsius.

Here is the relation between the resistance and temperature:

$$R_T = R_N * \exp(B(1/T_K - 1/T_N))$$

- $R_T$  is the resistance of the NTC thermistor when the temperature is  $T_K$ .

- **RN** is the resistance of the NTC thermistor under the rated temperature **TN**. Here, the numerical value of **RN** is 10k.
- **TK** is a Kelvin temperature and the unit is K. Here, the numerical value of **TK** is 273.15 + degree Celsius.
- **TN** is a rated Kelvin temperature; the unit is K too. Here, the numerical value of **TN** is 273.15+25.
- And **B(beta)**, the material constant of NTC thermistor, is also called heat sensitivity index with a numerical value 3950.
- **exp** is the abbreviation of exponential, and the base number **e** is a natural number and equals 2.7 approximately.

Convert this formula  $TK = 1 / (\ln(RT/RN) / B + 1 / TN)$  to get Kelvin temperature that minus 273.15 equals degree Celsius.

This relation is an empirical formula. It is accurate only when the temperature and resistance are within the effective range.

**Example**

- [2.7 Low Temperature Alarm](#) (Scratch Project)
- [6.3 High Temperature Alarm](#) (Basic Project)
- [4.5 Thermometer](#) (Basic Project)

## 1.24 DHT11 Humiture Sensor

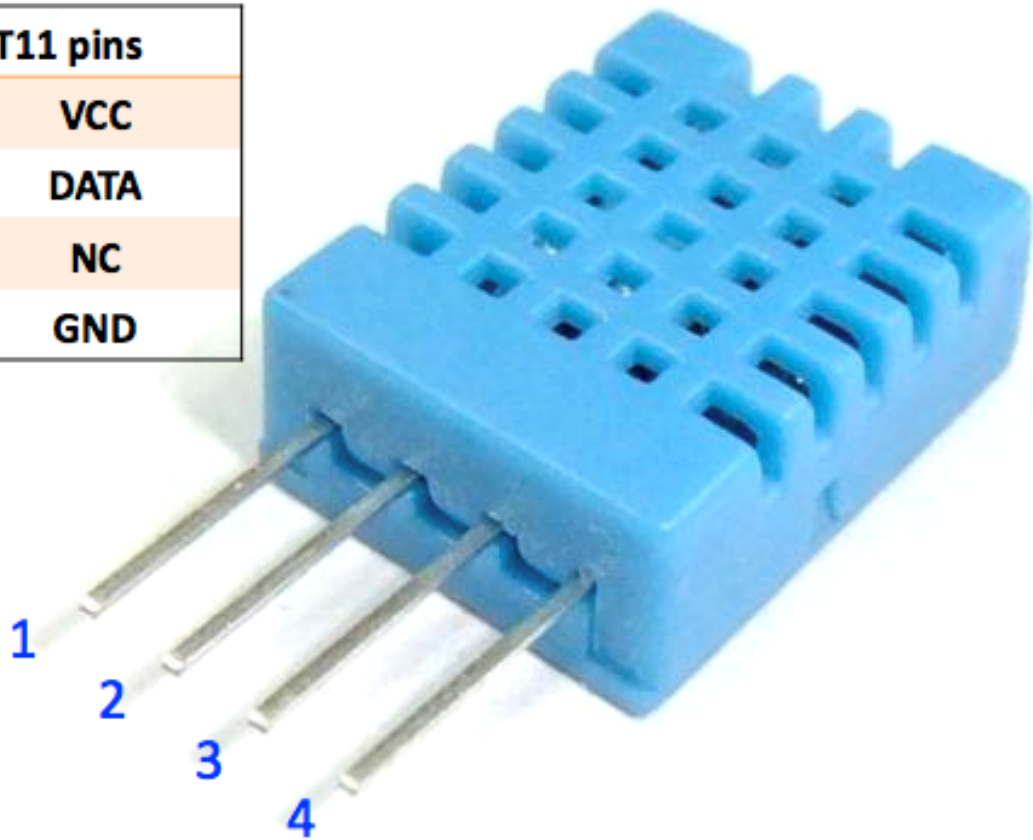
The digital temperature and humidity sensor DHT11 is a composite sensor that contains a calibrated digital signal output of temperature and humidity. The technology of a dedicated digital modules collection and the temperature and humidity sensing technology are applied to ensure that the product has high reliability and excellent long-term stability.

The sensor includes a resistive sense of wet component and an NTC temperature measurement device, and is connected with a high-performance 8-bit microcontroller.

Only three pins are available for use: VCC, GND, and DATA. The communication process begins with the DATA line sending start signals to DHT11, and DHT11 receives the signals and returns an answer signal. Then the host receives the answer signal and begins to receive 40-bit humiture data (8-bit humidity integer + 8-bit humidity decimal + 8-bit temperature integer + 8-bit temperature decimal + 8-bit checksum).



DHT11 pins	
1	VCC
2	DATA
3	NC
4	GND



### Features

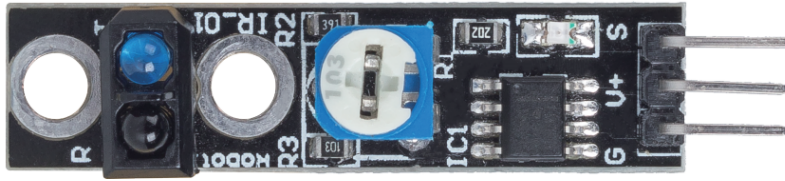
1. Humidity measurement range: 20 - 90%RH
2. Temperature measurement range: 0 - 60°C
3. Output digital signals indicating temperature and humidity
4. Working voltage:DC 5V; PCB size: 2.0 x 2.0 cm
5. Humidity measurement accuracy:  $\pm 5\%$  RH
6. Temperature measurement accuracy:  $\pm 2^\circ\text{C}$

- [DHT11 Datasheet](#)

### Example

- [5.11.3 Temperature - Humidity](#) (Basic Project)
- [5. Home Environment Monitoring](#) (IoT Project)
- [6. Plant Monitor](#) (IoT Project)

## 1.25 Line Tracking Module



- S: Usually low level, high level when the black line is detected.
- V+Power supply, 3.3v~5V
- G: Ground

This is a 1-channel Line Tracking module which, as the name suggests, tracks black lines on a white background or white lines against a black background.



The module uses a TCRT500 infrared sensor, which consists of an infrared LED (blue) and a photosensitive triplet (black).

- The blue infrared LED, when powered on, emits infrared light that is invisible to the human eye.
- The black phototransistor, which is used to receive infrared light, has an internal resistor whose resistance varies with the infrared light received; the more infrared light received, the lower its resistance decreases and vice versa.

There is a LM393 comparator on the module, which is used to compare the voltage of the phototransistor with the set voltage (adjusted by potentiometer), if it is greater than the set voltage, the output is 1; otherwise the output is 0.

Therefore, when the infrared emitter tube shines on a black surface, because the black will absorb light, the photosensitive transistor receives less infrared light, its resistance will increase (voltage increase), after LM393 comparator, the output high level.

Similarly, when it shines on a white surface, the reflected light will become more and the resistance of the photosensitive transistor will decrease (voltage decreases); therefore, the comparator outputs a low level and the indicator LED lights up.

- [TCRT5000](#)

### Features

- Using infrared emission sensor TCRT5000
- Detection distance: 1-8mm, focal length of 2.5mm
- Comparator output signal clean, good waveform, driving capacity greater than 15mA
- Using potentiometer for sensitivity adjustment

- Operating voltage: 3.3V-5V
- Digital output: 0 (white) and 1 (black)
- Uses wide voltage LM393 comparator.
- Size: 42mmx10mm

#### Example

- *3.4 Detect the Line* (Basic Project)
- *4. Follow the line* (Car Project)
- *2.21 GAME - Protect Your Heart* (Scratch Project)

## 1.26 Soil Moisture Module

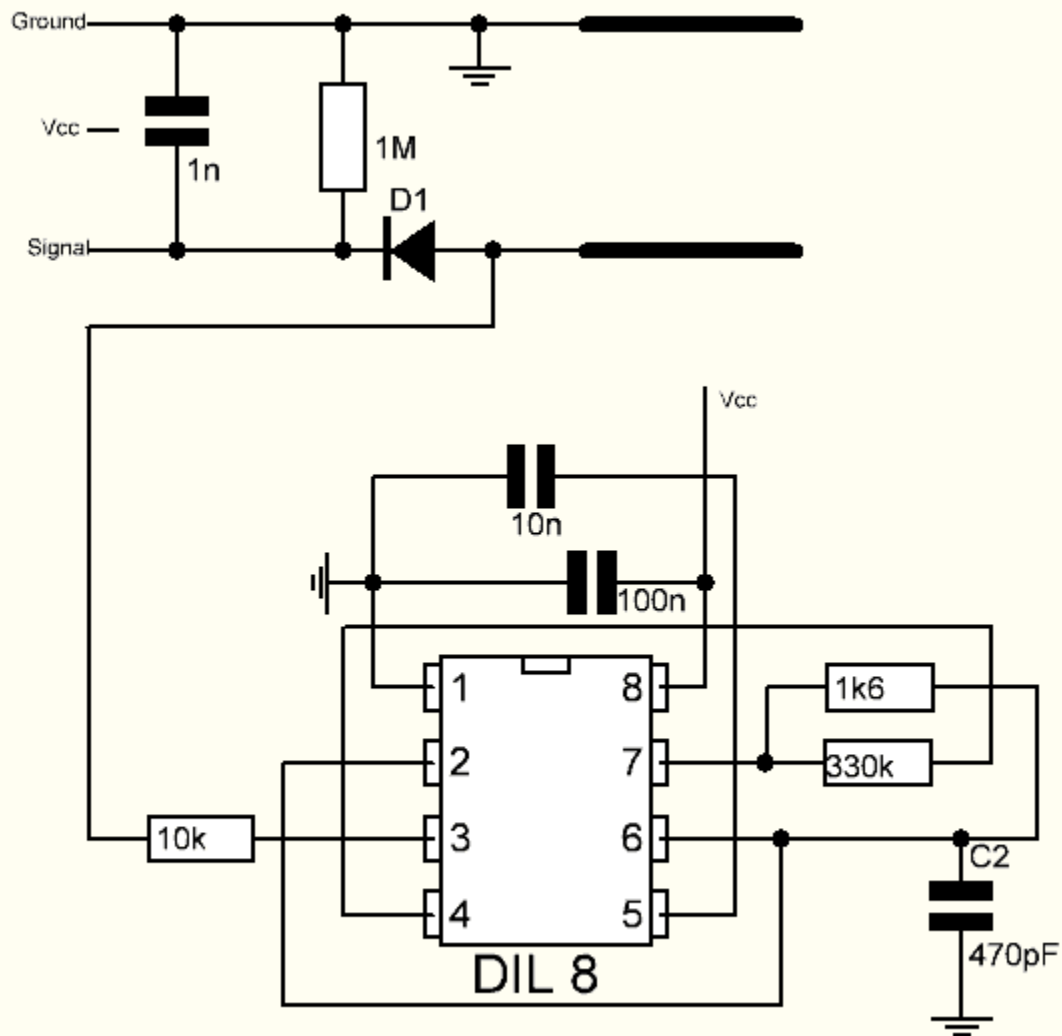


- GND: Ground
- VCCPower supply, 3.3v~5V
- AOUT: Outputs the soil moisture value, the wetter the soil, the smaller its value.

This capacitive soil moisture sensor is different from most of the resistive sensors on the market, using the principle of capacitive induction to detect soil moisture. It avoids the problem that resistive sensors are highly susceptible to corrosion and greatly extends its working life.

It is made of corrosion-resistant materials and has an excellent service life. Insert it into the soil around plants and monitor real-time soil moisture data. The module includes an on-board voltage regulator that allows it to operate over a voltage range of 3.3 ~ 5.5 V. It is ideal for low-voltage microcontrollers with 3.3 V and 5 V supplies.

The hardware schematic of the capacitive soil moisture sensor is shown below.



There is a fixed frequency oscillator, which is built with a 555 timer IC. The generated square wave is then fed to the sensor like a capacitor. However, for the square wave signal, the capacitor has a certain reactance or, for the sake of argument, a resistor with a pure ohmic resistor (10k resistor on pin 3) to form a voltage divider.

The higher the soil moisture, the higher the capacitance of the sensor. As a result, the square wave has less reactance, which reduces the voltage on the signal line, and the smaller the value of the analog input through the microcontroller.

#### Specification

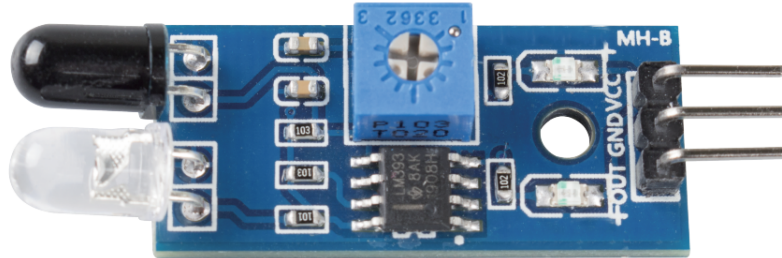
- Operating Voltage: 3.3 ~ 5.5 VDC
- Output Voltage: 0 ~ 3.0VDC
- Operating Current: 5mA
- Interface: PH2.0-3P
- Dimensions: 3.86 x 0.905 inches (L x W)
- Weight: 15g

#### Example

- [4.4 Measure Soil Moisture](#) (Basic Project)

- 6. *Plant Monitor* (IoT Project)

## 1.27 Obstacle Avoidance Module

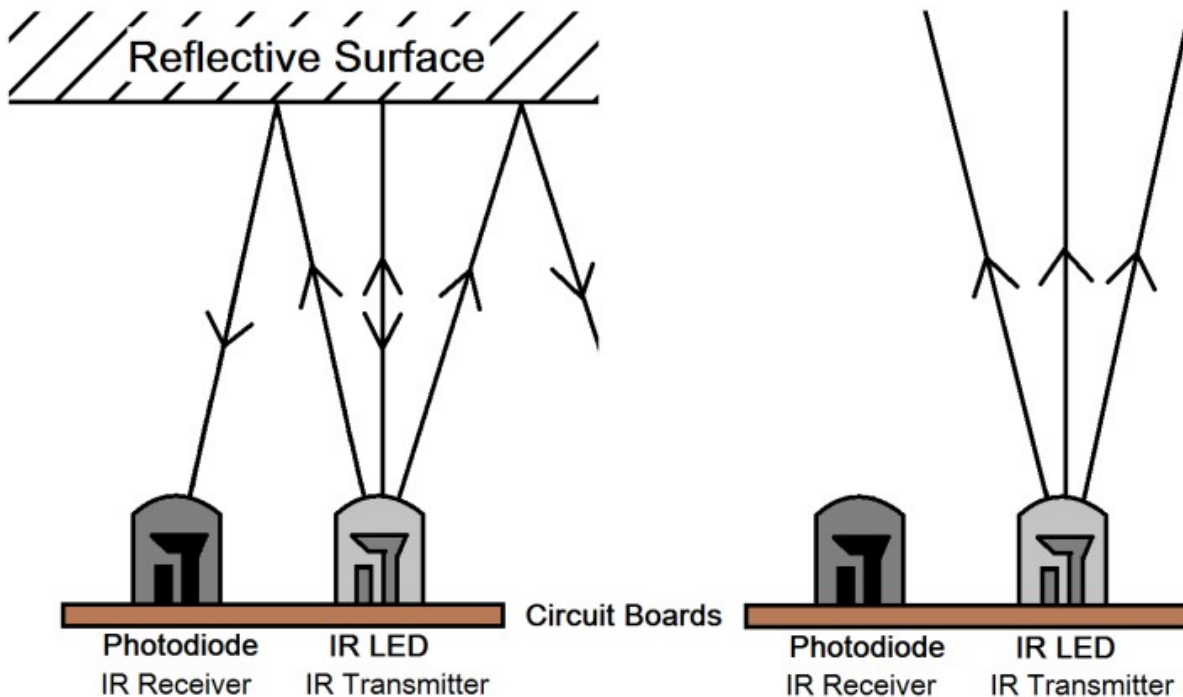


- **VCC:** Power supply, 3.3 ~ 5V DC.
- **GND:** Ground
- **OUT:** Signal pin, usually high level, and low level when an obstacle is detected.

The IR obstacle avoidance module has strong adaptability to environmental light, it has a pair of infrared transmitting and receiving tubes.

The transmitting tube emits infrared frequency, when the detection direction encounters an obstacle, the infrared radiation is received by the receiving tube, after the comparator circuit processing, the indicator will light up and output low level signal.

The detection distance can be adjusted by potentiometer, the effective distance range 2-30cm.



### Example

- 3.3 *Detect the Obstacle* (Basic Project)
- 5. *Play with Obstacle Avoidance Module* (Car Project)

- 8. *Self-Driving Car* (Car Project)
- 7. *Current Limiting Gate* (IoT Project)
- 2.13 *GAME - Shooting* (Scratch Project)
- 2.20 *GAME - Don't Tap on The White Tile* (Scratch Project)

## 1.28 Ultrasonic Module

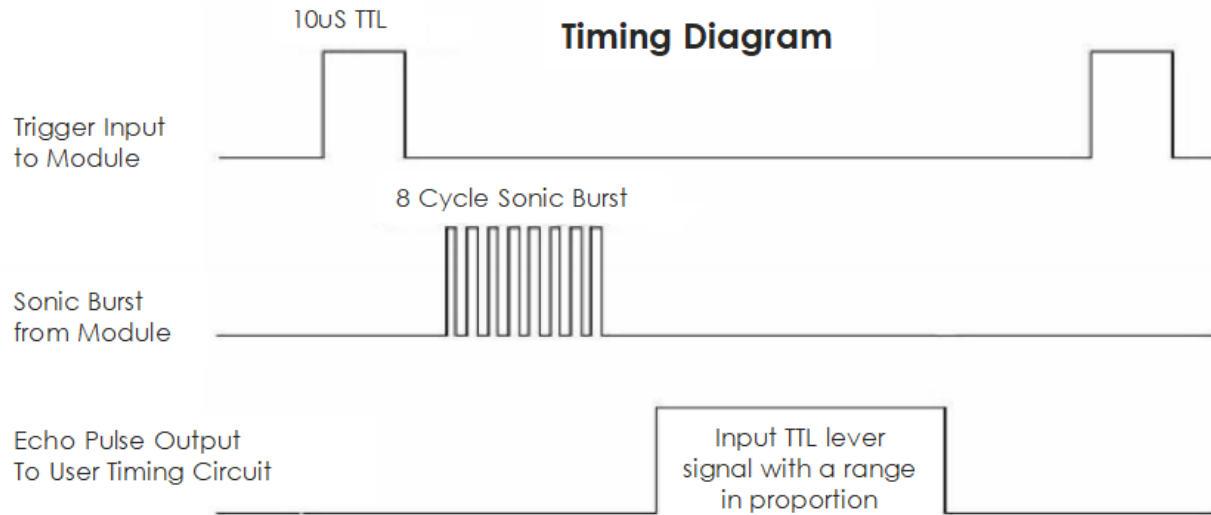


Ultrasonic ranging module provides 2cm - 400cm non-contact measurement function, and the ranging accuracy can reach to 3mm. It can ensure that the signal is stable within 5m, and the signal is gradually weakened after 5m, till the 7m position disappears.

The module includes ultrasonic transmitters, receiver and control circuit. The basic principles are as follows:

1. Use an IO flip-flop to process a high level signal of at least 10us.
2. The module automatically sends eight 40khz and detects if there is a pulse signal return.
3. If the signal returns, passing the high level, the high output IO duration is the time from the transmission of the ultrasonic wave to the return of it. Here, test distance = (high time x sound speed (340 m / s) / 2.

The timing diagram is shown below.



You only need to supply a short 10µs pulse for the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. You can calculate the range through the time interval between sending trigger signal and receiving echo signal.

Formula:  $\text{us} / 58 = \text{centimeters}$  or  $\text{us} / 148 = \text{inch}$ ; or: the range = high level time \* velocity (340M/S) / 2; you are suggested to use measurement cycle over 60ms in order to prevent signal collisions of trigger signal and the echo signal.

### Example

- *5.8 User-defined Function* (Basic Project)
- *7. Follow Your Hand* (Car Project)
- *6. Play with Ultrasonic Module* (Car Project)
- *2.17 GAME - Flappy Parrot* (Scratch Project)





## **GET STARTED WITH ARDUINO**

If you have no idea about Arduino. There are several words I would like to show you: electronics, design, programming, and even Maker. Some of you may think these words are quite far away from us, but in fact, they are not far at all. Because Arduino can take us into the world of programming and help us realize the dream of being a Maker. In this session we will learn:

- What is Arduino?
- what can Arduino do?
- How to build an Arduino Project?

### **2.1 What is Arduino?**

First of all, I will give you a brief introduction to Arduino.

Arduino is a convenient, flexible, and easy-to-use open-source electronic prototyping platform, including hardware Arduino boards of various models and software Arduino IDE. It is not only suitable for engineers for rapid prototyping, but also artists, designers, hobbyists, while it is almost a must-have tool for modern Makers.

Arduino is quite a large system. It has software, hardware, and a very huge online community of people who have never met each other but are able to work together because of a common hobby. Everyone in the Arduino family is using their wisdom, making with their hands, and sharing one great invention after another. And you can also be a part of it.

### **2.2 What can Arduino do?**

Speaking of which, you may have doubts about what Arduino can actually do. Suffice it to say, Arduino will solve all your problems.

Technically speaking, Arduino is a programmable logic controller. It is a development board that can be used to create many exciting and creative electronic creations: such as remote-controlled cars, robotic arms, bionic robots, smart homes, etc.

Arduino boards are straightforward, simple, and powerful, suitable for students, makers and even professional programmers.

To this day, electronics enthusiasts worldwide continue to develop creative electronic creations based on Arduino development boards.

## 2.3 How to build an Arduino Project

Follow these steps to learn how to use Arduino from zero!

### 2.3.1 Download and Install Arduino IDE 2.0

The Arduino IDE, known as Arduino Integrated Development Environment, provides all the software support needed to complete an Arduino project. It is a programming software specifically designed for Arduino, provided by the Arduino team, that allows us to write programs and upload them to the Arduino board.

The Arduino IDE 2.0 is an open-source project. It is a big step from its sturdy predecessor, Arduino IDE 1.x, and comes with revamped UI, improved board & library manager, debugger, autocomplete feature and much more.

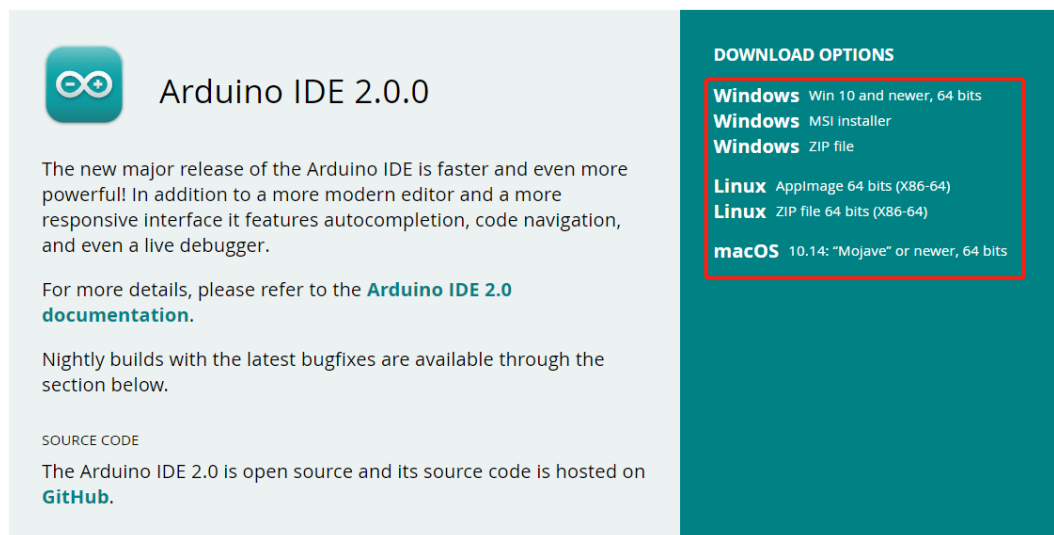
In this tutorial, we will show how to download and install the Arduino IDE 2.0 on your Windows, Mac, or Linux computer.


#### Requirements

- Windows - Win 10 and newer, 64 bits
- Linux - 64 bits
- Mac OS X - Version 10.14: “Mojave” or newer, 64 bits

#### Download the Arduino IDE 2.0

1. Visit .
2. Download the IDE for your OS version.



 **Arduino IDE 2.0.0**

The new major release of the Arduino IDE is faster and even more powerful! In addition to a more modern editor and a more responsive interface it features autocompletion, code navigation, and even a live debugger.

For more details, please refer to the [Arduino IDE 2.0 documentation](#).

Nightly builds with the latest bugfixes are available through the section below.

**SOURCE CODE**

The Arduino IDE 2.0 is open source and its source code is hosted on [GitHub](#).

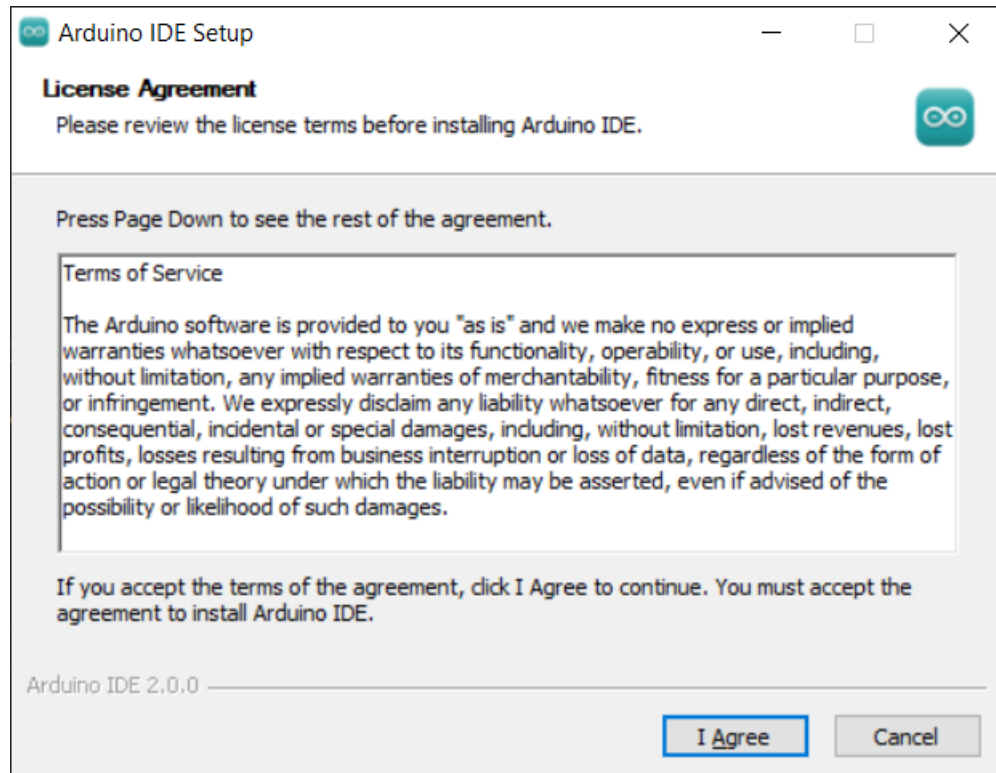
**DOWNLOAD OPTIONS**

- Windows** Win 10 and newer, 64 bits
- Windows** MSI installer
- Windows** ZIP file
- Linux** AppImage 64 bits (X86-64)
- Linux** ZIP file 64 bits (X86-64)
- macOS** 10.14: “Mojave” or newer, 64 bits

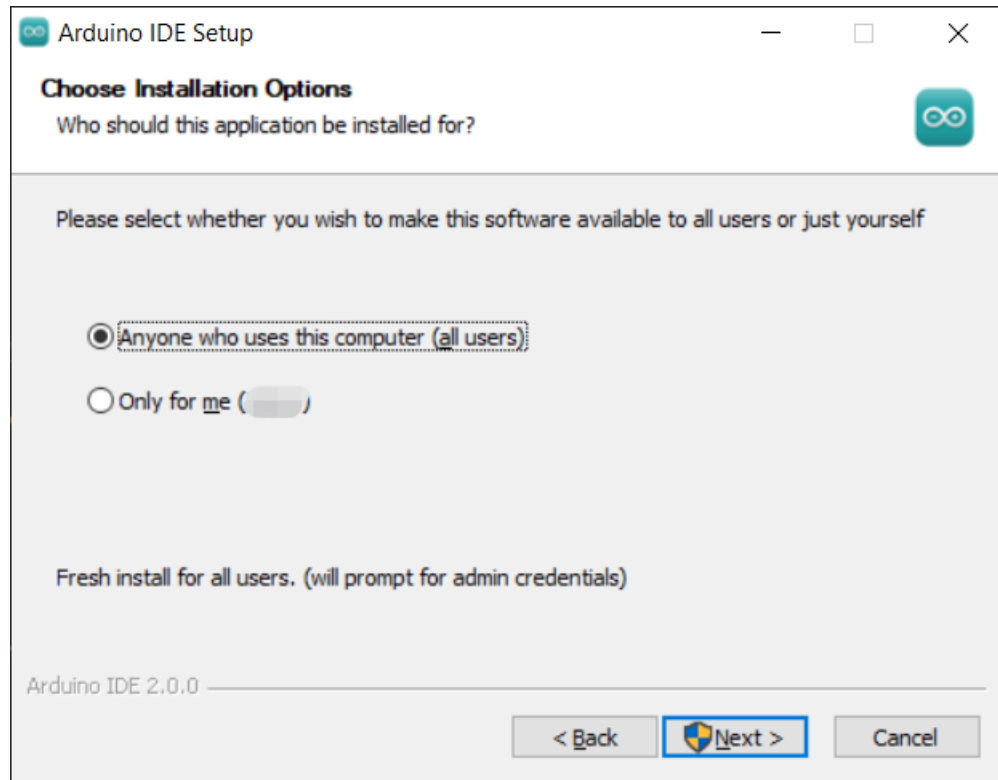
## Installation

### Windows

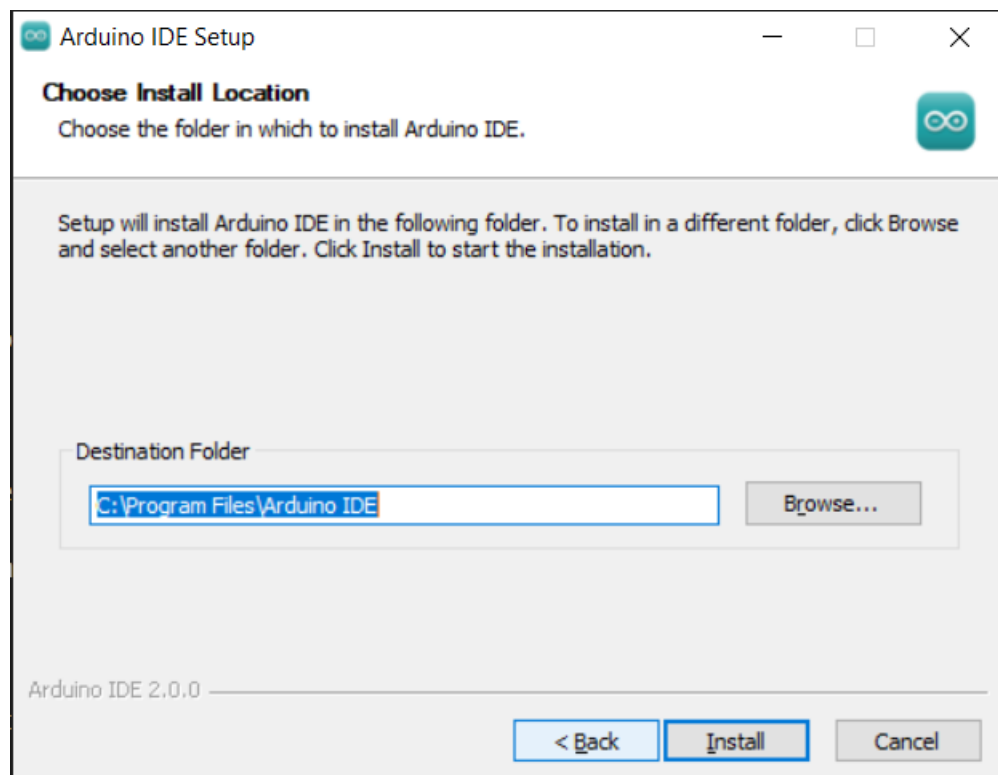
1. Double click the `arduino-ide_xxxx.exe` file to run the downloaded file.
2. Read the License Agreement and agree it.



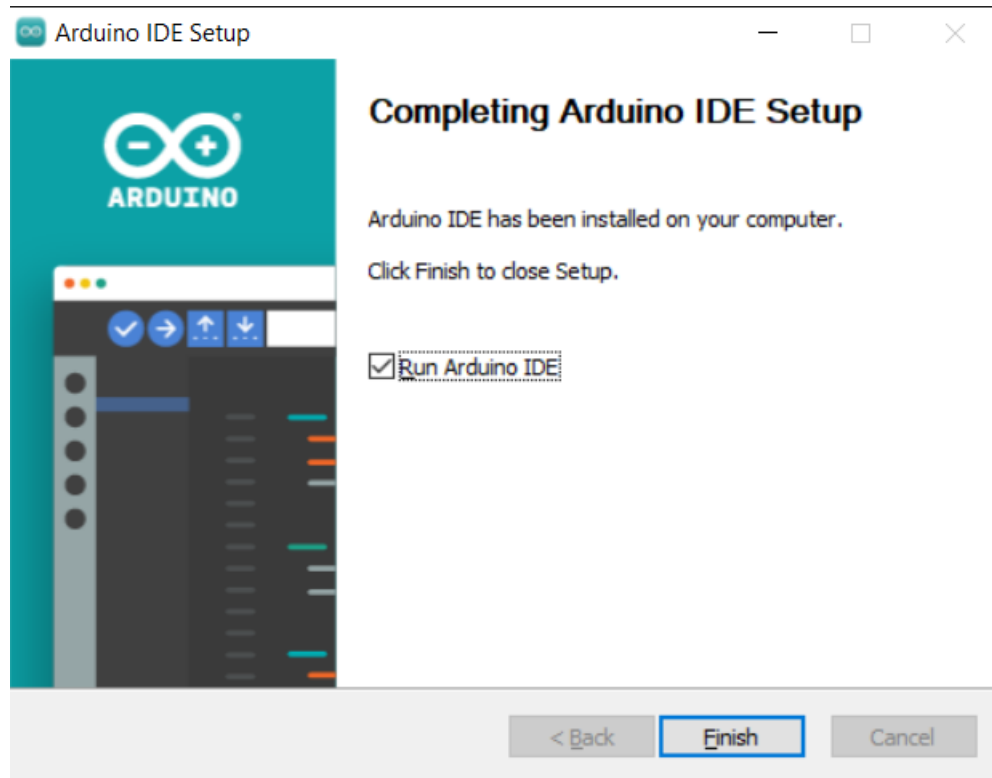
3. Choose installation options.



4. Choose install location. It is recommended that the software be installed on a drive other than the system drive.

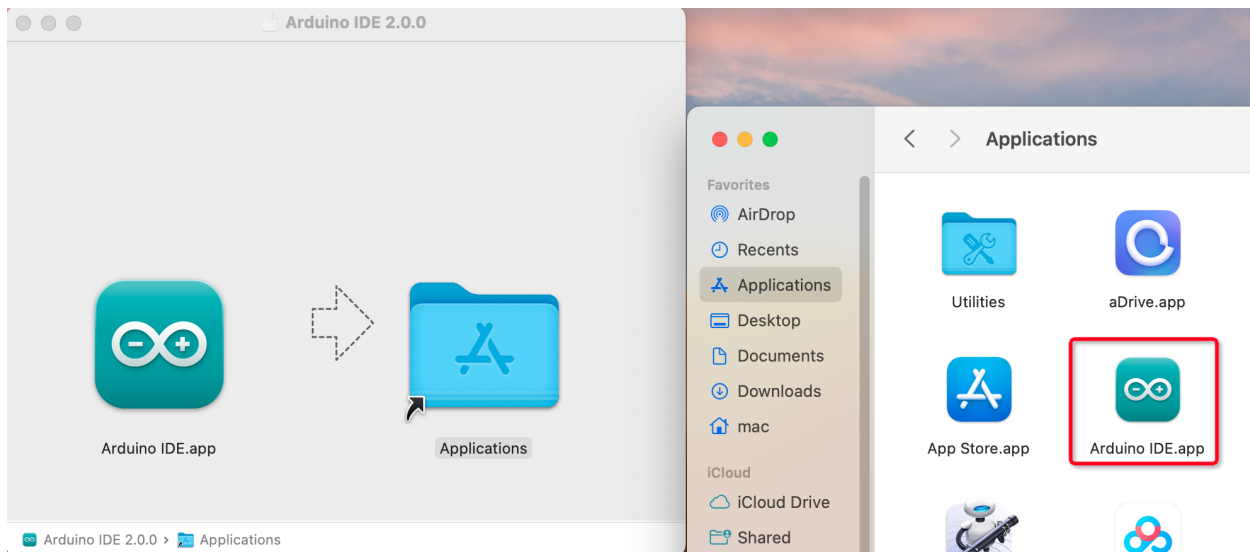


5. Then Finish.



## macOS

Double click on the downloaded `arduino_ide_xxxx.dmg` file and follow the instructions to copy the **Arduino IDE.app** to the **Applications** folder, you will see the Arduino IDE installed successfully after a few seconds.

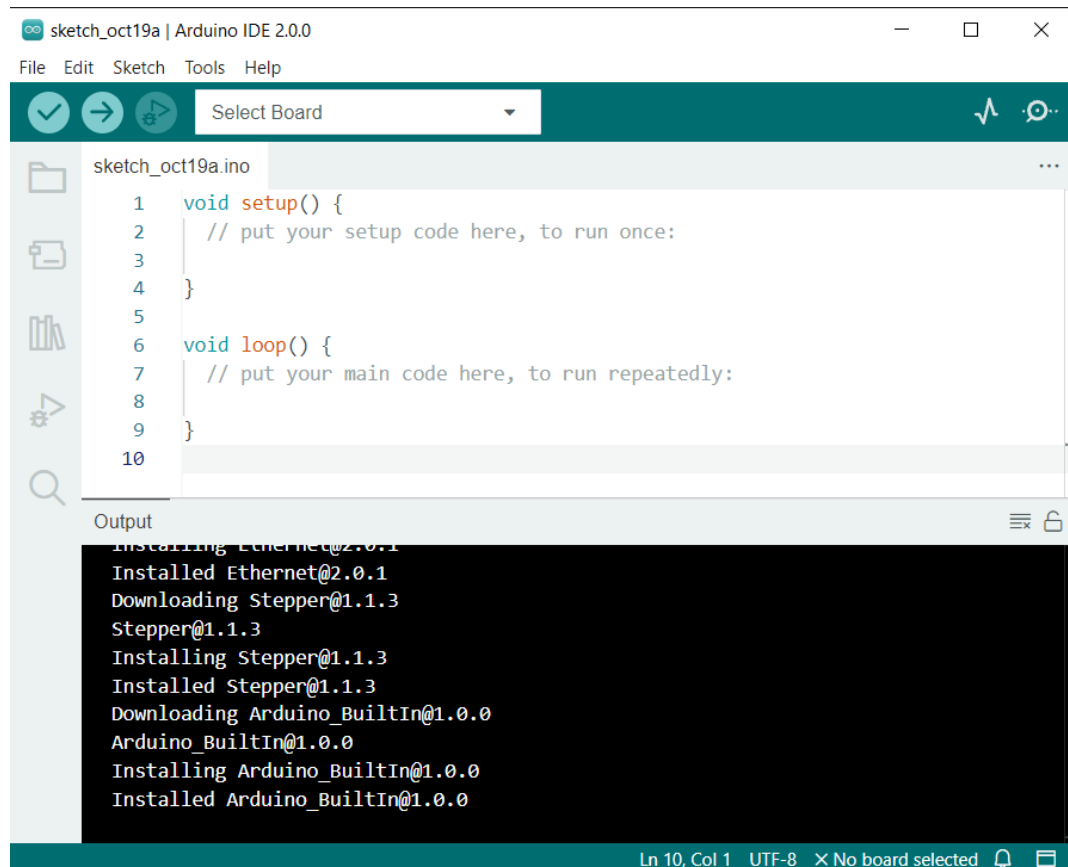


## Linux

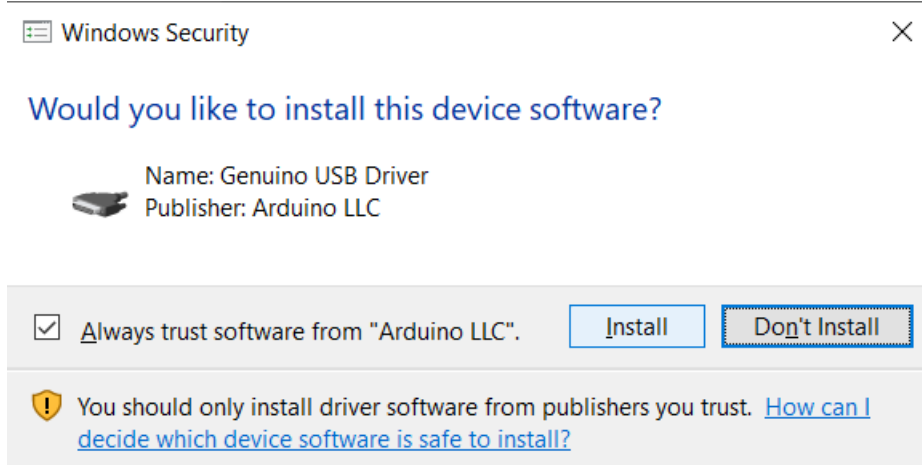
For the tutorial on installing the Arduino IDE 2.0 on a Linux system, please refer to: <https://docs.arduino.cc/software/ide-v2/tutorials/getting-started/ide-v2-downloading-and-installing#linux>

### Open the IDE

1. When you first open Arduino IDE 2.0, it automatically installs the Arduino AVR Boards, built-in libraries, and other required files.



2. In addition, your firewall or security center may pop up a few times asking you if you want to install some device driver. Please install all of them.



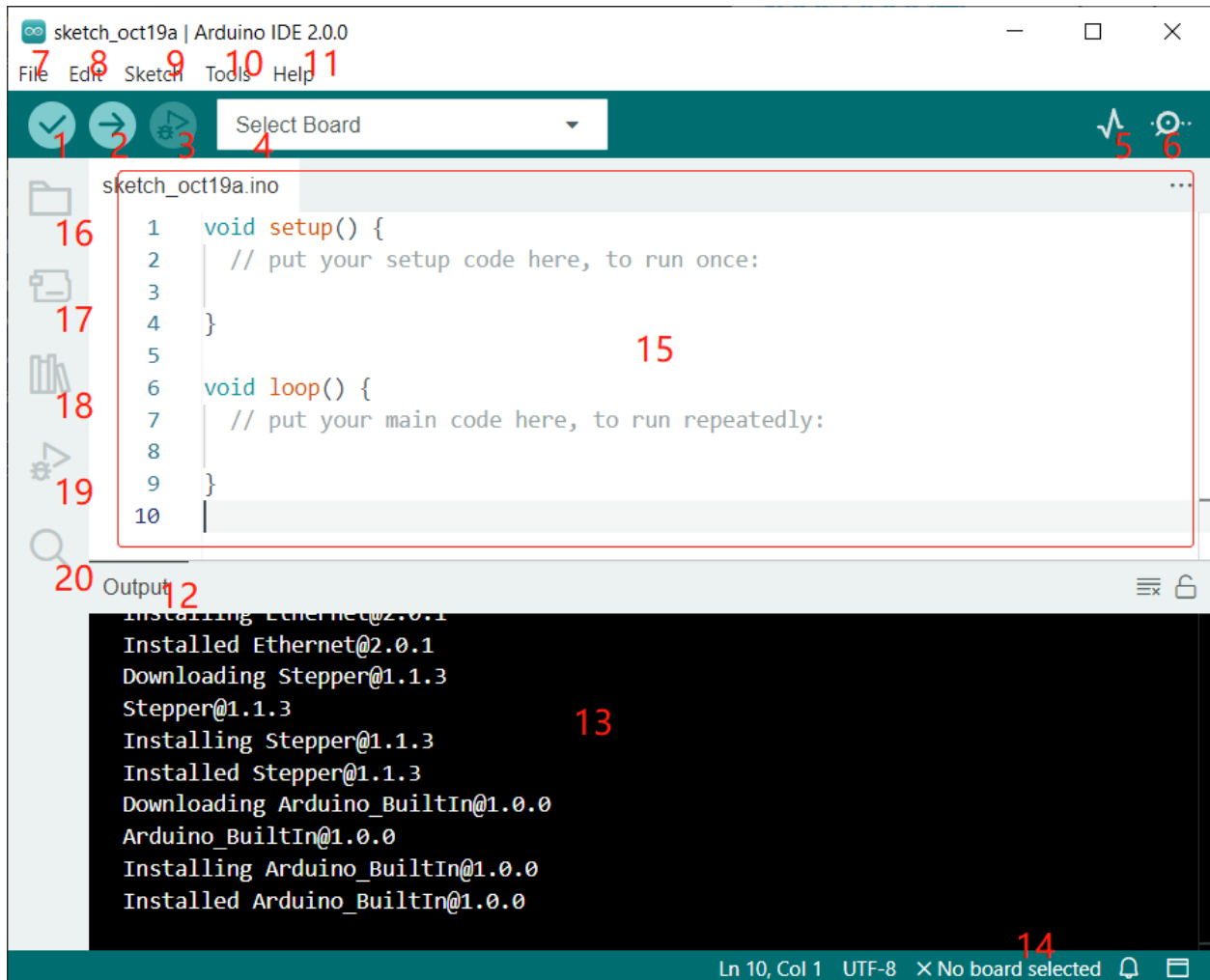
3. Now your Arduino IDE is ready!

---

**Note:** In the event that some installations didn't work due to network issues or other reasons, you can reopen the Arduino IDE and it will finish the rest of the installation. The Output window will not automatically open after all installations are complete unless you click Verify or Upload.

---

## 2.3.2 Introduce of Arduino IDE



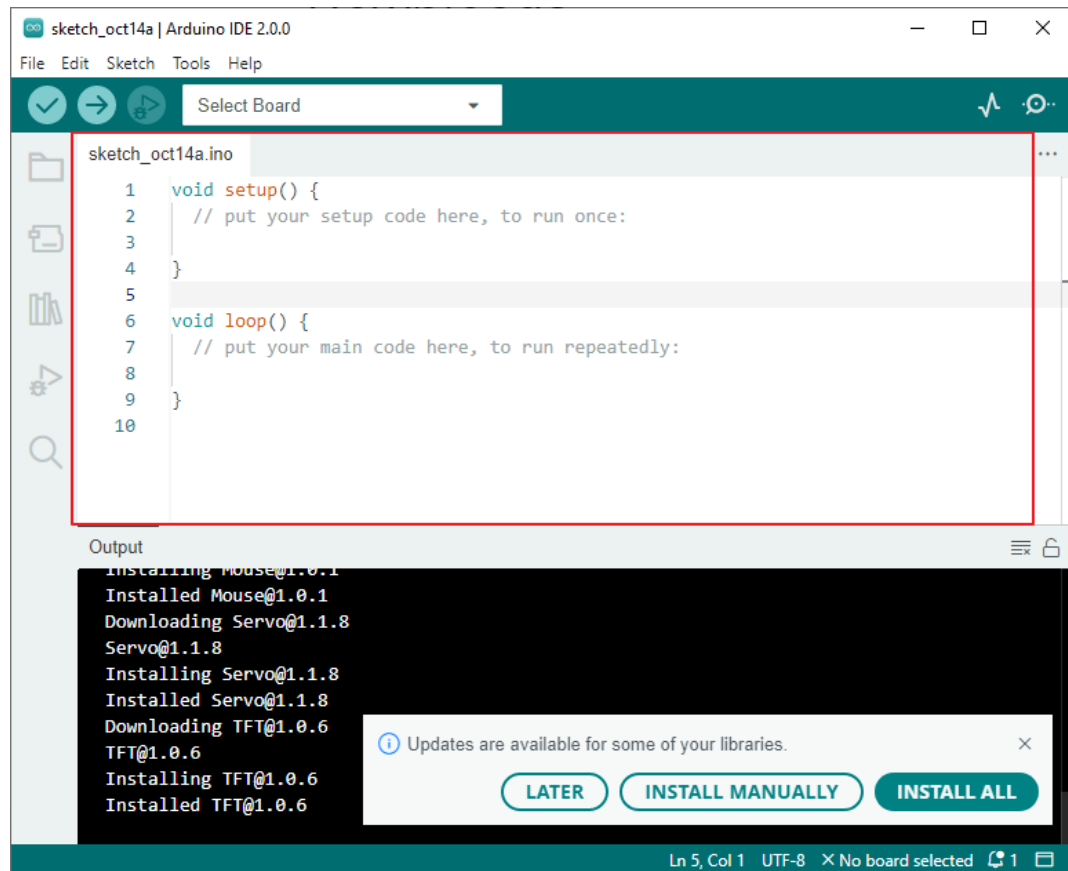
1. **Verify:** Compile your code. Any syntax problem will be prompted with errors.
2. **Upload:** Upload the code to your board. When you click the button, the RX and TX LEDs on the board will flicker fast and won't stop until the upload is done.
3. **Debug:** For line-by-line error checking.
4. **Select Board:** Quick setup board and port.
5. **Serial Plotter:** Check the change of reading value.
6. **Serial Monitor:** Click the button and a window will appear. It receives the data sent from your control board. It is very useful for debugging.
7. **File:** Click the menu and a drop-down list will appear, including file creating, opening, saving, closing, some parameter configuring, etc.
8. **Edit:** Click the menu. On the drop-down list, there are some editing operations like **Cut**, **Copy**, **Paste**, **Find**, and so on, with their corresponding shortcuts.
9. **Sketch:** Includes operations like **Verify**, **Upload**, **Add** files, etc. More important function is **Include Library** – where you can add libraries.



10. **Tool:** Includes some tools – the most frequently used Board (the board you use) and Port (the port your board is at). Every time you want to upload the code, you need to select or check them.
11. **Help:** If you're a beginner, you may check the options under the menu and get the help you need, including operations in IDE, introduction information, troubleshooting, code explanation, etc.
12. **Output Bar:** Switch the output tab here.
13. **Output Window:** Print information.
14. **Board and Port:** Here you can preview the board and port selected for code upload. You can select them again by **Tools -> Board / Port** if any is incorrect.
15. The editing area of the IDE. You can write code here.
16. **Sketchbook:** For managing sketch files.
17. **Board Manager:** For managing board driver.
18. **Library Manager:** For managing your library files.
19. **Debug:** Help debugging code.
20. **Search:** Search the codes from your sketches.

### 2.3.3 How to create, open or Save the Sketch?

1. When you open the Arduino IDE for the first time or create a new sketch, you will see a page like this, where the Arduino IDE creates a new file for you, which is called a “sketch”.



These sketch files have a regular temporary name, from which you can tell the date the file was created. `sketch_oct14a.ino` means October 14th first sketch, `.ino` is the file format of this sketch.

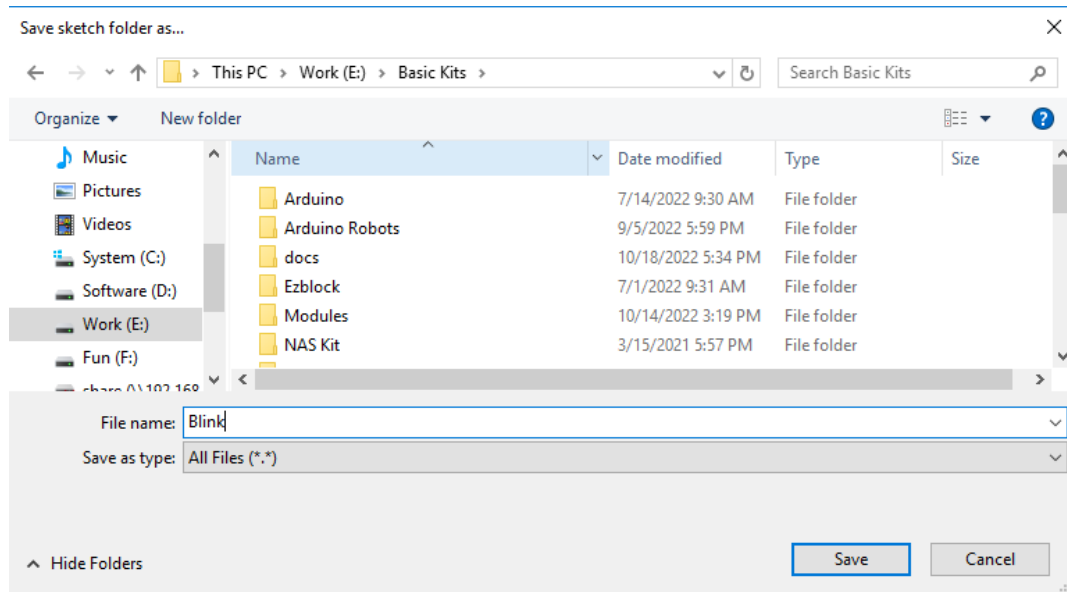
2. Now let's try to create a new sketch. Copy the following code into the Arduino IDE to replace the original code.



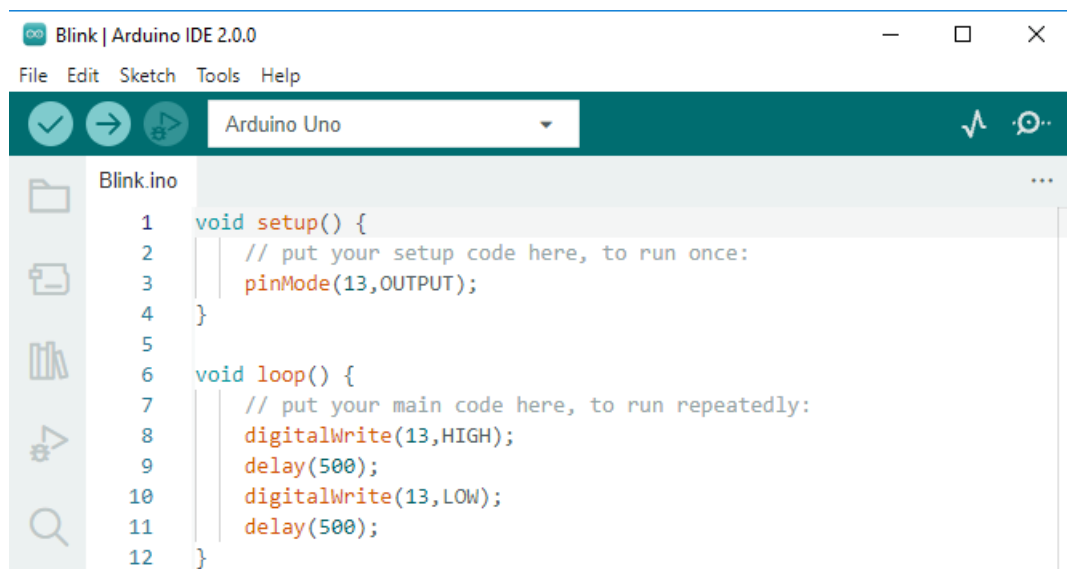
```
void setup() {
  // put your setup code here, to run once:
  pinMode(13,OUTPUT);
}

void loop() {
  // put your main code here, to run repeatedly:
  digitalWrite(13,HIGH);
  delay(500);
  digitalWrite(13,LOW);
  delay(500);
}
```

3. Press `Ctrl+S` or click **File** -> **Save**. The Sketch is saved in: `C:\Users\{your_user}\Documents\Arduino` by default, you can rename it or find a new path to save it.



4. After successful saving, you will see that the name in the Arduino IDE has been updated.



Please continue with the next section to learn how to upload this created sketch to your Arduino board.

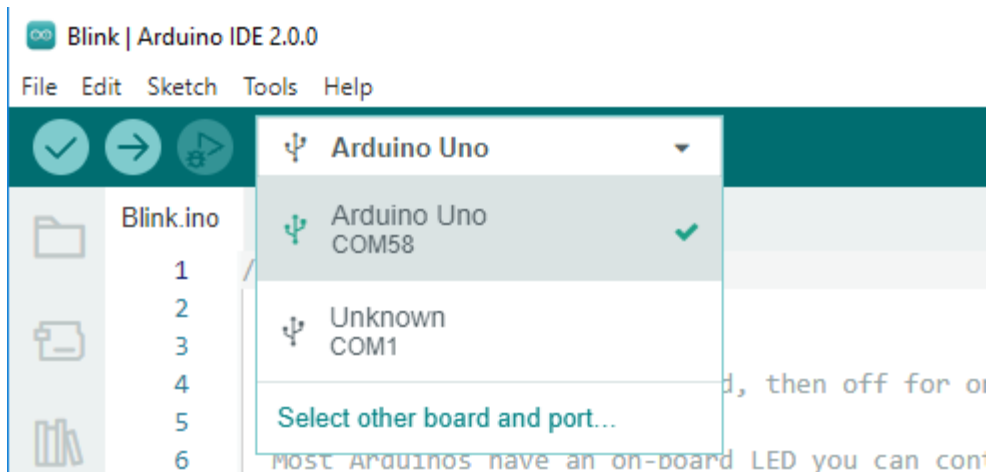
## 2.3.4 How to upload Sketch to the Board?

In this section, you will learn how to upload the sketch created previously to the Arduino board, as well as learn about some considerations.

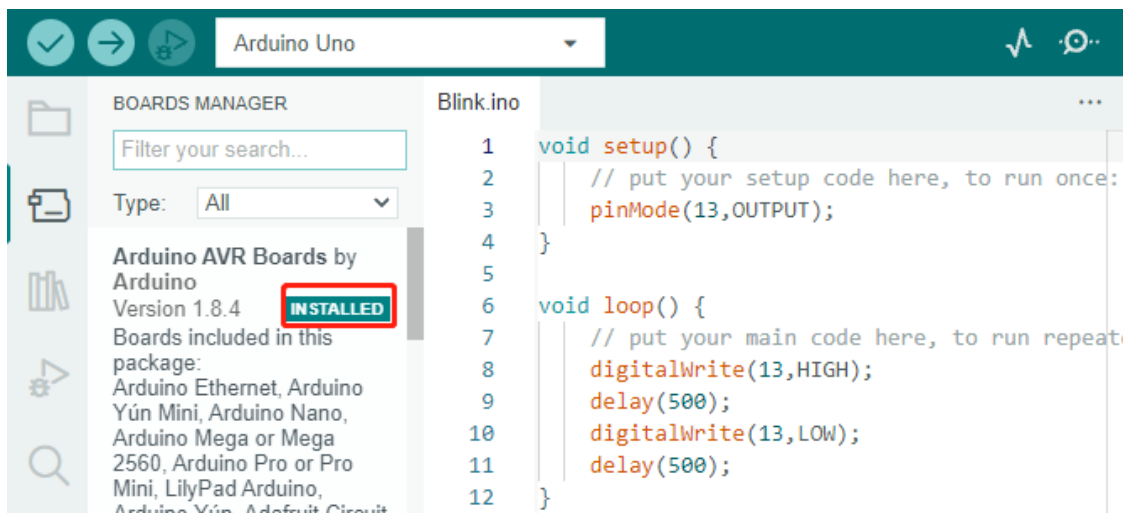
### 1. Choose Board and port

Arduino development boards usually come with a USB cable. You can use it to connect the board to your computer.

Select the correct **Board** and **Port** in the Arduino IDE. Normally, Arduino boards are recognized automatically by the computer and assigned a port, so you can select it here.



If your board is already plugged in, but not recognized, check if the **INSTALLED** logo appears in the **Arduino AVR Boards** section of the **Boards Manager**, if not, please scroll down a bit and click on **INSTALL**.



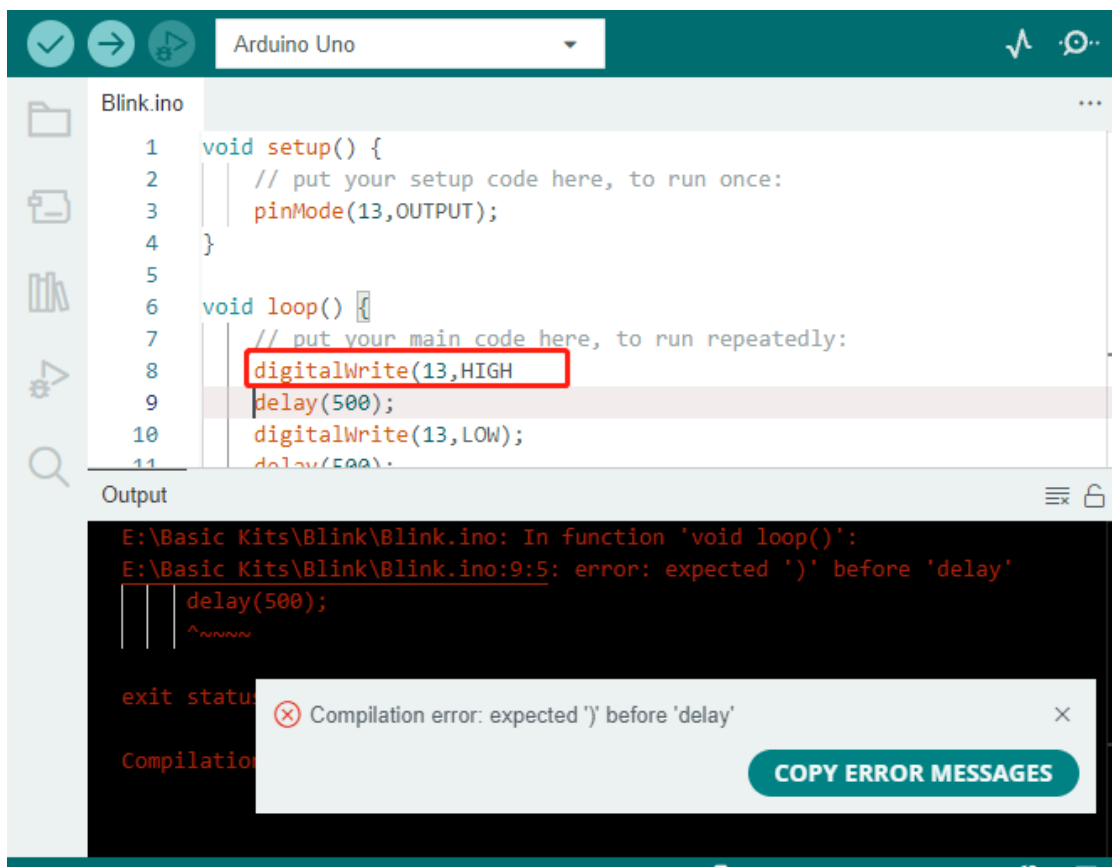
Reopening the Arduino IDE and re-plugging the Arduino board will fix most of the problems. You can also click **Tools** -> **Board** or **Port** to select them.

## 2. Verify the Sketch

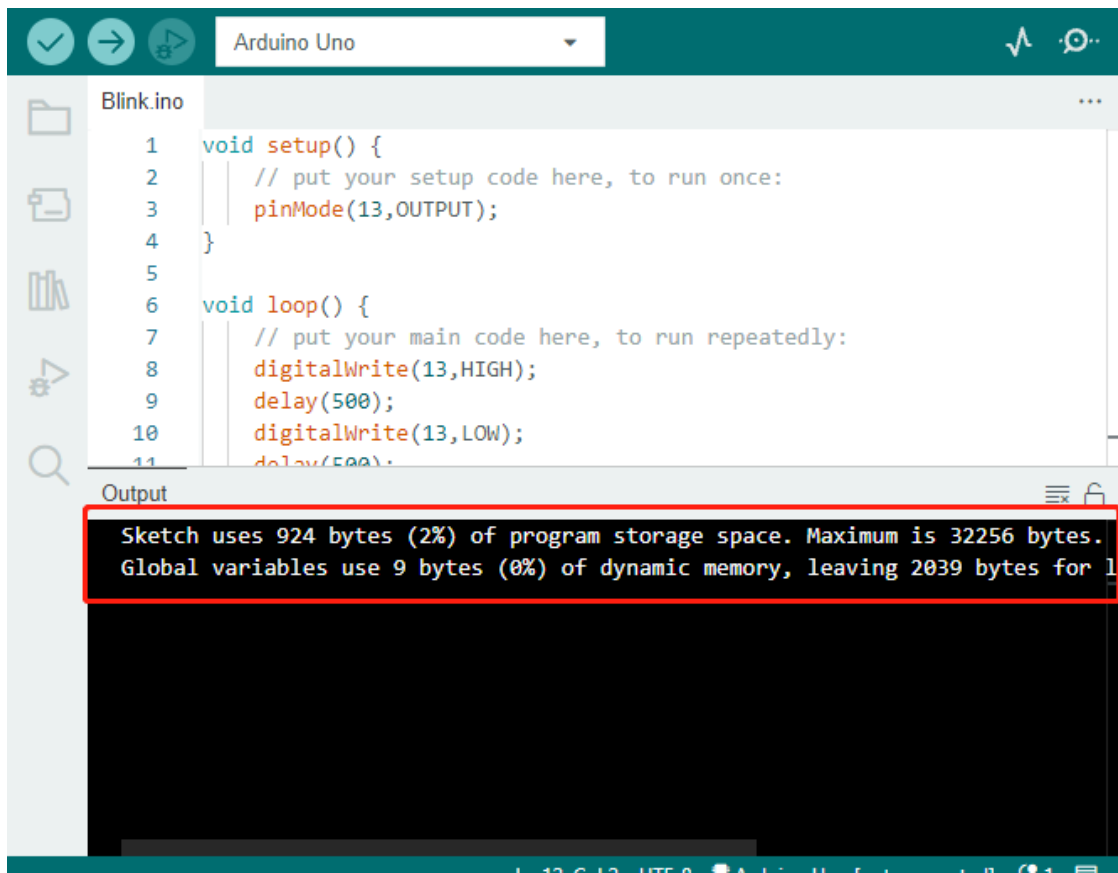
After clicking the Verify button, the sketch will be compiled to see if there are any errors.



You can use it to find mistakes if you delete some characters or type a few letters by mistake. From the message bar, you can see where and what type of errors occurred.

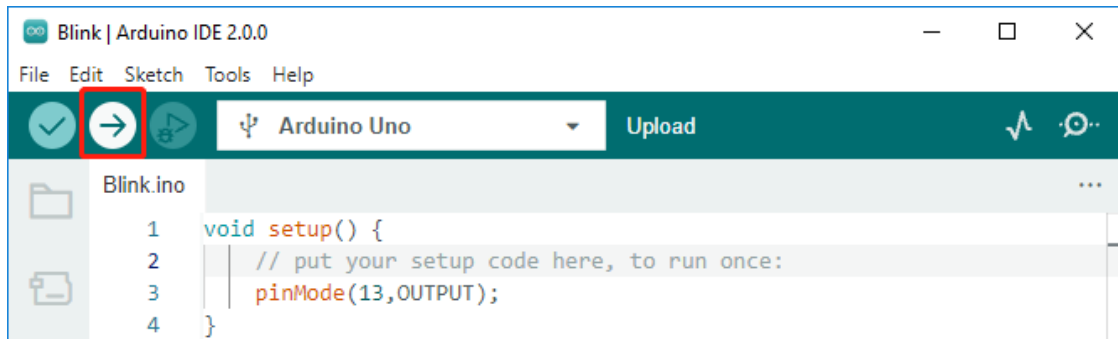


If there are no errors, you will see a message like the one below.

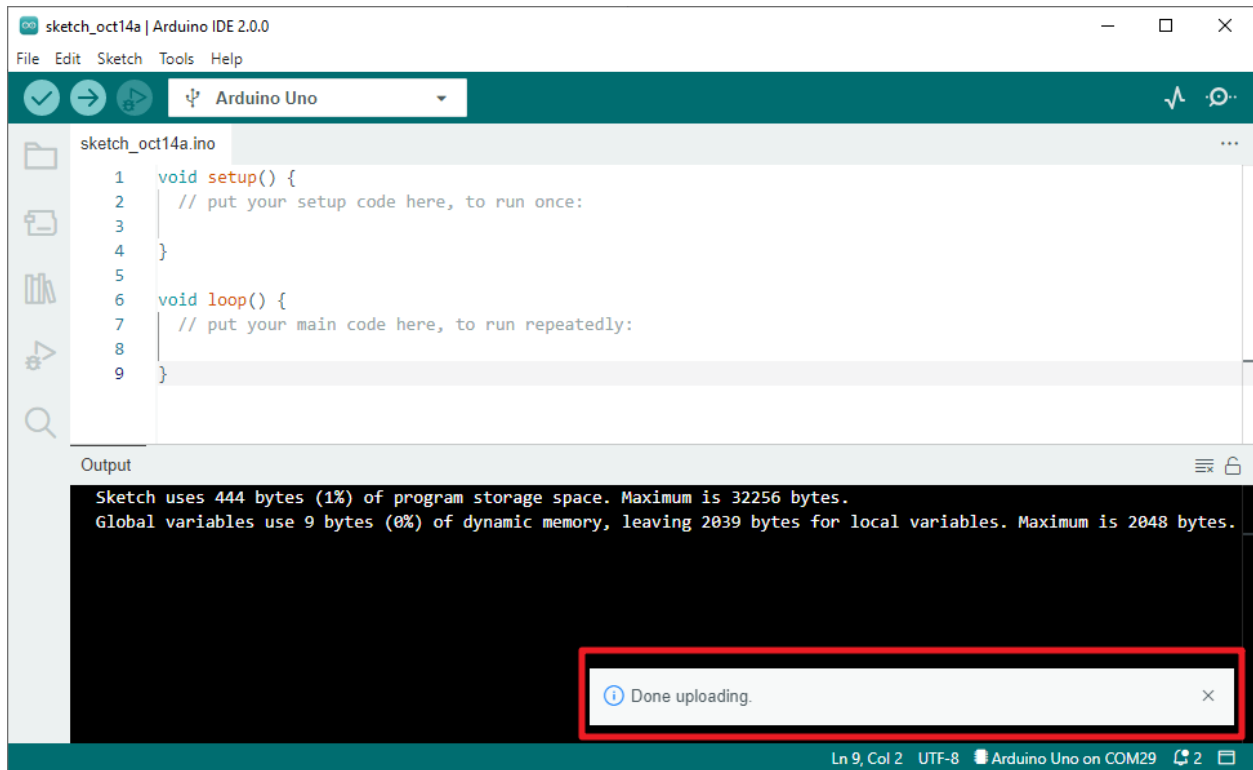


### 3. Upload sketch

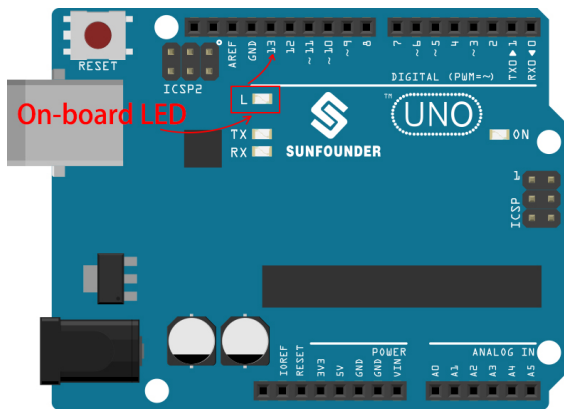
After completing the above steps, click the **Upload** button to upload this sketch to the board.



If successful, you will be able to see the following prompt.



At the same time, the on-board LED blink.



The Arduino board will automatically run the sketch after power is applied after the sketch is uploaded. The running program can be overwritten by uploading a new sketch.

### 2.3.5 Arduino Program Structure

Let's take a look at the new sketch file. Although it has a few lines of code itself, it is actually an “empty” sketch. Uploading this sketch to the development board will cause nothing to happen.

```

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

```

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

If we remove `setup()` and `loop()` and make the sketch a real blank file, you will find that it does not pass the verification. They are the equivalent of the human skeleton, and they are indispensable.

During sketching, `setup()` is run first, and the code inside it (inside `{}`) is run after the board is powered up or reset and only once. `loop()` is used to write the main feature, and the code inside it will run in a loop after `setup()` is executed.

To better understand `setup()` and `loop()`, let's use four sketches. Their purpose is to make the on-board LED of the Arduino blink. Please run each experiment in turn and record their specific effects.

- Sketch 1: Make the on-board LED blink continuously.

```
void setup() {  
  // put your setup code here, to run once:  
  pinMode(13,OUTPUT);  
}  
  
void loop() {  
  // put your main code here, to run repeatedly:  
  digitalWrite(13,HIGH);  
  delay(500);  
  digitalWrite(13,LOW);  
  delay(500);  
}
```

- Sketch 2: Make the on-board LED blink only once.

```
void setup() {  
  // put your setup code here, to run once:  
  pinMode(13,OUTPUT);  
  digitalWrite(13,HIGH);  
  delay(500);  
  digitalWrite(13,LOW);  
  delay(500);  
}  
  
void loop() {  
  // put your main code here, to run repeatedly:  
}
```

- Sketch 3: Make the on-board LED blink slowly once and then blink quickly.

```
void setup() {  
  // put your setup code here, to run once:  
  pinMode(13,OUTPUT);  
  digitalWrite(13,HIGH);  
  delay(1000);  
  digitalWrite(13,LOW);  
  delay(1000);  
}
```

(continues on next page)



(continued from previous page)

```

}

void loop() {
    // put your main code here, to run repeatedly:
    digitalWrite(13,HIGH);
    delay(200);
    digitalWrite(13,LOW);
    delay(200);
}

```

- Sketch 4: Report an error.

```

void setup() {
    // put your setup code here, to run once:
    pinMode(13,OUTPUT);
}

digitalWrite(13,HIGH);
delay(1000);
digitalWrite(13,LOW);
delay(1000);

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

```

With the help of these sketches, we can summarize several features of `setup-loop`.

- `loop()` will be run repeatedly after the board is powered up.
- `setup()` will run only once after the board is powered up.
- After the board is powered up, `setup()` will run first, followed by `loop()`.
- The code needs to be written within the `{}` scope of `setup()` or `loop()`, out of the framework will be an error.

---

**Note:** Statements such as `digitalWrite(13,HIGH)` are used to control the on-board LED, and we will talk about their usage in detail in later chapters.

---

### 2.3.6 Sketch Writing Rule

If you ask a friend to turn on the lights for you, you can say “Turn on the lights.”, or “Lights on, bro.”, you can use any tone of voice you want.

However, if you want the Arduino board to do something for you, you need to follow the Arduino program writing rules to type in the commands.

This chapter contains the basic rules of the Arduino language and will help you understand how to translate natural language into code.

Of course, this is a process that takes time to get familiar with, and it is also the most error-prone part of the process for newbies, so if you make mistakes often, it’s okay, just try a few more times.

### Semicolon ;

Just like writing a letter, where you write a period at the end of each sentence as the end, the Arduino language requires you to use ; to tell the board the end of the command.

Take the familiar “onboard LED blinking” example. A healthy sketch should look like this.

Example:

```
void setup() {  
    // put your setup code here, to run once:  
    pinMode(13,OUTPUT);  
}  
  
void loop() {  
    // put your main code here, to run repeatedly:  
    digitalWrite(13,HIGH);  
    delay(500);  
    digitalWrite(13,LOW);  
    delay(500);  
}
```

Next, let’s take a look at the following two sketches and guess if they can be correctly recognized by Arduino before running them.

Sketch A:

```
void setup() {  
    // put your setup code here, to run once:  
    pinMode(13,OUTPUT);  
}  
  
void loop() {  
    // put your main code here, to run repeatedly:  
    digitalWrite(13,HIGH)  
    delay(500)  
    digitalWrite(13,LOW)  
    delay(500)  
}
```

Sketch B:

```
void setup() {  
    // put your setup code here, to run once:  
    pinMode(13,OUTPUT);  
}  
  
void loop() {  
    // put your main code here, to run repeatedly:  
    digitalWrite(13,  
HIGH); delay  
    (500  
    );  
    digitalWrite(13,
```

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```
LOW);
    delay(500)
;
}
```

The result is that **Sketch A** reports an error and **Sketch B** runs.

- The errors in **Sketch A** are missing ; and although it looks normal, the Arduino can't read it.
- **Sketch B**, looks anti-human, but in fact, indentation, line breaks and spaces in statements are things that do not exist in Arduino programs, so to the Arduino compiler, it looks the same as in the example.

However, please don't write your code as **Sketch B**, because it is usually natural people who write and view the code, so don't get yourself into trouble.

### Curlybraces {}

{ } is the main component of the Arduino programming language, and they must appear in pairs. A better programming convention is to insert a structure that requires curly braces by typing the right curly brace directly after typing the left curly brace, and then moving the cursor between the curly braces to insert the statement.

### Comment //

Comment is the part of the sketch that the compiler ignores. They are usually used to tell others how the program works.

If we write two adjacent slashes in a line of code, the compiler will ignore anything up to the end of the line.

If we create a new sketch, it comes with two comments, and if we remove these two comments, the sketch will not be affected in any way.

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

}

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

}
```

Comment is very useful in programming, and several common uses are listed below.

- Usage A: Tell yourself or others what this section of code does.

```
void setup() {
    pinMode(13,OUTPUT); //Set pin 13 to output mode, it controls the onboard LED
}

void loop() {
    digitalWrite(13,HIGH); // Activate the onboard LED by setting pin 13 high
    delay(500); // Status quo for 500 ms
    digitalWrite(13,LOW); // Turn off the onboard LED
}
```

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```
    delay(500); // Status quo for 500 ms
}
```

- Usage B: Temporarily invalidate some statements (without deleting them) and uncomment them when you need to use them, so you don't have to rewrite them. This is very useful when debugging code and trying to locate program errors.

```
void setup() {
    pinMode(13,OUTPUT);
    // digitalWrite(13,HIGH);
    // delay(1000);
    // digitalWrite(13,LOW);
    // delay(1000);
}

void loop() {
    digitalWrite(13,HIGH);
    delay(200);
    digitalWrite(13,LOW);
    delay(200);
}
```

---

**Note:** Use the shortcut Ctrl+/ to help you quickly comment or uncomment your code.

---

### Comment /\*\*/

Same as // for comments. This type of comment can be more than one line long, and once the compiler reads /\*, it ignores anything that follows until it encounters \*/.

Example 1:

```
/* Blink */

void setup() {
    pinMode(13,OUTPUT);
}

void loop() {
    /*
    The following code will blink the onboard LED
    You can modify the number in delay() to change the blinking frequency
    */
    digitalWrite(13,HIGH);
    delay(500);
    digitalWrite(13,LOW);
    delay(500);
}
```

## #define

This is a useful C++ tool.

```
#define identifier token-string
```

The compiler automatically replaces `identifier` with `token-string` when it reads it, which is usually used for constant definitions.

As an example, here is a sketch that uses `define`, which improves the readability of the code.

```
#define ONBOARD_LED 13
#define DELAY_TIME 500

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

void loop() {
    digitalWrite(ONBOARD_LED, HIGH);
    delay(DELAY_TIME);
    digitalWrite(ONBOARD_LED, LOW);
    delay(DELAY_TIME);
}
```

To the compiler, it actually looks like this.

```
void setup() {
    pinMode(13, OUTPUT);
}

void loop() {
    digitalWrite(13, HIGH);
    delay(500);
    digitalWrite(13, LOW);
    delay(500);
}
```

We can see that the `identifier` is replaced and does not exist inside the program. Therefore, there are several caveats when using it.

1. A `token-string` can only be modified manually and cannot be converted into other values by arithmetic in the program.
2. Avoid using symbols such as `;`. For example.

```
#define ONBOARD_LED 13;

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

void loop() {
    digitalWrite(ONBOARD_LED, HIGH);
}
```

The compiler will recognize it as the following, which is what will be reported as an error.

```
void setup() {  
    pinMode(13,OUTPUT);  
}  
  
void loop() {  
    digitalWrite(13,HIGH);  
}
```

---

**Note:** A naming convention for `#define` is to capitalize `identifier` to avoid confusion with variables.

---

### 2.3.7 Variable

The variable is one of the most powerful and critical tools in a program. It helps us to store and call data in our programs.

The following sketch file uses variables. It stores the pin numbers of the on-board LED in the variable `ledPin` and a number “500” in the variable `delayTime`.

```
int ledPin = 13;  
int delayTime = 500;  
  
void setup() {  
    pinMode(ledPin,OUTPUT);  
}  
  
void loop() {  
    digitalWrite(ledPin,HIGH);  
    delay(delayTime);  
    digitalWrite(ledPin,LOW);  
    delay(delayTime);  
}
```

Wait, is this a duplicate of what `#define` does? The answer is NO.

- The role of `#define` is to simply and directly replace text, it is not considered by the compiler as part of the program.
- A variable, on the other hand, exists within the program and is used to store and call value. A variable can also modify its value within the program, something that a define cannot do.

The sketch file below self-adds to the variable and it will cause the on-board LED to blink longer after each blink.

```
int ledPin = 13;  
int delayTime = 500;  
  
void setup() {  
    pinMode(ledPin,OUTPUT);  
}  
  
void loop() {  
    digitalWrite(ledPin,HIGH);  
    delay(delayTime);
```

(continues on next page)

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```
digitalWrite(ledPin,LOW);
delay(delayTime);
delayTime = delayTime+200; //Each execution increments the value by 200
}
```

## Declare a variable

Declaring a variable means creating a variable.

To declare a variable, you need two things: the data type, and the variable name. The data type needs to be separated from the variable by a space, and the variable declaration needs to be terminated by a ;.

Let's use this variable as an example.

```
int delayTime;
```

## Data Type

Here `int` is a data type called integer type, which can be used to store integers from -32768 to 32766. It can also not be used to store decimals.

Variables can hold different kinds of data other than integers. The Arduino language (which, remember, is C++) has built-in support for a few of them (only the most frequently used and useful are listed here):

- `float`: Store a decimal number, for example 3.1415926.
- `byte`: Can hold numbers from 0 to 255.
- `boolean`: Holds only two possible values, `True` or `False`, even though it occupies a byte in memory.
- `char`: Holds a number from -127 to 127. Because it is marked as a `char` the compiler will try to match it to a character from the .
- `string`: Can stores a string of characters, e.g. Halloween.

## Variable Name

You can set the variable to any name you want, such as `i`, `apple`, `Bruce`, `R2D2`, `Sectumsempra`, but there are some basic rules to follow.

1. describe what it is used for. Here, I named the variable `delayTime`, so you can easily understand what it does. It works fine if I name the variable `barryAllen`, but it confuses the person looking at the code.
2. Use regular nomenclature. You can use CamelCase like I did, with the initial T in `delayTime` so that it is easy to see that the variable consists of two words. Also, you can use UnderScoreCase to write the variable as `delay_time`. It doesn't affect the program's running, but it would help the programmer to read the code if you use the nomenclature you prefer.
3. Don't use keywords. Similar to what happens when we type "`int`", the Arduino IDE will color it to remind you that it is a word with a special purpose and cannot be used as a variable name. Change the name of the variable if it is colored.
4. Special symbols are not allowed. For example, space, #, \$, /, +, %, etc. The combination of English letters (case sensitive), underscores, and numbers (but numbers cannot be used as the first character of a variable name) is rich enough.

## Assign a value to a variable

Once we have declared the variable, it is time to store the data. We use the assignment operator (i.e. `=`) to put value into the variable.

We can assign values to the variable as soon as we declare it.

```
int delayTime = 500;
```

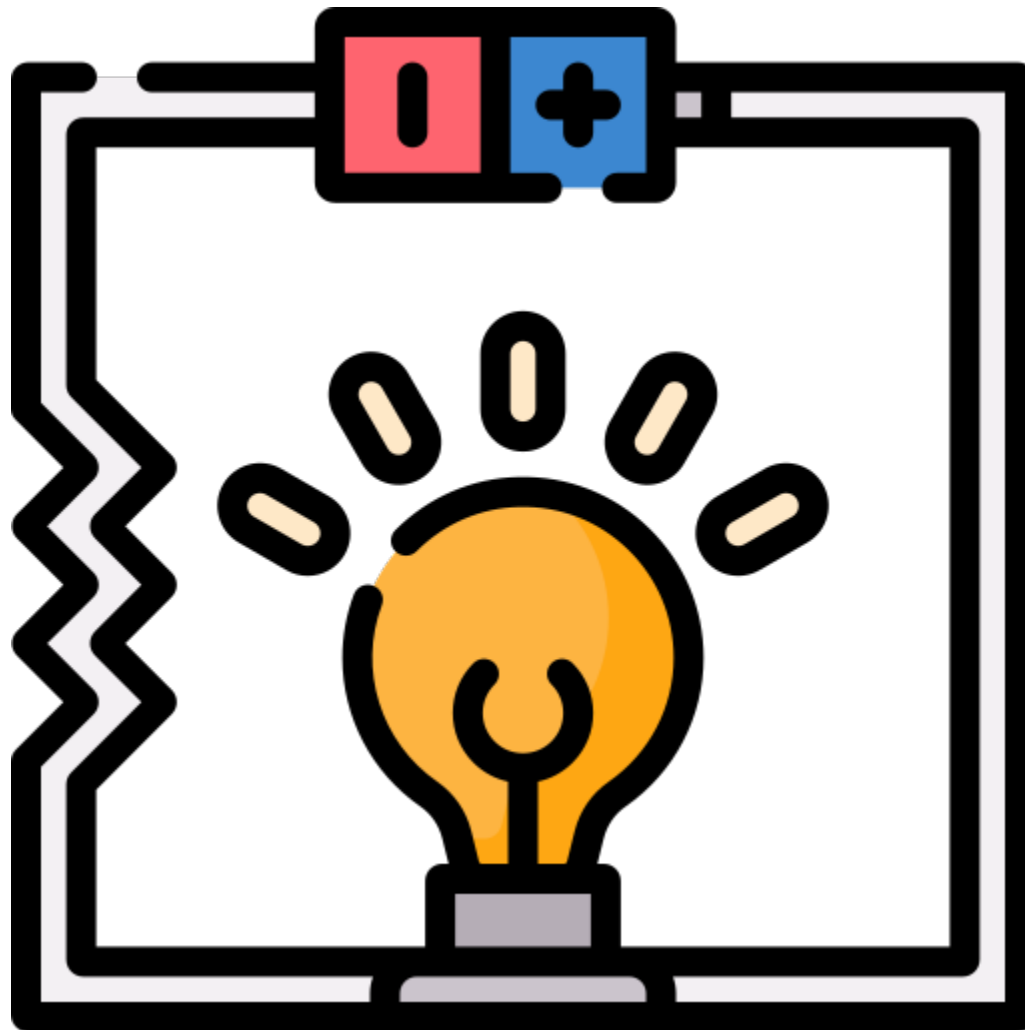
It is also possible to assign a new value to it at some time.

```
int delayTime; // no value  
delayTime = 500; // value is 500  
delayTime = delayTime + 200; // value is 700
```

### 2.3.8 How to Build the Circuit

Many of the things you use every day are powered by electricity, like the lights in your house and the computer you're reading.

To use electricity, you must build an electrical circuit. Basically, a circuit is a path through which electricity flows, or an electronic circuit, and is made up of electrical devices and components (appliances) that are connected in a certain way, such as resistors, capacitors, power supplies, and switches.

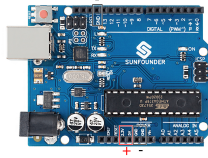


A circuit is a closed path in which electrons move to create an electric current. To flow current, there must be a conducting path between the positive terminal of the power supply and the negative terminal, which is called a closed



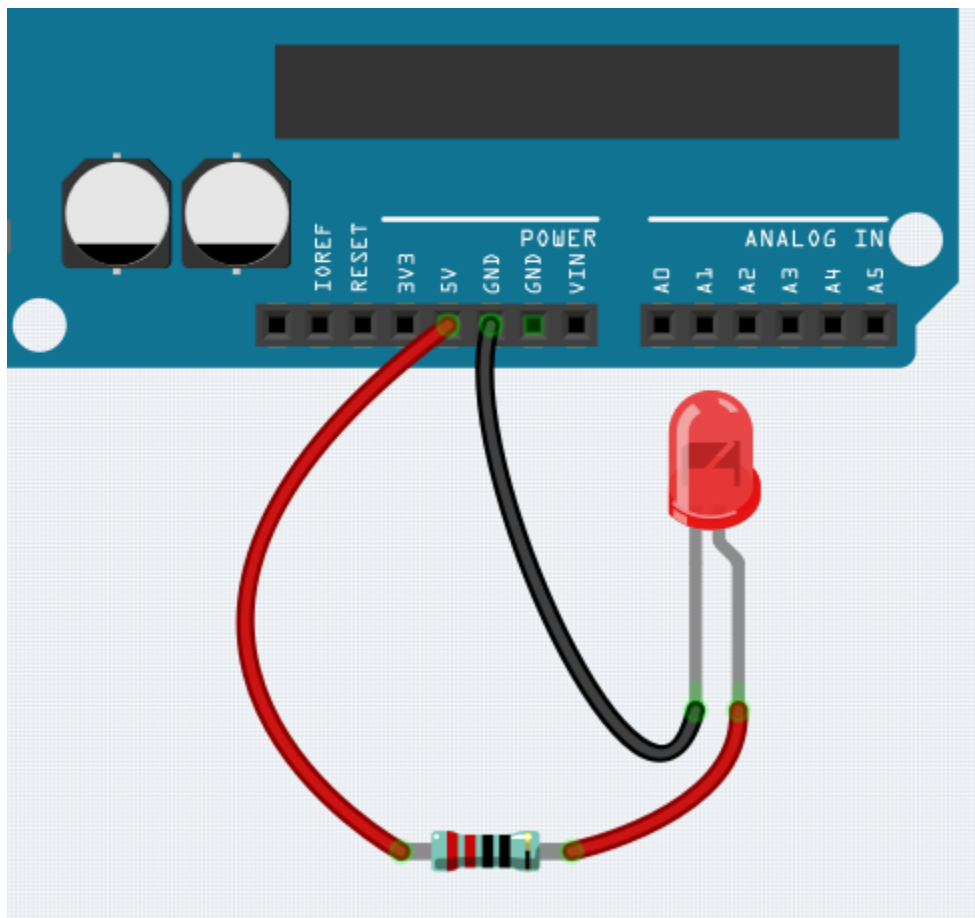
circuit (if it is broken, it is called an open circuit.) .

The Arduino Board has some power output pins (positive) and some ground pins (negative). You can use these pins as the positive and negative sides of the power supply by plugging the power source into the board.



With electricity, you can create works with light, sound, and motion. You can light up an LED by connecting the long pin to the positive terminal and the short pin to the negative terminal. The LED will break down very quickly if you do this, so you need to add a 220\* resistor inside the circuit to protect it.

The circuit they form is shown below.



You may have questions this time: how do I build this circuit? Hold the wires by hand, or tape the pins and wires?

In this situation, solderless breadboards will be your strongest allies.

### Hello, Breadboard!

A breadboard is a rectangular plastic plate with a bunch of small holes. These holes allow us to easily insert electronic components and build electronic circuits. Breadboards do not permanently fix electronic components, so we can easily repair a circuit and start over if something goes wrong.

**Note:** There is no need for special tools to use breadboards. However, many electronic components are very small, and a pair of tweezers can help us to pick up small parts better.

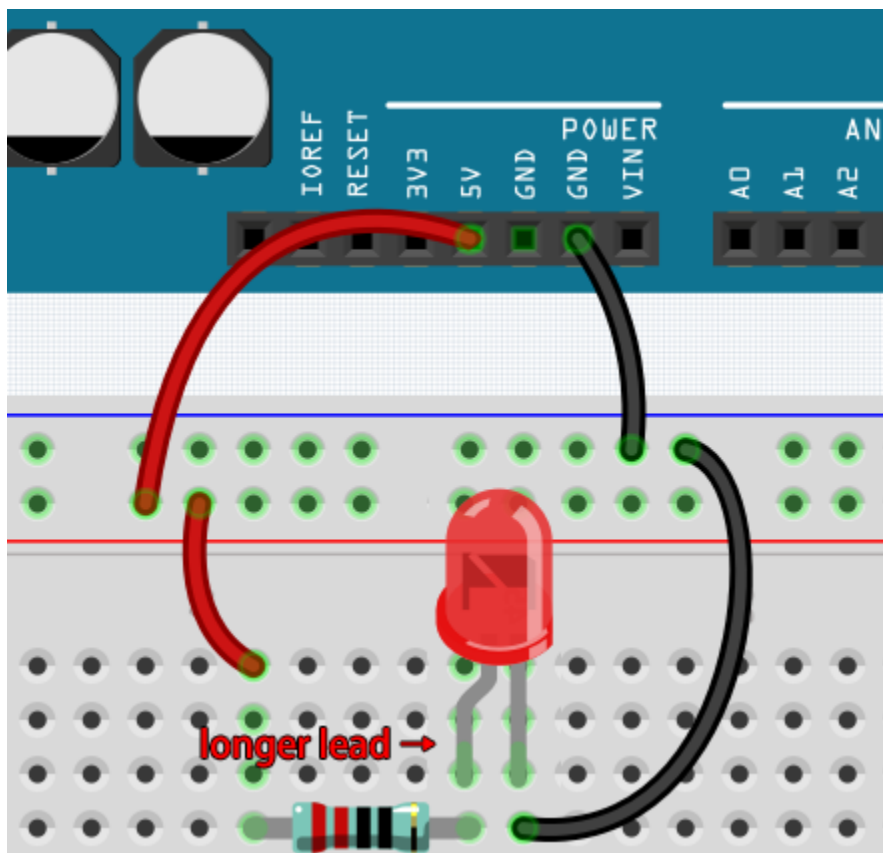
On the Internet, we can find a lot of information about breadboards.

- [How to Use a Breadboard - Science Buddies](#)
- [What is a BREADBOARD? - Makezine](#)

Here are some things you should know about breadboards.

1. Each half-row group (such as column A-E in row 1 or column F-J in row 3) is connected. Therefore, if an electrical signal flows in from A1, it can flow out from B1, C1, D1, E1, but not from F1 or A2.
2. In most cases, both sides of the breadboard are used as power buses, and the holes in each column (about 50 holes) are connected together. As a general rule, positive power supplies are connected to the holes near the red wire, and negative power supplies are connected to the holes near the blue wire.
3. In a circuit, current flows from the positive pole to the negative pole after passing through the load. In this case, a short circuit may occur.

Let us follow the direction of the current to build the circuit!



1. In this circuit, we use the 5V pin of the board to power the LED. Use a male-to-male (M2M) jumper wire to connect it to the red power bus.
2. To protect the LED, the current must pass through a 220 ohm resistor. Connect one end (either end) of the resistor to the red power bus, and the other end to the free row of the breadboard.

---

**Note:** The color ring of the 220 ohm resistor is red, red, black, black and brown.

---

3. If you pick up the LED, you will see that one of its leads is longer than the other. Connect the longer lead to the same row as the resistor, and the shorter lead to the other row.

---

**Note:** The longer lead is the anode, which represents the positive side of the circuit; the shorter lead is the cathode, which represents the negative side.

The anode needs to be connected to the GPIO pin through a resistor; the cathode needs to be connected to the GND pin.

---

4. Using a male-to-male (M2M) jumper wire, connect the LED short pin to the breadboard's negative power bus.
5. Connect the GND pin of board to the negative power bus using a jumper.

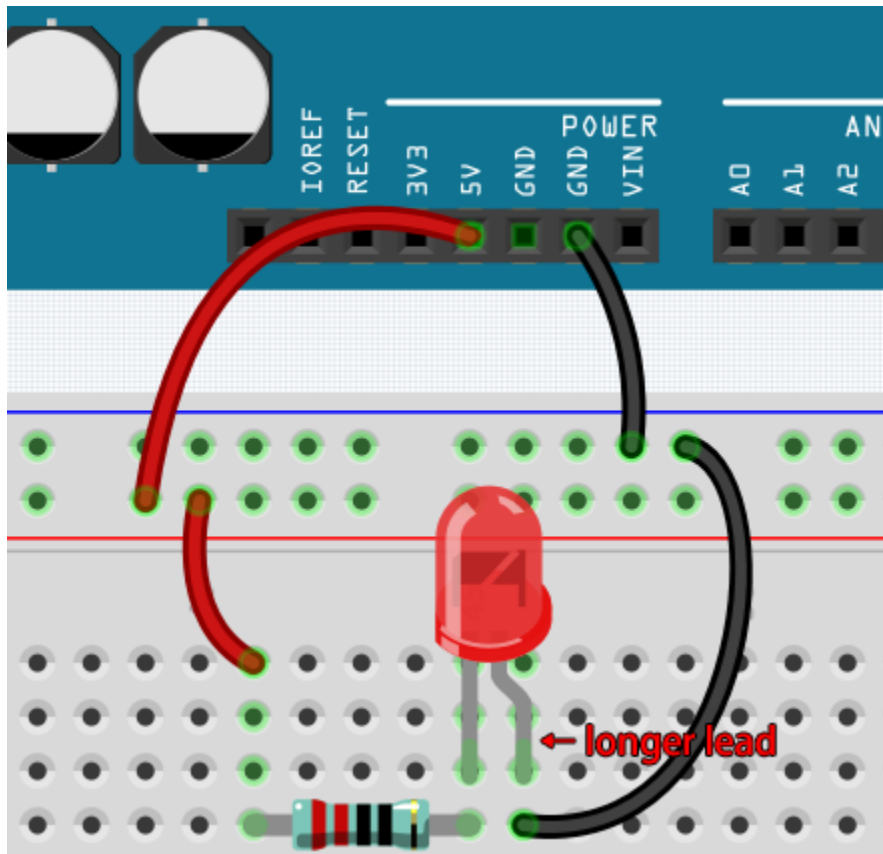
### Beware of short circuits

Short circuits can occur when two components that shouldn't be connected are "accidentally" connected. This kit includes resistors, transistors, capacitors, LEDs, etc. that have long metal pins that can bump into each other and cause a short. Some circuits are simply prevented from functioning properly when a short occurs. Occasionally, a short circuit can damage components permanently, especially between the power supply and the ground bus, causing the circuit to get very hot, melting the plastic on the breadboard and even burning the components!

Therefore, always make sure that the pins of all the electronics on the breadboard are not touching each other.

### Direction of the circuit

There is an orientation to circuits, and the orientation plays a significant role in certain electronic components. There are some devices with polarity, which means they must be connected correctly based on their positive and negative poles. Circuits built with the wrong orientation will not function properly.



If you reverse the LED in this simple circuit that we built earlier, you will find that it no longer works.

In contrast, some devices have no direction, such as the resistors in this circuit, so you can try inverting them without affecting the LEDs' normal operation.

Most components and modules with labels such as “+”, “-”, “GND”, “VCC” or have pins of different lengths must be connected to the circuit in a specific way.

### Protection of the circuit

Current is the rate at which electrons flow past a point in a complete electrical circuit. At its most basic, current = flow. An ampere (AM-pir), or amp, is the international unit used for measuring current. It expresses the quantity of electrons (sometimes called “electrical charge”) flowing past a point in a circuit over a given time.

The driving force (voltage) behind the flow of current is called voltage and is measured in volts (V).

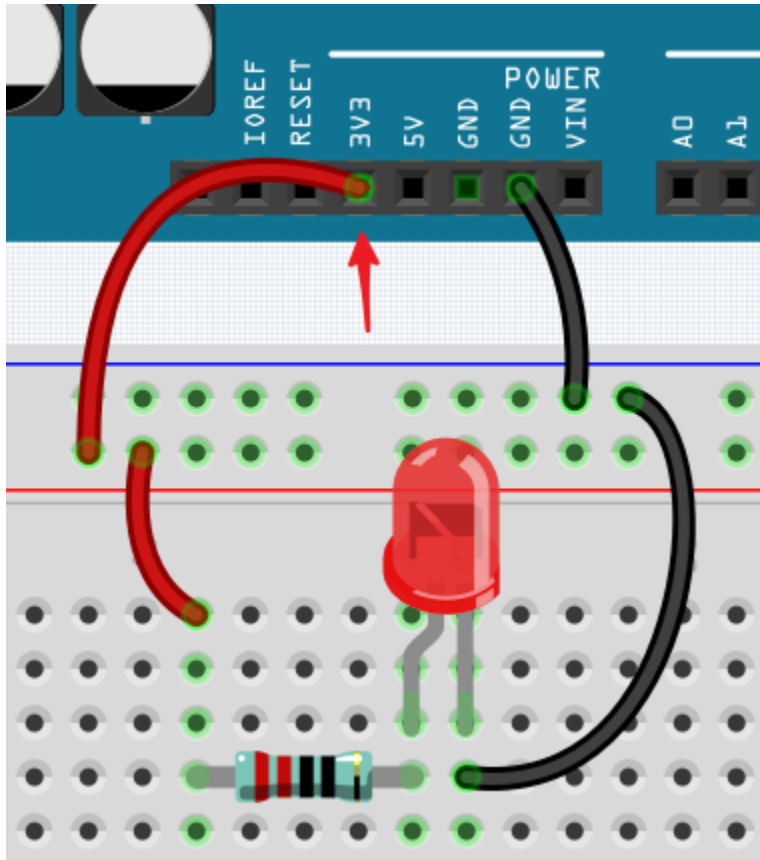
Resistance (R) is the property of the material that restricts the flow of current, and it is measured in ohms ( $\Omega$ ).

According to Ohm's law (as long as the temperature remains constant), current, voltage, and resistance are proportional. A circuit's current is proportional to its voltage and inversely proportional to its resistance.

Therefore, current (I) = voltage (V) / resistance (R).

- [Ohm's law - Wikipedia](#)

About Ohm's law we can do a simple experiment.



By changing the wire connecting 5V to 3.3V, the LED gets dimmer. If you change the resistor from 220ohm to 1000ohm (color ring: brown, black, black, brown and brown), you will notice that the LED becomes dimmer than before. The larger the resistor, the dimmer the LED.

---

**Note:** For an introduction to resistors and how to calculate resistance values, see [Resistor](#).

---

Most packaged modules only require access to the proper voltage (usually 3.3V or 5V), such as ultrasonic module.

However, in your self-built circuits, you need to be aware of the supply voltage and resistor usage for electrical devices.

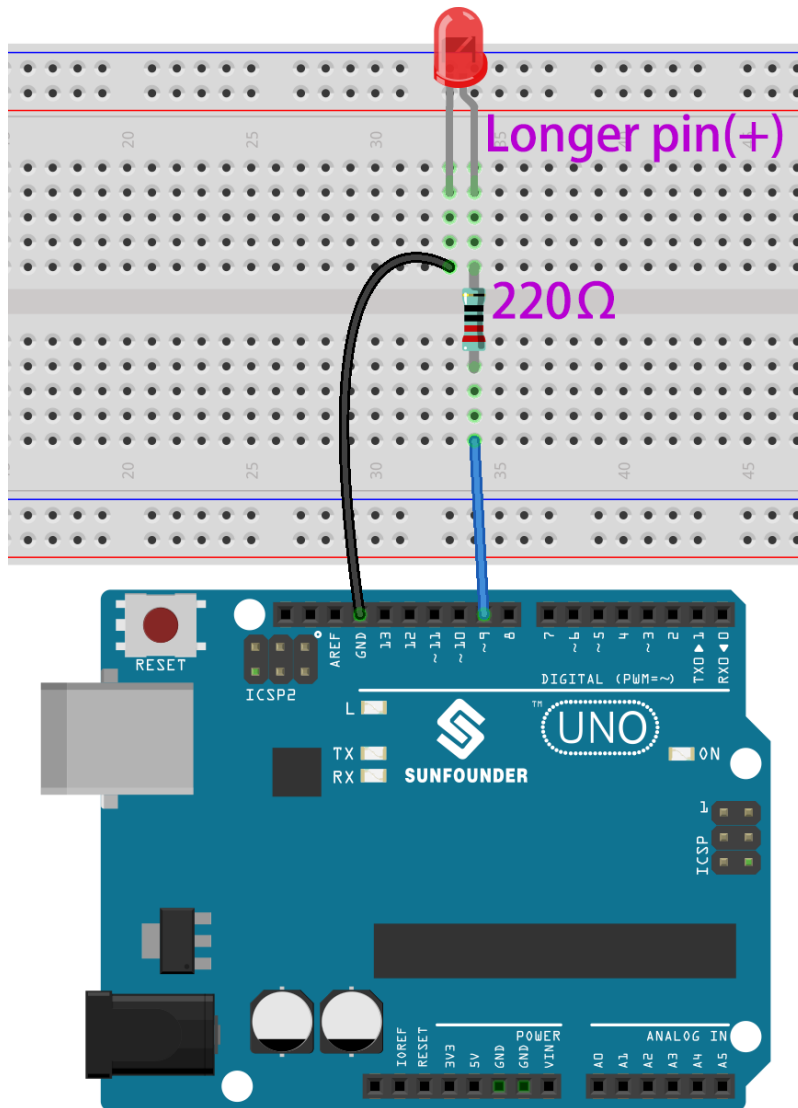
As an example, LEDs usually consume 20mA of current, and their voltage drop is about 1.8V. According to Ohm's law, if we use 5V power supply, we need to connect a minimum of 160ohm  $((5-1.8)/20\text{mA})$  resistor in order not to burn out the LED.

### Control circuit with Arduino

Now that we have a basic understanding of Arduino programming and electronic circuits, it's time to face the most critical question: How to control circuits with Arduino.

Simply put, the way Arduino controls a circuit is by changing the level of the pins on the board. For example, when controlling an on-board LED, it is writing a high or low level signal to pin 13.

Now let's try to code the Arduino board to control the blinking LED on the breadboard. Build the circuit so that the LED is connected to pin 9.



Next, upload this sketch to the Arduino development board.

```
int ledPin = 9;
int delayTime = 500;

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

void loop() {
  digitalWrite(ledPin,HIGH);
  delay(delayTime);
  digitalWrite(ledPin,LOW);
  delay(delayTime);
}
```

This sketch is very similar to the one we used to control the blinking of the on-board LED, the difference is that the value of `ledPin` has been changed to 9. This is because we are trying to control the level of pin 9 this time.

Now you can see the LED on the breadboard blinking.





## DOWNLOAD THE CODE

Download the relevant code from the link below.

- SunFounder 3 in 1 Kit for Arduino
- Or check out the code at [SunFounder 3 in 1 Kit for Arduino - GitHub](#)



## BASIC PROJECTS

This chapter is used to learn how to control electronic circuits using Arduino.

Depending on the components, the basic control methods of Arduino can be divided into four types:

- *1. Digital Write*: Set the output voltage of the pin to be high or low, which can be used to turn the light on and off.
- *2. Analog Write*: Write the analog value (**PWM wave**) to the pin, which can be used to adjust the brightness of the light.
- *3. Digital Read*: Read the level signal of the digital pin, which can be used to read the working condition of the switch.
- *4. Analog Read*: Read the voltage of the analog pin, which can be used to read the working condition of the knob.

There are also some components that require additional libraries for use, and these are grouped under the section *5.11 Install External Libraries*.

Finally, the kit also provides some *6. Funny Project*, which includes many simple and useful manipulations. Try this section of code and you will understand how most simple projects work.

### 4.1 1. Digital Write

**Digital Write** is to output or write a digital signal to a digital pin. The digital signal has only two states, 0 or 1, 0V or 5V, so it allows some components, such as the LED and buzzer, to be on or off.

On the Arduino R3 board, there are 14 digital I/O pins from 0 to 13, now use the `pinMode()` and `digitalWrite()` functions to write a high or low level to these digital pins.

- `pinMode(pin, mode)`: Configure the specific pin as INPUT or OUTPUT, here it needs to be set as OUTPUT.

#### Syntax

```
pinMode(pin, mode)
```

#### Parameters

- `pin`: the Arduino pin number to set the mode of.
- `mode`: INPUT, OUTPUT, or INPUT\_PULLUP.
- `digitalWrite(pin, value)`: Write a high level (5V) or a low level (0V) to a digital pin to change the operating state of the component. If the pin has been configured as an OUTPUT with `pinMode()`, its voltage will be set to the corresponding value: 5V (or 3.3V on 3.3V boards) for HIGH, 0V (ground) for LOW.

#### Syntax

```
digitalWrite(pin, value)
```

**Parameters**

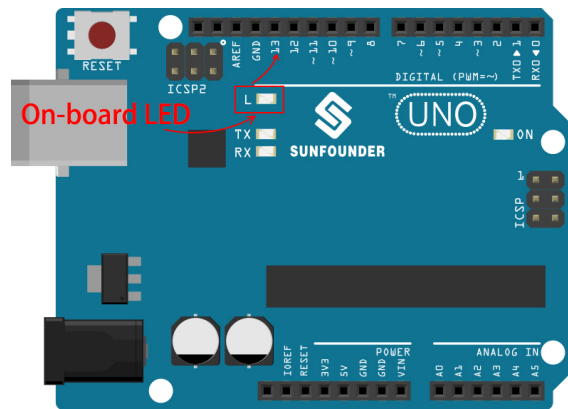
- pin: the Arduino pin number.
- value: HIGH or LOW.

**Example of Digital Write:**

```
const int pin = 13;

void setup() {
  pinMode(pin, OUTPUT);    // sets the digital pin as output
}

void loop() {
  digitalWrite(pin, HIGH); // sets the digital pin on
  delay(1000);             // waits for a second
  digitalWrite(pin, LOW);  // sets the digital pin off
  delay(1000);             // waits for a second
}
```

**Notes and Warnings**

- The pins 0~13 are all digital pins.
- Do not use pins 0 and 1, as they are used to communicate with the computer. Connecting anything to these pins will interfere with communication, including causing the upload board to fail.
- If the digital pins are used up, the analog pins (A0-A5) can also be used as digital pins.

**Related Components**

Below are the related components, you can click in to learn how to use them.

**4.1.1 1.1 Hello, LED!**

Just as printing “Hello, world!” is the first step in learning to program, using a program to drive an LED is the traditional introduction to learning physical programming.

**Required Components**

In this project, we need the following components.

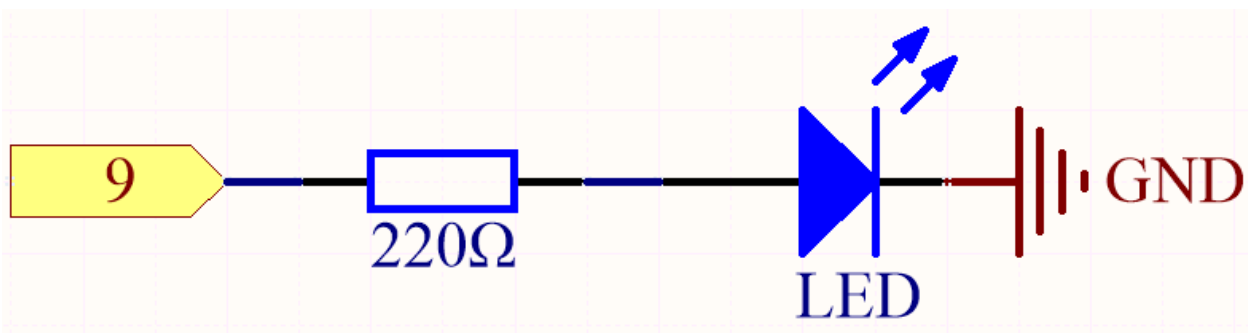
It’s definitely convenient to buy a whole kit, here’s the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

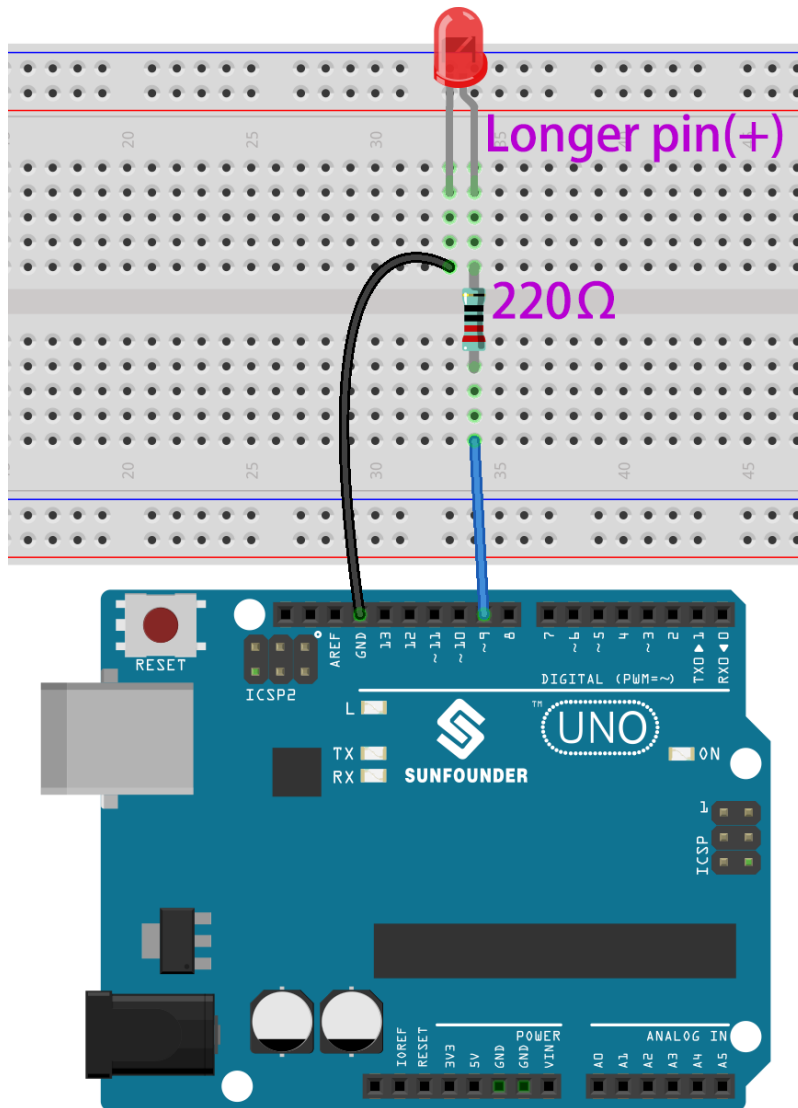
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>LED</i>	

### Schematic



The principle of this circuit is simple and the current direction is shown in the figure. When pin 9 outputs high level(5V), the LED will light up after the 220ohm current limiting resistor. When pin 9 outputs low level (0v), the LED will turn off.

### Wiring



## Code

### Note:

- You can open the file `1.1.hello_led.ino` under the path of `3in1-kit\basic_project\1.1.hello_led`.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

After the code is uploaded successfully, you will see the LED blinking.

### How it works?

Here, we connect the LED to the digital pin 9, so we need to declare an int variable called ledpin at the beginning of the program and assign a value of 9.

```
const int ledPin = 9;
```

Now, initialize the pin in the `setup()` function, where you need to initialize the pin to OUTPUT mode.

```
void setup() {
  pinMode(ledPin, OUTPUT);
}
```

In loop(), digitalWrite() is used to provide 5V high level signal for ledpin, which will cause voltage difference between LED pins and light LED up.

```
digitalWrite(ledPin, HIGH);
```

If the level signal is changed to LOW, the ledPin's signal will be returned to 0 V to turn LED off.

```
digitalWrite(ledPin, LOW);
```

An interval between on and off is required to allow people to see the change, so we use a delay(1000) code to let the controller do nothing for 1000 ms.

```
delay(1000);
```

### 4.1.2 1.2 Beep

The active buzzer is a typical digital output device that is as easy to use as lighting up an LED!

Two types of buzzers are included in the kit. We need to use active buzzer. Turn them around, the sealed back (not the exposed PCB) is the one we want.



#### Required Components

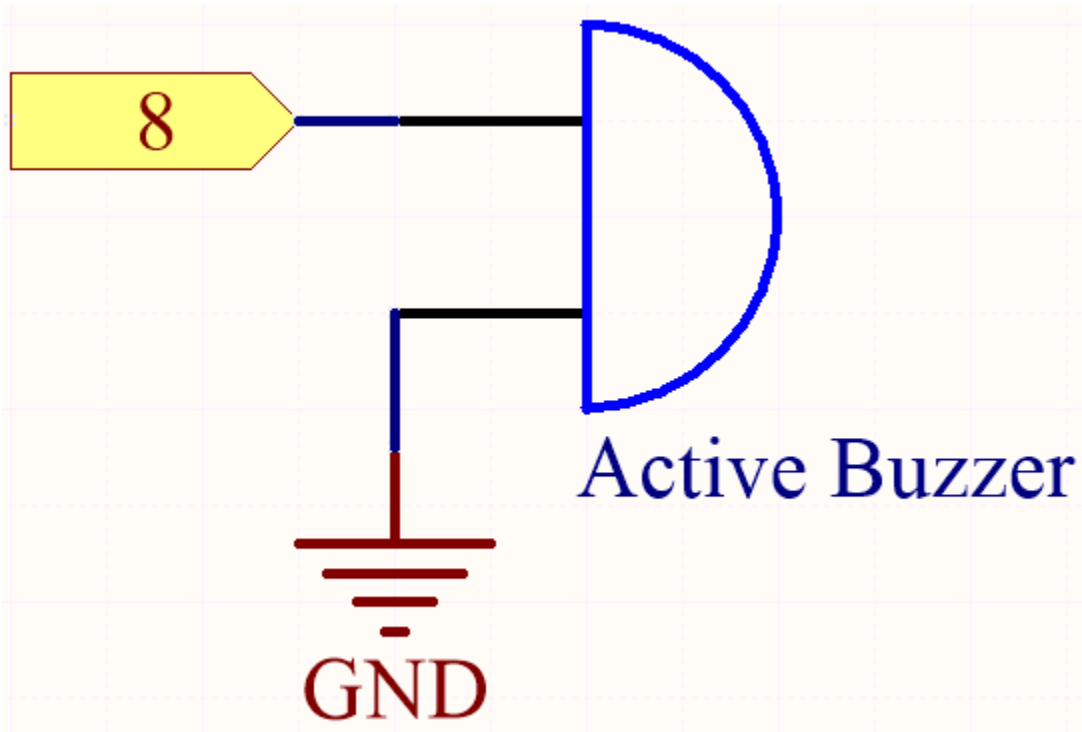
In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

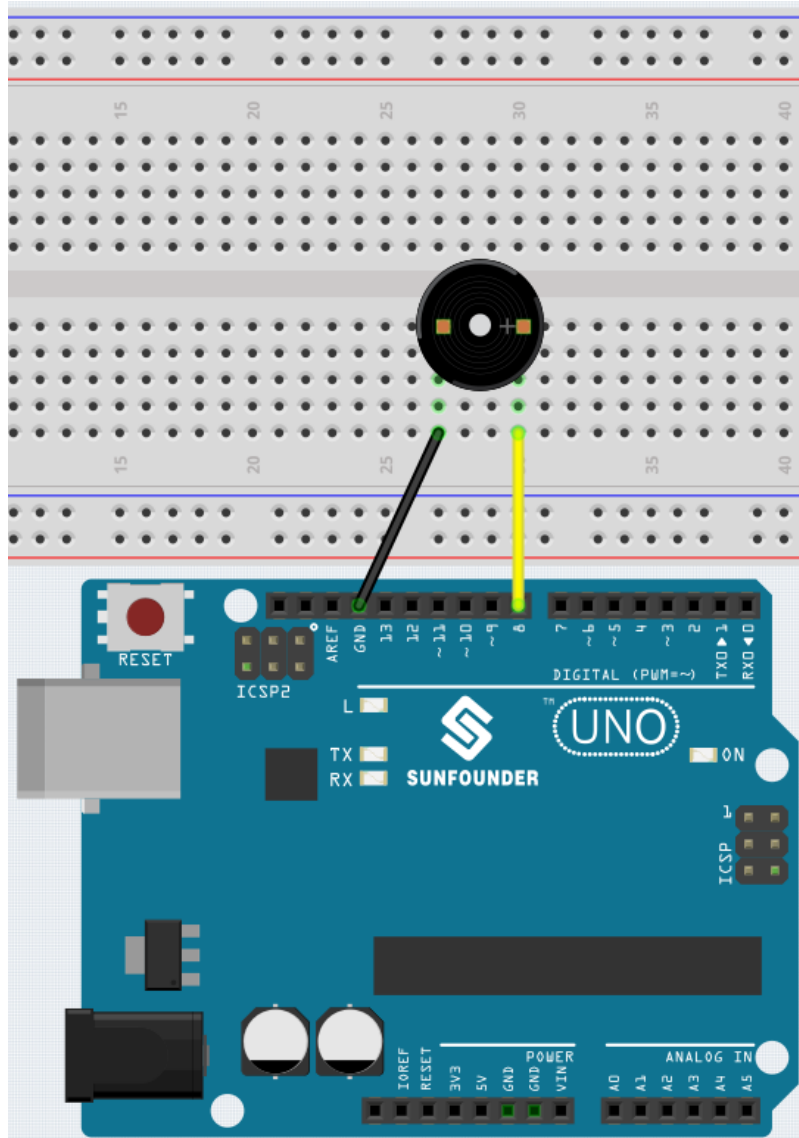
Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Buzzer</i>	-

**Schematic****Wiring**





## Code

### Note:

- You can open the file 1.2.beep.ino under the path of 3in1-kit\basic\_project\1.2.beep.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

After the code is uploaded successfully, you will hear a beep every second.

### 4.1.3 1.3 Turn the Wheel

A motor is a typical digital output device, and it is used in the same way as an LED. However, the motor needs to be driven with a large current, and the large current may damage the main control board such as R3 board. Therefore, an L298N module is used in this occasion, which is a good helper for the R3 board to control the motor safely.

#### Required Components

In this project, we need the following components.

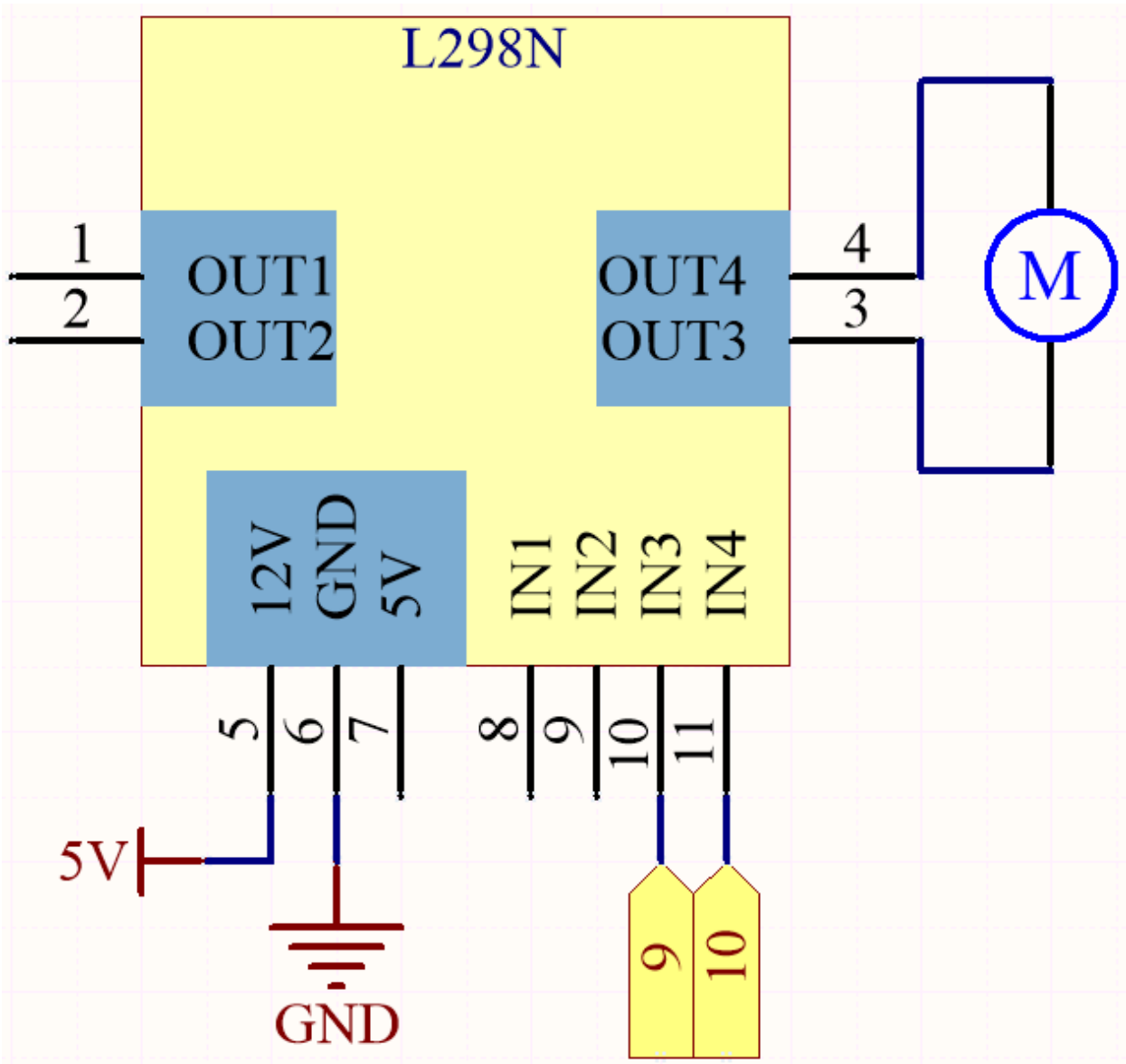
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>TT Motor</i>	-
<i>L298N Module</i>	

#### Schematic

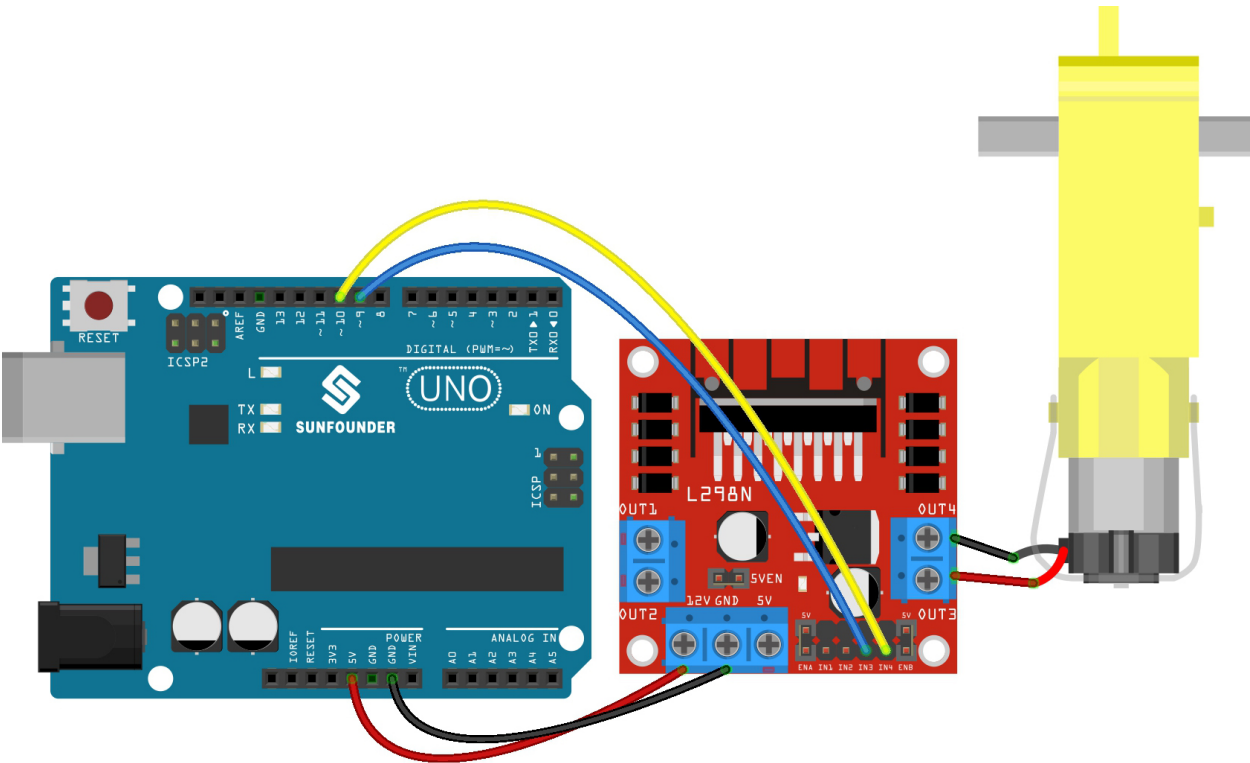


IN1~IN4 are the inputs of the L298N module, and OUT1~OUT4 are the outputs.

A simple way to use them is: input high level for INx, OUTx will output high level; input low level for INx, OUTx will output low level. Connecting the two ends of the motor to OUT1 and OUT2, inputting opposite level signals for IN1 and IN2 will make the motor rotate. OUT3 and OUT4 can be used in the same way.

#### Wiring

L298N	R3 Board	Motor
12V	5V	
GND	GND	
IN3	9	
IN4	10	
OUT3		one wire of the motor
OUT4		one wire of the motor



Code

Note:

- You can open the file 1.3.turn\_the\_wheel.ino under the path of 3in1-kit\basic\_project\1.3.turn\_the\_wheel.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

4.1.4 1.4 Pumping

The water pump is also a motor, which converts the mechanical energy of the motor or other external energy through a special structure to transport the liquid.

Required Components

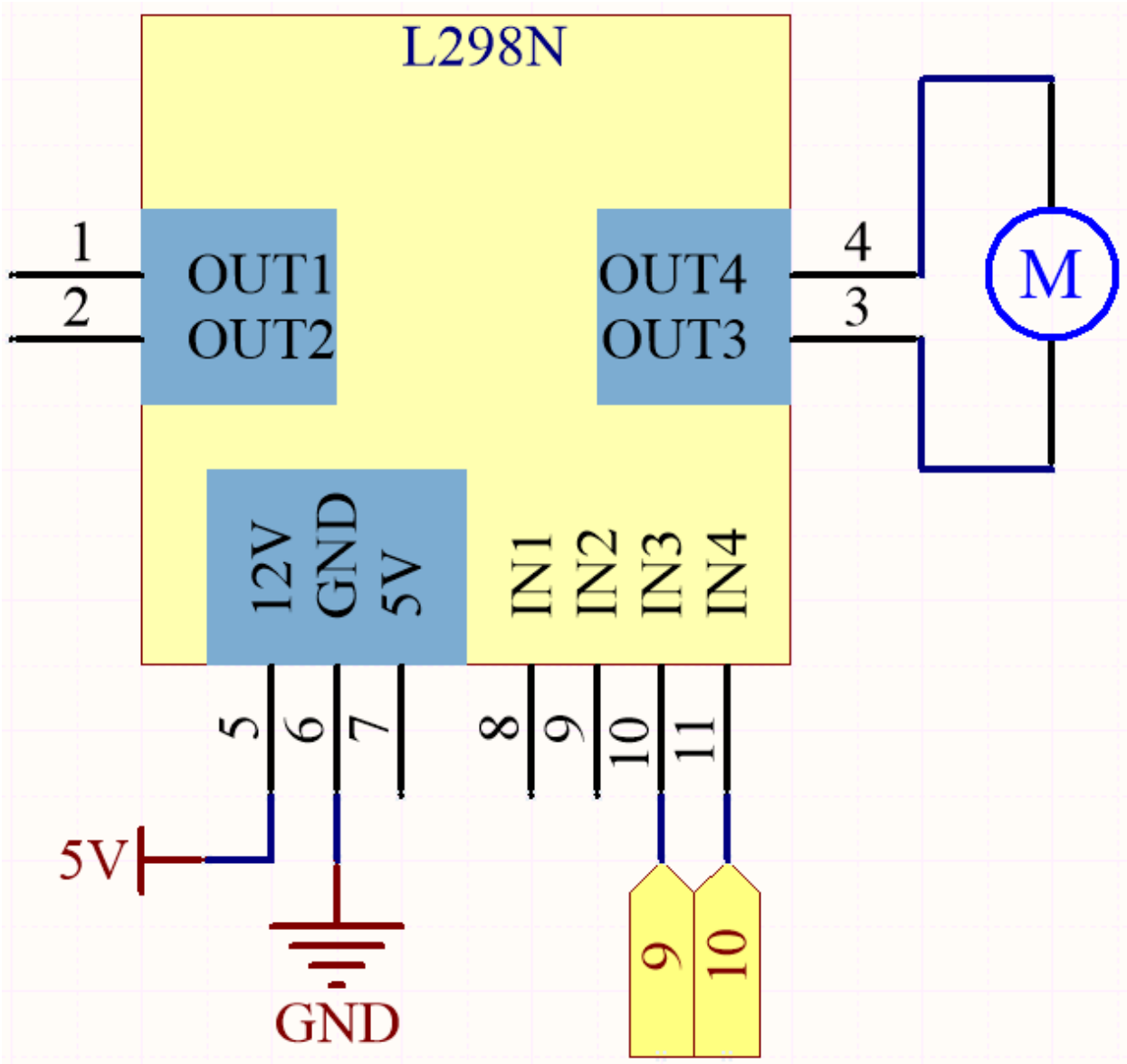
In this project, we need the following components.  
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>L298N Module</i>	
<i>Centrifugal Pump</i>	-

### Schematic

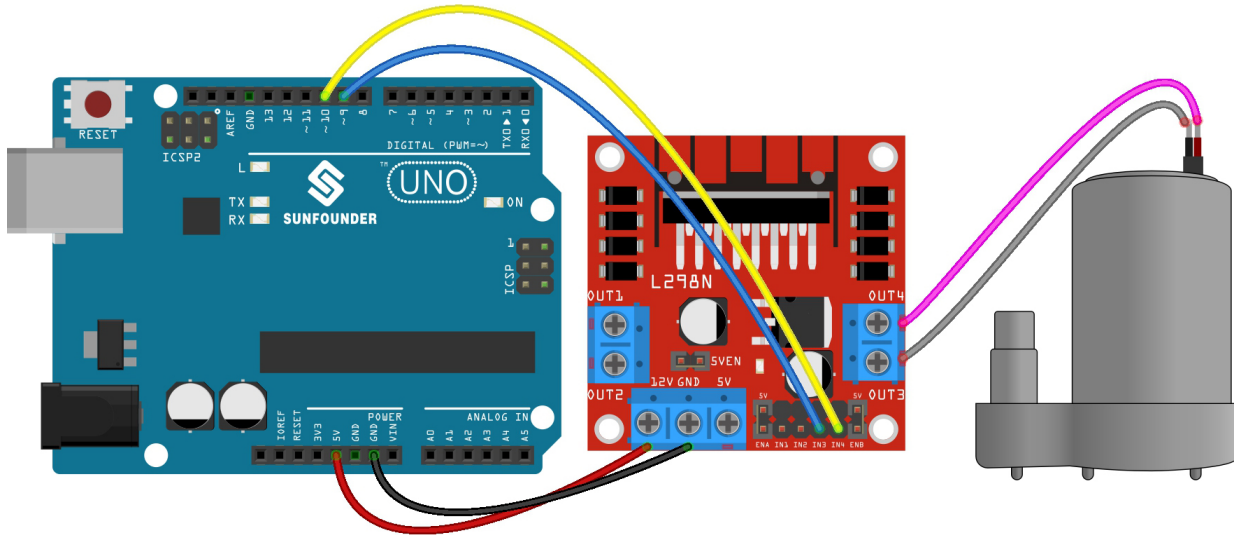


IN1~IN4 are the inputs of the L298N module, and OUT1~OUT4 are the outputs.

A simple way to use them is: input high level for INx, OUTx will output high level; input low level for INx, OUTx will output low level. Connecting the two ends of the motor to OUT1 and OUT2, inputting opposite level signals for IN1 and IN2 will make the motor rotate. OUT3 and OUT4 can be used in the same way.

## Wiring

L298N	R3 Board	Motor
12V	5V	
GND	GND	
IN3	9	
IN4	10	
OUT3		one wire of the motor
OUT4		one wire of the motor



## Code

### Note:

- You can open the file `1.4.pumping.ino` under the path of `3in1-kit/basic_project/1.4.pumping`.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

Add the tubing to the pump and place it in the basin. After the code is uploaded successfully, you can see that the water in the basin is drained after a while. When doing this experiment, please keep the circuit away from water to avoid short circuit!

## 4.2 2. Analog Write

6 of the Arduino's 14 digital pins also have PWM out function. Therefore, in addition to writing digital signals to these 6 pins, you can also write analog signals (PWM wave signals) to them. This way you can make the LEDs show different brightness or make the motor rotate at different speeds.

Pulse Width Modulation, or **PWM**, is a technique for getting analog results with digital means. Since it may be hard to grasp the literal meaning, here is an example of controlling the intensity of an LED to help you better understand.

A digital signal consisting of high and low levels is called a pulse. The pulse width of these pins can be adjusted by changing the ON/OFF speed. Simply put, when we turn the LED on, off, and on again for a short period of time (like

20ms, the visual dwell time of most people), We won't see that it has gone out, but the brightness of the light will be slightly weaker. During this period, the longer the LED is on, the brighter the LED will be. That is to say, within a period, the wider the pulse, the greater the "electrical signal strength" output by the microcontroller.

This is the function needed to write the PWM wave.

- `analogWrite(pin, value)`

Writes an analog value (PWM wave) to a pin. Different output voltages (0-5V) can be simulated by generating a specified pulse signal. The pin will hold this signal until it is called by a new read or write statement.

#### Syntax

`analogWrite(pin, value)`

#### Parameters

- pin: the Arduino pin to write to. Allowed data types: int.
- value: the duty cycle: between 0 (always off) and 255 (always on). Allowed data types: int.

#### Example of Analog Write

```
int pin = 9;           //connect to pwm pin

void setup() {
  pinMode(pin, OUTPUT); // sets the pin as output
}

void loop() {
  for (int i = 0 ;i<255 ; i++){
    analogWrite(pin, i); //analogWrite values from 0 to 255
    delay(30);
  }
}
```

#### Notes and Warnings

- Looking closely at the R3 board, the pins marked with the "~" symbol have analog output function.
- The PWM outputs generated on pins 5 and 6 will have higher-than-expected duty cycles. This is because of interactions with the `millis()` and `delay()` functions, which share the same internal timer used to generate those PWM outputs. This will be noticed mostly on low duty-cycle settings (e.g. 0 - 10) and may result in a value of 0 not fully turning off the output on pins 5 and 6.

#### Related Components

Below are the related components, you can click in to learn how to use them.

### 4.2.1 2.1 Fading

This project is similar to [1.1 Hello, LED!](#), the difference is the signal type. The former is to make the LED light on or off by outputting a digital signal (0&1), this project is to control the brightness of the LED by outputting an analog signal.

#### Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

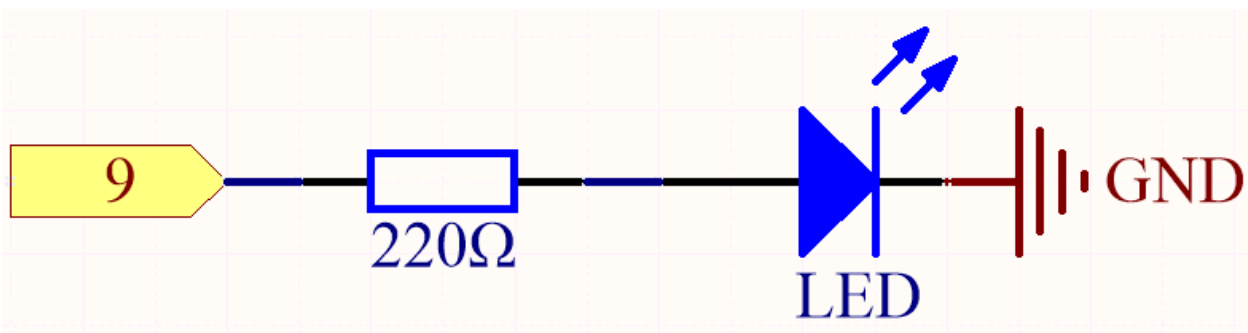
## SunFounder 3in1 Kit

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

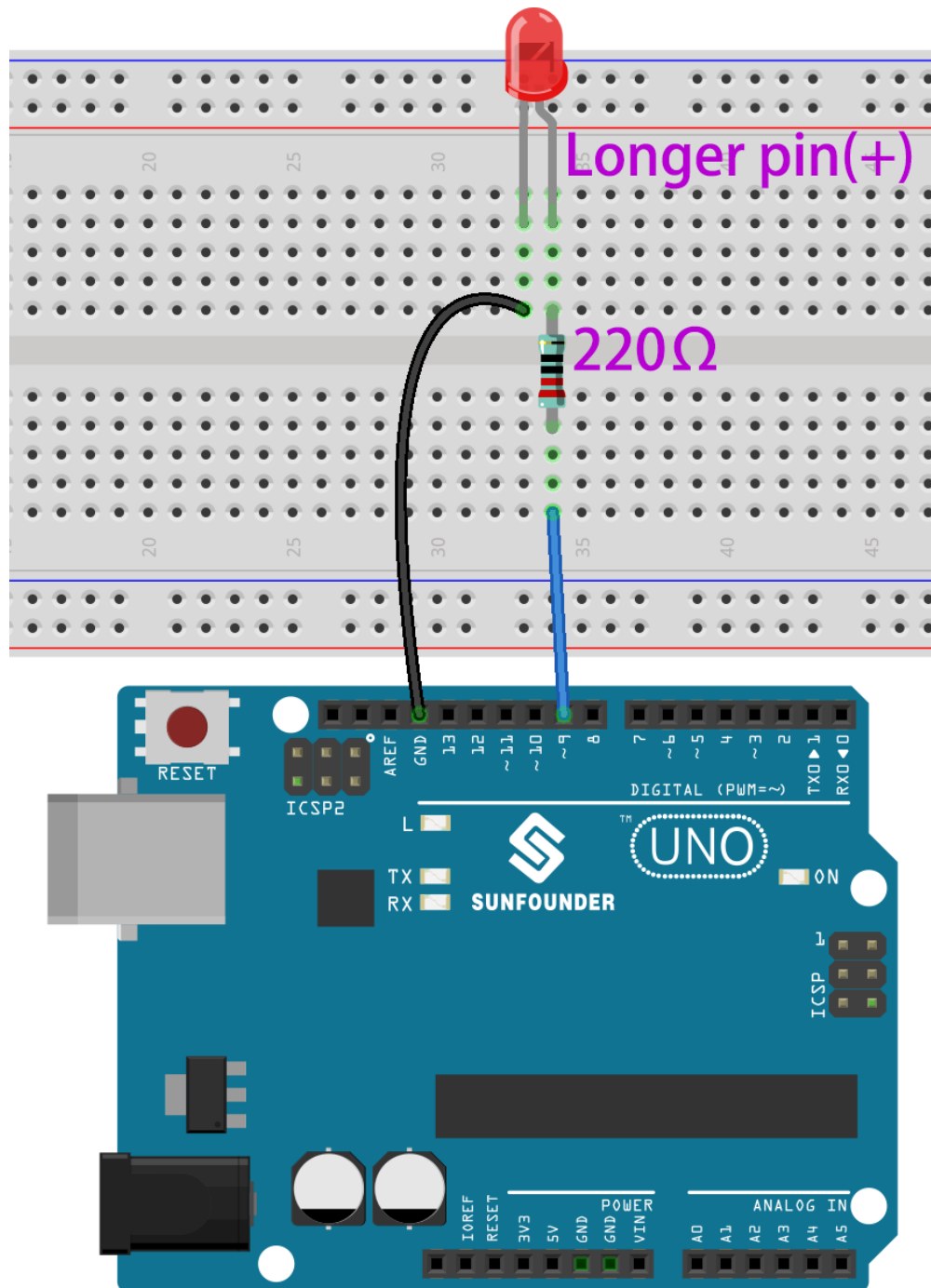
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>LED</i>	

### Schematic



### Wiring





### Code

#### Note:

- You can open the file 2.1.fading.ino under the path of 3in1-kit\basic\_project\2.analogWrite\2.1.fading.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

After the code is uploaded successfully, you can see the LED breathing.

### 4.2.2 2.2 Colorful Light

As we know, light can be superimposed. For example, mix blue light and green light give cyan light, red light and green light give yellow light. This is called “The additive method of color mixing”.

- [Additive color - Wikipedia](#)

Based on this method, we can use the three primary colors to mix the visible light of any color according to different specific gravity. For example, orange can be produced by more red and less green.

In this chapter, we will use RGB LED to explore the mystery of additive color mixing!

RGB LED is equivalent to encapsulating Red LED, Green LED, Blue LED under one lamp cap, and the three LEDs share one cathode pin. Since the electric signal is provided for each anode pin, the light of the corresponding color can be displayed. By changing the electrical signal intensity of each anode, it can be made to produce various colors.

#### Required Components

In this project, we need the following components.

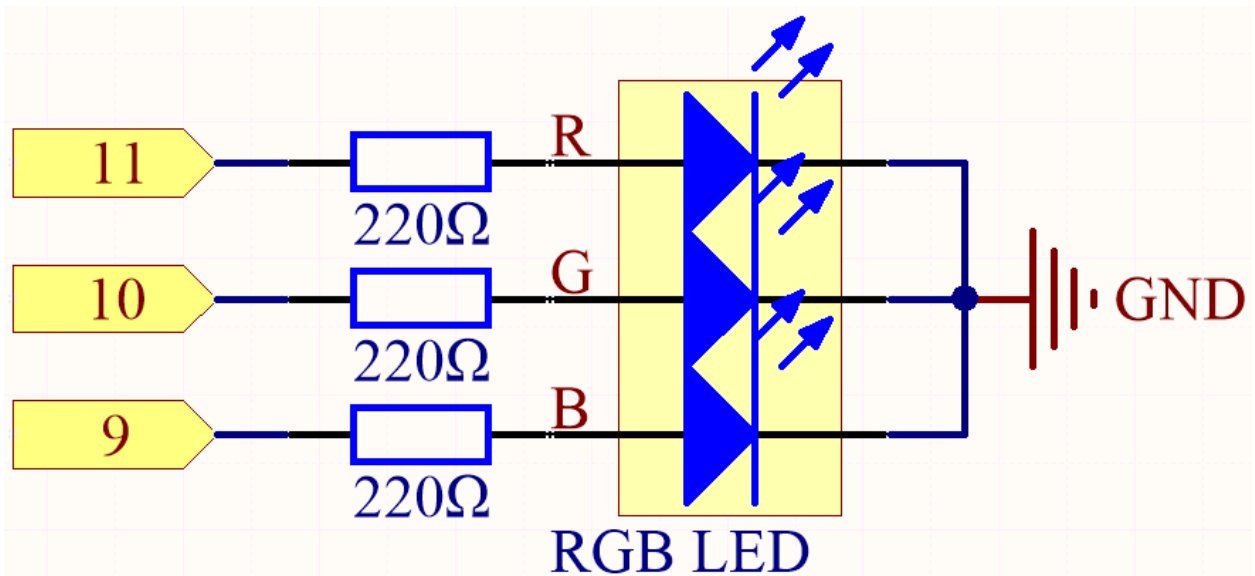
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

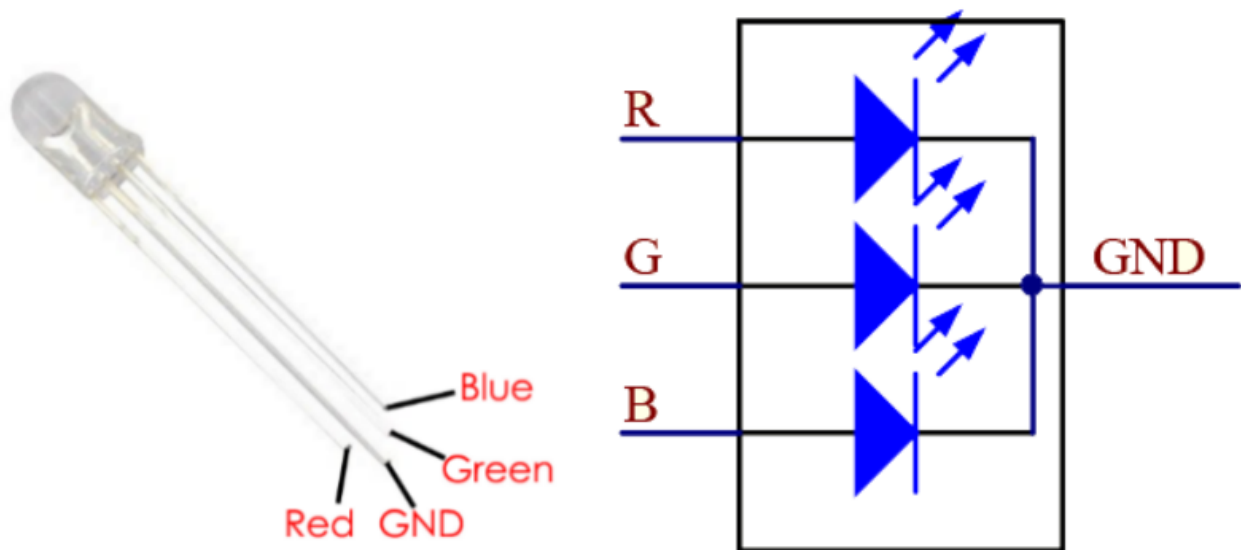
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>RGB LED</i>	

#### Schematic

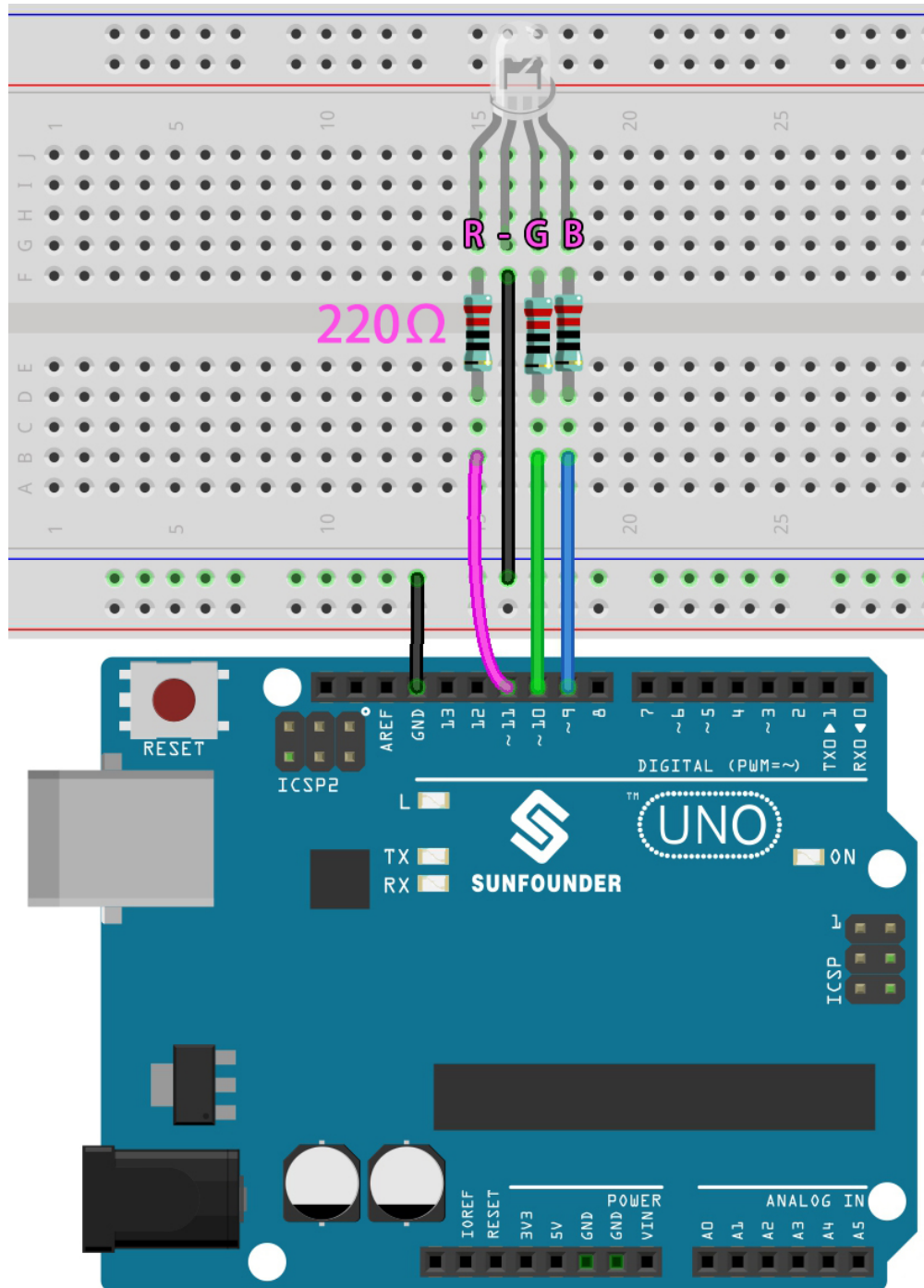


The PWM pins 11, 10 and 9 control the Red, Green and Blue pins of the RGB LED respectively, and connect the common cathode pin to GND. This allows the RGB LED to display a specific color by superimposing light on these pins with different PWM values.

#### Wiring



An RGB LED has 4 pins: the longest pin is the common cathode pin, which is usually connected to GND, the left pin next to the longest pin is Red, and the 2 pins on the right are Green and Blue.



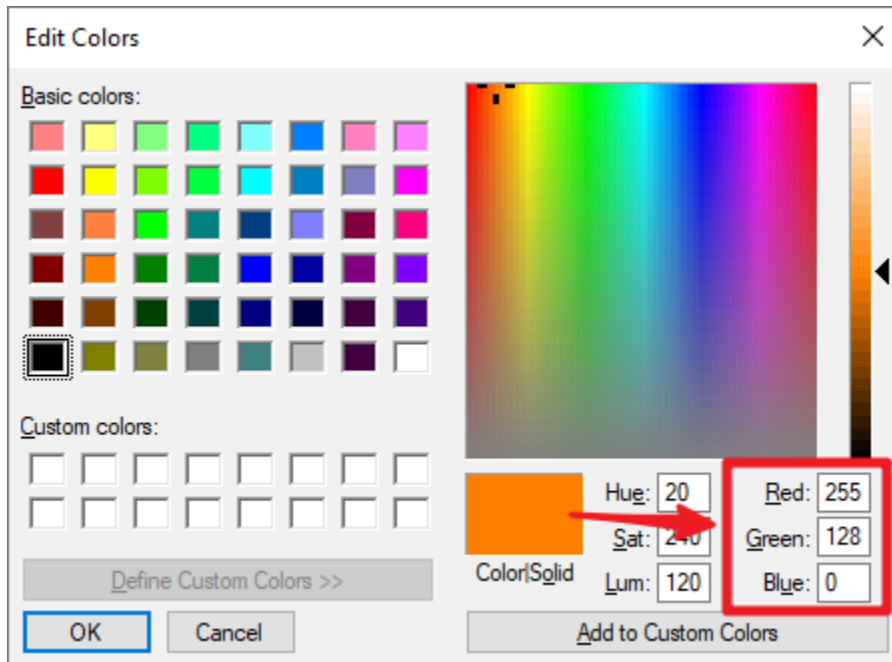
### Code

Here, we can choose our favorite color in drawing software (such as paint) and display it with RGB LED.

### Note:

- You can open the file `2.2.colorful_light.ino` under the path of `3in1-kit\basic_project\2.analogWrite\2.2.colorful_light`.
- Or copy this code into **Arduino IDE**.

- Or upload the code through the [Arduino Web Editor](#).



Write the RGB value into `color_set()`, you will be able to see the RGB light up the colors you want.

#### How it works?

In this example, the function used to assign values to the three pins of RGB is packaged in an independent subfunction `color()`.

```
void color (unsigned char red, unsigned char green, unsigned char blue)
{
    analogWrite(redPin, red);
    analogWrite(greenPin, green);
    analogWrite(bluePin, blue);
}
```

In `loop()`, RGB value works as an input argument to call the function `color()` to realize that the RGB can emit different colors.

```
void loop()
{
    color(255, 0, 0); // red
    delay(1000);
    color(0, 255, 0); // green
    delay(1000);
    color(0, 0, 255); // blue
    delay(1000);
}
```

## 4.3 3. Digital Read

Sensors capture real-world information, which is then communicated to the main board via pins (some digital, some analog) so that the computer can know the reality of the situation.

Therefore, the Arduino board can know the working status of digital sensors by reading the value of digital pins like buttons, IR obstacle avoidance module.

Here are the required functions.

- `pinMode(pin, mode)`: Configure the specific pin as INPUT or OUTPUT, here it needs to be set as INPUT.

### Syntax

```
pinMode(pin, mode)
```

### Parameters

- `pin`: the Arduino pin number to set the mode of.
- `mode`: INPUT, OUTPUT, or INPUT\_PULLUP.

- `digitalRead(pin)`: Read the value (level state) from the specified digital pin.

### Syntax

```
digitalRead(pin)
```

### Parameters

- `pin`: the Arduino pin number you want to read

### Returns

HIGH or LOW

### Example of Digital Read

```
int ledPin = 13;  // LED connected to digital pin 13
int inPin = 7;    // pushbutton connected to digital pin 7
int val = 0;      // variable to store the read value

void setup() {
  pinMode(ledPin, OUTPUT); // sets the digital pin 13 as output
  pinMode(inPin, INPUT);   // sets the digital pin 7 as input
}

void loop() {
  val = digitalRead(inPin); // read the input pin
  digitalWrite(ledPin, val); // sets the LED to the button's value
}
```

### Notes and Warnings

1. Pull Up & Pull Down.

`digitalRead()` may produce random, indeterminate values if the pin is not getting a level signal. So directing the input pins to a known state can make the project more reliable. When using an input component such as a button, it is usually necessary to connect a pull-up or pull-down resistor in parallel to the digital input pin.

Apart from connecting a pull-up resistor, you can also set the pin mode to `INPUT_PULLUP` in the code, for example `pinMode(pin, INPUT_PULLUP)`. In this case, the pin will access the Atmega's built-in pull-up resistor via software, and it will have the same effect as connecting a pull-up resistor.

## 2. About Pin13.

All digital pins (1-13) on the R3 board can be used as `digitalRead()`. But digital pin 13 is more difficult to use as a digital input than other digital pins. Because it connects an LED and resistor, it is soldered on most boards. If you enable its internal 20k pull-up resistor, it will hang around 1.7V instead of the expected 5V because the onboard LED and series resistor pull the voltage level low, which means it always returns LOW. If you must use pin 13 as a digital input, set its `pinMode()` to INPUT and use an external pull-down resistor.

## 3. Analog pins.

If the digital pins are not enough, the analog pins (A0-A5) can also be used as digital pins. It needs to be set to INPUT with `pinMode(pin,mode)`.

### Related Components

Below are the related components, you can click in to learn how to use them.

### 4.3.1 3.0 Serial Monitor

In the Arduino IDE, there is a serial monitor that allows you to send messages from your computer to the Arduino board (via USB) and also to receive messages from the Arduino.

So in this project we will learn how to receive data from the Arduino board.

---

**Note:** On Uno, Nano, Mini, and Mega, pins 0 and 1 are used for communication with the computer. Connecting anything to these pins can interfere with that communication, including causing failed uploads to the board.

---

### Using the Serial Monitor

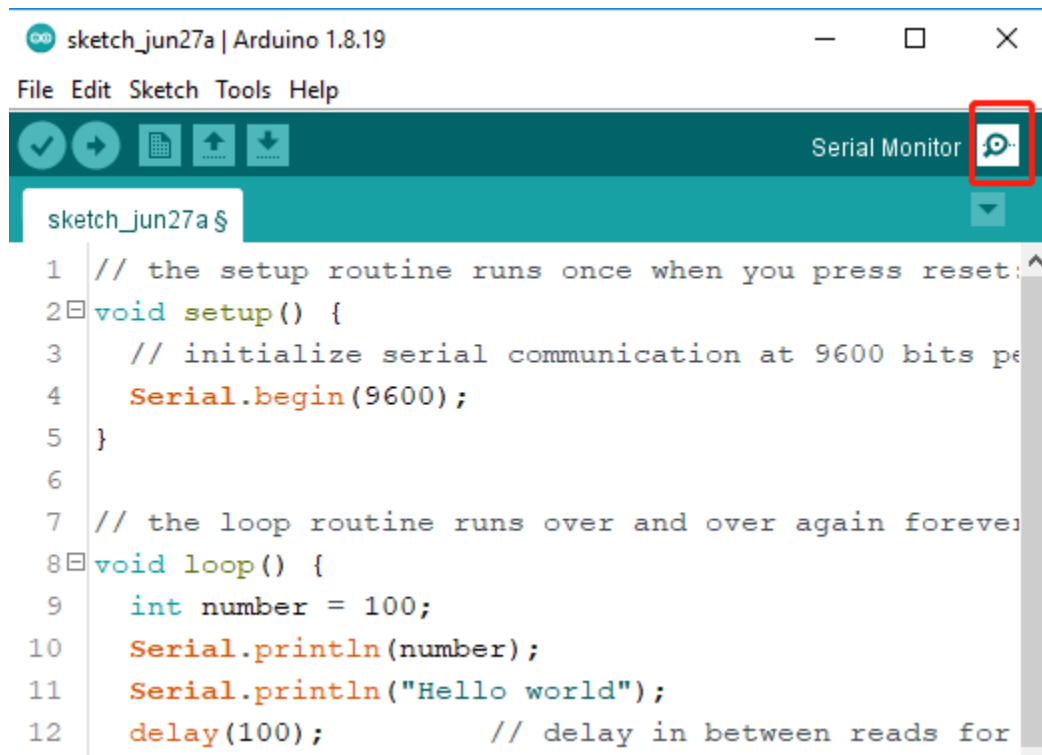
1. Open the Arduino IDE, and paste the following code in it.

```
// the setup routine runs once when you press reset:
void setup() {
    // initialize serial communication at 9600 bits per second:
    Serial.begin(9600);
}

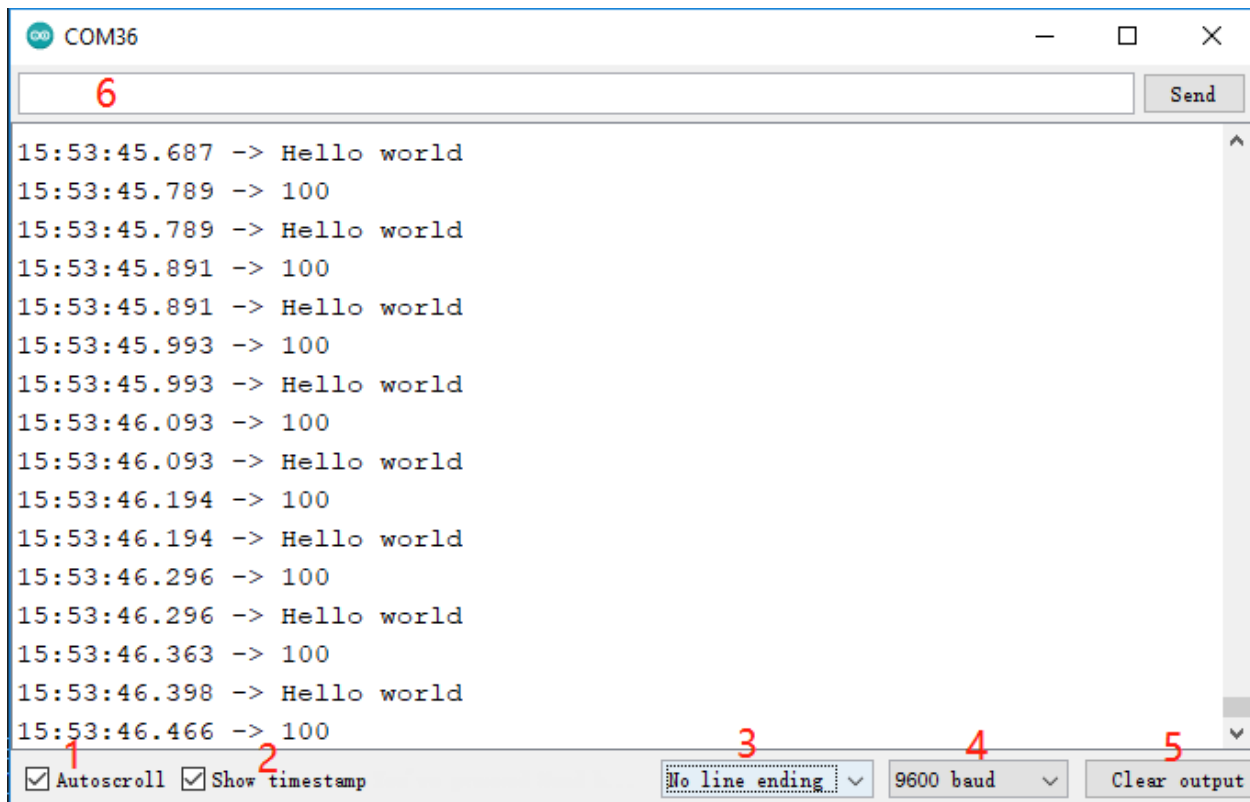
// the loop routine runs over and over again forever:
void loop() {
    int number = 100;
    Serial.println(number);
    Serial.println("Hello world");
    delay(100);           // delay in between reads for stability
}
```

- `Serial.begin()`: Sets the data rate in bits per second (baud) for serial data transmission, here set to 9600.
- `Serial.println()`: Prints data to the serial port as human-readable ASCII text followed by a carriage return character (ASCII 13, or 'r') and a newline character (ASCII 10, or 'n'). This command takes the same forms as `Serial.print()`.

2. Select the correct board and port to upload the code.
3. In the toolbar, click the magnifying glass icon to turn on Serial Monitor.



4. Here is the Serial Monitor.



- 1: Option to select between automatically scroll and not scroll.
- 2: Option to show timestamp prior to data displayed on Serial Monitor.



- **3:** Ending selection, select the ending characters appended to data sent to Arduino. Selection includes:
  - **No line Ending** just sends what you type;
  - **Newline** is `\n` and will send an ASCII new line code after what you type;
  - **Carriage Return** is `\r`, which will send an ASCII carriage return character after what you type;
  - **Both NL & CR** is `\r\n` which will send both a carriage return and a new line character after what you type.
- **4:** Select communication speed between Arduino board and PC. This value **MUST** be the same as the value set in `Serial.begin()`.
- **5:** Clear all text on the output console.
- **6:** A textbox to send characters to the Arduino board, see [5.12 Serial Read](#) for a tutorial.

### 4.3.2 3.1 Reading Button Value

In the previous projects, we used the output function, in this chapter we will use the input function to input read the button value.

#### Required Components

In this project, we need the following components.

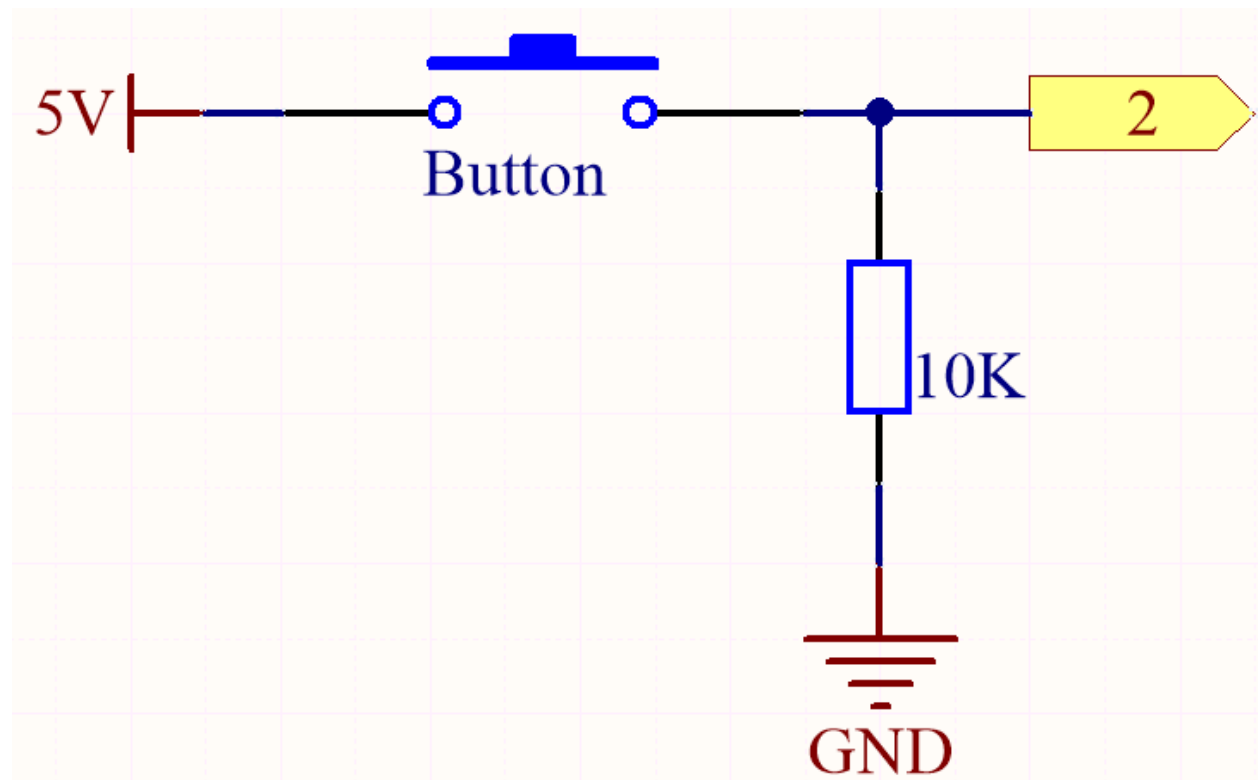
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

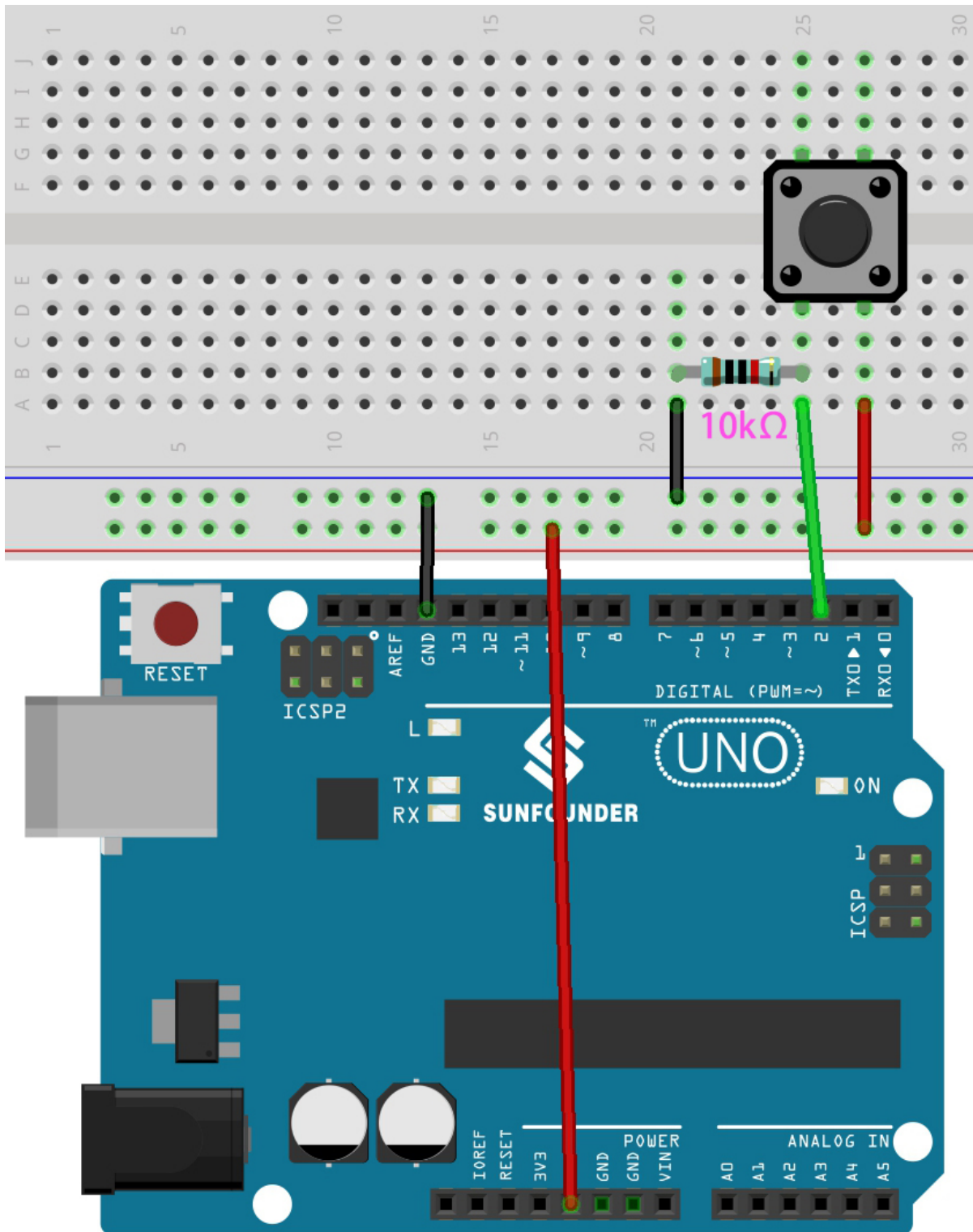
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Button</i>	

#### Schematic



One side of the button pin is connected to 5V, and the other side pin is connected to pin 2, so when the button is pressed, pin 2 will be high. However, when the button is not pressed, pin 2 is in a suspended state and may be high or low. In order to get a stable low level when the button is not pressed, pin 2 needs to be reconnected to GND through a 10K pull-down resistor.

#### Wiring



### Code

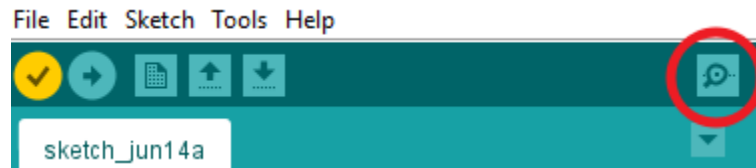
#### Note:

- You can open the file `3.1.read_button_value.ino` under the path of `3in1-kit\basic_project\3.1.`

```
read_button_value.
```

- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

After the code is uploaded successfully, click the magnifying glass icon in the upper right corner of the Arduino IDE (Serial Monitor).



When you press the button, the Serial Monitor will print “1”.

### 4.3.3 3.2 Feel the Magnetism

The most common type of reed switch contains a pair of magnetizable, flexible, metal reeds whose end portions are separated by a small gap when the switch is open.

A magnetic field from an electromagnet or a permanent magnet will cause the reeds to attract each other, thus completing an electrical circuit. The spring force of the reeds causes them to separate, and open the circuit, when the magnetic field ceases.

A common example of a reed switch application is to detect the opening of a door or windows, for a security alarm.

#### Required Components

In this project, we need the following components.

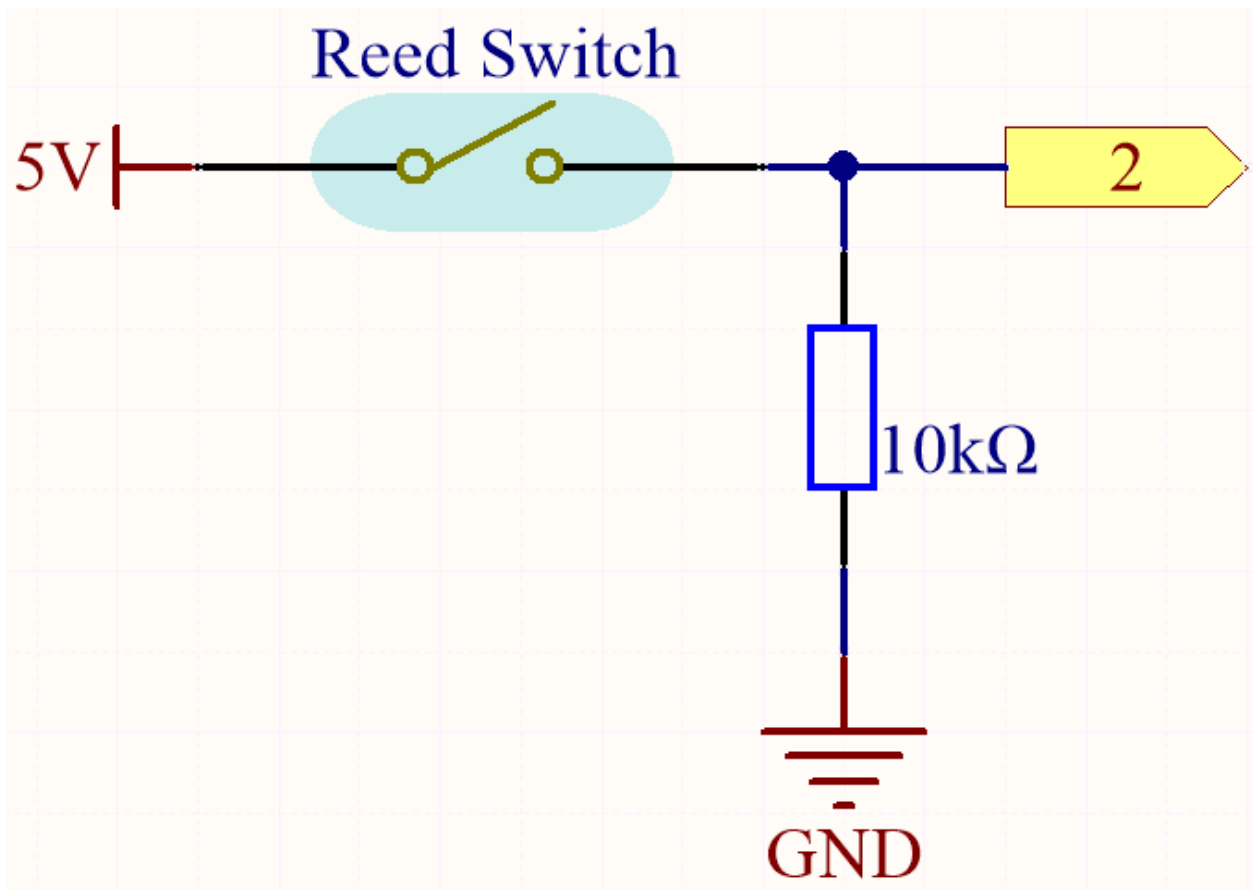
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Reed Switch</i>	-

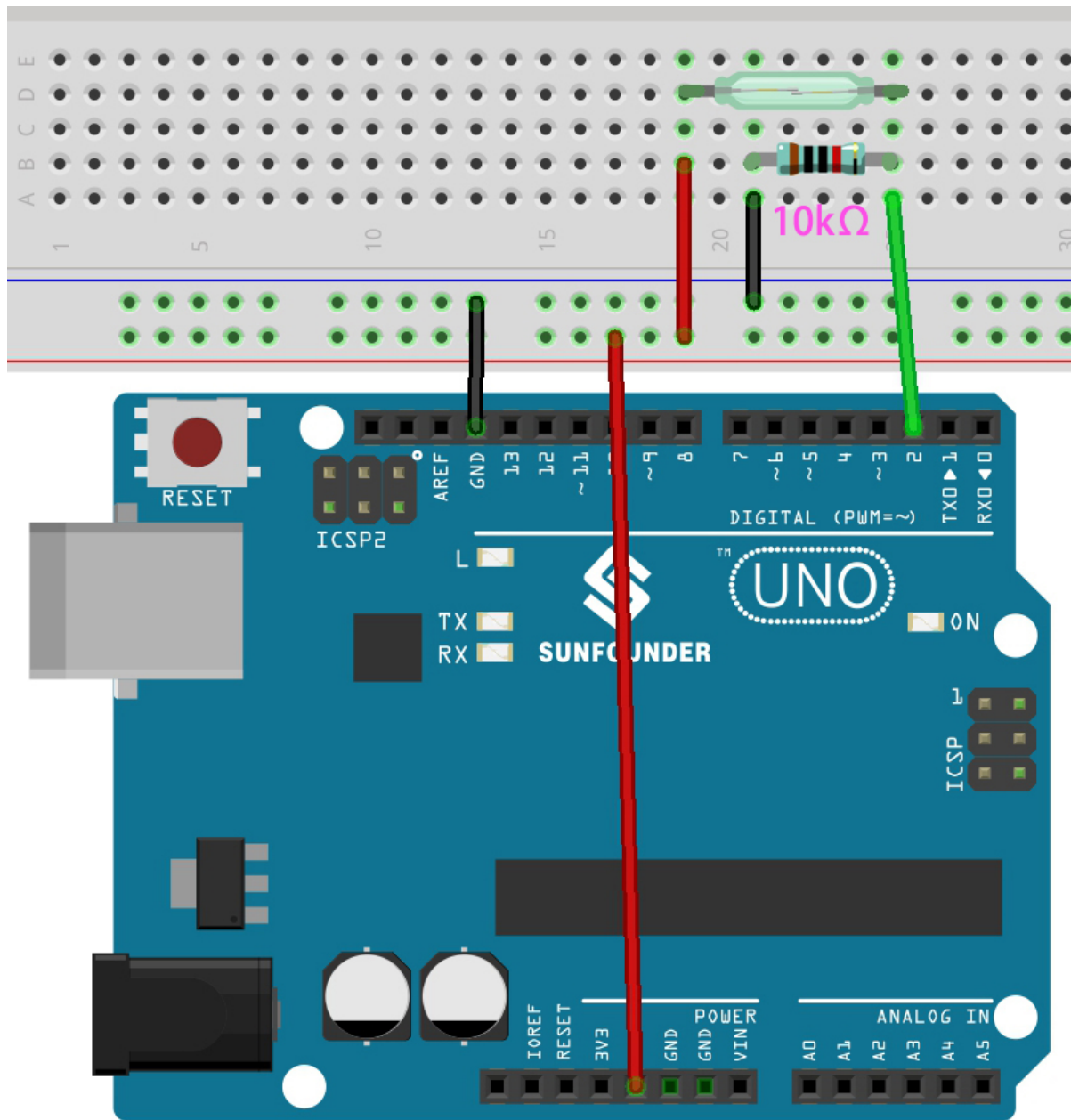
#### Schematic



By default, pin 2 is low; and will go high when the magnet is near the reed switch.

The purpose of the 10K resistor is to keep the pin 2 at a steady low level when no magnet is near.

#### Wiring



## Code

### Note:

- You can open the file `3.2.feel_the_magnetism.ino` under the path of `3in1-kit\basic_project\3.2.feel_the_magnetism`.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

After the code is uploaded successfully, when a magnet is near the reed switch, the serial monitor will print 1.

### 4.3.4 3.3 Detect the Obstacle

This module is commonly installed on the car and robot to judge the existence of the obstacles ahead. Also it is widely used in hand held device, water faucet and so on.

#### Required Components

In this project, we need the following components.

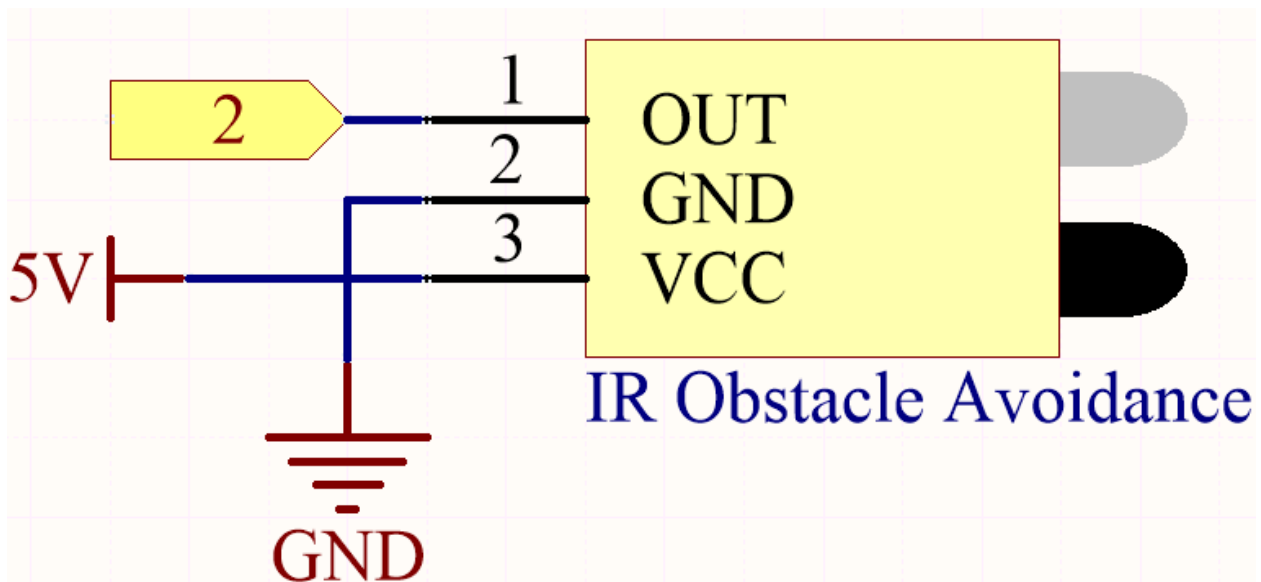
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

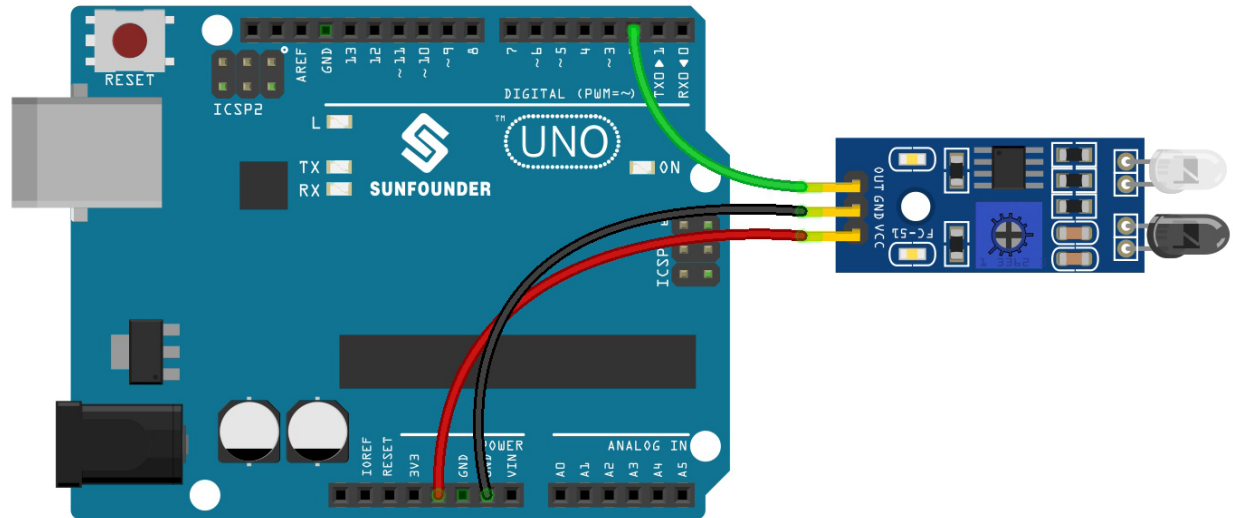
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>Obstacle Avoidance Module</i>	

#### Schematic



The digital pin 2 is used to read the signal of IR Obstacle Avoidance Module. We get the VCC of IR Sensor Module connected to 5V, GND to GND, OUT to digital pin 2.

#### Wiring



### Code

#### Note:

- You can open the file `3.3.detect_the_obstacle.ino` under the path of `3in1-kit\basic_project\3.3.detect_the_obstacle`.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

When the IR obstacle avoidance module detects something blocking in front of it, [0] will appear on the serial monitor, otherwise [1] will be displayed.

### 4.3.5 3.4 Detect the Line

The line tracking module is used to detect whether there are black areas on the ground, such as black lines pasted with electrical tape.

One of its LEDs emits appropriate infrared light to the ground, and the black surface has a relatively strong ability to absorb light and a weaker reflection ability. White surfaces are the opposite. If it detects reflected light, it means the ground is currently white. If not detected, it means black.

That's how it works.

#### Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

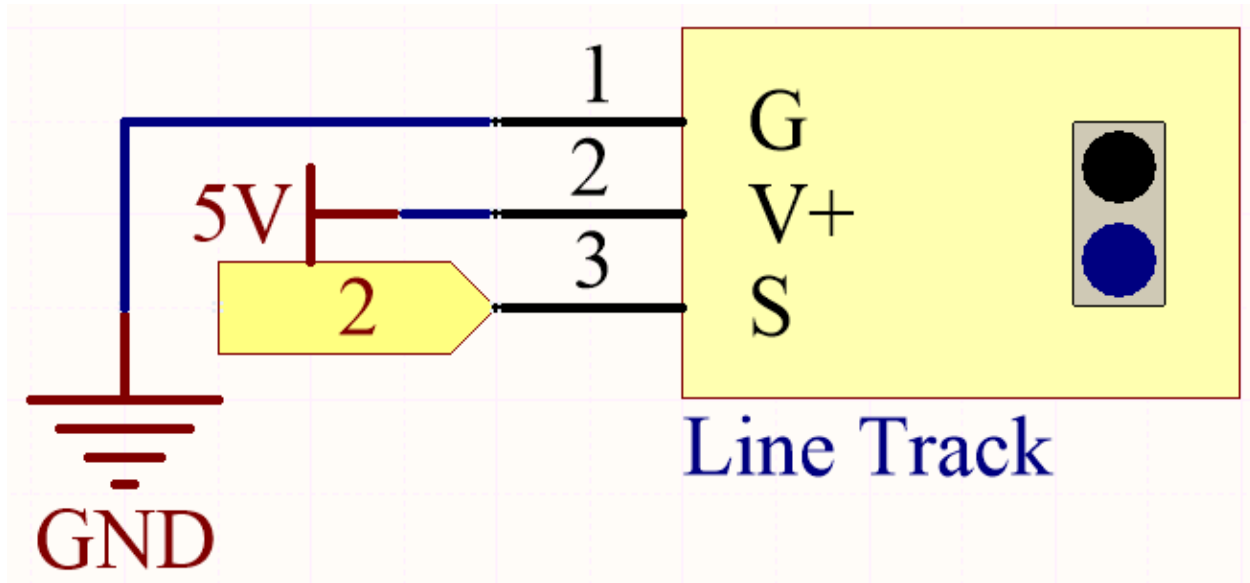
Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.



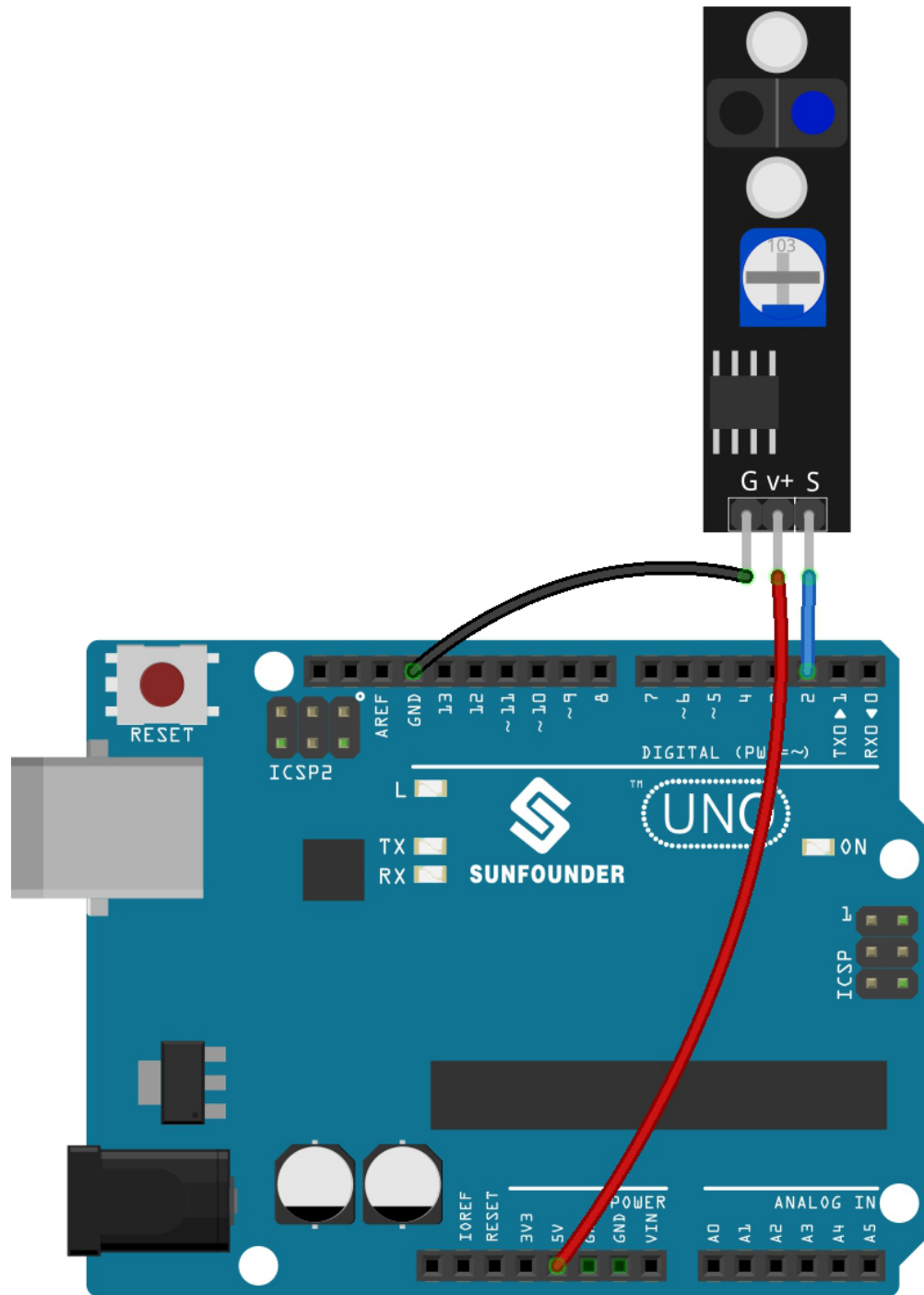
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>Line Tracking Module</i>	

### Schematic



The digital pin 2 is used to read the signal of line track module. We get the VCC of the module connected to 5V, GND to GND, OUT to digital pin 2.

### Wiring



## Code

---

### Note:

- You can open the file `3.4.detect_the_line.ino` under the path of `3in1-kit\basic_project\3.4.detect_the_line`.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

When the line tracking module detects there is black line, there appears [1] on the Serial Monitor; otherwise, [0] is displayed.

## 4.4 4. Analog Read

The Arduino can read the connected analog sensors through the analog pins.

The R3 board contains a multi-channel, 10-bit analog-to-digital converter. This means it maps the input voltage between 0 and the operating voltage (5V or 3.3V) to an integer value between 0 and 1023.

You need the `analogRead(pin)` function to read the value of the analog pin.

- `analogRead(pin)`: Read the value from the specified analog pin.

### Syntax

`analogRead(pin)`

### Parameters

- `pin`: the name of the analog input pin to read from (A0 to A5).

### Returns

0-1023. Data type: `int`.

### Example of Analog Read

```
int analogPin = A0; // device connected to analog pin A0
                    // outside leads to ground and +5V
int val = 0; // variable to store the value read

void setup() {
  Serial.begin(9600); // setup serial
}

void loop() {
  val = analogRead(analogPin); // read the input pin
  Serial.println(val); // debug value
}
```

### Notes and Warnings

- The analog pins are A0-A5.
- You don't need to call `pinMode()` before calling the analog pin, but if the pin was previously set to OUTPUT, the function `analogRead()` will not work properly, in which case you need to call `pinMode()` to set it back to INPUT.

### Related Components

Below are the related components, you can click in to learn how to use them.

### 4.4.1 4.1 Turn the Knob

Potentiometer is a resistor component with 3 terminals and its resistance value can be adjusted according to some regular variation.

#### Required Components

In this project, we need the following components.

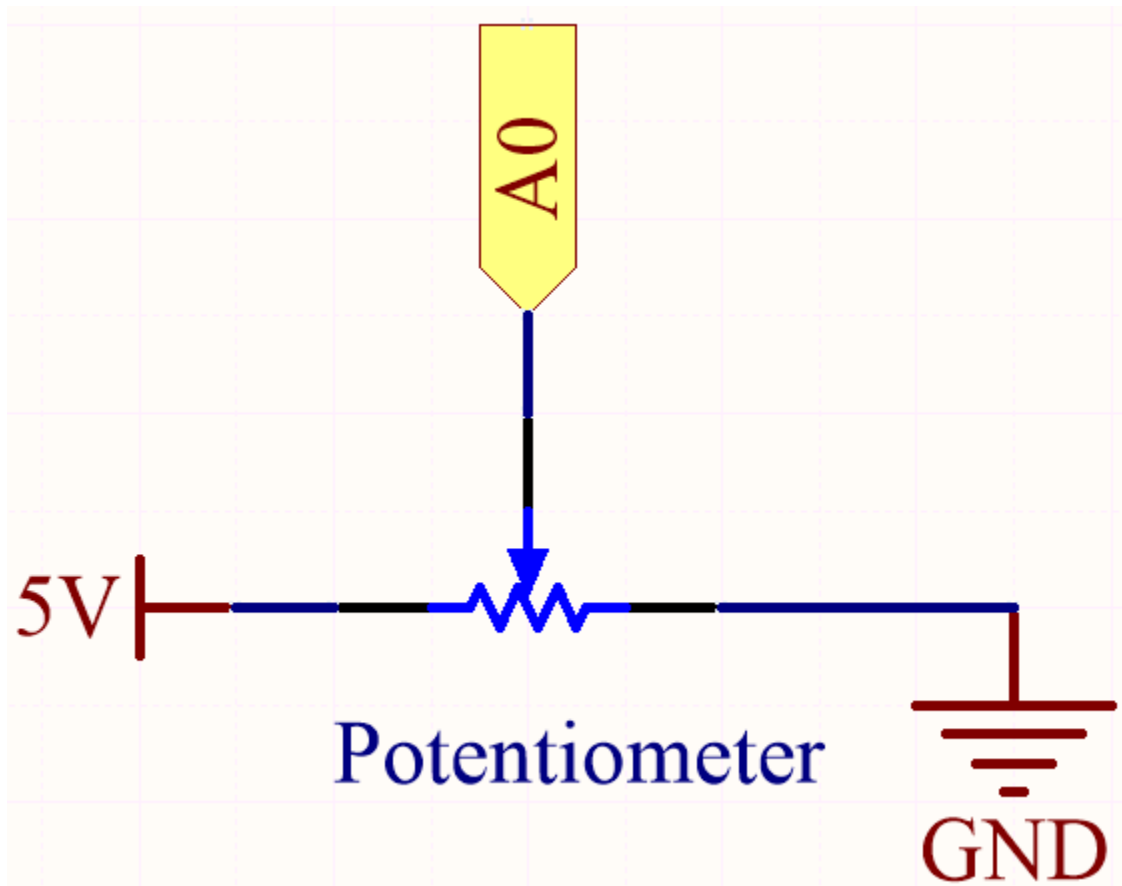
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

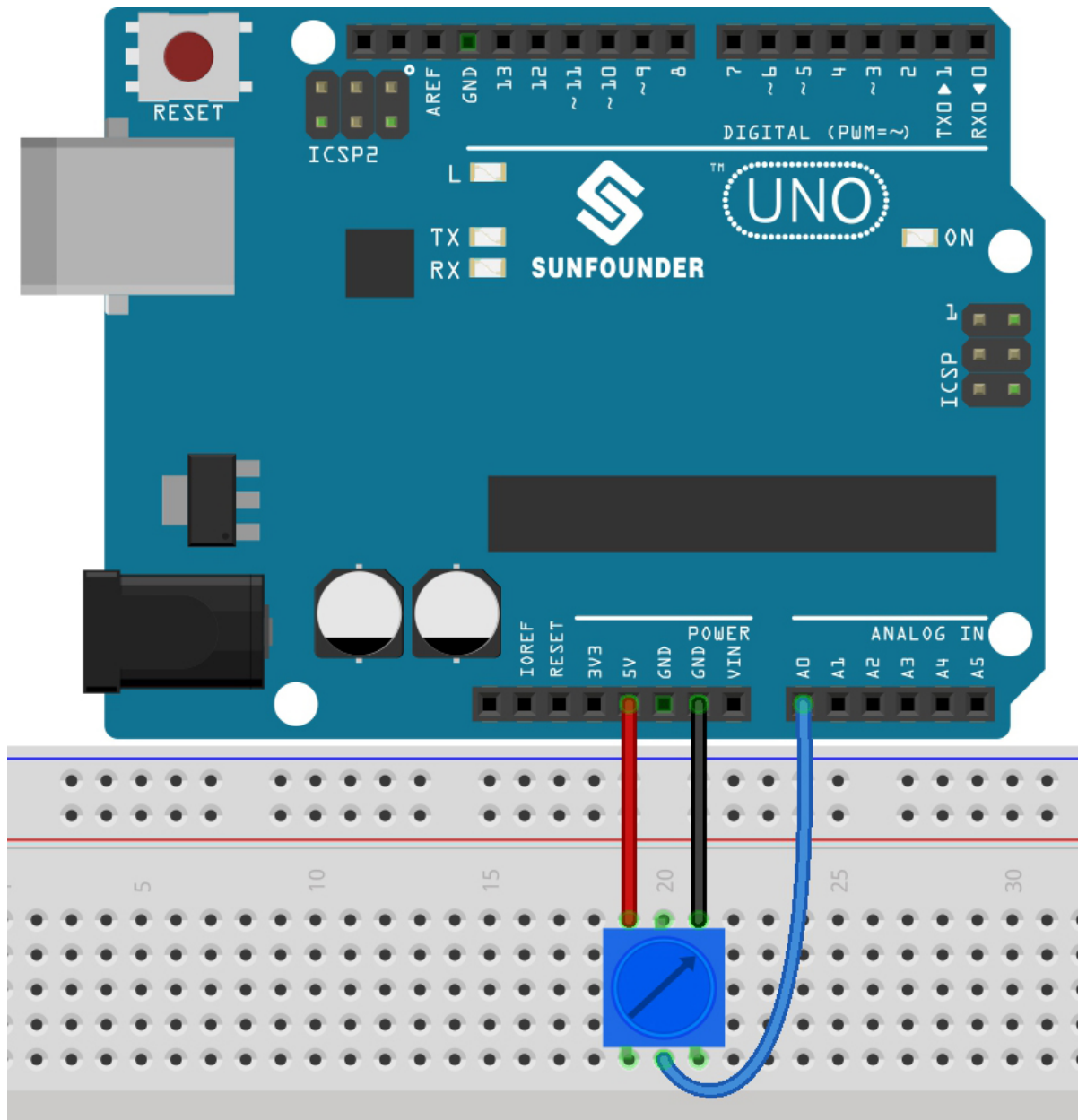
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Potentiometer</i>	

#### Schematic



In this example, we use the analog pin (A0) to read the value of the potentiometer. By rotating the axis of the potentiometer, you can change the distribution of resistance among these three pins, changing the voltage on the middle pin. When the resistance between the middle and a outside pin connected to 5V is close to zero (and the resistance between the middle and the other outside pin is close to 10k), the voltage at the middle pin is close to 5V. The reverse operation (the resistance between the middle and a outside pin connected to 5V is close to 10k) will make the voltage at the middle pin be close to 0V.

#### Wiring



## Code

### Note:

- You can open the file `4.1.turn_the_knob.ino` under the path of `3in1-kit\basic_project\4.1.turn_the_knob`.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

After uploading the codes to the board, you can open the serial monitor to see the reading value of the pin. When rotating the axis of the potentiometer, the serial monitor will print the value 0~1023.

### 4.4.2 4.2 Feel the Light

The photoresistor is a typical device for analog inputs and it is used in a very similar way to a potentiometer. Its resistance value depends on the intensity of the light, the stronger the irradiated light, the smaller its resistance value; conversely, it increases.

#### Required Components

In this project, we need the following components.

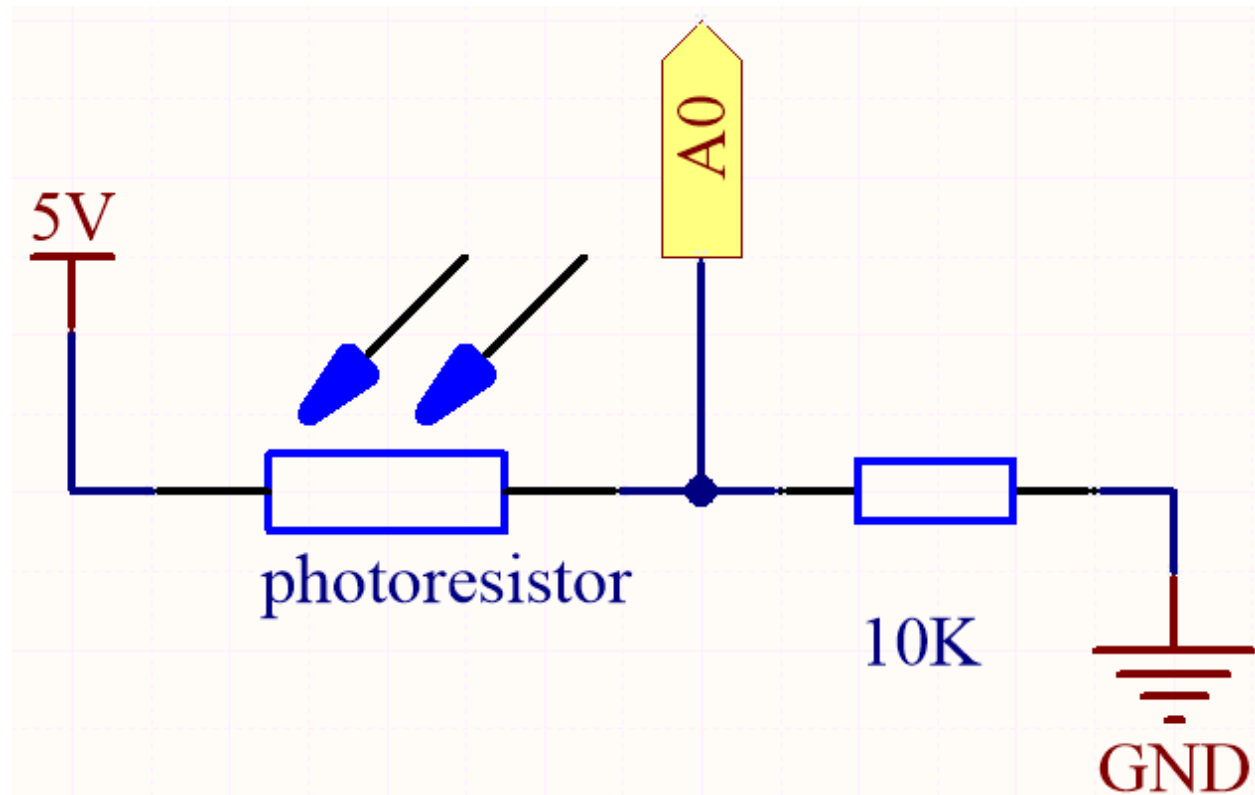
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Photoresistor</i>	

#### Schematic



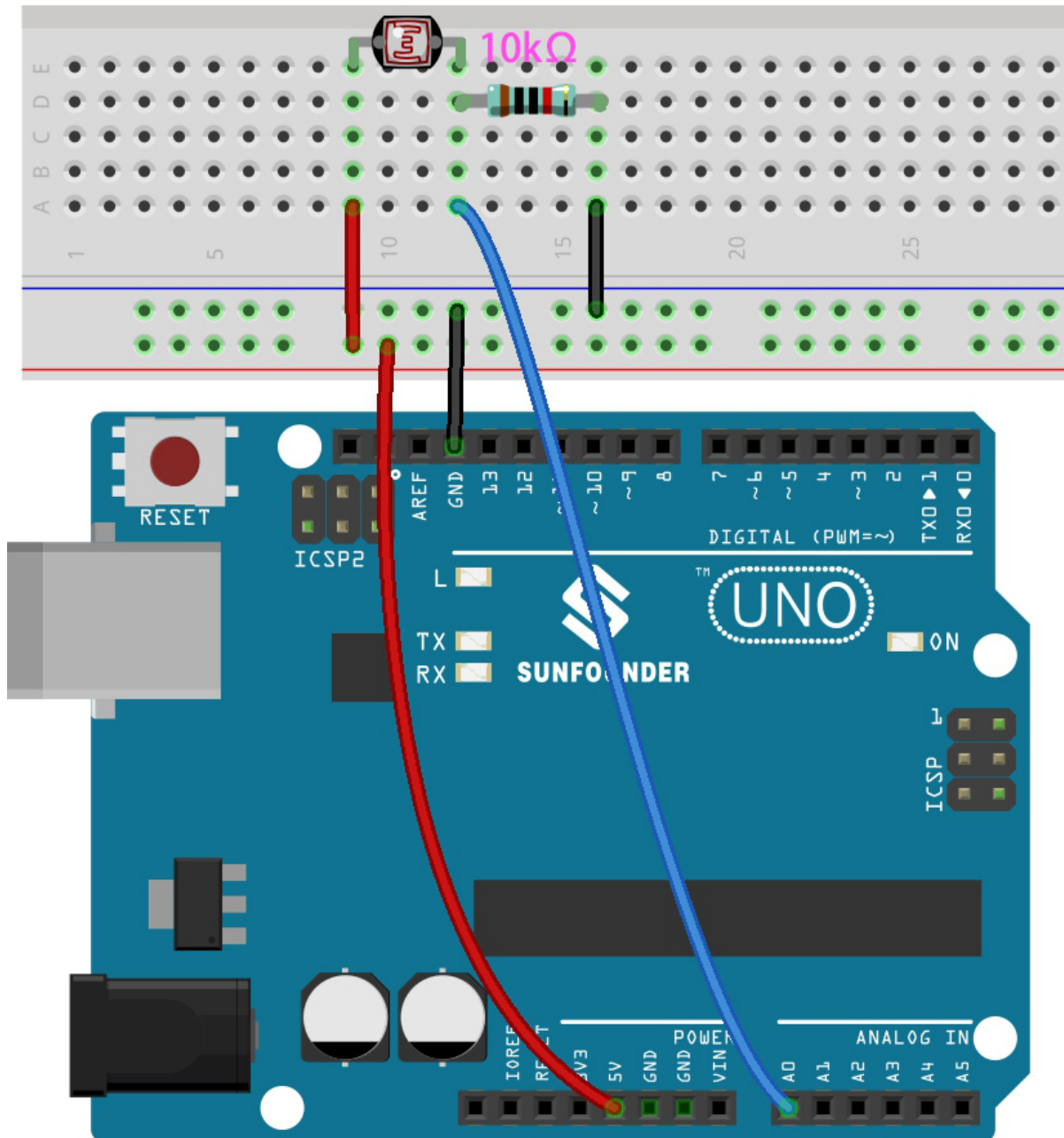
In this circuit, the 10K resistor and the photoresistor are connected in series, and the current passing through them is the same. The 10K resistor acts as a protection, and the pin A0 reads the value after the voltage conversion of the photoresistor.

When the light is enhanced, the resistance of the photoresistor decreases, then its voltage decreases, so the value from pin A0 will increase; if the light is strong enough, the resistance of the photoresistor will be close to 0, and the value of pin A0 will be close to 1023. At this time, the 10K resistor plays a protective role, so that 5V and GND are not connected together, resulting in a short circuit.

If you place the photoresistor in a dark situation, the value of pin A0 will decrease. In a dark enough situation, the resistance of the photoresistor will be infinite, and its voltage will be close to 5V (the 10K resistor is negligible), and the value of pin A0 will be close to 0.

### Wiring





### Code

#### Note:

- Open the 4.2.feel\_the\_light.ino file under the path of 3in1-kit\basic\_project\4.2.feel\_the\_light.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

After the code is uploaded successfully, the serial monitor prints out the photoresistor values. The stronger the current ambient brightness, the larger the value displayed on the serial monitor.

### 4.4.3 4.3 Toggle the Joystick

The joystick should be very familiar to anyone who plays video games regularly. It is usually used to move characters or rotate the screen.

Our movements can be read by the Joystick, which works on a very simple principle. It consists of two potentiometers that are perpendicular to each other. These two potentiometers measure the analog value of the joystick in both vertical and horizontal directions, producing a value (x,y) in a planar right-angle coordinate system.

This kit also includes a joystick with a digital input. It is activated when the joystick is pressed.

#### **Required Components**

In this project, we need the following components.

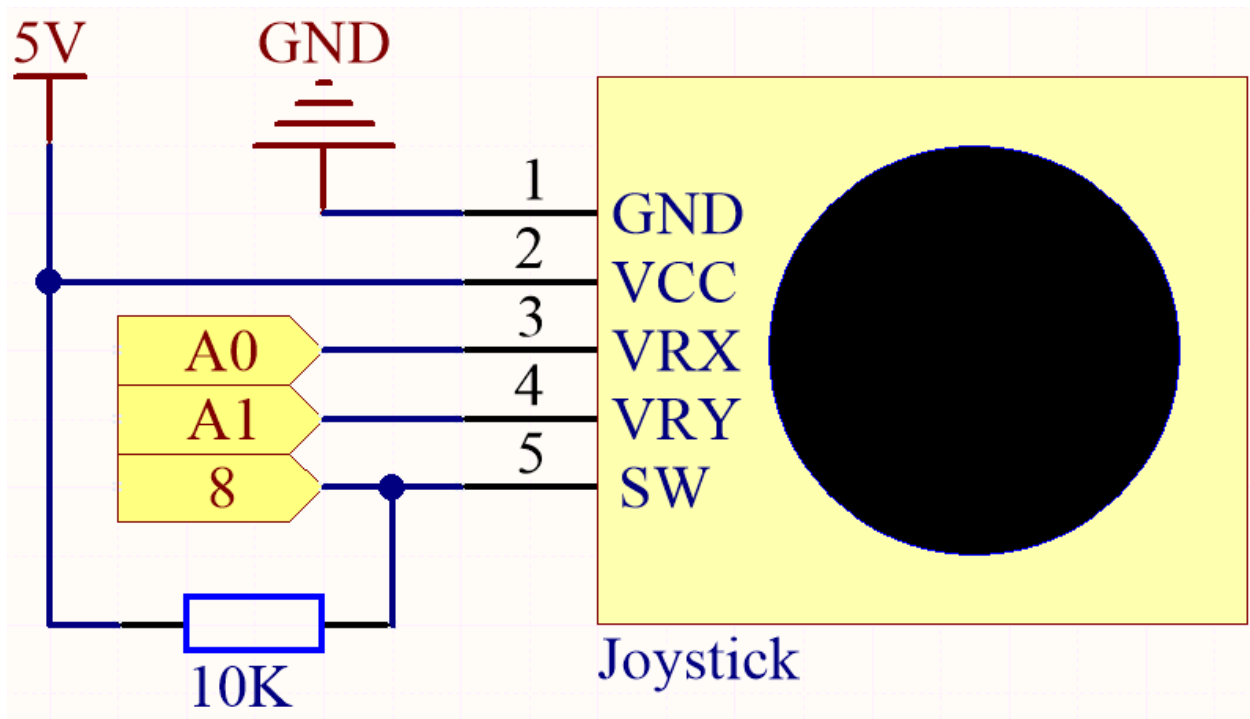
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

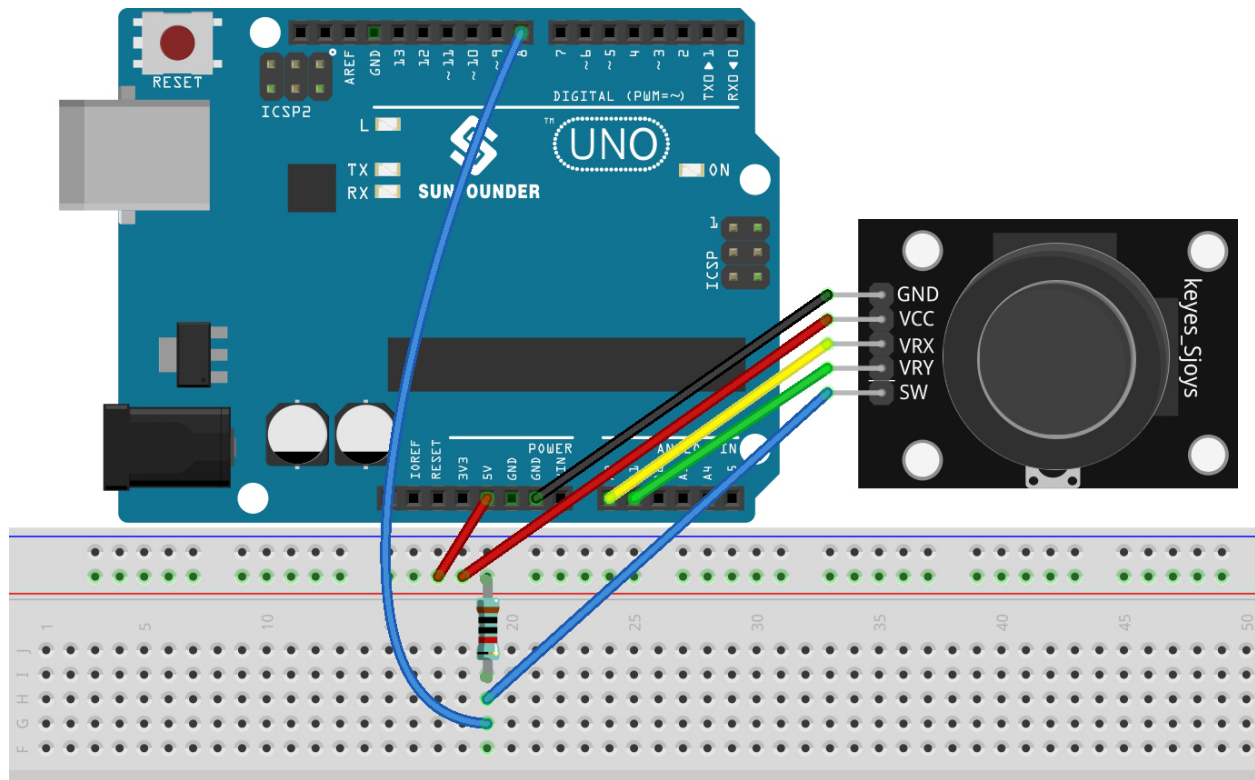
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Joystick Module</i>	-

#### **Schematic**



**Note:** The SW pin is connected to a 10K pull-up resistor, the reason is to be able to get a stable high level on the SW pin (Z axis) when the joystick is not pressed; otherwise the SW is in a suspended state and the output value may vary between 0/1.

#### Wiring



### Code

#### Note:

- Open the 4.3.toggle\_the\_joystick.ino file under the path of 3in1-kit\basic\_project\4.3.toggle\_the\_joystick.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

Open the serial monitor after the code has been uploaded successfully to see the x,y,z values of the joystick.

- The x-axis and y-axis values are analog values that vary from 0 to 1023.
- The Z-axis is a digital value with a status of 1 or 0 ( when pressed , it is 0 ).

### 4.4.4 4.4 Measure Soil Moisture

In the planting industry, the crops themselves cannot directly obtain the inorganic elements in the soil, Water in the soil acts as a solvent for dissolving these inorganic elements.

Crops absorb soil moisture through the root system, obtain nutrients, and promote growth.

In the process of crop growth and development, the requirements for soil temperature are also different. Therefore, a soil moisture sensor is required.

#### Required Components

In this project, we need the following components.

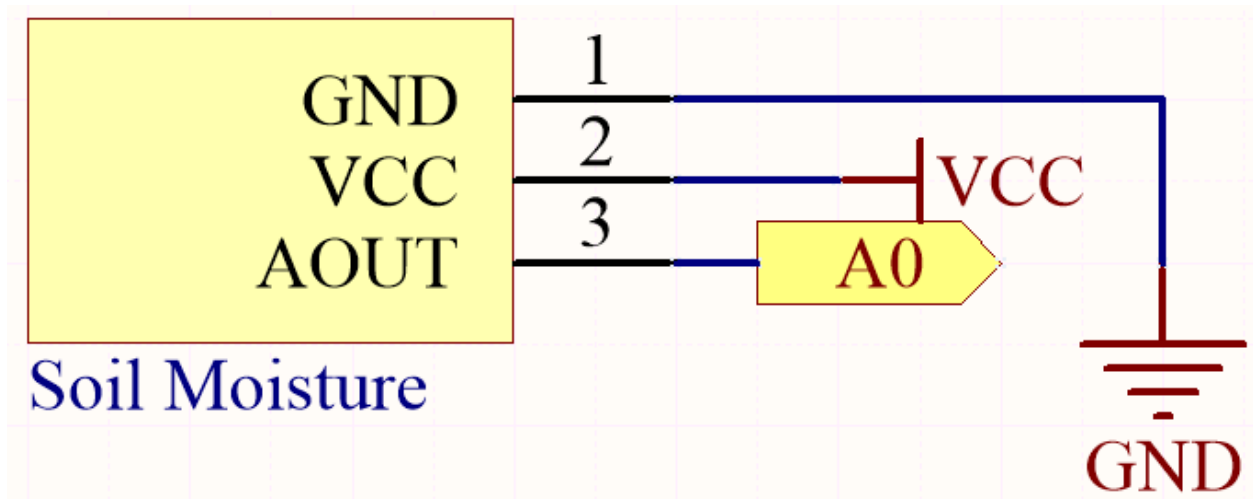
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

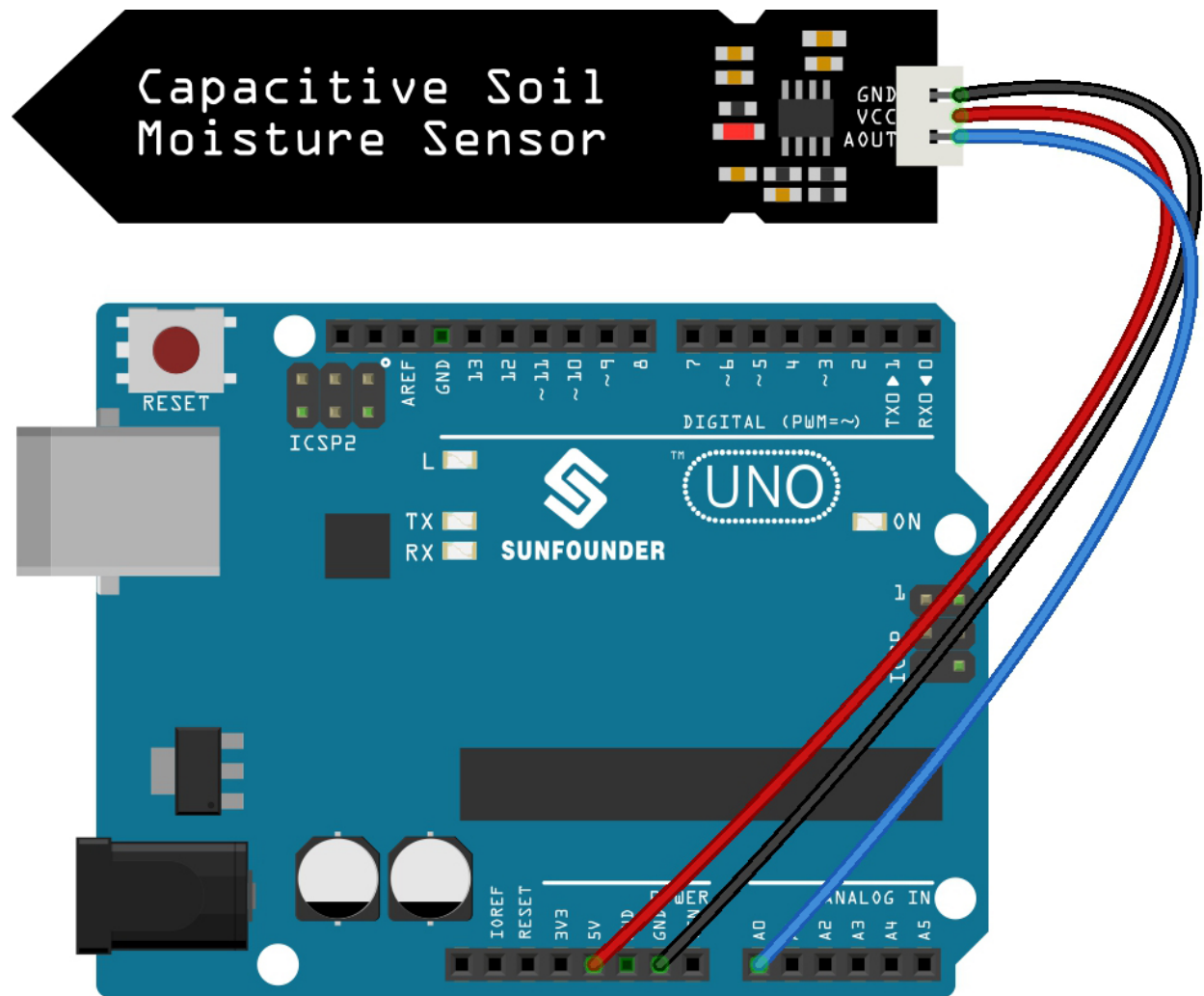
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>Soil Moisture Module</i>	

### Schematic



### Wiring



## Code

### Note:

- Open the 4.4.measure\_soil\_moisture.ino file under the path of 3in1-kit\basic\_project\4.4.measure\_soil\_moisture.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

Once the code is successfully uploaded, the serial monitor will print out the soil moisture value.

By inserting the module into the soil and watering it, the value of the soil moisture sensor will become smaller.

#### 4.4.5 4.5 Thermometer

A thermometer is a device that measures temperature or a temperature gradient (the degree of hotness or coldness of an object). A thermometer has two important elements: (1) a temperature sensor (e.g. the bulb of a mercury-in-glass thermometer or the pyrometric sensor in an infrared thermometer) in which some change occurs with a change in temperature; and (2) some means of converting this change into a numerical value (e.g. the visible scale that is marked on a mercury-in-glass thermometer or the digital readout on an infrared model). Thermometers are widely used in technology and industry to monitor processes, in meteorology, in medicine, and in scientific research.

A thermistor is a type of temperature sensor whose resistance is strongly dependent on temperature, and it has two types: Negative Temperature Coefficient (NTC) and Positive Temperature Coefficient (PTC), also known as NTC and PTC. The resistance of PTC thermistor increases with temperature, while the condition of NTC is opposite to the former.

In this experiment we use an **NTC thermistor** to make a thermometer.

#### Required Components

In this project, we need the following components.

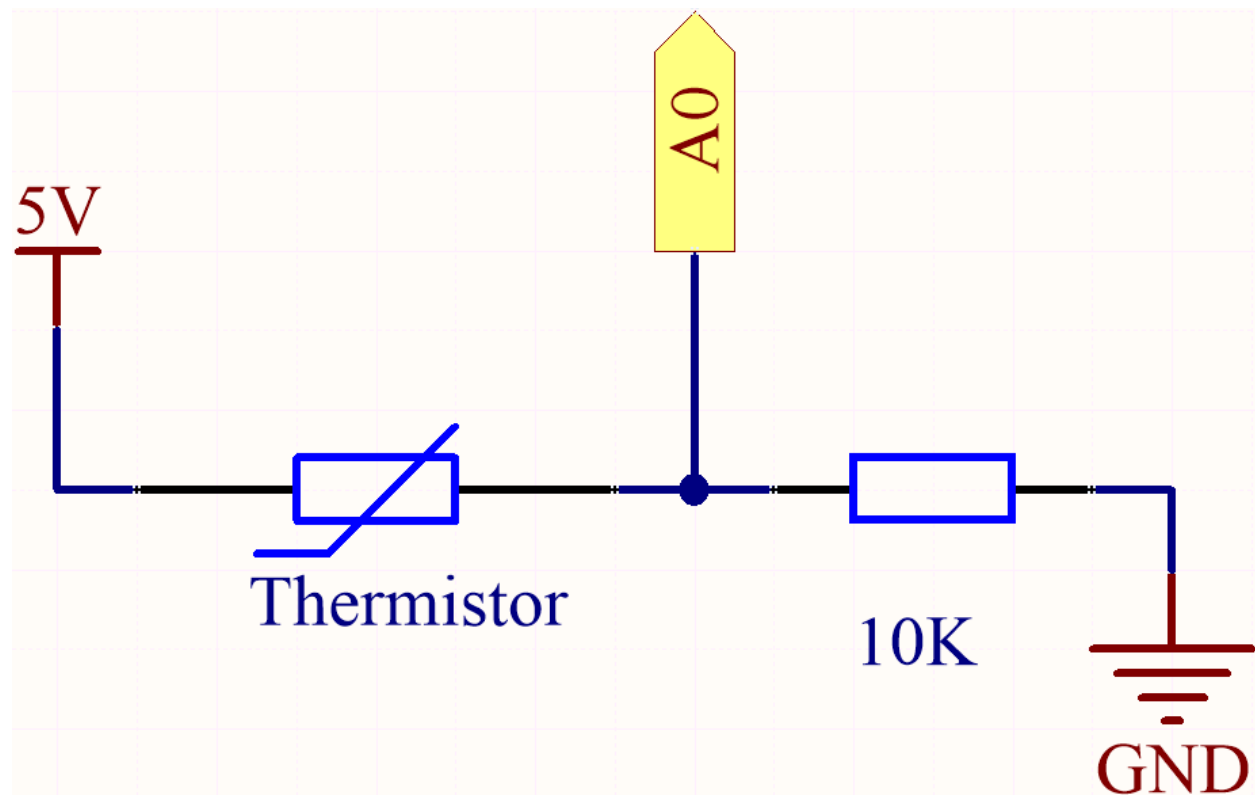
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Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Thermistor</i>	

#### Schematic



Each thermistor has a normal resistance. Here it is 10k ohm, which is measured under 25 degree Celsius.

When the temperature gets higher, the resistance of the thermistor decreases. Then the voltage data is converted to digital quantities by the A/D adapter.

The temperature in Celsius or Fahrenheit is output via programming.

Here is the relation between the resistance and temperature:

$$RT = RN \exp B(1/TK - 1/TN)$$

- **RT** is the resistance of the NTC thermistor when the temperature is **TK**.
- **RN** is the resistance of the NTC thermistor under the rated temperature **TN**. Here, the numerical value of **RN** is 10k.
- **TK** is a Kelvin temperature and the unit is K. Here, the numerical value of **TK** is  $273.15 + \text{degree Celsius}$ .
- **TN** is a rated Kelvin temperature; the unit is K too. Here, the numerical value of **TN** is  $273.15 + 25$ .
- And **B(beta)**, the material constant of NTC thermistor, is also called heat sensitivity index with a numerical value 3950.
- **exp** is the abbreviation of exponential, and the base number **e** is a natural number and equals 2.7 approximately.

Convert this formula  $TK = 1 / (\ln(RT/RN) / B + 1/TN)$  to get Kelvin temperature that minus 273.15 equals degree Celsius.

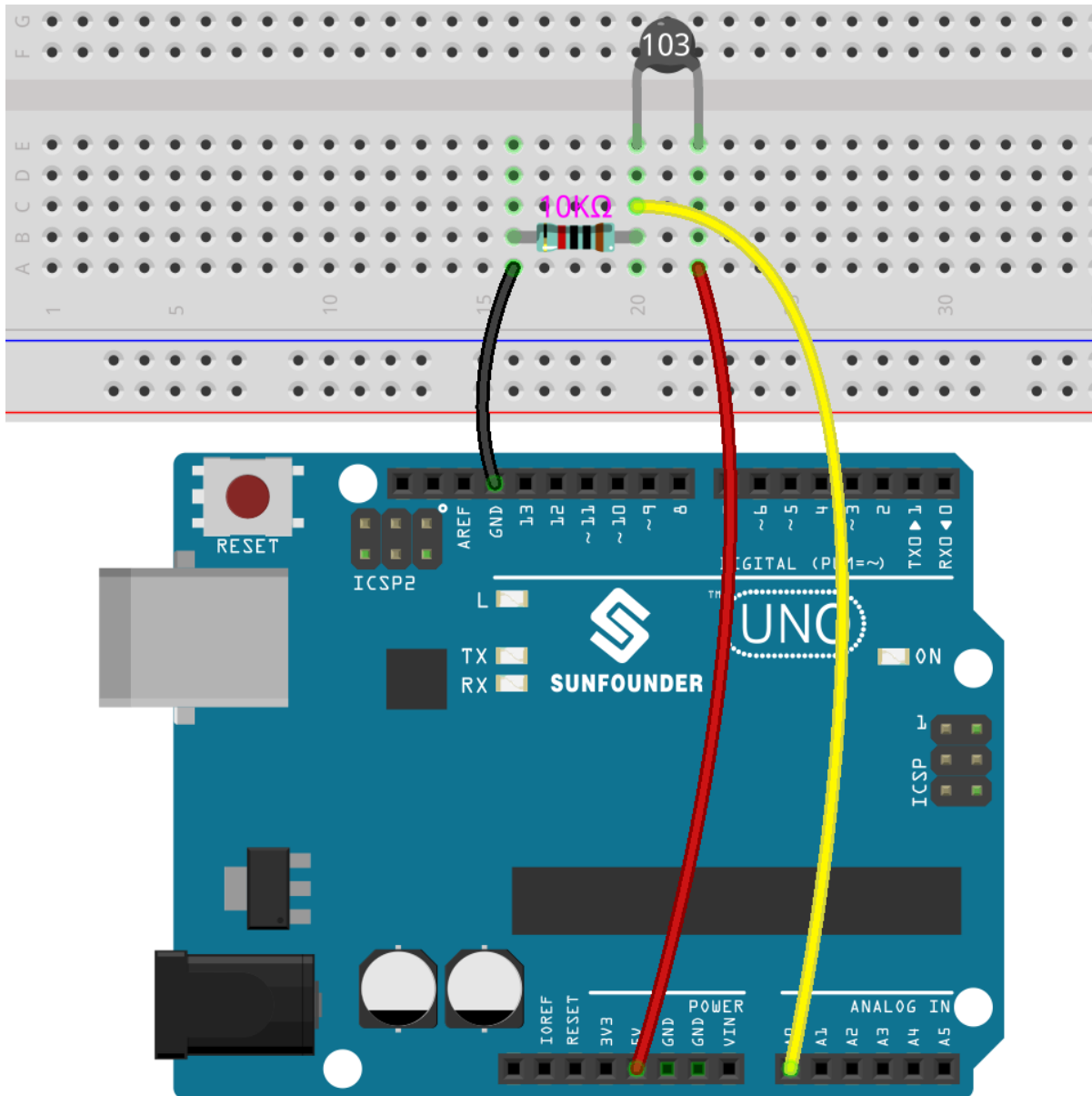
This relation is an empirical formula. It is accurate only when the temperature and resistance are within the effective range.

## Wiring



**Note:**

- The thermistor is black or green and marked 103.

**Code****Note:**

- You can open the file `4.5_thermometer.ino` under the path of `euler-kit/arduino/4.5_thermometer`.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

Don't forget to select the Raspberry Pi Pico board and the correct port before clicking the Upload button.

After the code is successfully uploaded, the Serial Monitor will print out the Celsius and Fahrenheit temperatures.

## 4.5 5. More Syntax

In this chapter, you will find some examples that illustrate the basic logic of how most programs interact with reality. This will help you become familiar with Arduino programming. When you have a creative idea in mind, programming will no longer be challenging for you.

### 4.5.1 5.1 If else

Usually we use conditional judgment to complete the most basic reality interaction projects. Here, we build a door detection system with reed switch and LED to show this logic.

Fix the magnet on one side of the door and the reed switch (with circuit) on the other side of the door. When the door is closed, the magnet is close to the reed switch, which will turn it on.

#### Required Components

In this project, we need the following components.

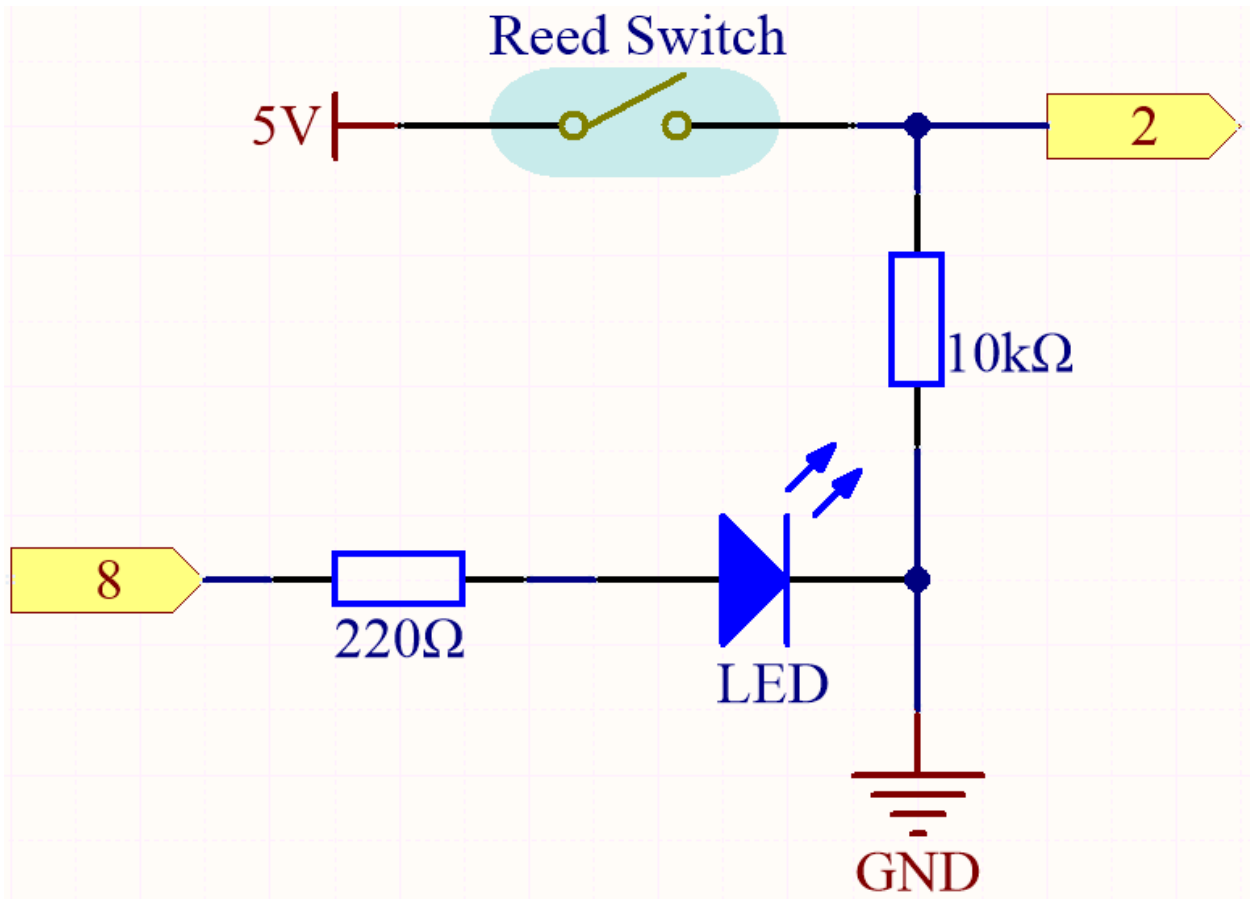
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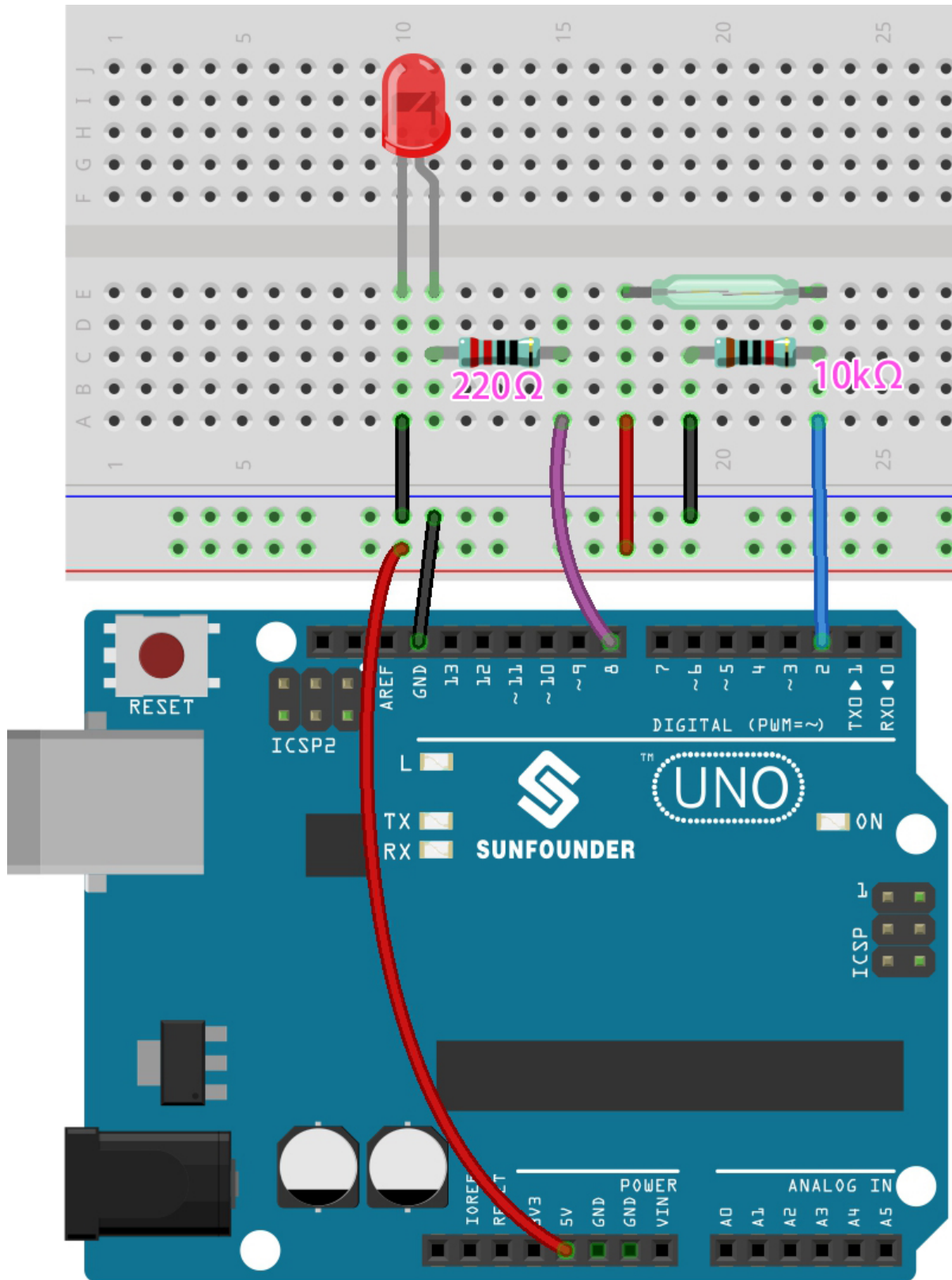
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>LED</i>	
<i>Reed Switch</i>	-

#### Schematic



Wiring



Code

**Note:**

- Open the `5.1.if_else.ino` file under the path of `3in1-kit\basic_project\5.1.if_else`.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

After the code is uploaded successfully, if you do not close the door, the LED will light up, prompting you to close the door.

By the way, if we need the opposite effect (lighting up the LED when the door is closed), we just need to modify the condition in the `if`.

- `if else`

The `if else` allows greater control over the flow of code than the basic `if` statement, by allowing multiple tests to be grouped.

## 4.5.2 5.2 Threshold

In many projects, you will encounter such a need. “When xxx reaches a certain level, then...”

For example, in a smart home, when the light intensity is lower than 50Lux, turn on the light; Another example is in the computer motherboard, if the operating temperature of the CPU is higher than 65 degrees Celsius, turn on the fan, and so on.

In these requirements, the keyword “threshold” is reflected.

We can adjust the value of the threshold to make the circuit operate more in line with individual needs. For example, if I like a brighter living environment, I can increase the threshold of the automatic lights of the smart home to 80Lux. Another example is that the ventilation environment of my studio is not very good, and the heat dissipation demand is higher, then the threshold value of automatic fan opening can be adjusted to 50 degrees Celsius.

Here we use soil moisture sensor and 2 LEDs to make a pot monitor. If the soil is too dry, the red LED will light up; if the soil is moist enough, the green LED will light up. You need to manually adjust the thresholds for determining the dryness and wetness of the soil.

### Required Components

In this project, we need the following components.

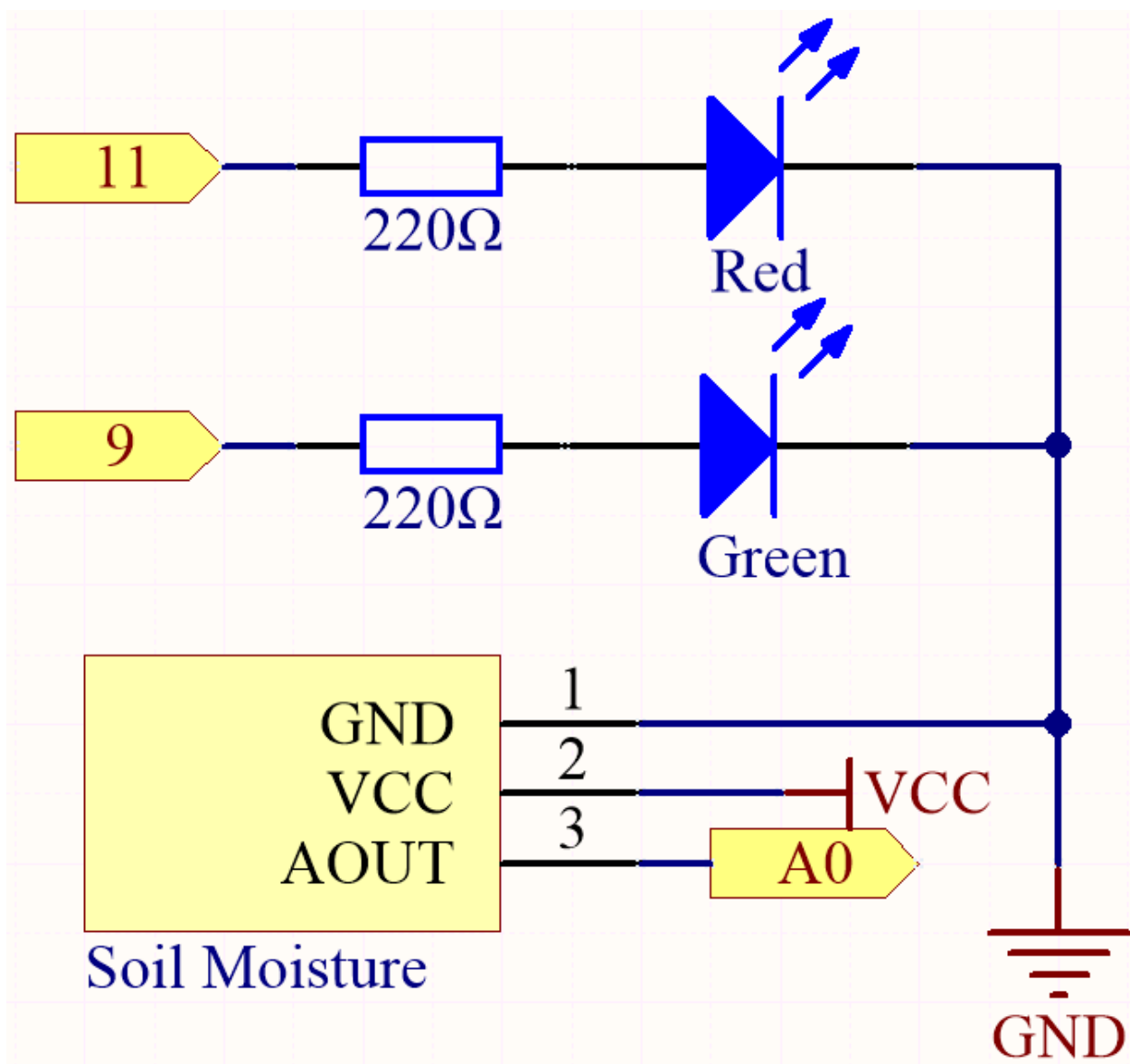
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

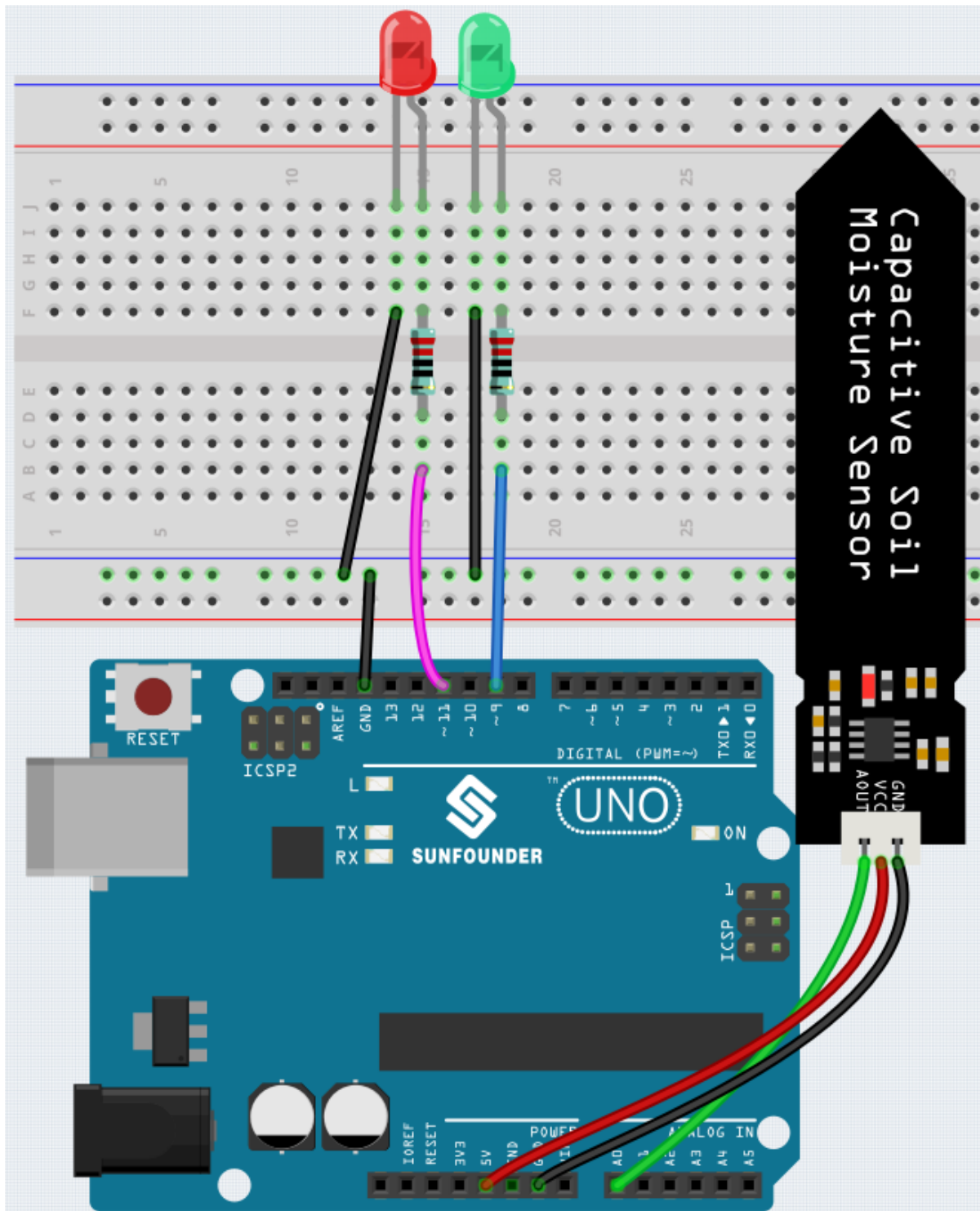
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>LED</i>	
<i>Soil Moisture Module</i>	

## Schematic



## Wiring



## Code

### Note:

- Open the 5.2.threshold.ino file under the path of 3in1-kit/basic\_project/5.2.threshold.

- Or copy this code into **Arduino IDE**.

After the code is uploaded successfully, if your threshold is set correctly, you will see the red LED light up when the soil is dry to remind you that you need to water; after watering, the green LED will light up.

#### How it works

```
...  
  
void loop() {  
    int sensorValue = analogRead(soilMoisture);  
    Serial.println(sensorValue);  
    if (sensorValue > threshold) {  
        digitalWrite(redPin, HIGH); // Turn the red LED  
        digitalWrite(greenPin, LOW); // green  
    } else {  
        digitalWrite(greenPin, HIGH); // Turn on the green LED  
        digitalWrite(redPin, LOW); // red  
    }  
}  
...
```

First set a **threshold** value and then read the value of the soil moisture module, its value decreases as the moisture level increases. If the value currently read is greater than the set **threshold**, then let the red LED light up, otherwise it will turn on the green LED.

This **threshold** value needs to be adjusted according to the actual situation, you can upload the code first, then open the serial monitor to check the value, record the value in both wet and dry conditions, and then choose a middle value as the **threshold** value.

### 4.5.3 5.3 State Change Detection

When the button controls other devices, it can not only work when it is pressed, but stop when it is released. It is also possible to switch the working state each time the button is pressed.

In order to achieve this effect, you need to know how to toggle the working state between off and on when the button is pressed, That is “state change detection”.

In this project, we will use the button to control the motor.

#### Required Components

In this project, we need the following components.

It’s definitely convenient to buy a whole kit, here’s the link:

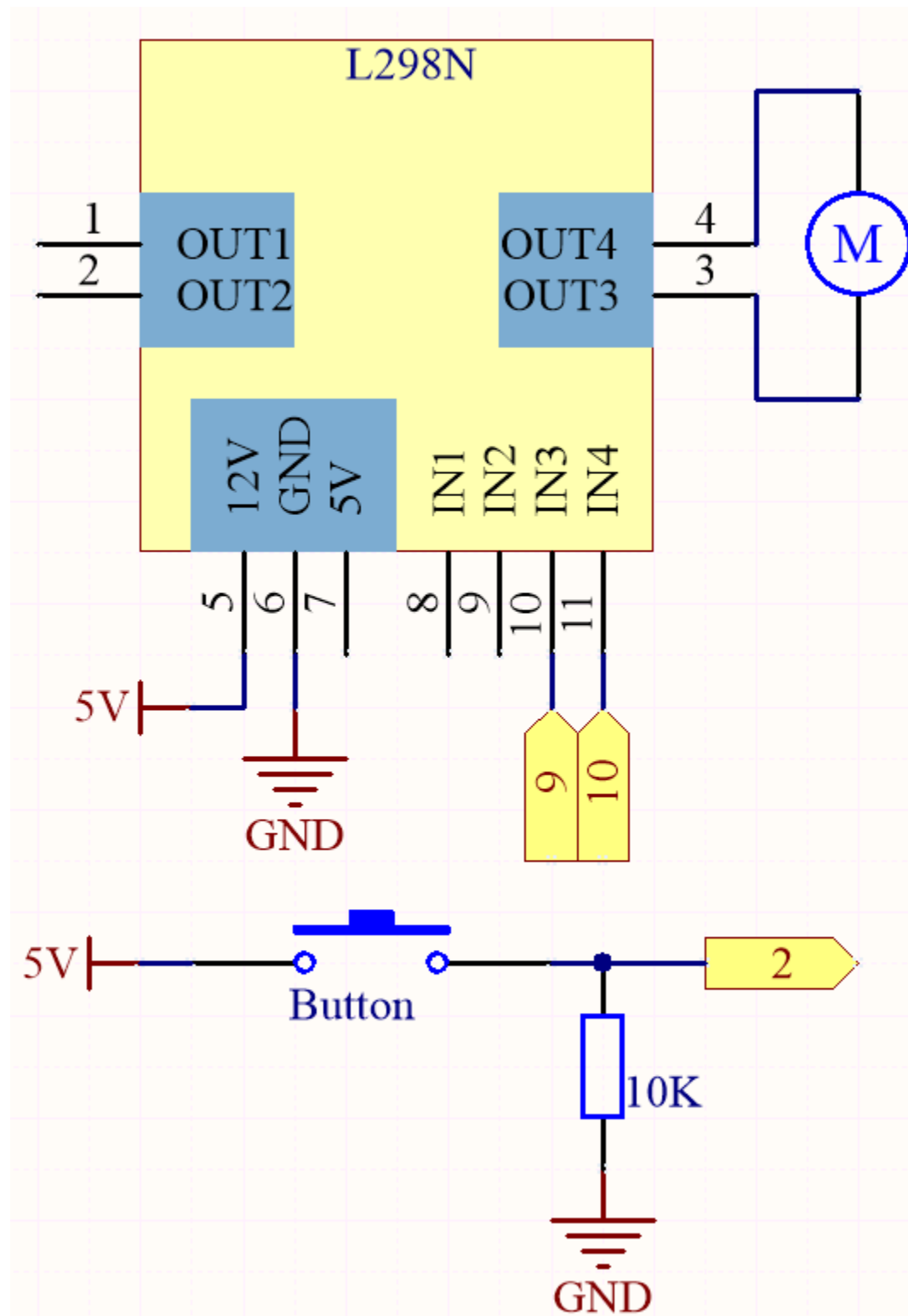
Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

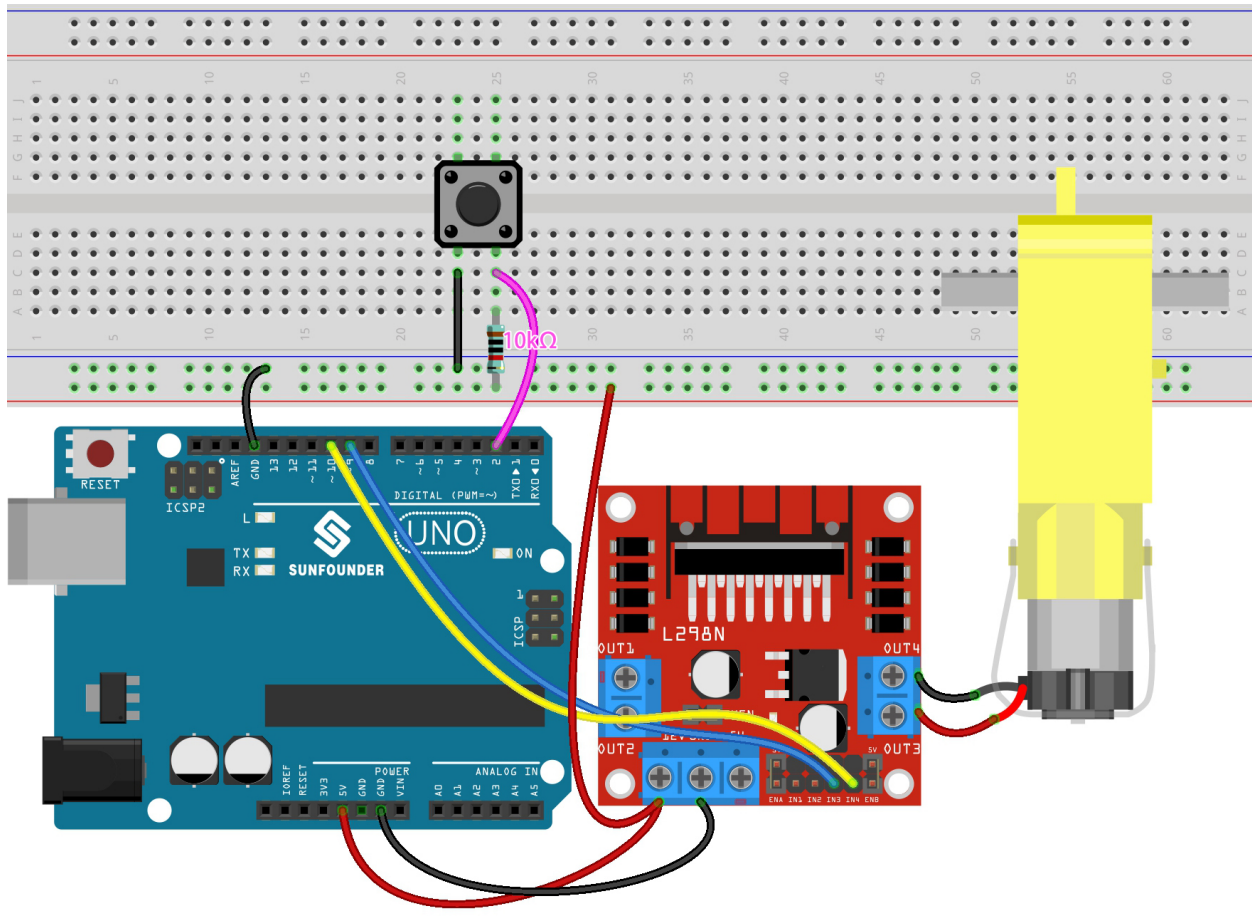


COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Button</i>	
<i>TT Motor</i>	-
<i>L298N Module</i>	

### Schematic



Wiring



## Code

### Note:

- Open the 5.3.state\_change\_detection.ino file under the path of 3in1-kit\basic\_project\5.3.state\_change\_detection.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

After the code is uploaded successfully, you press the button and the motor will turn; until you press the button again, the motor will stop.

### How it works?

1. Create variables and define pins for the motor and button.

```
...
int detectionState = 0;
int buttonState = 0;
int lastButtonState = 0;
```

- detectionState is a flag whose value changes each time the button is pressed, e.g., 0 this time, 1 the next, and so on alternately.

- `buttonState` and `lastButtonState` are used to record the state of the button this time and the last time, to compare whether the button was pressed or released.

2. Initialize each pin and set the baud rate of the serial monitor.

```
void setup() {
  pinMode(buttonPin, INPUT);
  Serial.begin(9600);
  pinMode(motorPinA, OUTPUT);
  pinMode(motorPinB, OUTPUT);
}
```

3. First read the state of the button, and if the button is pressed, the variable `detectionState` will switch its value from 0 to 1 or 1 to 0. When `detectionState` is 1, the motor will be turned. It has the effect that this time the button is pressed, the motor turns, the next time the button is pressed, the motor stops, and so on alternately.

```
void loop() {
  // Toggle the detectionState each time the button is pressed
  buttonState = digitalRead(buttonPin);
  if (buttonState != lastButtonState) {
    if (buttonState == HIGH) {
      detectionState=(detectionState+1)%2;
      Serial.print("The detection state is: ");
      Serial.println(detectionState);
    }
    delay(50);
  }
  lastButtonState = buttonState;

  // According to the detectionState, start the motor
  if(detectionState==1){
    digitalWrite(motorPinA,HIGH);
    digitalWrite(motorPinB,LOW);
  }else{
    digitalWrite(motorPinA,LOW);
    digitalWrite(motorPinB,LOW);
  }
}
```

The entire workflow is as follows.

- Read the button value.

```
buttonState = digitalRead(buttonPin);
```

- If `buttonState` and `lastButtonState` are not equal, it means that the button state has changed, continue with the next judgment, and store the button state at this time into the variable `lastButtonState`. `delay(50)` is used to eliminate jitter.

```
if (buttonState != lastButtonState) {
  ...
  delay(50);
}
lastButtonState = buttonState;
```

- When the button is pressed, its value is HIGH. Here, when the button is pressed, the value of the variable `detectionState` is changed, e.g., from 0 to 1 after an operation.

```
if (buttonState == HIGH) {
  detectionState=(detectionState+1)%2;
  Serial.print("The detection state is: ");
  Serial.println(detectionState);
}
```

- When the variable `detectionState` is 1, let the motor rotate, otherwise stop.

```
if(detectionState==1){
  digitalWrite(motorPinA,HIGH);
  digitalWrite(motorPinB,LOW);
}else{
  digitalWrite(motorPinA,LOW);
  digitalWrite(motorPinB,LOW);
}
```

#### 4.5.4 5.4 Interval

Sometimes you need to do two things at once. For example you might want to blink an LED while reading a button press. In this case, you can't use `delay()`, because Arduino pauses your program during the `delay()`. If the button is pressed while Arduino is paused waiting for the `delay()` to pass, your program will miss the button press.

An analogy would be warming up a pizza in your microwave, and also waiting some important email. You put the pizza in the microwave and set it for 10 minutes. The analogy to using `delay()` would be to sit in front of the microwave watching the timer count down from 10 minutes until the timer reaches zero. If the important email arrives during this time you will miss it.

What you would do in real life would be to turn on the pizza, and then check your email, and then maybe do something else (that doesn't take too long!) and every so often you will come back to the microwave to see if the timer has reached zero, indicating that your pizza is done.

This sketch demonstrates how to tone an buzzer without using `delay()`. It turns the buzzer on and then makes note of the time. Then, each time through `loop()`, it checks to see if the desired interval time has passed. If it has, it tone the buzzer and makes note of the new time. In this way the buzzer tones continuously while the sketch execution never lags on a single instruction.

Based on this condition, we can add the code of the button to control the LED, it will not be disturbed by the buzzer playing music.

#### Required Components

In this project, we need the following components.

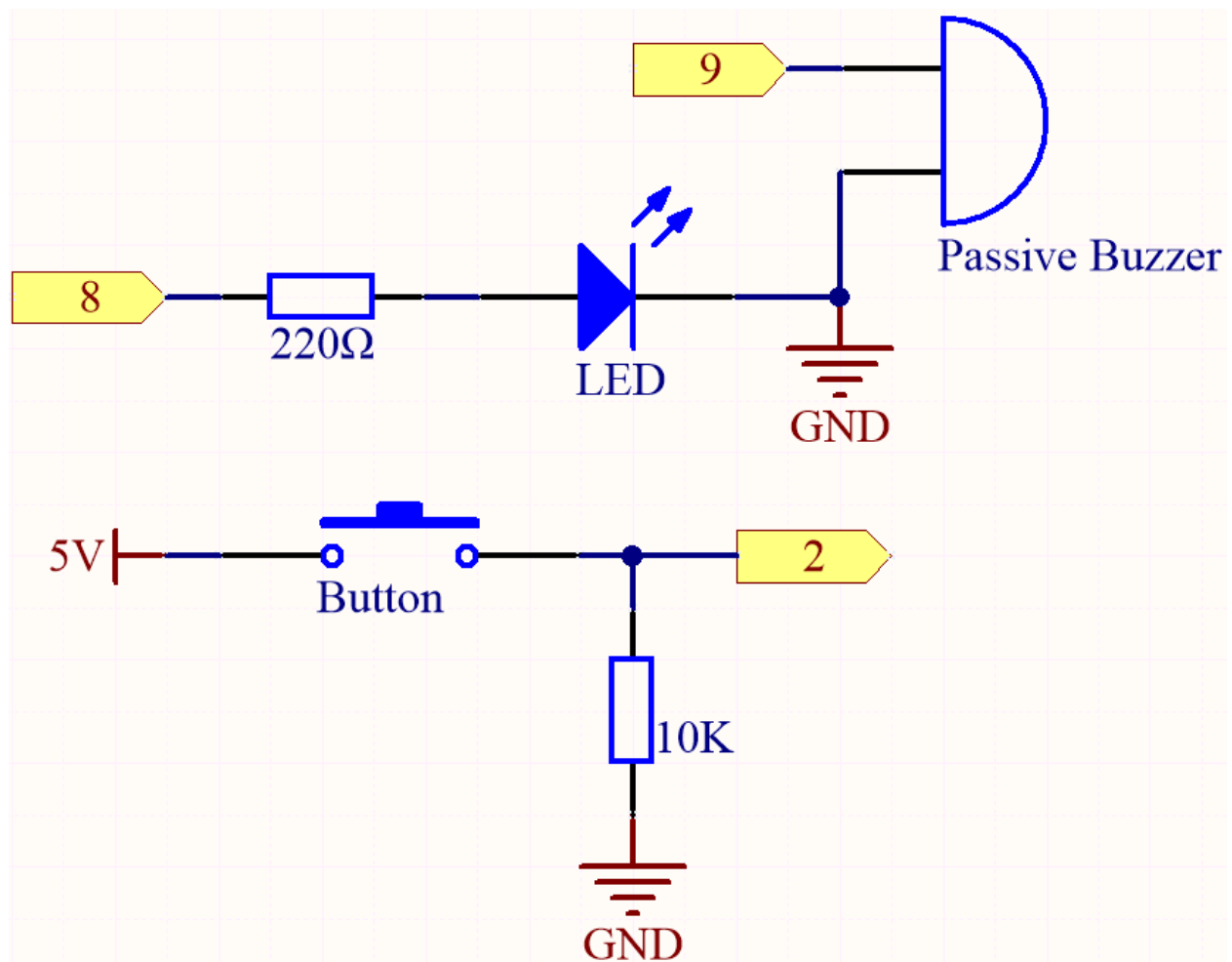
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

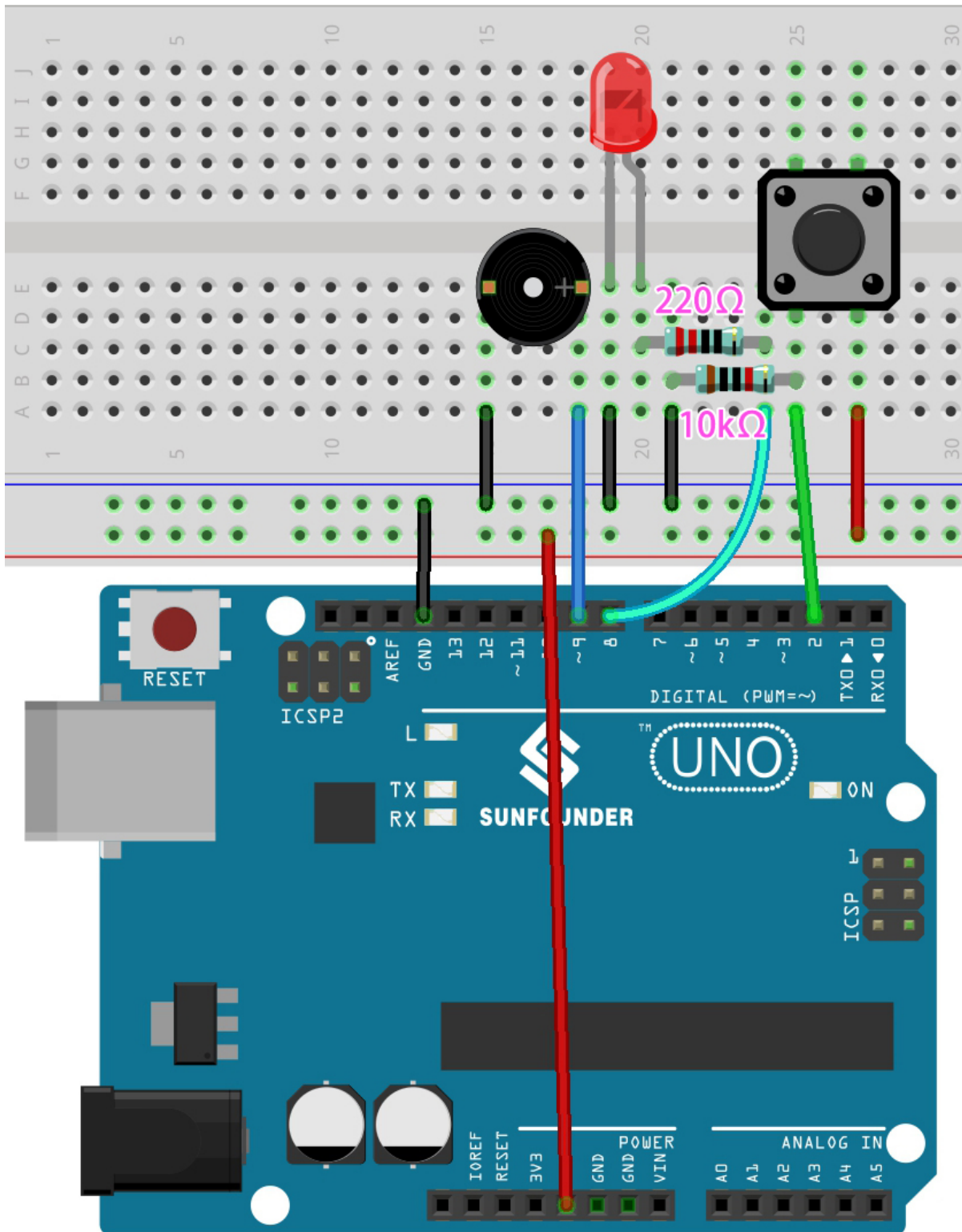
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>LED</i>	
<i>Button</i>	
<i>Buzzer</i>	

### Schematic



### Wiring



Code

Note:

- Open the 5.4.interval.ino file under the path of 3in1-kit\basic\_project\5.4.interval.
  - Or copy this code into **Arduino IDE**.
  - Or upload the code through the [Arduino Web Editor](#).
- 

After the code is uploaded successfully, the buzzer will play music; whenever you press the button, the LED will light up. The work of LED and buzzer does not interfere with each other.

### How it works?

Initial a variable named `previousMillis` to store previous operating time of microcontroller.

```
unsigned long previousMillis = 0;
```

Mark which note is played.

```
int thisNote=0;
```

The interval time of each note.

```
long interval = 1000;
```

In `loop()`, declare `currentMillis` to store the current time.

```
unsigned long currentMillis = millis();
```

When the interval between the current operating time and last updating time is larger than 1000ms, certain functions are triggered. Meanwhile, update the `previousMillis` to the current time for the next triggering that is to happen 1 second latter.

```
if (currentMillis - previousMillis >= interval) {  
    previousMillis = currentMillis; // save the last time of the last tone  
    //...  
}
```

Play the notes in the melody one by one.

```
tone(buzzerPin,melody[thisNote],100);  
interval=1000/noteDurations[thisNote]; // interval at which to tone  
thisNote=(thisNote+1)%(sizeof(melody)/2); //iterate over the notes of the melody
```

The button control the LED.

```
// play button & led  
digitalWrite(ledPin,digitalRead(buttonPin));
```



### 4.5.5 5.5 Use Internal Library

In the Arduino IDE, you can use many built-in libraries by adding the corresponding .h file directly to your code. This project uses the Servo library to drive the Servo, so that it can rotate between 0° and 180°.

#### Required Components

In this project, we need the following components.

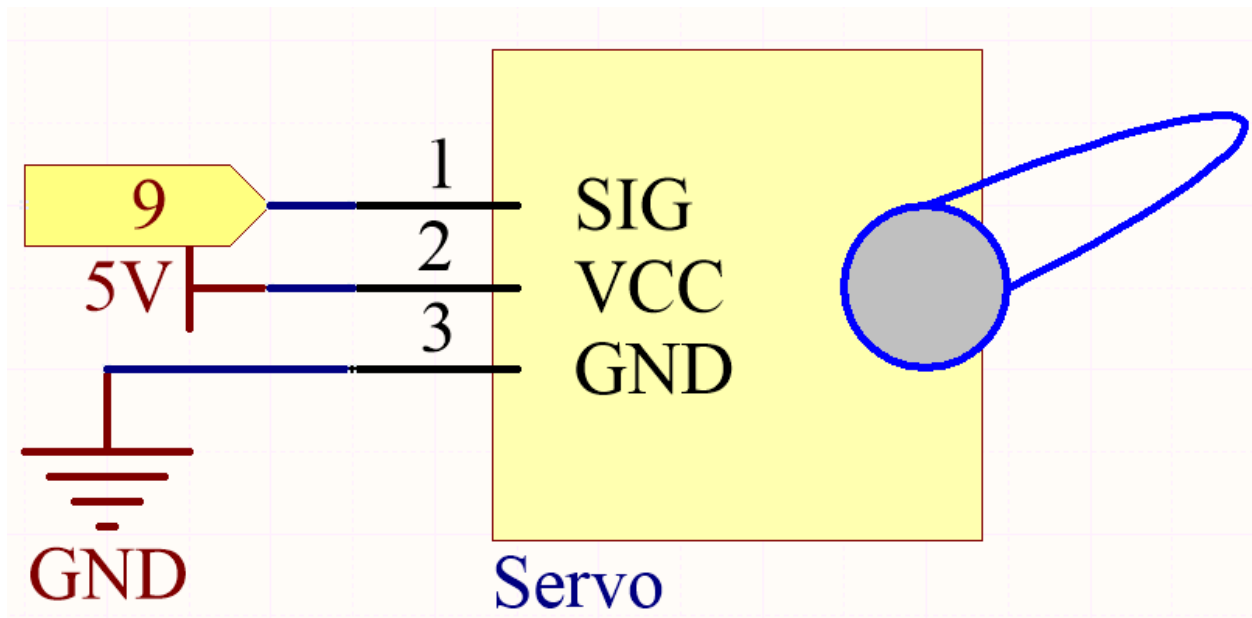
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

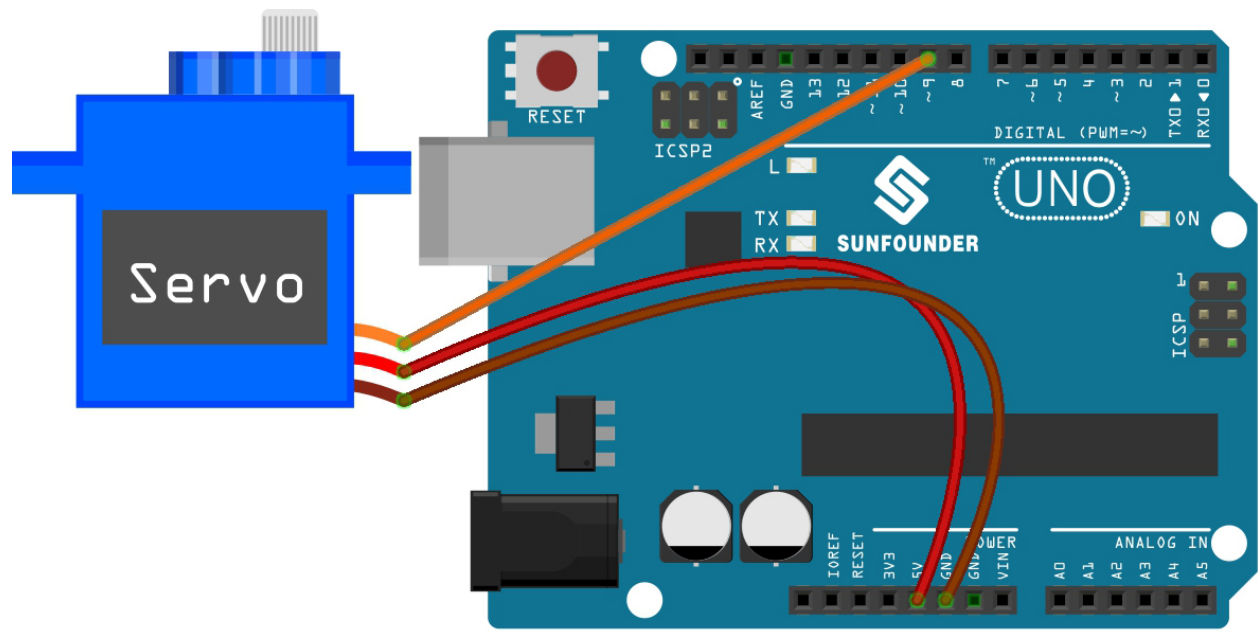
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>Servo</i>	

#### Schematic



In this project, we use PWM pin 9 to drive the Servo, and get the orange wire of the servo connected to the PWM pin 9, the red one to 5V, and the brown one to GND.

#### Wiring



### Code

#### Note:

- Open the 5.5.use\_internal\_library.ino file under the path of 3in1-kit\basic\_project\5.5.use\_internal\_library.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

Once you finish uploading the codes to the R3 board, you can see the servo arm rotating in the range 0°~180°.

#### How it works?

By calling the library `Servo.h`, you can drive the servo easily.

```
#include <Servo.h>
```

#### Library Functions

`Servo`

Create **Servo** object to control a servo.

```
uint8_t attach(int pin);
```

Call `pinMode()` to turn a pin into a servo driver and return 0 on failure.

```
void detach();
```

Release a pin from servo driving.

```
void write(int value);
```

Set the angle of the servo in degrees, 0 to 180.

```
int read();
```

Return that value set with the last `write()`.

```
bool attached();
```

Return 1 if the servo is currently attached.

## 4.5.6 5.6 Map

If you observe carefully, you will notice that many values have different ranges in programming. For example, the range of values for analog inputs is (0~1023). The value range for the analog output is (0~255). The output angle of the servo is (0~180).

This means that if we want to use the potentiometer to control the brightness of the LED or the angle of the servo, we need to go through a mapping operation.

Now let's see how to achieve it.

### Required Components

In this project, we need the following components.

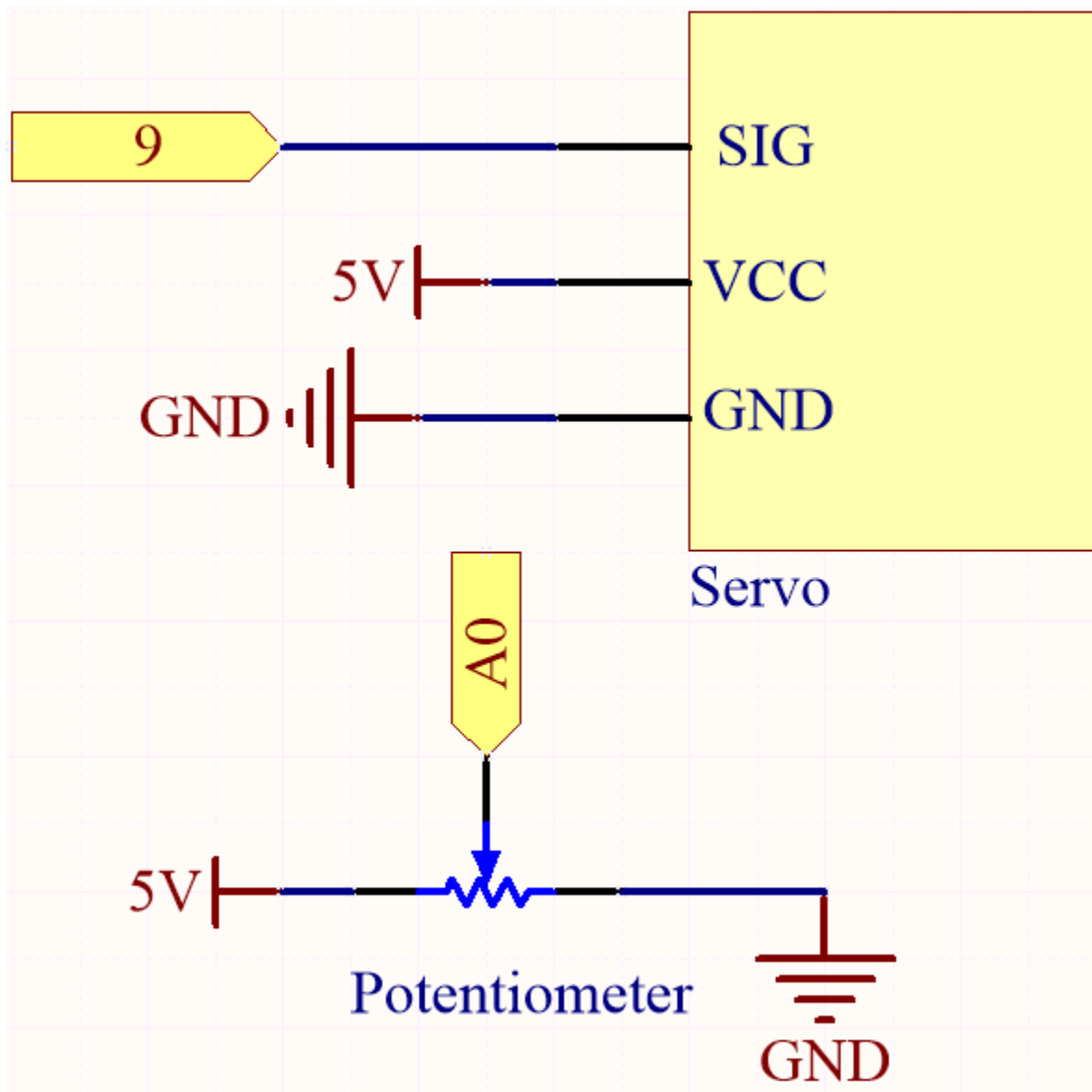
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Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

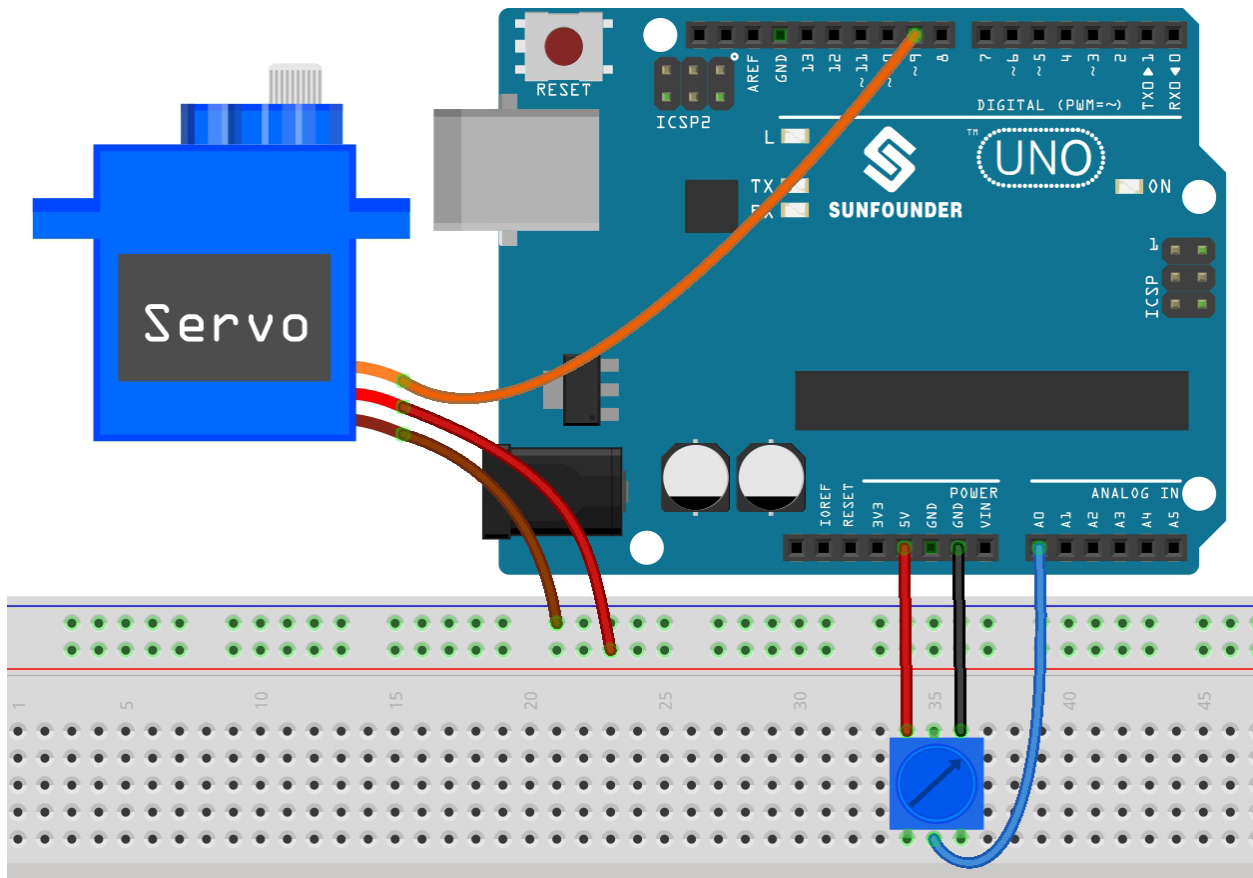
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Servo</i>	
<i>Potentiometer</i>	

### Schematic



Wiring



## Code

### Note:

- Open the 5.6.map.ino file under the path of 3in1-kit\basic\_project\5.6.map.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

After the code is uploaded successfully, you can rotate the potentiometer back and forth, and the output shaft of the servo will rotate back and forth.

### How it works?

`map(value, fromLow, fromHigh, toLow, toHigh)`: Map a number from one range to another. That is, a from-Low value is mapped to toLow, and a fromHigh value is mapped to toHigh.

#### Syntax

`map(value, fromLow, fromHigh, toLow, toHigh)`

#### Parameters

- `value`: the number to map.
- `fromLow`: the lower bound of the value's current range.
- `fromHigh`: the upper bound of the value's current range.
- `toLow`: the lower bound of the value's target range.

- `toHigh`: the upper bound of the value's target range.

If the potentiometer controls the LED, you can also use the `map` to complete the task.

```
int x = analogRead(knob);
int y = map(x,0,1023,0,255);
analogWrite(led,y);
```

### Notes and Warnings

- The “lower bound” of both ranges may be larger or smaller than the “upper bound”, which means that the `map()` function can be used to reverse a range of numbers.

```
y = map(x,0,180,180,0);
```

- Mapping also works well for negative numbers.

```
y = map(x,0,1023,-90,90);
```

- The mapping uses integers, and the decimal places of floats are discarded.

## 4.5.7 5.7 Tone() or noTone()

`Tone()` is used to generate a square wave of the specified frequency (and 50% duty cycle) on a pin. A duration can be specified, otherwise the wave continues until a call to `noTone()`.

In this project, use this two functions to make the passive buzzer vibrate to make sound. Like the active buzzer, the passive buzzer also uses the phenomenon of electromagnetic induction to work. The difference is that a passive buzzer does not have oscillating source, so it will not beep if DC signals are used. But this allows the passive buzzer to adjust its own oscillation frequency and can emit different notes such as “doh, re, mi, fa, sol, la, ti”.

### Required Components

In this project, we need the following components.

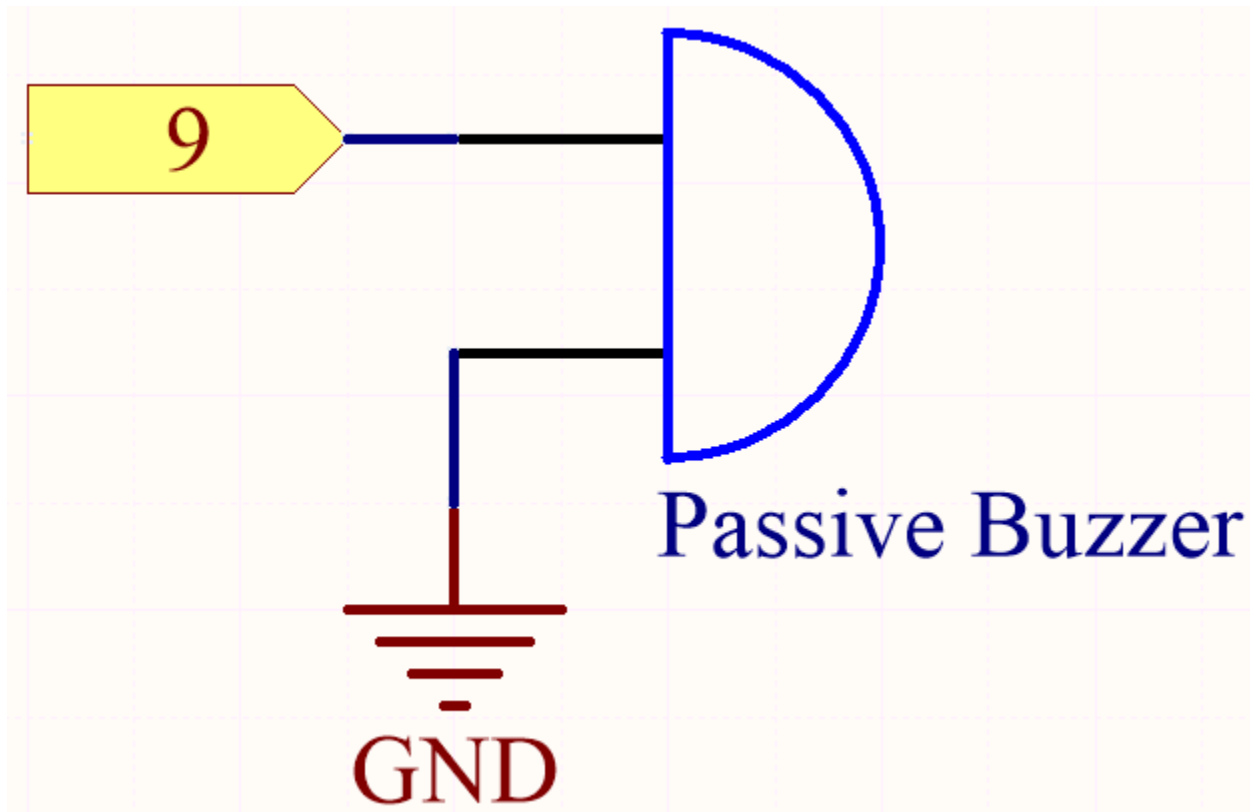
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

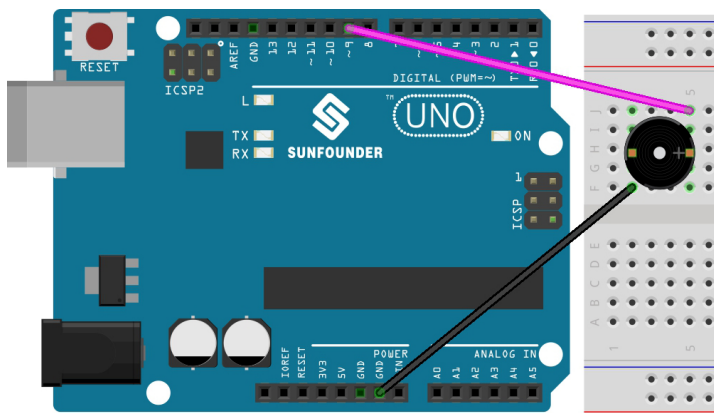
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Buzzer</i>	

### Schematic



Connect the cathode of the Buzzer to GND, and the anode to the digital pin 9.

### Wiring



### Code

#### Note:

- Open the 5.7.tone\_notone.ino file under the path of 3in1-kit/basic\_project/5.7.tone\_notone.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

At the time when you finish uploading the codes to the R3 board, you can hear a melody containing seven notes.

**How it works?**

There are two points needing your attention:

1. `tone()` & `noTone()`: This function is used to control the sound of the passive buzzer directly and its prototype is as follows:

**Syntax**

```
void tone(int pin, unsigned int frequency)
```

```
void tone(int pin, unsigned int frequency, unsigned long duration)
```

**Parameters**

- **pin**: The Arduino pin on which to generate the tone.
- **frequency**: The frequency of the tone in hertz.
- **duration**: The duration of the tone in milliseconds (optional)

Generates a square wave of the specified frequency (and 50% duty cycle) on a pin (so as to make the passive buzzer vibrate to make sound). A duration can be specified, otherwise the wave continues until a call to `noTone()`. The pin can be connected to a piezo buzzer or other speaker to play tones.

Only one tone can be generated at a time. If a tone is already playing on a different pin, the call to `tone()` will have no effect. If the tone is playing on the same pin, the call will set its frequency.

Use of the `tone()` function will interfere with PWM output on pins 3 and 11.

It is not possible to generate tones lower than 31Hz.

**Syntax**

```
void noTone(int pin)
```

**Parameters**

**pin**: The Arduino pin on which to generate the tone.

Stops the generation of a square wave triggered by `tone()`. Has no effect if no tone is being generated.

Having known the two functions, you may grasp the codes—the installation of the array `melody[]` and the array `noteDurations[]` is the preparation of the subsequently several times of calling of the function `tone()` and the changing of tone and duration in the loop for better effect of music play.

2. `pitches.h`: The code uses an extra file, `pitches.h`. This file contains all the pitch values for typical notes. For example, `NOTE_C4` is middle C. `NOTE_FS4` is F sharp, and so forth. This note table was originally written by Brett Hagman, on whose work the `tone()` command was based. You may find it useful whenever you want to make musical notes.

```
#include "pitches.h"
```

---

**Note:** There is already a `pitches.h` file in this sample program. If we put it together with the main code in one folder, the successive steps of installing `pitches.h` can be omitted.

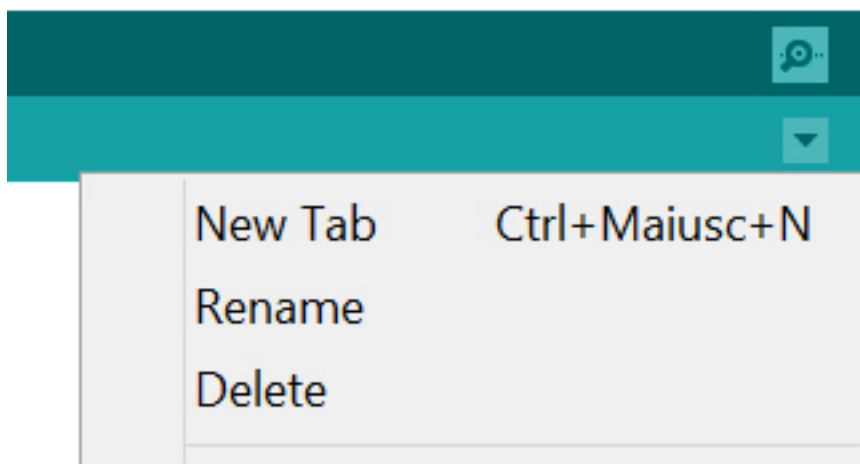
---





After you open the code file, if you cannot open the `pitches.h` code, you can just create one manually. The steps are as follows:

To make the `pitches.h` file, either click on the button just below the serial monitor icon and choose **New Tab**, or use **Ctrl+Shift+N**.



Then paste in the following code and save it as `pitches.h`:

```

/*****
Public Constants
*****/
#define NOTE_B0  31
#define NOTE_C1  33
#define NOTE_CS1 35
#define NOTE_D1  37
#define NOTE_DS1 39
#define NOTE_E1  41
#define NOTE_F1  44
#define NOTE_FS1 46
#define NOTE_G1  49
#define NOTE_GS1 52
#define NOTE_A1  55
#define NOTE_AS1 58
#define NOTE_B1  62
#define NOTE_C2  65
#define NOTE_CS2 69
#define NOTE_D2  73
#define NOTE_DS2 78

```

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```
#define NOTE_E2 82
#define NOTE_F2 87
#define NOTE_FS2 93
#define NOTE_G2 98
#define NOTE_GS2 104
#define NOTE_A2 110
#define NOTE_AS2 117
#define NOTE_B2 123
#define NOTE_C3 131
#define NOTE_CS3 139
#define NOTE_D3 147
#define NOTE_DS3 156
#define NOTE_E3 165
#define NOTE_F3 175
#define NOTE_FS3 185
#define NOTE_G3 196
#define NOTE_GS3 208
#define NOTE_A3 220
#define NOTE_AS3 233
#define NOTE_B3 247
#define NOTE_C4 262
#define NOTE_CS4 277
#define NOTE_D4 294
#define NOTE_DS4 311
#define NOTE_E4 330
#define NOTE_F4 349
#define NOTE_FS4 370
#define NOTE_G4 392
#define NOTE_GS4 415
#define NOTE_A4 440
#define NOTE_AS4 466
#define NOTE_B4 494
#define NOTE_C5 523
#define NOTE_CS5 554
#define NOTE_D5 587
#define NOTE_DS5 622
#define NOTE_E5 659
#define NOTE_F5 698
#define NOTE_FS5 740
#define NOTE_G5 784
#define NOTE_GS5 831
#define NOTE_A5 880
#define NOTE_AS5 932
#define NOTE_B5 988
#define NOTE_C6 1047
#define NOTE_CS6 1109
#define NOTE_D6 1175
#define NOTE_DS6 1245
#define NOTE_E6 1319
#define NOTE_F6 1397
#define NOTE_FS6 1480
#define NOTE_G6 1568
```

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```

#define NOTE_GS6 1661
#define NOTE_A6 1760
#define NOTE_AS6 1865
#define NOTE_B6 1976
#define NOTE_C7 2093
#define NOTE_CS7 2217
#define NOTE_D7 2349
#define NOTE_DS7 2489
#define NOTE_E7 2637
#define NOTE_F7 2794
#define NOTE_FS7 2960
#define NOTE_G7 3136
#define NOTE_GS7 3322
#define NOTE_A7 3520
#define NOTE_AS7 3729
#define NOTE_B7 3951
#define NOTE_C8 4186
#define NOTE_CS8 4435
#define NOTE_D8 4699
#define NOTE_DS8 49

```

#### 4.5.8 5.8 User-defined Function

In c, we can divide a large program into the basic building blocks known as function. The function contains the set of programming statements enclosed by { }. A function can be called multiple times to provide reusability and modularity to the C program. In other words, we can say that the collection of functions creates a program. The function is also known as procedure or subroutine in other programming languages.

There are the following advantages of functions.

- By using functions, we can avoid rewriting same logic/code again and again in a program.
- We can call C functions any number of times in a program and from any place in a program.
- We can track a large C program easily when it is divided into multiple functions.
- Reusability is the main achievement of C functions.
- However, Function calling is always a overhead in a C program.

There are two types of functions in C programming:

- **Library Functions:** the functions which are declared in the C header files.
- **User-defined functions:** the functions which are created by the C programmer, so that he/she can use it many times. It reduces the complexity of a big program and optimizes the code.

In this project, define a function to read the value of the ultrasonic module.

#### Required Components

In this project, we need the following components.

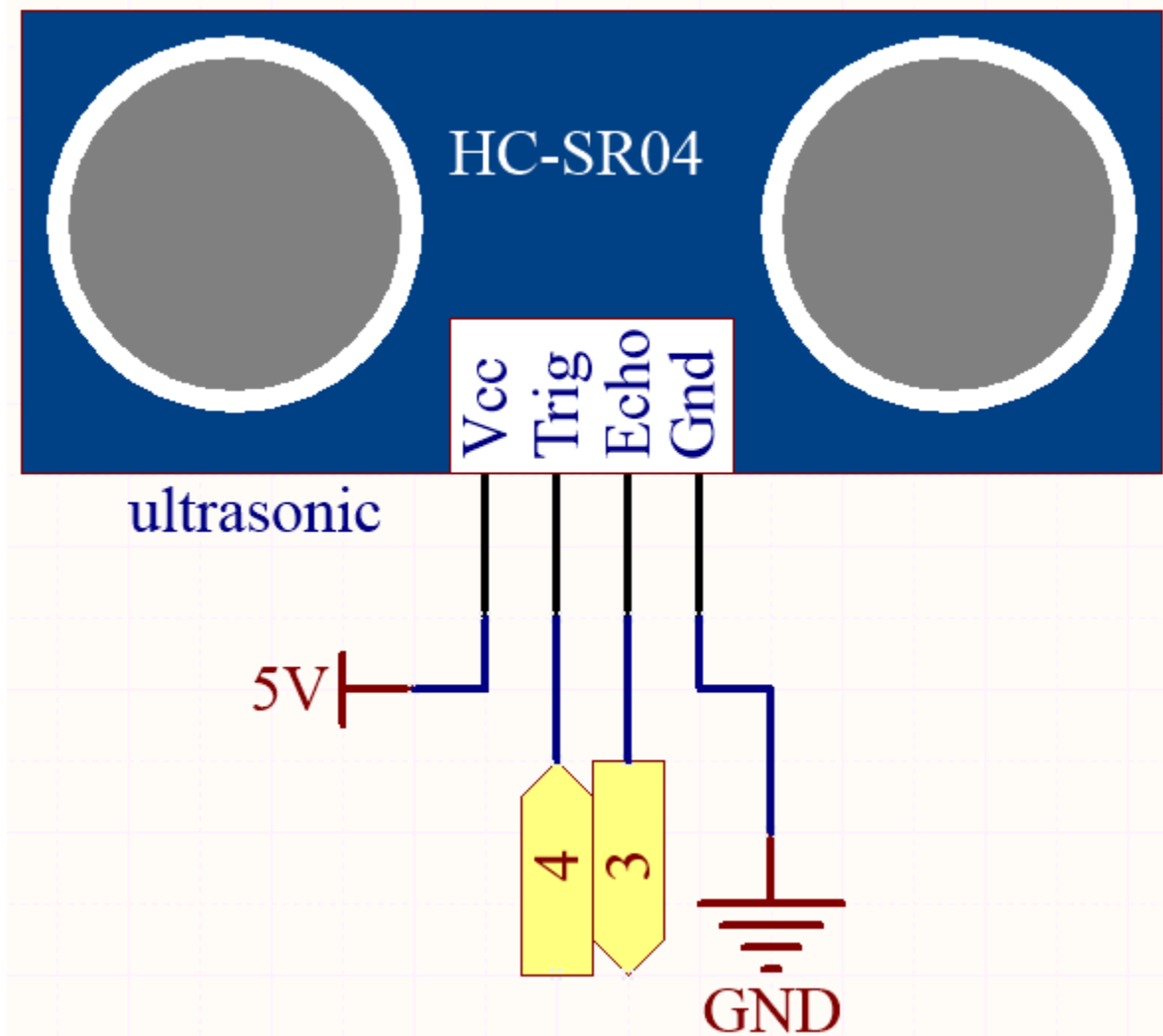
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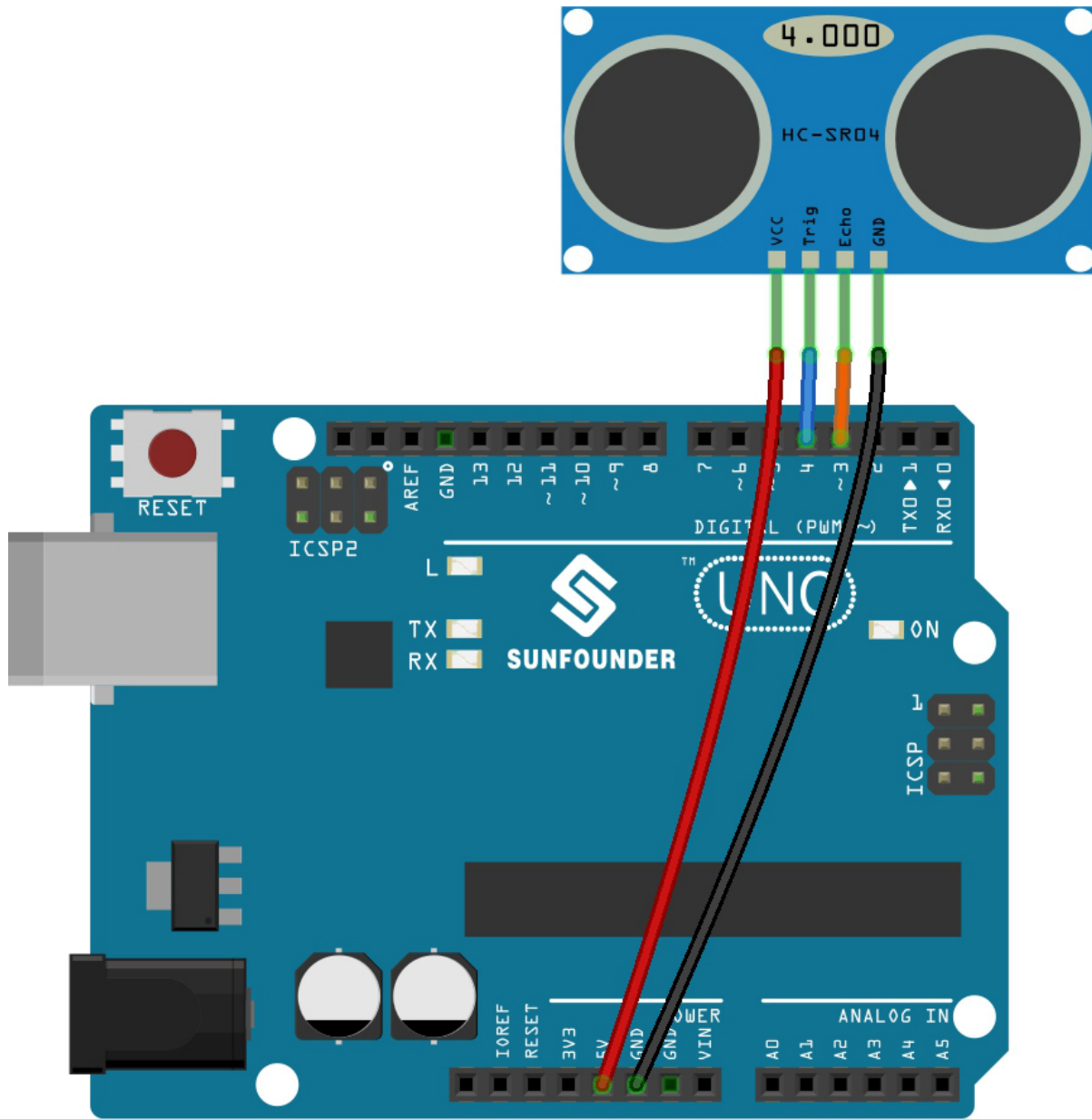
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>Ultrasonic Module</i>	

### Schematic



### Wiring



### Code

#### Note:

- Open the `5.8.user_function.ino` file under the path of `3in1-kit\basic_project\5.8.user_function`.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

After the code is successfully uploaded, the serial monitor will print out the distance between the ultrasonic sensor and the obstacle ahead.

#### How it works?

About the application of ultrasonic sensor, we can directly check the subfunction.

```
float readSensorData(){// ...}
```

The trigPin of the ultrasonic module transmits a 10us square wave signal every 2us

```
digitalWrite(trigPin, LOW);  
delayMicroseconds(2);  
digitalWrite(trigPin, HIGH);  
delayMicroseconds(10);  
digitalWrite(trigPin, LOW);
```

The echoPin receives a high level signal if there is an obstacle within the range and use the pulseIn() function to record the time from sending to receiving.

```
microsecond=pulseIn(echoPin, HIGH);
```

The speed of sound is 340 m/s or 29 microseconds per centimeter.

This gives the distance travelled by the square wave, outbound and return, so we divide by 2 to get the distance of the obstacle.

```
float distance = microsecond / 29.00 / 2;
```

Note that the ultrasonic sensor will pause the program when it is working, which may cause some lagging when writing complex projects.

### 4.5.9 5.9 ShiftOut(LED)

shiftOut() will make 74HC595 output 8 digital signals. It outputs the last bit of the binary number to Q0, and the output of the first bit to Q7. In other words, writing the binary number “00000001” will make Q0 output high level and Q1~Q7 output low level.

In this project, you will learn how to use 74HC595. 74HC595 consists of an 8bit shift register and a storage register with threestate parallel outputs. It converts serial input into parallel output so you can save IO ports of an MCU.

Specifically, 74hc595 can replace 8 pins for digital signal output by writing an 8-bit binary number.

- [Binary number - Wikipedia](#)

#### **Required Components**

In this project, we need the following components.

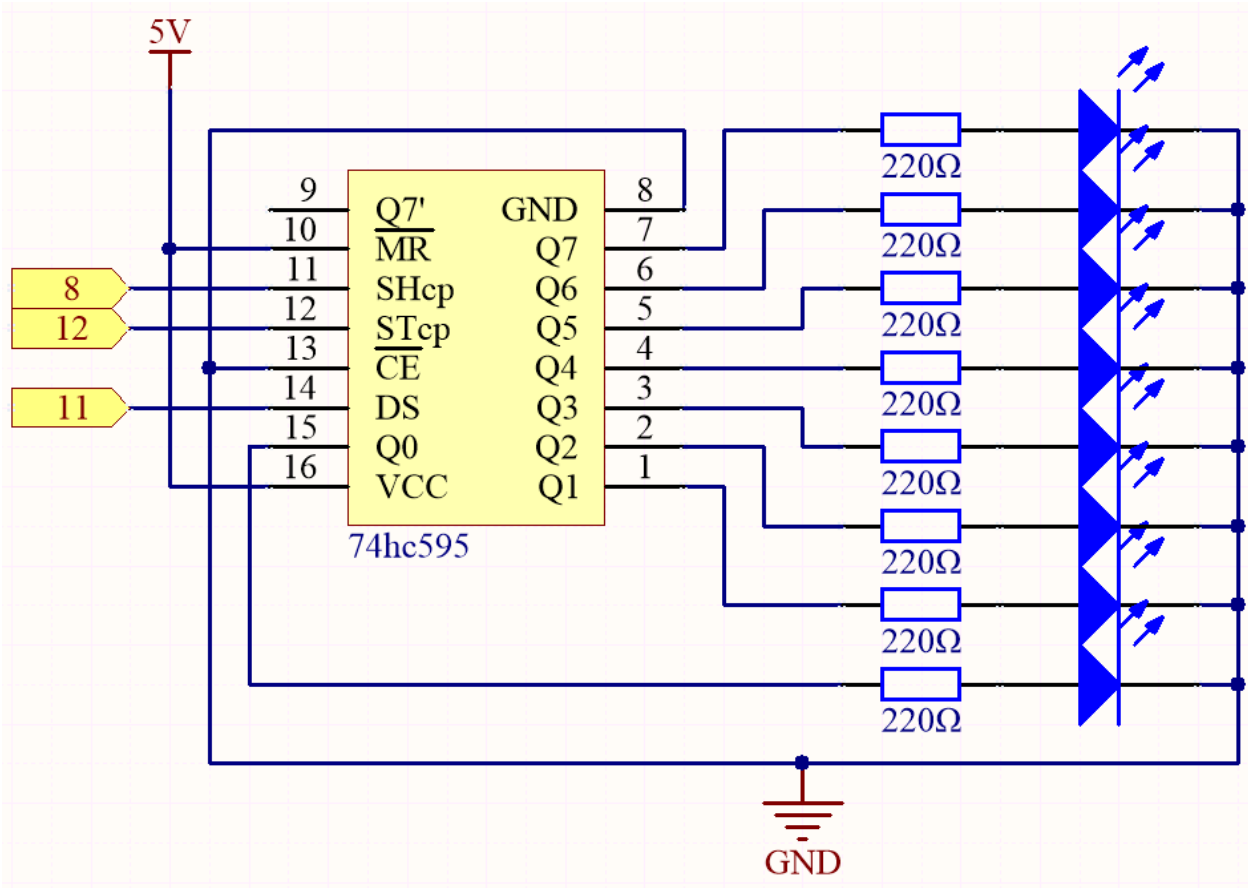
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

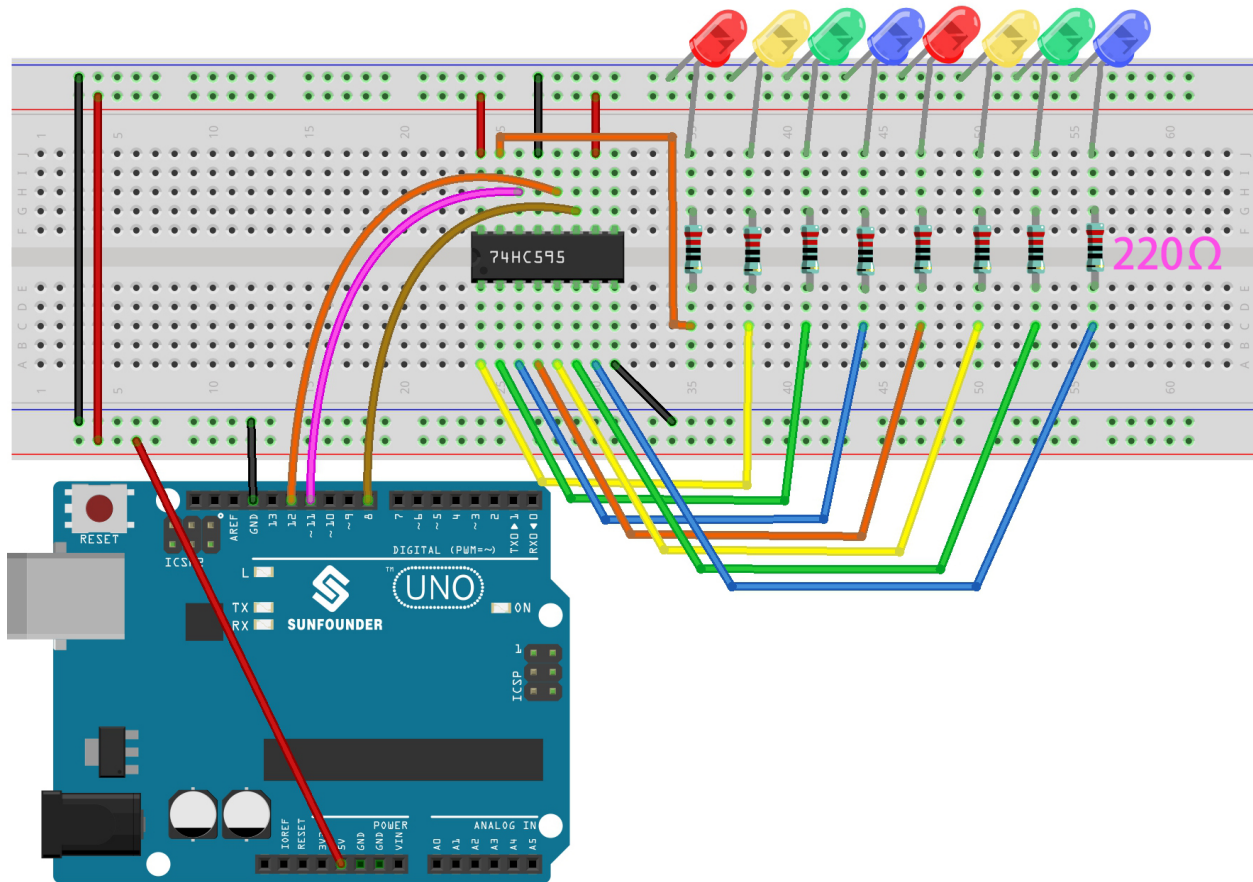
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>LED</i>	
<i>74HC595</i>	

### Schematic



- When MR (pin10) is high level and OE (pin13) is low level, data is input in the rising edge of SHcp and goes to the memory register through the rising edge of SHcp.
- If the two clocks are connected together, the shift register is always one pulse earlier than the memory register.
- There is a serial shift input pin (Ds), a serial output pin (Q) and an asynchronous reset button (low level) in the memory register.
- The memory register outputs a Bus with a parallel 8-bit and in three states.
- When OE is enabled (low level), the data in memory register is output to the bus(Q0 ~ Q7).

## Wiring



## Code

## Note:

- Open the 5.9.shiftout\_led.ino file under the path of 3in1-kit\basic\_project\5.9.shiftout\_led.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

When you finish uploading the codes to the R3 board, you can see the LEDs turning on one after another.

## How it works?

Declare an array, store several 8 bit binary numbers that are used to change the working state of the eight LEDs controlled by 74HC595.

```
int dataArray[] = {B00000000, B00000001, B00000011, B00000111, B00001111, B00011111, B00111111, B01111111, B11111111};
```

Set STcp to low level first and then high level. It will generate a rising edge pulse of STcp.

```
digitalWrite(STcp, LOW);
```

shiftOut() is used to shift out a byte of data one bit at a time, which means to shift a byte of data in dataArray[num] to the shifting register with the DS pin. **MSBFIRST** means to move from high bits.



```
shiftOut(DS, SHcp, MSBFIRST, dataArray[num]);
```

After `digitalWrite(STcp, HIGH)` is run, the `STcp` will be at the rising edge. At this time, the data in the shift register will be moved to the memory register.

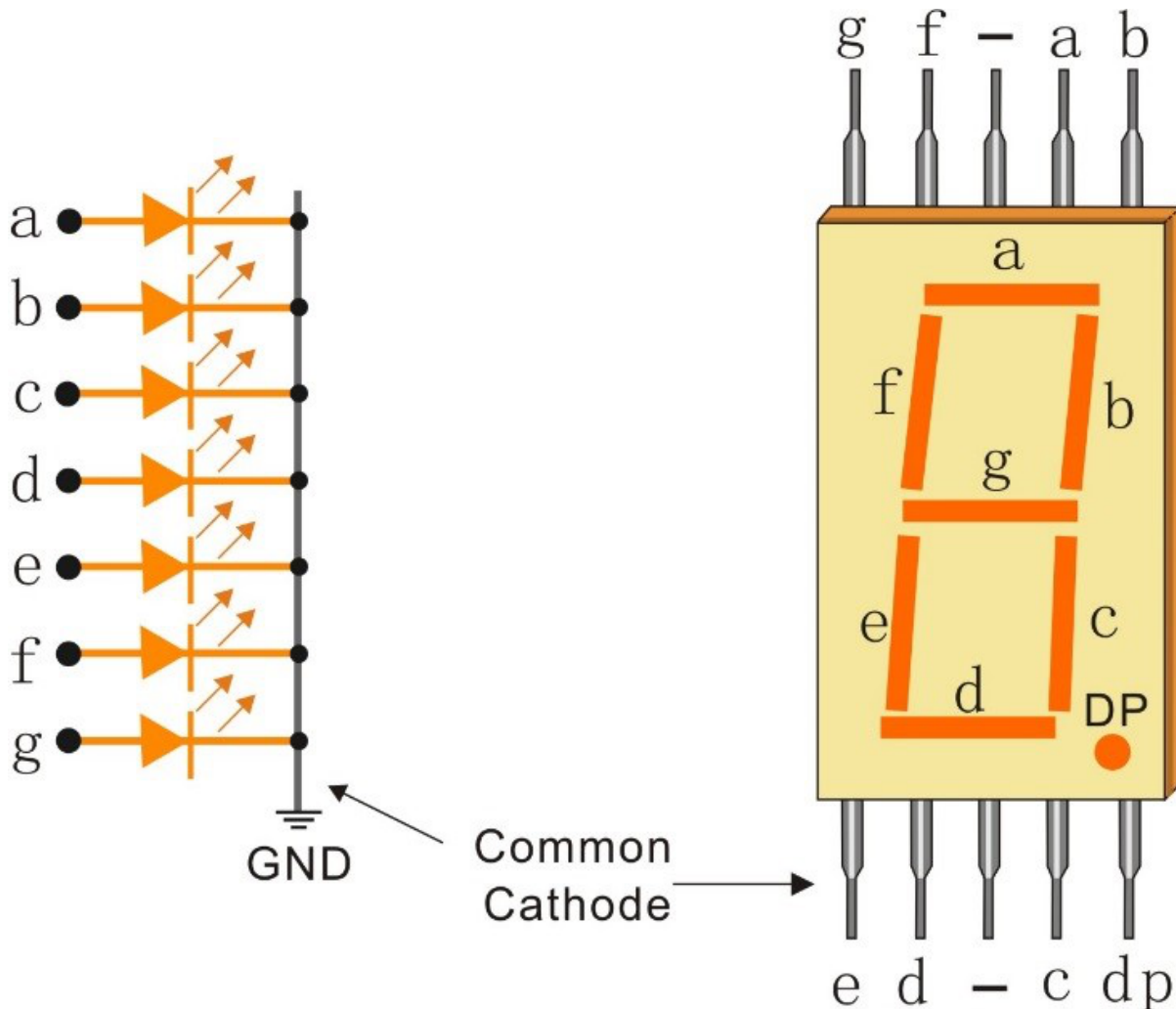
```
digitalWrite(STcp, HIGH);
```

A byte of data will be transferred into the memory register after 8 times. Then the data of memory register are output to the bus (Q0-Q7). For example, shiftout `B00000001` will light up the LED controlled by Q0 and turn off the LED controlled by Q1~Q7.

#### 4.5.10 5.10 ShiftOut(Segment Display)

Previously, we used the `shiftout()` function to light up eight LEDs; here we use it to display 0-9 on the 7-segment Display.

The 7-segment Display is essentially a device packaged by 8 LEDs, of which 7 strip-shaped LEDs form an “8” shape, and there is a slightly smaller dotted LED as a decimal point. These LEDs are marked as a, b, c, d, e, f, g, and dp. They have their own anode pins and share cathodes. Their pin locations are shown in the figure below.



#### Required Components

In this project, we need the following components.

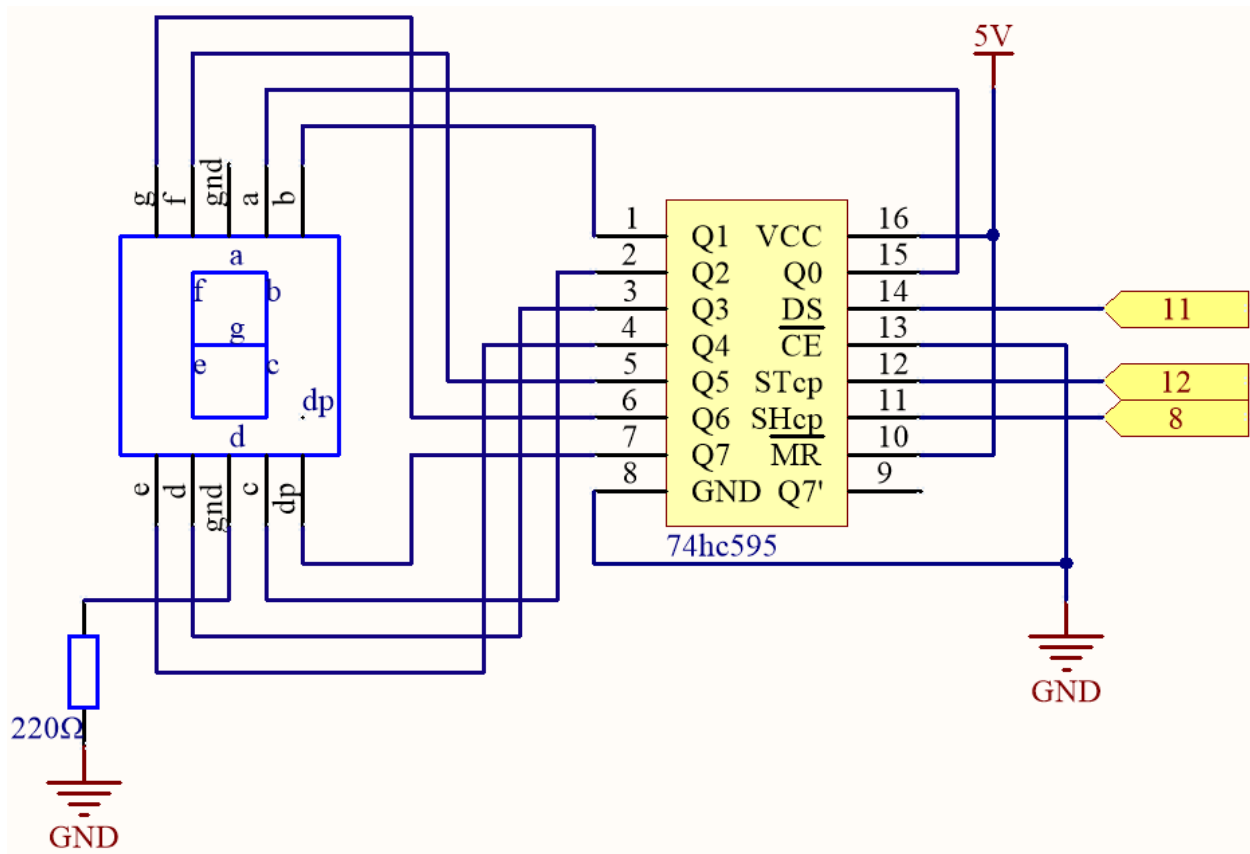
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>7-segment Display</i>	
<i>74HC595</i>	

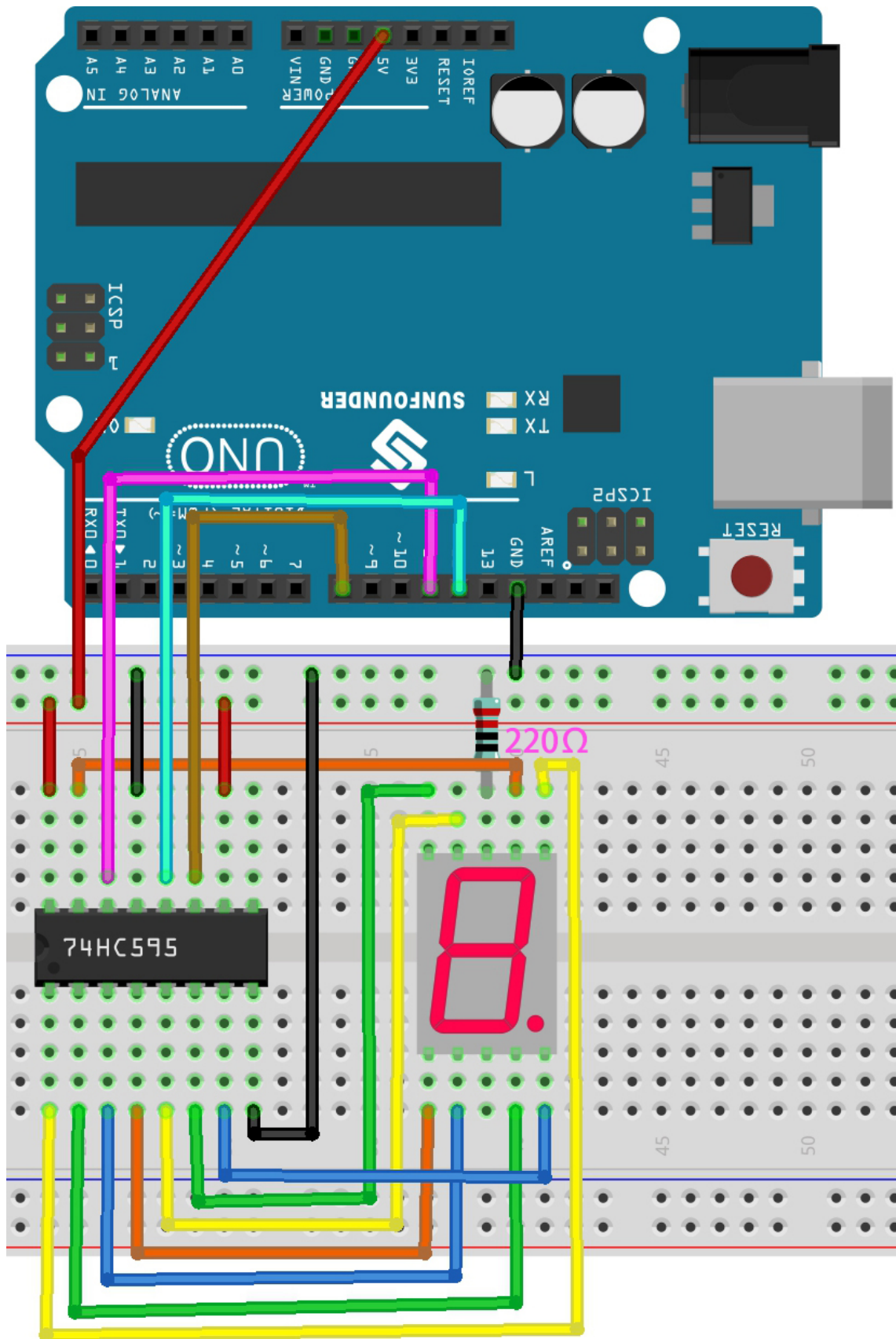
### Schematic



## Wiring

Table 1: Wiring

74HC595	LED Segment Display
Q0	a
Q1	b
Q2	c
Q3	d
Q4	e
Q5	f
Q6	g
Q7	dp



---

## Code

---

### Note:

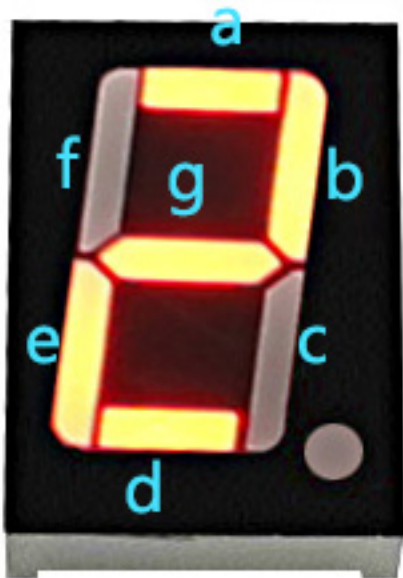
- Open the 5.10.shiftout\_segment.ino file under the path of 3in1-kit\basic\_project\5.10.shiftout\_segment.
  - Or copy this code into **Arduino IDE**.
  - Or upload the code through the [Arduino Web Editor](#).
- 

After the code is uploaded successfully, you will be able to see the LED Segment Display display 0~9 in sequence.

### How it works?

shiftOut() will make 74HC595 output 8 digital signals. It outputs the last bit of the binary number to Q0, and the output of the first bit to Q7. In other words, writing the binary number “00000001” will make Q0 output high level and Q1~Q7 output low level.

Suppose that the 7-segment Display display the number “2”, we need to write a high level for a, b, d, e and g, and write a low level for c, f and dp. That is, the binary number ” 01011011” needs to be written. For readability, we will use hexadecimal notation as “0x5b”.



- [Hexadecimal](#)
- [BinaryHex Converter](#)

Similarly, we can also make the 7-Segment Display display other numbers in the same way. The following table shows the codes corresponding to these numbers.

Table 2: Glyph Code

Numbers	Binary Code	Hex Code
0	00111111	0x3f
1	00000110	0x06
2	01011011	0x5b
3	01001111	0x4f
4	01100110	0x66
5	01101101	0x6d
6	01111101	0x7d
7	00000111	0x07
8	01111111	0x7f
9	01101111	0x6f

Write these codes into `shiftOut()` to make the LED Segment Display display the corresponding numbers.

#### 4.5.11 5.11 Install External Libraries

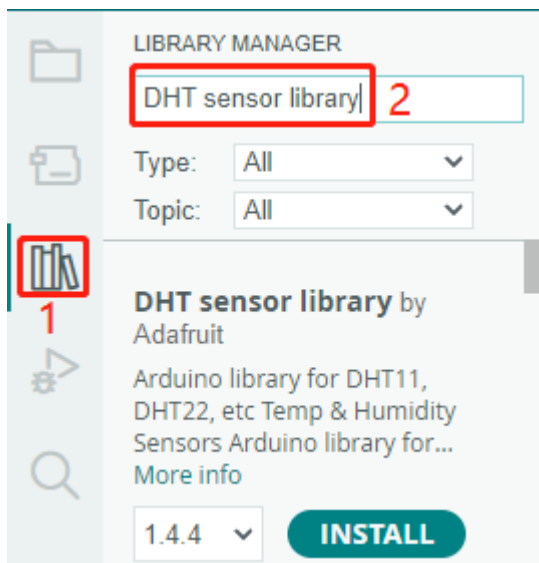
A library is a collection of pre-written code or functions that extend the capabilities of the Arduino IDE. Libraries provide ready-to-use code for various functionalities, allowing you to save time and effort in coding complex features.

There are two main ways to install libraries:

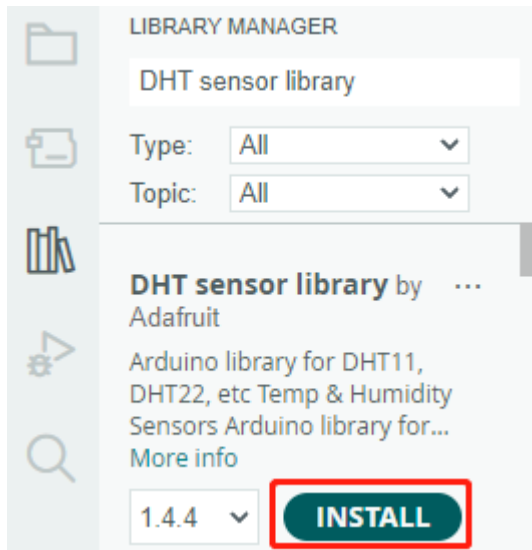
Many libraries are available directly through the Arduino **Library Manager**. You can access the **Library Manager** by following these steps:

1. In the **Library Manager**, you can search for the desired library by name or browse through different categories.

**Note:** In projects where library installation is required, there will be prompts indicating which libraries to install. Follow the instructions provided, such as “The DHT sensor library is used here, you can install it from the **Library Manager**.” Simply install the recommended libraries as prompted.



2. Once you find the library you want to install, click on it and then click the **Install** button.



3. The Arduino IDE will automatically download and install the library for you.

### Related Components

Below are the related components, you can click in to learn how to use them.

#### 5.11.1 Liquid Crystal Display

An I2C LCD1602 is composed of an LCD1602 and an I2C module, LCD1602 can be used to display characters, numbers, etc., but need to take up a lot of pins of the main control, after configuring an I2C module, only 2 I/O pins are needed to drive this LCD1602.

Now look at how to make this I2C CDL1602 work.

### Required Components

In this project, we need the following components.

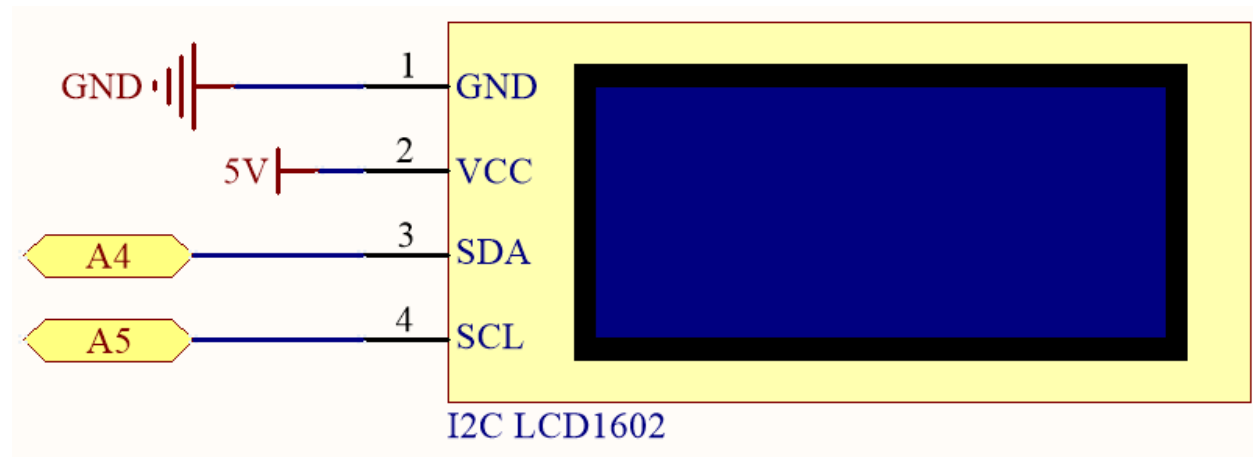
It's definitely convenient to buy a whole kit, here's the link:

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3 in 1 Starter Kit	380+	

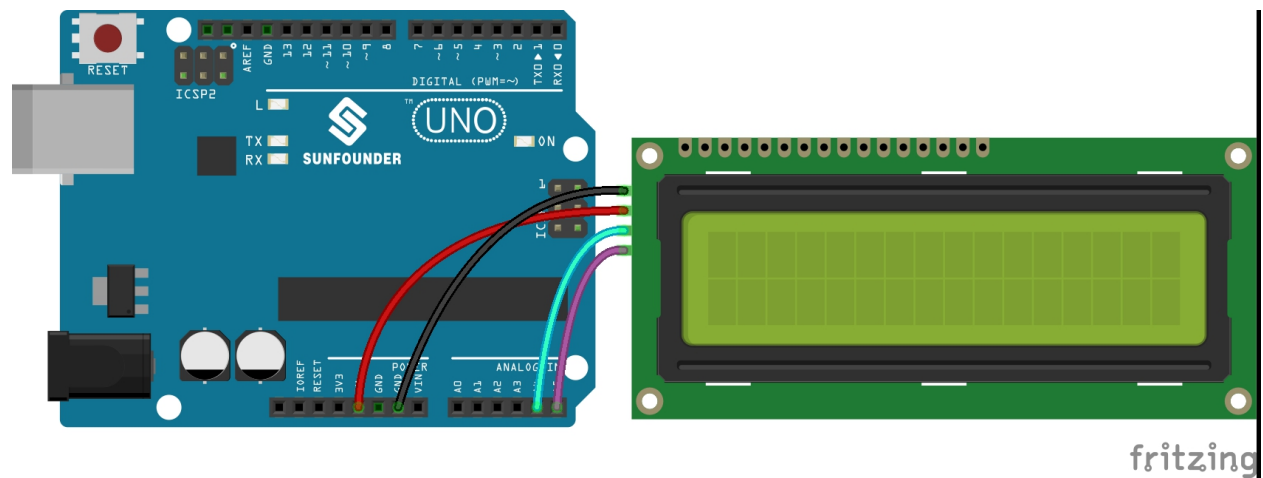
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>I2C LCD1602</i>	

### Schematic



### Wiring



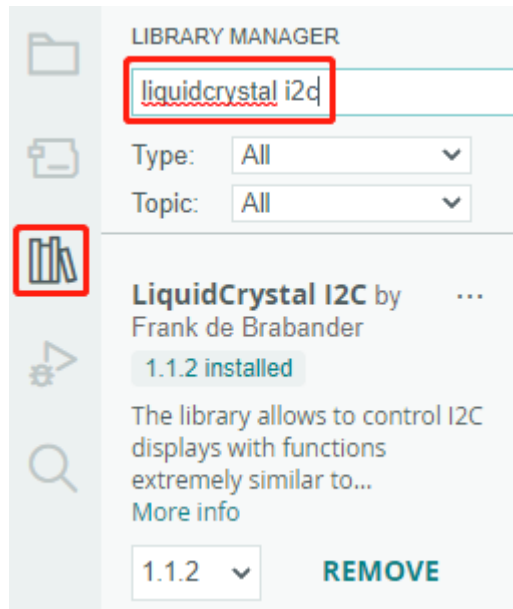
**Note:** The SDA and SCL of the R3 board are the pins A4 and A5.

### Code

#### Note:

- Open the 5.11.liquid\_crystal\_display.ino file under the path of 3in1-kit\basic\_project\5.11.liquid\_crystal\_display.
- Or copy this code into **Arduino IDE**.
- The LiquidCrystal I2C library is used here, you can install it from the **Library Manager**.





After the code is uploaded successfully, you will see “SunFounder”, “Hello World” on the I2C LCD1602.

**Note:** If the code and wiring are fine, but the LCD still does not display content, you can turn the potentiometer on the back.

### How it works?

By calling the library `LiquidCrystal_I2C.h`, you can easily drive the LCD.

```
#include "LiquidCrystal_I2C.h"
```

Library Functions

```
LiquidCrystal_I2C(uint8_t lcd_Addr,uint8_t lcd_cols,uint8_t lcd_rows)
```

Creates a new instance of the `LiquidCrystal_I2C` class that represents a particular LCD attached to your Arduino board.

- `lcd_Addr`: The address of the LCD defaults to 0x27.
- `lcd_cols`: The LCD1602 has 16 columns.
- `lcd_rows`: The LCD1602 has 2 rows.

```
void init()
```

Initialize the lcd.

```
void backlight()
```

Turn the (optional) backlight on.

```
void nobacklight()
```

Turn the (optional) backlight off.

```
void display()
```

Turn the LCD display on.

```
void nodisplay()
```

Turn the LCD display off quickly.

```
void clear()
```

Clear display, set cursor position to zero.

```
void setCursor(uint8_t col, uint8_t row)
```

Set the cursor position to col,row.

```
void print(data, BASE)
```

Prints text to the LCD.

- **data:** The data to print (char, byte, int, long, or string).
- **BASE (optional):** The base in which to print numbers: BIN for binary (base 2), DEC for decimal (base 10), OCT for octal (base 8), HEX for hexadecimal (base 16).

### 5.11.2 IR Receiver

In this project, you will learn to use IR Receiver.

An infrared-receiver is a component which receives infrared signals and can independently receive infrared rays and output signals compatible with TTL level. It is similar with a normal plastic-packaged transistor in size and is suitable for all kinds of infrared remote control and infrared transmission.

#### Required Components

In this project, we need the following components.

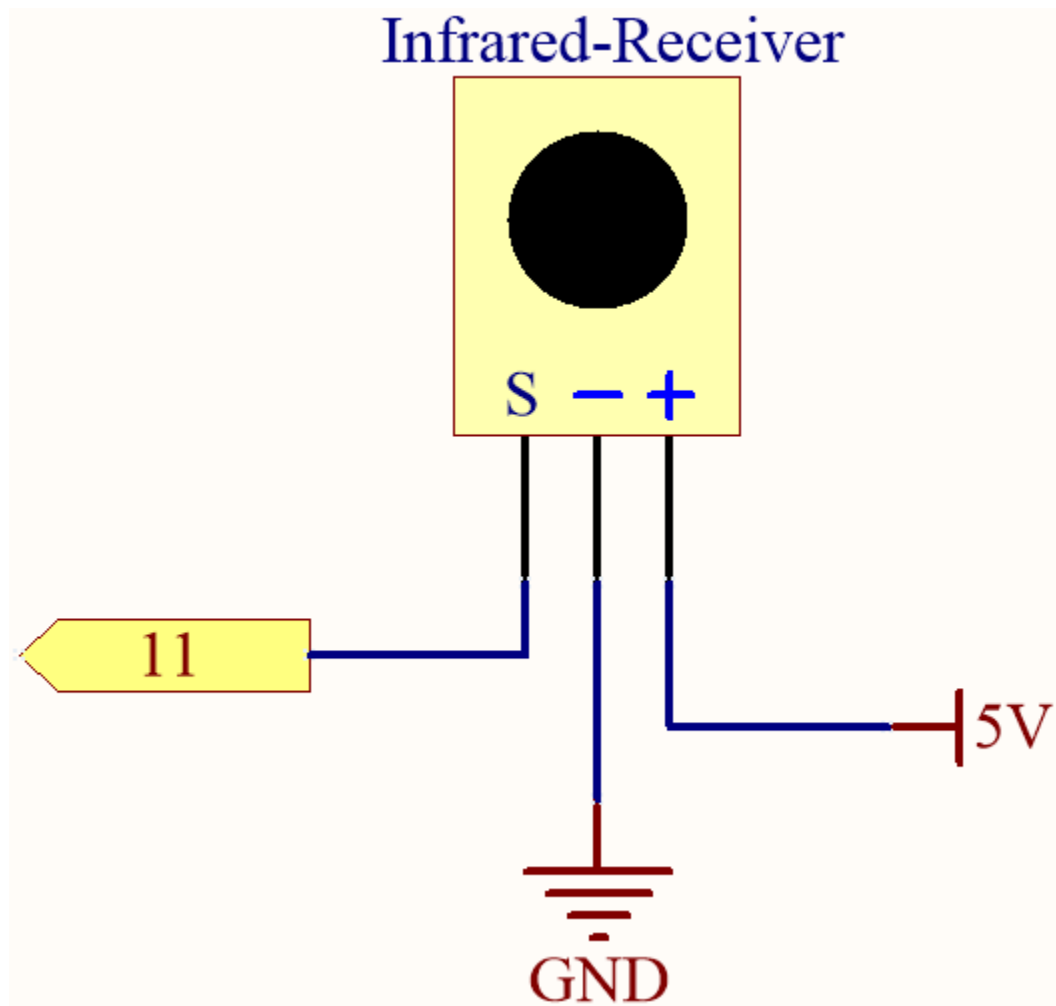
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

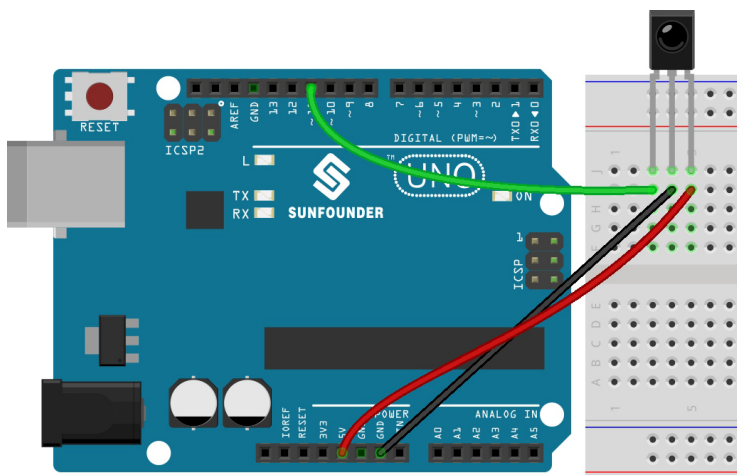
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>IR Receiver</i>	-

#### Schematic



### Wiring

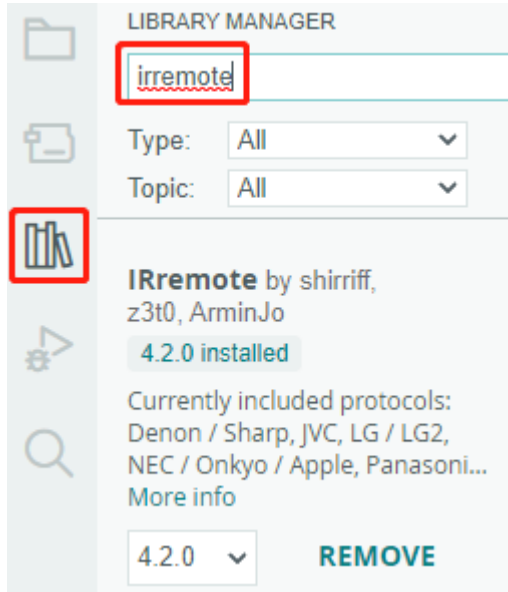
In this example, we wire up the left pin of IR Receiver to pin 11, the middle pin to GND, and the right pin to 5V.



### Code

**Note:**

- Open the 5.11.ir\_receiver.ino file under the path of 3in1-kit\basic\_project\5.11.ir\_receiver.
- Or copy this code into **Arduino IDE**.
- The IRremote library is used here, you can install it from the **Library Manager**.



After uploading the codes to the R3 board, you can see that the current value of the pressed button of IR Remote Controller displays on the serial monitor.

**How it works?**

This code is designed to work with an infrared (IR) remote control using the IRremote library. Here's the breakdown:

1. Include Libraries: This includes the IRremote library, which provides functions to work with IR remote controls.

```
#include <IRremote.h>
```

2. Defines the Arduino pin to which the IR sensor's signal pin.

```
const int IR_RECEIVE_PIN = 11; // Define the pin number for the IR Sensor
```

3. Initializes serial communication at a baud rate of 9600. Initializes the IR receiver on the specified pin (IR\_RECEIVE\_PIN) and enables LED feedback (if applicable).

```
void setup() {  
    Serial.begin(9600); // Start serial  
    ↪communication at 9600 baud rate  
    IrReceiver.begin(IR_RECEIVE_PIN, ENABLE_LED_FEEDBACK); // Start the IR  
    ↪receiver  
}
```

4. The loop runs continuously to process incoming IR remote signals.

```

void loop() {
  if (IrReceiver.decode()) {
    String decodedValue = decodeKeyValue(IrReceiver.decodedIRData.
    ←command);
    if (decodedValue != "ERROR") {
      Serial.println(decodedValue);
      delay(100);
    }
    IrReceiver.resume(); // Enable receiving of the next value
  }
}

```

- Checks if an IR signal is received and successfully decoded.
- Decodes the IR command and stores it in decodedValue using a custom decodeKeyValue() function.
- Checks if the decoded value is not an error.
- Prints the decoded IR value to the serial monitor.
- Resumes IR signal reception for the next signal.

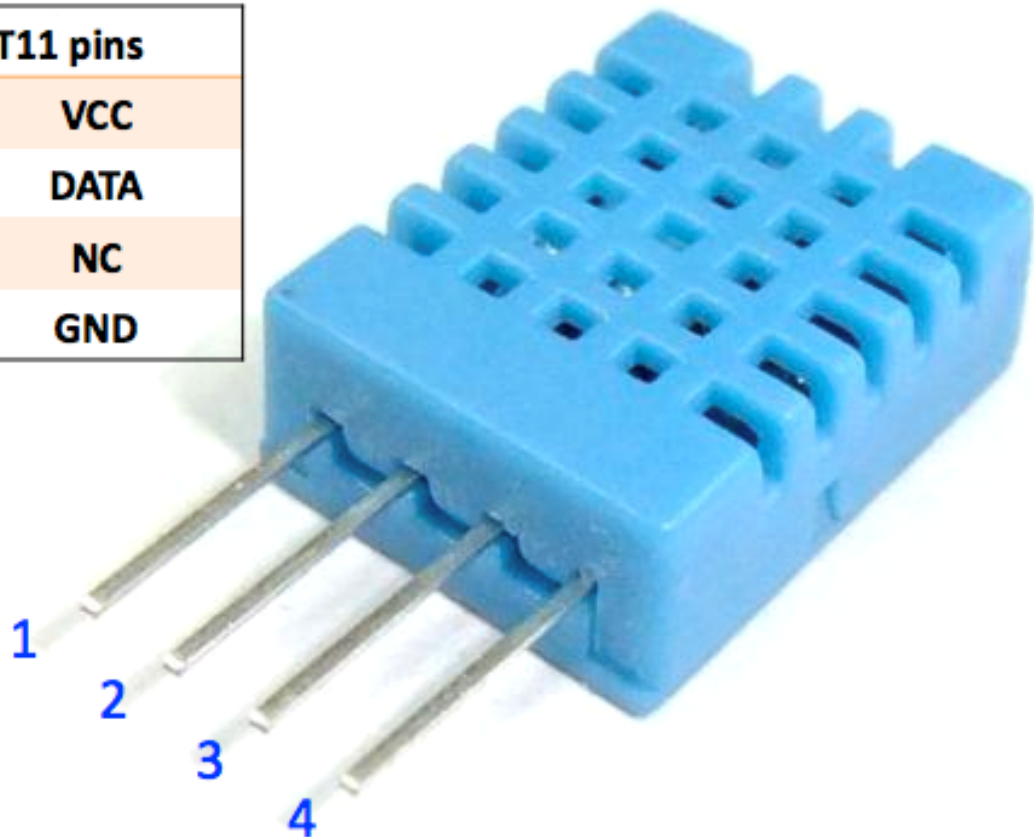
### 5.11.3 Temperature - Humidity

Humidity and temperature are closely related from the physical quantity itself to the actual people's life. The temperature and humidity of human environment will directly affect the thermoregulatory function and heat transfer effect of human body. It will further affect the thinking activity and mental state, thus affecting the efficiency of our study and work.

Temperature is one of the seven basic physical quantities in the International System of Units, which is used to measure the degree of hot and cold of an object. Celsius is one of the more widely used temperature scales in the world, expressed by the symbol "°C".

Humidity is the concentration of water vapor present in the air. The relative humidity of air is commonly used in life and is expressed in %RH. Relative humidity is closely related to temperature. For a certain volume of sealed gas, the higher the temperature, the lower the relative humidity, and the lower the temperature, the higher the relative humidity.

DHT11 pins	
1	VCC
2	DATA
3	NC
4	GND



The dht11, a digital temperature and humidity sensor, is provided in this kit. It uses a capacitive humidity sensor and thermistor to measure the surrounding air and outputs a digital signal on the data pin.

### Required Components

In this project, we need the following components.

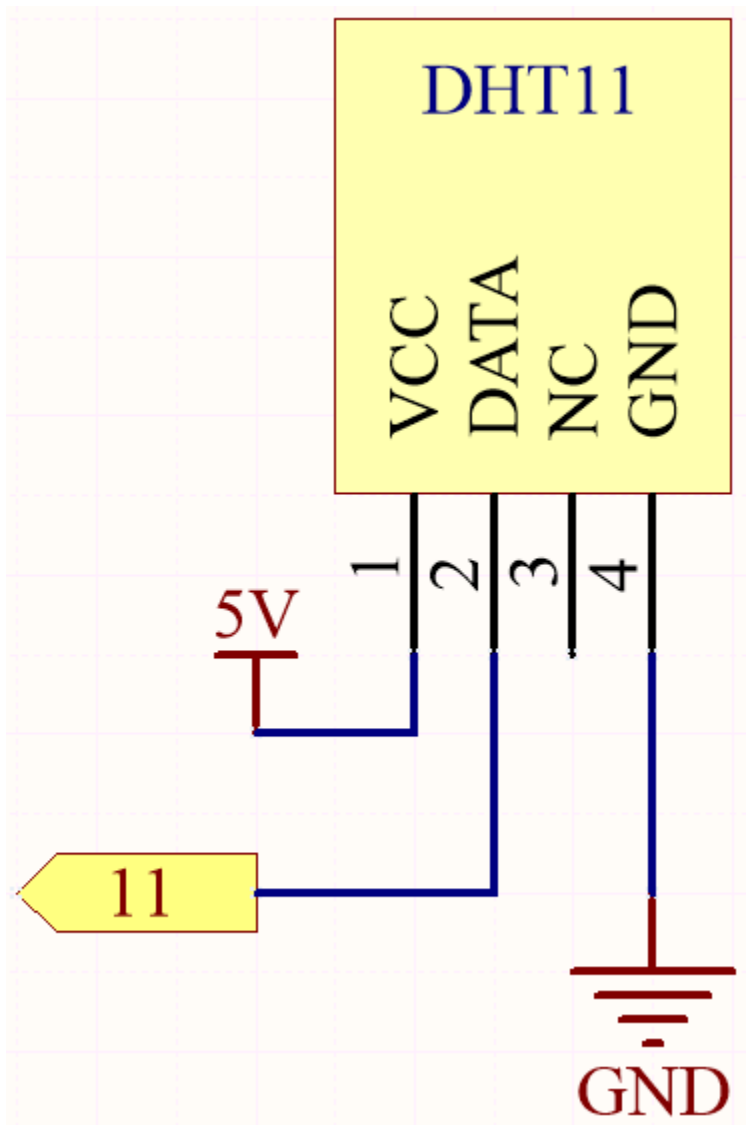
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

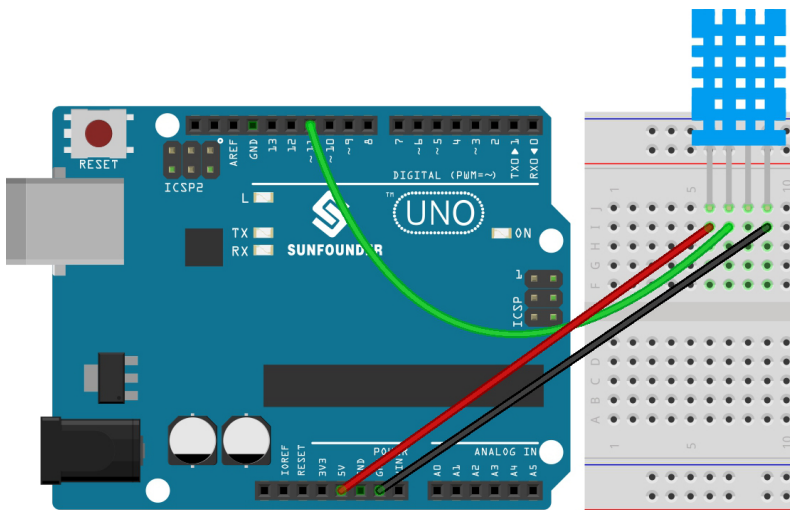
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>DHT11 Humiture Sensor</i>	-

### Schematic



### Wiring

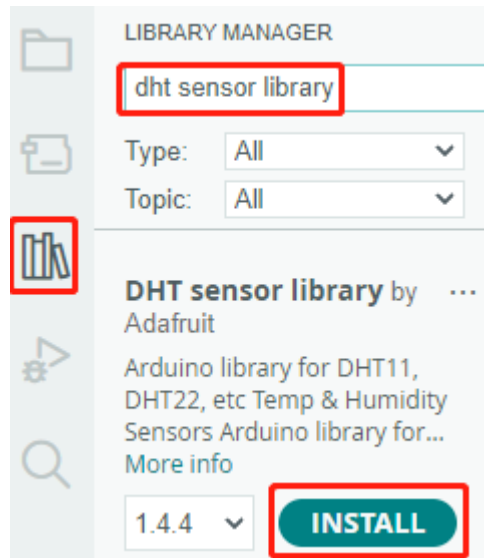


## Code

---

### Note:

- Open the 5.11.temperature\_humidity.ino file under the path of 3in1-kit\basic\_project\5.11.temperature\_humidity.
- Or copy this code into **Arduino IDE**.
- The DHT sensor library is used here, you can install it from the **Library Manager**.



After the code is uploaded successfully, you will see the Serial Monitor continuously print out the temperature and humidity, and as the program runs steadily, these two values will become more and more accurate.

### How it works?

1. Includes the DHT.h library, which provides functions to interact with the DHT sensors. Then, set the pin and type for the DHT sensor.

```
#include "DHT.h"

#define DHTPIN 11 // Set the pin connected to the DHT11 data pin
#define DHTTYPE DHT11 // DHT 11

DHT dht(DHTPIN, DHTTYPE);
```

2. Initializes serial communication at a baud rate of 115200 and initializes the DHT sensor.

```
void setup() {
  Serial.begin(115200);
  Serial.println("DHT11 test!");
  dht.begin();
}
```

3. In the loop() function, read temperature and humidity values from the DHT11 sensor, and print them to the serial monitor.



```

void loop() {
    // Wait a few seconds between measurements.
    delay(2000);

    // Reading temperature or humidity takes about 250 milliseconds!
    // Sensor readings may also be up to 2 seconds 'old' (it's a very slow
    ↪sensor)
    float humidity = dht.readHumidity();
    // Read temperature as Celsius (the default)
    float temperture = dht.readTemperature();

    // Check if any reads failed and exit early (to try again).
    if (isnan(humidity) || isnan(temperture)) {
        Serial.println("Failed to read from DHT sensor!");
        return;
    }
    // Print the humidity and temperature
    Serial.print("Humidity: ");
    Serial.print(humidity);
    Serial.print(" %\t");
    Serial.print("Temperature: ");
    Serial.print(temperture);
    Serial.println(" *C");
}

```

- The `dht.readHumidity()` function is called to read the humidity value from the DHT sensor.
- The `dht.readTemperature()` function is called to read the temperature value from the DHT sensor.
- The `isnan()` function is used to check if the readings are valid. If either the humidity or temperature value is NaN (not a number), it indicates a failed reading from the sensor, and an error message is printed.

#### 4.5.12 5.12 Serial Read

You may have noticed this when using the `Serial.print()` function. Since there is printing, is there reading? What is the text box on the Serial Monitor used for? Yes, you guessed it, there are ways to control programs and circuits by entering information through the text box on the Serial Monitor.

In this project, we will use the I2C LCD1602 to display the text entered in the Serial Monitor in order to experience the usage of `Serial.read()`.

##### Required Components

In this project, we need the following components.

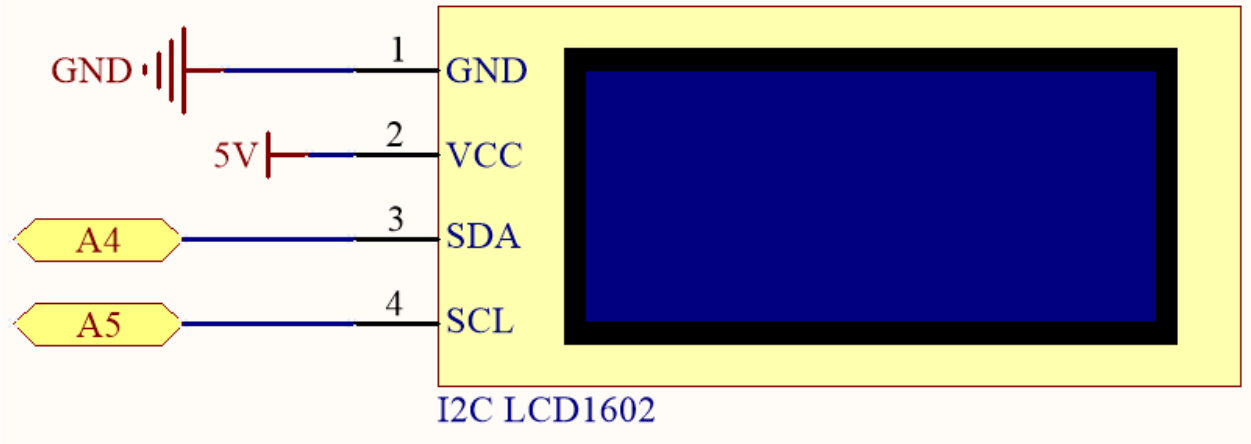
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Name	ITEMS IN THIS KIT	LINK
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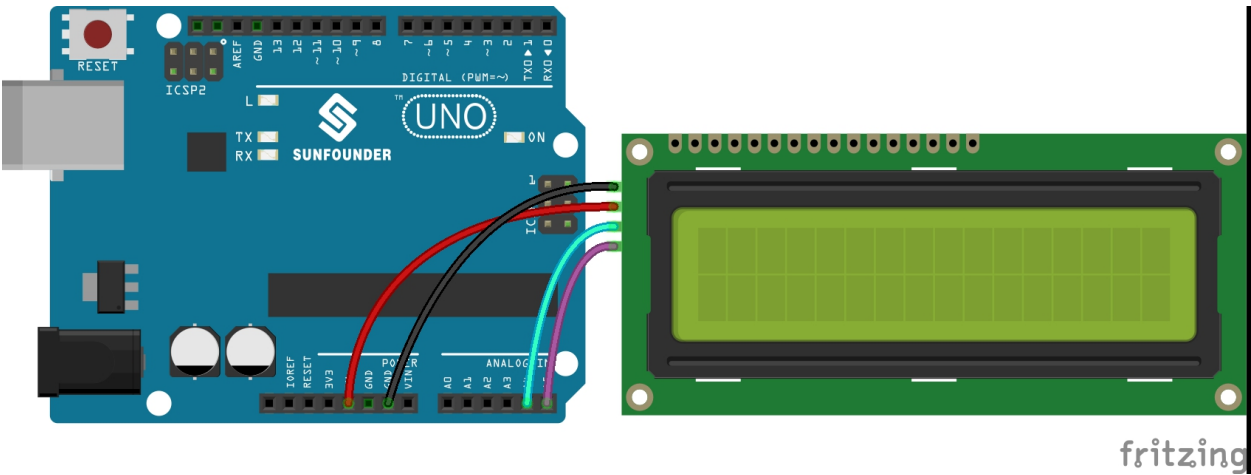
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>I2C LCD1602</i>	

Schematic



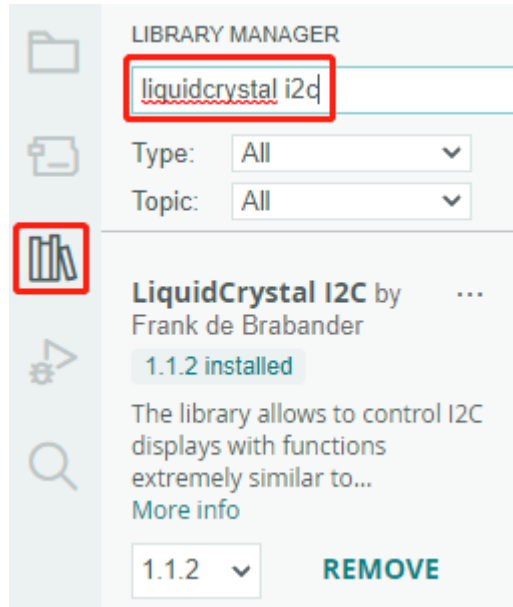
Wiring



Code

Note:

- Open the 5.12.serial\_read.ino file under the path of 3in1-kit\basic\_project\5.12.serial\_read.
- Or copy this code into **Arduino IDE**.
- The LiquidCrystal I2C library is used here, you can install it from the **Library Manager**.



After the code is uploaded successfully, you can enter text in the text box on the serial monitor, and the LCD will display the information.

#### How it works?

```
void loop()
{
  // when characters arrive over the serial port...
  if (Serial.available()) {
    // wait a bit for the entire message to arrive
    delay(100);
    // clear the screen
    lcd.clear();
    // read all the available characters
    while (Serial.available() > 0) {
      // display each character to the LCD
      lcd.write(Serial.read());
    }
  }
}
```

- `Serial.available()` can get the number of characters available in the incoming stream when you type something from the textbox. Since there are two terminators in the input, you actually have 3 characters when you type A, and 4 characters when you type AB.
- `Serial.read()` will take the first character from the incoming stream. For example, if you typed AB, calling `Serial.read()` only once, will get the character A; The second call, you will get B; the third and fourth call, you will get two end symbols; calling this function when the input stream has no characters available will result in an error.

To sum up, it is common to combine the above two, using a `while` loop to read all characters entered each time.

```
while (Serial.available() > 0) {
  Serial.print(Serial.read());
}
```

By the way, if you don't use `Serial.read()` to get characters from the incoming stream, the characters from the incoming stream will be stacked together. For example, if you type A followed by AB, the incoming stream will accumulate 7 characters.

### 4.5.13 5.13 Interrupt

If you use some `delay()` in a project that uses sensors, you may find that when you trigger these sensors, the program may have no effect. This is because the delay statement will cause the program to suspend, and the program will not be able to obtain the signal sent by the sensor to the main control board.

In this case, interrupt can be used. Interrupt allows the program not to miss a pulse.

In this chapter, we use the active buzzer and buttons to experience the process of using interrupt.

In the `loop()` function, `delay(1000)` is used to count seconds. Put the button to control the buzzer into the ISR, so that it will not be disturbed by the delay and complete the task smoothly.

---

**Note:** ISRs are special kinds of functions that have some unique limitations most other functions do not have. An ISR cannot have any parameters, and they shouldn't return anything. Generally, an ISR should be as short and fast as possible. If your sketch uses multiple ISRs, only one can run at a time, other interrupts will be executed after the current one finishes in an order that depends on the priority they have.

---

#### Required Components

In this project, we need the following components.

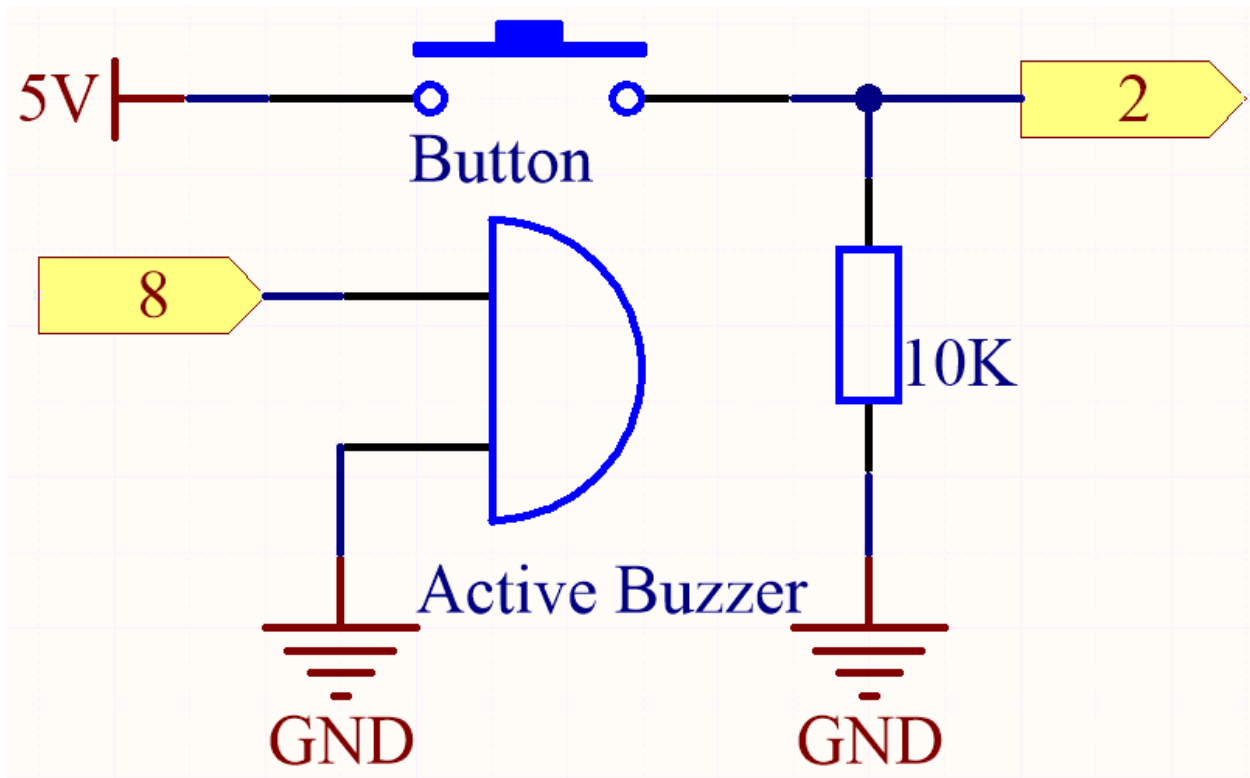
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Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

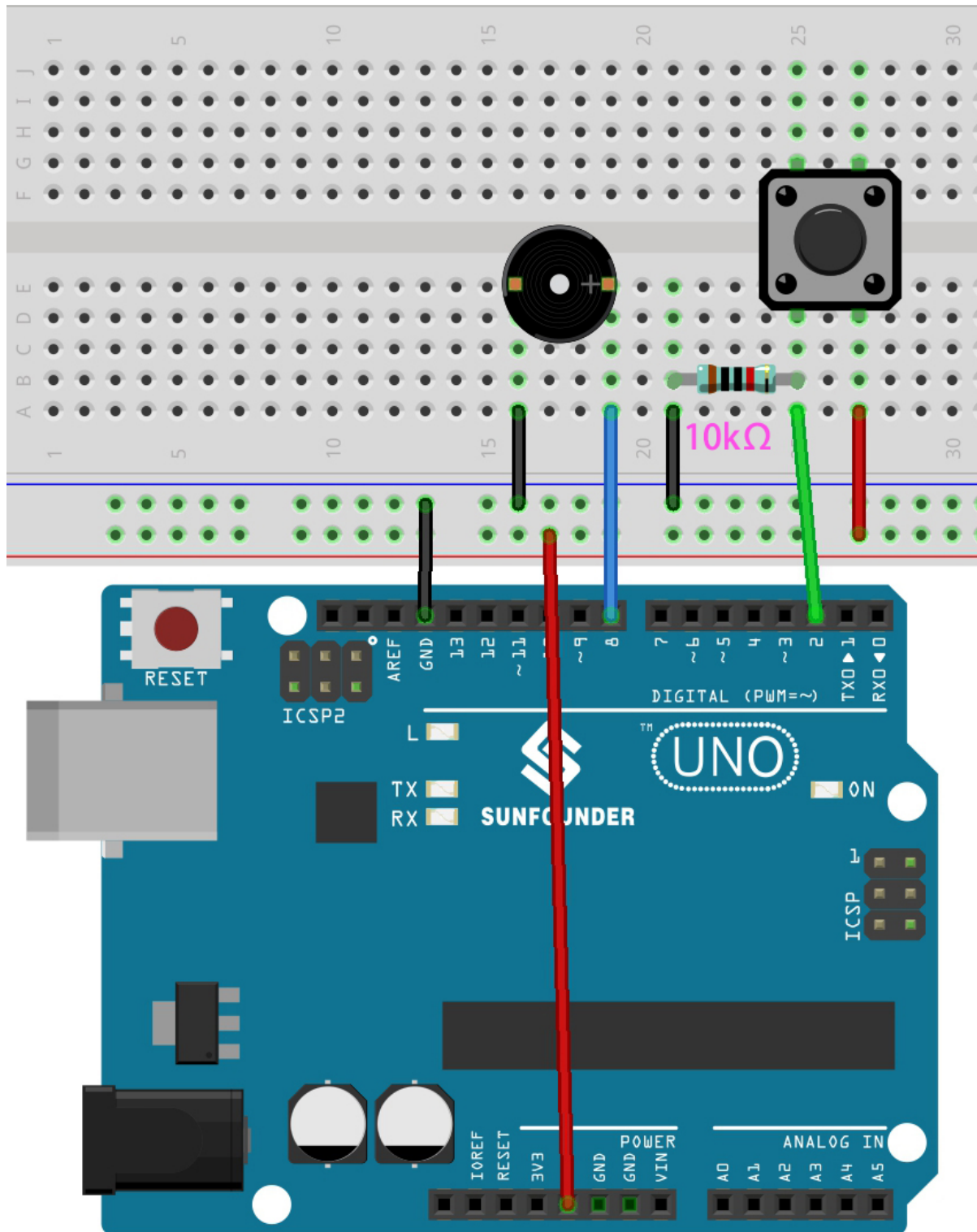
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Button</i>	
<i>Buzzer</i>	-

#### Schematic



Wiring



## Code

### Note:

- Open the `5.13.interrupt.ino` file under the path of `3in1-kit/basic_project/5.13.interrupt`.

- Or copy this code into **Arduino IDE**.
  - Or upload the code through the [Arduino Web Editor](#).
- 

After the code is successfully uploaded, turn on the Serial Monitor and you will see an auto-incrementing number printed out every second. If you press the button, the buzzer will sound. The button-controlled buzzer function and the timing function do not conflict with each other.

#### How it works?

- `attachInterrupt(digitalPinToInterrupt(pin), ISR, mode)`: Add an interrupt.

##### Syntax

```
attachInterrupt(digitalPinToInterrupt(pin), ISR, mode)
```

##### Parameters

- `pin`: the Arduino pin number. You should use `digitalPinToInterrupt(pin)` to convert the actual digital pin to a specific interrupt number. For example, if you connect to pin 3, use its `digitalPinToInterrupt(3)` as the first parameter.
- `ISR`: the ISR to call when the interrupt occurs; this function must take no parameters and return nothing. This function is sometimes referred to as an interrupt service routine.
- `mode`: defines when the interrupt should be triggered. Four constants are predefined as valid values:
  - \* `LOW` to trigger the interrupt whenever the pin is low,
  - \* `CHANGE` to trigger the interrupt whenever the pin changes value.
  - \* `RISING` to trigger when the pin goes from low to high.
  - \* `FALLING` for when the pin goes from high to low.

---

**Note:** Different main control boards can use interrupt pins differently. On R3 board, only pin 2 and pin 3 can use interrupt.

---

## 4.5.14 5.14 Calibration

When you use analog input components, such as photoresistors, soil moisture sensors, etc., you may find that their reading range is not 0 to 1023, but rather a range like 0 to 800 or 600 to 1000, because it is impossible to reach the limits of these devices with normal use.

In this case, a technique for calibrating the sensor inputs can be used. During startup, have the control board measure the sensor readings for five seconds and record the highest and lowest readings. This five-second reading defines the minimum and maximum expected values of the readings taken during the cycle.

In this project, we use a photoresistor and a passive buzzer to implement a [theremin](#) -like game using the calibration technique described above.

---

**Note:** The [theremin](#) is an electronic musical instrument that requires no physical contact. It generates different tones by sensing the position of the player's hands.

---

#### Required Components

In this project, we need the following components.

## SunFounder 3in1 Kit

---

It's definitely convenient to buy a whole kit, here's the link:

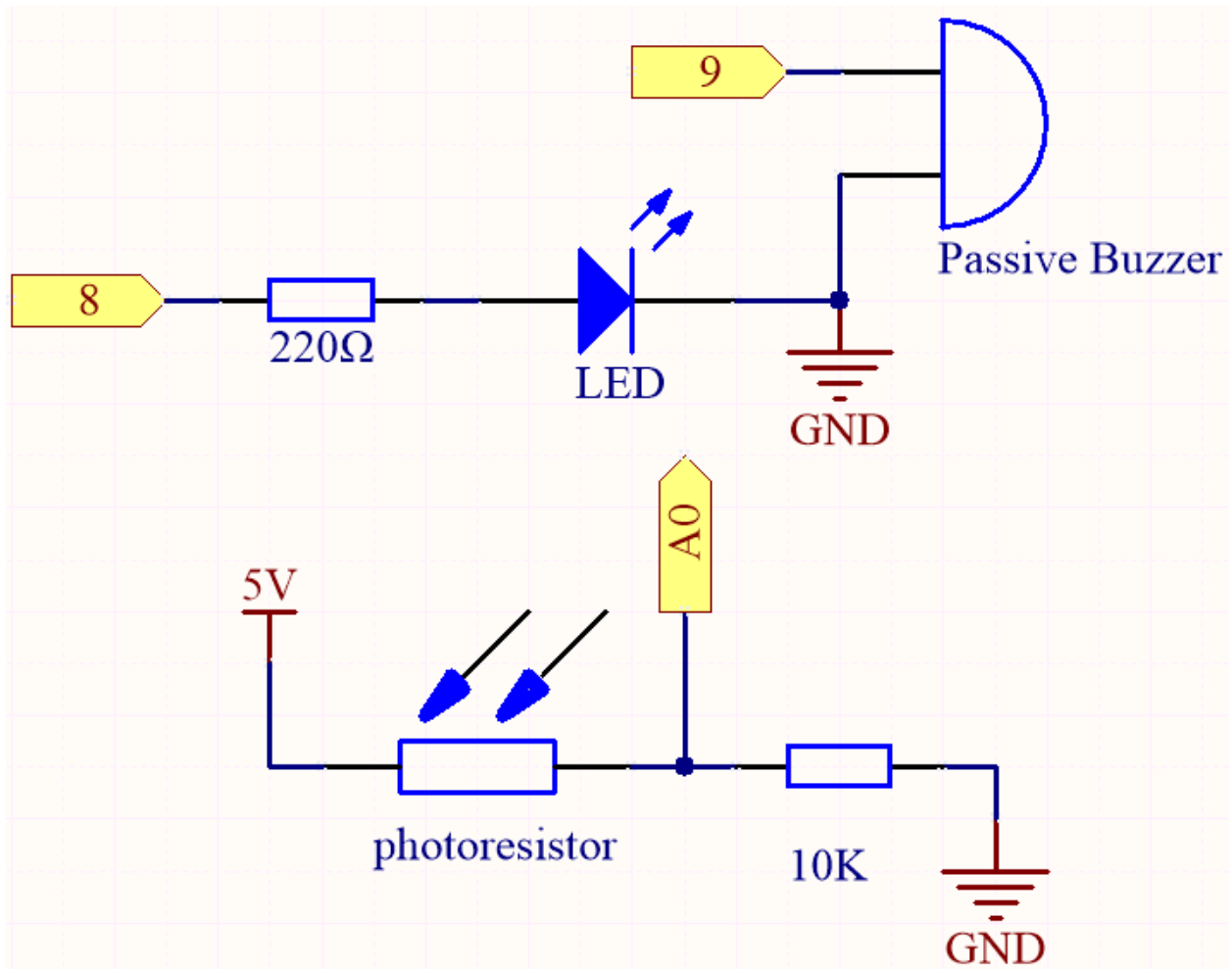
Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

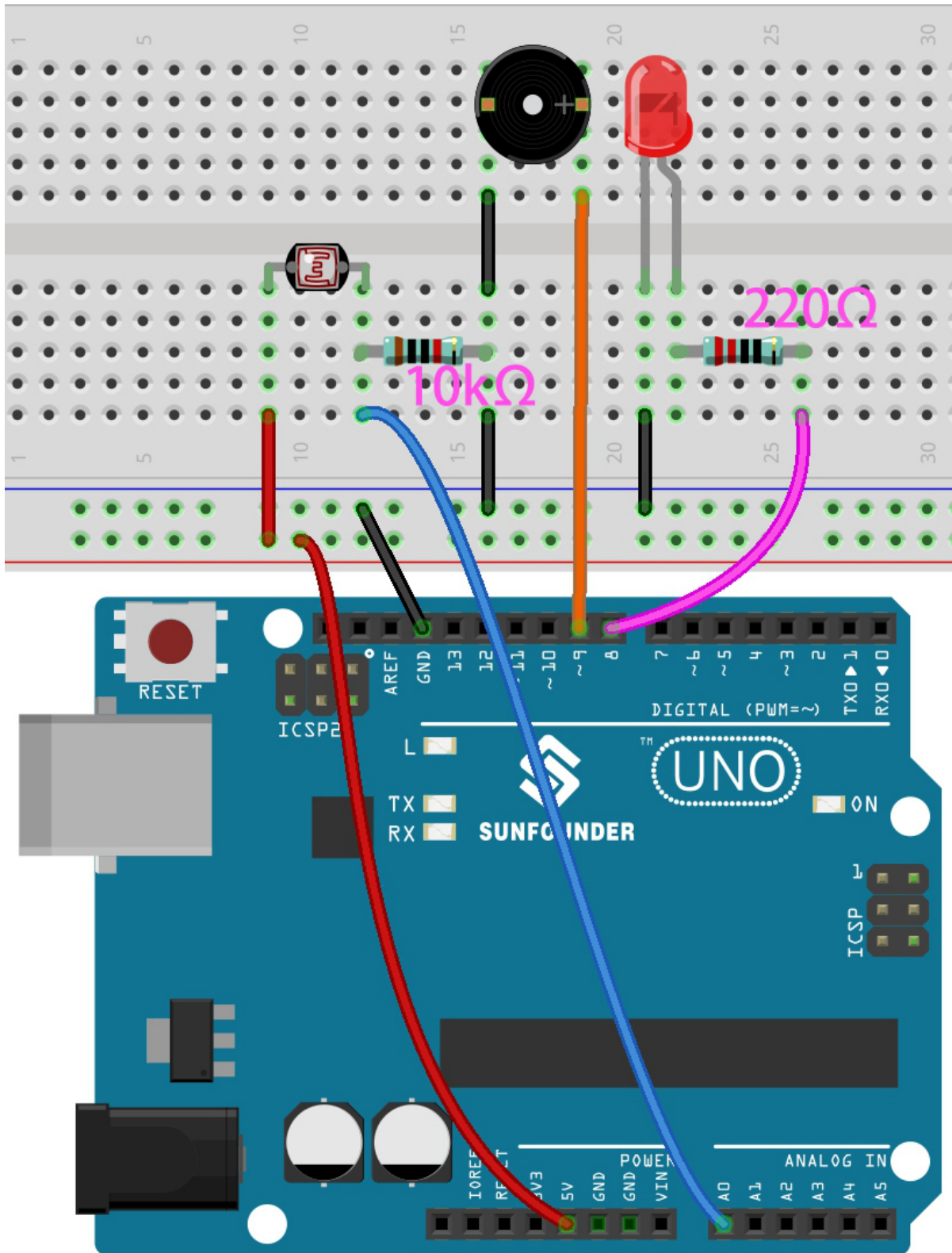
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Buzzer</i>	
<i>LED</i>	
<i>Photoresistor</i>	

## Schematic





Wiring



Code

Note:

- Open the 5.14.calibration.ino file under the path of 3in1-kit\basic\_project\5.14.calibration.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

After the code is uploaded successfully, the LED will light up, and we will have 5 seconds to calibrate the detection range of the photoresistor. This is because we may be in a different light environment each time we use it (e.g. the light intensity is different between midday and dusk).

At this time, we need to swing our hands up and down on top of the photoresistor, and the movement range of the hand will be calibrated to the playing range of this instrument.

After 5 seconds, the LED will go out and we can wave our hands on the photoresistor to play.

#### How it works?

1. Set the initial values and pins of all components.

```
const int buzzerPin = 9;
const int ledPin = 8;
const int photocellPin = A0; //photoresistor attach to A2

int lightLow = 1023;
int lightHigh = 0;

int sensorValue = 0; // value read from the sensor
int pitch = 0; // sensor value converted into LED 'bars'

unsigned long previousMillis = 0;
const long interval = 5000;
```

2. Set up a calibration process in setup().

```
void setup()
{
  pinMode(buzzerPin, OUTPUT); // make all the LED pins outputs
  pinMode(ledPin, OUTPUT); // make the LED pin output

  /* calibrate the photoresistor max & min values */
  previousMillis = millis();
  digitalWrite(ledPin, HIGH);
  while (millis() - previousMillis <= interval) {
    sensorValue = analogRead(photocellPin);
    if (sensorValue > lightHigh) {
      lightHigh = sensorValue;
    }
    if (sensorValue < lightLow) {
      lightLow = sensorValue;
    }
  }
  digitalWrite(ledPin, LOW);
}
```

The work flow is as follows.

- using `millis()` for timing with an interval of 5000ms.

```
previousMillis = millis();
...
while (millis() - previousMillis <= interval) {
...
}
```

- During these five seconds, wave a hand around the photoresistor, the maximum and minimum values of the detected light are recorded and assigned to `lightHigh` and `lightLow` respectively.

```
sensorValue = analogRead(photocellPin);
if (sensorValue > lightHigh) {
    lightHigh = sensorValue;
}
if (sensorValue < lightLow) {
    lightLow = sensorValue;
}
```

3. Now you can start playing this Thermin. Read the value of the photoresistor to `sensorValue` and map it from the small range to the large range to be used as the frequency of the buzzer.

```
void loop()
{
    /* play*/
    sensorValue = analogRead(photocellPin); //read the value of A0
    pitch = map(sensorValue, lightLow, lightHigh, 50, 6000); // map to the
    ↪ buzzer frequency
    if (pitch > 50) {
        tone(buzzerPin, pitch, 20);
    }
    delay(10);
}
```

#### 4.5.15 5.15 EEPROM

**EEPROM** is a memory, so the data it stores will not be erased when the main control board is turned off. You can use it to record some data and read it the next time you turn it on.

As an example, you can make a sports counter that keeps track of how many rope skipings you do every day.

You can also write data to it in one program and read it in another. For example, when you are working on a car project, the speeds of the two motors are inconsistent. You can write a calibration program to record the compensation value of the motor speed.

#### Required Components

In this project, we need the following components.

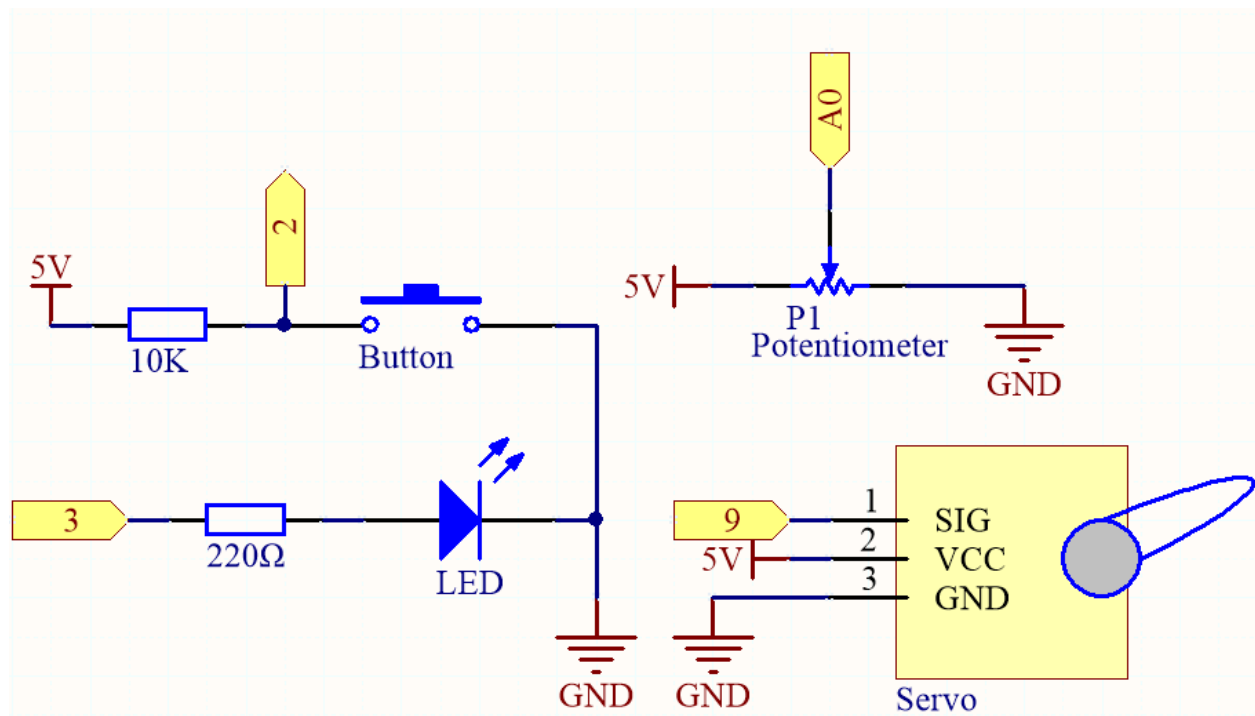
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3 in 1 Starter Kit	380+	

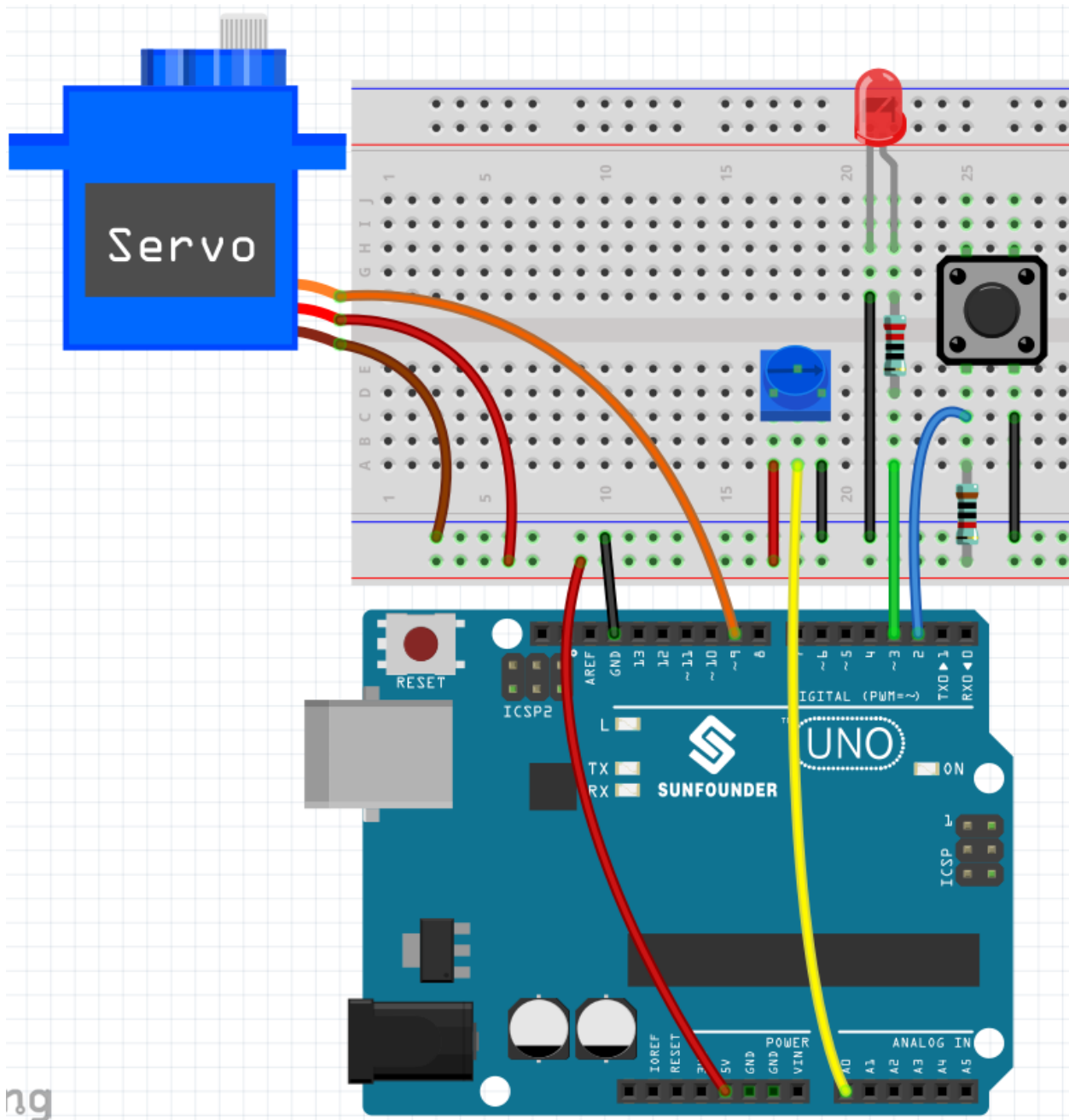
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>LED</i>	
<i>Servo</i>	
<i>Button</i>	
<i>Potentiometer</i>	

### Schematic



### Wiring



## Code

### Note:

- Open the 5.15.eeprom.ino file under the path of 3in1-kit\basic\_project\5.15.eeprom.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

To use this circuit, you simply press the button to begin recording and input the desired information through a potentiometer. Now, the board will repeat your actions endlessly (and it blinks an led each iteration) until you press the button

again to record new actions. You may also vary the amount of time recorded by changing the values of resolution and recordTime.

### How it works?

1. Import the EEPROM.h library, and initialize the EEPROM memory.

```
...
#include <EEPROM.h> //used to store recorded values

...
float resolution = 1000; //MUST be less than EEPROM.length()
float recordTime = 5; //delay time
bool recording = false;
...
```

Please note that /MUST be less than EEPROM.length(), in setup() it will print the memory of your board's EEPROM, which should be 1024 for SunFounder R3 board. If you are using a different board, you can change the value of the variable resolution.

2. Print the EEPROM memory of your board.

```
void setup() {
    ...
    Serial.begin(9600);
    //Serial.println(EEPROM.length());
}
```

To find the size of your board's EEPROM memory, uncomment the line Serial.println(EEPROM.read(i)). This will print the size of EEPROM in the serial monitor, and you can change the value of the variable resolution accordingly.

3. As soon as a button press is detected, then recording begins and the required information is entered via a potentiometer. Now the board repeats your action endlessly (and flashes an LED for each repetition) until you press the button again, recording a new action.

```
void loop() {
    if (recording == true) { //record
        for (int i = 1; i <= resolution; i++) {
            digitalWrite(ledPin, HIGH); //light status led
            int val = map(analogRead(A0), 0, 1023, 0, 180);
            EEPROM.write(i, val);
            //Serial.println(EEPROM.read(i));
            myServo.write(val);
            delay(recordTime);
        }
        digitalWrite(ledPin, LOW); //turn off status led
        delay(1000); //give time for person
        recording = false;
    }
    else {
        for (int i = 1; i <= resolution; i++) { //playback
            if (digitalRead(buttonPin) == 0) { //stop playback and record
                ↪ new values
                recording = true;
                break;
            }
        }
    }
}
```

(continues on next page)

(continued from previous page)

```

    }
    int readval = EEPROM.read(i);
    myServo.write(readval);
    //Serial.println(readval);
    delay(recordTime);
  }
  digitalWrite(ledPin, HIGH); //show a new repeat
  delay(100);
  digitalWrite(ledPin, LOW);
}
}

```

- Make the variable recording true when the button is pressed.
- When the variable recording is true, start recording the action in the memory range.
- Read the value of the potentiometer and map it to 0-180 to store it in EEPROM and control the rotation of the servo.
- The LED lights up at the start of recording and goes off at the end.
- Repeat the recorded action with a quick flash of the LED to remind you of a new repeat.

#### 4. About the EEPROM library.

Here are some of its functions.

- `write(address, value)`: Write a byte to the EEPROM.
  - `address`: the location to write to, starting from 0 (int)
  - `value`: the value to write, from 0 to 255 (byte)
  - An EEPROM write takes 3.3 ms to complete. The EEPROM memory has a specified life of 100,000 write/erase cycles, so you may need to be careful about how often you write to it.
- `Read(address)`: Reads a byte from the EEPROM. Locations that have never been written to have the value of 255.
- `update(address, value)`: Write a byte to the EEPROM. The value is written only if differs from the one already saved at the same address.
  - An EEPROM write takes 3.3 ms to complete. The EEPROM memory has a specified life of 100,000 write/erase cycles, so using this function instead of `write()` can save cycles if the written data does not change often
- `EEPROM.put(address, data)`: Write any data type or object to the EEPROM.
  - `address`: the location to read from, starting from 0 (int).
  - `data`: the data to read, can be a primitive type (eg. float) or a custom struct.
  - This function uses `EEPROM.update()` to perform the write, so does not rewrites the value if it didn't change.
- `EEPROM.get(address, data)`: Read any data type or object from the EEPROM.
  - `address`: the location to read from, starting from 0 (int).
  - `data`: the data to read, can be a primitive type (eg. float) or a custom struct.



## 4.6 6. Funny Project

In this chapter, you will find some examples that illustrate the basic logic of how most programs interact with reality. This will help you become familiar with Arduino programming. When you have a creative idea in mind, programming will no longer be challenging for you.

### 4.6.1 6.1 Light-sensitive Array

A photoresistor or photocell is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. A photoresistor can be applied in light-sensitive detector circuits, and light- and darkness-activated switching circuits.

The resistance of a photoresistor changes with incident light intensity. If the light intensity gets higher, the resistance decreases; if it gets lower, the resistance increases. In this experiment, we will use eight LEDs to show the light intensity. The higher the light intensity is, the more LEDs will light up. When the light intensity is high enough, all the LEDs will be on. When there is no light, all the LEDs will go out.

#### Required Components

In this project, we need the following components.

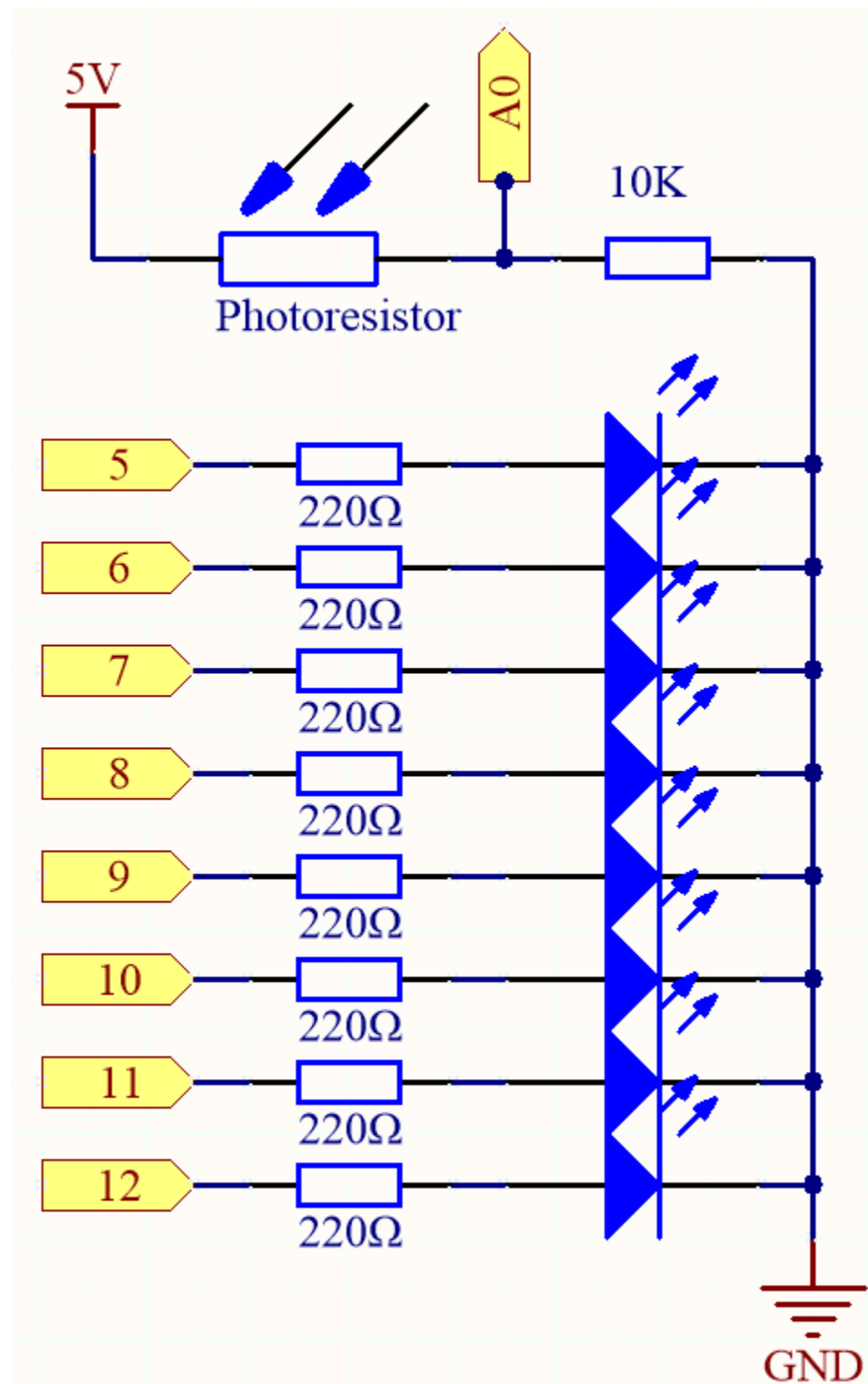
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

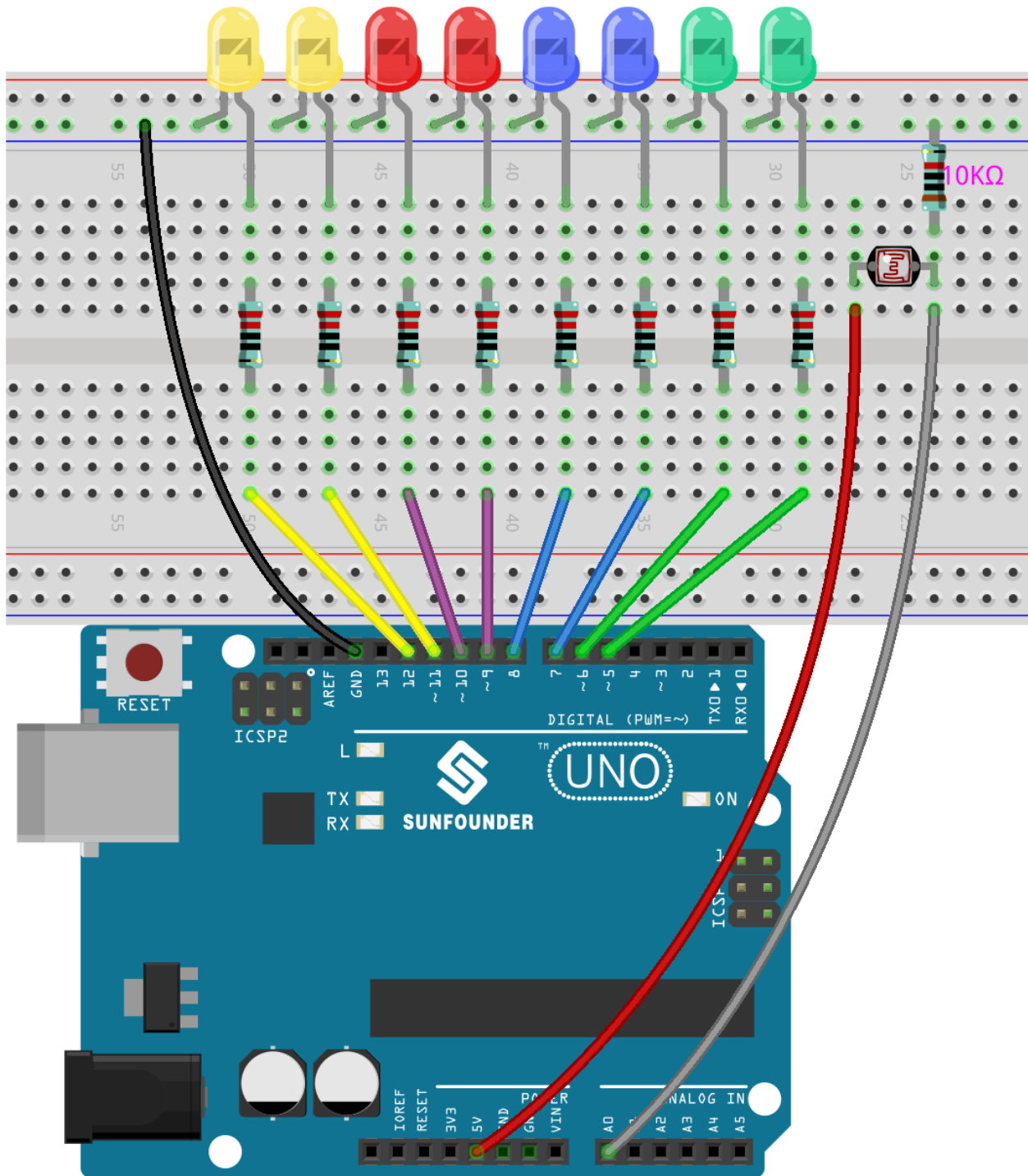
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>LED</i>	
<i>Photoresistor</i>	

#### Schematic



Wiring



## Code

### Note:

- Open the 6.1.light\_control\_led.ino file under the path of 3in1-kit\basic\_project\6.1.light\_control\_led.
- Or copy this code into **Arduino IDE**.

- Or upload the code through the [Arduino Web Editor](#).
- 

Now, shine some light on the photoresistor, and you will see several LEDs light up. Shine more light and you will see more LEDs light up. When you place it in a dark environment, all the LEDs will go out.

### How it works?

```
void loop()
{
    sensorValue = analogRead(photocellPin); //read the value of A0
    ledLevel = map(sensorValue, 300, 1023, 0, NbrLEDs); // map to the number of LEDs
    for (int led = 0; led < NbrLEDs; led++)//
    {
        if (led < ledLevel ) //When led is smaller than ledLevel, run the following code.
        {
            digitalWrite(ledPins[led], HIGH); // turn on pins less than the level
        }
        else
        {
            digitalWrite(ledPins[led],LOW); // turn off pins higher than
        }
    }
}
```

By using the `map()` function, you can map the photoresistor value to the 8 LEDs, for example, if `sensorValue` is 560, then `ledLevel` is 4, so at this point, `ledPins[0]` to `ledPins[4]` should be lit, and `ledPins[5]` to `ledPins[7]` should be off.

## 4.6.2 6.2 Electronic Dice

Here we use button, 7-segment and 74hc595 to make an electronic dice. Each time the button is pressed, a random number ranging from 1 to 6 is generated and displayed on the 7-segment Display.

### Required Components

In this project, we need the following components.

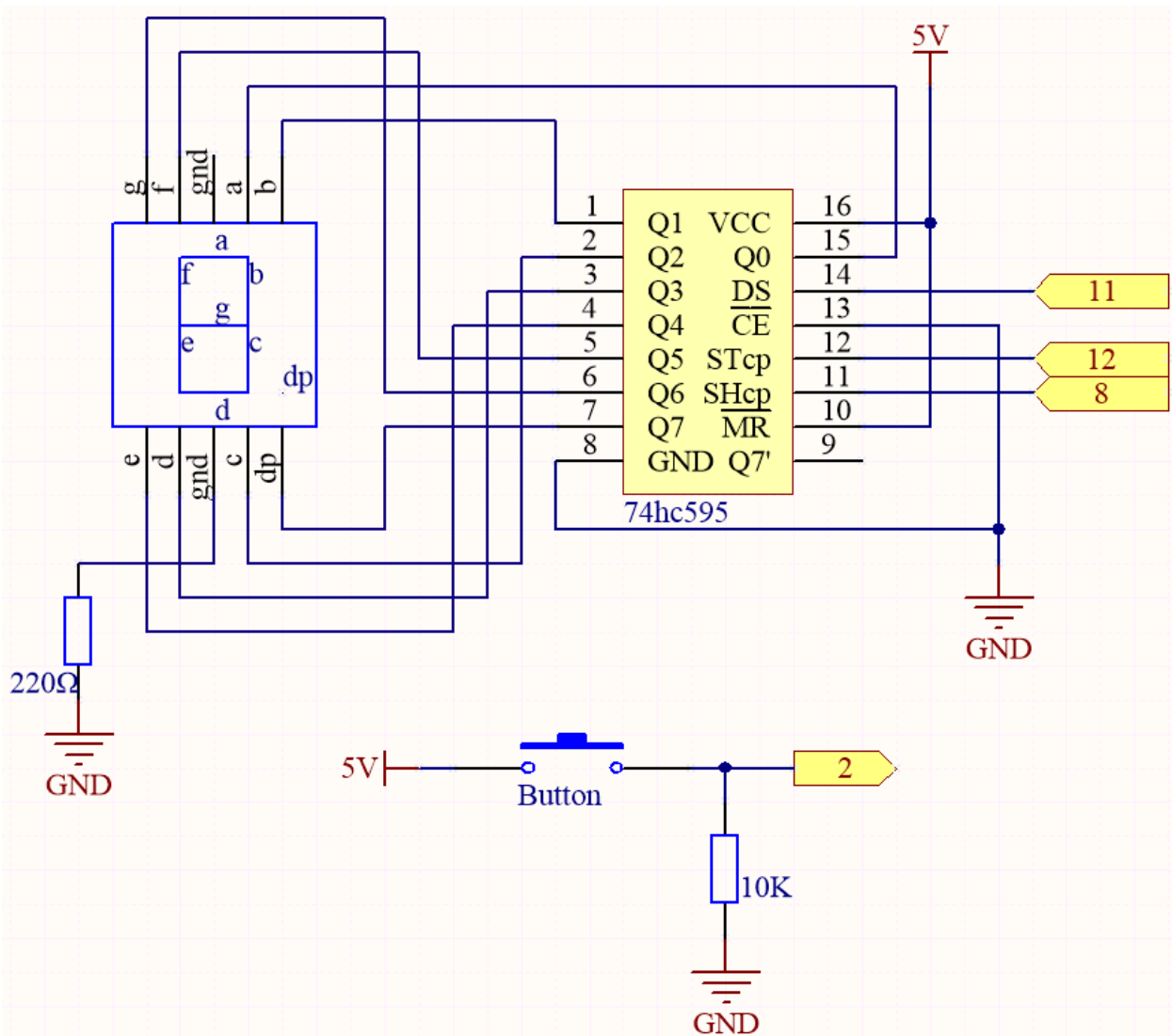
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

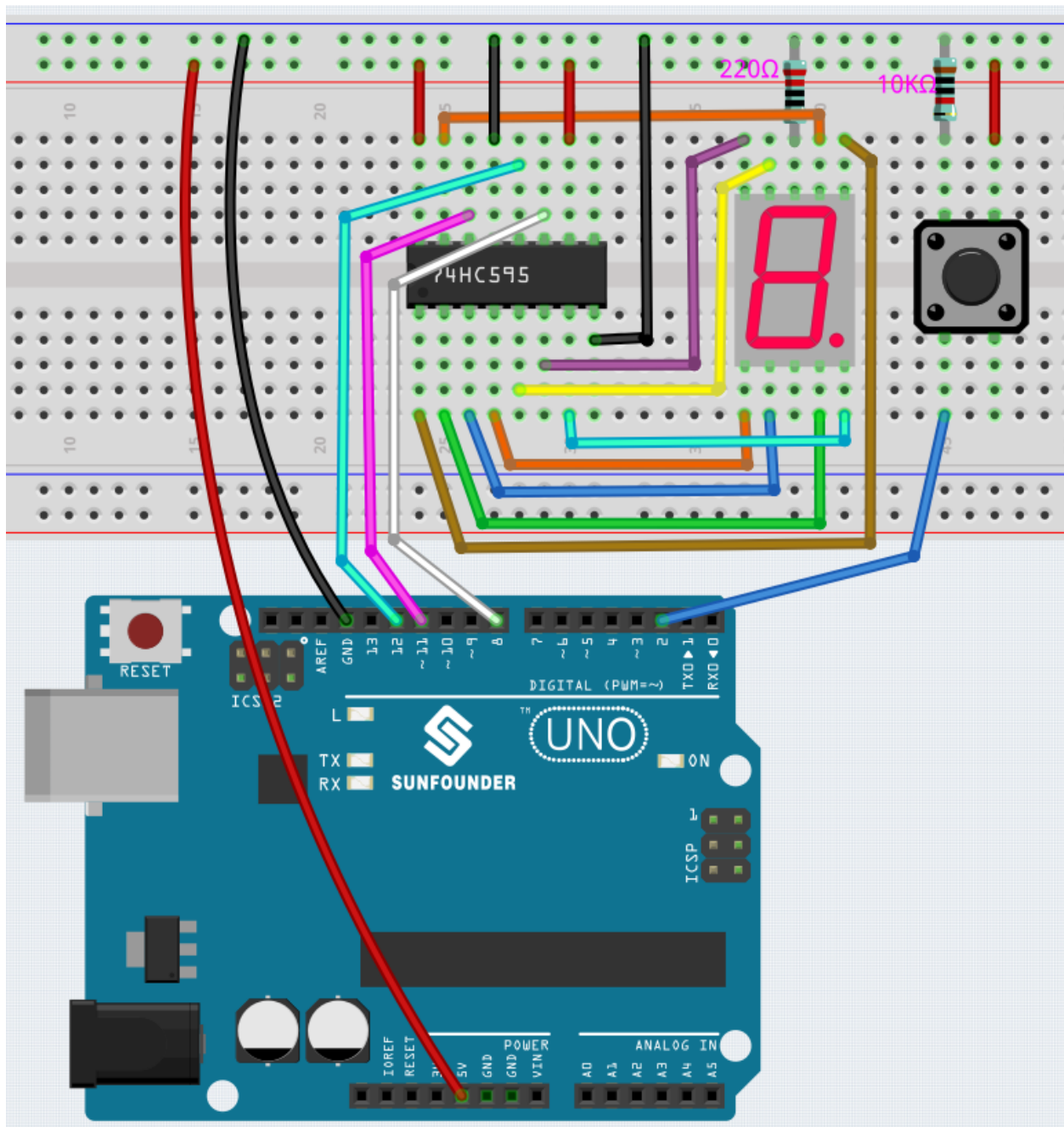
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Button</i>	
<i>74HC595</i>	
<i>7-segment Display</i>	

### Schematic



## Wiring



## Code

### Note:

- Open the 6.2.electronic\_dice.ino file under the path of 3in1-kit\basic\_project\6.2.electronic\_dice.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

When the code is uploaded successfully, the 7-segment Display will display 0-7 in a fast scroll, and when you press the button, it will display a random number and stop scrolling. The scrolling display starts again when you press the button again.

### How it works?

This project is based on *5.10 ShiftOut(Segment Display)* with a button to start/pause the scrolling display on the 7-segment Display.

1. Initialize each pin and read the value of the button.

```
void setup ()
{
    ...
    attachInterrupt(digitalPinToInterrupt(buttonPin), rollDice, FALLING);
}
```

- The interrupt is used here to read the state of the button. The default value of `buttonPin` is low, which changes from low to high when the button is pressed.
- `rollDice` represents the function to be called when the interrupt is triggered, it is used to toggle the value of the variable `state`.
- `FALLING` means the interrupt is triggered when the `buttonPin` goes from low to high.

2. When the variable `state` is 0, the function `showNumber()` is called to make the 7-segment Display randomly display a number between 1 and 7.

```
void loop()
{
    if (state == 0) {
        showNumber((int)random(1, 7));
        delay(50);
    }
}
```

3. About `rollDice()` function.

```
void rollDice() {
    state = !state;
}
```

When this function is called, it toggles the value of `state`, such as 1 last time and 0 this time.

4. About `showNumber()` function.

```
void showNumber(int num) {
    digitalWrite(STcp, LOW); //ground ST_CP and hold low for as long as you
    //are transmitting
    shiftOut(DS, SHcp, MSBFIRST, dataArray[num]);
    //return the latch pin high to signal chip that it
    //no longer needs to listen for information
    digitalWrite(STcp, HIGH); //pull the ST_CPST_CP to save the data
}
```

This is the code inside `loop()` in the project *5.10 ShiftOut(Segment Display)* into the function `showNumber()`.

### 4.6.3 6.3 High Temperature Alarm

Next, we will make a high temperature alarm device using thermistor, push button, potentiometer and LCD. The LCD1602 shows the temperature detected by the thermistor and the high temperature threshold value, which can be adjusted using a potentiometer. The threshold value is stored on EEPROM at the same time, so if the current temperature exceeds the threshold value, the buzzer will sound.

#### Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

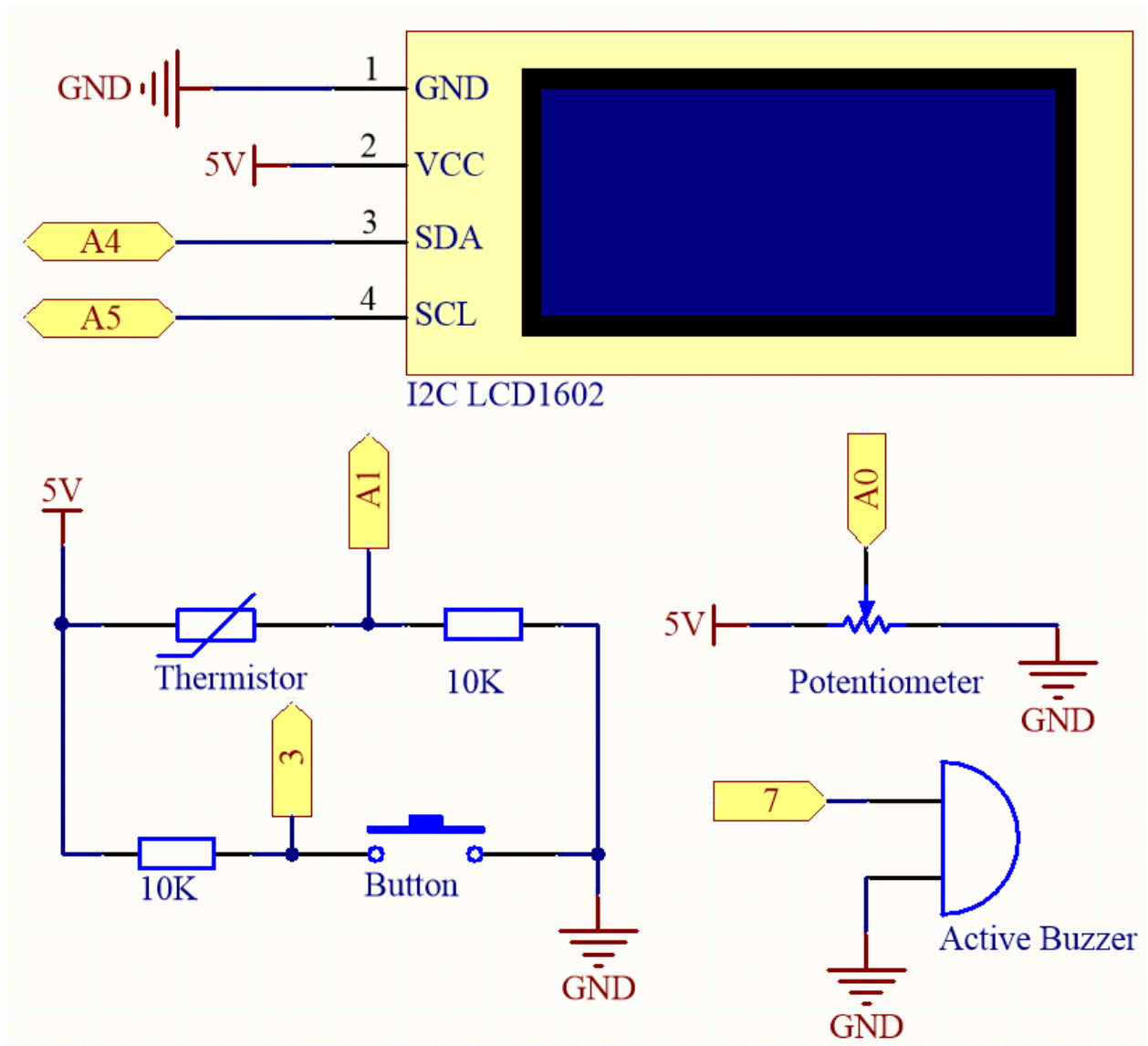
Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

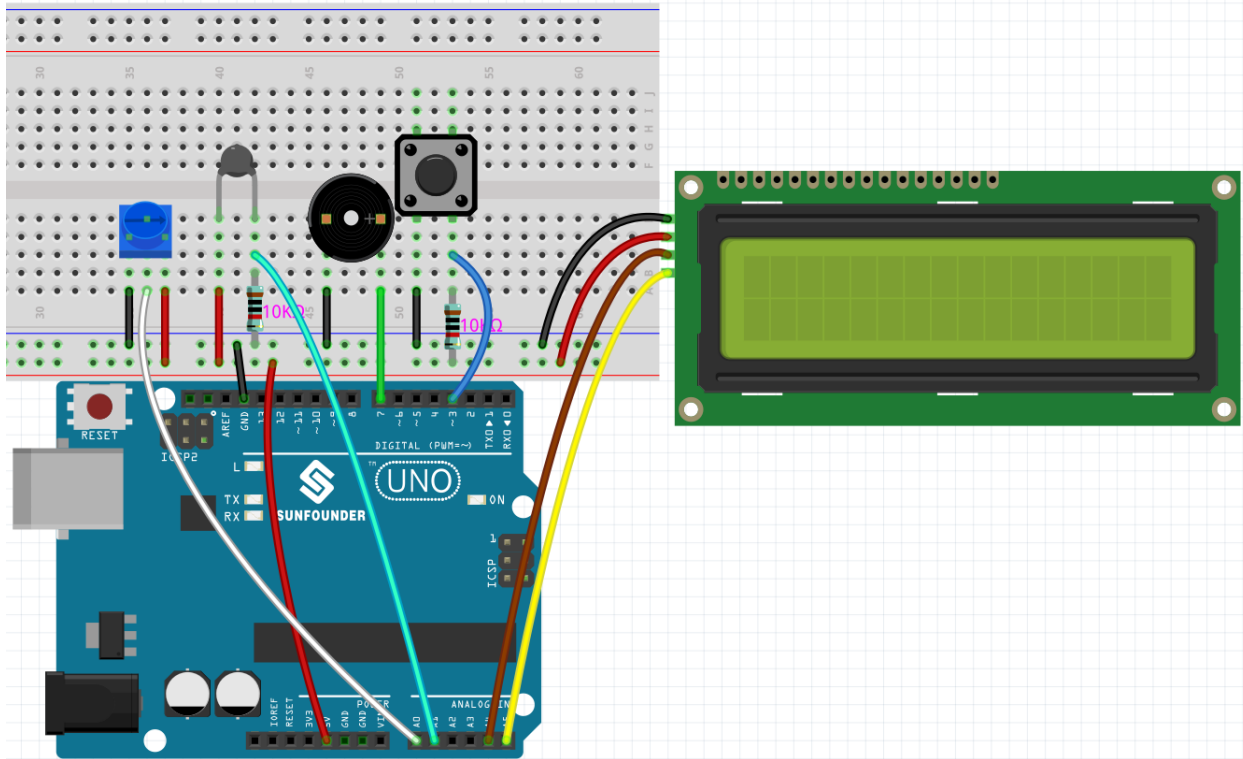
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Buzzer</i>	-
<i>Button</i>	
<i>I2C LCD1602</i>	
<i>Thermistor</i>	
<i>Potentiometer</i>	

#### Schematic





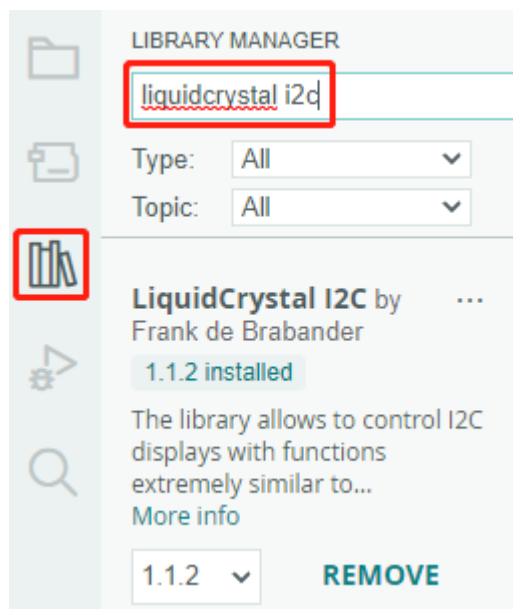
Wiring



### Code

#### Note:

- You can open the file `6.3.high_tem_alarm.ino` under the path of `3in1-kit\basic_project\6.3.high_tem_alarm` directly.
- Or copy this code into Arduino IDE 1/2.
- The LiquidCrystal I2C library is used here, you can install it from the **Library Manager**.



After the code is successfully uploaded, The LCD1602 shows the temperature detected by the thermistor and the high temperature threshold value, which can be adjusted using a potentiometer. The threshold value is stored on EEPROM at the same time, so if the current temperature exceeds the threshold value, the buzzer will sound.

**Note:** If the code and wiring are fine, but the LCD still does not display content, you can turn the potentiometer on the back.

### How it works?

1. Initialize the button, buzzer and I2C LCD1602, and read the EEPROM values. An interrupt is also used here to read the button status.

```
void setup()
{
    pinMode(buzzerPin, OUTPUT);
    pinMode(buttonPin, INPUT);
    lcd.init();
    lcd.backlight();
    upperTem = EEPROM.read(0);
    delay(1000);
    attachInterrupt(digitalPinToInterrupt(buttonPin), buttonState, FALLING);
}
```

- The interrupt is used here to read the button's state. When the button is pressed, buttonPin changes from low to high.
  - The function buttonState is called when the interrupt triggers, and it toggles the value of the variable state.
  - FALLING means the interrupt occurs when buttonPin goes from low to high.
2. To set the high temperature threshold, the function upperTemSetting() is called when state is 1 (state switches between 0 and 1 with button press) in the main program, otherwise monitoringTemp() is called to display the current temperature and the set threshold.

```
void loop()
{
    if (state == 1)
    {
        upperTemSetting();
    }
    else {
        monitoringTemp();
    }
}
```

3. About upperTemSetting() function.

```
void upperTemSetting()
{
    int setTem = 0;

    lcd.clear();
```

(continues on next page)

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```

    lcd.setCursor(0, 0);
    lcd.print("Adjusting...");
    lcd.setCursor(0, 1);
    lcd.print("Upper Tem: ");

    while (1) {
        lcd.setCursor(11, 1);
        setTem = map(analogRead(potPin), 0, 1023, 0, 100);
        lcd.print(setTem);
        if (state == 0)
        {
            EEPROM.write(0, setTem);
            upperTem = setTem;
            lcd.clear();
            return;
        }
    }
}

```

- A threshold can be set with this function. When you enter this function, the LCD1602 displays the current threshold value, which can be modified using the potentiometer. This threshold value will be stored in EEPROM and exited when the button is pressed again.

#### 4. About monitoringTemp() function.

```

void monitoringTemp()
{
    long a = analogRead(temPin);
    float tempC = beta / (log((1025.0 * 10 / a - 10) / 10) + beta / 298.0) - 273.0;
    float tempF = 1.8 * tempC + 32.0;
    lcd.setCursor(0, 0);
    lcd.print("Temp: ");
    lcd.print(tempC);
    lcd.print(char(223));
    lcd.print("C  ");
    lcd.setCursor(0, 1);
    lcd.print("Upper: ");
    lcd.print(upperTem);
    lcd.print(char(223));
    lcd.print("C  ");
    delay(300);
    if (tempC >= upperTem)
    {
        digitalWrite(buzzerPin, HIGH);
        delay(50);
        digitalWrite(buzzerPin, LOW);
        delay(10);
    }
    else
    {
        digitalWrite(buzzerPin, LOW);
    }
}

```

(continues on next page)

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}

- Using this function, you can display temperature and set an alarm.
- The thermistor value is read and then converted to Celsius temperature by the formula and displayed on the LCD1602.
- The set threshold is also displayed on the LCD.
- If the current temperature is greater than the threshold, the buzzer will sound an alarm.

#### 4.6.4 6.4 Reversing Aid

With the development of science and technology, a lot of high-tech products have been installed in cars, among which the reversing assist system is one of them. Here we use ultrasonic module, LCD, LED and buzzer to make a simple ultrasonic reversing assist system.

##### Required Components

In this project, we need the following components.

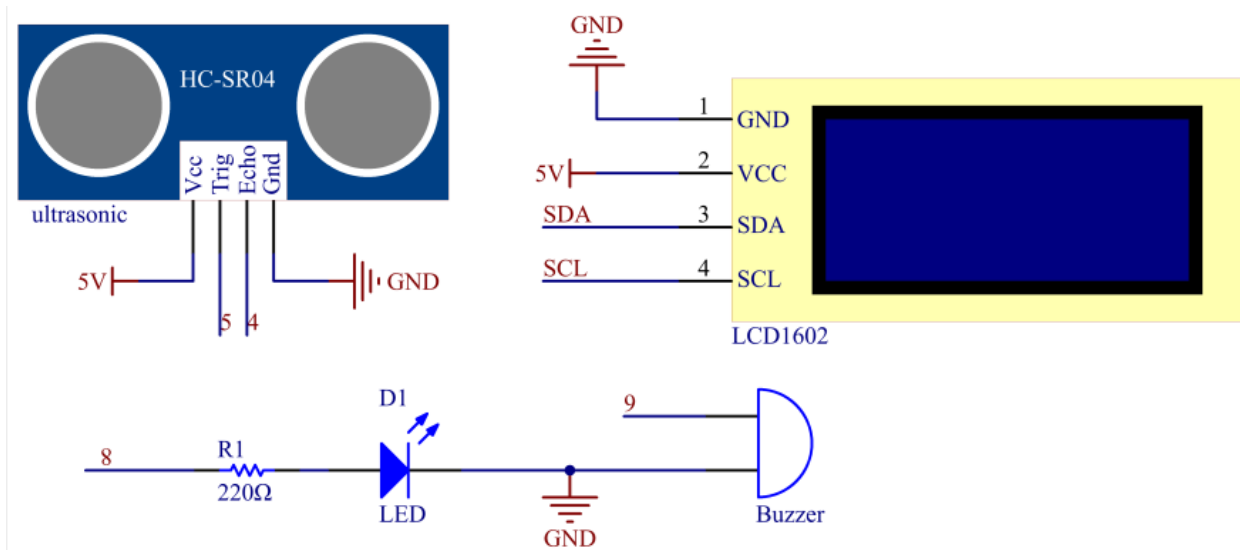
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

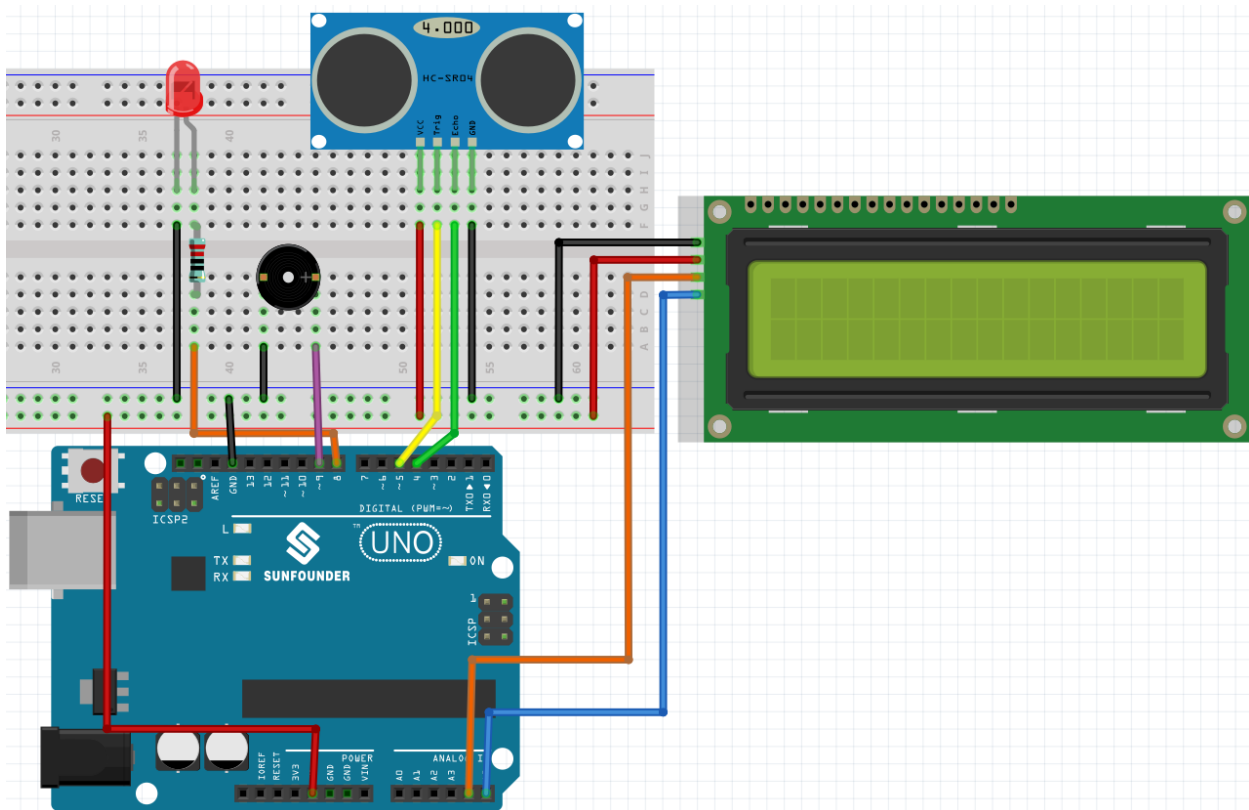
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>LED</i>	
<i>Buzzer</i>	
<i>I2C LCD1602</i>	
<i>Ultrasonic Module</i>	

##### Schematic



## Wiring

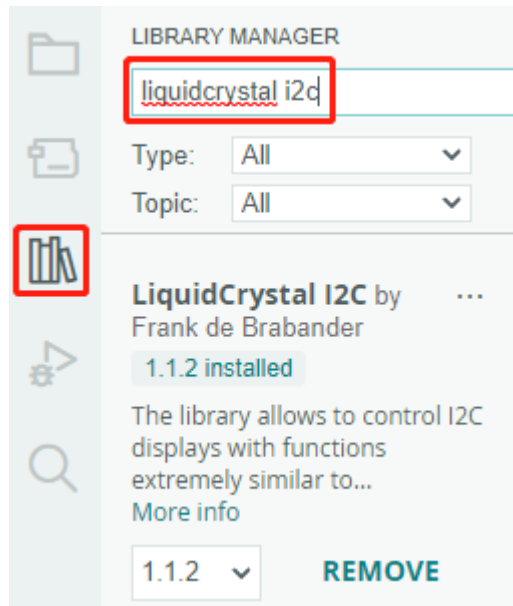


## Code

### Note:

- You can open the file 6.4\_reversingAid.ino under the path of 3in1-kit\basic\_project\6.4\_reversingAid directly.
- Or copy this code into Arduino IDE 1/2.

- The LiquidCrystal I2C library is used here, you can install it from the **Library Manager**.



After the code is successfully uploaded, the current detected distance will be displayed on the LCD. Then the buzzer will change the sounding frequency according to different distances.

**Note:** If the code and wiring are fine, but the LCD still does not display content, you can turn the potentiometer on the back.

### How it works?

This code helps us create a simple distance measuring device that can measure the distance between objects and provide feedback through an LCD display and a buzzer.

The `loop()` function contains the main logic of the program and runs continuously. Let's take a closer look at the `loop()` function.

#### 1. Loop to read distance and update parameters

In the loop, the code first reads the distance measured by the ultrasonic module and updates the interval parameter based on the distance.

```
// Update the distance
distance = readDistance();

// Update intervals based on distance
if (distance <= 10) {
  intervals = 300;
} else if (distance <= 20) {
  intervals = 500;
} else if (distance <= 50) {
  intervals = 1000;
} else {
  intervals = 2000;
}
```

## 2. Check if it's time to beep

The code calculates the difference between the current time and the previous beep time, and if the difference is greater than or equal to the interval time, it triggers the buzzer and updates the previous beep time.

```
unsigned long currentMillis = millis();
if (currentMillis - previousMillis >= intervals) {
  Serial.println("Beeping!");
  beep();
  previousMillis = currentMillis;
}
```

## 3. Update LCD display

The code clears the LCD display and then displays “Dis:” and the current distance in centimeters on the first line.

```
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Dis: ");
lcd.print(distance);
lcd.print(" cm");

delay(100);
```

# 4.6.5 6.5 Reaction Game

Our body has many reaction times, such as audio RT, visual RT, touch RT, etc.

Reaction times have many effects on our daily life, for example, slower than normal reaction times when driving can lead to serious consequences.

In this project, we use 3 buttons and 2 LEDs to measure our visual reaction time.

The serial monitor of the Arduino displays the message “waiting...” After pressing the Ready button, one of the two LEDs must light up randomly after a random time interval. It is important that the testee pushes the corresponding button as soon as possible. The Arduino records the time difference between when the LED lights up and when the person presses the corresponding button, and prints the measured response time on the Arduino serial monitor.

## Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

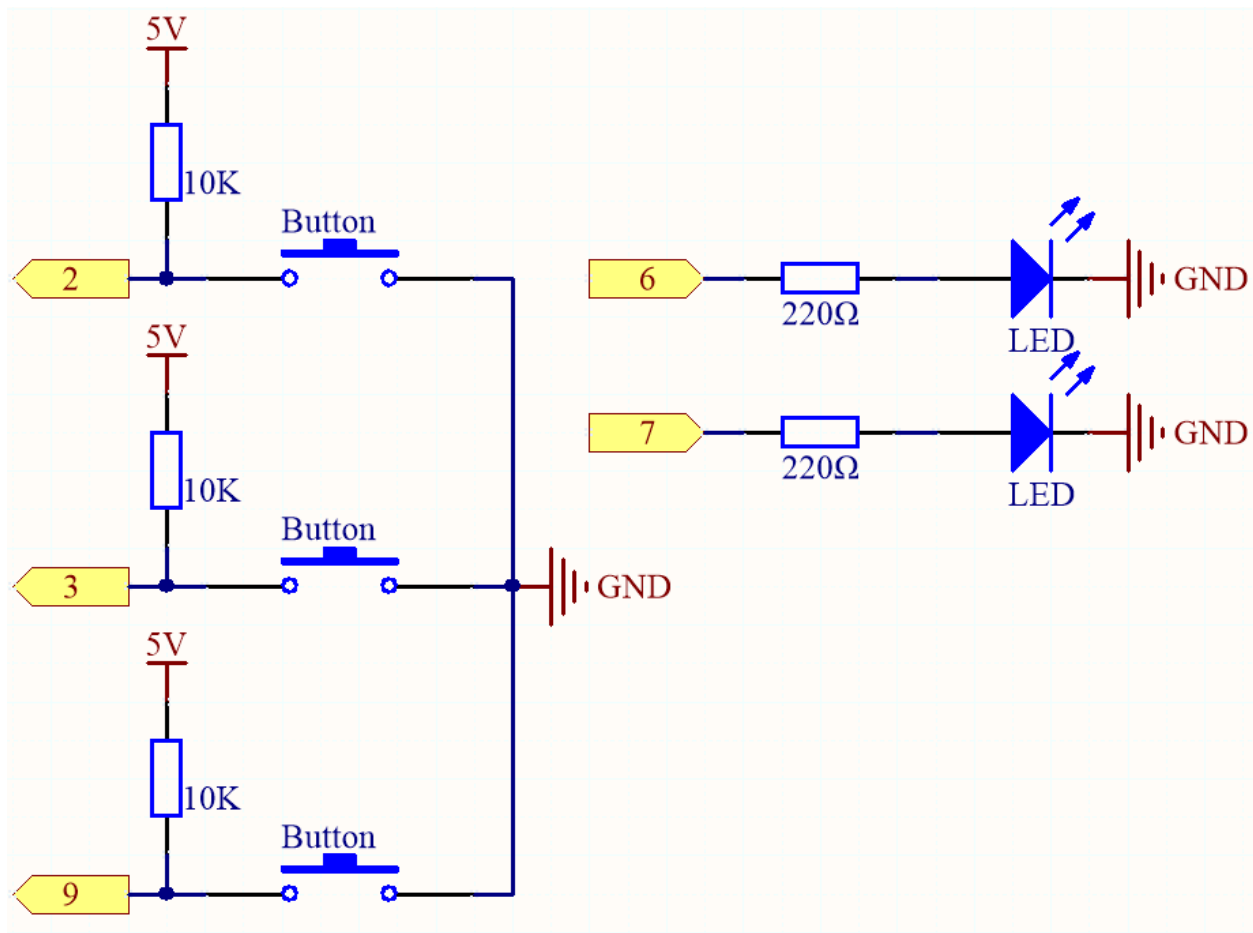
Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

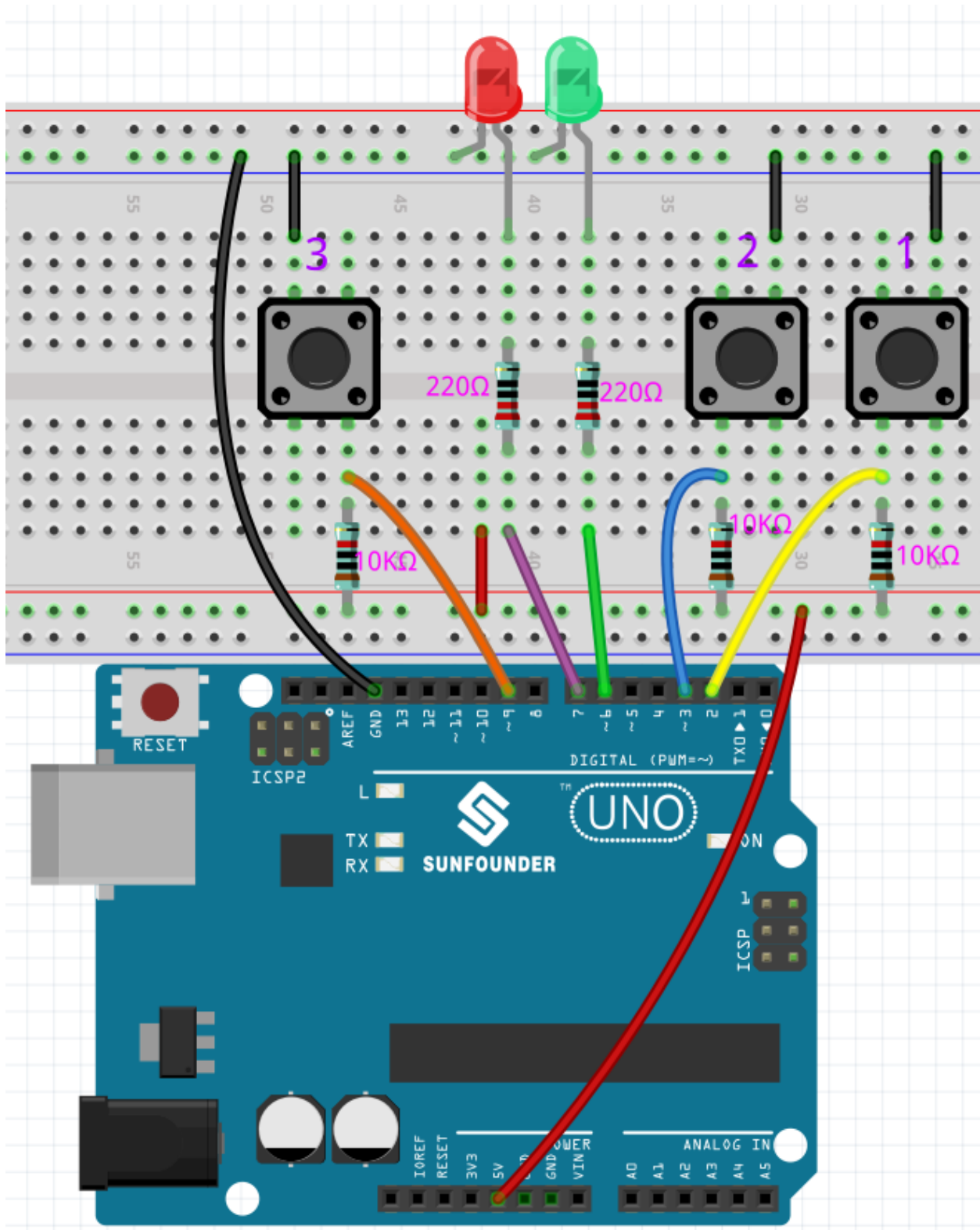


COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>LED</i>	
<i>Button</i>	

### Schematic



### Wiring



Code

Note:

- You can open the file 6.5\_reaction\_time.ino under the path of 3in1-kit\basic\_project\6.5\_reversingAid directly.
- Or copy this code into Arduino IDE 1/2.
- Please make sure you have added the LiquidCrystal\_I2C library, detailed tutorials refer to [5.11 Install External Libraries](#).

### How it works?

1. Initialize the buttons and LEDs, 2 interrupt are used here to read the button status.

```
void setup()
{
    ...

    attachInterrupt(digitalPinToInterrupt(buttonPin1), pressed1, FALLING);
    attachInterrupt(digitalPinToInterrupt(buttonPin2), pressed2, FALLING);
    ...
}
```

2. If the rstBtn button is pressed, the game starts again. At a random time between 2 and 5ms, make one of the LEDs light up.

```
void loop()
{
    if (flag == -1 && digitalRead(rstBtn) == LOW) {
        digitalWrite(ledPin1, LOW);
        digitalWrite(ledPin2, LOW);
        Serial.println("Waiting...");
        int randomTime = random(2000, 5000);
        delay(randomTime);

        timer = millis();
        flag = randomTime % 2;
        Serial.println("Light!");

        if (flag == 0) {
            digitalWrite(ledPin1, HIGH);
        } else if (flag == 1) {
            digitalWrite(ledPin2, HIGH);
        }
    }
    delay(200);
}
```

- When flag is -1 and rstBtn button is pressed, use random() function to generate a random time of 2-5s.
  - This time is then used to control the lighting of the LEDs.
  - Also the lighting of 2 LEDs is randomly generated by randomTime % 2 with 0 and 1. If flag is 0, then LED1 is lit; if 1, then LED2 is lit.
3. About pressed1() function

```
void pressed1() {
  if (flag == -1) {
    return;
  }
  if (flag == 0) {
    int currentTime = millis();
    Serial.print("Correct! You reaction time is : ");
    Serial.print(currentTime - timer);
    Serial.println(" ms");
  } else if (flag == 1) {
    Serial.println("Wrong Click!");
  }
  flag = -1;
}
```

This is the function that will be triggered when button 1 is pressed. When button 1 is pressed, if the flag is 0 at this time, the response time will be printed, otherwise the press error will be prompted.

#### 4. About pressed2() function

```
void pressed2() {
  if (flag == -1) {
    return;
  }
  if (flag == 1) {
    int currentTime = millis();
    Serial.print("Correct! You reaction time is : ");
    Serial.print(currentTime - timer);
    Serial.println(" ms");
  } else if (flag == 0) {
    Serial.println("Wrong Click!");
  }
  flag = -1;
}
```

This is the function that will be triggered when button 2 is pressed. When button 2 is pressed, if the flag is 1 at this time, the response time will be printed, otherwise the press error will be prompted.

## 4.6.6 6.6 Guess Number

Guessing Numbers is a fun party game where you and your friends take turns inputting a number (0~99). The range will be smaller with the inputting of the number till a player answers the riddle correctly. Then the player is defeated and punished. For example, if the lucky number is 51 which the players cannot see, and the player 1 inputs 50, the prompt of number range changes to 50~99; if the player 2 inputs 70, the range of number can be 50~70; if the player 3 inputs 51, he or she is the unlucky one. Here, we use IR Remote Controller to input numbers and use LCD to output outcomes.

### Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

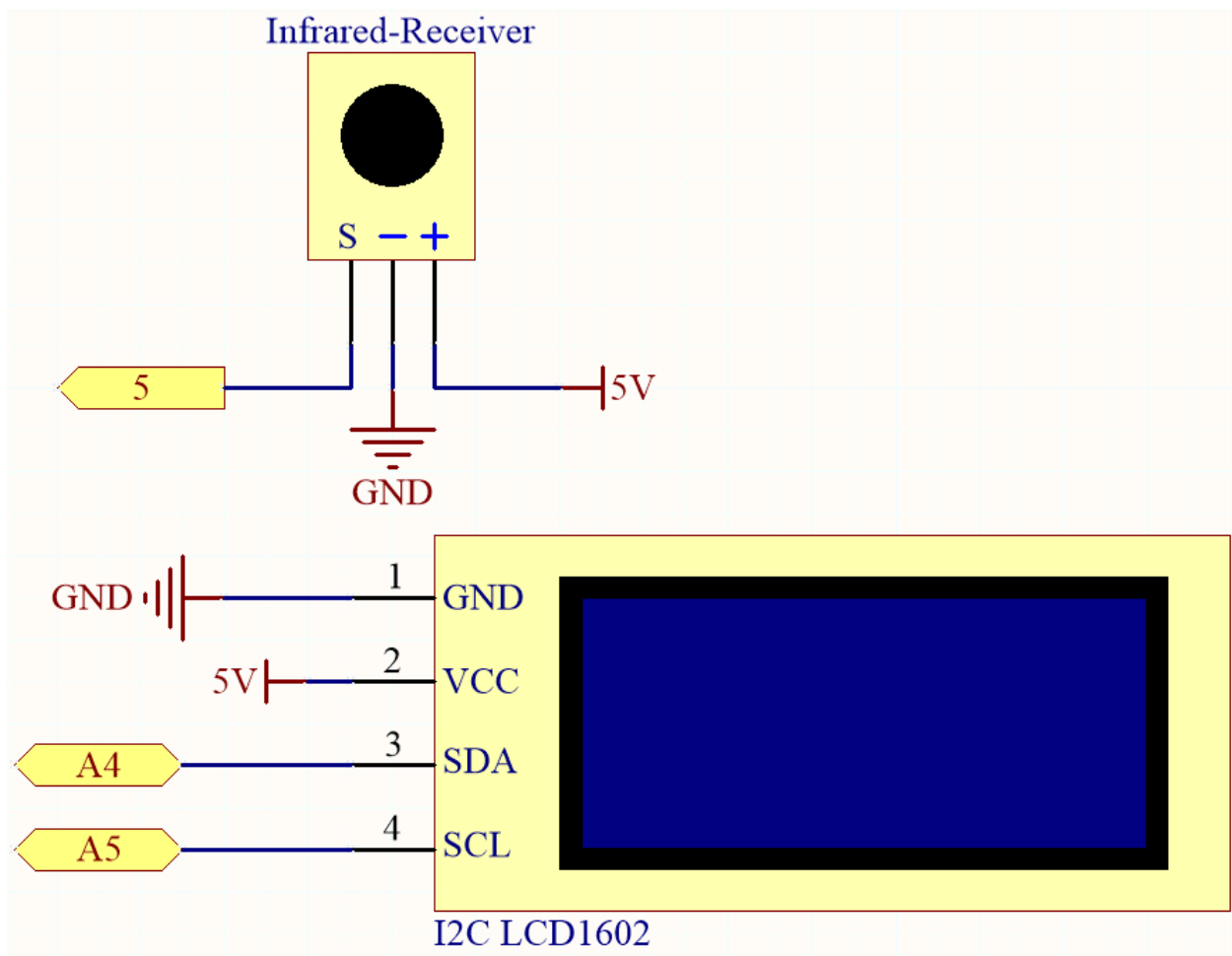
Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

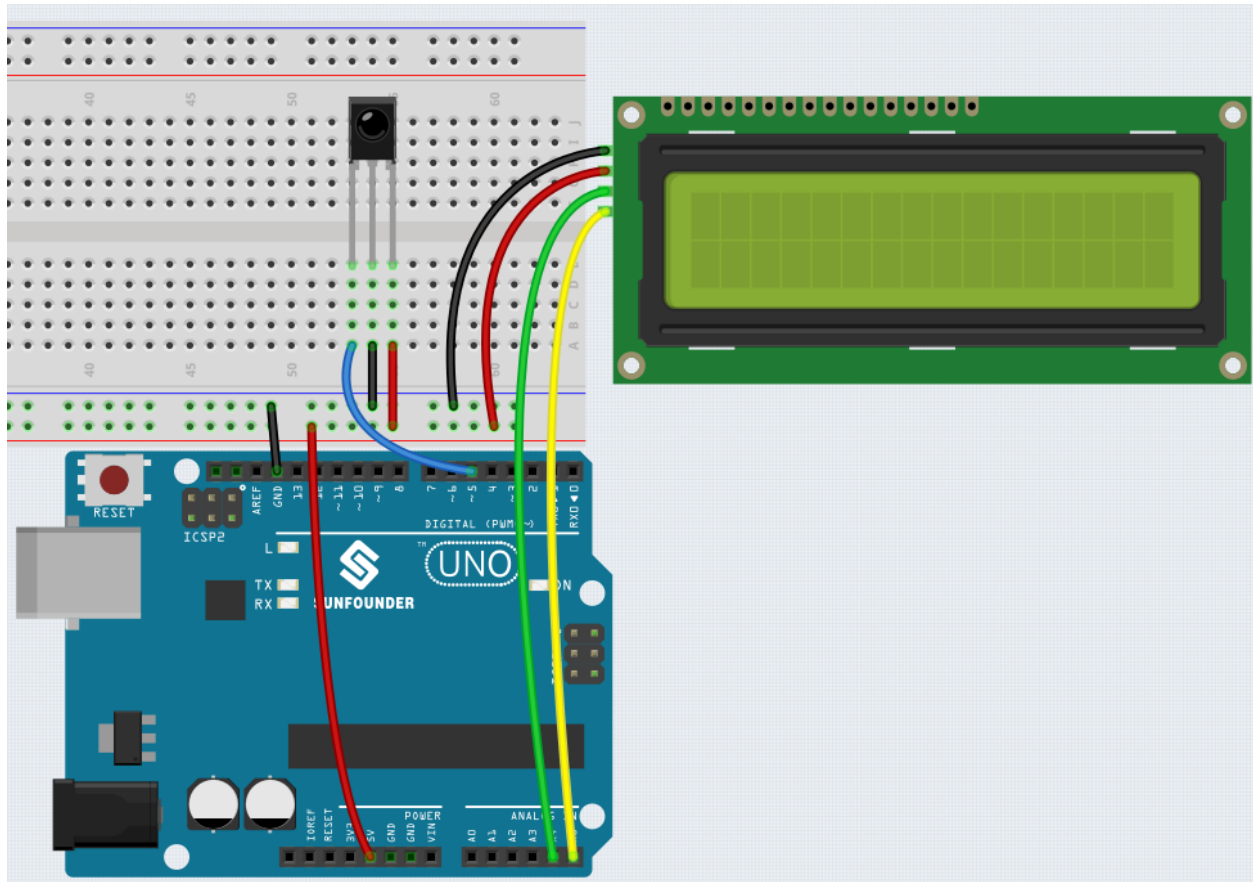
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>I2C LCD1602</i>	
<i>IR Receiver</i>	-

### Schematic

In this example, the wiring of LCD1602 and infrared receiving module is as follows.



### Wiring



### Code

---

#### Note:

- You can open the file `6.6.guess_number.ino` under the path of `3in1-kit\basic_project\6.6.guess_number` directly.
  - Or copy this code into Arduino IDE 1/2.
  - The `LiquidCrystal I2C` and `IRremote` libraries are used here, you can install them from the **Library Manager**.
- 

After the code is successfully uploaded, the welcome characters will appear on the LCD1602. Now press the number according to the range prompt on the screen, the display will get smaller and smaller unless you guess that lucky number.

---

**Note:** If the code and wiring are fine, but the LCD still does not display content, you can turn the potentiometer on the back to increase the contrast.

---

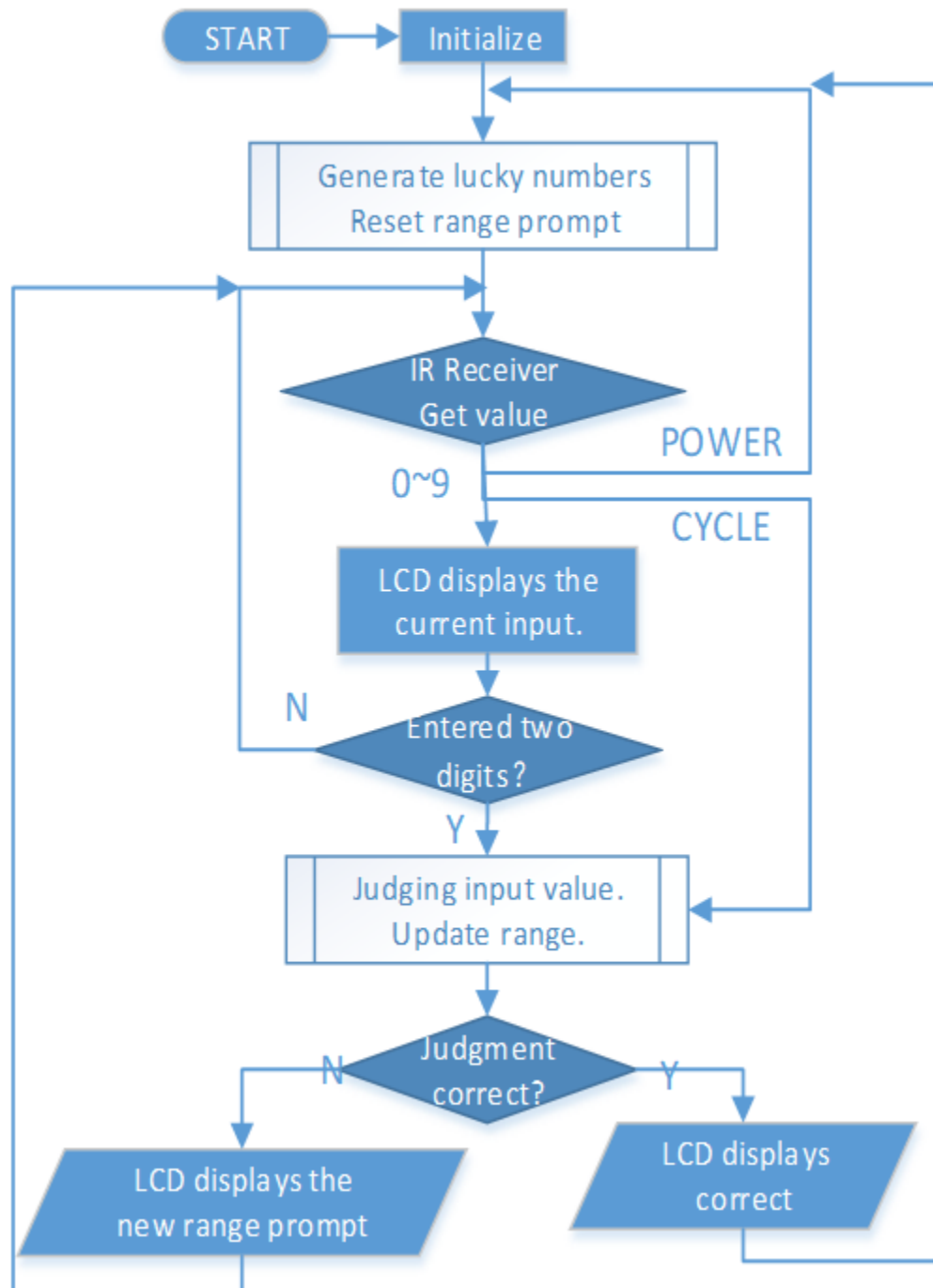
#### How it works?

In order to make the number guessing game become vivid and funny, we need to achieve the following functions:

1. The lucky number will be displayed when we start and reset the game, and the number range prompt is reset to 0 ~ 99.
2. LCD will display the number being input and the number range prompt.

3. After inputting two digits, there appears result judgment automatically.
4. If you input a single digit, you can press the CYCLE key (the key at the center of the Controller) to start the result judgment.
5. If the answer is not guessed, the new number range prompt will be displayed (if the lucky number is 51 and you enter 50, the number range prompt will change to 50~99).
6. The game is automatically reset after the lucky number is guessed, so that the player can play a new round.
7. The game can be reset by directly pressing the POWER button (the button in the upper left corner).

In conclusion, the work flow of the project is shown in the flow chart.





## CAR PROJECTS

I believe you have seen a lot of different smart robot car, their basic functions are similar, basic movement, obstacle avoidance, line following, following and control by remote control, etc..

Here, we use the simplest structure to build a smart robot car, which can also achieve all the above functions. In addition you can control it with your cell phone, please refer to [8. IoT Car](#) for the tutorial.

### assembly instructions

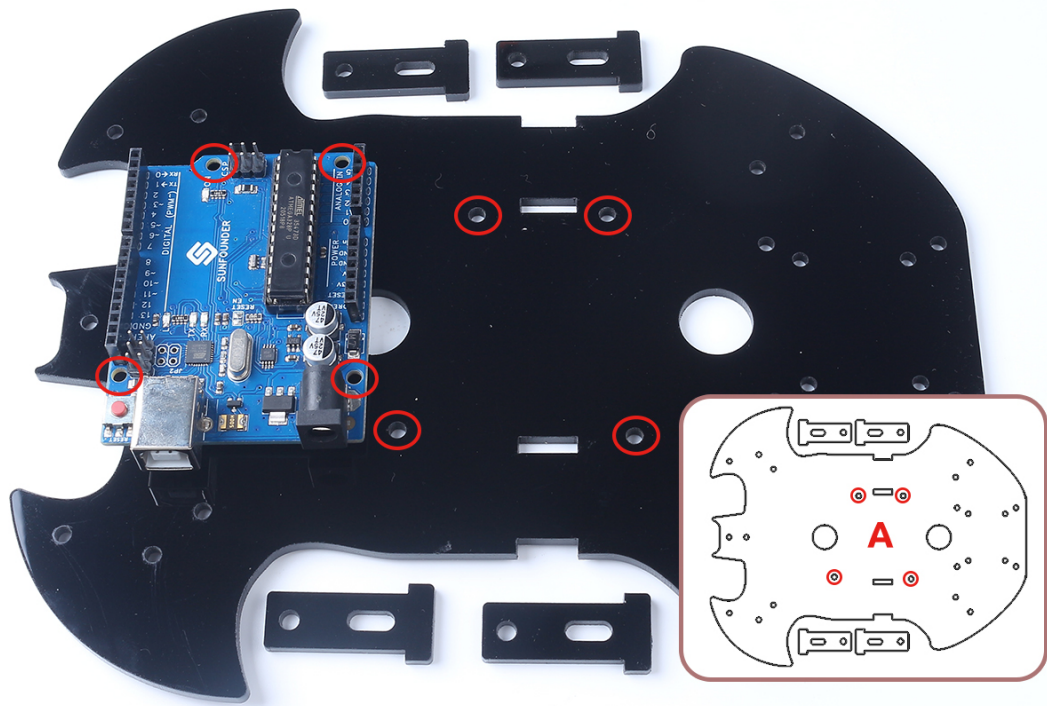
## 5.1 Assemble the Car

Please follow the steps below to complete the assembly of the car.

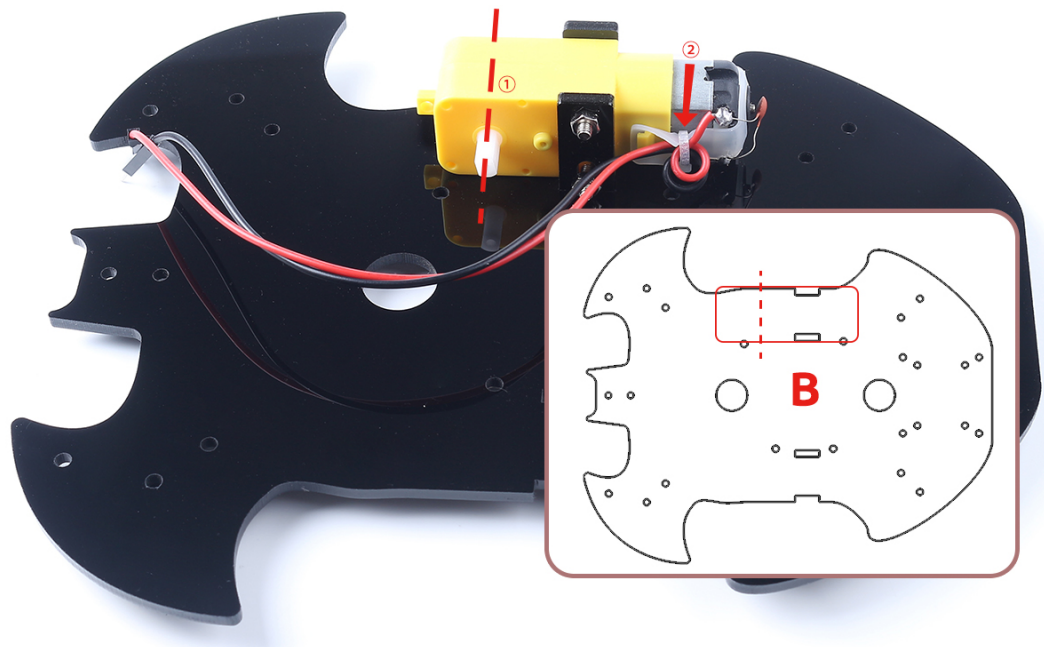
1. Remove the protective film on the acrylic.



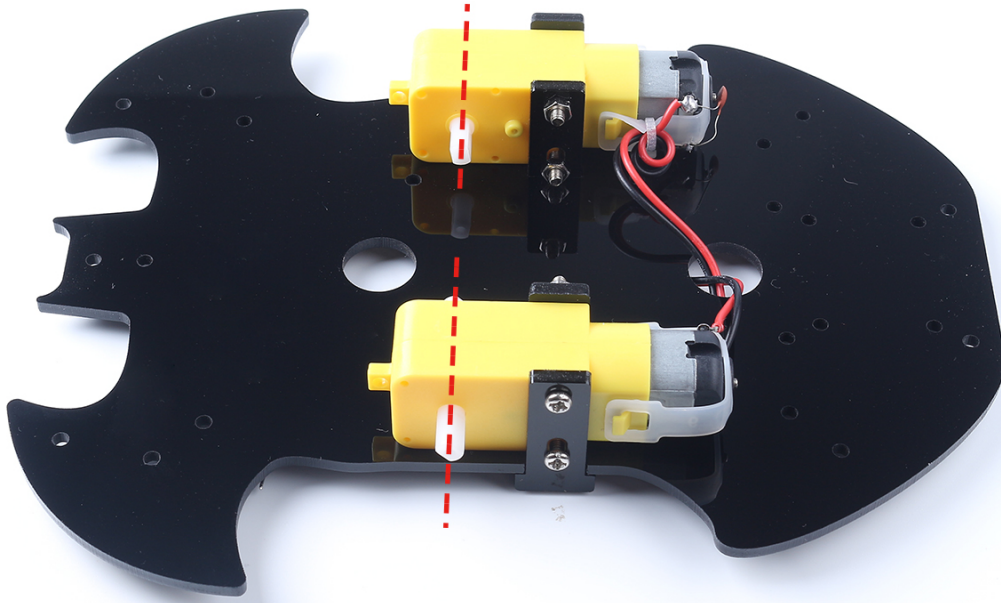
2. Place the board on the table as shown in the picture, the side with the same hole as the R3 board, we call A; the back is B. This will help you avoid mistakes during assembly.



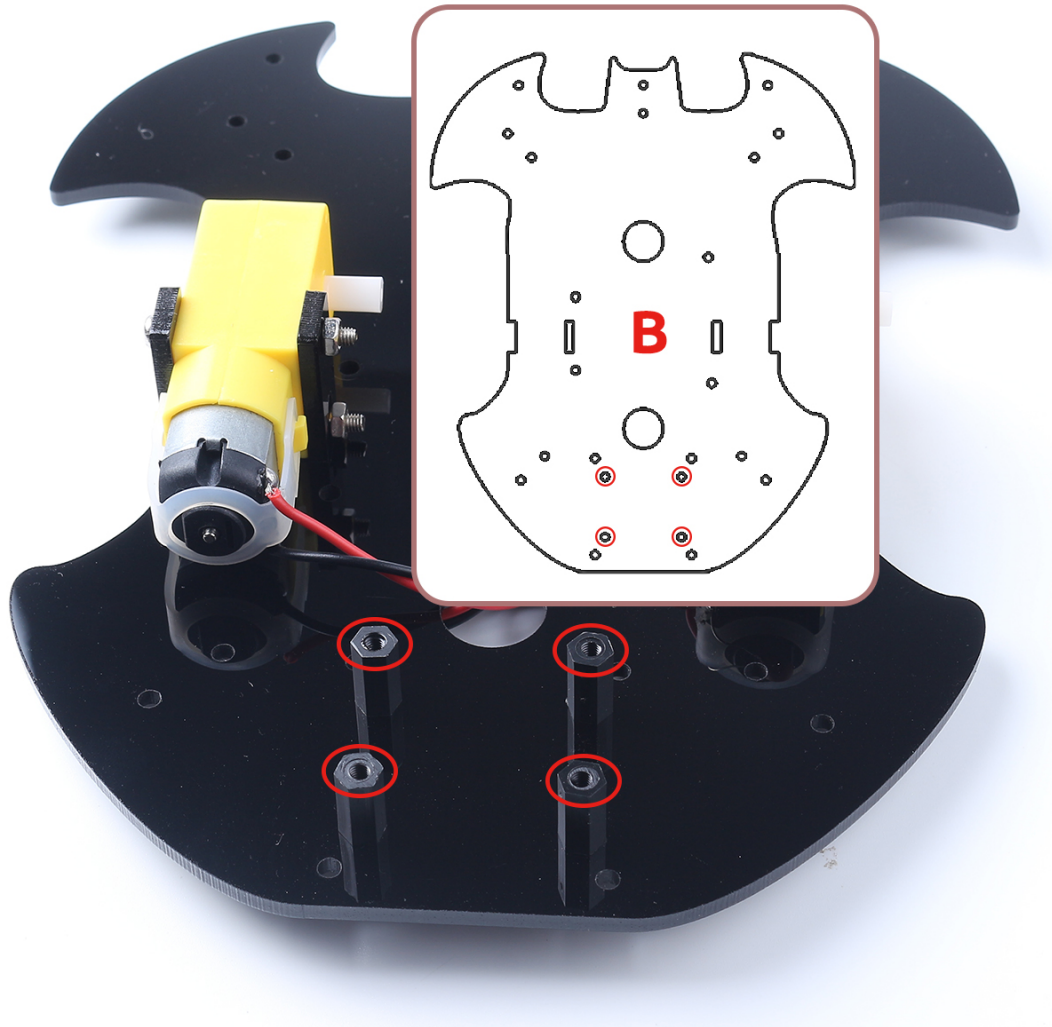
3. Turn to the B side, use M3x30mm screws and M3 nuts to attach the TT Motor. 2 details here: 1 - the output shaft is facing the bat-shaped side; 2 - the motor cable is facing the inside.



4. Mount another TT Motor, the same attention needs to be paid to the direction of the output shaft and the direction of the cable.

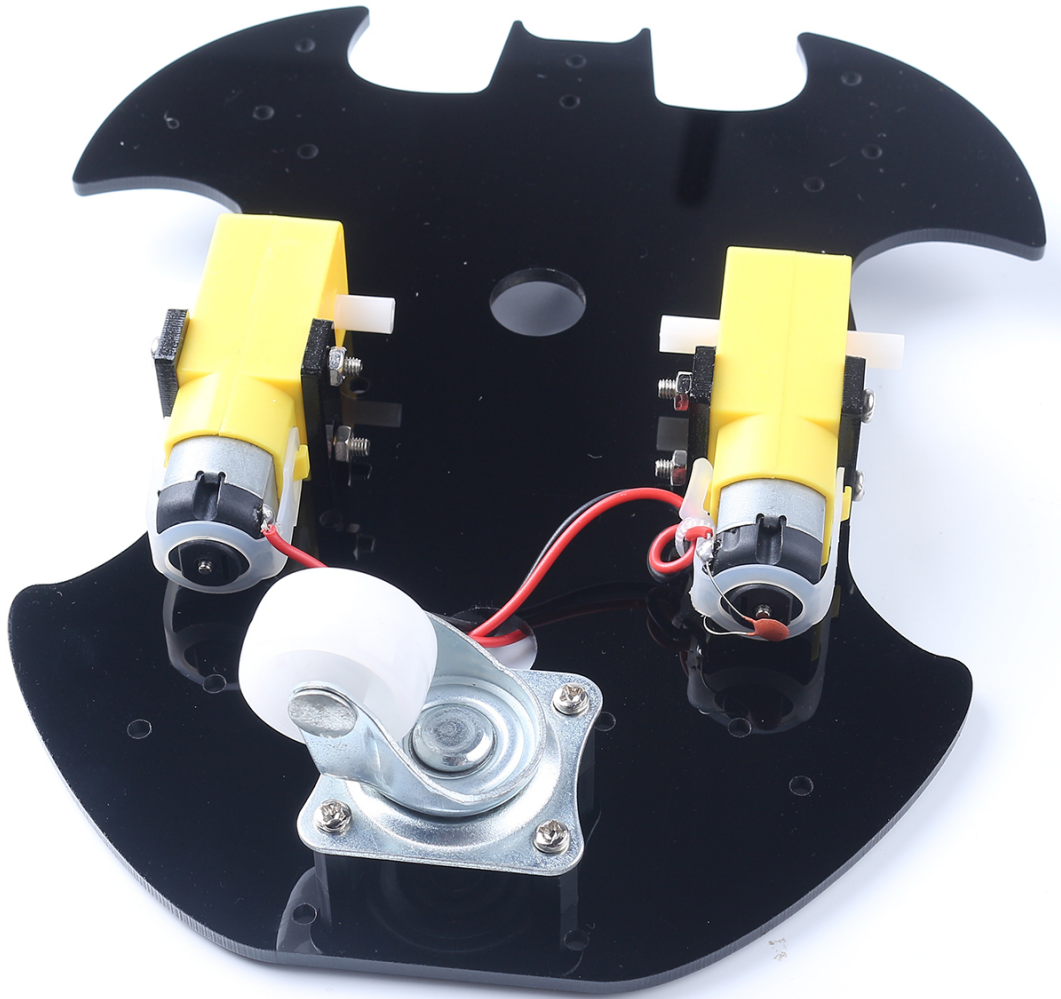


5. Use M3x6mm screws to mount the M3x12mm standoff in the position as shown below.

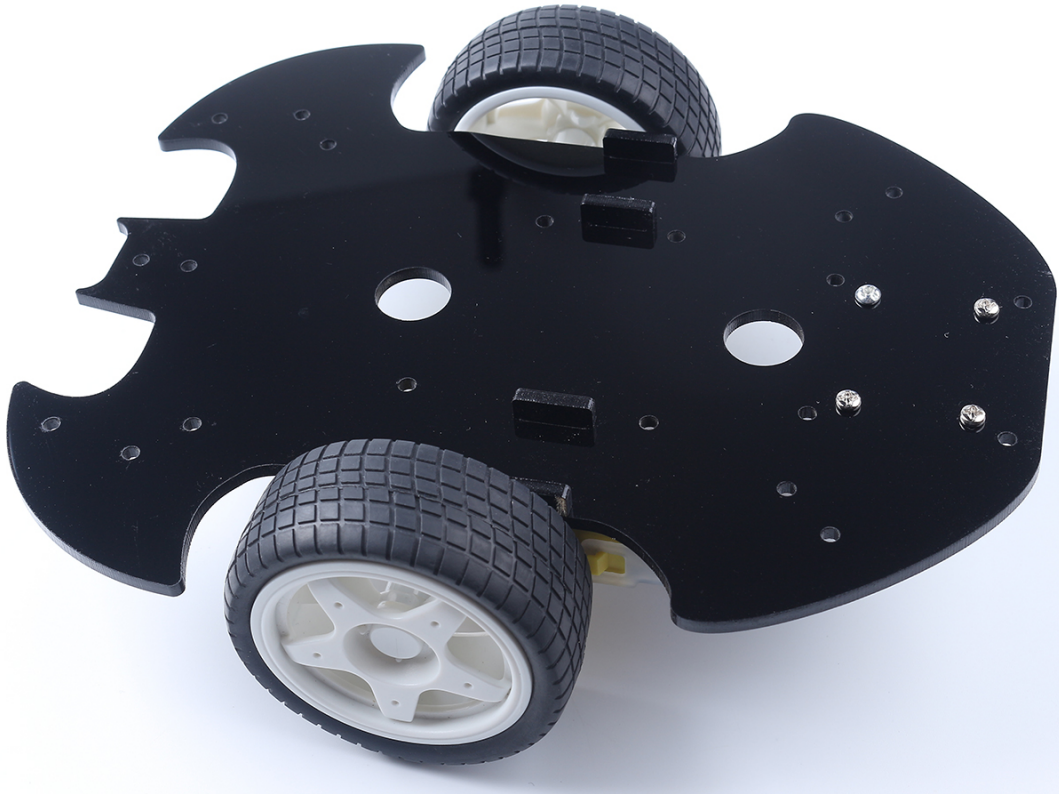


6. Use M3x6mm screws to mount the universal wheel.





7. Putting on the 2 wheels and the car's basic structure has been completed.

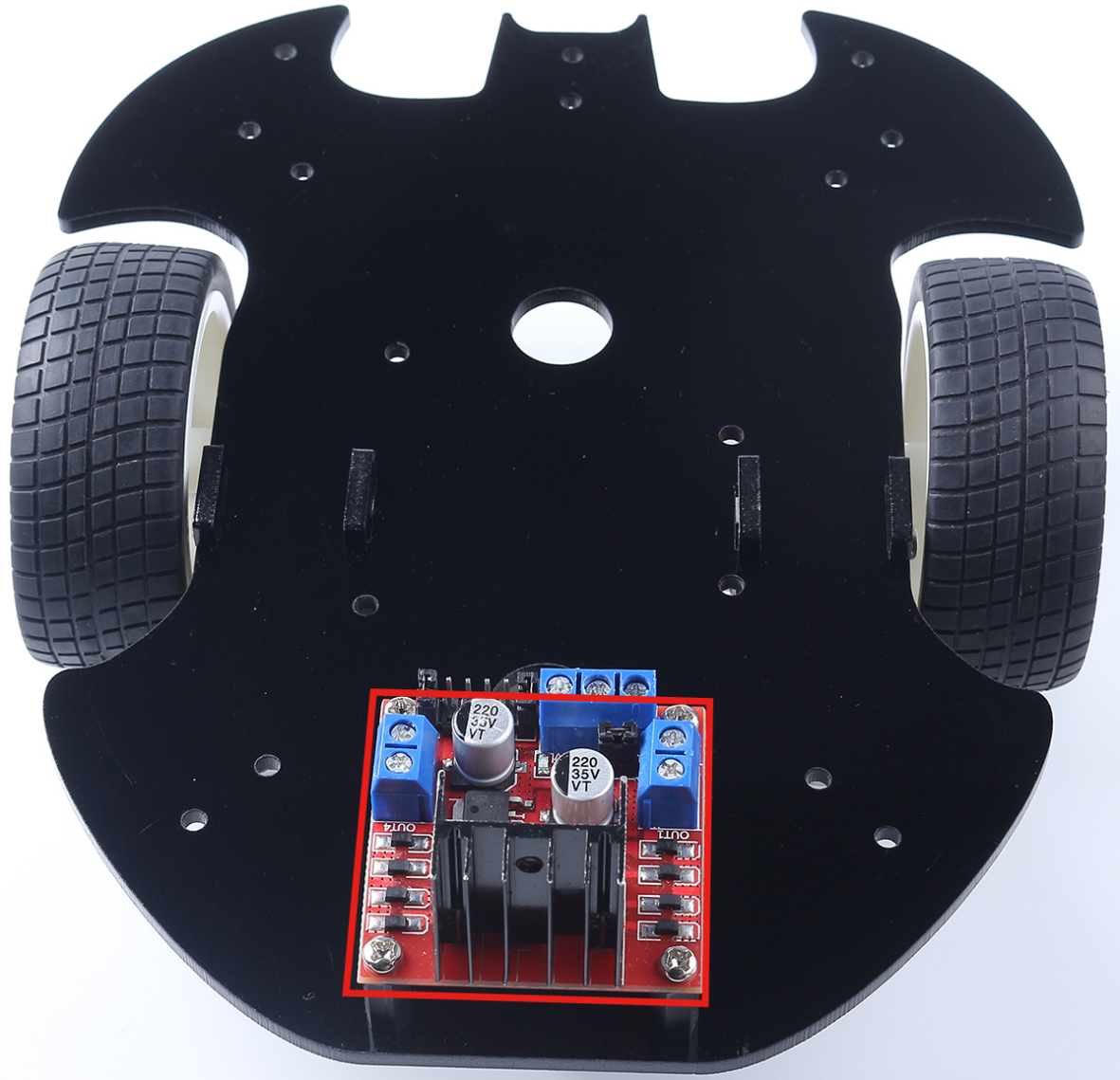


8. Attach the M3x12mm bracket to the rear of the car with M3x6mm screws



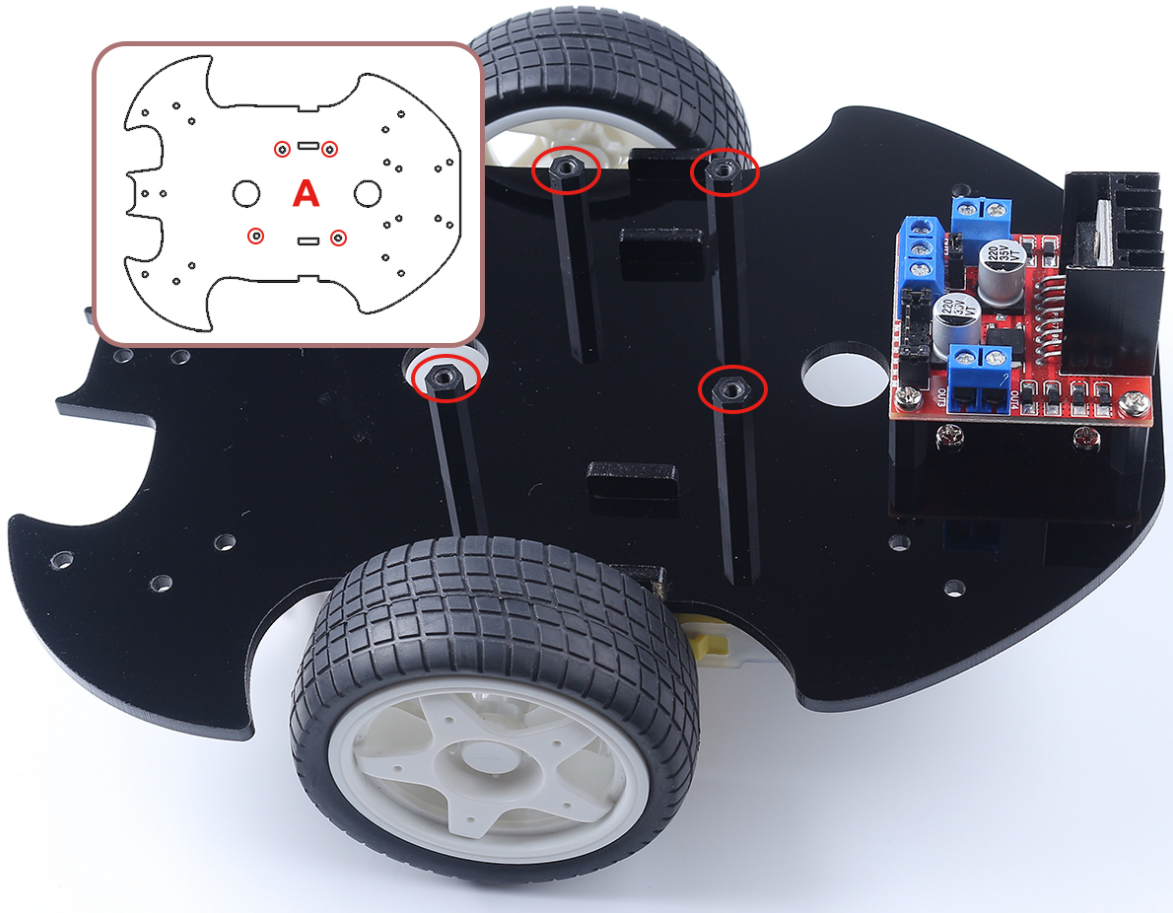
9. Attach the L298N module with M3x6mm screws.



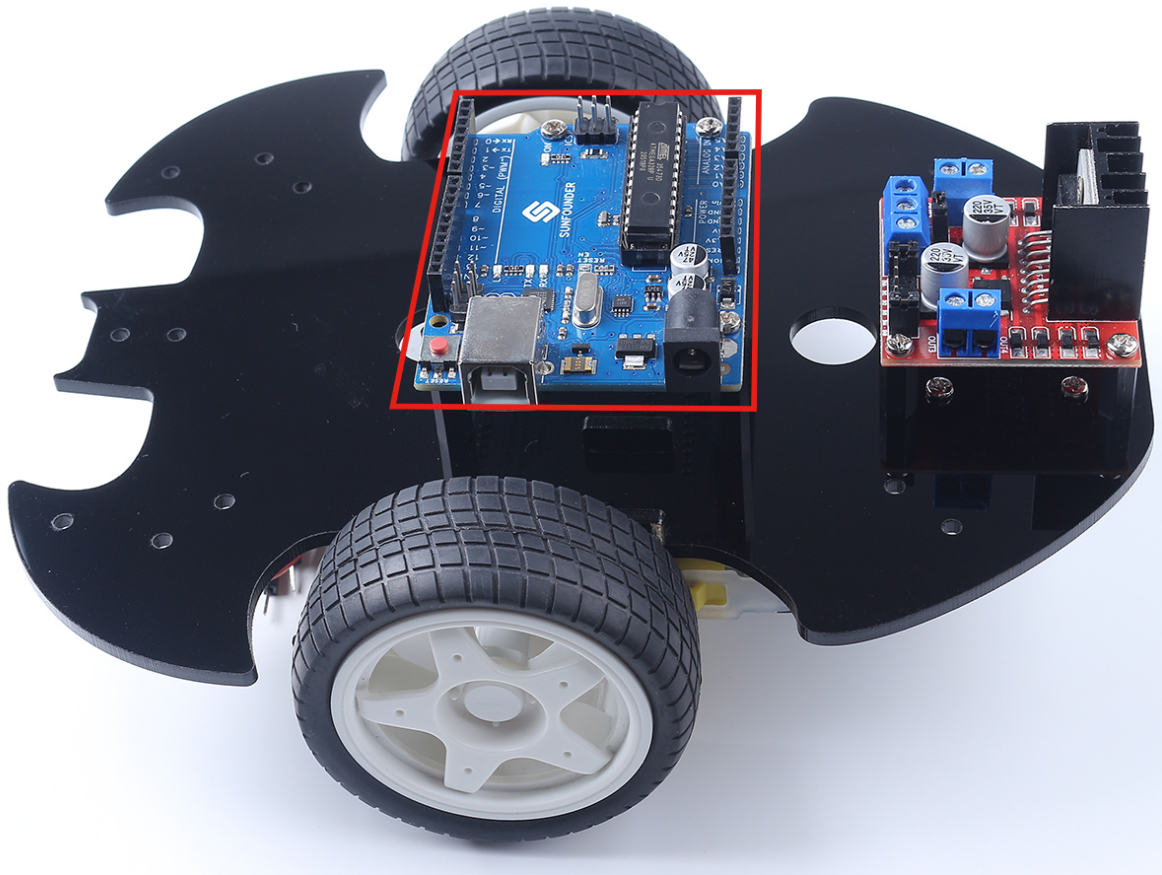


10. Mount the M3x24mm standoff with M3x6mm screws in the position as shown below.

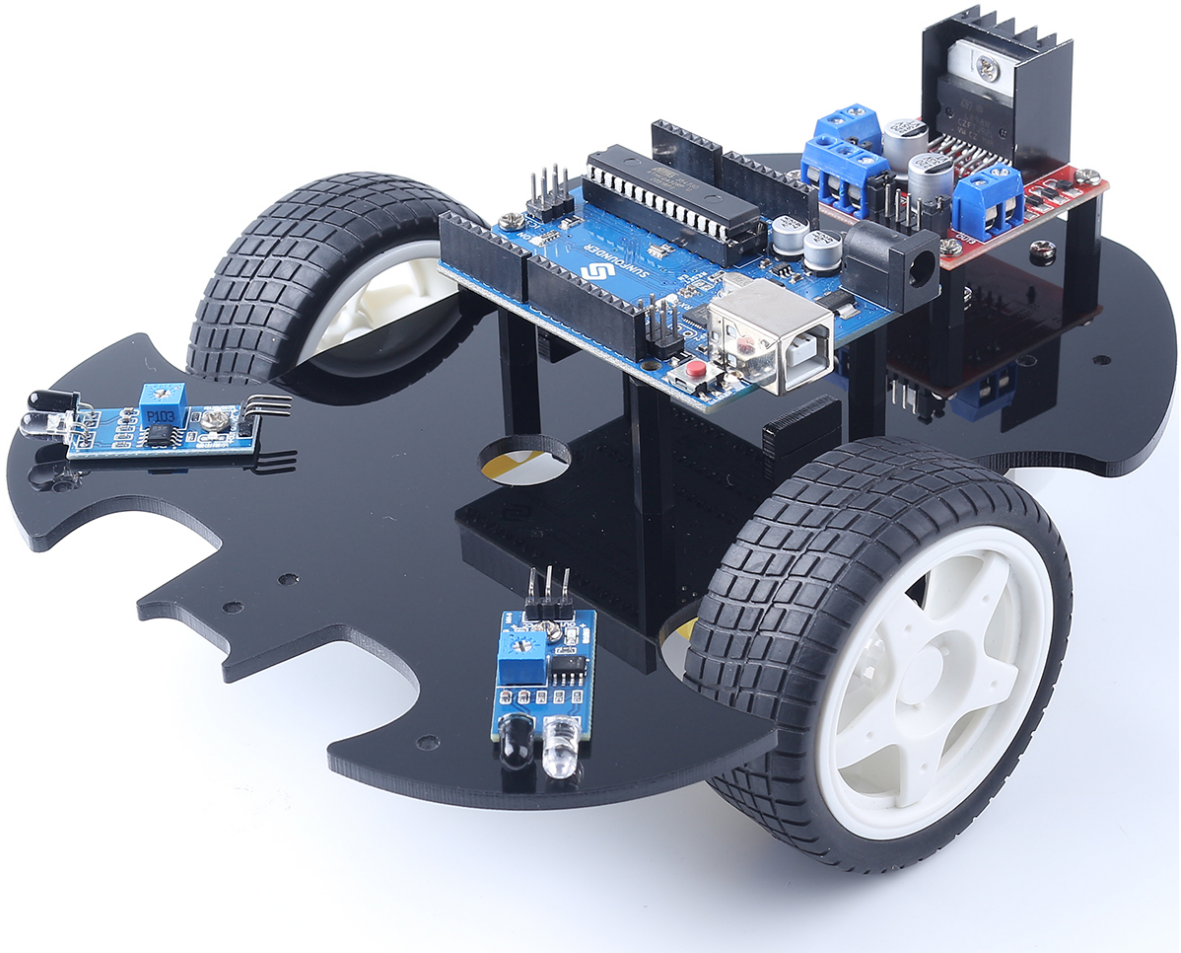




11. Mount the R3 board with M3x6mm screws.

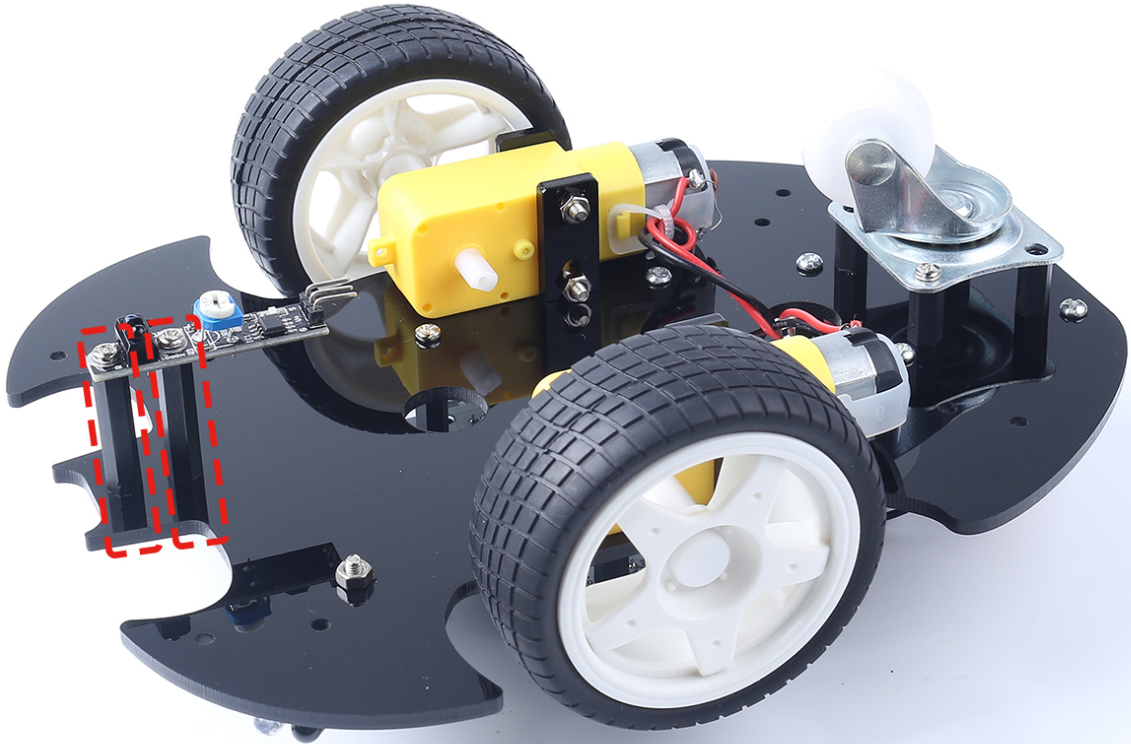


12. Assemble the two IR Obstacle Modules with M3x10mm screws and M3 nuts.

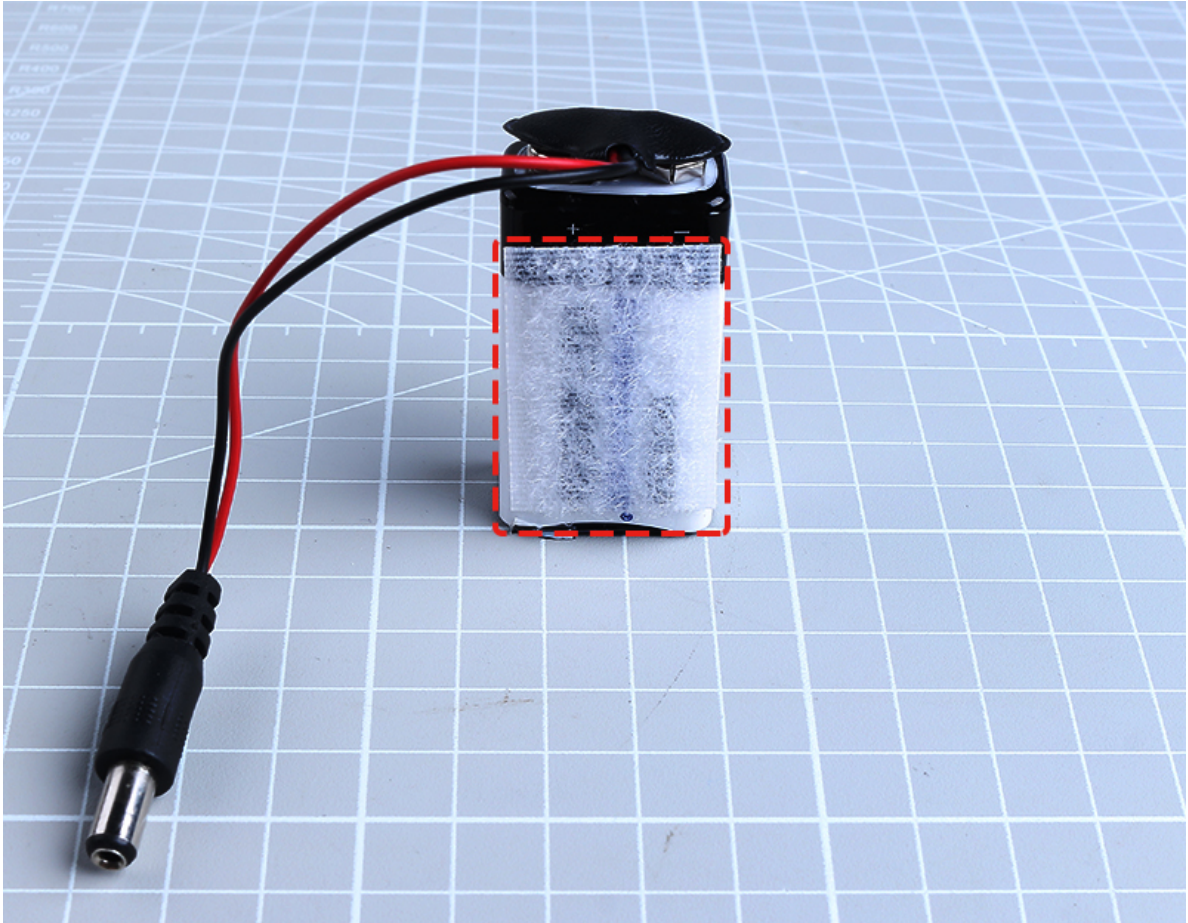


13. Turn to side B and attach the Line Track module with four M3x6mm screws and two M3x24mm standoffs.





14. Stick the velcro on the 9V battery and put on the battery clip.

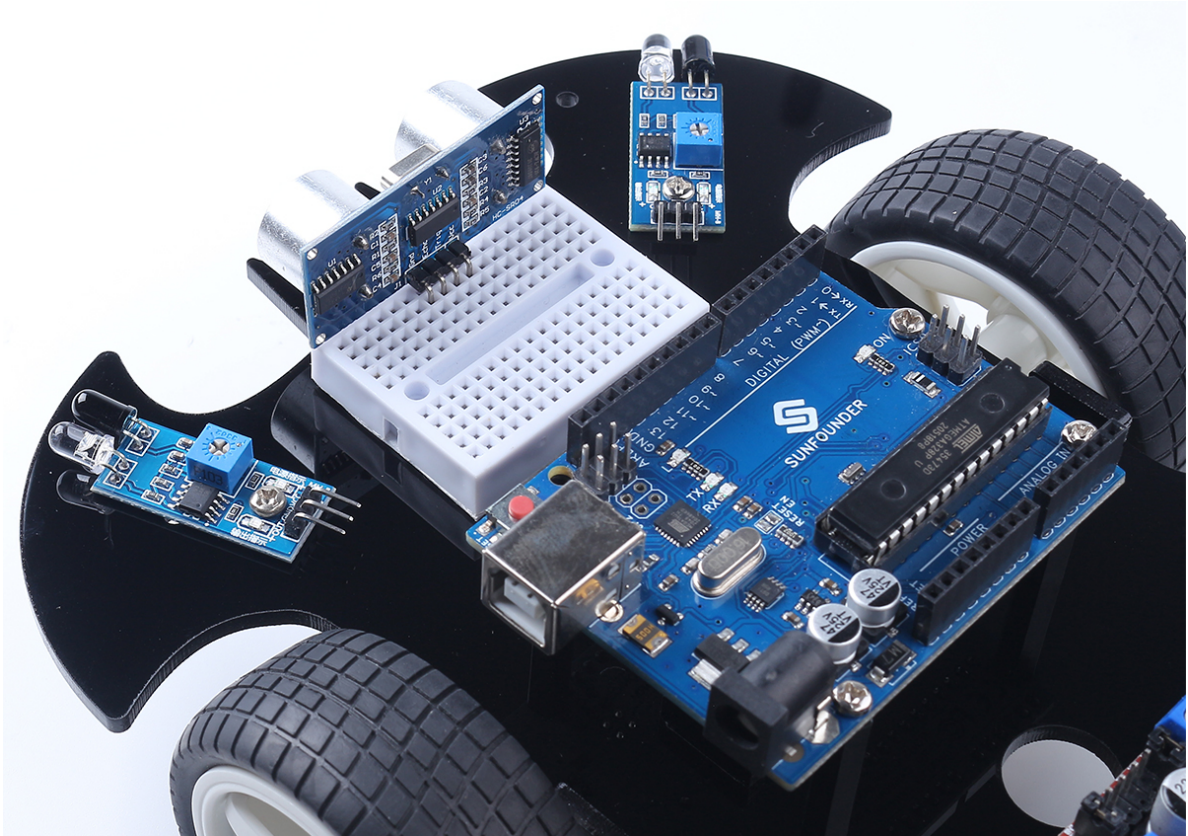


15. Stick the other section of the Velcro on the car to secure the battery.



16. Turn over to side A and attach the breadboard to the front of the car. Thereafter, you will be able to add different components (e.g. ultrasonic module) to the breadboard as required for your project.





17. Getting the car running also requires wiring it up and writing code, which will be written in subsequent sections.

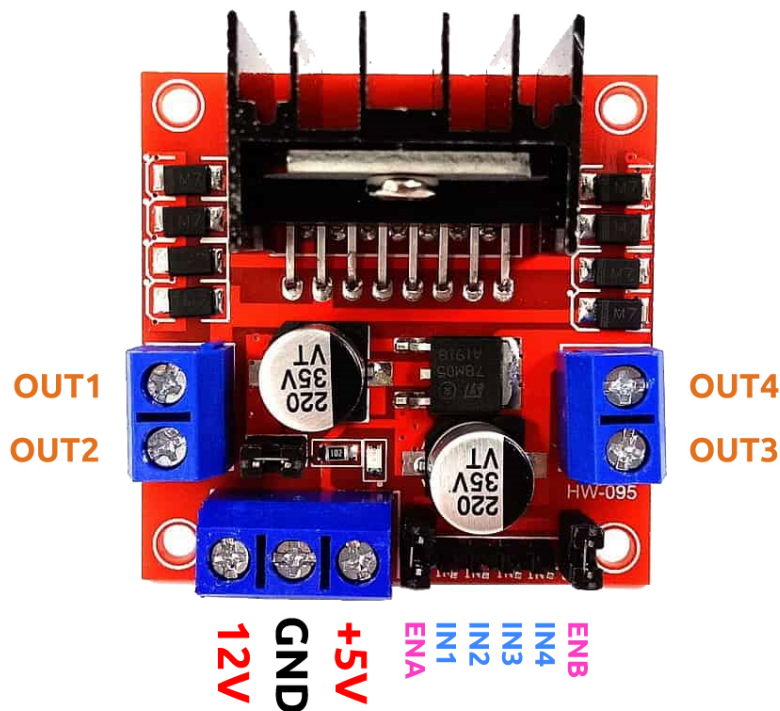
### Projects

Here are some projects for the car, programmed in C with the Arduino IDE, if you are not particularly skilled with Arduino, you can refer to *Get Started with Arduino*.

The following projects are written in order of programming difficulty, it is recommended to read these books in order.

If you want to program a car with Scratch, please refer to: *Play with Scratch*.

5.2 1. Move



Before we start programming, let’s review the working principle of L298N.

IN1~IN4 are the inputs of the L298N module, and OUT1~OUT4 are the outputs.

A simple way to use them is: input high level for IN1, OUT1 will output high level; input low level for IN1, OUT1 will output low level. Connecting the two ends of the motor to OUT1 and OUT2, inputting opposite level signals for IN1 and IN2 will make the motor rotate. OUT3 and OUT4 can be used in the same way.

The working relationship between ENA and IN1,IN2 is as follows.

ENA	IN1	IN2	The state of right motor(A)
0	X	X	Stop
1	0	0	Brake
1	0	1	Rotate clockwise
1	1	0	Rotate counterclockwise
1	1	1	Brake

The working relationship between ENB and IN3,IN4 is as follows.

ENB	IN3	IN4	The state of left motor(B)
0	X	X	Stop
1	0	0	Brake
1	0	1	Rotate clockwise
1	1	0	Rotate counterclockwise
1	1	1	Brake

Required Components



In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

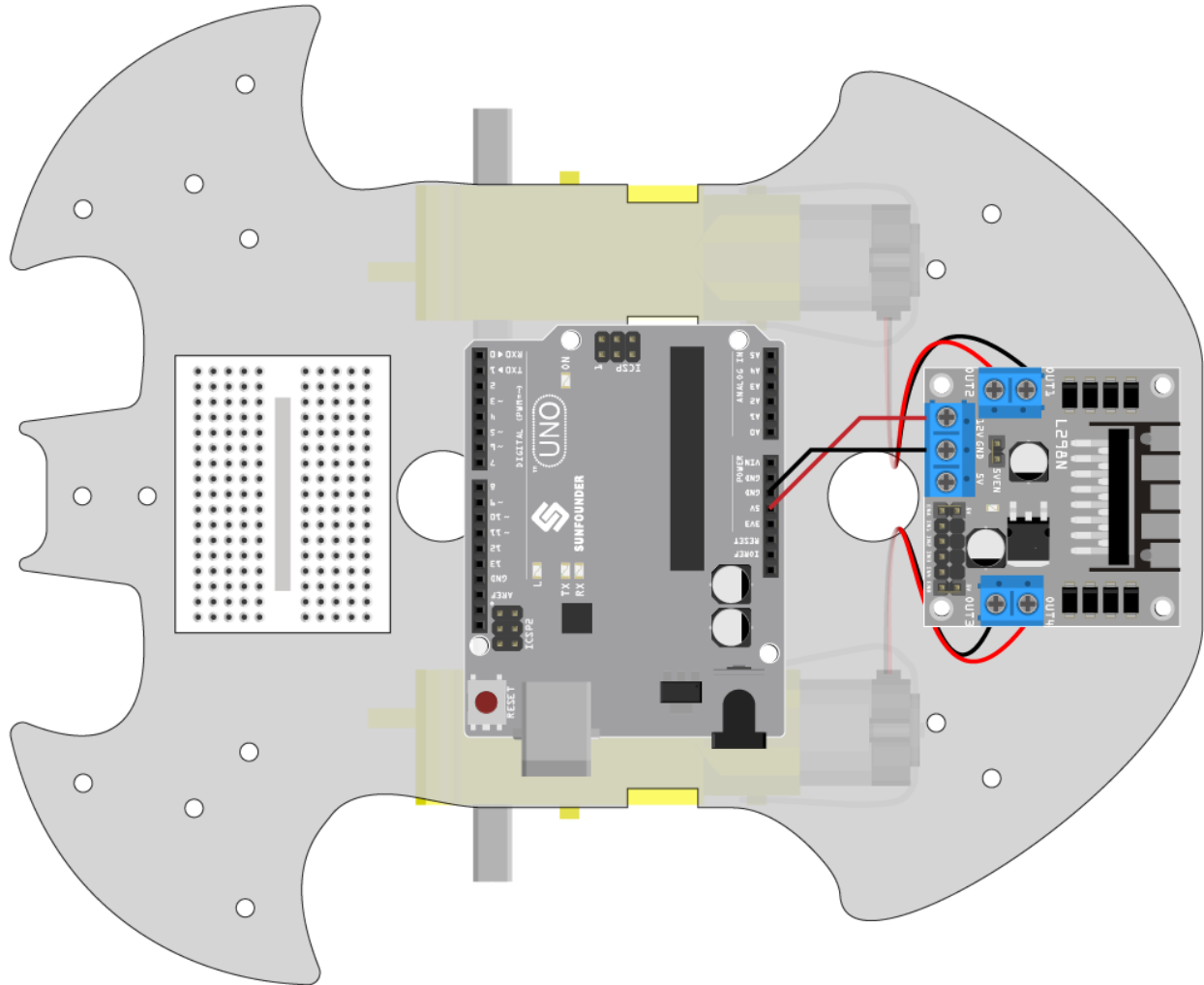
COMPONENT INTRODUCTION	PURCHASE LINK
<a href="#"><i>L298N Module</i></a>	

### Forward

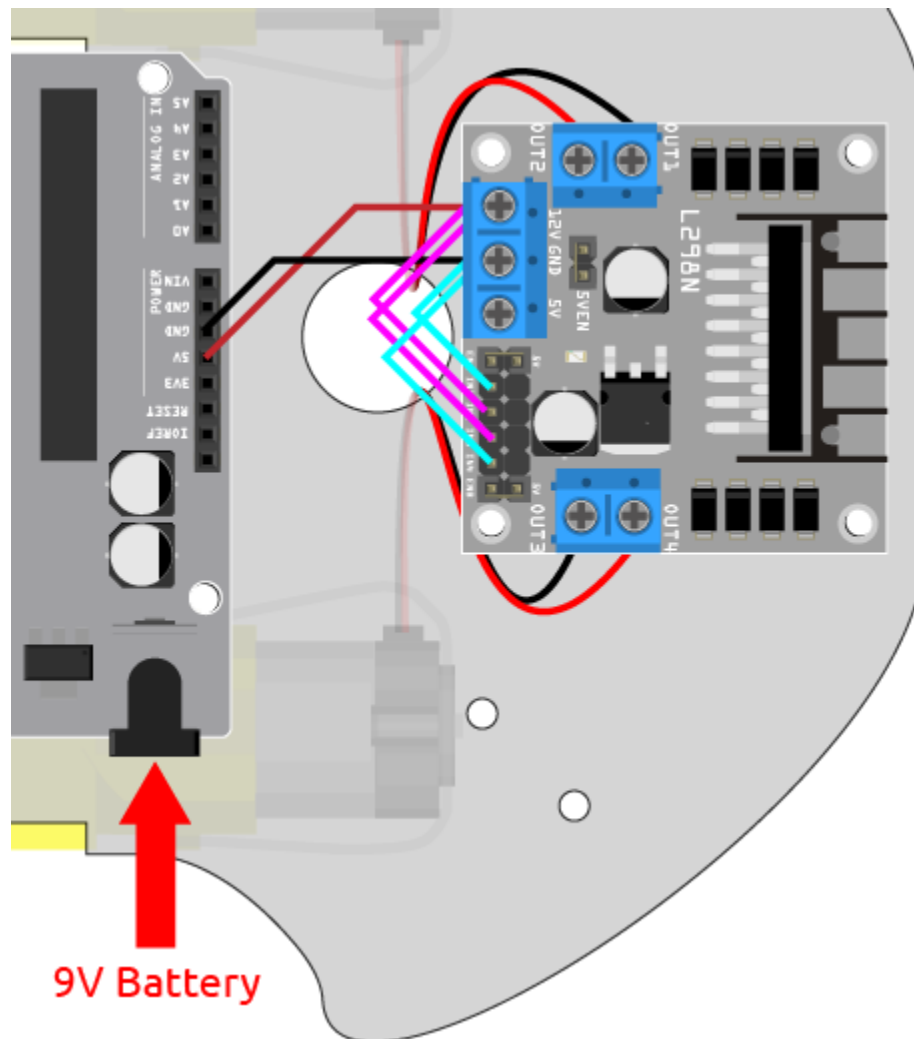
Now let's connect the input of L298N module directly to 12V and GND respectively to make the car move.

1. Connect R3 board, L298N module and 2 motors.

L298N	R3 Board	Motor
12V	5V	
GND	GND	
OUT1		Black wire of right motor
OUT2		Red wire of right motor
OUT3		Black wire of left motor
OUT4		Red wire of left motor



2. Connect IN2 and IN3 to 12V, and IN1 and IN4 to GND, then you will be able to see the car moving forward.



If not both turn forward, but the following situations occur, you need to readjust the wiring of the two motors.

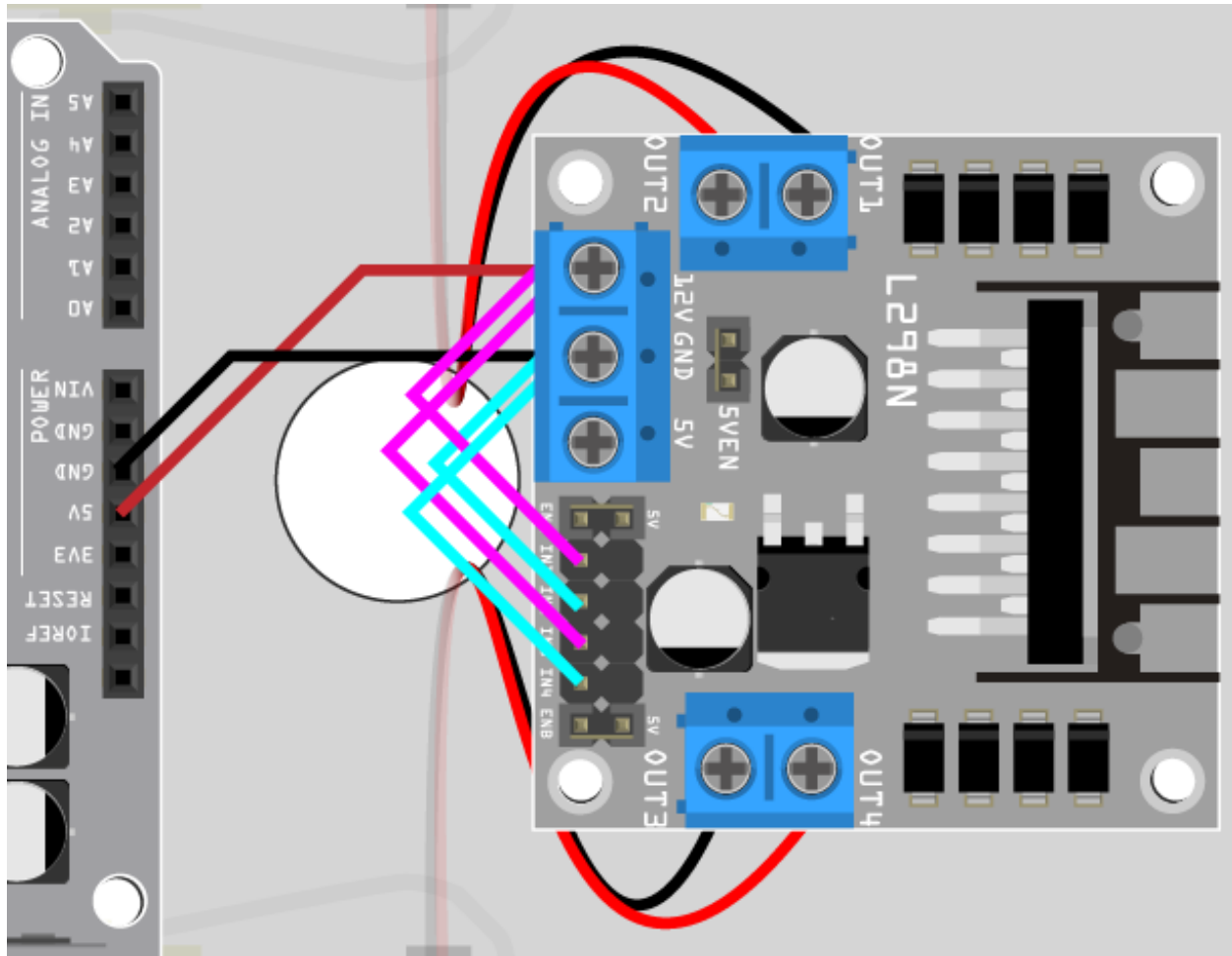
- If both motors turn backward at the same time (left motor turns clockwise, right motor turns counterclockwise), swap the wiring of the left and right motors at the same time, OUT1 and OUT2 swap, OUT3 and OUT4 swap.
- If the left motor turns backward (clockwise rotation), exchange the wiring of OUT3 and OUT4 of the left motor.
- If the right motor turns backward (counterclockwise rotation), swap the wiring of OUT1 and OUT1 of the right motor.

### Backward

Connect IN2 and IN3 to GND, and IN1 and IN4 to 12V, then you will be able to see the car moving backward.







### Stop

To stop the motor, connect the inputs on the same side to 12V or GND at the same time, e.g. connect IN1 and IN2 to 12V or 5V at the same time, and the same for IN3 and IN4.

This is of course theoretical and needed later on when controlling with code. Here remove the power supply to the car can stop it.

## 5.3 2. Move by Code

In the previous project, we have tried to control the operation of the motor by using different level signals for the input of the L298N.

If we modify the level signals through the program, then we can control the movement of the car in a flexible way. Here we connect the pins IN1~IN4 of L298N to pins 5, 6, 9 and 10 on the R3 board in turn.

### Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

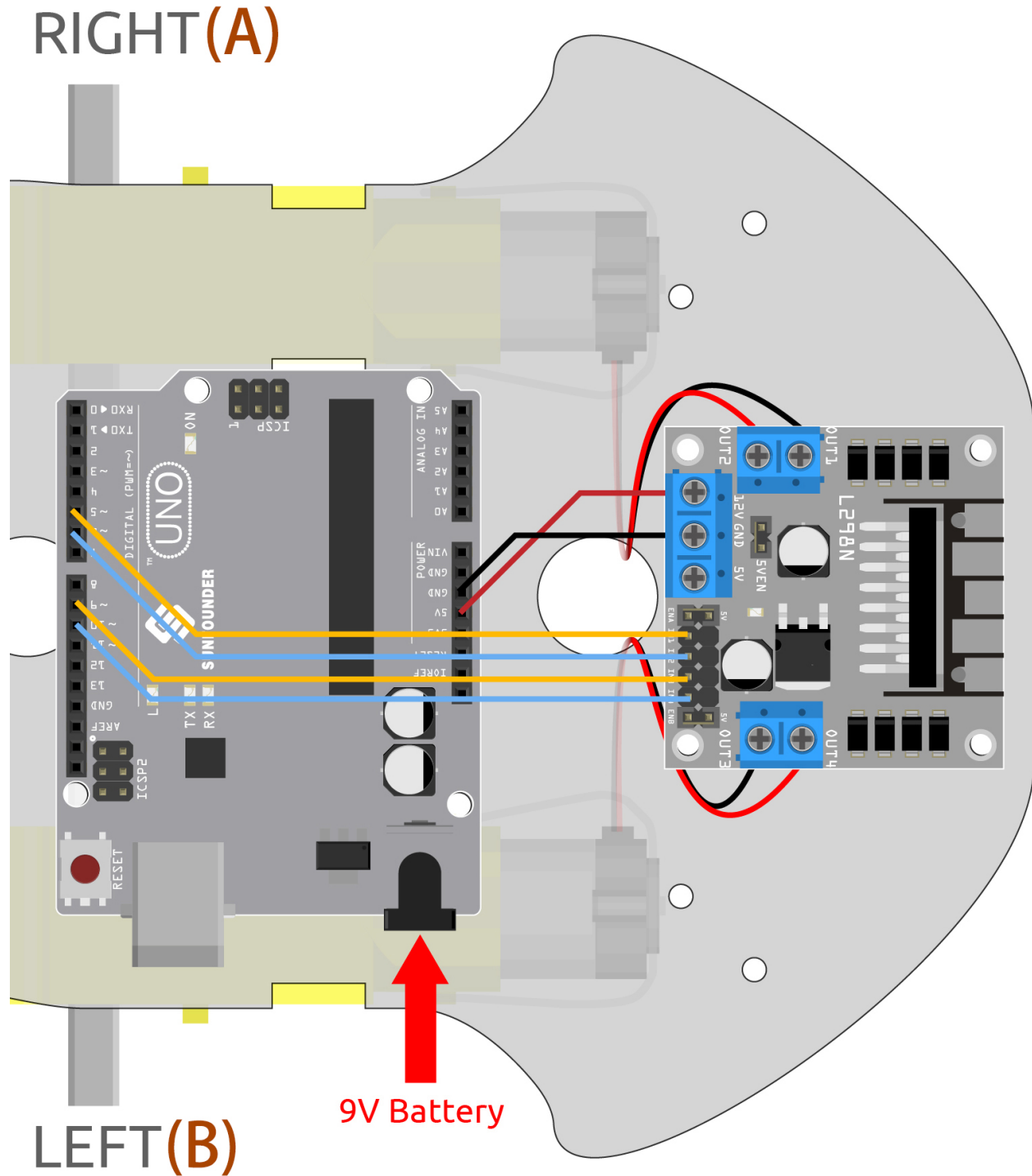
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>L298N Module</i>	
<i>TT Motor</i>	-

### Wiring

The L298N motor driver module is a high power motor driver module for driving DC and stepper motors. The L298N module can control up to 4 DC motors, or 2 DC motors with direction and speed control.

Connect the wires between the L298N module and the R3 board according to the diagram below.

L298N	R3 Board	Motor
IN1	5	
IN2	6	
IN3	9	
IN4	10	
OUT1		Black wire of right motor
OUT2		Red wire of right motor
OUT3		Black wire of left motor
OUT4		Red wire of left motor



### Code

#### Note:

- Open the 2.move.ino file under the path of 3in1-kit\car\_project\2.move.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).



After the code is uploaded, the car will move forward, backward, left and right for two seconds respectively.

### How it works?

This project is basically the same as the previous one, which is to make the car move forward, backward, left and right and stop by giving different levels from IN1 to IN4.

1. Initialize the pin wiring of IN1~IN4.

```
const int in1 = 5;
const int in2 = 6;
const int in3 = 9;
const int in4 = 10;

void setup() {
  pinMode(in1, OUTPUT);
  pinMode(in2, OUTPUT);
  pinMode(in3, OUTPUT);
  pinMode(in4, OUTPUT);
}
```

2. Set IN1~IN4 to different high or low levels to control the rotation of the left and right motors, and then encapsulate them in individual functions.

```
void moveForward() {
  digitalWrite(in1, LOW);
  digitalWrite(in2, HIGH);
  digitalWrite(in3, HIGH);
  digitalWrite(in4, LOW);
}

void moveBackward() {
  digitalWrite(in1, HIGH);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4, HIGH);
}
...
```

3. Call these functions in loop().

```
void loop() {
  moveForward();
  delay(2000);
  stopMove();
  delay(500);

  moveBackward();
  delay(2000);
  stopMove();
  delay(500);
  ...
}
```

- digitalWrite(pin, value)

- **pin**: the Arduino pin number.
- **value**: HIGH or LOW.

Write a HIGH or a LOW value to a digital pin. If the pin has been configured as an OUTPUT with `pinMode()`, its voltage will be set to the corresponding value: 5V (or 3.3V on 3.3V boards) for HIGH, 0V (ground) for LOW.

- `pinMode(pin, mode)`

- **pin**: the Arduino pin number to set the mode of.
- **mode**: INPUT, OUTPUT, or INPUT\_PULLUP.

Configures the specified pin to behave either as an input or an output.

- `delay(ms)`

- **ms**: the number of milliseconds to pause. Allowed data types: unsigned long.

Pauses the program for the amount of time (in milliseconds) specified as parameter. (There are 1000 milliseconds in a second.)

## 5.4 3. Speed Up

In addition to the digital signal (HIGH/LOW), the input of L298N can also receive PWM signal to control the speed of the output.

In other words, we can use `AnalogWrite()` to control the moving speed of the car.

In this project, we let the car gradually change its forward speed, first accelerating and then decelerating.

### Wiring

This project is the same wiring as 2. *Move by Code*.

### Code

---

#### Note:

- Open the `3.speed_up.ino` file under the path of `3in1-kit\car_project\3.speed_up`.
  - Or copy this code into **Arduino IDE**.
  - Or upload the code through the [Arduino Web Editor](#).
- 

After the program runs, the car will gradually accelerate and then gradually decelerate.

#### How it works?

The purpose of this project is to write different PWM values to IN1~IN4 to control the forward speed of the car.

1. Use the `for()` statement to give speed in steps of 5, writing values from 0 to 255 so you can see the change in the car's forward speed.

```
void loop() {  
    for(int i=0;i<=255;i+=5){  
        moveForward(i);  
        delay(500);  
    }  
    for(int i=255;i>=0;i-=5){
```

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(continued from previous page)

```

        moveForward(i);
        delay(500);
    }
}

```

## 2. About the moveForward() function.

As opposed to 2. *Move by Code* which directly gives high/low levels to IN1~IN4, here we pass a parameter speed to where we need to give high levels.

```

void moveForward(int speed) {
    analogWrite(in1, 0);
    analogWrite(in2, speed);
    analogWrite(in3, speed);
    analogWrite(in4, 0);
}

```

- for

The for statement is used to repeat a block of statements enclosed in curly braces. An increment counter is usually used to increment and terminate the loop.

```

for (initialization; condition; increment) {
    // statement(s);
}

```

- **initialization:** happens first and exactly once.
- **condition:** each time through the loop, condition is tested; if it's true, the statement block, and the increment is executed, then the condition is tested again. When the condition becomes false, the loop ends.
- **increment:** executed each time through the loop when condition is true.

## 5.5 4. Follow the line

The car is equipped with a Line Track module, which can be used to make the car follow the black line.

When the line following module detects the black line, the right motor rotates while the left motor does not, so that the car moves one step to the left front. As the car moves, the line module will be moved out of the line, then the left motor turns and the right motor does not turn, the car will move one step to the right to return to the line. Repeat the above two steps, the car can move along the black line.

Before starting the project, you need to build a curve map with black line tape, the recommended line width is between 0.8-1.5cm and the angle of the turn should not be less than 90 degrees.

### Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

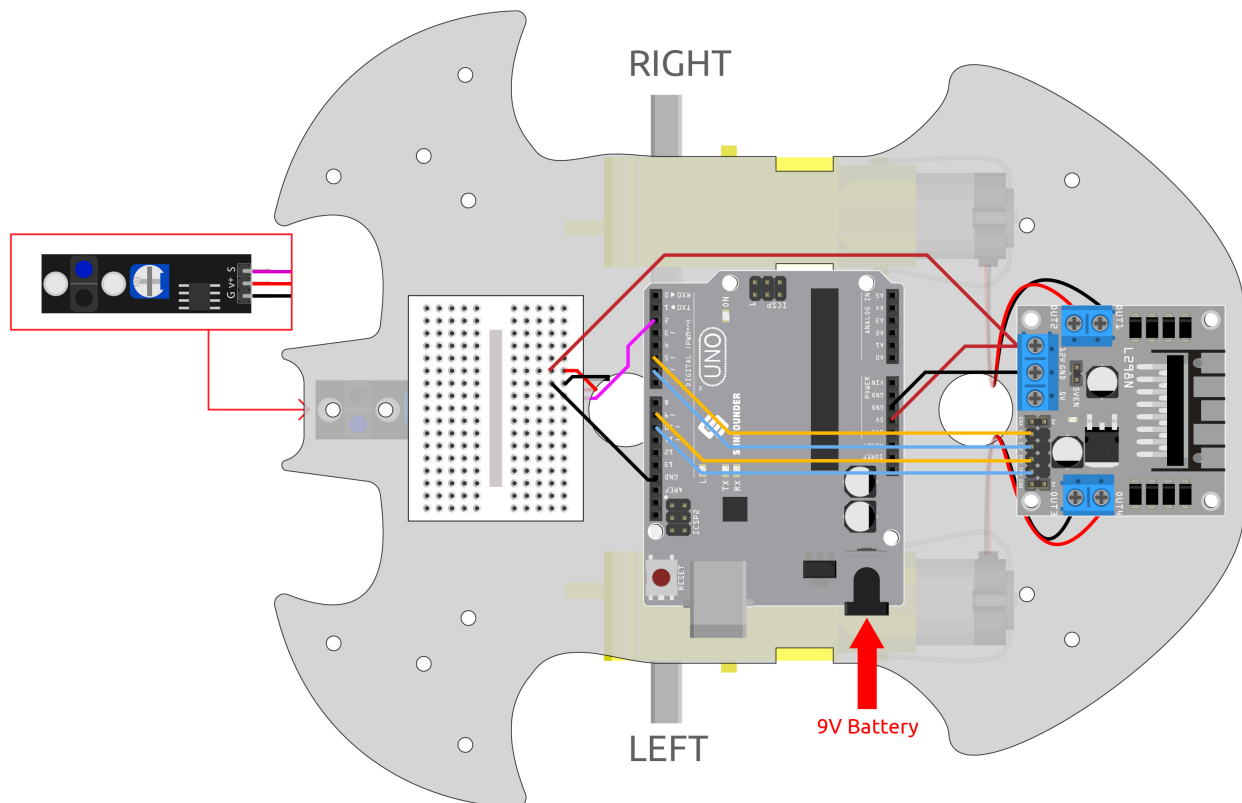
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>L298N Module</i>	
<i>TT Motor</i>	-
<i>Line Tracking Module</i>	

### Wiring

This is a digital Line Tracking module, when a black line is detected, it outputs 1; when a white line is detected, it outputs a value of 0. In addition, you can adjust its sensing distance through the potentiometer on the module.

Build the circuit according to the following diagram.

Line Tracking Module	R3 Board
S	2
V+	5V
G	GND



### Adjust the Module

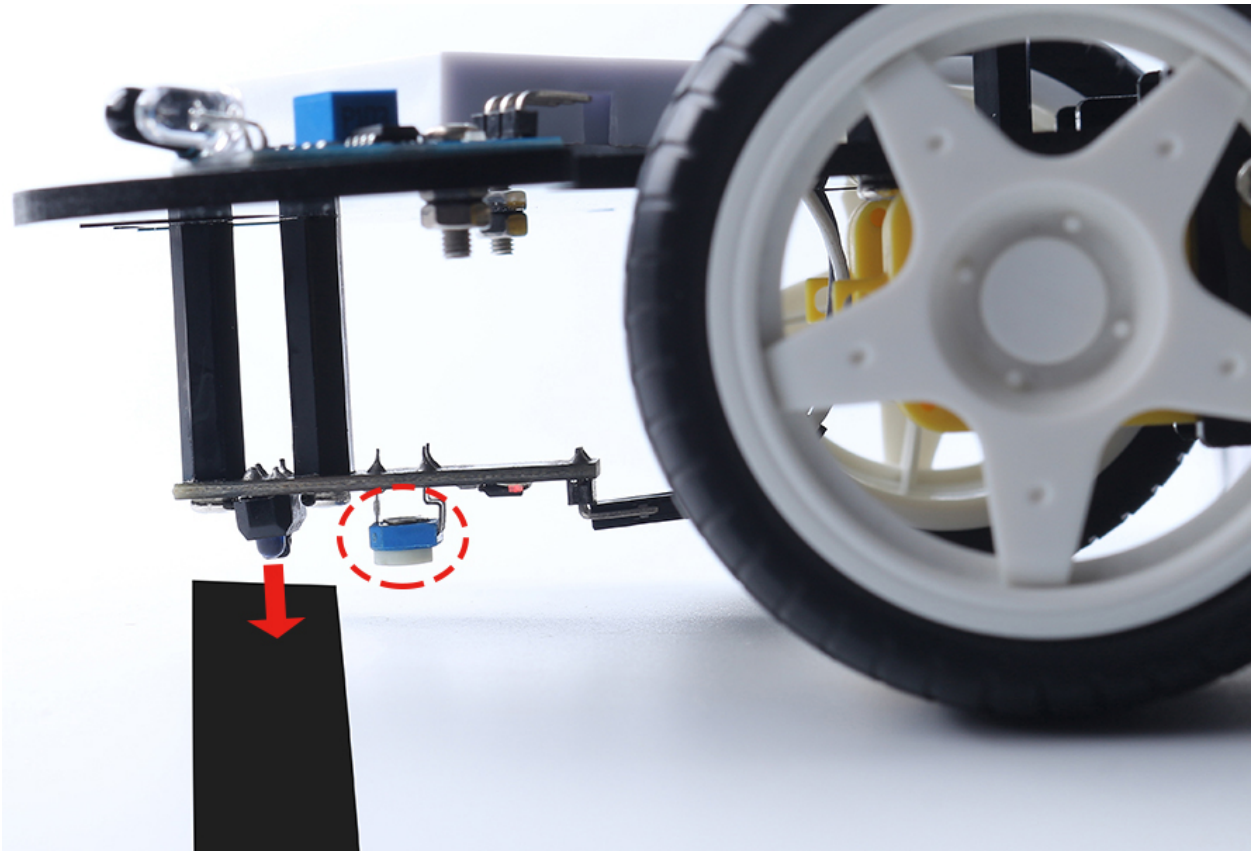
Before starting the project, you need to adjust the sensitivity of the module.

Wiring according to the above diagram, then power up the R3 board (either directly into the USB cable or the 9V battery button cable), without uploading the code.

Stick a black electrical tape on the table and put the cart on it.

Observe the signal LED on the module to make sure it lights up on the white table and goes off on the black tape.

If not, you need to adjust the potentiometer on the module, so that it can do the above effect.



## Code

### Note:

- Open the `4.follow_the_line.ino` file under the path of `3in1-kit\car_project\4.follow_the_line`.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

After uploading the code to the R3 board, then align the Line Tracking module under the car with the black line, and you will see the car following the line.

### How it works?

In this code, it is letting the two motors micro-rotate left and right according to the value of the Line Track module so that you can see the car following the black line.

1. Add the pin definition for the Line Tracking module, here it is set to `INPUT`. Here also initialize the serial monitor and set the baud rate to 9600bps.

```
...  
const int lineTrack = 2;
```

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```
Serial.begin(9600);
void setup() {
  ...
  pinMode(lineTrack, INPUT);
}
```

2. Read the value of the Line Tracking module, if it is 1, then let the car go forward to the left; otherwise go forward to the right. Also you can open the serial monitor by clicking the magnifying glass icon in the upper right corner to see the change of the Line Tracking module value on the black and white line before unplugging the USB cable.

```
void loop() {

  int speed = 150;

  int lineColor = digitalRead(lineTrack); // 0:white    1:black
  Serial.println(lineColor);
  if (lineColor) {
    moveLeft(speed);
  } else {
    moveRight(speed);
  }
}
```

3. About the `moveLeft()` and `moveRight()` functions.

Unlike the left-right turn function in project 2. *Move by Code*, only small left-right turns are needed here, so you only need to adjust the value of IN2 or IN3 each time. For example, if you move to the left front (`moveLeft()`), you only need to set the speed to IN2 and all others to 0, it will make the right motor turn clockwise and the left motor not move.

```
void moveLeft(int speed) {
  analogWrite(in1, 0);
  analogWrite(in2, speed);
  analogWrite(in3, 0);
  analogWrite(in4, 0);
}

void moveRight(int speed) {
  analogWrite(in1, 0);
  analogWrite(in2, 0);
  analogWrite(in3, speed);
  analogWrite(in4, 0);
}
```

- **Serial**

Used for communication between the Arduino board and a computer or other devices

- `Serial.begin()`: Sets the data rate in bits per second (baud) for serial data transmission.
- `Serial.println()`: Prints data to the serial port as human-readable ASCII text followed by a car return character (ASCII 13, or 'r') and a newline character (ASCII 10, or 'n').

- **if else**

The `if else` allows greater control over the flow of code than the basic `if` statement, by allowing multiple tests to be grouped.

## 5.6 5. Play with Obstacle Avoidance Module

Two infrared obstacle avoidance modules are mounted on the front of the car, which can be used to detect some close obstacles.

In this project, the car is allowed to move forward freely, and when it encounters an obstacle it is able to avoid it and continue to move in other directions.

### Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>L298N Module</i>	
<i>TT Motor</i>	-
<i>Obstacle Avoidance Module</i>	

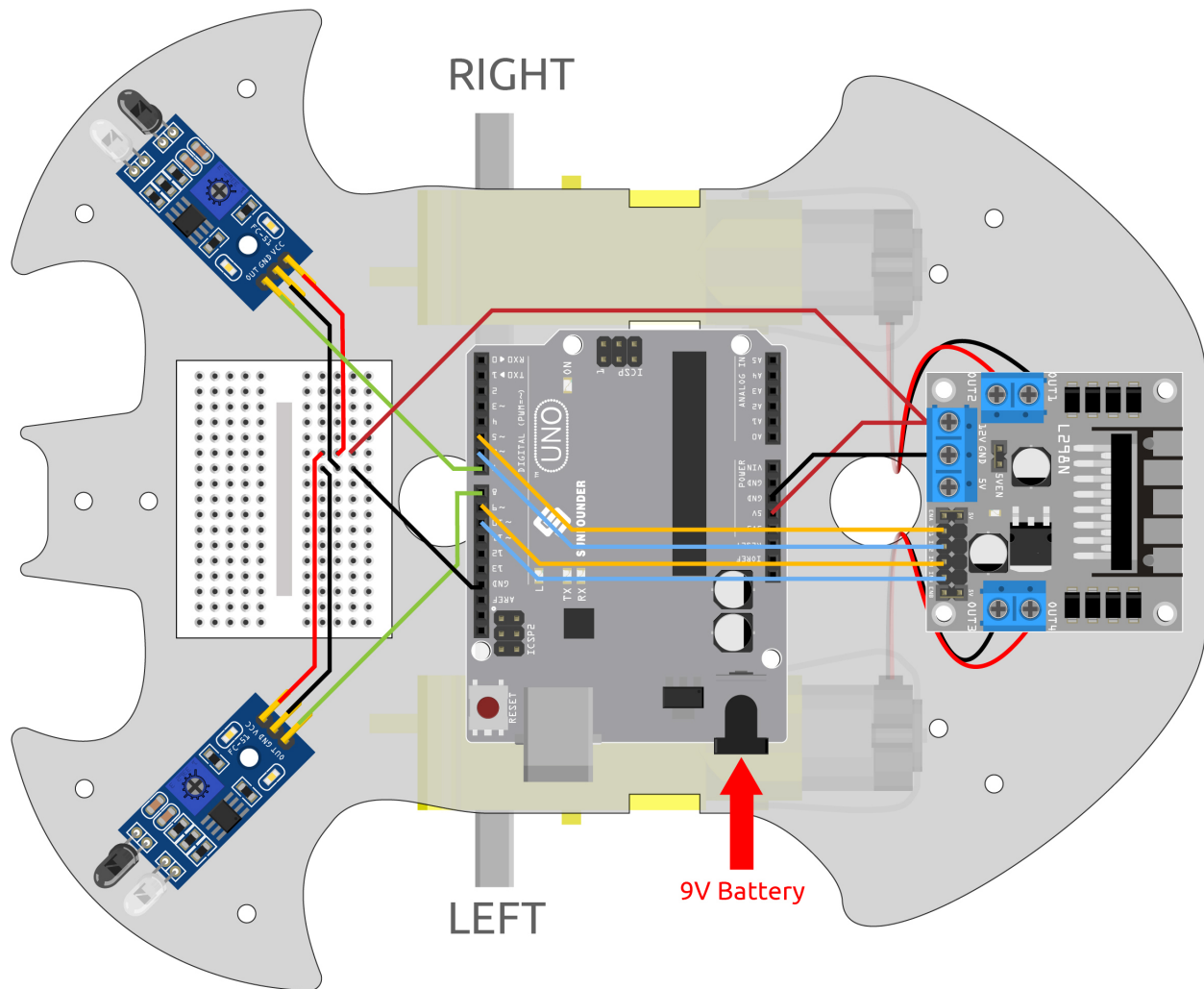
### Wiring

The obstacle avoidance module is a distance-adjustable infrared proximity sensor whose output is normally high and low when an obstacle is detected.

Now build the circuit according to the diagram below.

Left IR Module	R3 Board
OUT	8
GND	GND
VCC	5V

Right IR Module	R3 Board
OUT	7
GND	GND
VCC	5V



### Adjust the Module

Before starting the project, you need to adjust the detection distance of the module.

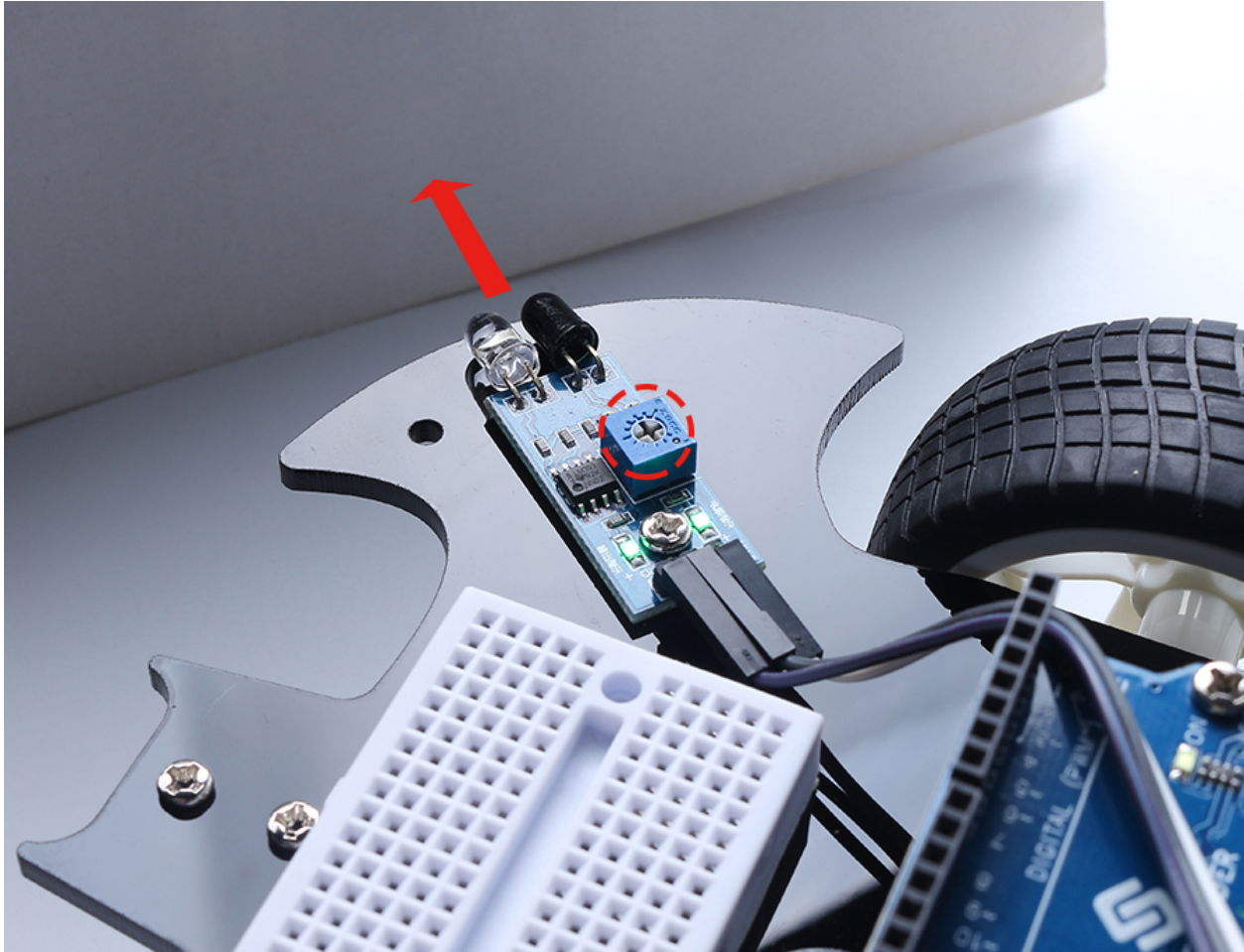
Wiring according to the above diagram, power up the R3 board (either by plugging in the USB cable directly or by snapping the 9V battery cable), without uploading the code.

Place a notebook or any other flat object about 5cm in front of the IR obstacle avoidance.

Then use a screwdriver to rotate the potentiometer on the module until the signal indicator on the module just lights up, so as to adjust its maximum detection distance of 5cm.

Follow the same method to adjust another infrared module.





### Code

#### Note:

- Open the 5.obstacle\_avoidance\_module.ino file under the path of 3in1-kit\car\_project\5.obstacle\_avoidance\_module.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

The car will move forward once the code has been successfully uploaded. When the left infrared module detects an obstacle, it will go backwards to the left; when the right infrared module detects an obstacle, it will go backwards to the right; if both sides detect an obstacle, it will go backwards squarely.

#### How it works?

This project is based on the value of the left and right infrared obstacle avoidance modules to make the car make the appropriate action.

1. Add the pin definition for the 2 obstacle avoidance modules, here they are set to INPUT.

```
...  
const int rightIR = 7;  
const int leftIR = 8;
```

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```

void setup() {
  ...

  //IR obstacle
  pinMode(leftIR, INPUT);
  pinMode(rightIR, INPUT);
}

```

2. Read the values of the left and right infrared modules and let the car to make the corresponding action.

```

void loop() {

  int left = digitalRead(leftIR);  // 0: Obstructed  1: Empty
  int right = digitalRead(rightIR);
  int speed = 150;

  if (!left && right) {
    backLeft(speed);
  } else if (left && !right) {
    backRight(speed);
  } else if (!left && !right) {
    moveBackward(speed);
  } else {
    moveForward(speed);
  }
}

```

- If the left IR module is 0 (obstacle detected) and the right IR module is 1, let the car back up to the left.
- If the right IR module is 0 (obstacle detected), let the car go back up to the right.
- If 2 IR modules detect the obstacle at the same time, the car will go backward.
- Otherwise the car will keep going forward.

3. About the backLeft() function.

When the right motor is turning counterclockwise and the left motor is not turning, the car will go backward to the left.

```

void backLeft(int speed) {
  analogWrite(in1, speed);
  analogWrite(in2, 0);
  analogWrite(in3, 0);
  analogWrite(in4, 0);
}

```

4. About the backRight() function.

When the left motor is turning clockwise and the right motor is not turning, the car will go backward to the right.

```

void backRight(int speed) {
  analogWrite(in1, 0);

```

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```

analogWrite(in2, 0);
analogWrite(in3, 0);
analogWrite(in4, speed);
}

```

- **&&**: Logical AND results in true only if both operands are true.
- **!**: Logical NOT results in a true if the operand is false and vice versa.

## 5.7 6. Play with Ultrasonic Module

In *5. Play with Obstacle Avoidance Module* project, the 2 infrared obstacle avoidance modules are used for obstacle avoidance, but the detection distance of IR obstacle avoidance module is short, which may make the car too late to avoid the obstacles.

In this project, we use ultrasonic module to do some long-distance detection, so that the car can sense obstacles at a farther distance to make a judgment.

### Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

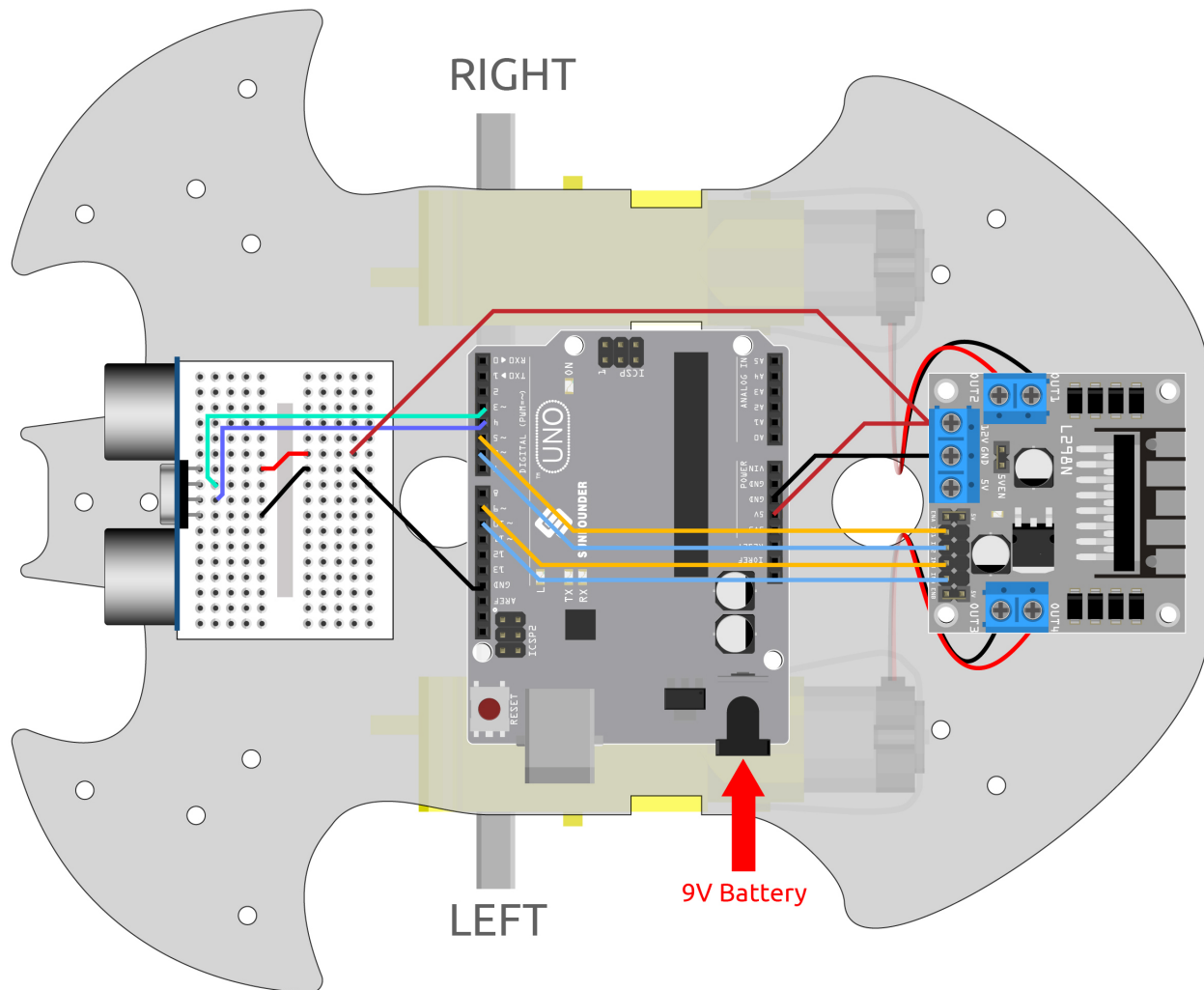
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>L298N Module</i>	
<i>TT Motor</i>	-
<i>Ultrasonic Module</i>	

### Wiring

An ultrasonic sensor module is an instrument that measures the distance to an object using ultrasonic sound waves. It has two probes. One is to send ultrasonic waves and the other is to receive the waves and transform the time of sending and receiving into a distance, thus detecting the distance between the device and an obstacle.

Now build the circuit according to the following diagram.

Ultrasonic Module	R3 Board
Vcc	5V
Trig	3
Echo	4
Gnd	GND



## Code

### Note:

- Open the 6.ultrasonic\_module.ino file under the path of 3in1-kit\car\_project\6.ultrasonic\_module.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

After the code is successfully uploaded, turn the car towards the wall. If the distance is too far, it will move forward; if it is too close, it will move backward; if it is at a safe distance, it will stop.

### How it works?

This project is based on the distance read by the ultrasonic module to make the car move accordingly.

1. Add the pin definition for the ultrasonic module, `trigPin` is used to transmit ultrasonic wave, so set it to OUTPUT; `echoPin` is set to INPUT to receive ultrasonic wave.

```
...
const int trigPin = 3;
```

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```

const int echoPin = 4;

void setup() {
  ...

  //ultrasonic
  pinMode(echoPin, INPUT);
  pinMode(trigPin, OUTPUT);
}

```

2. First read the distance value obtained from the ultrasonic module, if the distance is greater than 25, let the car move forward; if the distance is between 2-10cm, let the car move backward, otherwise (between 10~25) stop.

```

void loop() {
  float distance = readSensorData();
  if (distance > 25) {
    moveForward(200);
  }
  else if (distance < 10 && distance > 2) {
    moveBackward(200);
  } else {
    stopMove();
  }
}

```

3. About readSensorData() function.

The transmitter of the ultrasonic module transmits a 10us square wave signal every 2us, and the receiver receives a high level signal if there is an obstacle within the range. Use the pulseIn() function to record the time from sending to receiving, divide by the speed of sound 340m/s, and then divide by 2, the result is the distance between this module and the obstacle with units: cm.

```

float readSensorData() {
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  float distance = pulseIn(echoPin, HIGH) / 58.00; //Equivalent to (340m/
↪ S*1us)/2
  return distance;
}

```

- pulseIn(pin, value)
  - pin: the number of the Arduino pin on which you want to read the pulse. Allowed data types: int.
  - value: type of pulse to read: either HIGH or LOW. Allowed data types: int.

Reads a pulse (either HIGH or LOW) on a pin. For example, if value is HIGH, pulseIn() waits for the pin to go from LOW to HIGH, starts timing, then waits for the pin to go LOW and stops timing.

## 5.8 7. Follow Your Hand

Think of this car as your pet here, and when you will wave to him, it comes running to you.

### Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>L298N Module</i>	
<i>TT Motor</i>	-
<i>Ultrasonic Module</i>	
<i>Obstacle Avoidance Module</i>	

### Wiring

Connect the ultrasonic module and the 2 IR obstacle avoidance modules at the same time.

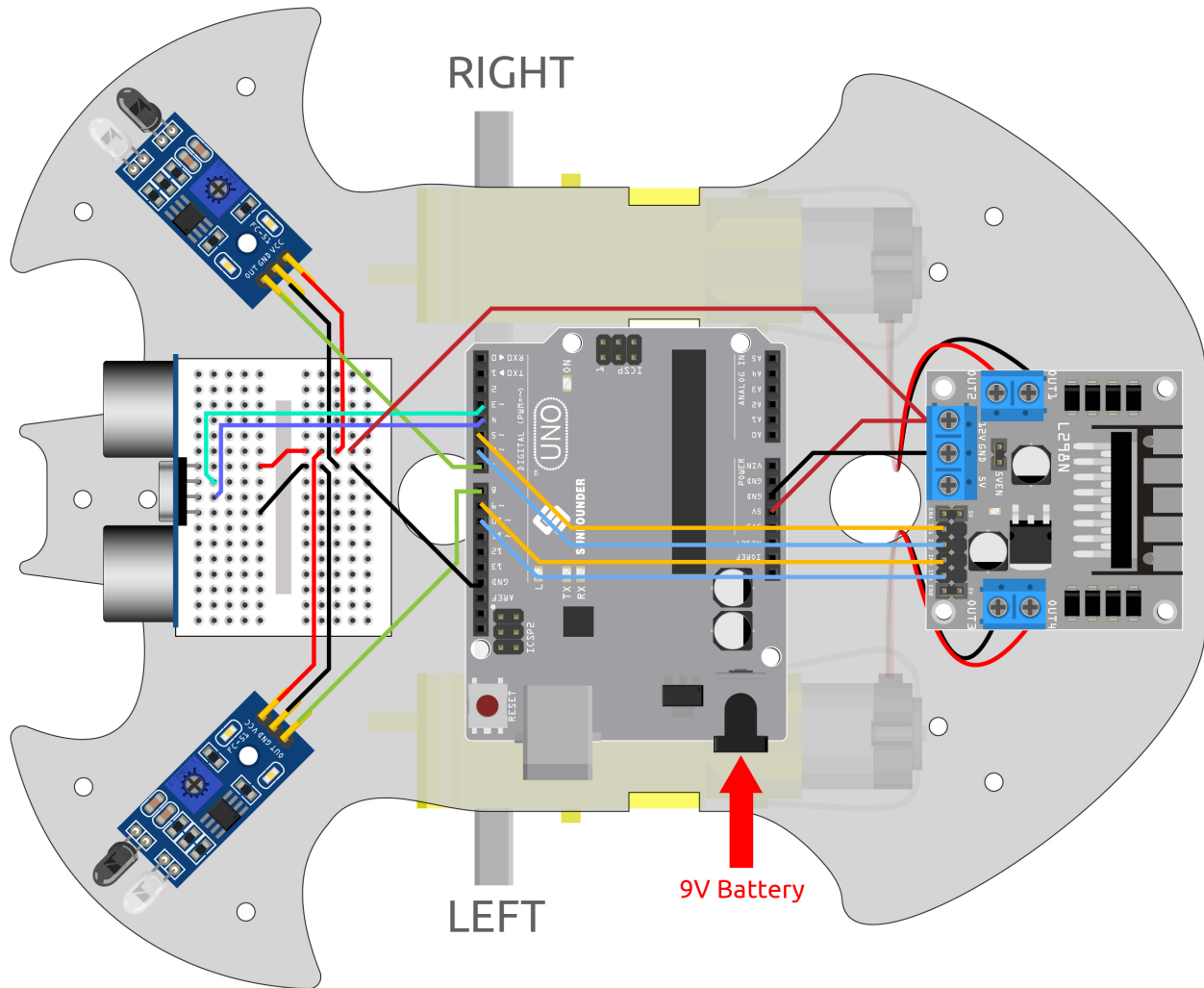
Wire the ultrasonic to the R3 board as follows.

Ultrasonic Module	R3 Board
Vcc	5V
Trig	3
Echo	4
Gnd	GND

The wiring of the 2 IR obstacle avoidance modules to the R3 board is as follows.

Left IR Module	R3 Board
OUT	8
GND	GND
VCC	5V

Right IR Module	R3 Board
OUT	7
GND	GND
VCC	5V



### Code

#### Note:

- Open the `7. follow_your_hand.ino` file under the path of `3in1-kit\car_project\7. follow_your_hand`.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

Place the car on the ground after the code has been uploaded successfully. Place your hand close to 5\*10cm in front of the car, and it will follow your hand forward. If you put your hand close to the IR Obstacle module on both sides, it will also turn to the corresponding direction.

#### How it works?

This project is a combination of the previous two projects [6. Play with Ultrasonic Module](#) and [5. Play with Obstacle Avoidance Module](#), but the implemented effect is different. The previous 2 projects are detecting an obstacle backwards, but here it is detecting that your hand will follow the forward or turn direction. The workflow of this project is as follows.

- Read the distance detected by the ultrasonic module and the value of both infrared modules.
- If the distance is 5~10cm, let the car move with your hand.

- If the left IR module detects your hand, turn left.
- If the right IR module detects your hand, turn right.
- If neither the infrared module nor the ultrasonic module detects your hand, let the car stop.

```
void loop() {

    float distance = readSensorData();

    int left = digitalRead(leftIR);    // 0: Obstructed  1: Empty
    int right = digitalRead(rightIR);
    int speed = 150;

    if (distance>5 && distance<10){
        moveForward(speed);
    }
    if(!left&&right){
        turnLeft(speed);
    }else if(left&&!right){
        turnRight(speed);
    }else{
        stopMove();
    }
}
```

## 5.9 8. Self-Driving Car

This project is a combination of the two projects *6. Play with Ultrasonic Module* and *5. Play with Obstacle Avoidance Module*. 2 infrared obstacle avoidance modules do short distance or edge detection, and ultrasonic modules do long distance detection to confirm that the car does not hit an obstacle during the free driving process.

### Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>L298N Module</i>	
<i>TT Motor</i>	-
<i>Ultrasonic Module</i>	
<i>Obstacle Avoidance Module</i>	



## Wiring

Connect the ultrasonic module and the 2 IR obstacle avoidance modules at the same time.

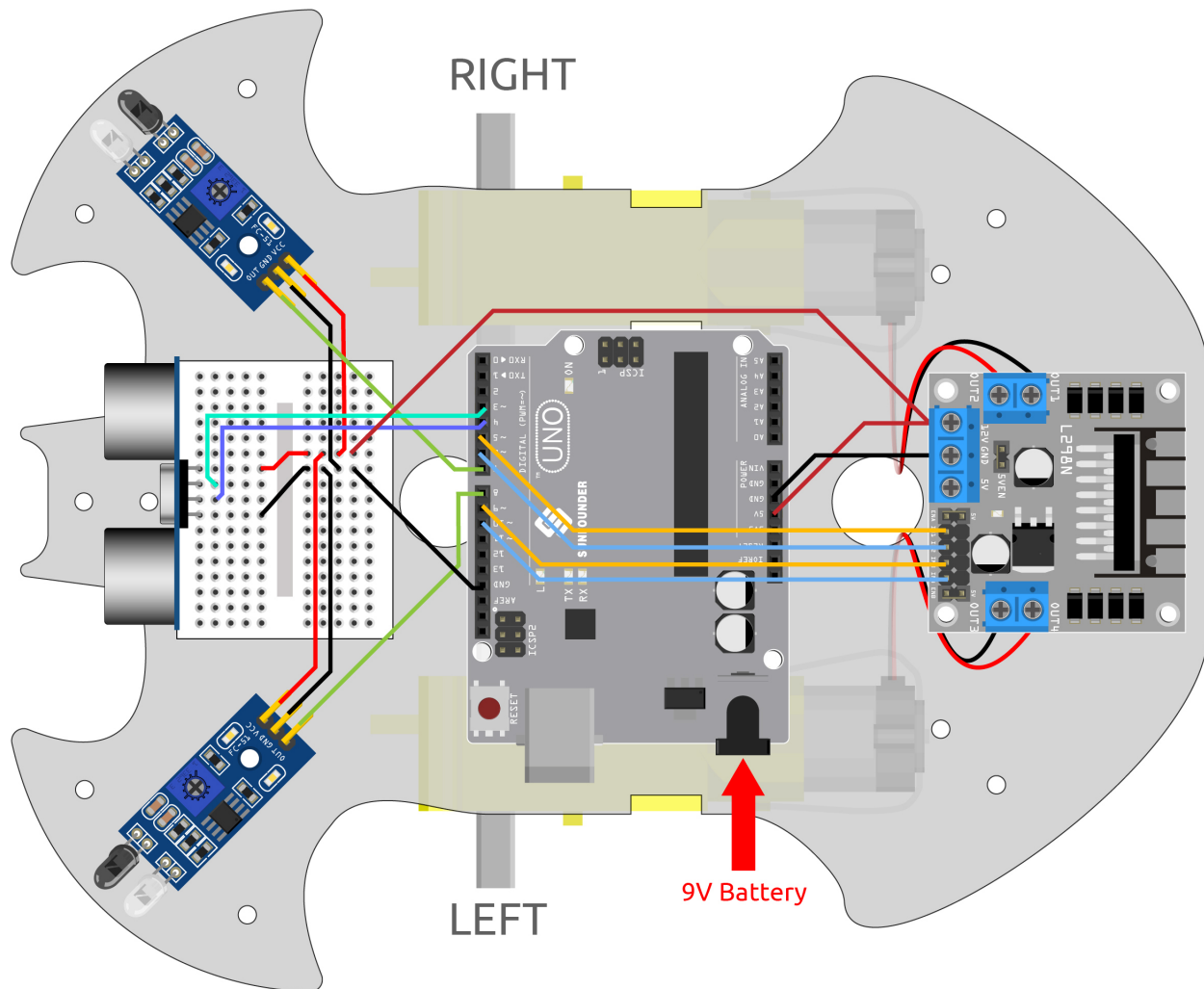
Wire the ultrasonic to the R3 board as follows.

Ultrasonic Module	R3 Board
Vcc	5V
Trig	3
Echo	4
Gnd	GND

The wiring of the 2 IR obstacle avoidance modules to the R3 board is as follows.

Left IR Module	R3 Board
OUT	8
GND	GND
VCC	5V

Right IR Module	R3 Board
OUT	7
GND	GND
VCC	5V



## Code

### Note:

- Open the `8.self_driving_car.ino` file under the path of `3in1-kit\car_project\8.self_driving_car`.
- Or copy this code into **Arduino IDE**.
- Or upload the code through the [Arduino Web Editor](#).

The car will drive freely once the code has been uploaded successfully. When the IR obstruction module on both sides detects an obstacle, it will move in the opposite direction for emergency evasion; if there is an obstacle within 2~10cm directly in front of the car, it will back up to the left, adjust its direction, and then move forward.

### How it works?

The workflow of this project is as follows.

- Priority read the value of left and right IR obstacle avoidance module.
- If the left IR module is 0 (obstacle detected), the right IR module is 1, let the car back up to the left.
- If the right IR module is 0 (obstacle detected), let the car back up to the right.
- If 2 IR modules detect the obstacle at the same time, the car will back up.

- Otherwise read the distance detected by the ultrasonic module.
- If the distance is greater than 50cm, let the car go forward.
- If the distance is between 2-10cm, let the car backward before turning.
- If the distance is between 10-50cm, let the car go forward at low speed.

```
void loop() {

  int left = digitalRead(leftIR);  // 0: Obstructed  1: Empty
  int right = digitalRead(rightIR);

  if (!left && right) {
    backLeft(150);
  } else if (left && !right) {
    backRight(150);
  } else if (!left && !right) {
    moveBackward(150);
  } else {
    float distance = readSensorData();
    Serial.println(distance);
    if (distance > 50) { // Safe
      moveForward(200);
    } else if (distance < 10 && distance > 2) { // Attention
      moveBackward(200);
      delay(1000);
      backLeft(150);
      delay(500);
    } else {
      moveForward(150);
    }
  }
}
```

## 5.10 9. Remote Control

This kit comes with an IR receiver, which allows you to use an IR remote control to control the movement of the car.

### Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

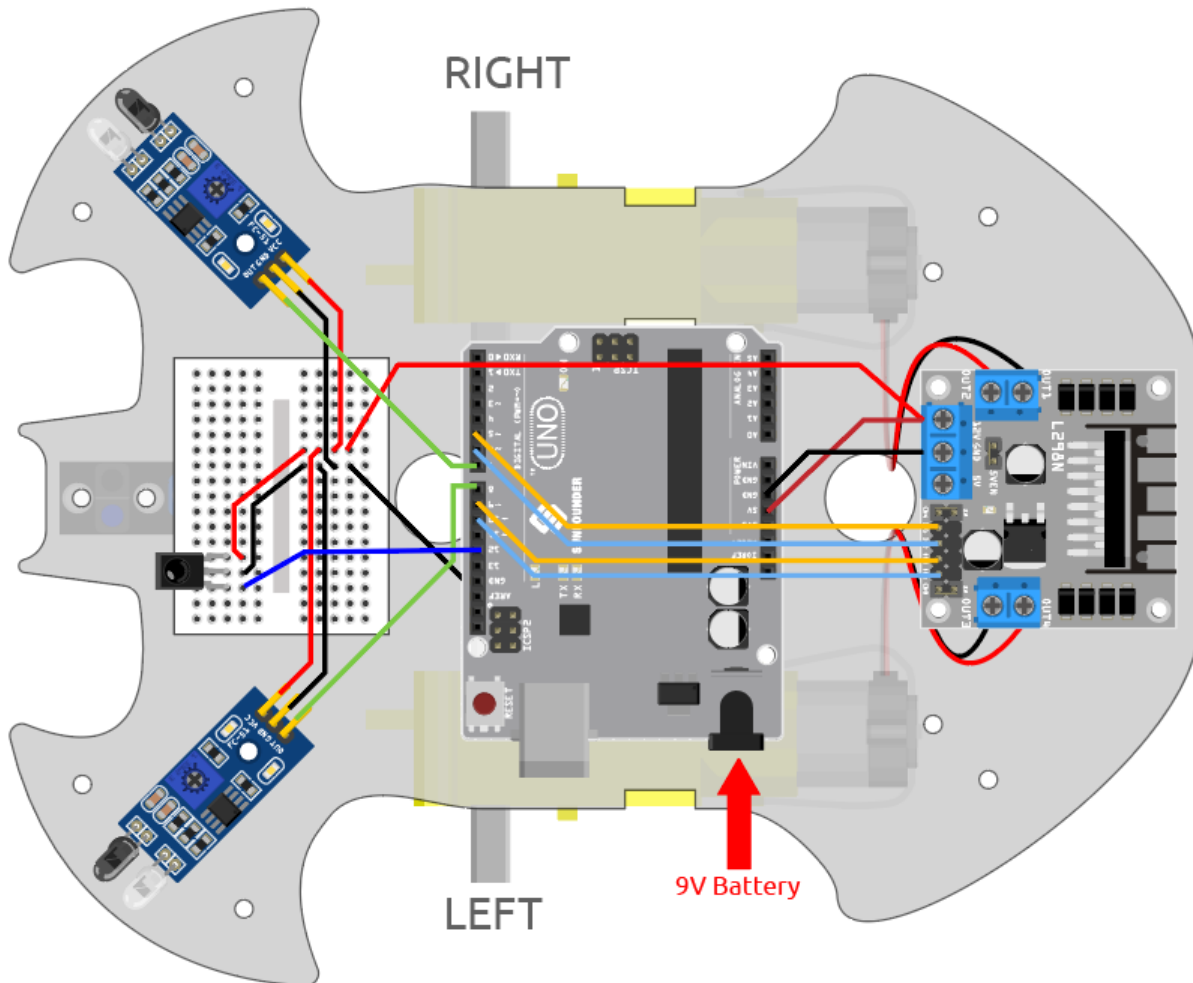
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>L298N Module</i>	
<i>TT Motor</i>	-
<i>LED</i>	
<i>IR Receiver</i>	-

**Wiring**

Now build the circuit according to the diagram below.

IR Receiver	R3 Board
OUT	12
GND	GND
VCC	5V

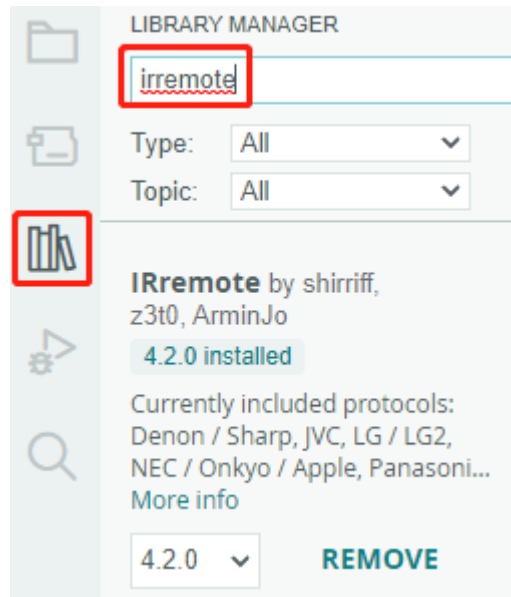
LED	R3 Board
Anode(The longer pin)	13
Cathode	GND



## Code

### Note:

- Open the `9.remote_control.ino` file under the path of `3in1-kit\car_project\9.remote_control`.
- Or copy this code into **Arduino IDE**.
- The `IRremote` library is used here, you can install it from the **Library Manager**.



After the code is uploaded successfully, press the button on the remote control, the LED will blink once to represent that the signal has been received, and the car will move according to the button you pressed. You can press the following keys to control the car.

- +: Accelerate
- -: Decelerate
- 1: Forward to the left
- 2: Forward
- 3: Forward to the right
- 4: Turn left
- 6: Turn right
- 7: Backward to the left
- 8: Backward
- 9: Backward to the right

### How it works?

The effect of this project is to make the car move by reading the key value of the IR remote control. Additionally, the LED on pin 13 will blink to indicate the successful reception of the IR signal.

1. Import the IRremote library, you can install it from the **Library Manager**.

```
#include <IRremote.h>

const int IR_RECEIVE_PIN = 12;  // Define the pin number for the IR Sensor
```

2. Initializes serial communication at a baud rate of 9600. Initializes the IR receiver on the specified pin (IR\_RECEIVE\_PIN) and enables LED feedback (if applicable).

```
...
```

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```

void setup() {
    ...
    //IR remote
    IrReceiver.begin(IR_RECEIVE_PIN, ENABLE_LED_FEEDBACK); // Start the
    ↪receiver
    Serial.println("REMOTE CONTROL START");
}

```

3. When you press the keys on the remote control, the infrared receiver will know which key is pressed, and then the car will move according to the corresponding key value.

```

void loop() {

    if (IrReceiver.decode()) {
        // Serial.println(results.value,HEX);
        String key = decodeKeyValue(IrReceiver.decodedIRData.command);
        if (key != "ERROR") {
            Serial.println(key);

            if (key == "+") {
                speed += 50;
            } else if (key == "-") {
                speed -= 50;
            } else if (key == "2") {
                moveForward(speed);
                delay(1000);
            }
            ...
        }
        IrReceiver.resume(); // Enable receiving of the next value
    }
}

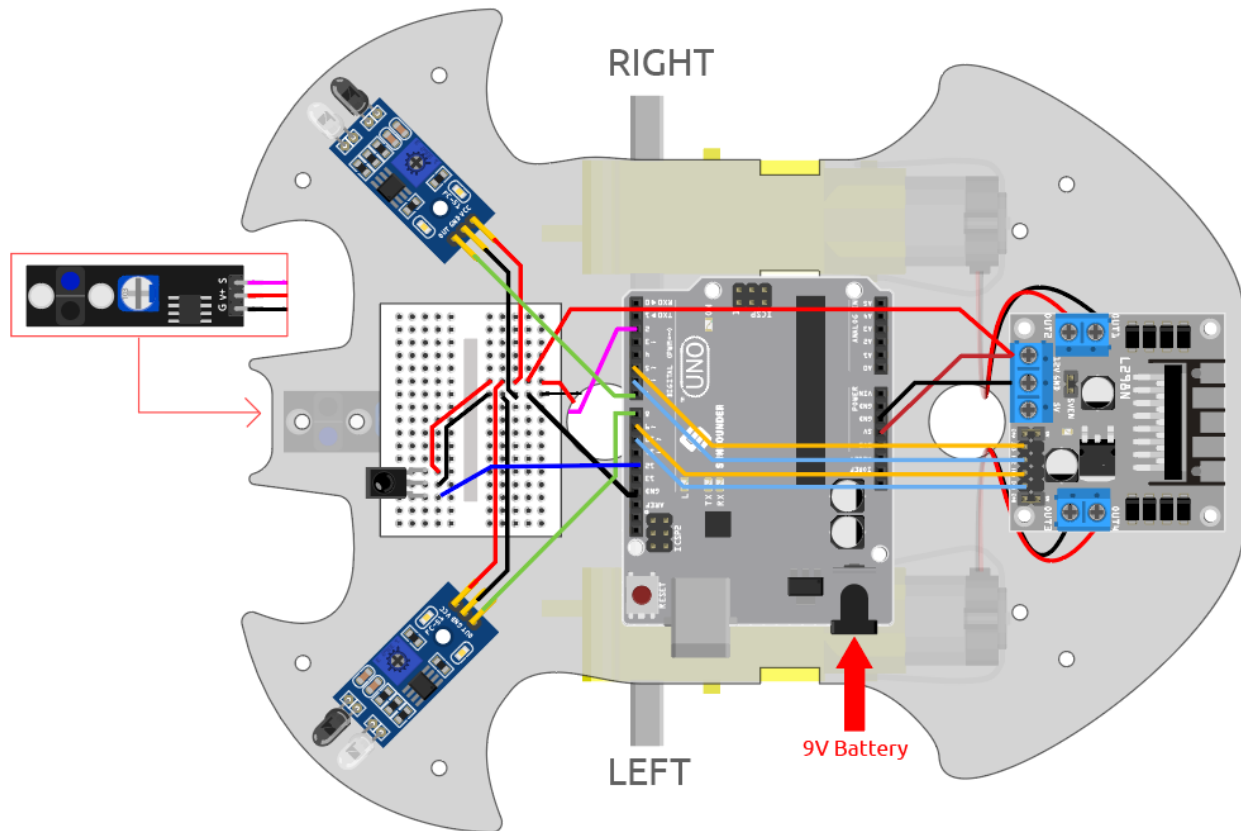
```

- Checks if an IR signal is received and successfully decoded.
- Decodes the IR command and stores it in `key` using a custom `decodeKeyValue()` function.
- Checks if the decoded value is not an error.
- Prints the decoded IR value to the serial monitor.
- Resumes IR signal reception for the next signal.

## 5.11 10. One Touch Start

In this project, we have integrated the previous projects - line following, following, obstacle avoidance, self-driving, etc. together. They can be switched by buttons on the remote control, so you can start the car and experience all functions at once.

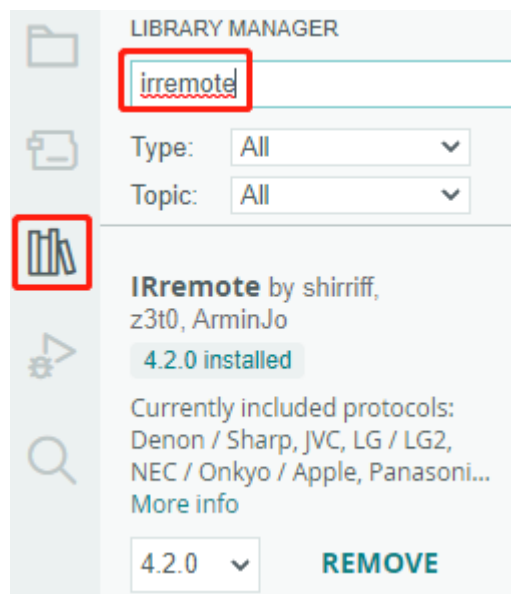
### Wiring



## Code

### Note:

- Open the `10.one_touch_start.ino` file under the path of `3in1-kit\car_project\10.one_touch_start`.
- Or copy this code into **Arduino IDE**.
- The **IRremote** library is used here, you can install it from the **Library Manager**.





After the code is uploaded successfully, the LED will flash rapidly 3 times for every signal received from the remote control by the IR receiver. You can press the following keys to operate the car.

- **+**: Accelerate
- **-**: Decelerate
- **1**: Move to the left front
- **2**: Forward
- **3**: Move to the right.
- **4**: Turn left
- **6**: Turn right
- **7**: Backward to the left
- **8**: Backward.
- **9**: Backward to the right
- **CYCLE**: Follow the line
- **U/SD**: Self-driving
- **|**: Obstacle avoidance with ultrasonic module
- **|**: Obstacle avoidance with IR Obstacle module
- **EQ**: Follow your hand
- **0**: Stop

## 5.12 11. Speed Calibration

In getting the car to move forward, you may find that the car does not travel in a straight line. This is because the two motors may not have the same speed at the factory. But we can write offset to the two motors to make their rotational speeds converge.

In this project, we will learn to store the offset into **EEPROM**, the point of this is that after each calibration, all projects can get the offset value directly from the EEPROM, so that the car can go in a straight line smoothly.

### Wiring

This project is the same wiring as [2. Move by Code](#).

### How to play?

1. Open the `11.speed_calibration.ino` file under the path of `3in1-kit\car_project\11.speed_calibration`. Or copy this code into **Arduino IDE**.
  2. After the code is uploaded successfully, connect the car with 9V battery, put it on the ground and let it move forward to see which side it is offset to.
- If the car moves to the left front, it means the right motor speed is too fast and needs to be reduced.

```
EEPROM.write(1, 100) // 1 means the right motor, 100 means 100% speed, can
↳ be set to 90, 95, etc., depending on the actual situation.
```

- If the car moves to the right, it means the left motor speed is too fast and needs to be reduced.

```
EEPROM.write(0, 100) // 0 means the right motor, 100 means the speed is 100
↪%, can be set to 90, 95, etc., depending on the actual situation. 3.
```

3. After modifying the code, upload the code to R3 board to see the effect. Repeat the above steps until the car is almost straight.
4. This offset will be recorded in EEPROM, you only need to read this offset when you use it in other projects, take 5. *Play with Obstacle Avoidance Module* as an example.

```
#include <EEPROM.h>

float leftOffset = 1.0;
float rightOffset = 1.0;

const int in1 = 5;
const int in2 = 6;
const int in3 = 9;
const int in4 = 10;

const int rightIR = 7;
const int leftIR = 8;

void setup() {
    Serial.begin(9600);

    //motor
    pinMode(in1, OUTPUT);
    pinMode(in2, OUTPUT);
    pinMode(in3, OUTPUT);
    pinMode(in4, OUTPUT);

    //IR obstacle
    pinMode(leftIR, INPUT);
    pinMode(rightIR, INPUT);

    leftOffset = EEPROM.read(0) * 0.01; //read the offset of the left motor
    rightOffset = EEPROM.read(1) * 0.01; //read the offset of the right motor
}

void loop() {

    int left = digitalRead(leftIR); // 0: Obstructed 1: Empty
    int right = digitalRead(rightIR);
    int speed = 150;

    if (!left && right) {
        backLeft(speed);
    } else if (left && !right) {
        backRight(speed);
    } else if (!left && !right) {
        moveBackward(speed);
    } else {
        moveForward(speed);
    }
}
```

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```
    }  
}  
  
void moveForward(int speed) {  
    analogWrite(in1, 0);  
    analogWrite(in2, int(speed * leftOffset));  
    analogWrite(in3, int(speed * rightOffset));  
    analogWrite(in4, 0);  
}  
  
void moveBackward(int speed) {  
    analogWrite(in1, speed);  
    analogWrite(in2, 0);  
    analogWrite(in3, 0);  
    analogWrite(in4, speed);  
}  
  
void backLeft(int speed) {  
    analogWrite(in1, speed);  
    analogWrite(in2, 0);  
    analogWrite(in3, 0);  
    analogWrite(in4, 0);  
}  
  
void backRight(int speed) {  
    analogWrite(in1, 0);  
    analogWrite(in2, 0);  
    analogWrite(in3, 0);  
    analogWrite(in4, speed);  
}
```

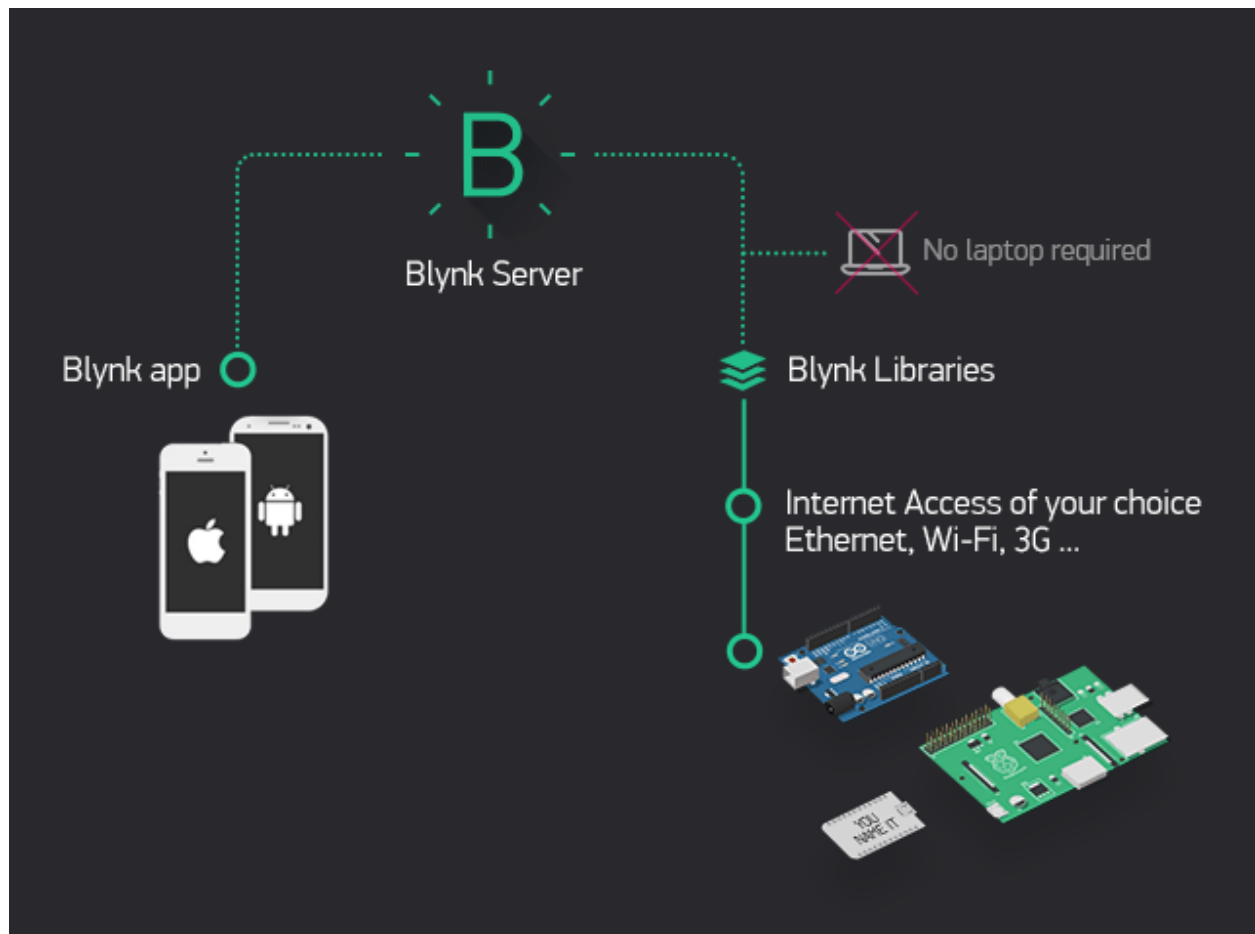


## IOT PROJECTS

This kit has the ESP8266 Wifi module which allows Arduino to connect to the internet for IoT experiments.

Here we will guide you how to make Arduino connect to [BLYNK](#) platform with the help of ESP8266 Wifi module to do some interesting IoT projects. Also you can use the Blynk APP on your cell phone to control the smart car.

Blynk is a full suite of software required to prototype, deploy, and remotely manage connected electronic devices at any scale: from personal IoT projects to millions of commercial connected products. With Blynk anyone can connect their hardware to the cloud and build a no-code iOS, Android, and web applications to analyze real-time and historical data coming from devices, control them remotely from anywhere in the world, receive important notifications, and much more...



## 6.1 1. Get Started with Blynk

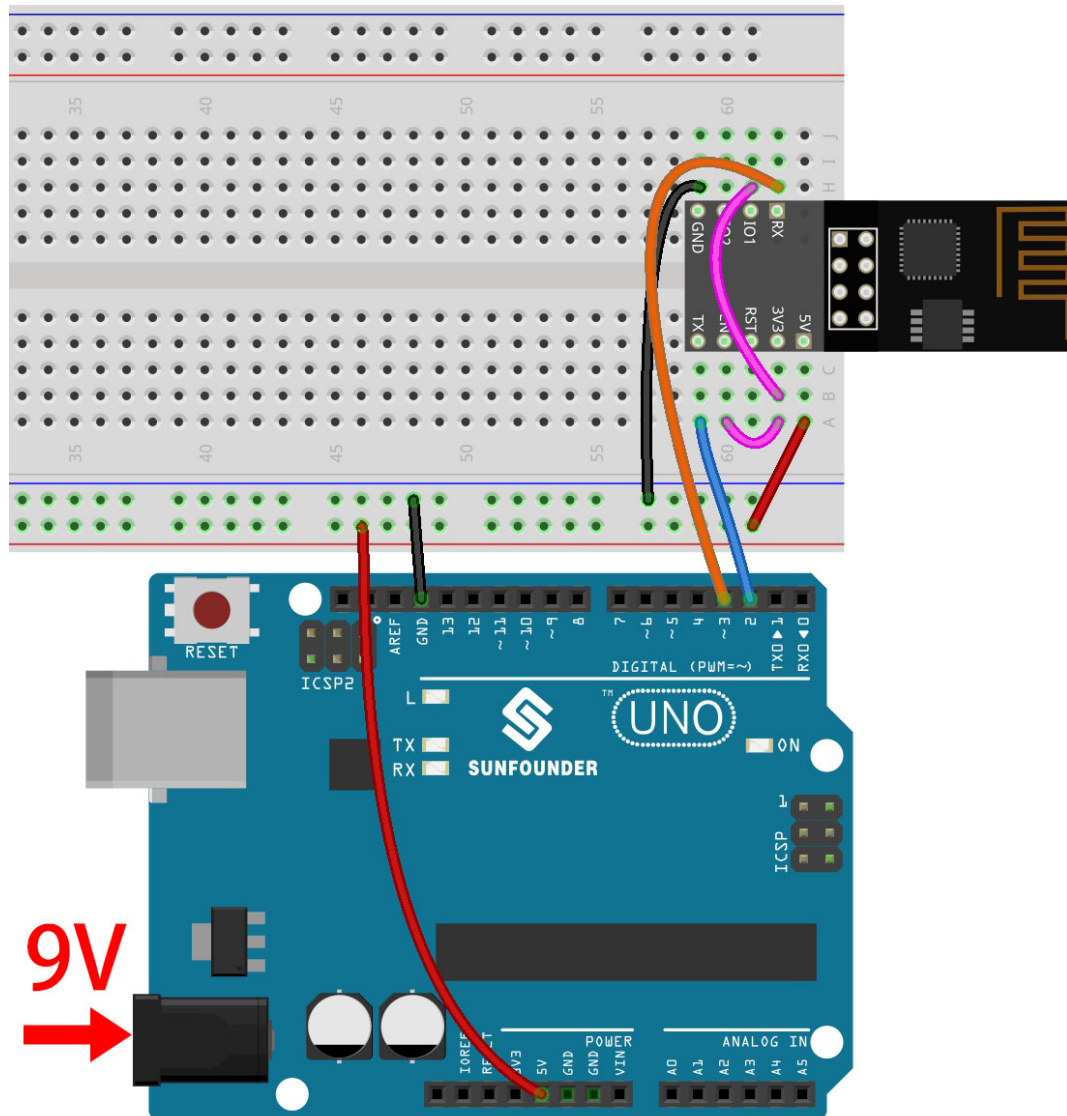
Getting the R3 board to communicate with Blynk requires some configuration when you first use Blynk.

Follow the steps below, and note that you must do them in order and not skip any chapters.

### 6.1.1 1.1 Configuring the ESP8266

The ESP8266 module that comes with the kit is already pre-burned with AT firmware, but you still need to modify its configuration by following the steps below.

1. Build the circuit.



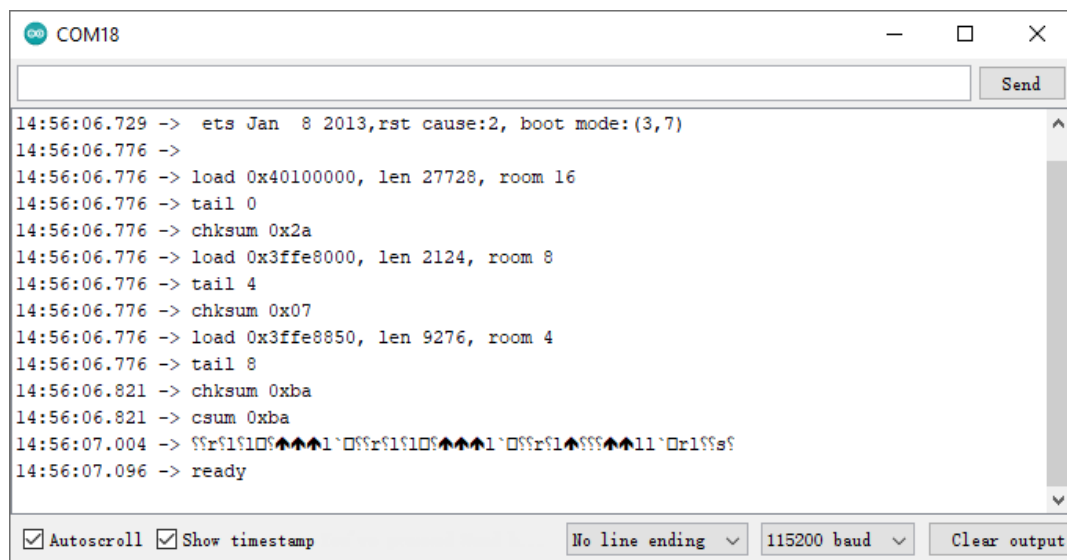
2. Open the 1.set\_software\_serial.ino file under the path of 3in1-kit\iot\_project\1.set\_software\_serial. Or copy this code into **Arduino IDE**.

```
#include <SoftwareSerial.h>
SoftwareSerial espSerial(2, 3); //Rx,Tx

void setup() {
    // put your setup code here, to run once:
    Serial.begin(115200);
    espSerial.begin(115200);
}

void loop() {
    if (espSerial.available()) {
        Serial.write(espSerial.read());
    }
    if (Serial.available()) {
        espSerial.write(Serial.read());
    }
}
```

3. Click the magnifying glass icon (Serial Monitor) in the upper right corner and set the baud rate to **115200**. (You may have some printed information like me, or you may not, it doesn't matter, just go to the next step.)



**Warning:**

- If ready doesn't appear, you can try to reset the ESP8266 module(connect RST to GND) and re-open the Serial Monitor.
- In addition, if the result is OK, you may need to re-burn the firmware, please refer to [How to re-burn the firmware for ESP8266 module?](#) for details. If you still can't solve it, please take a screenshot of the serial monitor and send it to [sevice@sunfounder.com](mailto:sevice@sunfounder.com), we will help you solve the problem as soon as possible.

4. Click on **NEWLINE DROPDOWN BOX**, select both NL & CR in the drop down option, enter AT, if it returns OK, it means ESP8266 has successfully established connection with R3 board.

```

COM18
AT2
14:56:06.776 -> load 0x40100000, len 27728, room 16
14:56:06.776 -> tail 0
14:56:06.776 -> chksum 0x2a
14:56:06.776 -> load 0x3ffe8000, len 2124, room 8
14:56:06.776 -> tail 4
14:56:06.776 -> chksum 0x07
14:56:06.776 -> load 0x3ffe8850, len 9276, room 4
14:56:06.776 -> tail 8
14:56:06.821 -> chksum 0xba
14:56:06.821 -> csum 0xba
14:56:07.004 -> $$$r$1$10$####1`0$$r$1$10$####1`0$$r$1$10$####1`0r1$$s$
14:56:07.096 -> ready
15:00:05.119 -> AT
15:00:05.119 ->
15:00:05.119 -> OK

```

☒ Autoscroll ☒ Show timestamp Both NL & CR 115200 baud Clear output

5. Enter AT+CWMODE=3 and the managed mode will be changed to **Station and AP** coexistence.

```

COM18
AT+CWMODE=3
14:56:06.776 -> tail 4
14:56:06.776 -> chksum 0x07
14:56:06.776 -> load 0x3ffe8850, len 9276, room 4
14:56:06.776 -> tail 8
14:56:06.821 -> chksum 0xba
14:56:06.821 -> csum 0xba
14:56:07.004 -> $$$r$1$10$####1`0$$r$1$10$####1`0$$r$1$10$####1`0r1$$s$
14:56:07.096 -> ready
15:00:05.119 -> AT
15:00:05.119 ->
15:00:05.119 -> OK
15:01:08.226 -> AT+CWMODE=3
15:01:08.319 ->
15:01:08.319 -> OK

```

☒ Autoscroll ☒ Show timestamp Both NL & CR 115200 baud Clear output

6. In order to use the software serial later, you must input AT+UART=9600,8,1,0,0 to modify the ESP8266's baud rate to 9600.



```

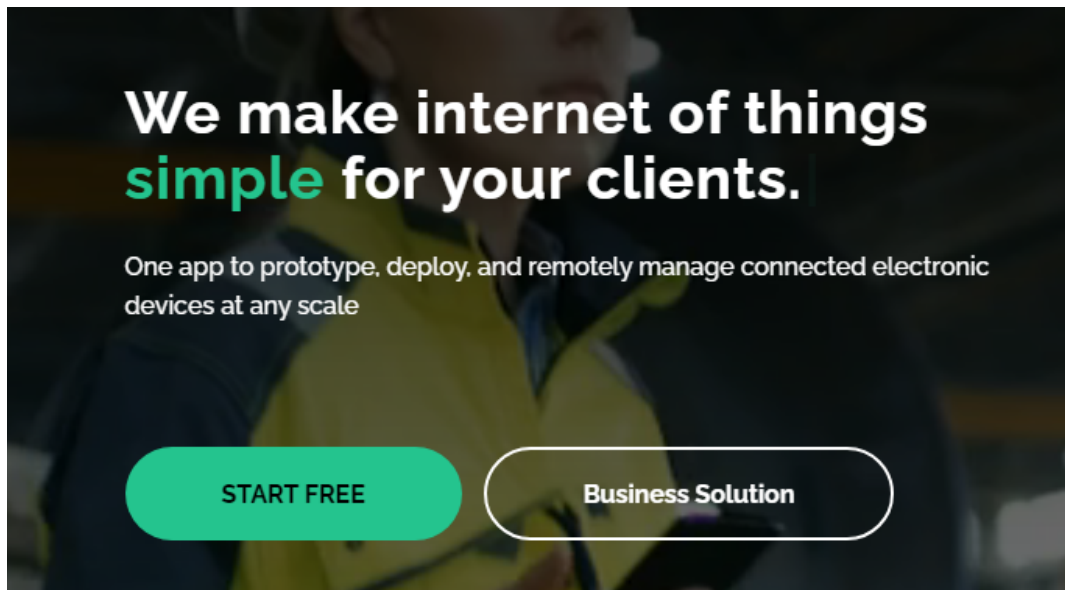
COM18
AT+UART=9600,8,1,0,0
14:56:06.776 -> tail 8
14:56:06.821 -> chksum 0xba
14:56:06.821 -> csum 0xba
14:56:07.004 -> ??r$1$10$1111`0$?r$1$10$1111`0$?r$11111`0r1$1$1
14:56:07.096 -> ready
15:00:05.119 -> AT
15:00:05.119 ->
15:00:05.119 -> OK
15:01:08.226 -> AT+CWMODE=3
15:01:08.319 ->
15:01:08.319 -> OK
15:03:06.853 -> AT+UART=9600,8,1,0,0
15:03:06.853 ->
15:03:06.853 -> OK

```

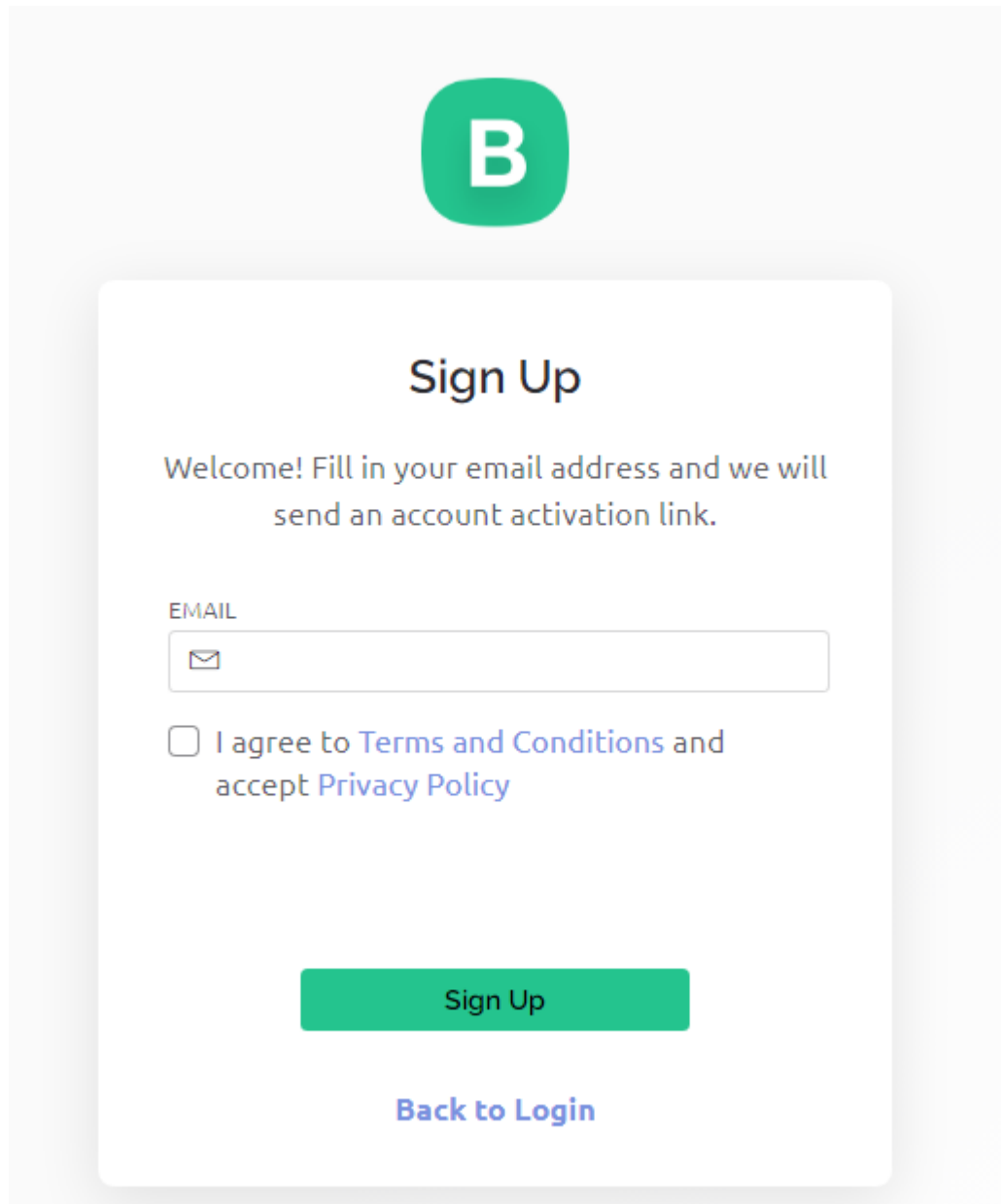
☒ Autoscroll ☒ Show timestamp Both NL & CR 115200 baud Clear output

### 6.1.2 1.2 Configuring the Blynk

1. Go to the [BLYNK](#) and click **START FREE**.



2. Fill in your email address to register an account.



The image shows a 'Sign Up' form for a platform. At the top is a green rounded square logo with a white letter 'B'. Below the logo, the title 'Sign Up' is centered in a large, dark font. A welcome message follows: 'Welcome! Fill in your email address and we will send an account activation link.' Below this is an email input field with the label 'EMAIL' and a small envelope icon. Under the input field is a checkbox with the text 'I agree to Terms and Conditions and accept Privacy Policy'. At the bottom of the form is a green 'Sign Up' button and a blue 'Back to Login' link.

**B**

## Sign Up

Welcome! Fill in your email address and we will send an account activation link.

EMAIL

☐ I agree to [Terms and Conditions](#) and accept [Privacy Policy](#)

**Sign Up**

[Back to Login](#)

3. Go to your email address to complete your account registration.

Welcome!

We're excited to see you on board.

To get started, you'll need to create a password for your account.

Create Password

The link will expire in 30 days.

4. Afterwards, **Blynk Tour** will appear and you can read it to learn the basic information about the Blynk.

### Blynk Tour

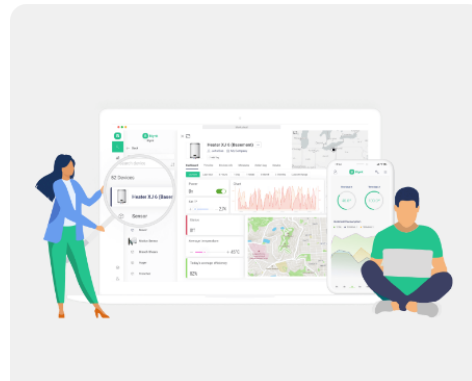
1 Welcome 2 Platform 3 Modes 4 Devices 5 Template 6 Template components 7 Features 8 Business

#### Hi Blynker!

You've just joined the community of more than 500,000+ developers building amazing IoT products and projects.

With Blynk you can connect your devices to the Internet and create mobile and web dashboards to control your devices from anywhere in the world.

Let's save your learning time with a few quick steps.



Skip

Let's go!

5. Next we need to create a template and device with this **Quick Start**, click **Let's go**.

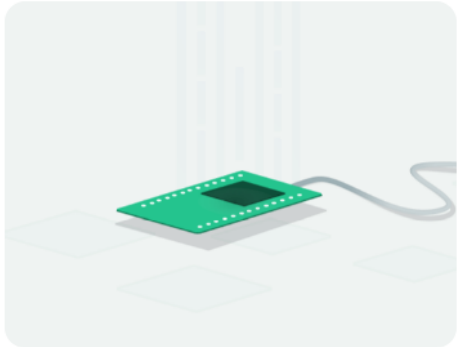
## Quickstart

This is a step by step guide to get your first device online and start controlling it from anywhere in the world in **less than 5 minutes**

**What you will need:**

- Supported hardware. Check the full list of supported hardware [here](#).
- IDE. You can use Arduino IDE or PlatformIO or any other editor.
- Blynk Library
- It will be beneficial if you already know how to upload code to your hardware.

CancelLet's go!



6. Select the hardware and connection type.

## Quickstart

1

 Hardware — 

2

 IDE — 

3

 Blynk Library — 

4

 Code — 

5

 Device activation

**Which hardware are you using?**

We will help you prepare the code for you board

ESP8266

▼

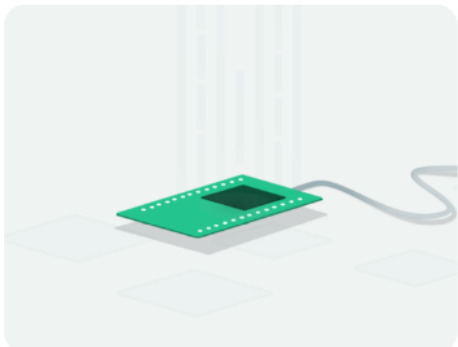
**What is your device connectivity type**

Blynk supports various connection types (BLE is not supported yet).

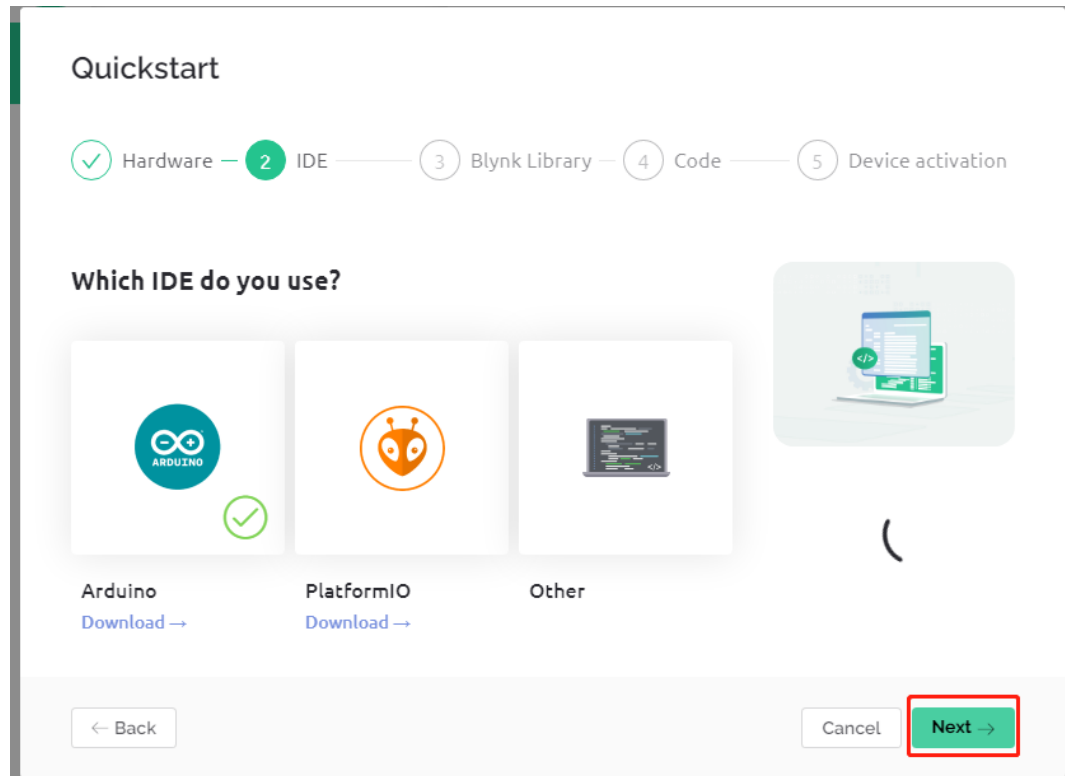
WiFi

▼

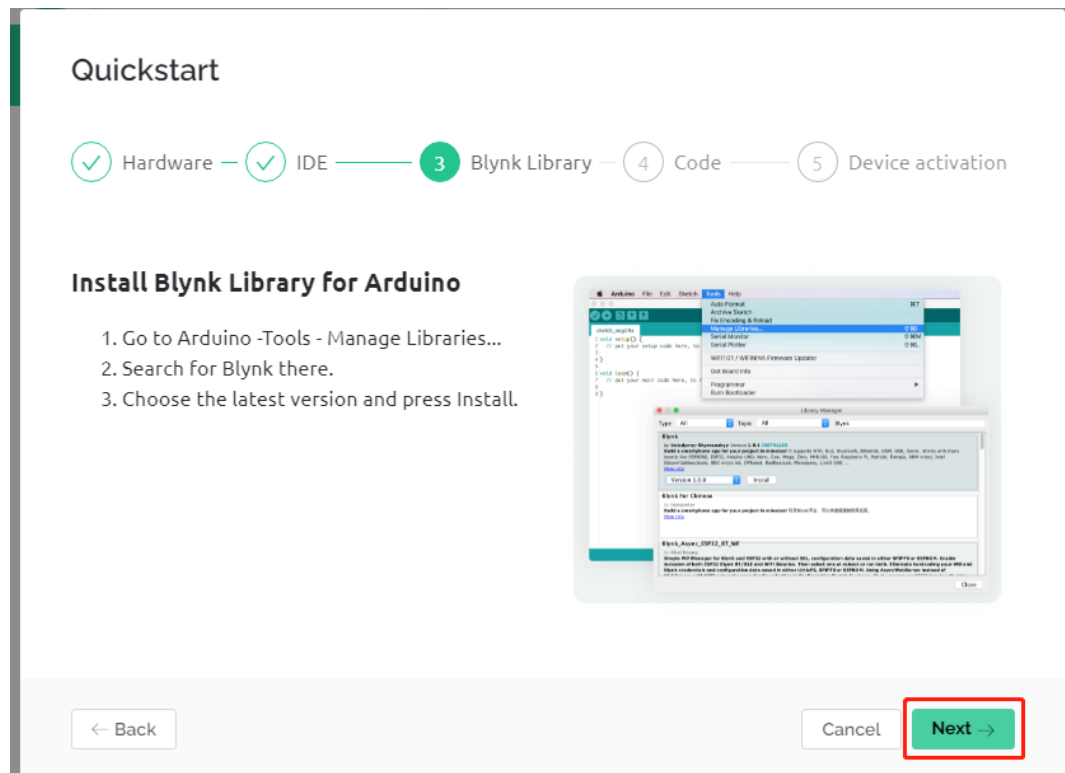
CancelNext →



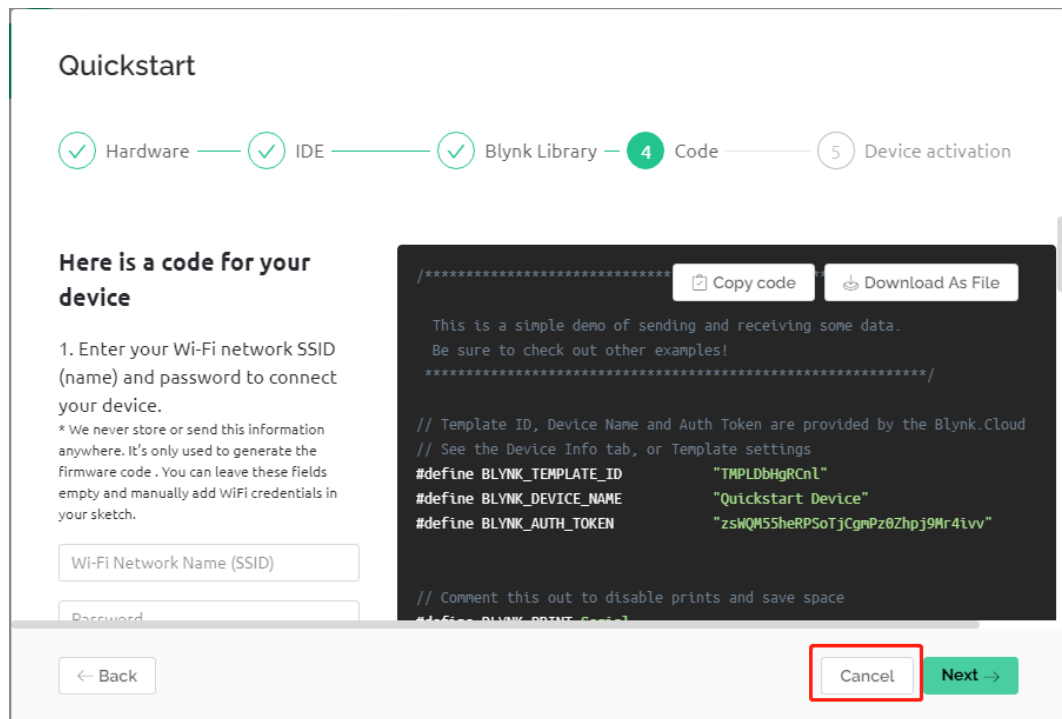
7. Here you are told which IDE you need to prepare, we recommend the **Arduino IDE**.



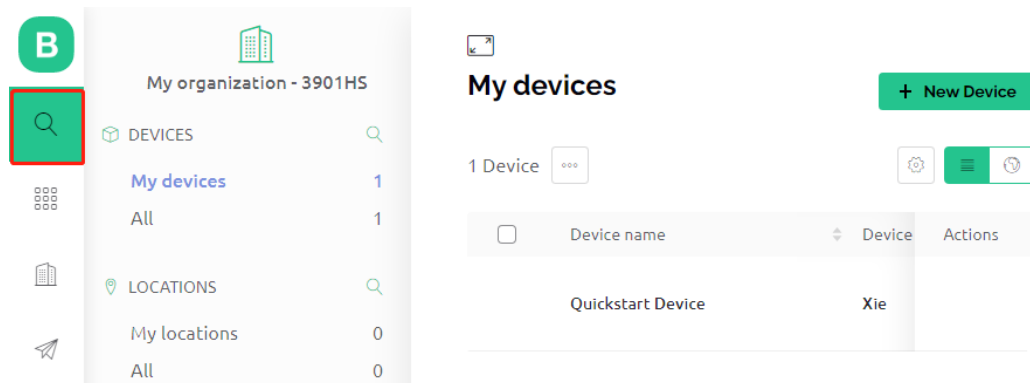
8. Here is the library you need to add, but the recommended library here is a bit problematic, we need to add other libraries manually (we will mention it later). Click **Next** here, and a new template and device will be created.



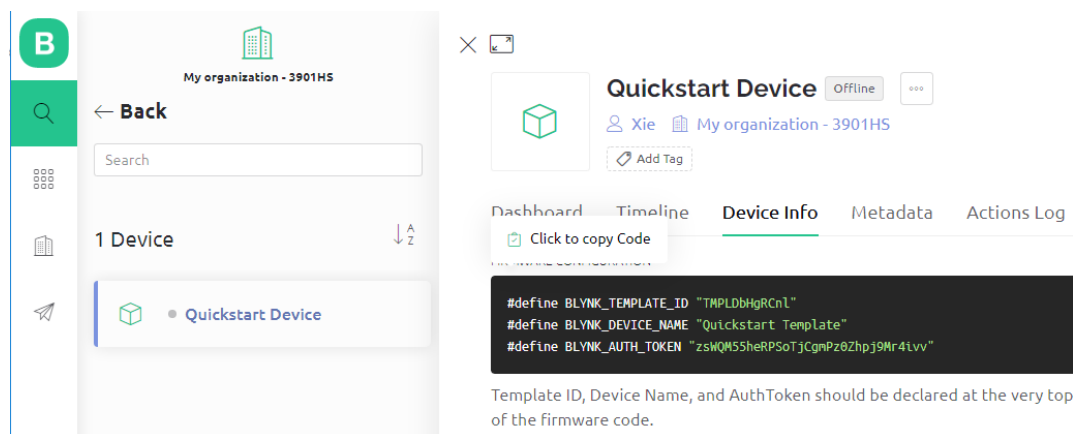
9. The next steps are to upload the relevant code and connect your board to Blynk, but since there is a problem with the library provided earlier, you need to add other libraries again. So click **Cancel** here to stop **Quick Start**.



10. Click the **Search** button and you will see the new device you just created.



11. Go to this **Quickstart Device** and you will see TEMPLATE\_ID, DEVICE\_NAME and AUTH\_TOKEN on the **Device info** page, and you will need to copy them later.






### 6.1.3 1.3 Adding the required libraries

You need to add the correct libraries for the Arduino IDE to use Blynk.

1. Click [HERE](#), scroll down to the bottom of the page and download the first .zip file.

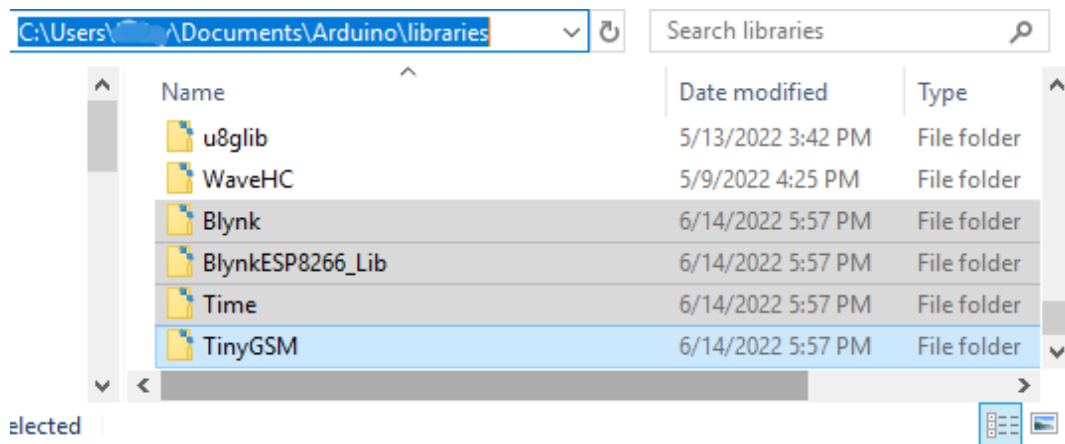
#### ▼ Assets 3

 Blynk_Release_v1.1.0.zip	779 KB	22 days ago
 Source code (zip)		22 days ago
 Source code (tar.gz)		22 days ago

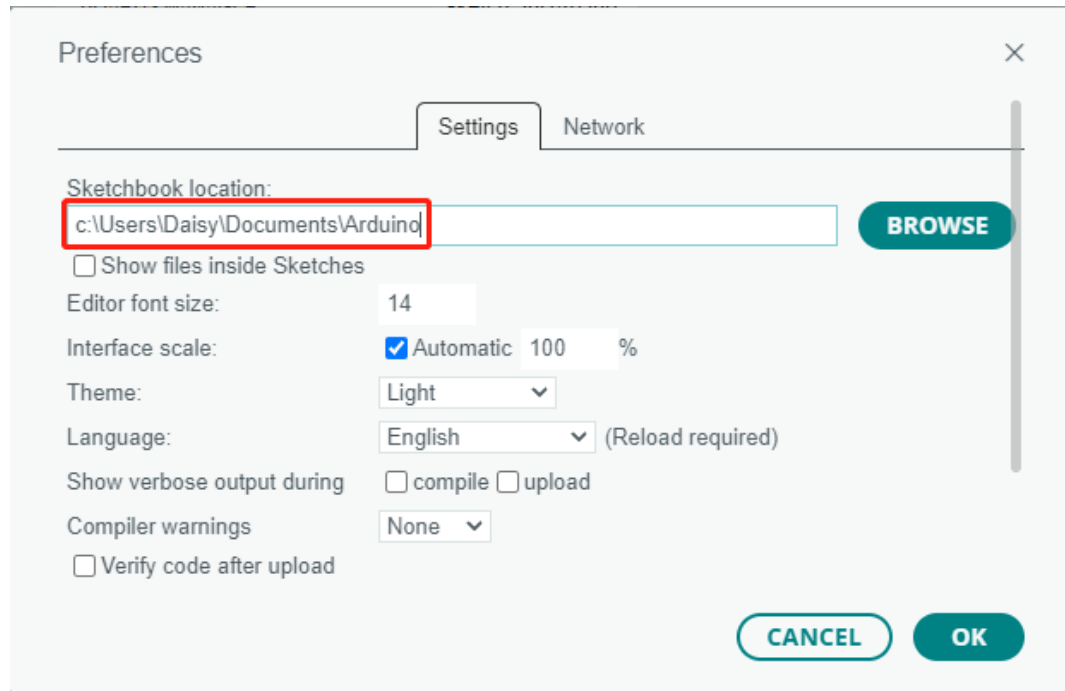
2. Unzip this file and you can see the following folders.

..			File folder	
Blynk	1,060,482	459,412	File folder	7/16/2021 1:13 ...
BlynkESP8266_Lib	57,090	11,208	File folder	5/25/2021 5:12 ...
Time	63,774	25,512	File folder	5/25/2021 5:12 ...
TinyGSM	602,241	172,967	File folder	5/25/2021 5:12 ...

3. Copy them all and paste them to the default libraries directory of the Arduino IDE, which is usually located at C:\Users\xxx\Documents\Arduino\libraries.



4. If your libraries directory is different, you can check it by going to **File -> Preferences**.



### 6.1.4 1.4 Connecting the R3 board to Blynk

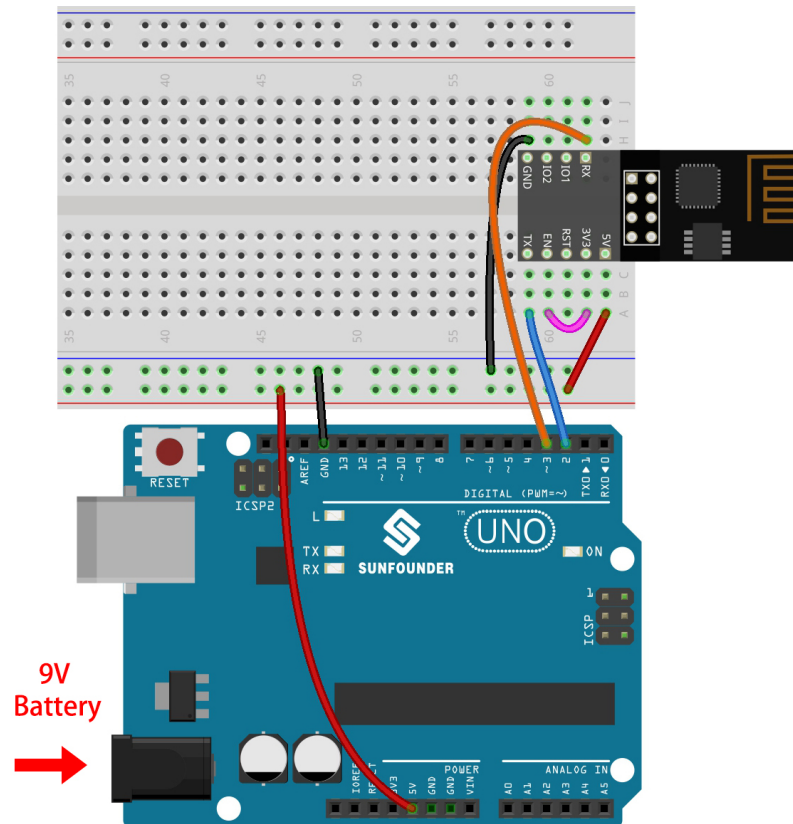
1. Reconnect the ESP8266 module and R3 board, here the software serial is used, so TX and RX are connected to pins 2 and 3 of R3 board respectively.

---

**Note:** The ESP8266 module requires a high current to provide a stable operating environment, so make sure the 9V battery is plugged in.

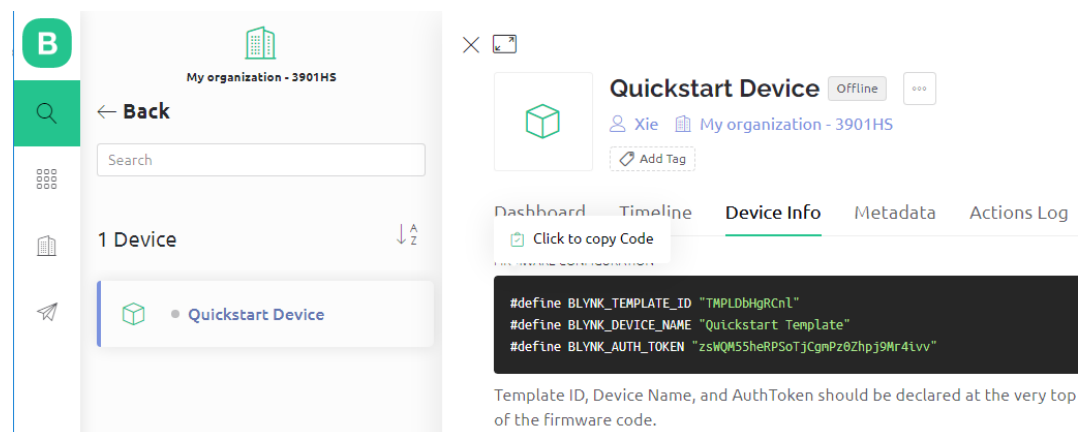
---





- Open the `1.connect.ino` file under the path of `3in1-kit\iot_project\1.connect`. Or copy this code into **Arduino IDE**.
- Replace the following three lines of code that you can copy from your account's **Device info** page. These three lines of code will allow your R3 board to find your blynk account.


```
#define BLYNK_TEMPLATE_ID "TMPLxxxxxx"
#define BLYNK_DEVICE_NAME "Device"
#define BLYNK_AUTH_TOKEN "YourAuthToken"
```



- Fill in the ssid and password of the WiFi you are using.

```
char ssid[] = "ssid";  
char pass[] = "password";
```

5. Upload the code to the R3 board, then open the serial monitor and set the baud rate to 115200. when the R3 board communicates with Blynk successfully, the serial monitor will show the ready character.



The screenshot shows the Arduino IDE serial monitor window. The title bar reads "COM25". The serial monitor displays the following output:

```

17:01:37.230 -> [9]
17:01:37.230 ->
17:01:37.230 ->   / _ ) / / _ _ _ / / _
17:01:37.230 -> / _ / / / / _ \ ' \
17:01:37.230 -> / _ _ / _ \ _ / / / _ \ _
17:01:37.230 ->   / _ _ / v1.0.1 on Arduino Uno
17:01:37.735 -> [517] Connecting to JM
17:01:50.843 -> [13604] AT version:2.3.0.0-dev(s-bcd64d2 - ESP8266 - Jun 23 2021 11:42:05)
17:01:50.843 -> SDK version:v3.4-22-g967752e2
17:01:50.843 -> compile time(b498b58):Jun 30 2021 11:28:20
17:01:50.843 -> Bin version22(S86_BO
17:01:50.843 ->
17:01:53.808 -> [16596] +CIFSR:STAIP,"192.168.18.237"
17:01:53.856 -> +CIFSR:STAMAC,"c8:c9:a3:72:6c:db"
17:01:53.856 -> [16598] Connected to WiFi
17:02:05.278 -> [28008] Redirecting to ry3.blynk.cloud:80
17:02:11.765 -> [34525] Ready (ping: 493ms).

```

At the bottom of the window, there are several controls:

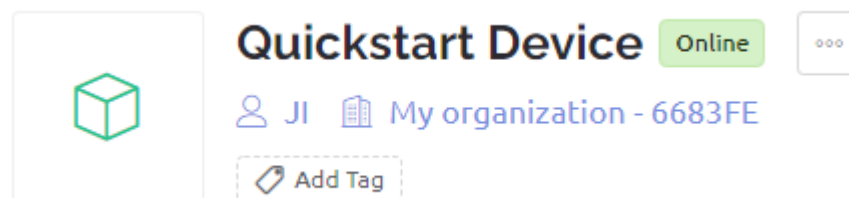
- Autoscroll: ☒
- Show timestamp: ☒
- Both NL & CR:
- 115200 baud:
- Clear output:

**Note:** If the message ESP is not responding appears when you connect, please follow these steps.

- Make sure the 9V battery is plugged in.
- Reset the ESP8266 module by connecting the pin RST to GND for 1 second, then unplug it.
- Press the reset button on the R3 board.

Sometimes, you may need to repeat the above operation 3-5 times, please be patient.

6. The status of Blynk will change from **offline** to **online**.



## 6.2 2. Get Data from Blynk

You will learn how to control the circuit with Blynk in this chapter. Let's light up the LEDs over the Internet!

### Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

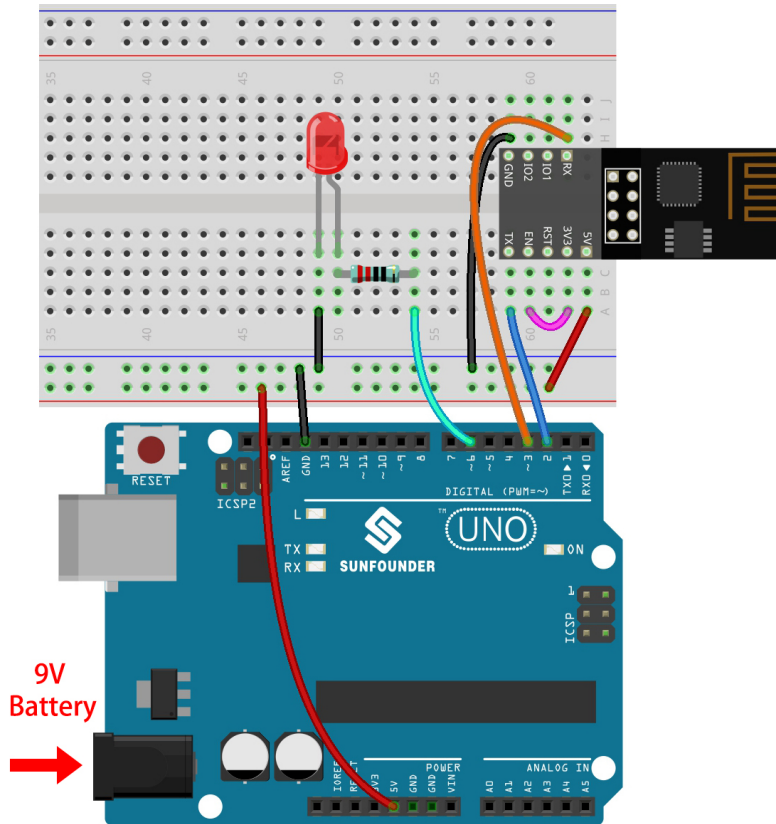
Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>ESP8266 Module</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>LED</i>	

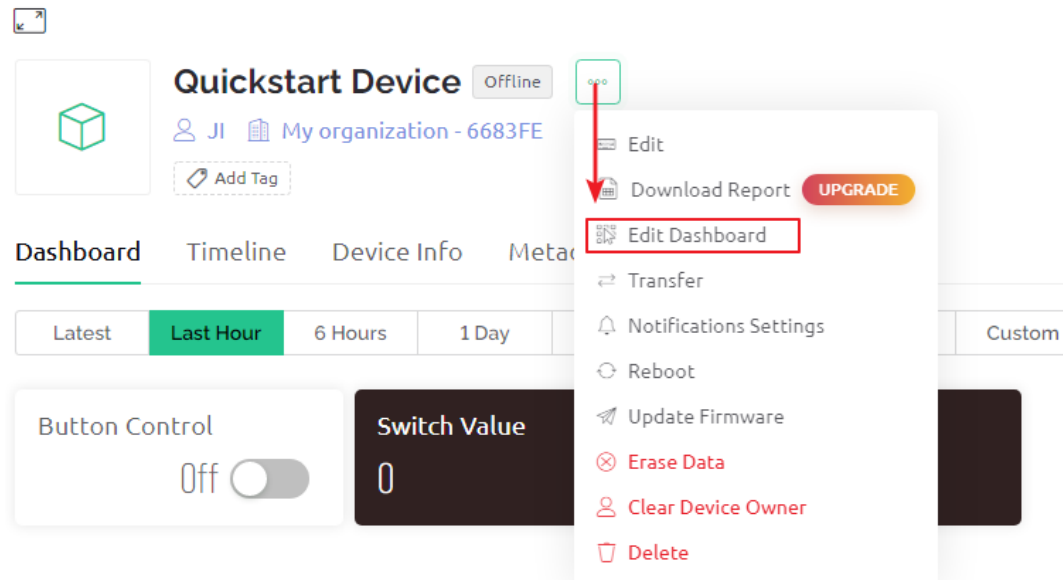
### 1. Build the Circuit

**Note:** The ESP8266 module requires a high current to provide a stable operating environment, so make sure the 9V battery is plugged in.



## 2. Edit Dashboard

1. Go to the **Quickstart Device** you created earlier, click on the menu icon in the upper right corner and select **edit dashboard**.



2. Datastreams allow the widgets on Blynk and the code on the R3 board to recognize each other. To experience the complete configuration process, remove all Datastreams from the Datastreams page.

## Quickstart Template



Cancel

Save And Apply

Info

Metadata

**Datastreams**

Events

Automations

Web Dashboard

Mobile Dashboard

[+ New Datastream](#)4 Datastreams selected of 4 [Clear selection](#)

<input checked="" type="checkbox"/>	Id	Name	Alias	Color	Pin	Data Type	Units	Is	Actions
<input checked="" type="checkbox"/>	1	Switch Control	Switch Control		V0	Integer		fa	
<input checked="" type="checkbox"/>	2	Switch Value	Switch Value		V1	Integer		fa	
<input checked="" type="checkbox"/>	3	Seconds	Seconds		V2	Integer		fa	
<input checked="" type="checkbox"/>	4	Button Image	Button Image		V3	String		fa	

3. Please read the warning carefully and confirm it is correct before deleting the Datastreams.

## DANGER ZONE

Deleting Datastream(s) can lead to breaking changes.

- All widgets using this Datastream(s) will stop working
- All Automation scenarios using this Datastream(s) will stop working
- All active rules in Rules Engine using this Datastream(s) will stop working

This can not be undone.

Type DELETE in the field below to proceed with the deletion.

☒ I fully understand that this action is critical and will lead to data loss

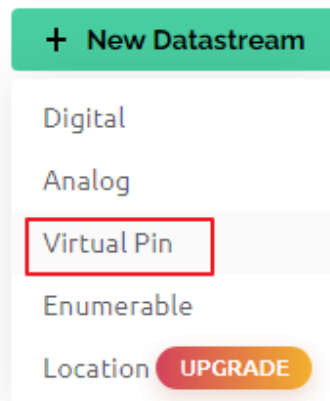
Cancel

Delete

4. Create a Datastream of type **Virtual Pin**, which will be used to control the LED using Blynk's switch.

## Datastreams

Datastreams is a way to structure data that regularly flows in and out from device. Use it for sensor data, any telemetry, or actuators.



5. Configure the **Virtual Pin**. As the button and LED only need to be ON and OFF, set DATA TYPE to Integer and MIN and MAX to 0 and 1.

**Virtual Pin Datastream**

NAME:  ALIAS:

PIN:  DATA TYPE:

UNITS:

MIN:  MAX:  DEFAULT VALUE:

6. Go to the **Web Dashboard** page and delete the existing widgets.

**Quickstart Template**

Info Metadata Datastreams Events Automations **Web Dashboard** Mobile Dashboard

**Widget Box**  
3 of 30 widgets

**CONTROL**

Switch ☒

Slider

Number Input

**Device name** Online

Device Owner Company Name

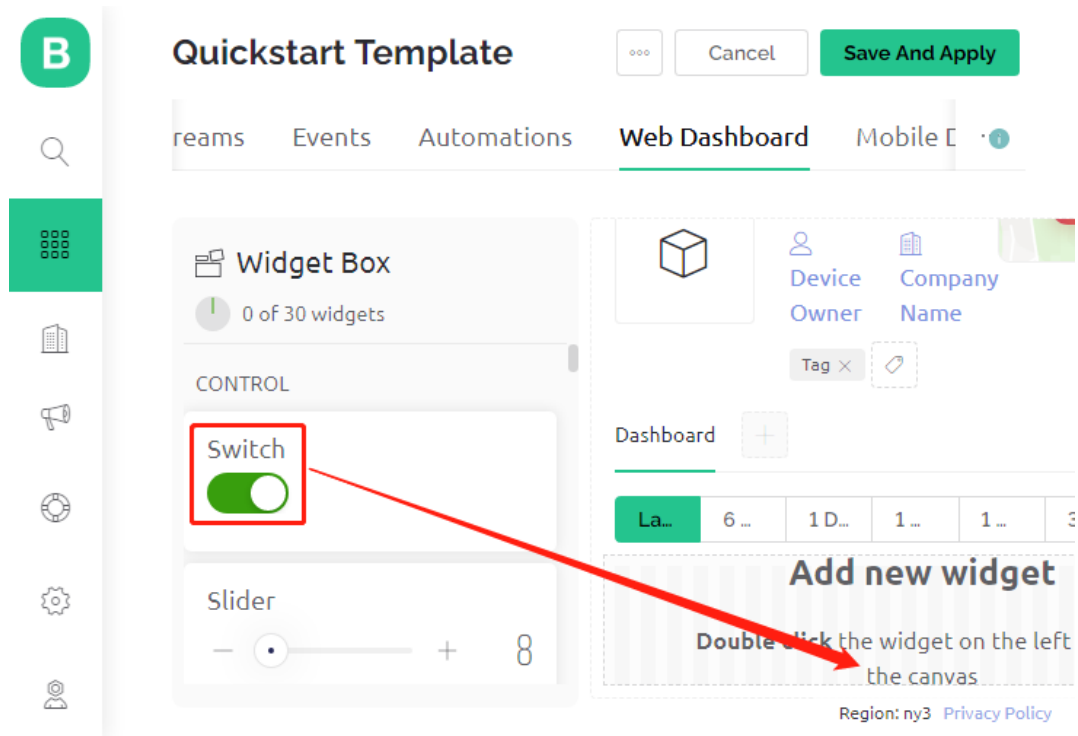
Tag

**Dashboard**

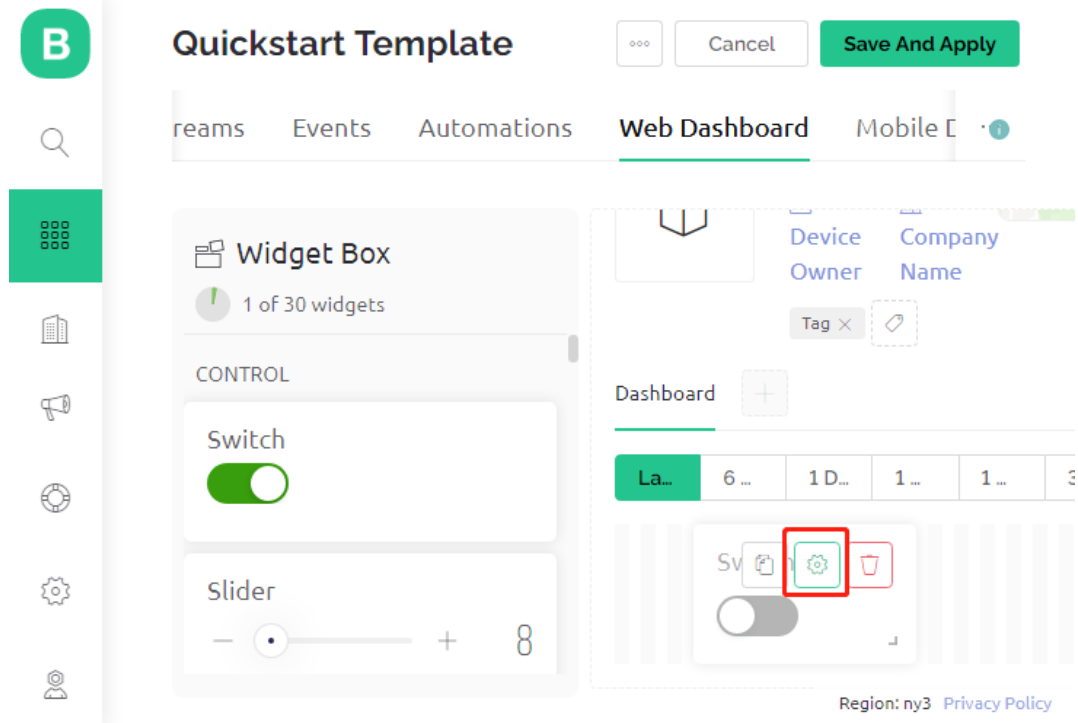
Last H... 6 Hours 1 Day 1 Week 1 Month 3 Mont... Custom

Switch... Uptime

7. Drag and drop a **switch** widget from the **Widget Box** on the left.

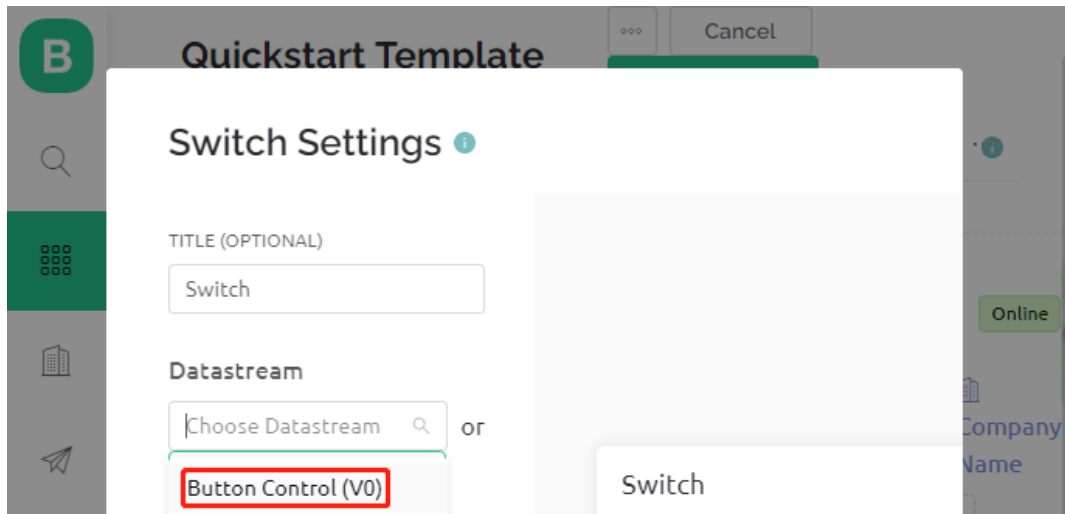


8. Now to set it up.

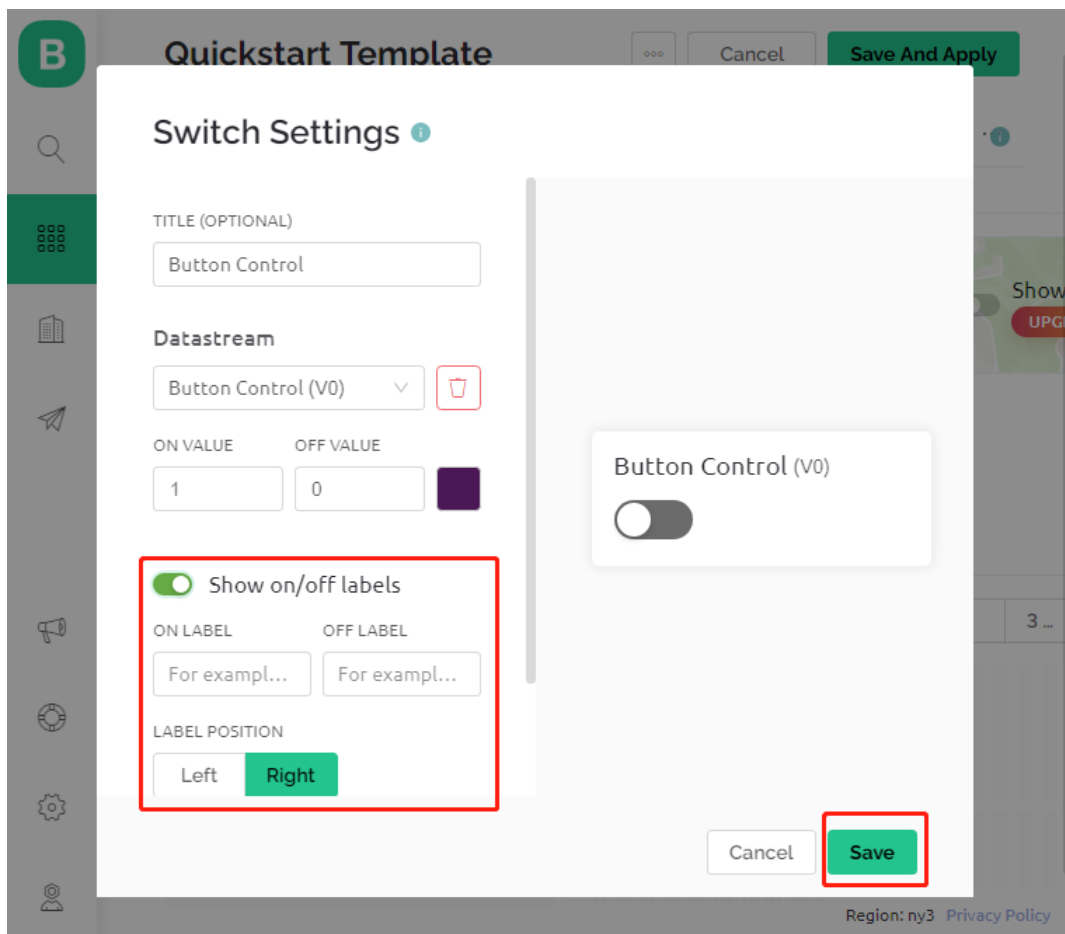


9. Select **Datastream** as the one you set earlier.





10. After selecting Datastream, you will see a few custom settings, then press Save.

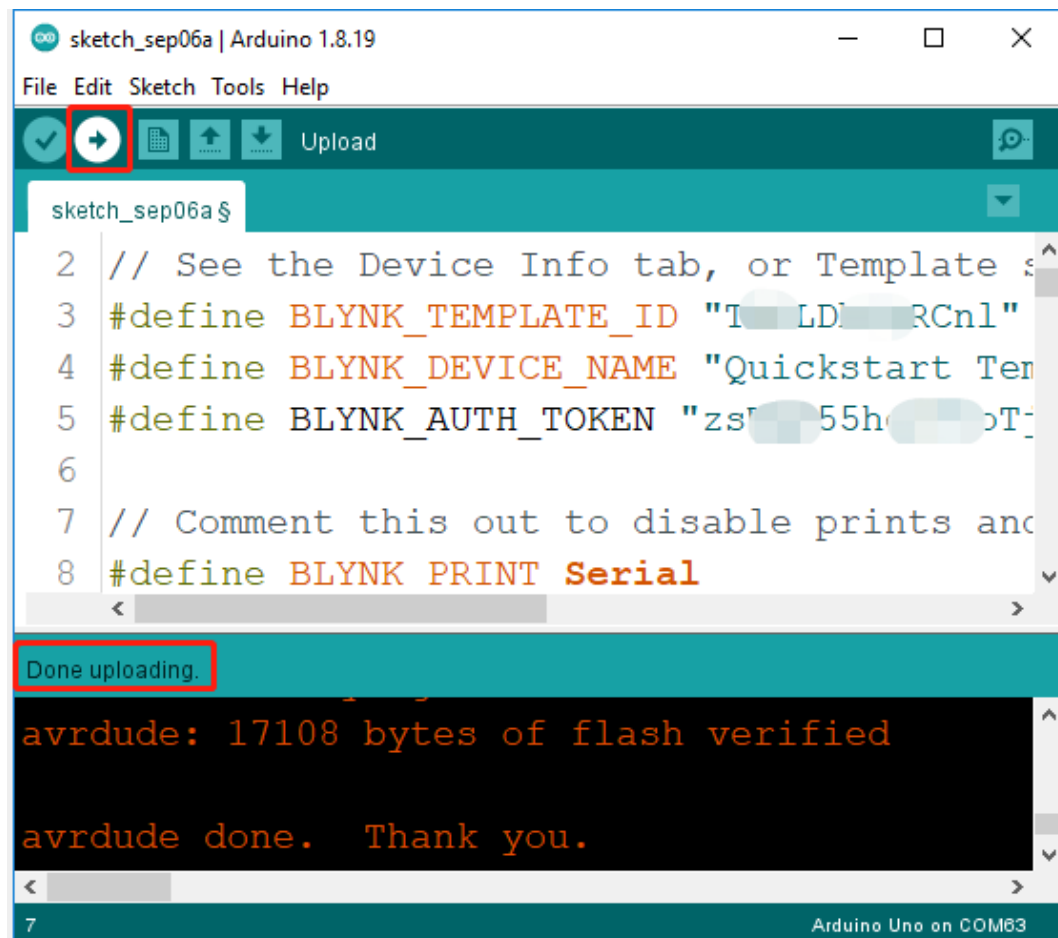


11. Finally, click **Save And Apply**.

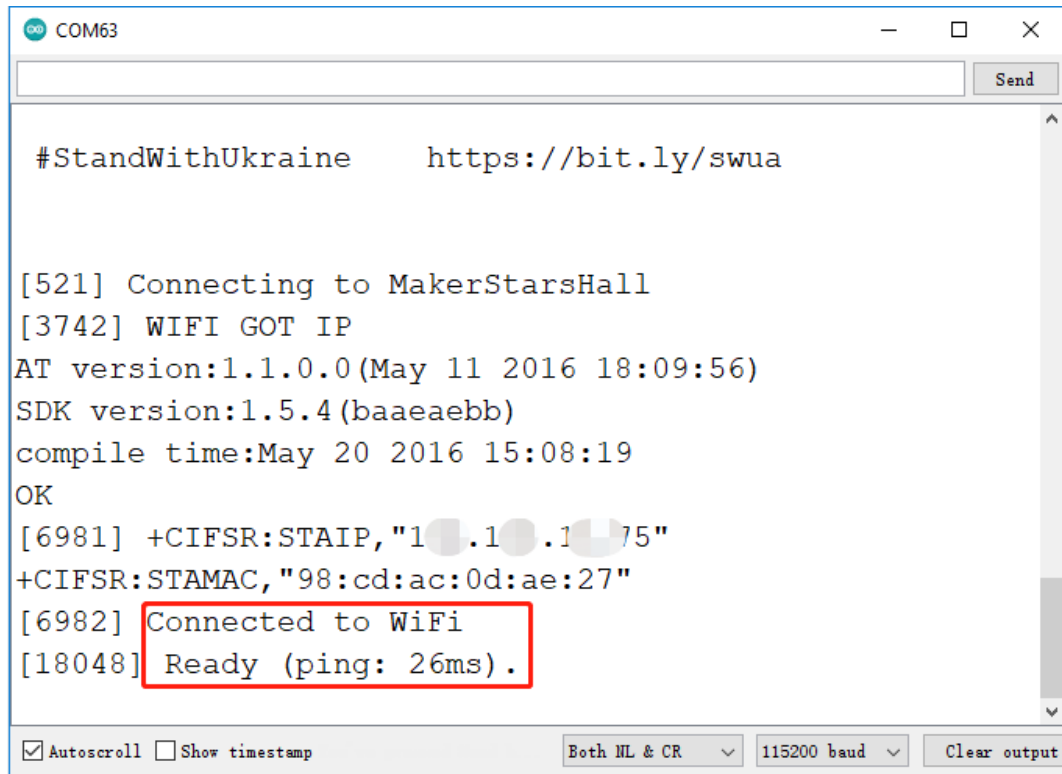


### 3. Run the Code

1. Open the `2.get_data_from_blynk.ino` file under the path of `3in1-kit\iot_project\2.get_data_from_blynk`, or copy this code into **Arduino IDE**.
2. Replace the Template ID, Device Name, and Auth Token with your own. You also need to enter the ssid and password of the WiFi you are using. For detailed tutorials, please refer to [1.4 Connecting the R3 board to Blynk](#).
3. After selecting the correct board and port, click the **Upload** button.



4. Open the Serial monitor(set baudrate to 115200) and wait for a prompt such as a successful connection to appear.

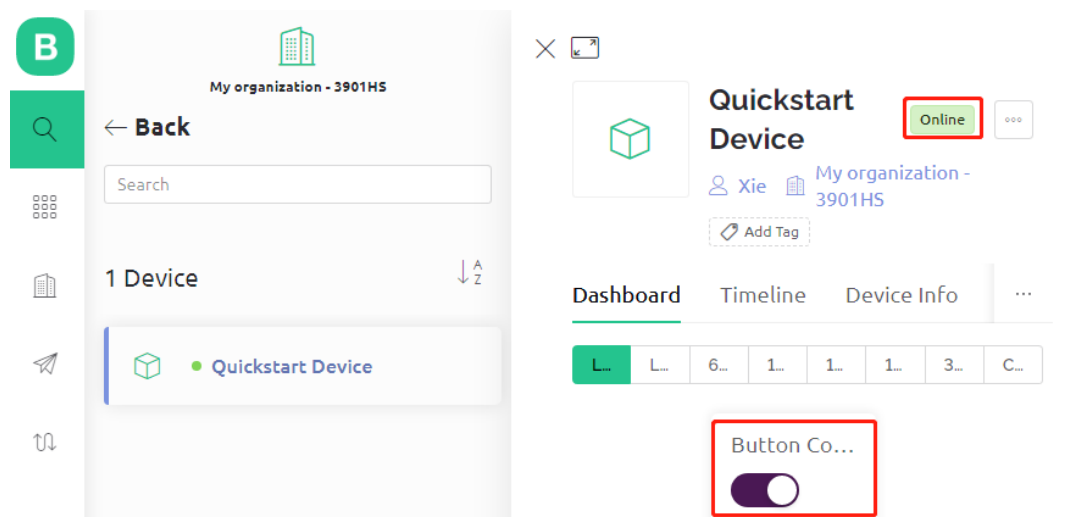


**Note:** If the message ESP is not responding appears when you connect, please follow these steps.

- Make sure the 9V battery is plugged in.
- Reset the ESP8266 module by connecting the pin RST to GND for 1 second, then unplug it.
- Press the reset button on the R3 board.

Sometimes, you may need to repeat the above operation 3-5 times, please be patient.

5. Back at Blynk, you can see that the status has changed to online and you can now use the switch widget on blynk to control the LED connected to the R3 board.



6. If you want to use Blynk on mobile devices, please refer to *How to use Blynk on mobile device?*.

### How it works?

The difference between the code in this project and the code in the previous chapter *1.4 Connecting the R3 board to Blynk* is the following lines.

```
const int ledPin=6;

BLYNK_WRITE(V0)
{
    int pinValue = param.asInt(); // assigning incoming value from pin V0 to a variable
    // You can also use:
    // String i = param.asStr();
    // double d = param.asDouble();
    digitalWrite(ledPin,pinValue);
}

void setup()
{
    pinMode(ledPin,OUTPUT);
}
```

Regarding the `pinMode` and `digitalWrite` of the `ledPin`, I'm sure you're already familiar with them, so I won't go over them again. What you need to focus on is the `BLYNK_WRITE(V0)` function.

What it will do is that when the value of Blynk's `V0` changes, Blynk.Cloud will tell your device "I am writing to **Virtual Pin V0**", and your device will be able to perform something once it gets this information.

We created the `V0` Datastream in the previous step and applied it to the Switch Widget. This means that every time we operate the Switch Widget, `BLYNK_WRITE(V0)` will be triggered.

We write two instructions in this function.

```
int pinValue = param.asInt();
```

Get the value of `V0` and assign it to the variable `pinValue`.

```
digitalWrite(ledPin,pinValue);
```

Write the value of `V0` obtained to the `ledPin`, so that the Switch widget on Blynk can control the LED.

## 6.3 3. Push Data to Blynk

This chapter will show you how to send data to Blynk.

We create a door and window detection device here. The circuit with the reed switch is placed next to the door and window, and the magnet is mounted on the edge of the door and window. When the door or window is closed, the Reed Switch will be turned on by the magnetic force and the corresponding pin value on the R3 board will change. Blynk.cloud will receive this value so that you can see if your house's doors and windows are closed even when you're away from home.

Now we will use an LED widget in Blynk to indicate if your windows and doors are closed (i.e. if the Reed Switch is on or off).

### Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

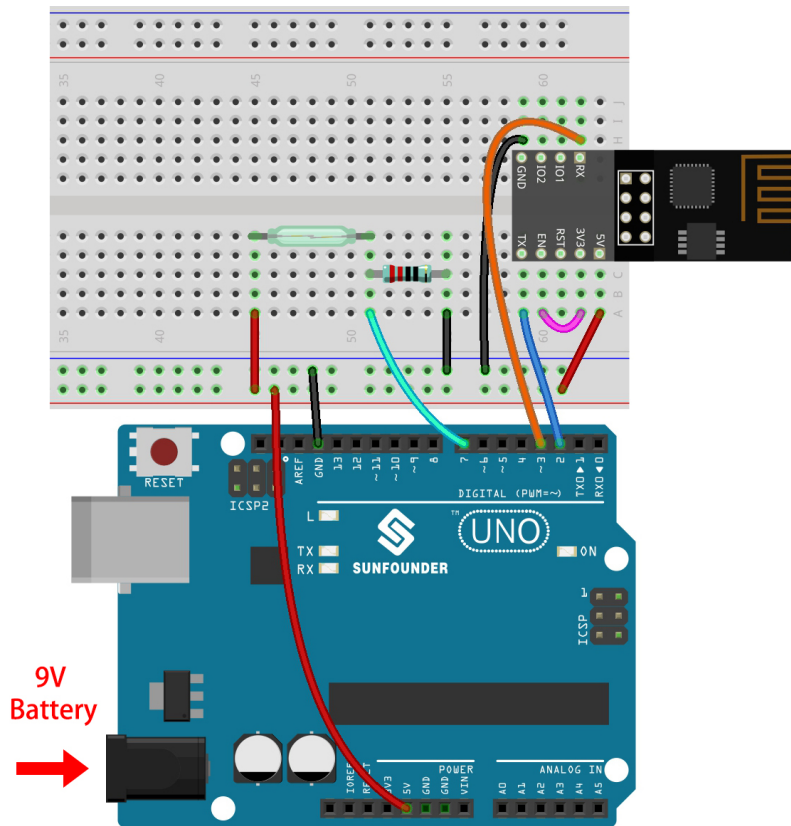
Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>ESP8266 Module</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Reed Switch</i>	-

## 1. Build the Circuit

**Note:** The ESP8266 module requires a high current to provide a stable operating environment, so make sure the 9V battery is plugged in.



## 2. Edit Dashboard

1. Create a **Datastream** of type **Virtual Pin** in the **Datastream** page to get the value of Reed Switch. Set the DATA TYPE to **Integer** and MIN and MAX to **0** and **1**.

**Quickstart Template** [Cancel] [Save And Apply]

### Virtual Pin Datastream

NAME:  ALIAS:

PIN:  DATA TYPE:

UNITS:

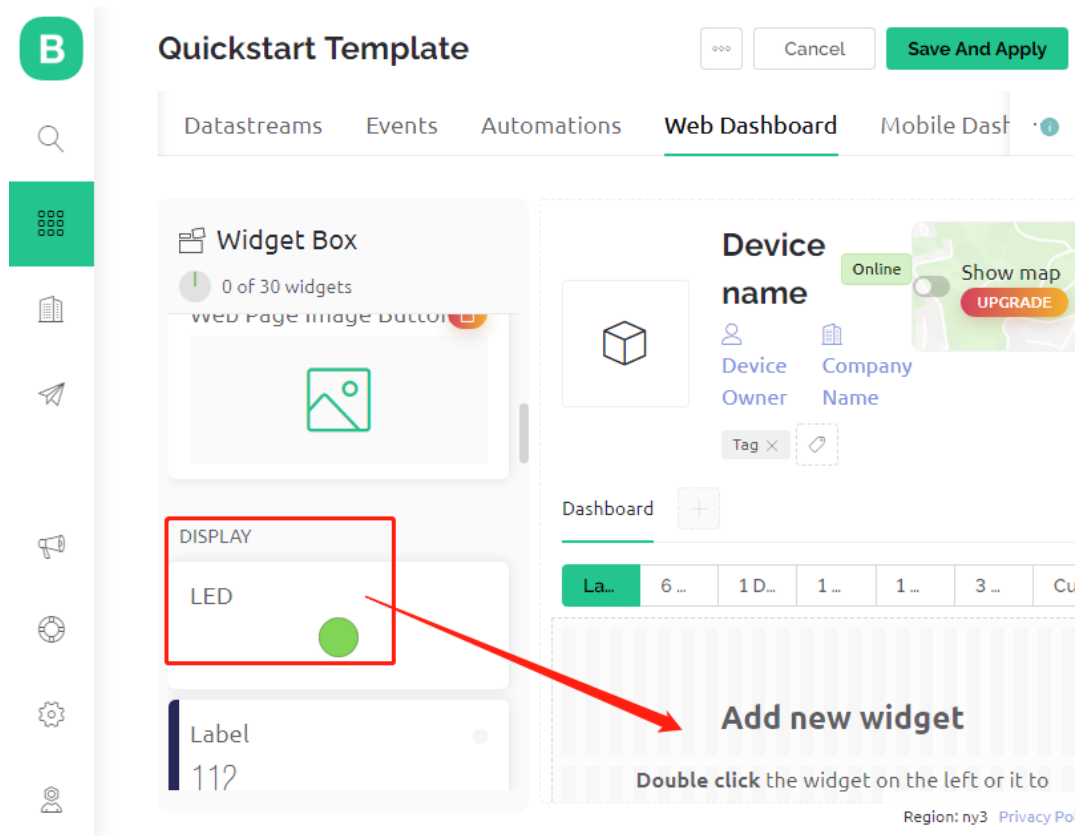
MIN:  MAX:  DEFAULT VALUE:

☐ ADVANCED SETTINGS

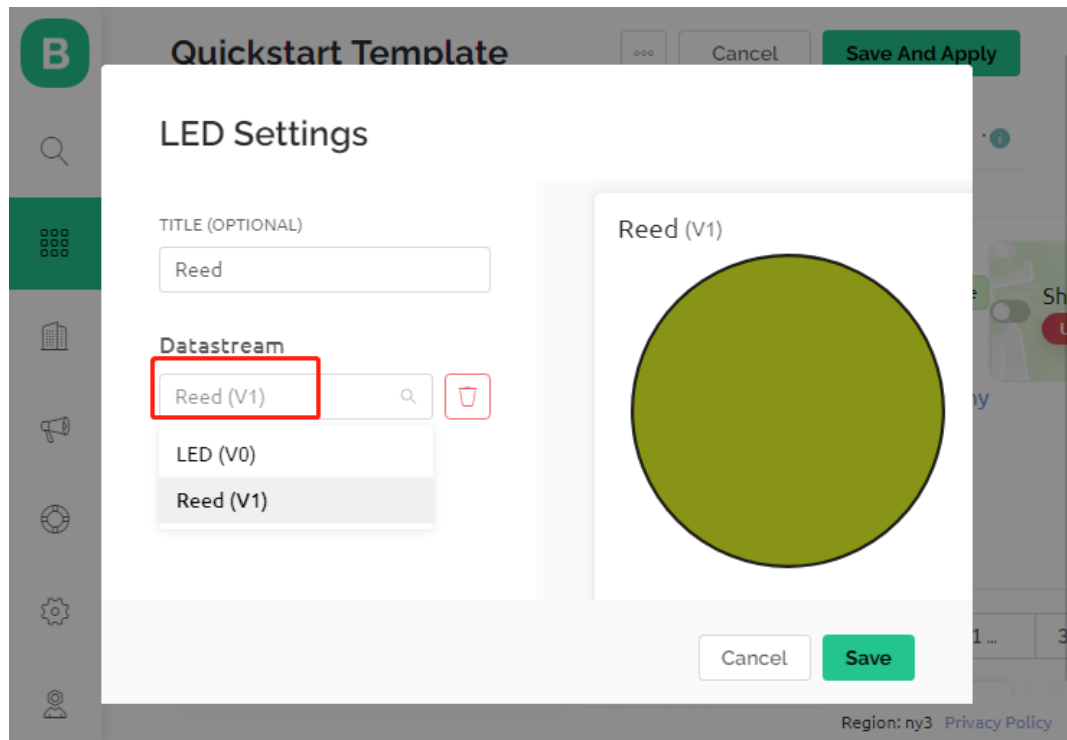
[Cancel] [Save]

Region: ny3 Privacy Policy

2. Drag and drop an **LED widget** on the **Web Dashboard** page, at a value of 1, it will light up (with color), otherwise it will be white.

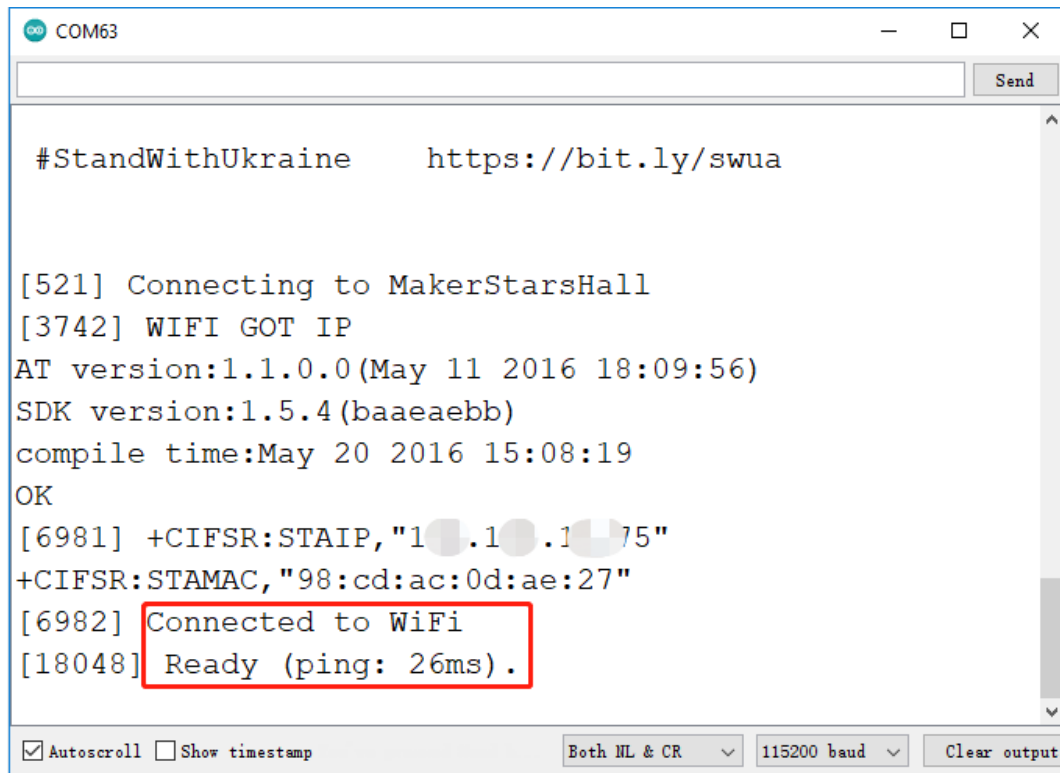


3. In the settings page of the **LED widget**, select **Datastream** as **Reed(V1)**, and save it.



### 3. Run the Code

1. Open the `3.push_data_to_blynk.ino` file under the path of `3in1-kit\iot_project\3.push_data_to_blynk`, or copy this code into **Arduino IDE**.
2. Replace the Template ID, Device Name, and Auth Token with your own. You also need to enter the ssid and password of the WiFi you are using. For detailed tutorials, please refer to [1.4 Connecting the R3 board to Blynk](#).
3. After selecting the correct board and port, click the **Upload** button.
4. Open the Serial monitor(set baudrate to 115200) and wait for a prompt such as a successful connection to appear.



```
COM63

#StandWithUkraine https://bit.ly/swua

[521] Connecting to MakerStarsHall
[3742] WIFI GOT IP
AT version:1.1.0.0(May 11 2016 18:09:56)
SDK version:1.5.4(baaeaebb)
compile time:May 20 2016 15:08:19
OK
[6981] +CIFSR:STAIP,"1.1.1.175"
+CIFSR:STAMAC,"98:cd:ac:0d:ae:27"
[6982] Connected to WiFi
[18048] Ready (ping: 26ms).
```

---

**Note:** If the message ESP is not responding appears when you connect, please follow these steps.

- Make sure the 9V battery is plugged in.
- Reset the ESP8266 module by connecting the pin RST to GND for 1 second, then unplug it.
- Press the reset button on the R3 board.

Sometimes, you may need to repeat the above operation 3-5 times, please be patient.

---

5. Now, Blynk will show the status of your doors and windows. If your doors and windows are closed, the LED widget will be green, otherwise, it will be gray.
6. If you want to use Blynk on mobile devices, please refer to [How to use Blynk on mobile device?](#).

### How it works?



For this example, you should focus on the following lines. “Write data every second to Blynk Cloud’s V1 Datastream” is defined by these lines.

```
BlynkTimer timer;

void myTimerEvent()
{
    Blynk.virtualWrite(V1, pinValue);
}

void setup()
{
    timer.setInterval(1000L, myTimerEvent);
}

void loop()
{
    timer.run(); // Initiates BlynkTimer
}
```

Blynk library provides a built-in timer, first we create a timer object.

```
BlynkTimer timer;
```

Set the timer interval in `setup()`, here we set to execute the `myTimerEvent()` function every 1000ms

```
timer.setInterval(1000L, myTimerEvent);
```

Run BlynkTimer in `loop()`.

```
timer.run();
```

Edit the custom function `myTimerEvent()`, the code `Blynk.virtualWrite(V1, pinValue)` is used to write the data `pinValue` for `V1`.

```
void myTimerEvent()
{
    Blynk.virtualWrite(V1, pinValue);
}
```

## 6.4 4. Cloud Music Player

The goal of this project is to create a music player using Blynk. Music is played in the same way as in *5.7 Tone() or noTone()*, by writing the song in the program and playing it with a passive buzzer. however, in this example, we can click the switch to play/pause and slide the slider to change the playback progress.

### Required Components

In this project, we need the following components.

It’s definitely convenient to buy a whole kit, here’s the link:

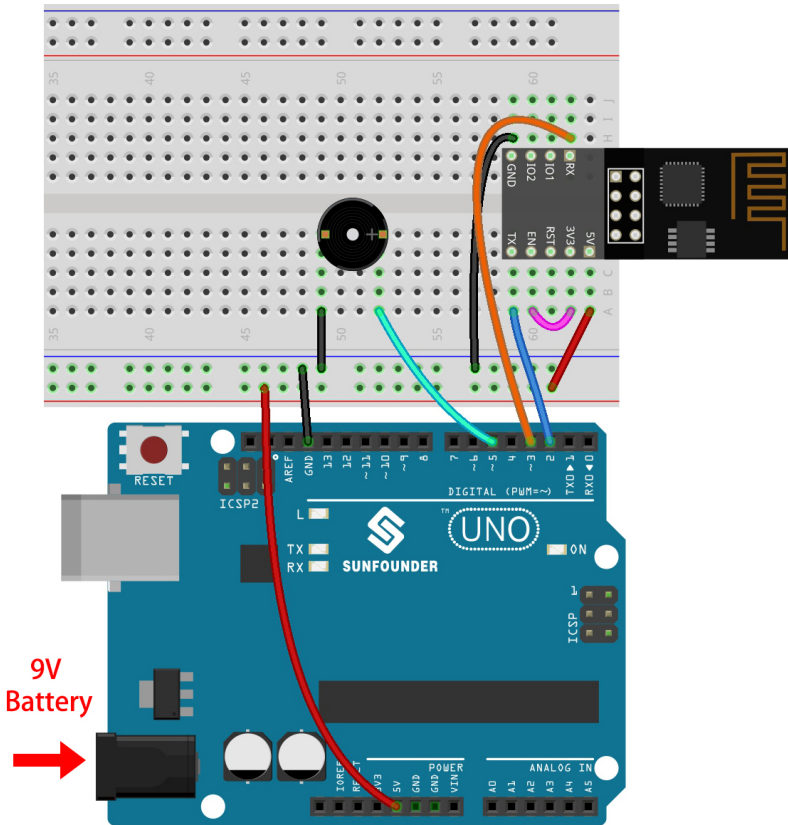
Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>ESP8266 Module</i>	
<i>Jumper Wires</i>	
<i>Buzzer</i>	

1. Build the Cirduit

**Note:** The ESP8266 module requires a high current to provide a stable operating environment, so make sure the 9V battery is plugged in.



2. Edit Dashboard

1. Create a **Datastream** of type **Virtual Pin** on the **Datastream** page as the value modified by the Slider widget added later or code. Set the DATA TYPE to **Integer** and MIN and MAX to **0** and **30**.

**Virtual Pin Datastream**

NAME:  ALIAS:

PIN:  DATA TYPE:

UNITS:

MIN:  MAX:  DEFAULT VALUE:

[+ ADVANCED SETTINGS](#)

Region: ny3 [Privacy Policy](#)

2. Also create another **Datastream** of type **Virtual Pin** to display the music name, and set the DATA TYPE to **String**.

**Virtual Pin Datastream**

NAME:  ALIAS:

PIN:  DATA TYPE:

DEFAULT VALUE:

Region: ny3 [Privacy Policy](#)

3. Go to the **Web Dashboard** page, drag a **Switch** widget and set **Datastream** to V0 (V0 is already set in 2. *Get Data from Blynk*); drag a **Label** widget and set it to V3; drag a **Slider** widget and set it to V2.

**Widget Box**  
3 of 30 widgets

**Chart**

**Map**

**Device name** Online  
[Device Owner](#) [Company Name](#)  
 Tag

**Dashboard**

**Last Hour** 6 Hours 1 Day 1 Week 1 Month

Button Co... (V0) Slider (V2)

Song Name (V3)  
String

**Note:** Your virtual pins may be different from mine, yours will prevail, but you need to modify the corresponding pin number in the code.

### 3. Run the Code

1. Open the 4.cloud\_music\_player.ino file under the path of 3in1-kit\iot\_project\4.cloud\_music\_player.
2. Replace the Template ID, Device Name, and Auth Token with your own. You also need to enter the ssid and password of the WiFi you are using. For detailed tutorials, please refer to [1.4 Connecting the R3 board to Blynk](#).
3. After selecting the correct board and port, click the **Upload** button.
4. Open the Serial monitor(set baudrate to 115200) and wait for a prompt such as a successful connection to appear.

```

COM63

#StandWithUkraine https://bit.ly/swua

[521] Connecting to MakerStarsHall
[3742] WIFI GOT IP
AT version:1.1.0.0(May 11 2016 18:09:56)
SDK version:1.5.4(baaeaebb)
compile time:May 20 2016 15:08:19
OK
[6981] +CIFSR:STAIP,"1.1.1.175"
+CIFSR:STAMAC,"98:cd:ac:0d:ae:27"
[6982] Connected to WiFi
[18048] Ready (ping: 26ms).

Autoscroll Show timestamp Both NL & CR 115200 baud Clear output

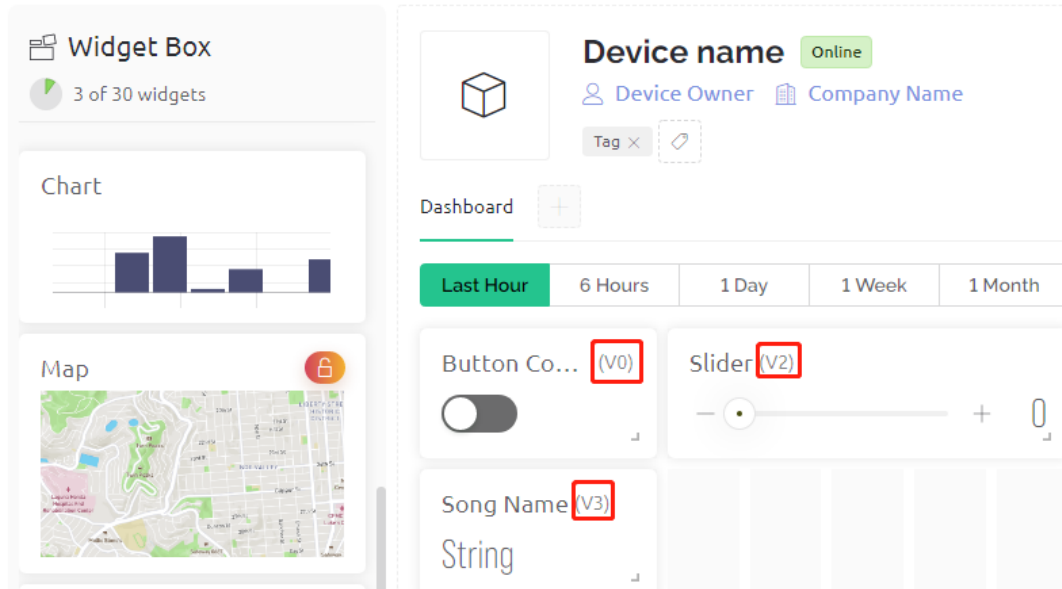
```

**Note:** If the message ESP is not responding appears when you connect, please follow these steps.

- Make sure the 9V battery is plugged in.
- Reset the ESP8266 module by connecting the pin RST to GND for 1 second, then unplug it.
- Press the reset button on the R3 board.

Sometimes, you may need to repeat the above operation 3-5 times, please be patient.

5. Now, you can use Blynk's Button Control widget to start/pause the music and the Slider to adjust the playback progress, and you'll also see the name of the music.



6. If you want to use Blynk on mobile devices, please refer to [How to use Blynk on mobile device?](#).

#### How it works?

The datastream **V0** is used to get the status of the Switch widget and assign it to the variable **musicPlayFlag**, which controls pausing and playing the music.

```
int musicPlayFlag=0;

BLYNK_WRITE(V0)
{
    musicPlayFlag = param.asInt(); // START/PAUSE MUSIC
}
```

The data stream **V2** is used to get the value of the slider widget and assign it to the variable **scrubBar** when the slider is moved.

```
int scrubBar=0;

BLYNK_WRITE(V2)
{
    scrubBar=param.asInt();
}
```

When the device is connected to the **Blynk Cloud**, write the music name for the **V3** datastream and then display it with the **Label** widget.

```
BLYNK_CONNECTED() {
    String songName = "Ode to Joy";
    Blynk.virtualWrite(V3, songName);
}
```

**Blynk Timer** will execute every second. Music is played if **musicPlayFlag** is not 0, i.e. the **Switch** widget is ON. As soon as two notes are played, the progress bar variable **scrubBar** is incremented by 2, and the value is then written to the **Blynk Cloud**, which synchronizes the value of the **Slider** widget.

```

void myTimerEvent()
{
    if(musicPlayFlag!=0)
    {
        tone(buzzerPin,melody[scrubBar],250);
        scrubBar=(scrubBar+1)%(sizeof(melody)/sizeof(int));
        delay(500);
        tone(buzzerPin,melody[scrubBar],250);
        scrubBar=(scrubBar+1)%(sizeof(melody)/sizeof(int));
        Serial.println(scrubBar);
        Blynk.virtualWrite(V2, scrubBar);
    }
}

```

## 6.5 5. Home Environment Monitoring

In this chapter, we will use Blynk to create a home environment monitor. You can measure the temperature, humidity, and light intensity of a room using the DHT11 and photoresistor. By sending these values to Blynk, you will be able to know the environment of your home via the internet.

### Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

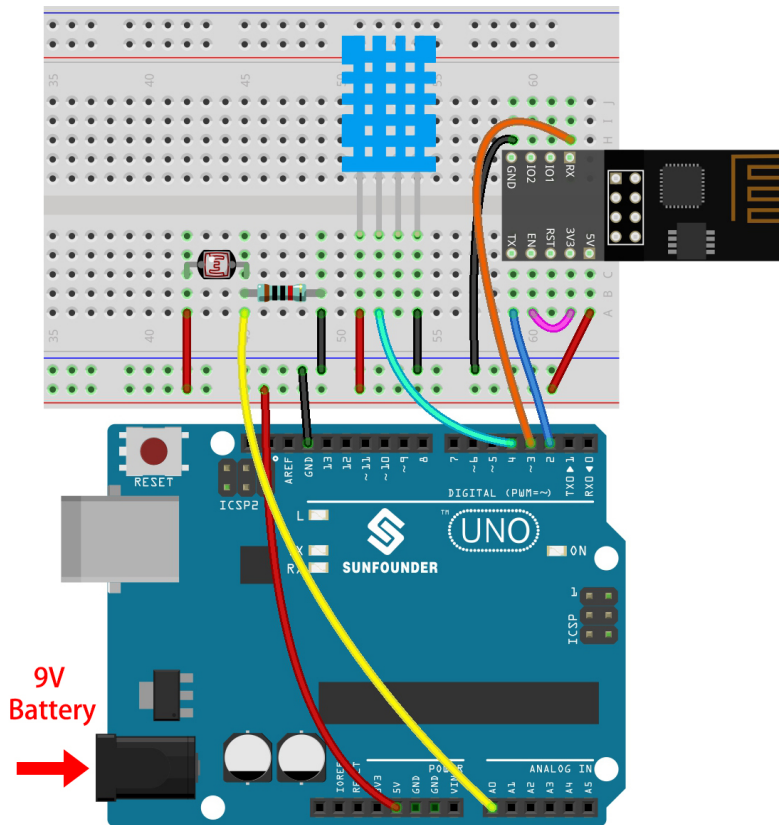
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>ESP8266 Module</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Photoresistor</i>	
<i>DHT11 Humiture Sensor</i>	-

### 1. Build the Cirduit

**Note:** The ESP8266 module requires a high current to provide a stable operating environment, so make sure the 9V

battery is plugged in.

---



## 2. Edit Dashboard

1. For recording humidity values, create a **Datastream** of type **Virtual Pin** on the **Datastream** page. Set the DATA TYPE to **Double** and MIN and MAX to **0** and **100**. Also set the units to **Percentage, %**.



**Virtual Pin Datastream**

NAME:  ALIAS:

PIN:  DATA TYPE:

UNITS:

MIN:  MAX:  DECIMALS:  DEFAULT VALUE:

ADVANCED SETTINGS

Region: ny3 [Privacy Policy](#)

- Then create a **Datastream** of type **Virtual Pin** for recording the temperature. Set DATA TYPE to Double, MIN and MAX to -30 and 50, and units to **Celsius, °C**.

**Virtual Pin Datastream**

NAME:  ALIAS:

PIN:  DATA TYPE:

UNITS:

MIN:  MAX:  DECIMALS:  DEFAULT VALUE:

☐ ADVANCED SETTINGS

- Also create a **Datastream** of type **Virtual Pin** to record the light intensity. Use the default data type - **Integer**, with MIN and MAX set to 0 and 1024.

**Virtual Pin Datastream**

NAME:  ALIAS:

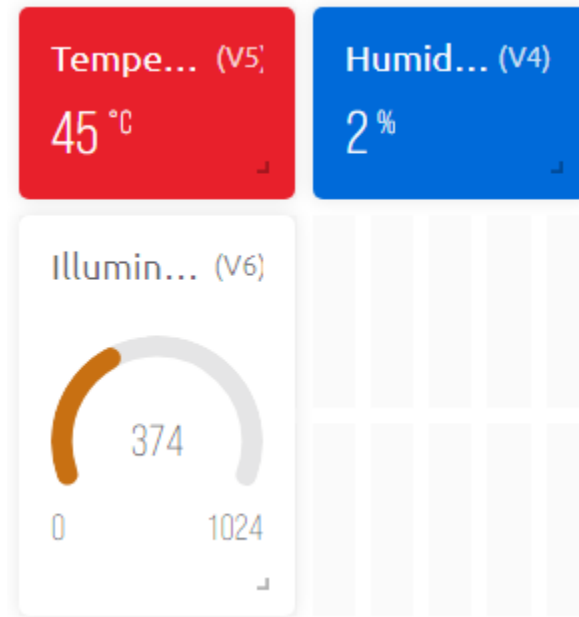
PIN:  DATA TYPE:

UNITS:

MIN:  MAX:  DEFAULT VALUE:

Region: ny3 [Privacy Policy](#)

- Go to the **Web Dashboard** page, drag two **Label** widgets and set their data streams to **V4** and **V5** respectively, and drag a **Gauge** widget and set the data stream to **V6**. Also in the widget setting, you can enable **Change color based on value** and select the appropriate color to make the widget look better and more intuitive.



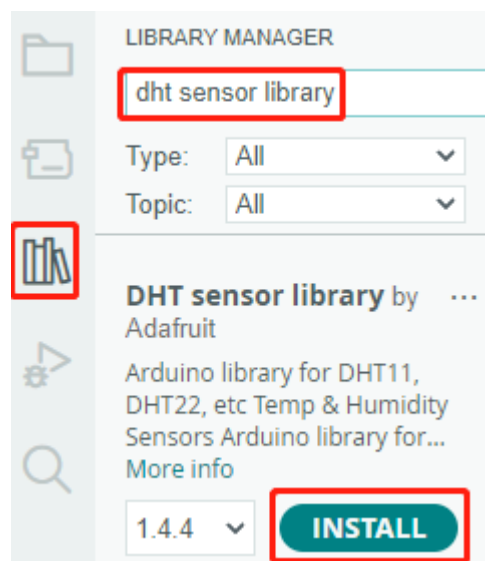
### 3. Run the Code

1. Open the `5.home_environment_monitoring.ino` file under the path of `3in1-kit\iot_project\5.home_environment_monitoring`, or copy this code into **Arduino IDE**.

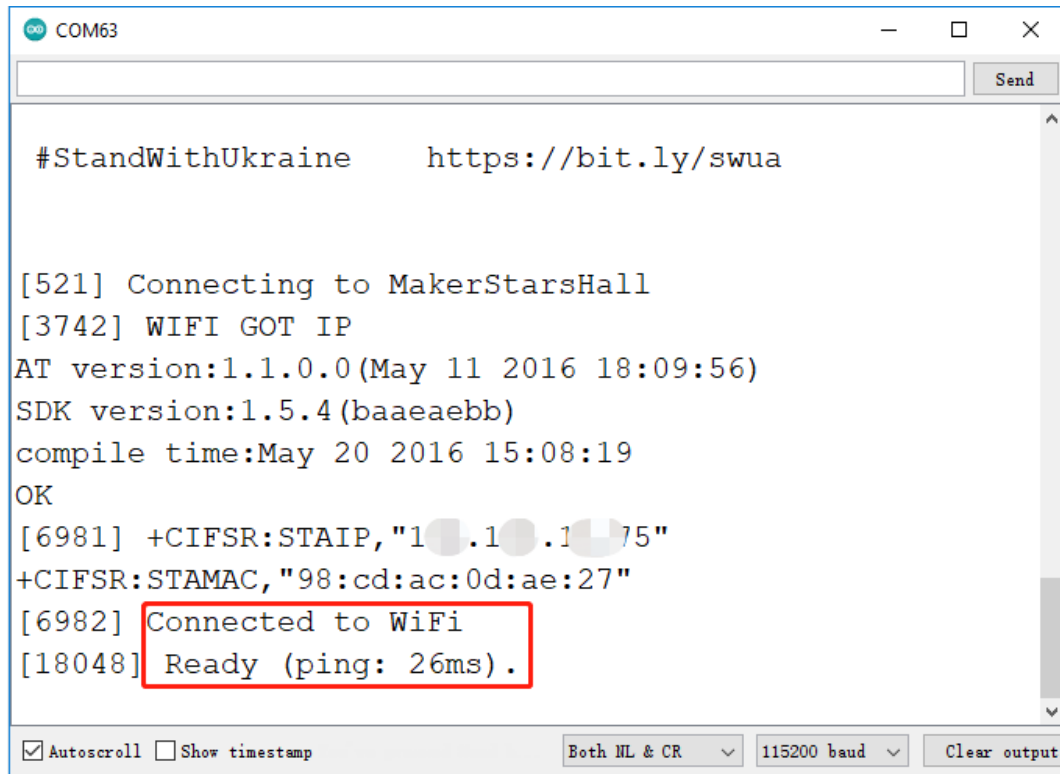
---

#### Note:

- The DHT sensor library is used here, you can install it from the **Library Manager**.



2. Replace the Template ID, Device Name, and Auth Token with your own. You also need to enter the ssid and password of the WiFi you are using. For detailed tutorials, please refer to [1.4 Connecting the R3 board to Blynk](#).
3. After selecting the correct board and port, click the **Upload** button.
4. Open the Serial monitor (set baudrate to 115200) and wait for a prompt such as a successful connection to appear.



```
COM63

#StandWithUkraine  https://bit.ly/swua

[521] Connecting to MakerStarsHall
[3742] WIFI GOT IP
AT version:1.1.0.0(May 11 2016 18:09:56)
SDK version:1.5.4(baaeaebb)
compile time:May 20 2016 15:08:19
OK
[6981] +CIFSR:STAIP,"1.1.1.1"
+CIFSR:STAMAC,"98:cd:ac:0d:ae:27"
[6982] Connected to WiFi
[18048] Ready (ping: 26ms).
```

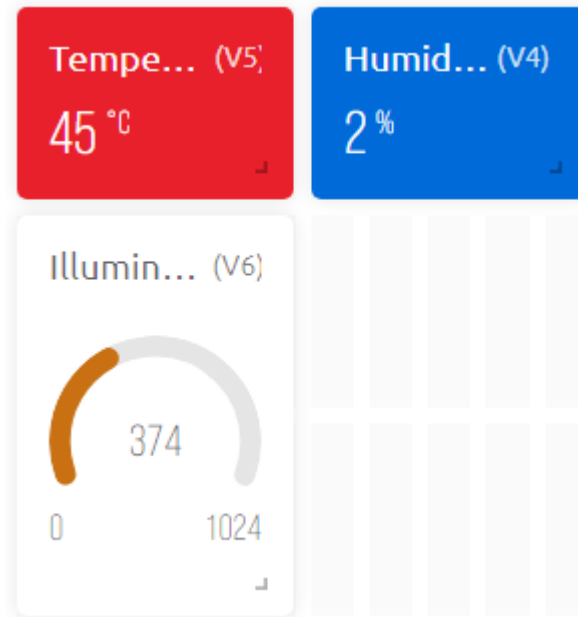
☒ Autoscroll ☐ Show timestamp Both NL & CR 115200 baud Clear output

**Note:** If the message ESP is not responding appears when you connect, please follow these steps.

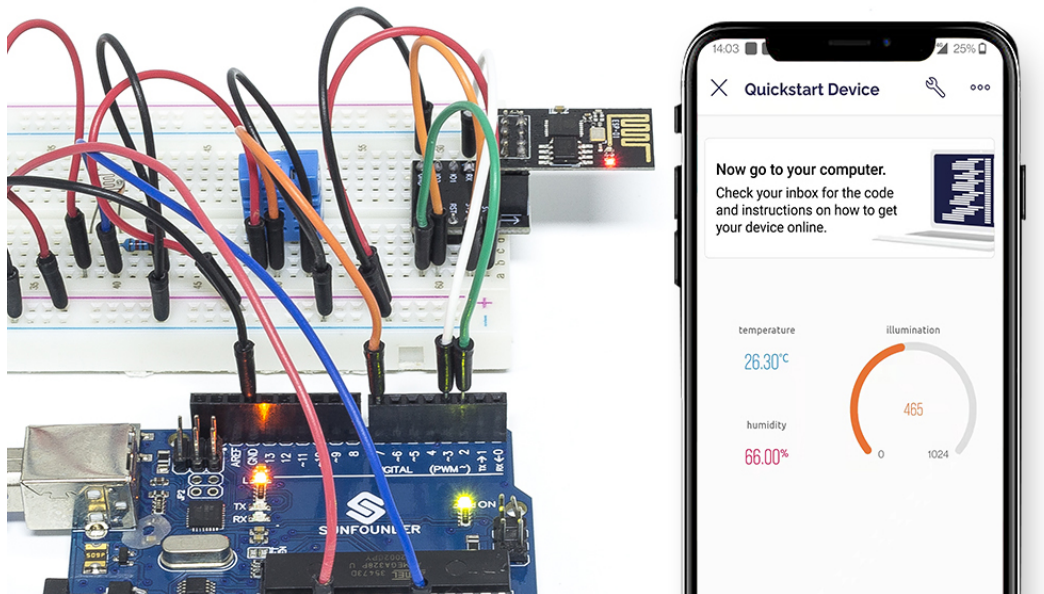
- Make sure the 9V battery is plugged in.
- Reset the ESP8266 module by connecting the pin RST to GND for 1 second, then unplug it.
- Press the reset button on the R3 board.

Sometimes, you may need to repeat the above operation 3-5 times, please be patient.

5. Now, you will see the current ambient temperature, humidity and light intensity on Blynk.



6. If you want to use Blynk on mobile devices, please refer to *How to use Blynk on mobile device?*.



### How it works?

These two functions are used to get the temperature, humidity and light intensity of the room.

```
int readLight(){
    return analogRead(lightPin);
}

bool readDHT() {

    // Reading temperature or humidity takes about 250 milliseconds!
    // Sensor readings may also be up to 2 seconds 'old' (it's a very slow sensor)
```

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```

humidity = dht.readHumidity();
// Read temperature as Celsius (the default)
temperature = dht.readTemperature();

// Check if any reads failed and exit early (to try again).
if (isnan(humidity) || isnan(temperature)) {
    Serial.println("Failed to read from DHT sensor!");
    return false;
}
return true;
}

```

With the Blynk Timer, the ambient temperature, humidity, and light intensity are obtained every second and sent to the data stream on the Blynk Cloud, from which the widgets display the data.

```

void myTimerEvent()
{
    bool chk = readDHT();
    int light = readLight();
    if(chk){
        Blynk.virtualWrite(V4,humidity);
        Blynk.virtualWrite(V5,temperature);
    }
    Blynk.virtualWrite(V6,light);
}

```

## 6.6 6. Plant Monitor

The purpose of this project is to create a smart watering system that detects the current temperature, humidity, intensity of light, and soil moisture and displays them on Blynk.

As soon as you turn on the Switch toggle in Blynk Cloud, the pump will start working and the plants will be hydrated.

### Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

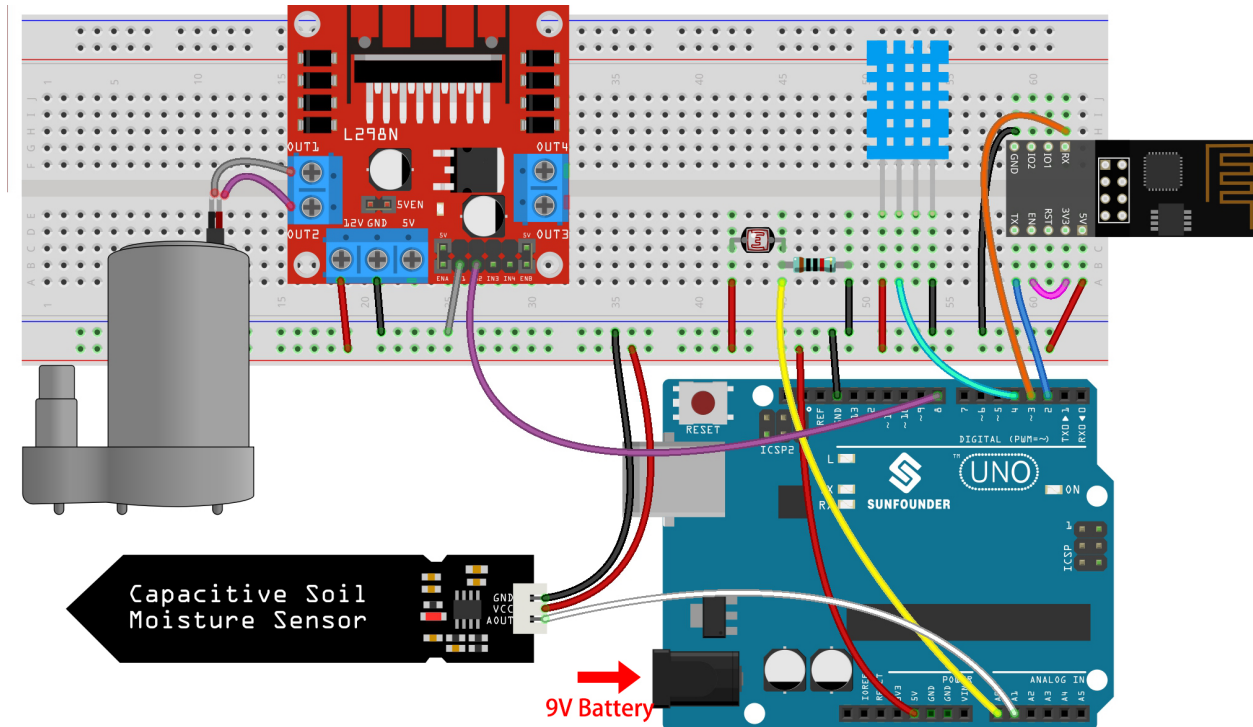
Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>ESP8266 Module</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Photoresistor</i>	
<i>DHT11 Humiture Sensor</i>	-
<i>Soil Moisture Module</i>	
<i>L298N Module</i>	
<i>Centrifugal Pump</i>	-

## 1. Build the Cirduit

**Note:** The ESP8266 module requires a high current to provide a stable operating environment, so make sure the 9V battery is plugged in.



## 2. Edit Dashboard

1. The data streams created in the previous projects need to be saved, and they will be used in this project as well.



- For recording soil moisture, create another **Datastream** of type **Virtual Pin** on the **Datastream** page. Set DATA TYPE to Integer and MIN and MAX to 0 and 1024.

**Virtual Pin Datastream**

NAME:  ALIAS:

PIN:  DATA TYPE:

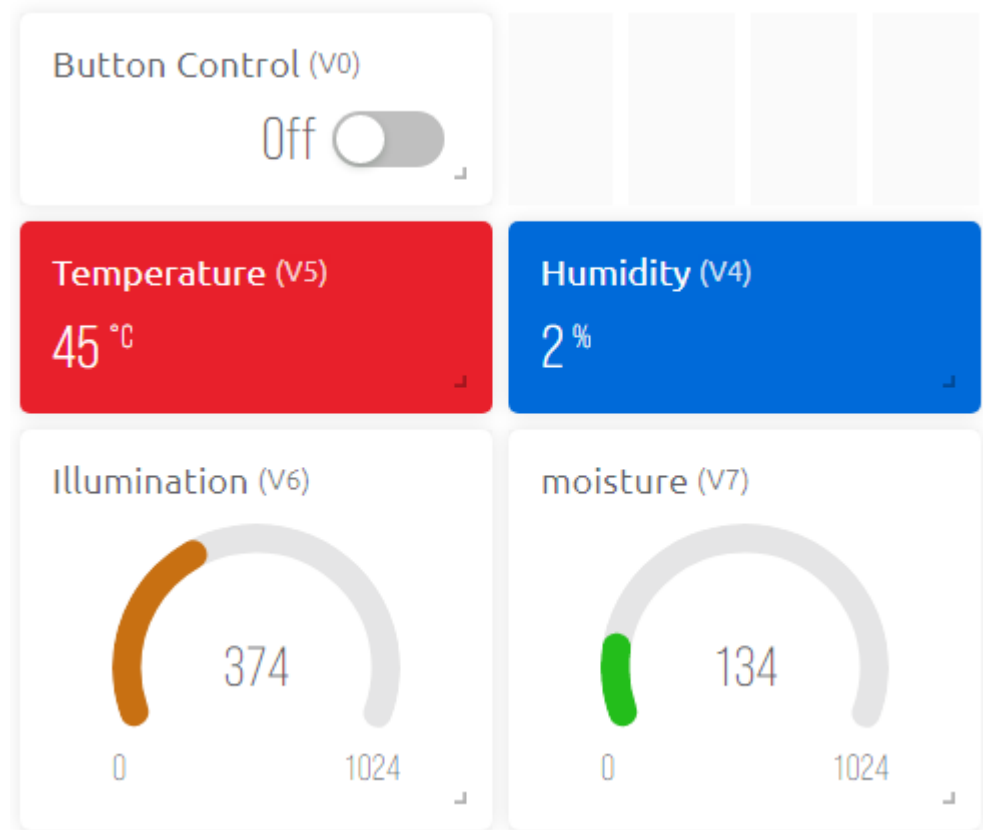
UNITS:

MIN:  MAX:  DEFAULT VALUE:

[+ ADVANCED SETTINGS](#)

Region: ny3 [Privacy Policy](#)

- Now go to the **Web Dashboard** page, drag 2 **Label** widgets and set their data streams to **V4** and **V5** respectively; drag 2 **Gauge** widgets and set their data streams to show **V6** and **V7** respectively; and finally drag a **Switch** widget and set its data stream to **V0**.



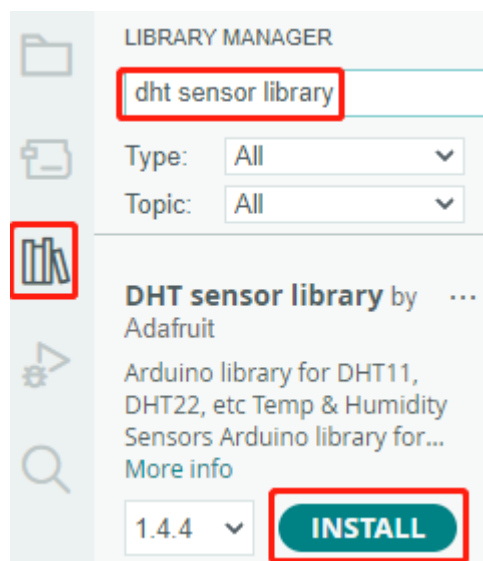
### 3. Run the Code

Open the 6.plant\_monitoring.ino file under the path of 3in1-kit\iot\_project\6.plant\_monitoring, or copy this code into **Arduino IDE**.

---

#### Note:

- The DHT sensor library is used here, you can install it from the **Library Manager**.



1. Replace the Template ID, Device Name, and Auth Token with your own. You also need to enter the ssid and password of the WiFi you are using. For detailed tutorials, please refer to [1.4 Connecting the R3 board to Blynk](#).
2. After selecting the correct board and port, click the **Upload** button.
3. Open the Serial monitor(set baudrate to 115200) and wait for a prompt such as a successful connection to appear.

```

COM63

#StandWithUkraine https://bit.ly/swua

[521] Connecting to MakerStarsHall
[3742] WIFI GOT IP
AT version:1.1.0.0(May 11 2016 18:09:56)
SDK version:1.5.4(baaeaebb)
compile time:May 20 2016 15:08:19
OK
[6981] +CIFSR:STAIP,"1.1.1.175"
+CIFSR:STAMAC,"98:cd:ac:0d:ae:27"
[6982] Connected to WiFi
[18048] Ready (ping: 26ms).

☒ Autoscroll ☐ Show timestamp
Both NL & CR 115200 baud Clear output

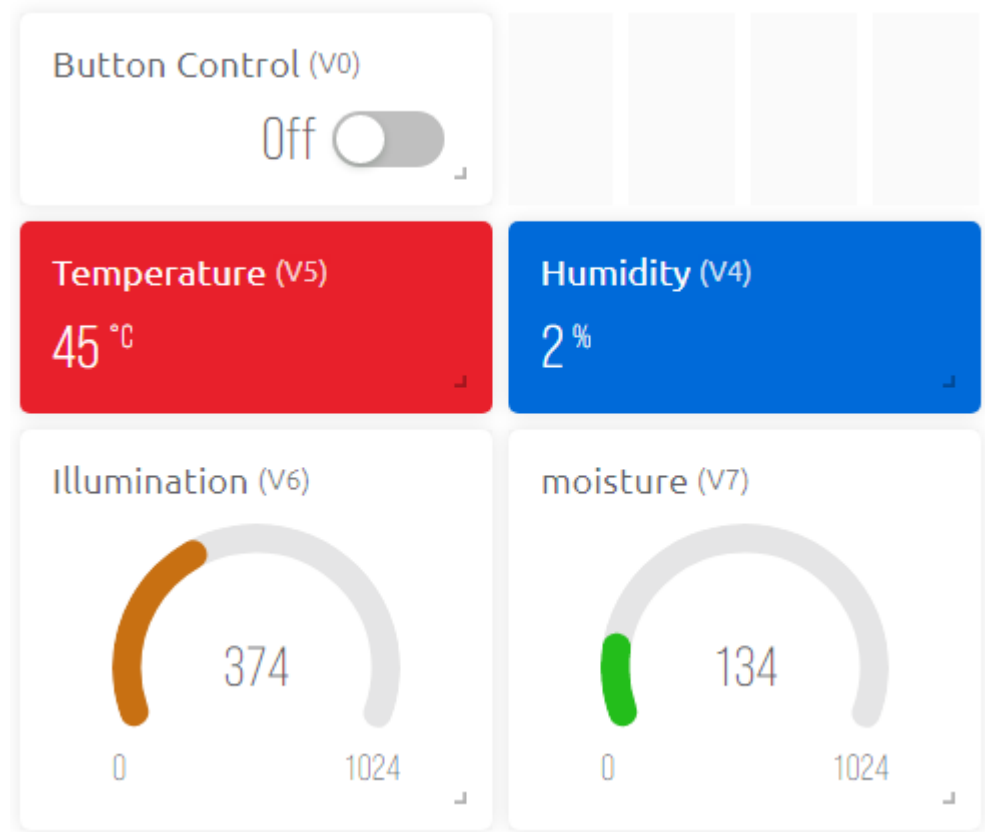
```

**Note:** If the message ESP is not responding appears when you connect, please follow these steps.

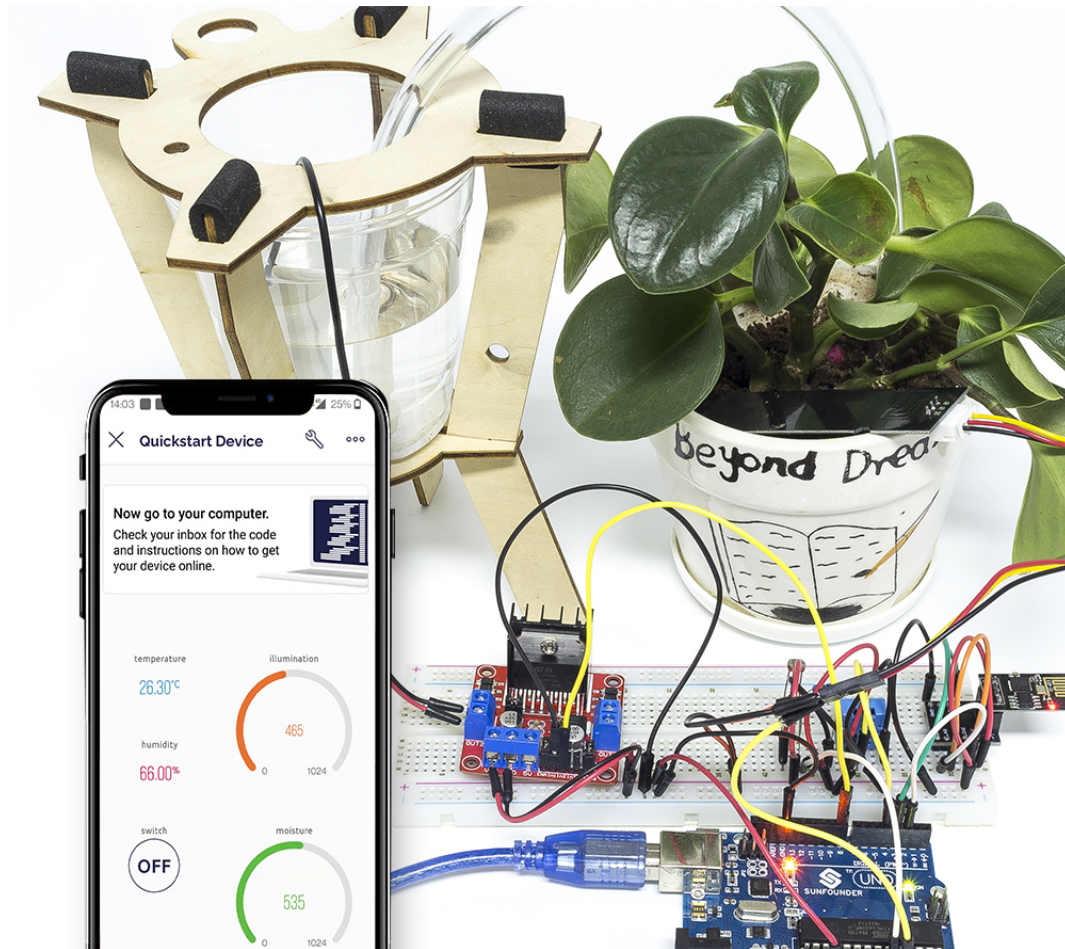
- Make sure the 9V battery is plugged in.
- Reset the ESP8266 module by connecting the pin RST to GND for 1 second, then unplug it.
- Press the reset button on the R3 board.

Sometimes, you may need to repeat the above operation 3-5 times, please be patient.

4. Back to the Blynk, you will see the current temperature, humidity, light intensity, and soil moisture. You can let the pump water the plants if necessary by clicking the Button Control widget.



5. If you want to use Blynk on mobile devices, please refer to [How to use Blynk on mobile device?](#).



### How it works?

This BLYNK\_WRITE causes Blynk's **Switch** widget to start the pump when it is ON and turn it off when it is OFF.

```
BLYNK_WRITE(V0)
{
  if(param.asInt()==1){
    digitalWrite(pumpA,HIGH);
  }else{
    digitalWrite(pumpA,LOW);
  }
}
```

These three functions are used to get the current environment temperature, humidity, light intensity and soil moisture.

```
int readMoisture(){
  return analogRead(moisturePin);
}

int readLight(){
  return analogRead(lightPin);
}

bool readDHT() {
```

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(continued from previous page)

```

// Reading temperature or humidity takes about 250 milliseconds!
// Sensor readings may also be up to 2 seconds 'old' (it's a very slow sensor)
humidity = dht.readHumidity();
// Read temperature as Celsius (the default)
temperature = dht.readTemperature();

// Check if any reads failed and exit early (to try again).
if (isnan(humidity) || isnan(temperature)) {
    Serial.println("Failed to read from DHT sensor!");
    return false;
}
return true;
}

```

With the Blynk Timer, the ambient temperature, humidity, light intensity and soil moisture are obtained every second and sent to the data stream on the **Blynk Cloud**, from which the widgets display the data.

```

void myTimerEvent()
{
    bool chk = readDHT();
    int light = readLight();
    int moisture = readMoisture();
    if(chk){
        Blynk.virtualWrite(V4,humidity);
        Blynk.virtualWrite(V5,temperature);
    }
    Blynk.virtualWrite(V6,light);
    Blynk.virtualWrite(V7,moisture);
}

```

## 6.7 7. Current Limiting Gate

Some situations, such as parking lots, require quantity management.

Here we create a smart gate: a servo is used as the gate, and an IR obstacle detector is placed in front of it; if an object (like a car) is detected, the gate will open and the number will be increased by 1. The count is displayed with a 7-segment display and is also uploaded to the Blynk Cloud for you to view remotely. Finally, Blynk has a Switch widget to enable or disable this smart gate system.

### Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

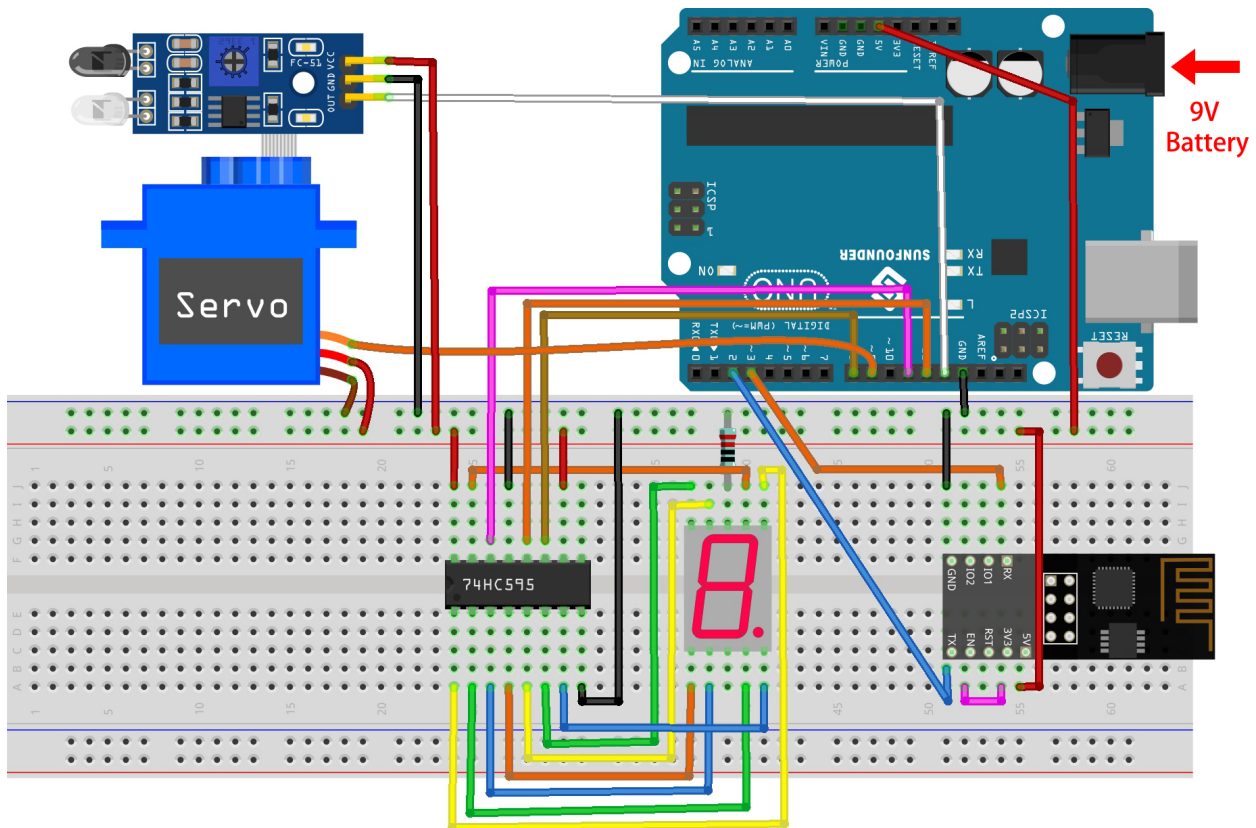
Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>ESP8266 Module</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Servo</i>	
<i>Obstacle Avoidance Module</i>	
<i>7-segment Display</i>	
<i>74HC595</i>	

### 1. Build the Circuit

**Note:** The ESP8266 module requires a high current to provide a stable operating environment, so make sure the 9V battery is plugged in.



## 2. Edit Dashboard

1. To record the number, create a **Datastream** of type **Virtual Pin** on the **Datastream** page. Set DATA TYPE to Integer and MIN and MAX to 0 and 10.

**Virtual Pin Datastream**

NAME:  ALIAS:

PIN:  DATA TYPE:

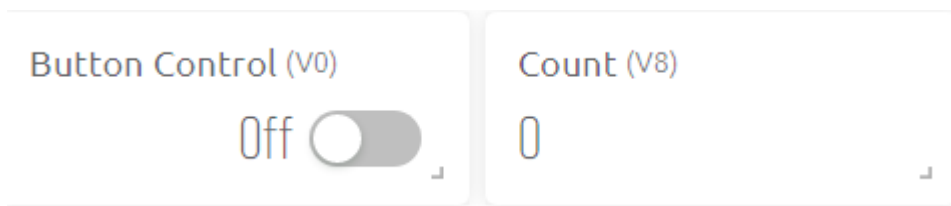
UNITS:

MIN:  MAX:  DEFAULT VALUE:

[+ ADVANCED SETTINGS](#)

Region: ny3 [Privacy Policy](#)

2. Now go to the **Wed Dashboard** page, drag a **Switch** widget to set its data stream to **V0** and a **Label** widget to set its data stream to **V8**.



## 3. Run the Code

1. Open the `7.current_limiting_gate.ino` file under the path of `3in1-kit\iot_project\7.current_limiting_gate`, or copy this code into **Arduino IDE**.
2. Replace the Template ID, Device Name, and Auth Token with your own. You also need to enter the ssid and password of the WiFi you are using. For detailed tutorials, please refer to [1.4 Connecting the R3 board to Blynk](#).
3. After selecting the correct board and port, click the **Upoad** button.
4. Open the Serial monitor(set baudrate to 115200) and wait for a prompt such as a successful connection to appear.



```

COM63

#StandWithUkraine https://bit.ly/swua

[521] Connecting to MakerStarsHall
[3742] WIFI GOT IP
AT version:1.1.0.0(May 11 2016 18:09:56)
SDK version:1.5.4(baaeaebb)
compile time:May 20 2016 15:08:19
OK
[6981] +CIFSR:STAIP,"1.1.1.1"
+CIFSR:STAMAC,"98:cd:ac:0d:ae:27"
[6982] Connected to WiFi
[18048] Ready (ping: 26ms).

☒ Autoscroll ☐ Show timestamp
Both NL & CR 115200 baud Clear output

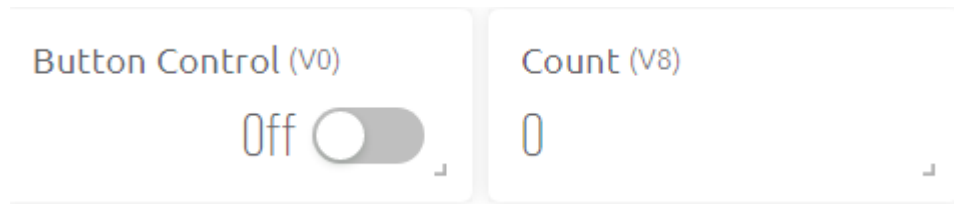
```

**Note:** If the message ESP is not responding appears when you connect, please follow these steps.

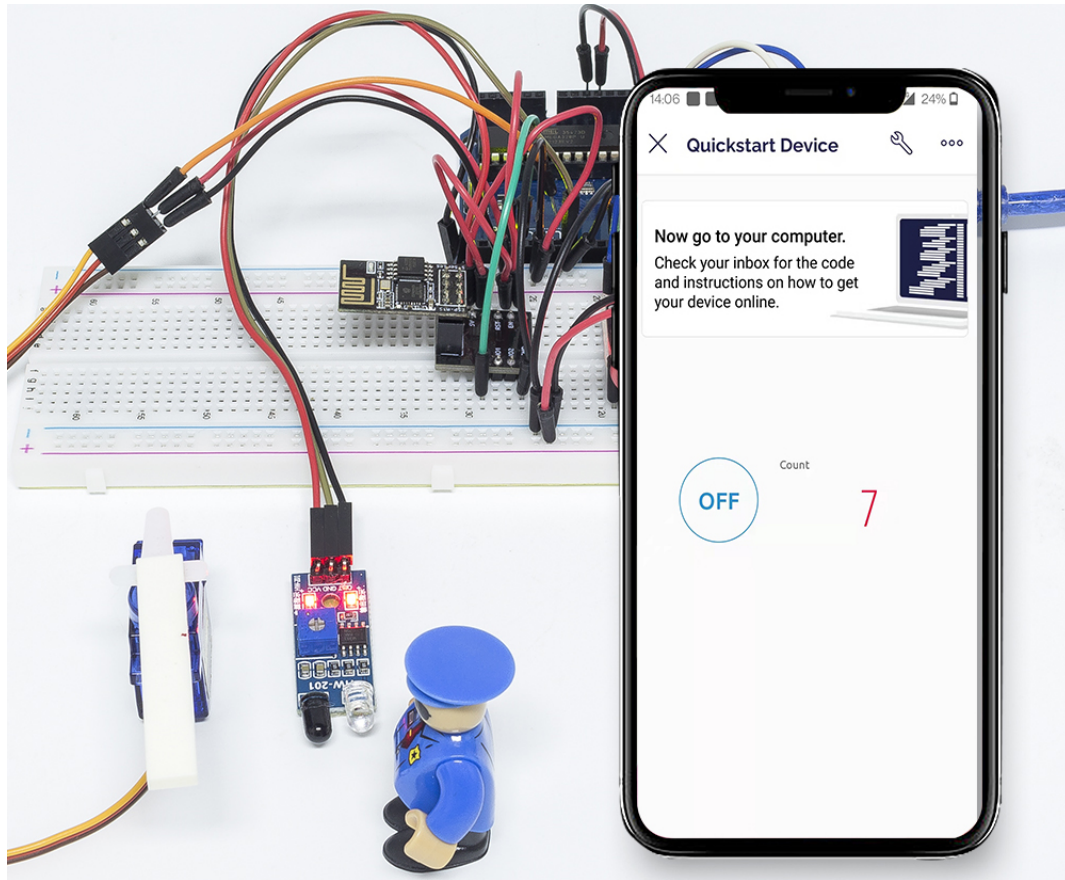
- Make sure the 9V battery is plugged in.
- Reset the ESP8266 module by connecting the pin RST to GND for 1 second, then unplug it.
- Press the reset button on the R3 board.

Sometimes, you may need to repeat the above operation 3-5 times, please be patient.

5. Now click on the Button Control widget on Blynk to enable the smart door system. If the IR obstacle avoidance module detects an obstacle, the gate will open and the 7-segment display and the Count widget on Blynk will add 1.



6. If you want to use Blynk on mobile devices, please refer to *How to use Blynk on mobile device?*.



### How it works?

The function `BLYNK_WRITE(V0)` gets the status of the **Switch** widget and assigns it to the variable `doorFlag`, which will be used to determine if the smart gate system is enabled or not.

```
BLYNK_WRITE(V0)
{
    doorFlag = param.asInt(); // Enable Gate
}
```

In the Blynk Timer, `doorFlag` is judged every second and if it is enabled, the main function of the gate is executed.

```
void myTimerEvent()
{
    if (doorFlag)
    {
        channelEntrance();
    }
}
```

The main function of the gate is `channelEntrance()`. When an object approaches the gate (the sensor detects that there is an obstacle), the count is increased by 1. Write count to the datastream V8 of Blynk Cloud and 7-segment display on the circuit, and open the door. If the object goes from present to absent, which means the object has entered the door, close the door.

```
void channelEntrance()
```

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```

{
  int currentState = digitalRead(irPin); // 0:obstacle 1:no-obstacle
  if (currentState == 0 && lastState == 1) {
    count=(count+1)%10;
    Blynk.virtualWrite(V8, count);
    showNumber(count);
    operateGate(true);
  } else if ((currentState == 1 && lastState == 0)) {
    operateGate(false);
  }
  lastState = currentState;
}

```

The function showNumber(int num) is used to make the 7-segment display show the value.

```

void showNumber(int num)
{
  digitalWrite(STcp, LOW); //ground ST_CP and hold low for as long as you are
  ↳transmitting
  shiftOut(DS, SHcp, MSBFIRST, dataArray[num]);
  digitalWrite(STcp, HIGH); //pull the ST_CPST_CP to save the data
}

```

The function operateGate(bool openGate) slowly opens the door when the reference is True, and slowly closes the door when the reference is False.

```

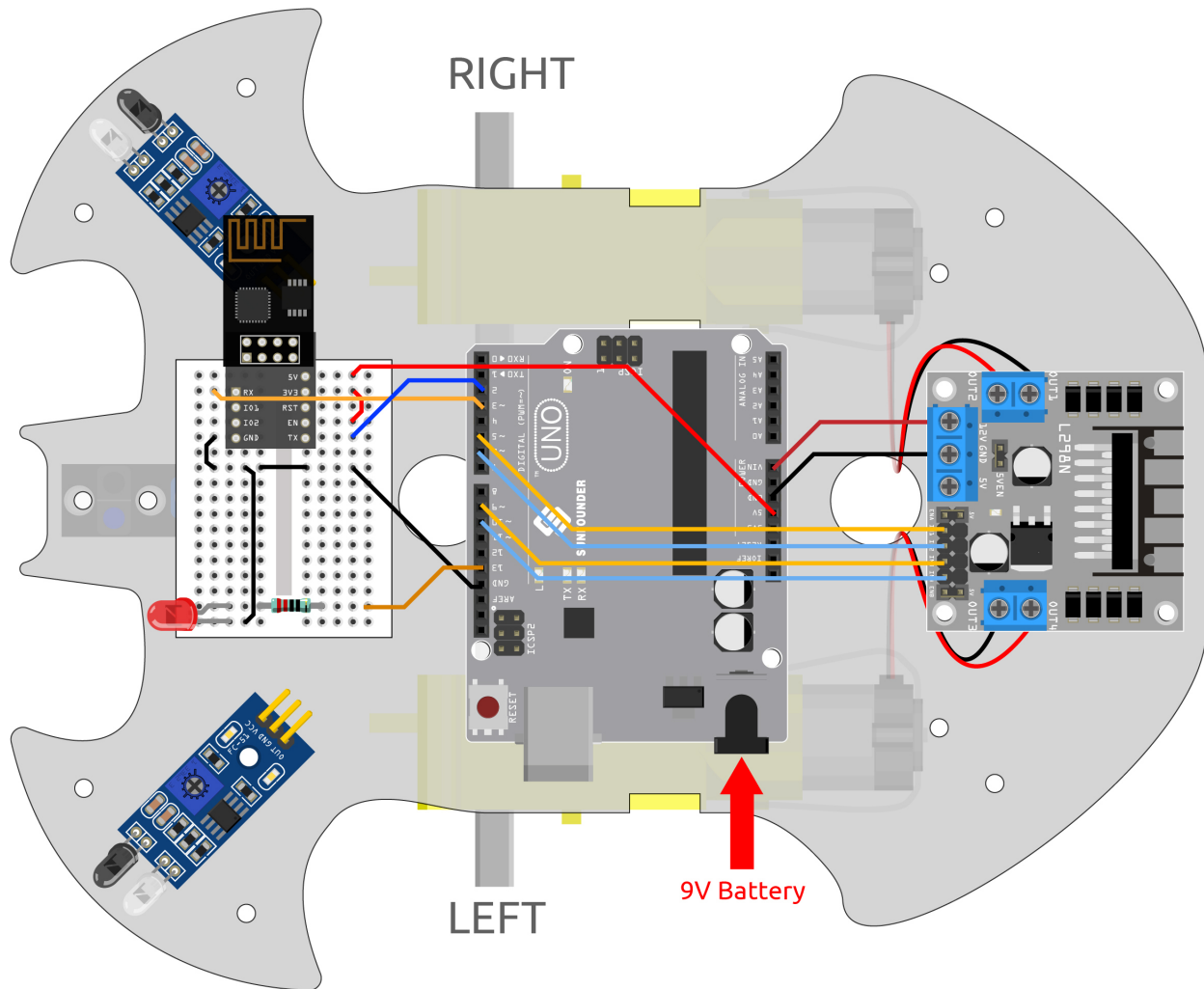
void operateGate(bool openGate) {
  if (openGate == true)
  {
    // open gate
    while (angle <= 90) {
      angle++;
      myservo.write(angle);
      delay(5);
    }
  } else {
    // close gate
    while (angle >= 0){
      angle--;
      myservo.write(angle);
      delay(5);
    }
  }
}
}

```

## 6.8 8. IoT Car

We used the Blynk APP on the cell phone to control the car for this project. But you need to refer to [Car Projects](#) to assemble the car and to get a basic understanding of it. In the era of 5G network popularity, this mode may become one of the main production methods in many industries, so let's experience this play in advance.

### 1. Build the Circuit



### 2. Edit Dashboard

Blynk on mobile cannot edit Datastream, so we still need to do these steps on the web side.

1. Create a **Datastream** of type **Virtual Pin** on the **Datastream** page, to record the X-axis value of the joystick. Set NAME to Xvalue, DATA TYPE to Integer, and MIN and MAX to -10 and 10.

**Virtual Pin Datastream**

NAME: Xvalue ALIAS: Xvalue

PIN: V9 DATA TYPE: Integer

UNITS: None

MIN: -10 MAX: 10 DEFAULT VALUE: 0

+ ADVANCED SETTINGS Cancel Create

2. Create a **Datastream** of type **Virtual Pin** to record the Y-axis value of the joystick. Set NAME to Yvalue, DATA TYPE to Integer, MIN and MAX to -10 and 10.

**Virtual Pin Datastream**

NAME: Yvalue ALIAS: Yvalue

PIN: V10 DATA TYPE: Integer

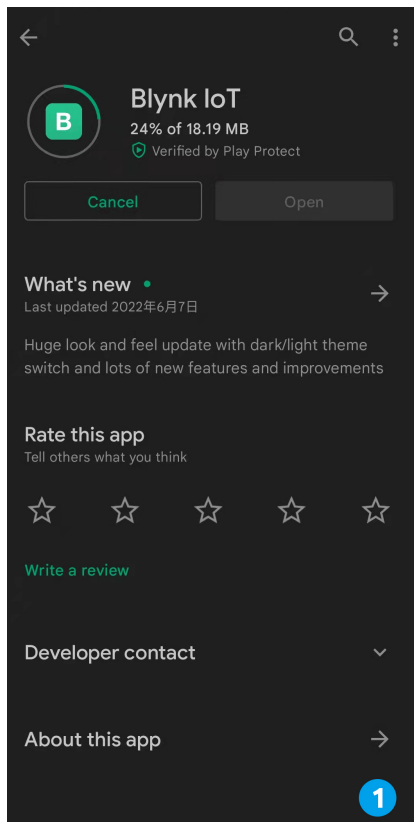
UNITS: None

MIN: -10 MAX: 10 DEFAULT VALUE: 0

[+ ADVANCED SETTINGS](#) [Cancel](#) [Create](#)

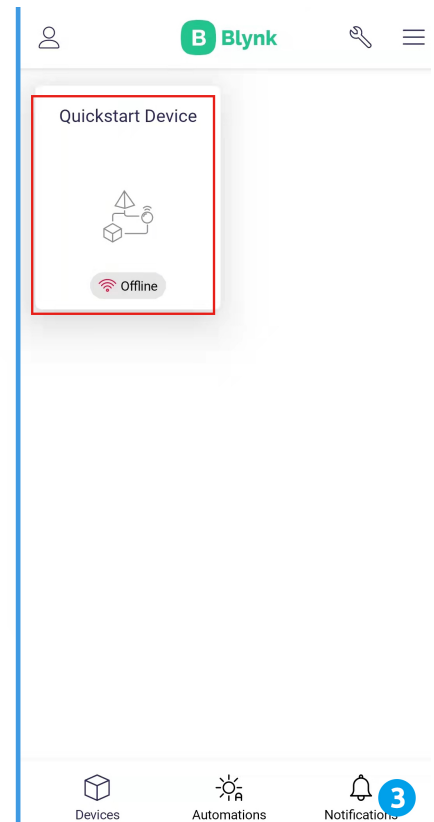
Next you need to do the following on your phone.

1. Search for “Blynk IoT” (not Blynk(legacy)) in GOOGLE Play or APP Store to download it.
2. After opening the APP, sign in, this account should be the same as the account used on the web client.
3. Then go to Dashboard (if you don’t have one, create one) and you will see that the Dashboard for mobile and web are independent of each other.

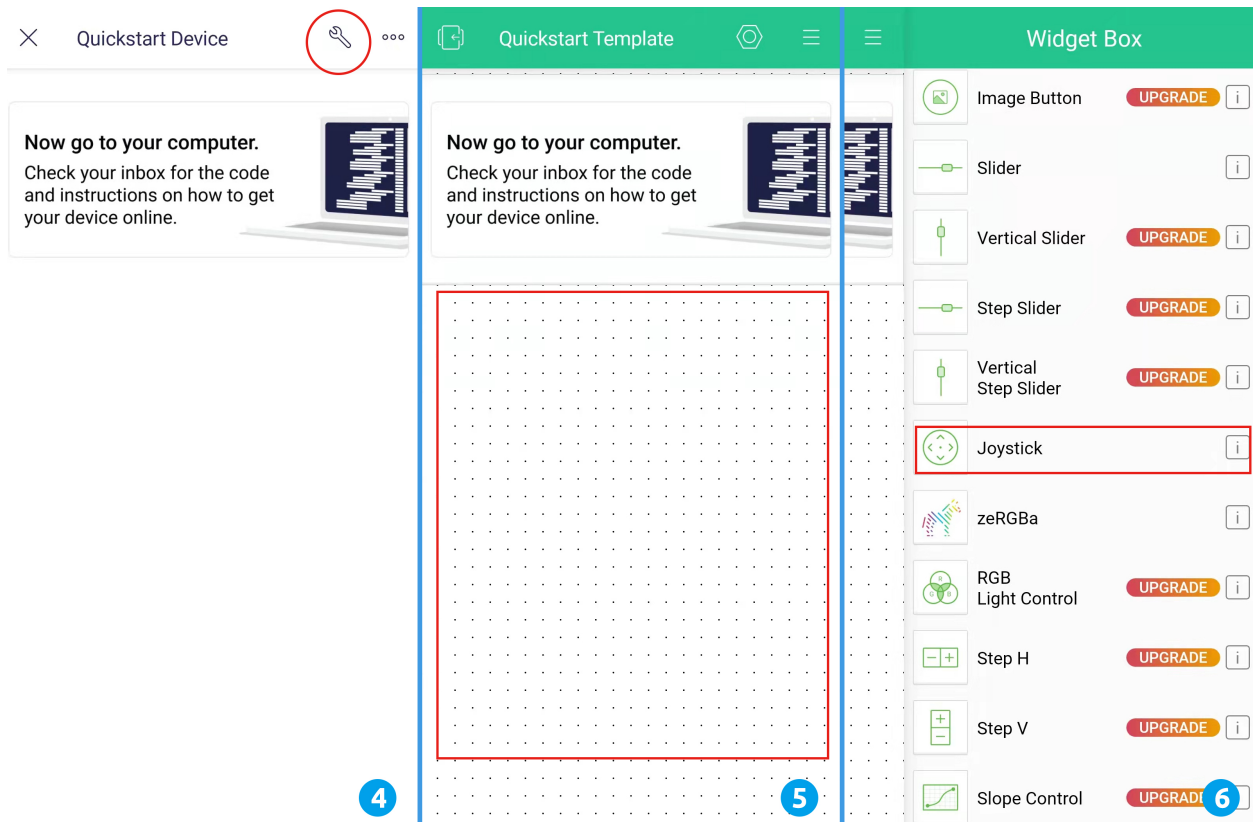


Sign Up

Log In

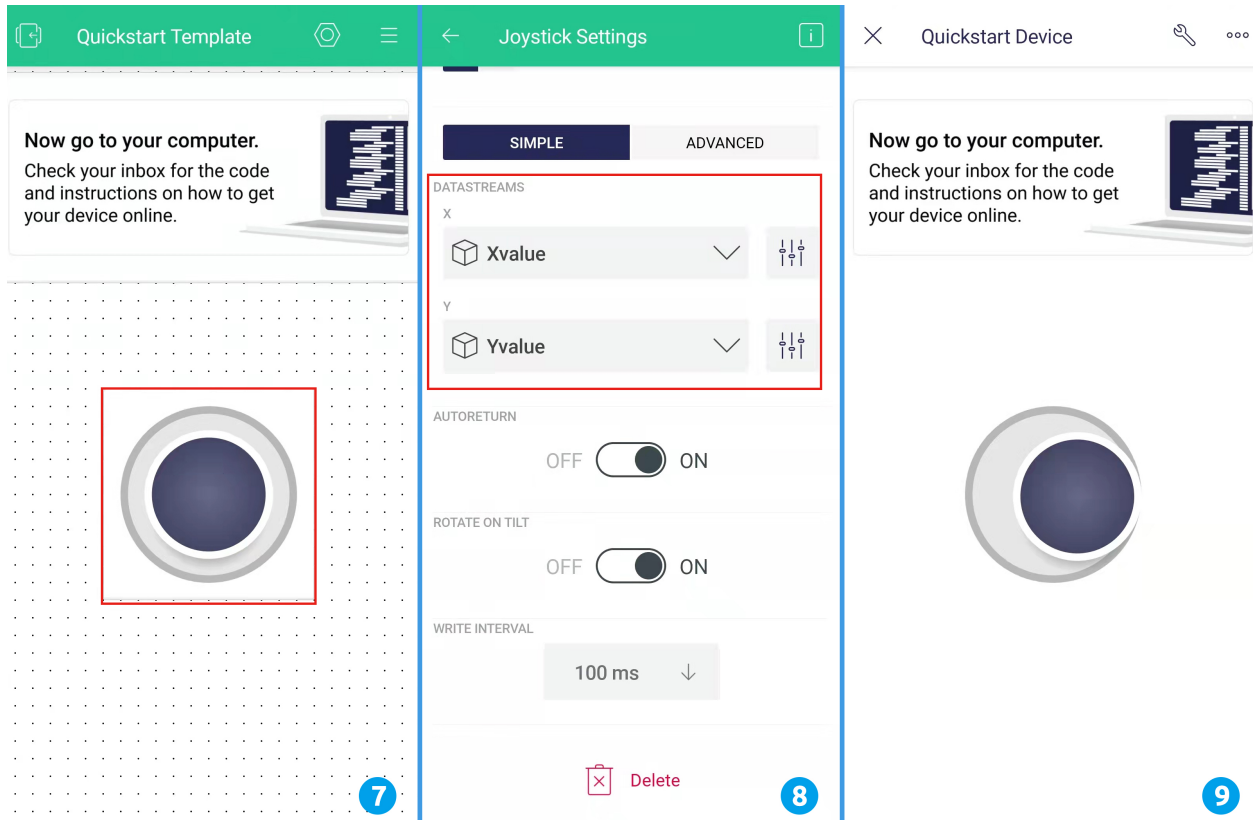


4. Click Edit Icon.
5. Click on the blank area.
6. Select a Joystick widget.



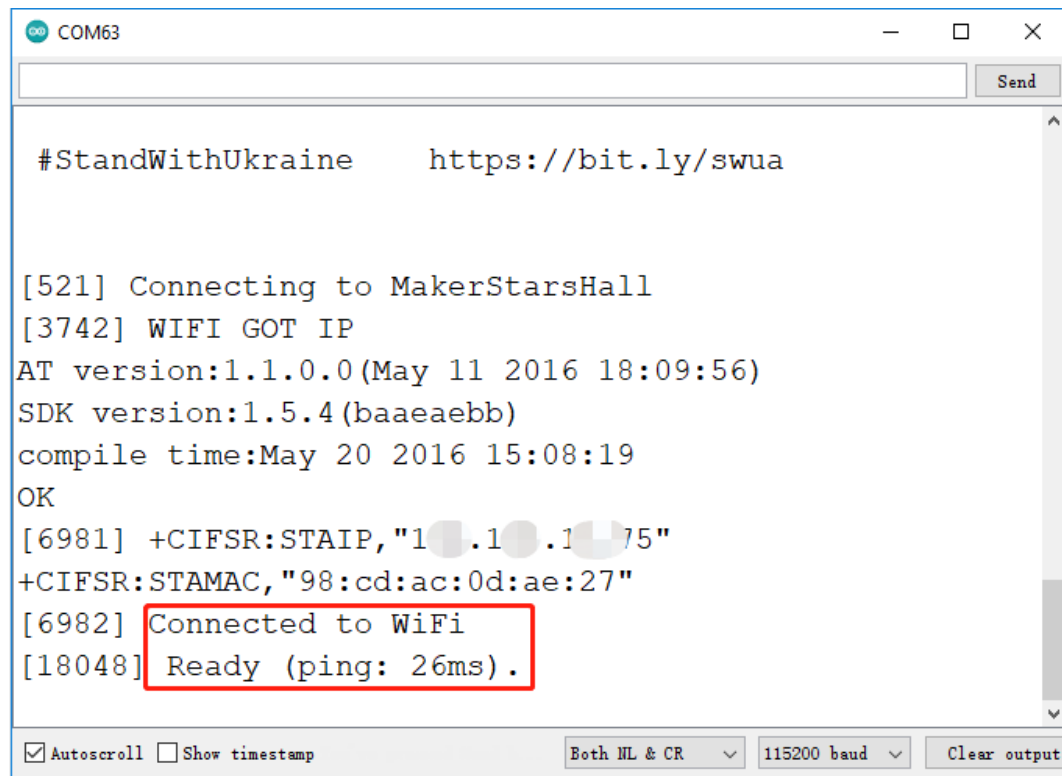
7. Now you will see a Joystick widget appear in the blank area, click on it.
8. Joystick Settings will appear, select the Xvalue and Yvalue you just set in the datastreams.
9. Go back to the Dashboard page and you can operate the Joystick when you want.





### 3. Run the Code

1. Open the `8.iot_car.ino` file under the path of `3in1-kit\iot_project\8.iot_car`, or copy this code into **Arduino IDE**.
2. Replace the **Template ID**, **Device Name**, and **Auth Token** with your own. You also need to enter the **ssid** and **password** of the WiFi you are using. For detailed tutorials, please refer to [1.4 Connecting the R3 board to Blynk](#).
3. After selecting the correct board and port, click the **Upload** button.
4. Open the Serial monitor(set baudrate to 115200) and wait for a prompt such as a successful connection to appear.



```
COM63

#StandWithUkraine  https://bit.ly/swua

[521] Connecting to MakerStarsHall
[3742] WIFI GOT IP
AT version:1.1.0.0(May 11 2016 18:09:56)
SDK version:1.5.4(baaeaebb)
compile time:May 20 2016 15:08:19
OK
[6981] +CIFSR:STAIP,"1.1.1.1"
+CIFSR:STAMAC,"98:cd:ac:0d:ae:27"
[6982] Connected to WiFi
[18048] Ready (ping: 26ms).

☒ Autoscroll ☐ Show timestamp
Both NL & CR 115200 baud Clear output
```

**Note:** If the message ESP is not responding appears when you connect, please follow these steps.

- Make sure the 9V battery is plugged in.
- Reset the ESP8266 module by connecting the pin RST to GND for 1 second, then unplug it.
- Press the reset button on the R3 board.

Sometimes, you may need to repeat the above operation 3-5 times, please be patient.

5. Now unplug the USB cable and power the cart with a 9V battery alone, then wait for the LED to light up, representing that the car is connected to Blynk.
6. Open Blynk on your phone and you can use the Joystick widget to control the movement of the car.



### How it works?

These functions are used to control the movement of the car.

```
void moveForward(int speed) {...}
void moveBackward(int speed) {...}
void turnRight(int speed) {...}
void turnLeft(int speed) {...}
void stopMove() {...}
```

The IoT section reads the values of the Joystick widget and assigns them to the variables Xvalue and Yvalue.

```
int Xvalue = 0;
int Yvalue = 0;

BLYNK_WRITE(V9)
{
    Xvalue = param.asInt();
}

BLYNK_WRITE(V10)
{
    Yvalue = param.asInt();
}
```

At loop(), make the car perform different actions based on Xvalue and Yvalue.

```
if (Yvalue >= 5) {
    moveForward(255);
} else if (Yvalue <= -5) {
    moveBackward(255);
} else if (Xvalue >= 5) {
```

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```
    turnRight(150);
} else if (Xvalue <= -5) {
    turnLeft(150);
} else {
    stopMove();
}
```

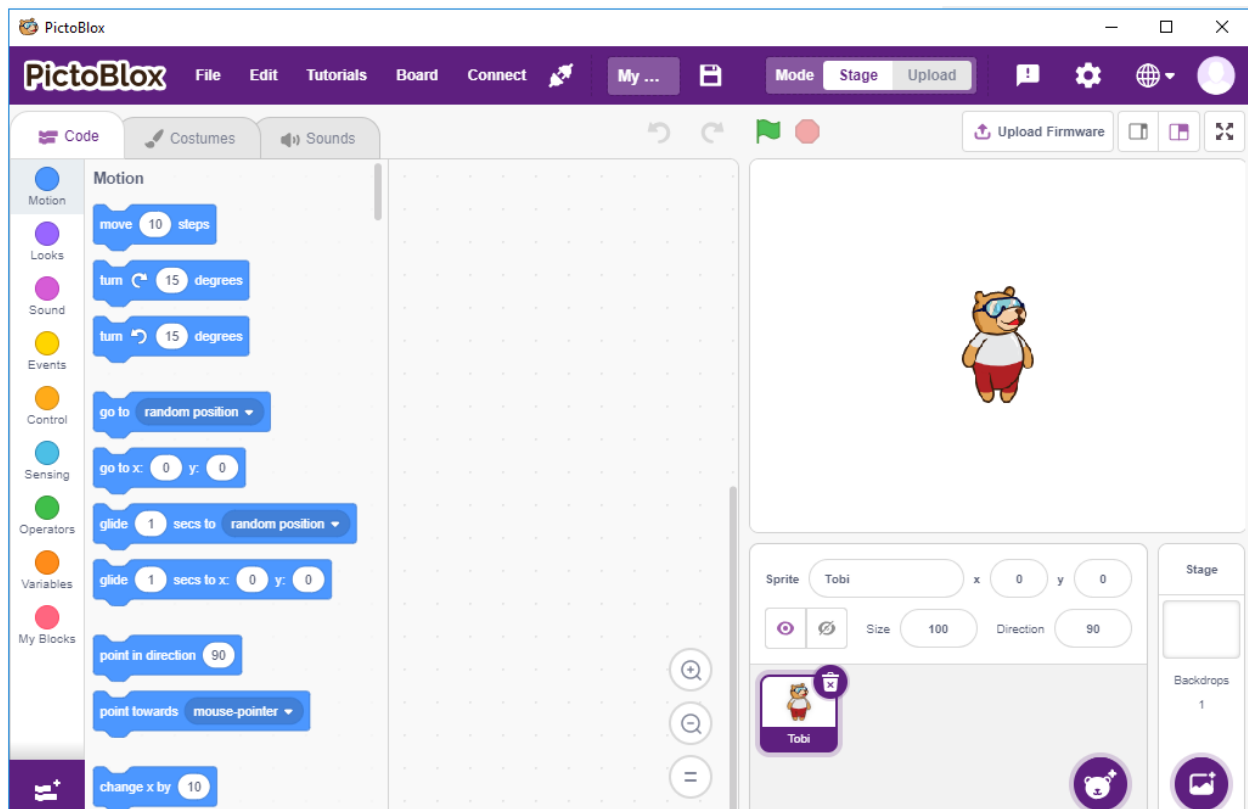
Also, add a network status determination to `loop()` to light up an LED if it is connected to Blynk Cloud.

```
if (!Blynk.connected()) {
    digitalWrite(ledPin, LOW);
    Serial.print("offline!");
    bool result = Blynk.connect();
    Serial.println(result);
} else {
    digitalWrite(ledPin, HIGH);
}
```

## PLAY WITH SCRATCH

Besides programming on the Arduino IDE, we can also use graphical programming.

Here we recommend programming with Scratch, but the official Scratch is currently only compatible with Raspberry Pi, so we have partnered with a company, STEMPedia, who has developed a Scratch 3 based graphical programming software for Arduino boards (Uno, Mega2560 and Nano) - [PictoBlox](#).



It keeps the basic functions of Scratch 3, but also adds control boards, such as Arduino Uno, Mega, Nano, ESP32, Microbit and STEMPedia homemade main boards, which can use external sensors, robots to control the sprites on the stage, with strong hardware interaction capabilities.

In addition, it has AI and machine learning, even if you do not have much programming foundation, you can learn and use these popular and high-tech.

Just drag and drop the Scratch coding blocks and make cool games, animations, interactive projects, and even control robots the way you want!

Now let's start the journey of discovery!

## 1. Get Started

### 7.1 1.1 Install PictoBlox

Click this link [https://thetempedia.com/product/pictoblox/download-pictoblox/choose-the-appropriate-Operating-System-\(Windows,-macOS,-Linux\)-and-follow-the-steps-to-install](https://thetempedia.com/product/pictoblox/download-pictoblox/choose-the-appropriate-Operating-System-(Windows,-macOS,-Linux)-and-follow-the-steps-to-install) and follow the steps to install.

**STEMpedia** NEW [QUARKY](#) [LEARN](#) [EDUCATORS](#) [PRODUCTS](#) [PROJECTS](#) [SHOP](#) [SIGN IN](#)

# Download PictoBlox

CHOOSE YOUR DEVICE

[Click here to choose difference systems](#)

[Windows](#) [macOS](#) [Linux](#) [Android](#)

## Windows Installer (.exe)

**STEP 1:** Download the Pictoblox Installer (.exe) for Windows 7 and above ([Release Notes](#)).

[WINDOWS INSTALLER 64-BIT V4.1.0](#)

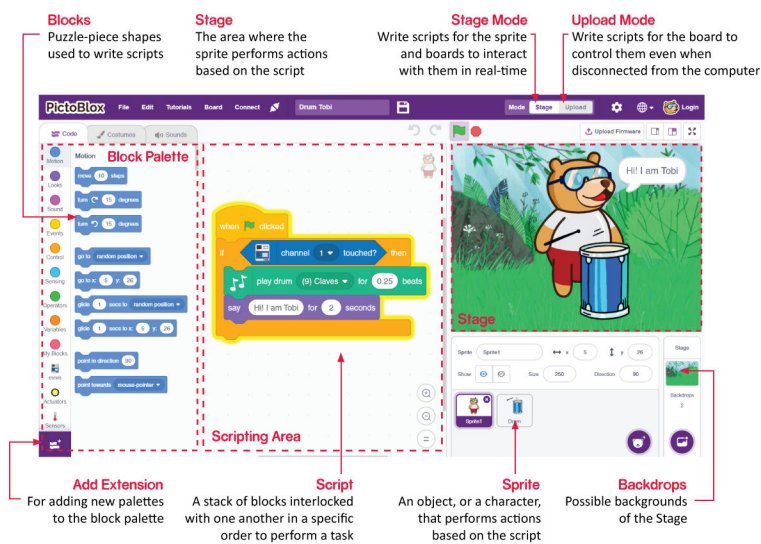
[WINDOWS INSTALLER 32-BIT V4.1.0](#)

**STEP 2:** Run the .exe file.

Some of the device gives the following popup. You don't have to worry, this software is harmless. Click on **More info** and then click on **Run anyway**.

**STEP 3:** Rest of the installation is straight forward, you can follow the popup and check on the option appropriate for your need.

## 7.2 1.2 Interface Introduction



### Sprites

A sprite is an object, or a character, that performs different actions in a project. It understands and obeys the commands given to it. Each sprite has specific costumes and sounds that you can also customize.

### Stage

The stage is the area where the sprite performs actions in backdrops according to your program.

### Backdrops

Backdrops are used to decorate the stage. You can choose a backdrop from PictoBlox, draw one yourself or upload an image from your computer.

### Script Area

A script is a program or a code in PictoBlox/Scratch lingo. It is a set of “blocks” arranged in a specific order to perform a task or a series of tasks. You can write multiple scripts, all of which can run simultaneously. You can only write scripts in the script area in the center of the screen.

### Blocks

Blocks are like pieces of a puzzle that are used to write programs by simply stacking them together in the script area. Using blocks to write code can make programming easier and reduce the probability of errors.

### Block Palette

The block palettes are located in the left area and are named by their functions, such as motion, sound and control. Each palette has different blocks, for example, the blocks in the Motion palette will control the movement of the sprites, and the blocks in the Control palette will control the work of the script based on specific conditions.

There are other kinds of block palettes that can be loaded from the **Add Extension** button located at the bottom left.

### Modes

Unlike Scratch, PictoBlox has two modes:

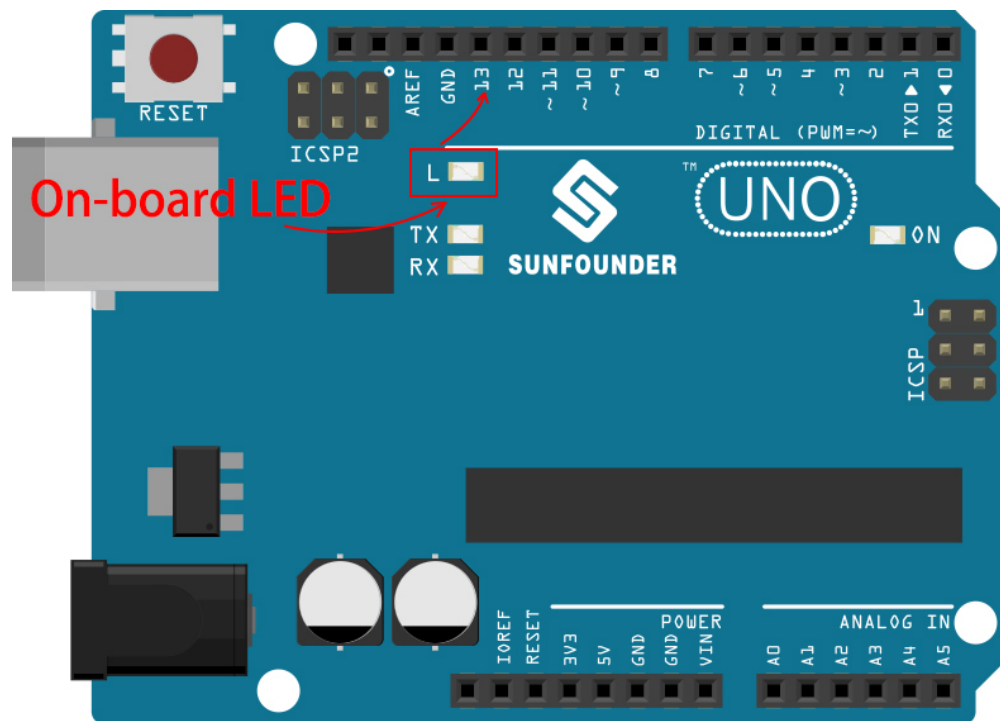
- **Stage Mode:** In this mode, you can write scripts for the sprite and boards to interact with sprites in real-time. If you disconnect the board with Pictoblox, you cannot interact anymore.
- **Upload Mode:** This mode allows you to write scripts and upload it to the board so that you can use even when it is not connected to your computer, for example, you need to upload a script for making moving robots.

For more information, please refer to: <https://thestempedia.com/tutorials/getting-started-pictoblox>

## 7.3 1.3 Quick Guide on PictoBlox

Now let's learn how to use PictoBlox in two modes.

Also, there is an On-board LED connected to Pin 13 on the R3 board, we will learn to make this LED blink in 2 different modes.

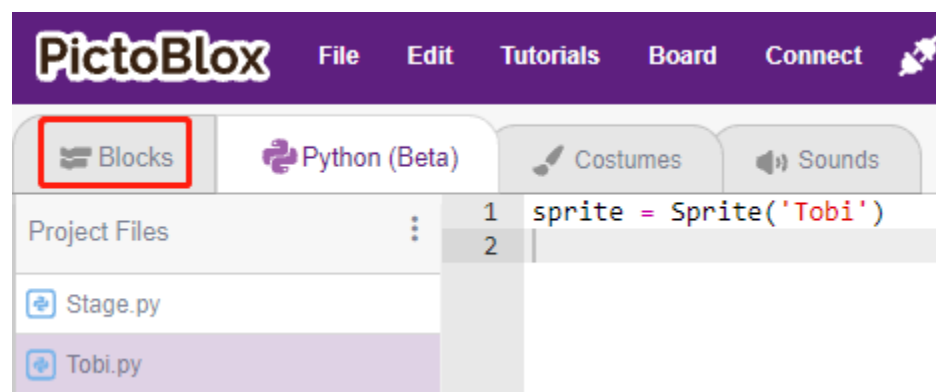


### 7.3.1 Stage Mode

#### 1. Connect to Arduino Board

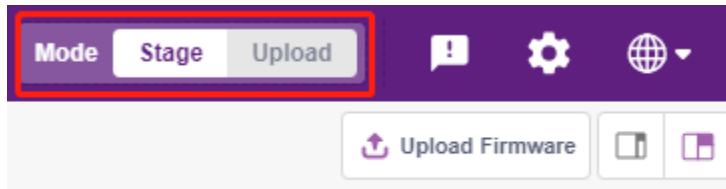
Connect your Arduino board to the computer with a USB cable, usually the computer will automatically recognize your board and finally assign a COM port.

Open PictoBlox, the Python programming interface will open by default. And we need to switch to the Blocks interface.

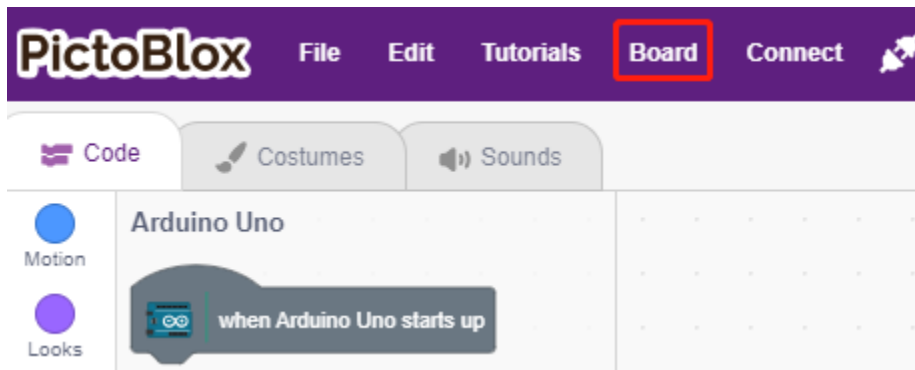




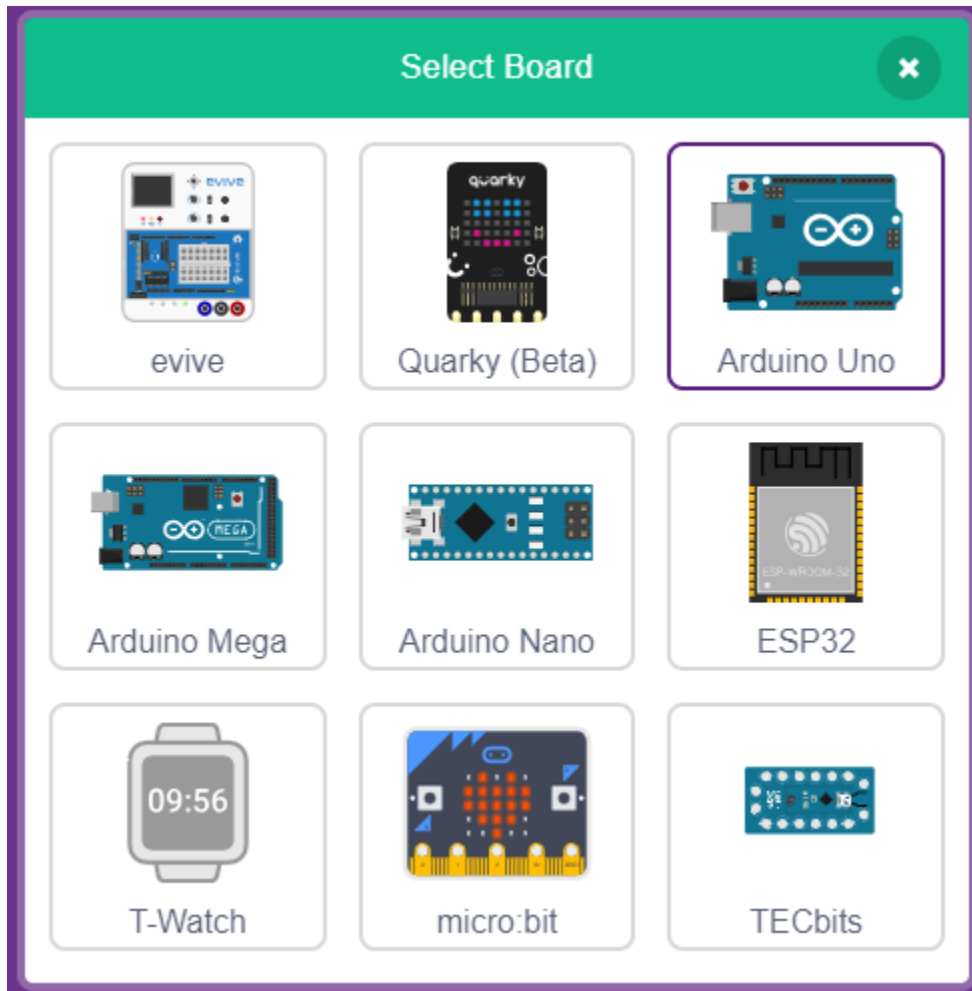
Then you will see the top right corner for mode switching. The default is Stage mode, where Tobi is standing on the stage.



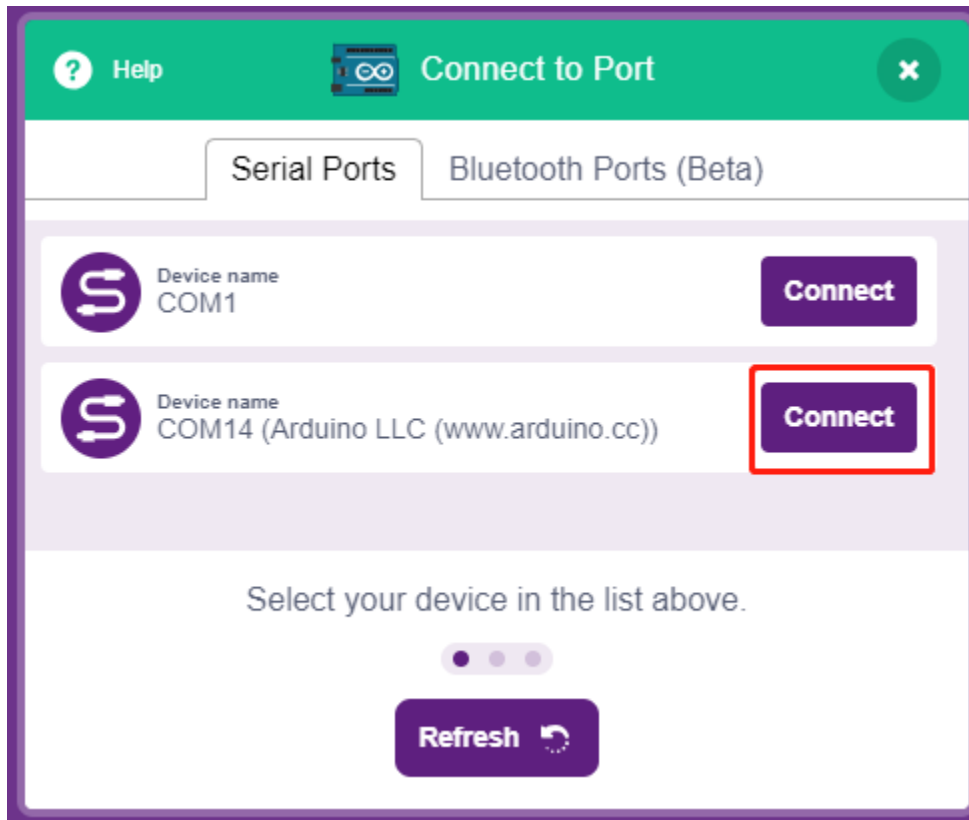
Click **Board** in the upper right navigation bar to select the board.



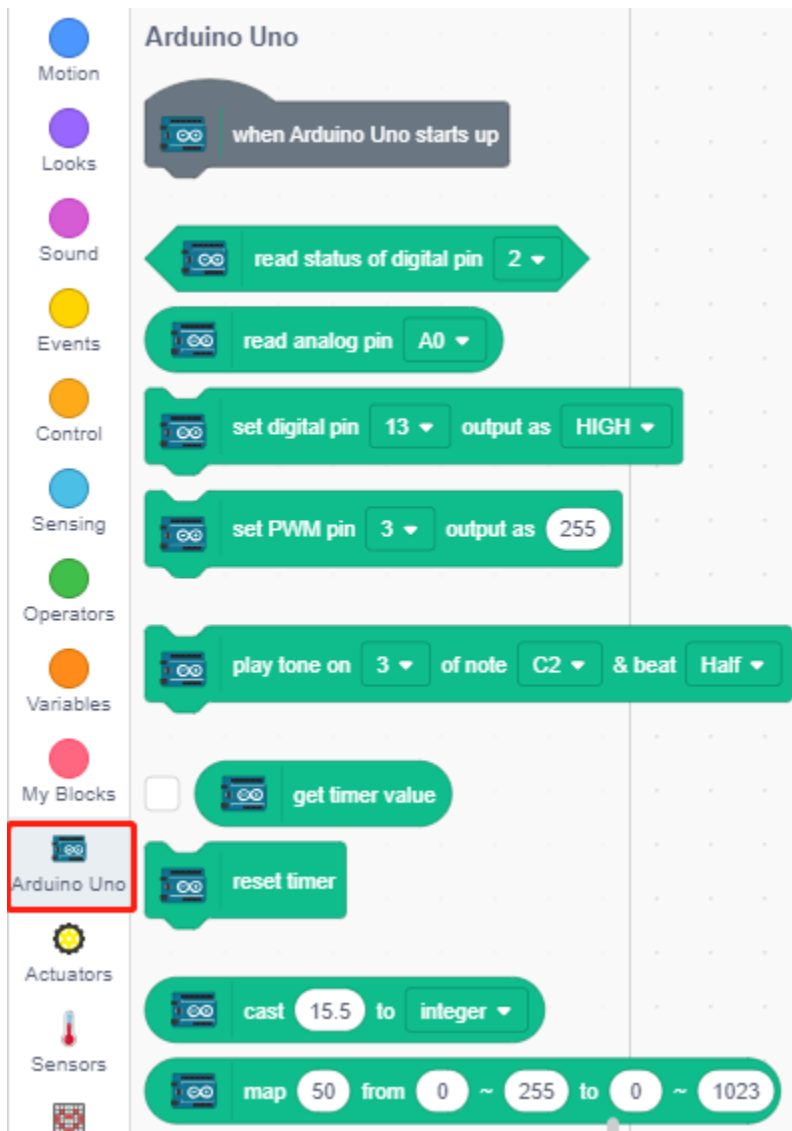
For example, choose **Arduino Uno**.



A connection window will then pop up for you to select the port to connect to, and return to the home page when the connection is complete. If you break the connection during use, you can also click **Connect** to reconnect.



At the same time, Arduino Uno related palettes, such as Arduino Uno, Actuators, etc., will appear in the **Block Palette**.



## 2. Upload Firmware

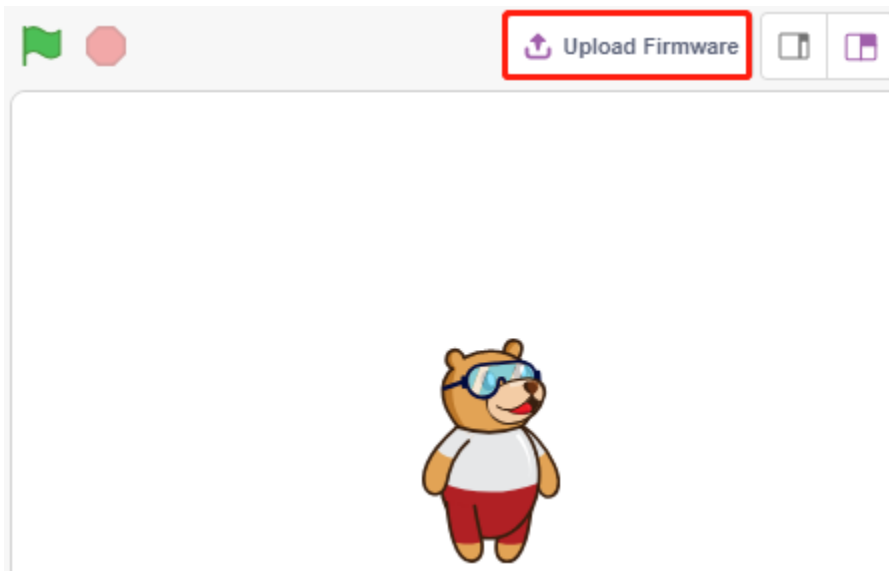
Since we're going to work in the Stage mode, we must upload the firmware to the board. It will ensure real-time communication between the board and the computer. Uploading the firmware it is a one-time process. To do so, click on the Upload Firmware button.

After waiting for a while, the upload success message will appear.

---

**Note:** If you are using this Arduino board in PictoBlox for the first time, or if this Arduino was previously uploaded with the Arduino IDE. Then you need to tap **Upload Firmware** before you can use it.

---

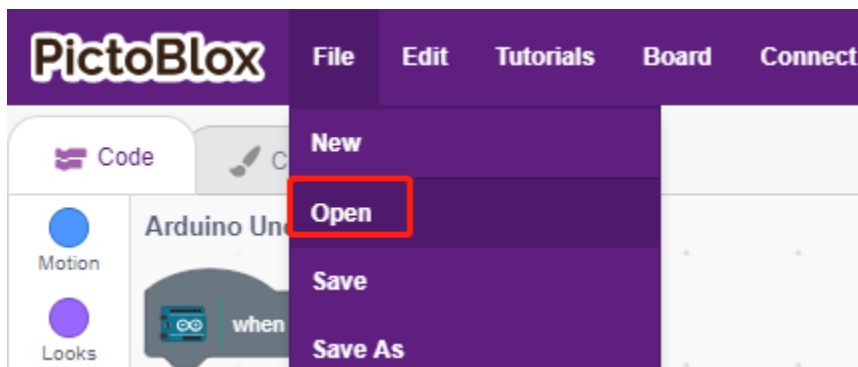


### 3. Programming

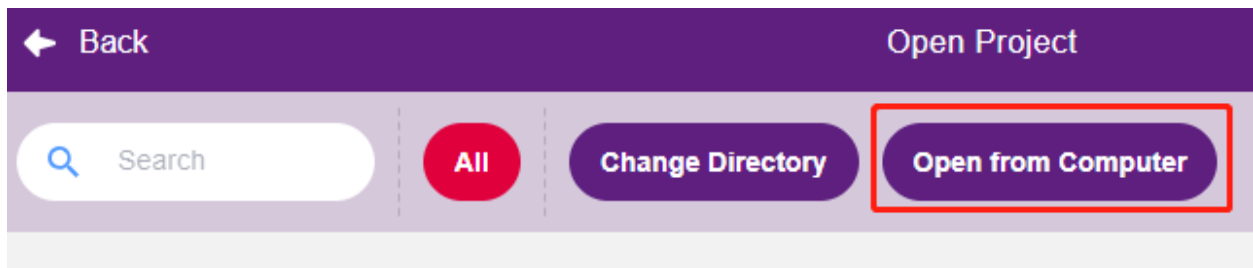
- Open and run the script directly

Of course, you can open the scripts directly to run them, but please download them from [github](#) first.

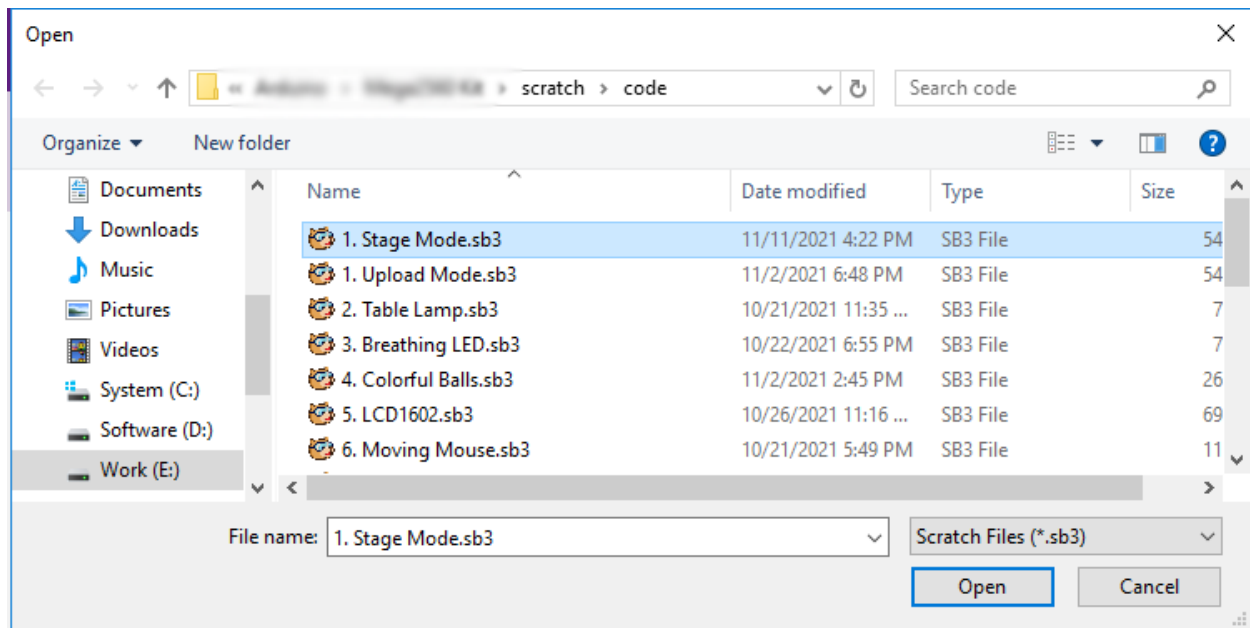
You can click on **File** in the top right corner and then choose **Open**.



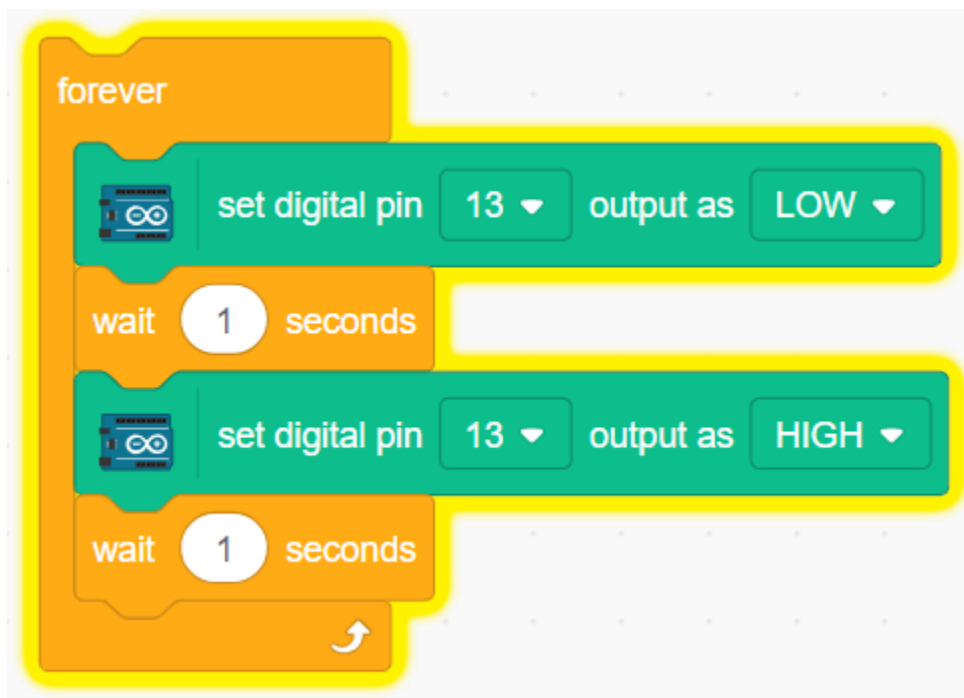
Choose **Open from Computer**.



Then go to the path of 3in1-kit\scratch\_project\code, and open **1. Stage Mode.sb3**. Please ensure that you have downloaded the required code from [github](#).



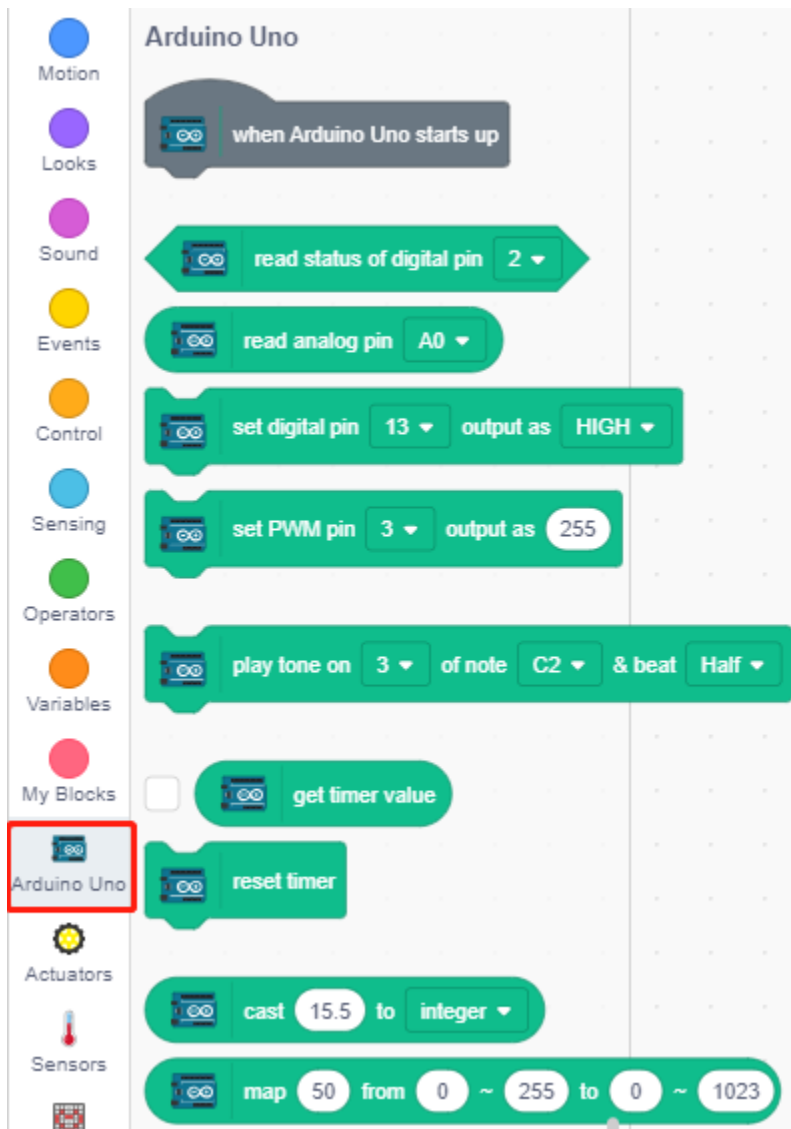
Click directly on the script to run it, some projects are click on the green flag or click on the sprite.



- Program step by step

You can also write the script step by step by following these steps.

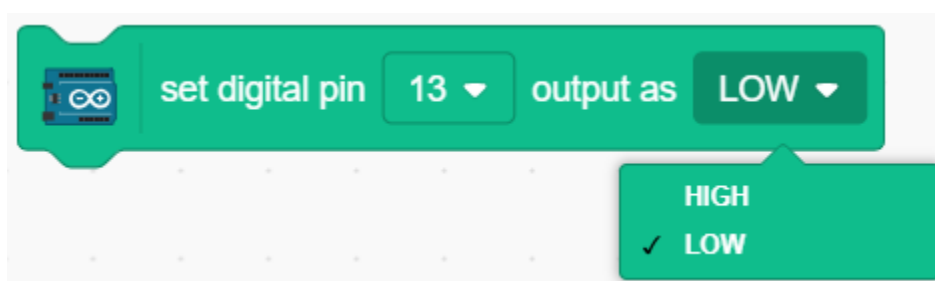
Click on the **Arduino Uno** palette.



The LED on the Arduino board is controlled by the digital pin 13 (only 2 states, HIGH or LOW), so drag the [set digital pin out as] block to the script area.

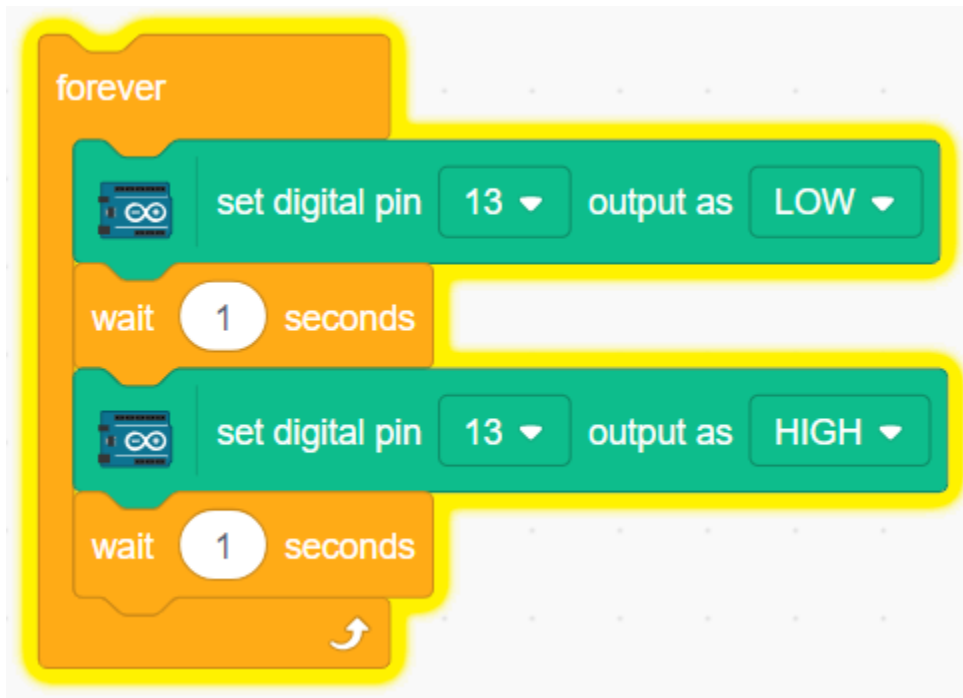
Since the default state of the LED is lit, now set pin 13 to LOW and click on this block and you will see the LED go off.

- [set digital pin out as]: Set the digital pins (2~13) to (HIGH/LOW) level.



In order to see the effect of continuous blinking LED, you need to use the [Wait 1 seconds] and [forever] blocks in the **Control** palette. Click on these blocks after writing, there is a yellow halo means it is running.

- [Wait 1 seconds]: from the **Control** palette, used to set the time interval between 2 blocks.
- [forever]: from the **Control** palette, allows the script to keep running unless manually paused.

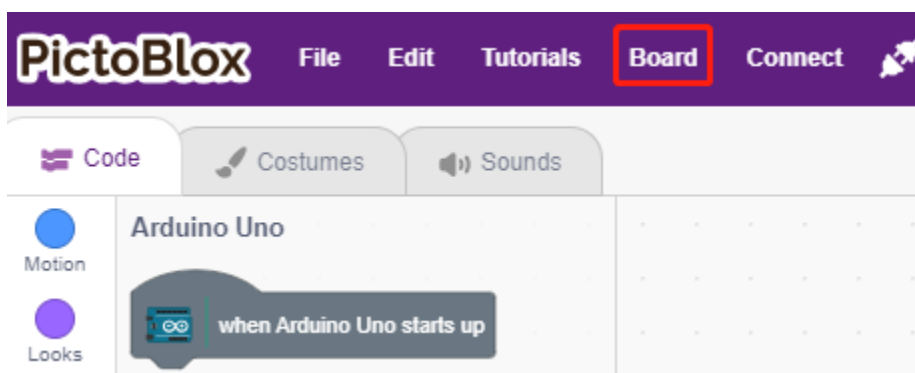


### 7.3.2 Upload Mode

#### 1. Connect to Arduino Board

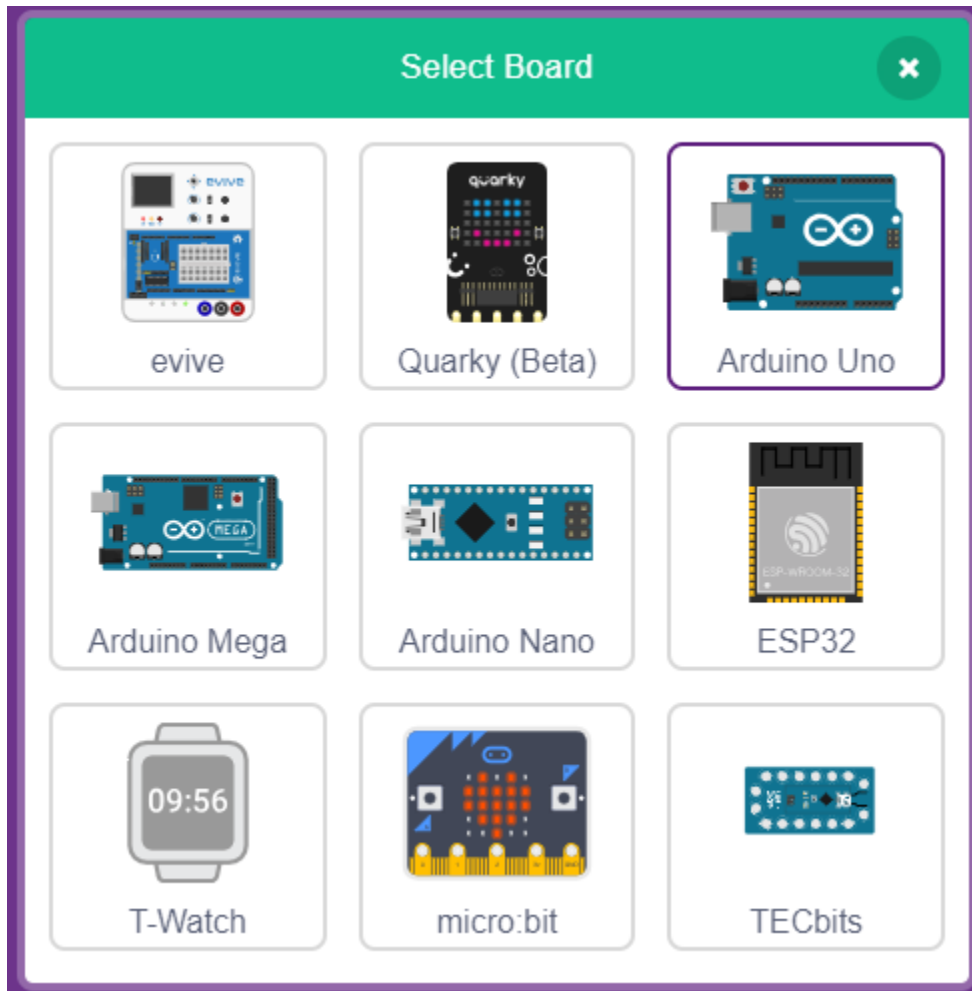
Connect your Arduino board to the computer with a USB cable, usually the computer will automatically recognize your board and finally assign a COM port.

Open PictoBlox and click **Board** in the top right navigation bar to select the board.

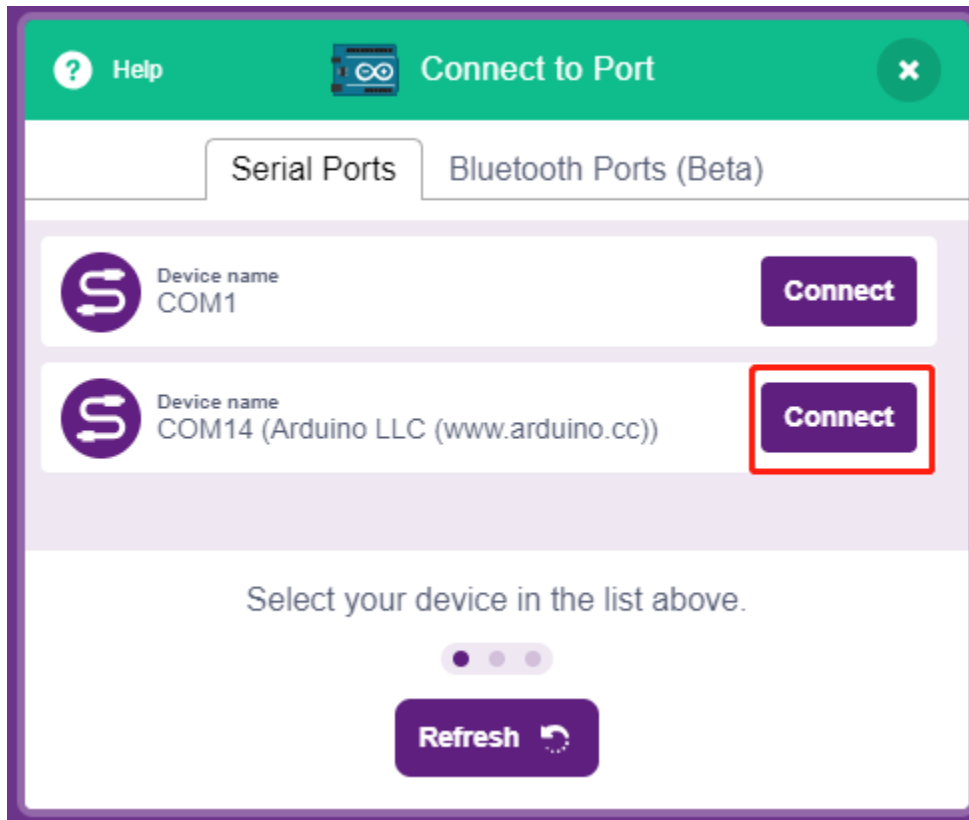


For example, choose **Arduino Uno**.

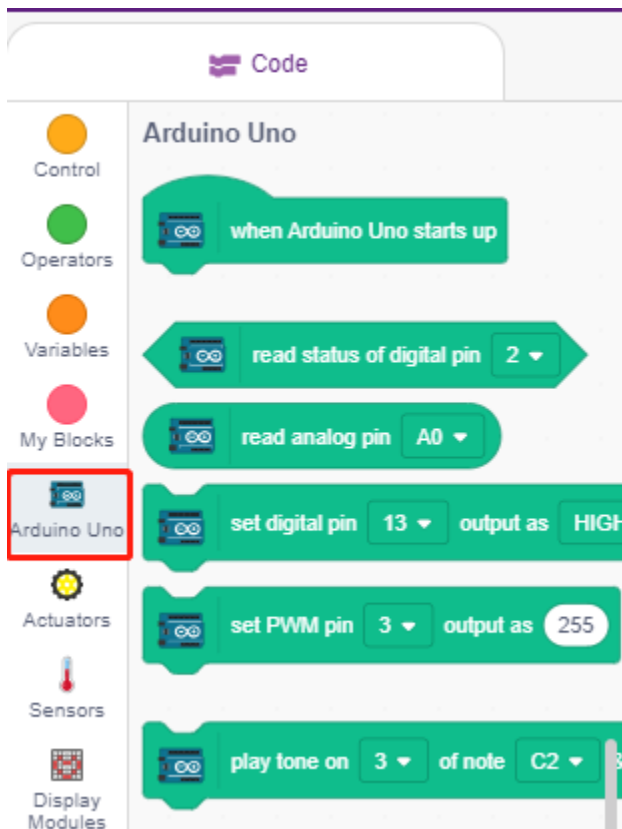




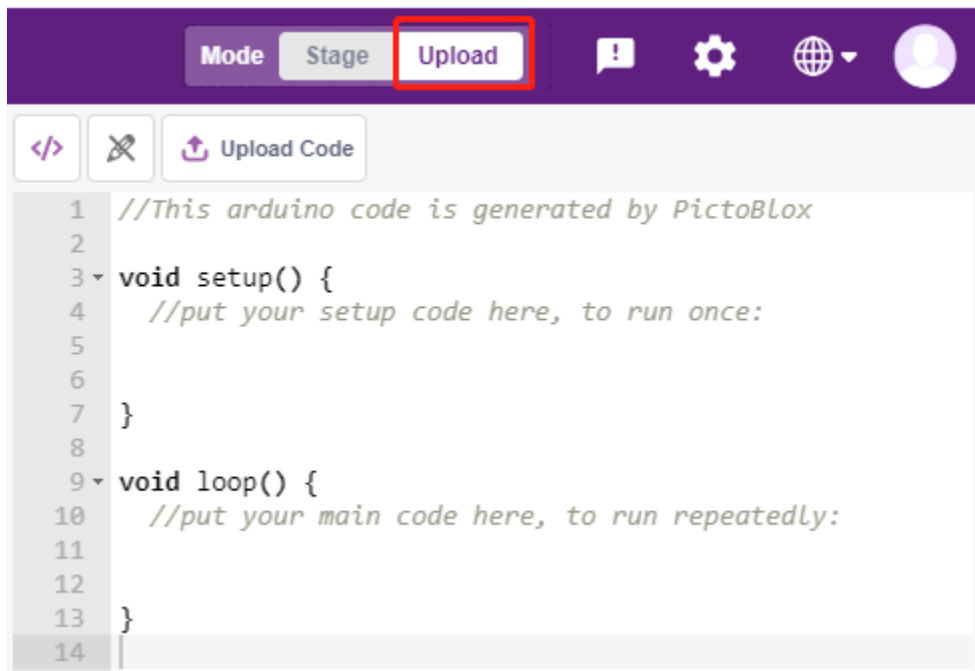
A connection window will then pop up for you to select the port to connect to, and return to the home page when the connection is complete. If you break the connection during use, you can also click **Connect** to reconnect.



At the same time, Arduino Uno related palettes, such as Arduino Uno, Actuators, etc., will appear in the **Block Palette**.



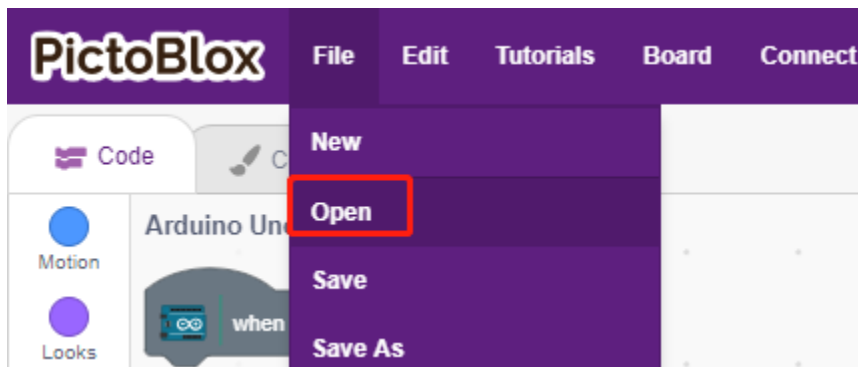
After selecting Upload mode, the stage will switch to the original Arduino code area.



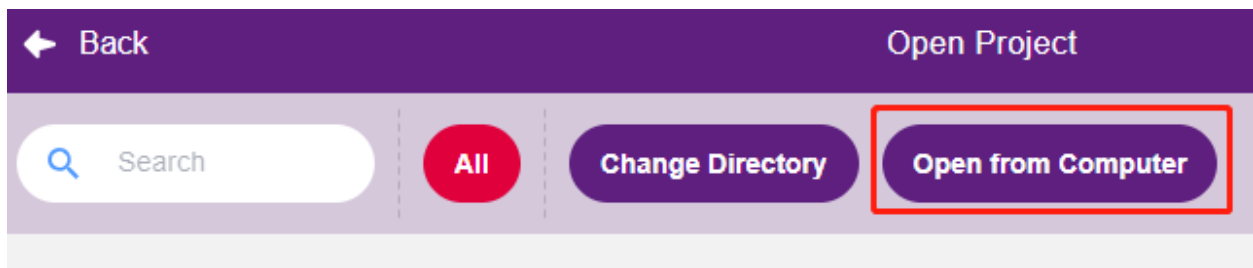
## 2. Programming

- Open and run the script directly

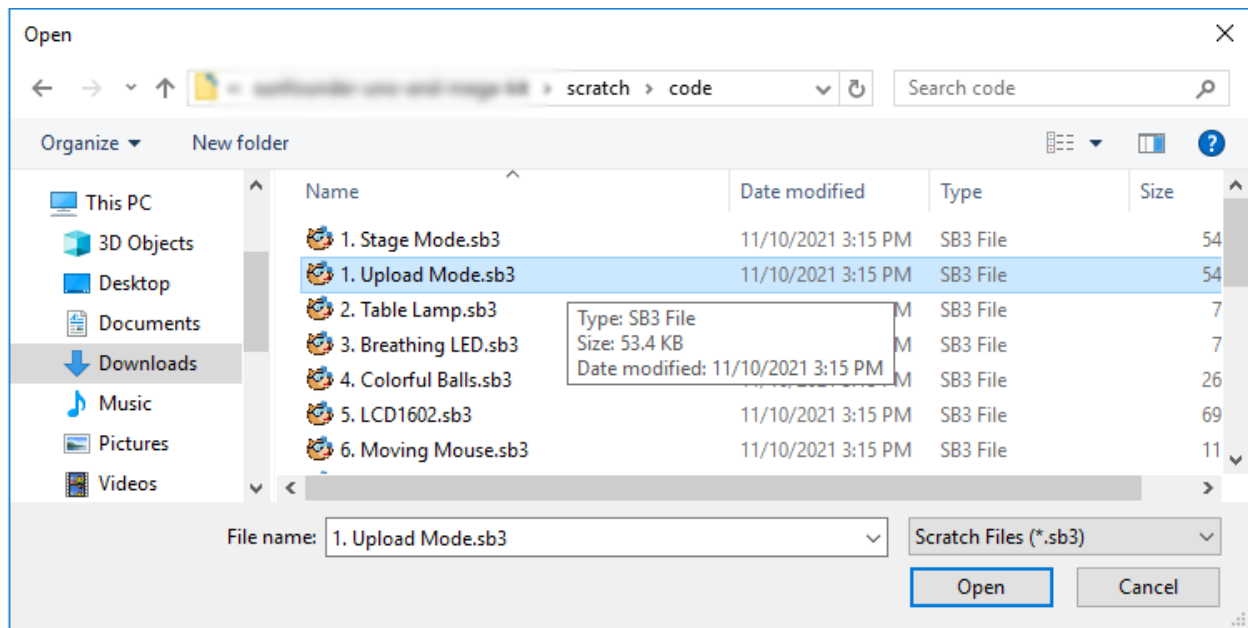
You can click on **File** in the top right corner.



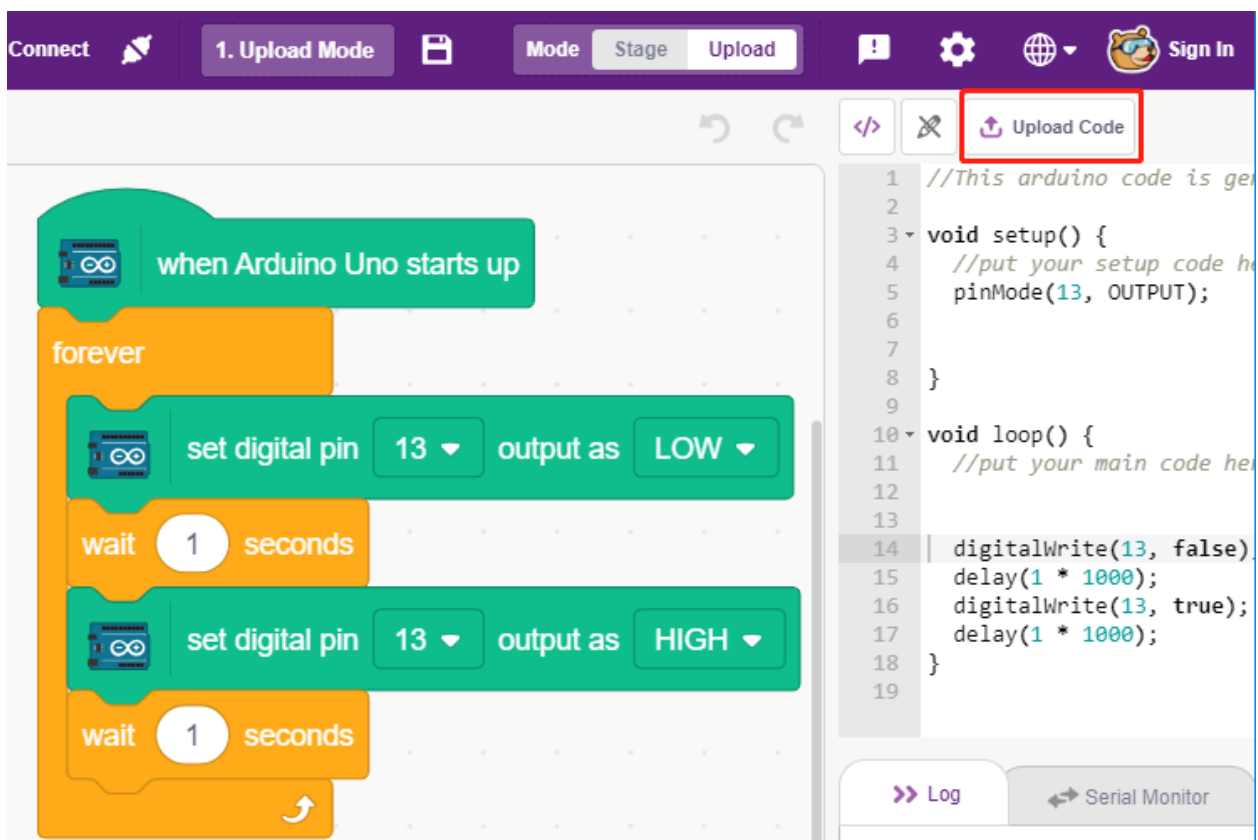
Choose **Open from Computer**.



Then go to the path of 3in1-kit\scratch\_project\code, and open **1. Upload Mode.sb3**. Please ensure that you have downloaded the required code from [github](#).



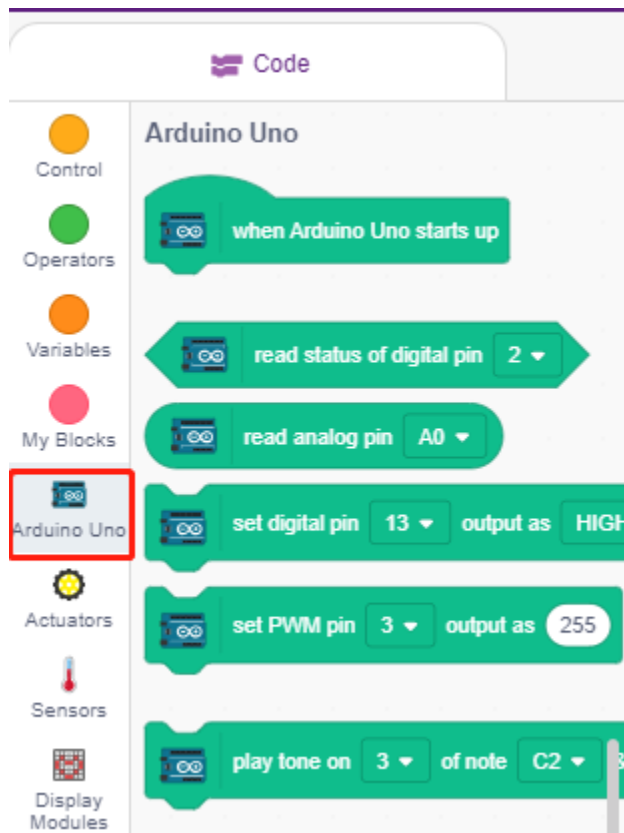
Finally, click the **Upload Code** button.



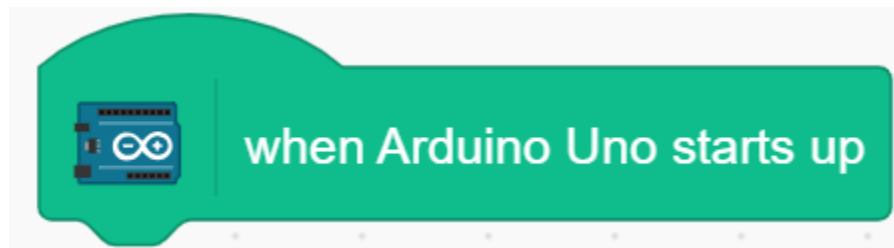
- Program step by step

You can also write the script step by step by following these steps.

Click on the **Arduino Uno** palette.



Drag [when Arduino Uno starts up] to the script area, which is required for every script.



The LED on the Arduino board is controlled by the digital pin13 (only 2 states HIGH or LOW), so drag the [set digital pin out as] block to the script area.

Since the default state of the LED is lit, now set pin 13 to LOW and click on this block and you will see the LED go off.

- [set digital pin out as]: Set the digital pin (2~13) to (HIGH/LOW) level.

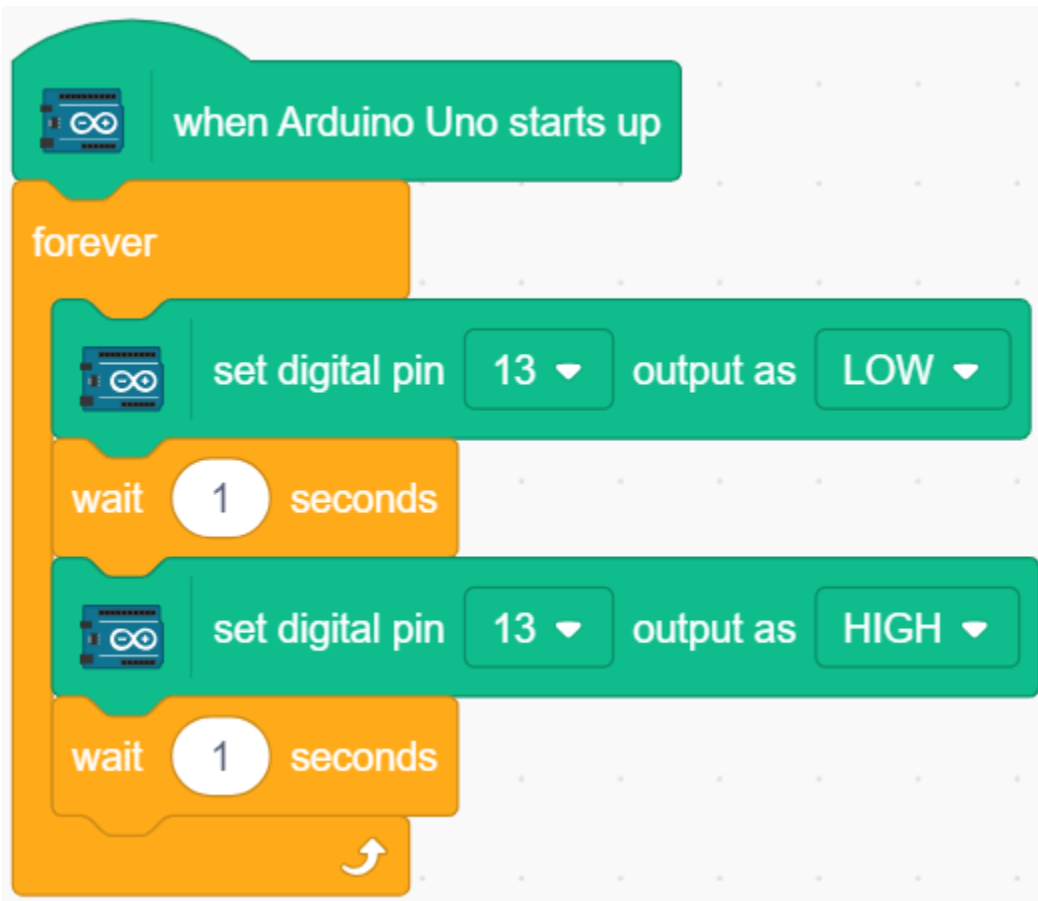


At this point you will see the Arduino code appear on the right side, if you want to edit this code, then you can turn Edit mode on.

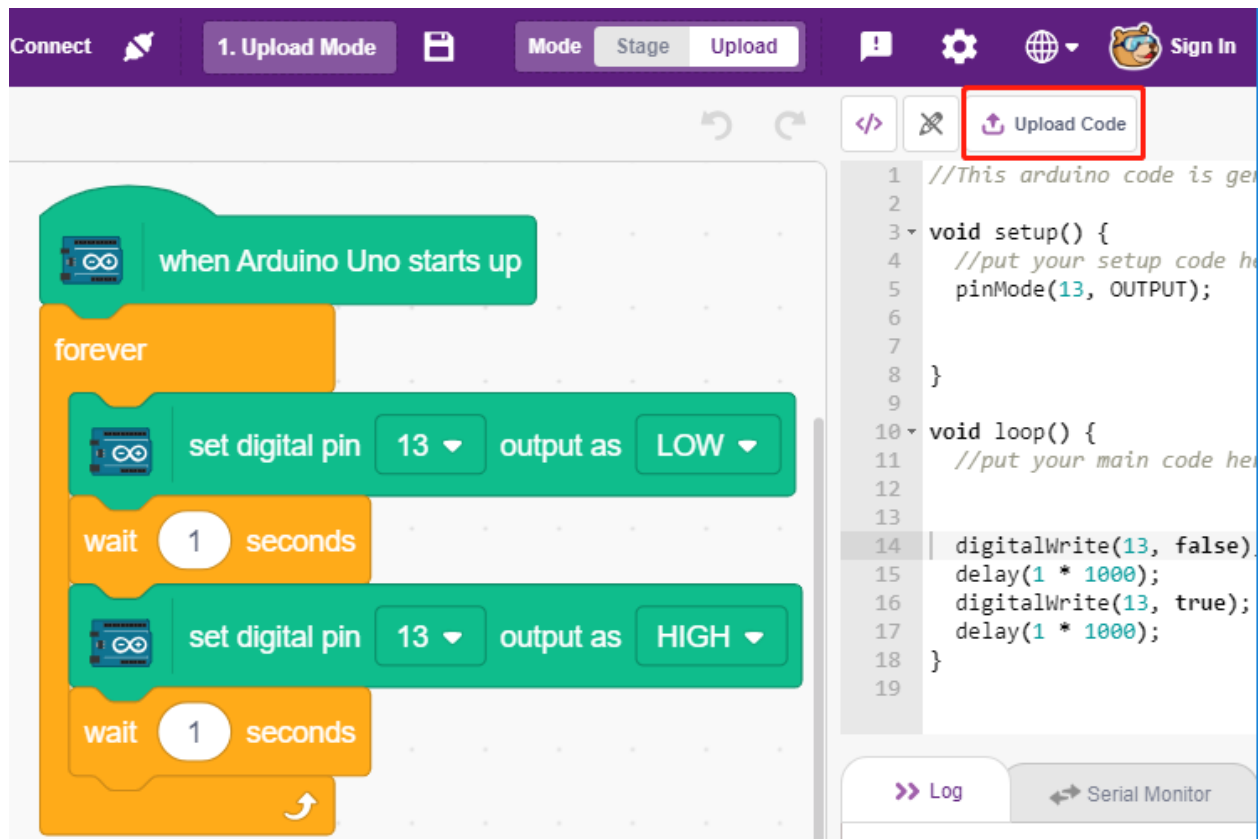


In order to see the effect of continuous blinking LED, you need to use the [Wait 1 seconds] and [forever] blocks in the **Control** palette. Click on these blocks after writing, there is a yellow halo means it is running.

- [Wait 1 seconds]: from the **Control** palette, used to set the time interval between 2 blocks.
- [forever]: from the **Control** palette, allows the script to keep running unless the power is off.



Finally, click the **Upload Code** button.



## 2. Projects

The following projects are written in order of programming difficulty, it is recommended to read these books in order.

In each project, there are very detailed steps to teach you how to build the circuit and how to program it step by step to achieve the final result.

Of course, you can also open the script directly to run it, but you need to make sure you have downloaded the relevant material from [github](#).

Once the download is complete, unzip it. Refer to *Stage Mode* to run individual scripts directly.

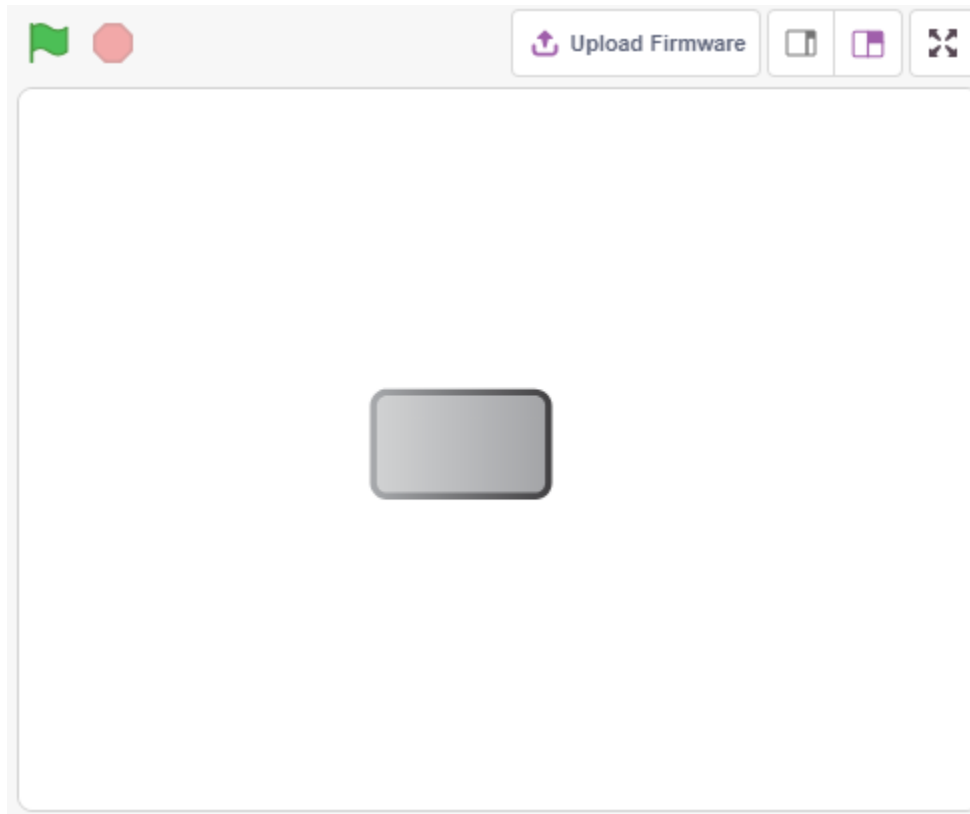
But the *2.9 Read Temperature and Humidity* is used the *Upload Mode*.



## 7.4 2.1 Table Lamp

Here, we connect an LED on the breadboard and have the sprite control the blinking of this LED.

When the Button sprite on the stage is clicked, the LED will blink 5 times and then stop.



### 7.4.1 You Will Learn

- Breadboard, LEDs and Resistors
- Building a circuit on a breadboard
- Delete and select sprites
- Switching costumes
- Set a limited number of repeat loops

### 7.4.2 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

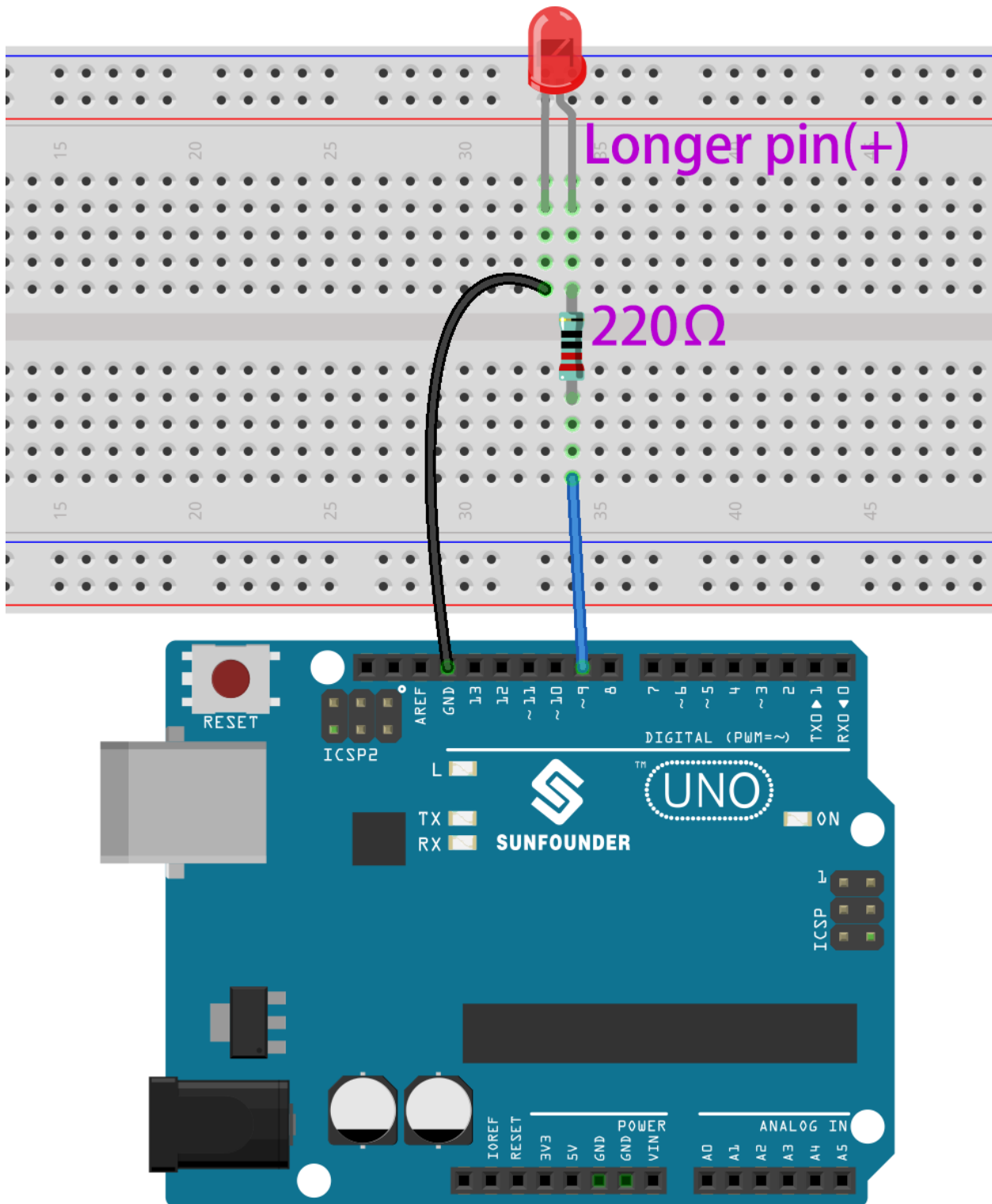
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>LED</i>	

### 7.4.3 Build the Circuit

Follow the diagram below to build the circuit on the breadboard.

Since the anode of the LED (the longer pin) is connected to pin 9 through a 220 resistor, and the cathode of the LED is connected to GND, you can light up the LED by giving pin 9 a high level.

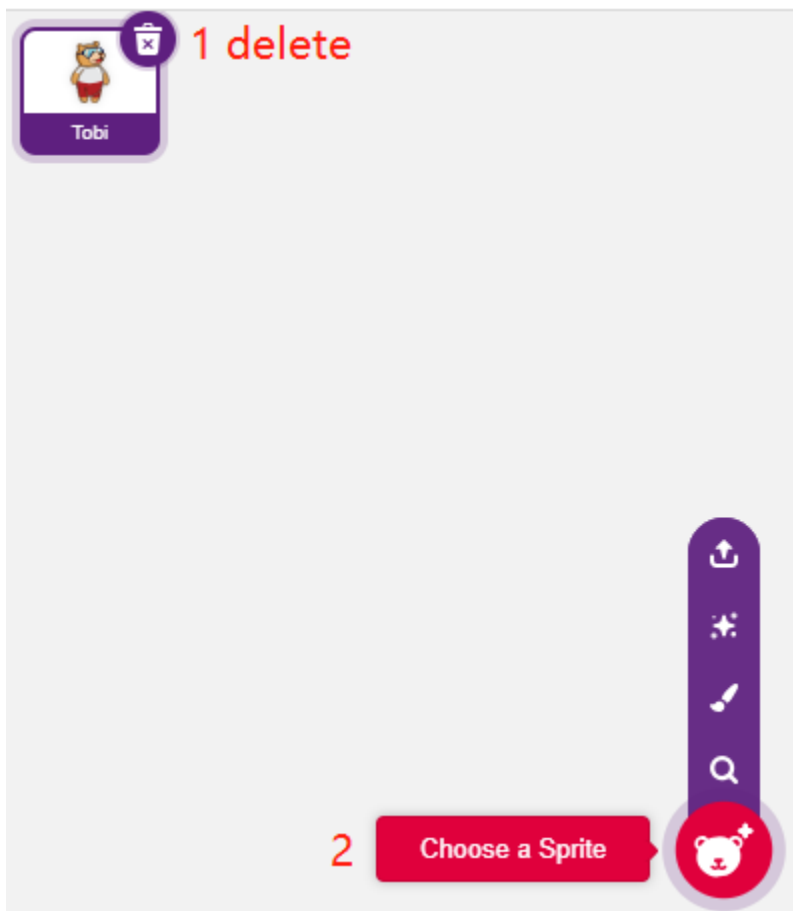


## 7.4.4 Programming

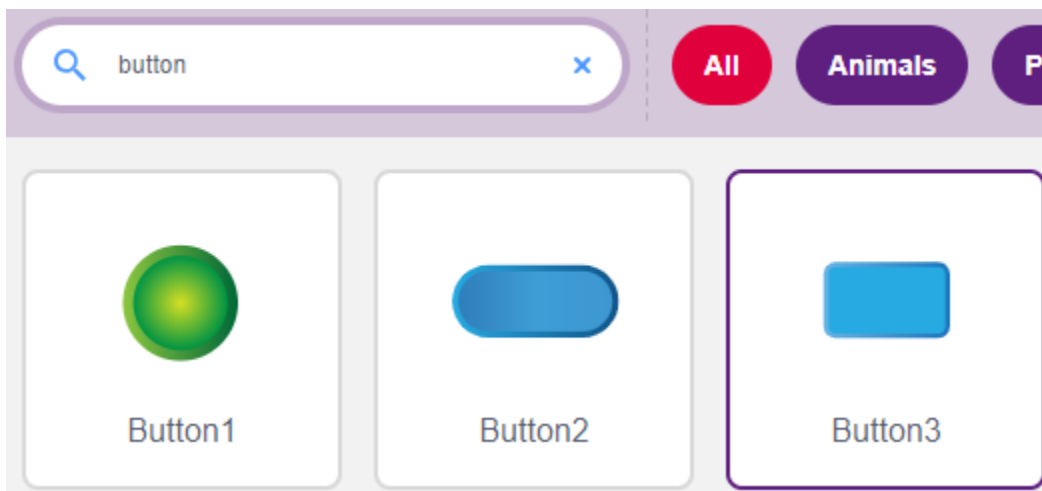
The whole programming is divided into 3 parts, the first part is to select the desired sprite, the second part is to switch the costume for the sprite to make it look clickable, and the third part is to make the LED blink.

### 1. Select Button3 sprite

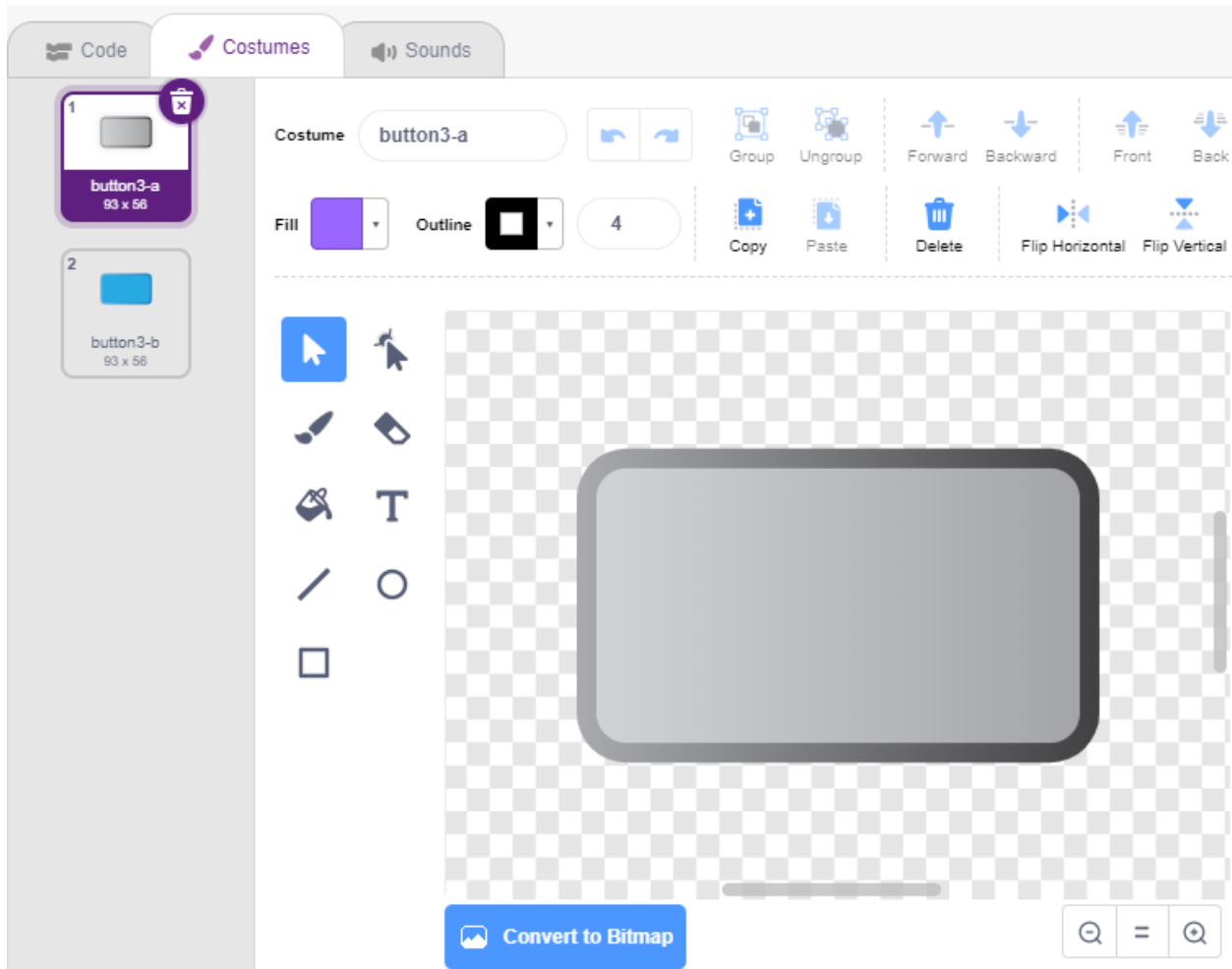
Delete the existing Tobi sprite by using the Delete button in the upper right corner, and select a sprite again.



Here, we select the **Button3** sprite.

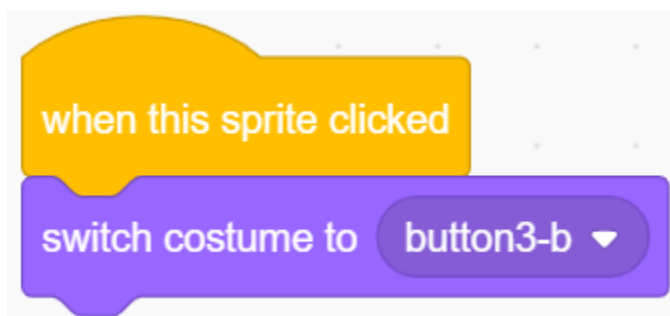


Click on Costumes in the top right corner and you will see that the Button3 sprite has 2 costumes, we set **button3-a** to be released and **button3-b** to be pressed.



## 2. Switching costumes.

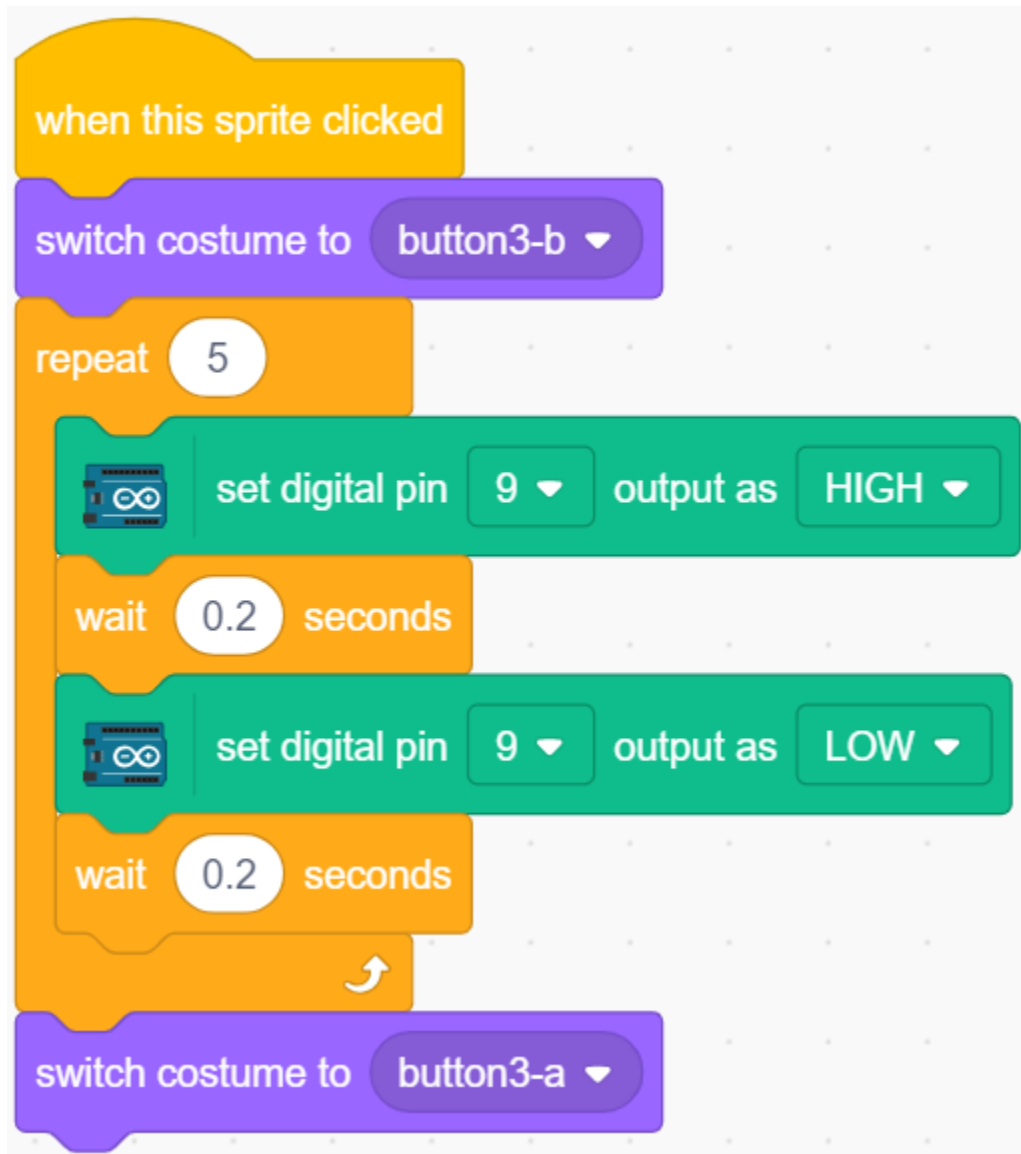
When the sprite is clicked (**Events** palette), it switches to costume for **button3-b** (**looks** palette).



## 3. Make the LED blink 5 times

Use the [Repeat] block to make the LED blink 5 times (High-> LOW cycle), remember to change pin 13 to pin 9, and finally switch the costume back to **button3-a**.

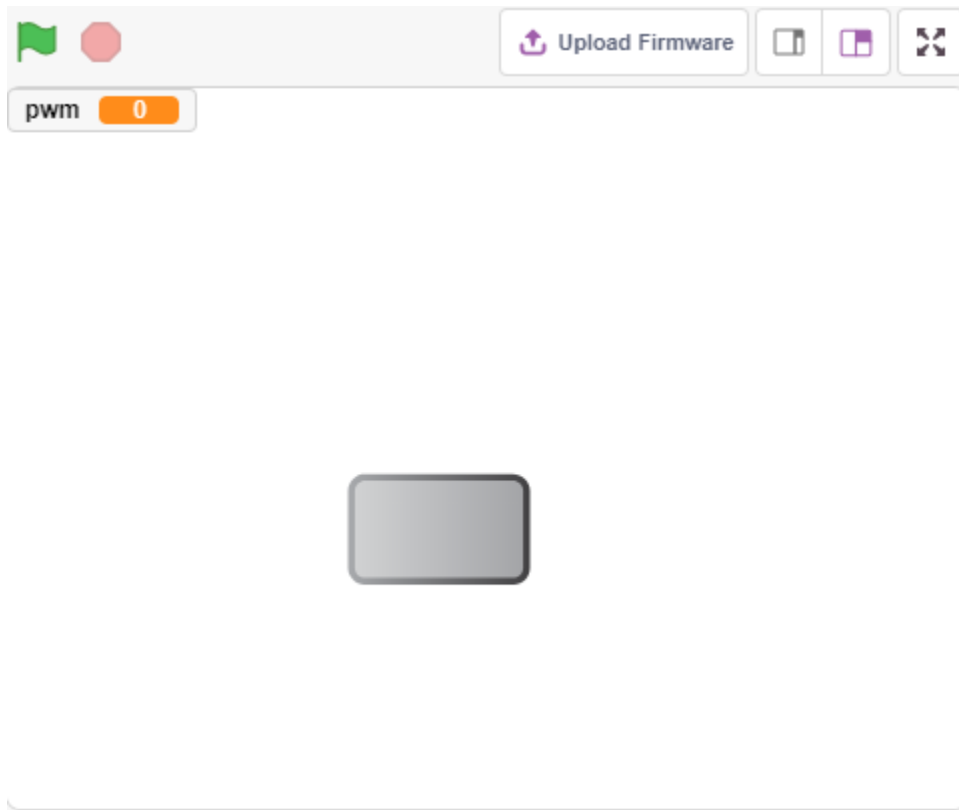
- [Repeat 10]: limited number of repeat loops, you can set the number of repeats yourself, from the **Control** palette.



## 7.5 2.2 Breathing LED

Now use another method to control the brightness of the LED. Unlike the previous project, here the brightness of the LED is made to slowly diminish until it disappears.

When the sprite on the stage is clicked, the brightness of the LED slowly increases and then goes out instantly.



### 7.5.1 You Will Learn

- Set the output value of the PWM pin
- Create variables
- Change the brightness of the sprite

### 7.5.2 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

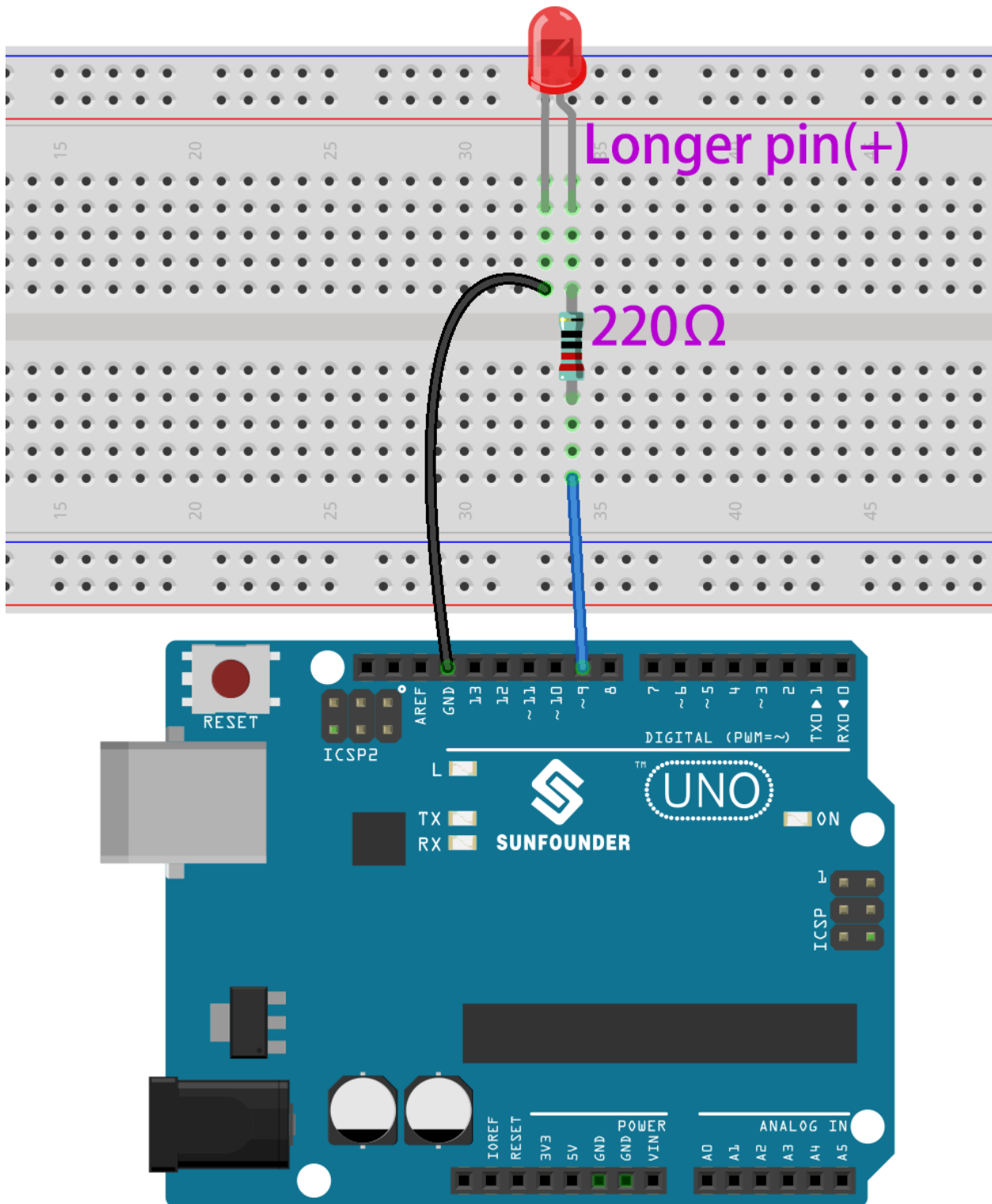
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>LED</i>	

### 7.5.3 Build the Circuit

This project uses the same circuit as the previous project [2.1 Table Lamp](#), but instead of using HIGH/LOW to make the LEDs light up or turn off, this project uses the [PWM - Wikipedia](#) signal to slowly light up or dim down the LED.

The PWM signal range is 0-255, on the Arduino Uno board, 3, 5, 6, 9, 10, 11 can output PWM signal; on the Mega2560, 2 - 13, 44 - 46 can output PWM signal.

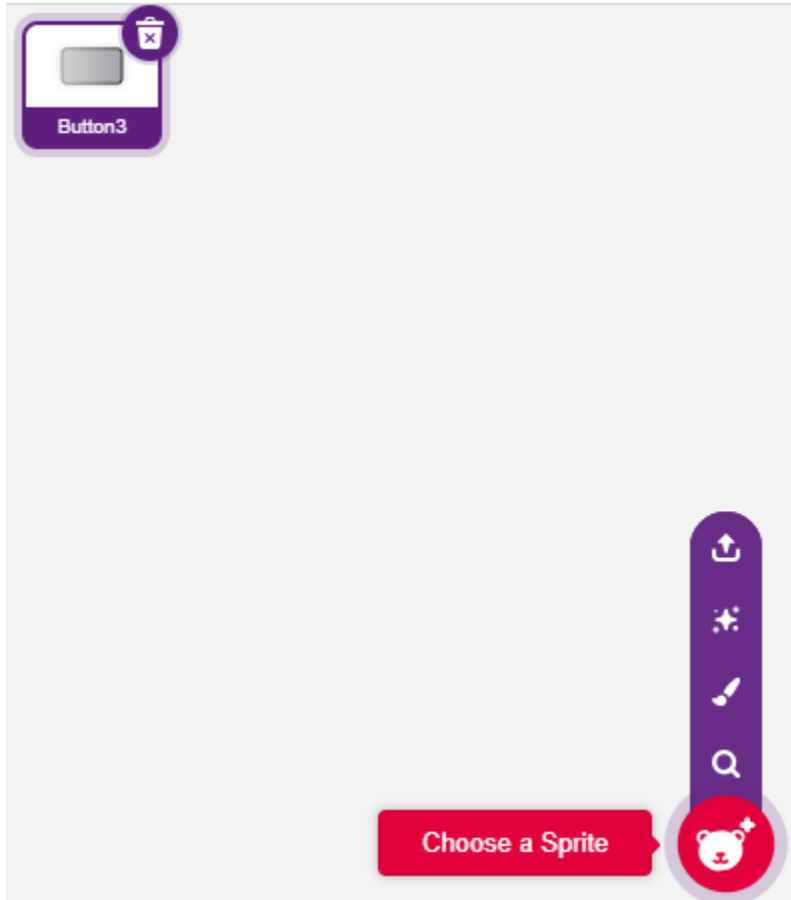




## 7.5.4 Programming

### 1. Select a sprite

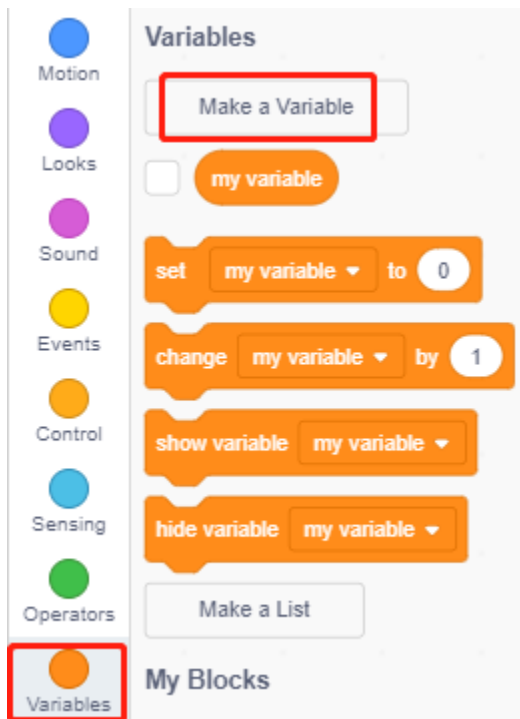
Delete the default sprite, click the **Choose a Sprite** button in the lower right corner of the sprite area, enter **button3** in the search box, and then click to add it.



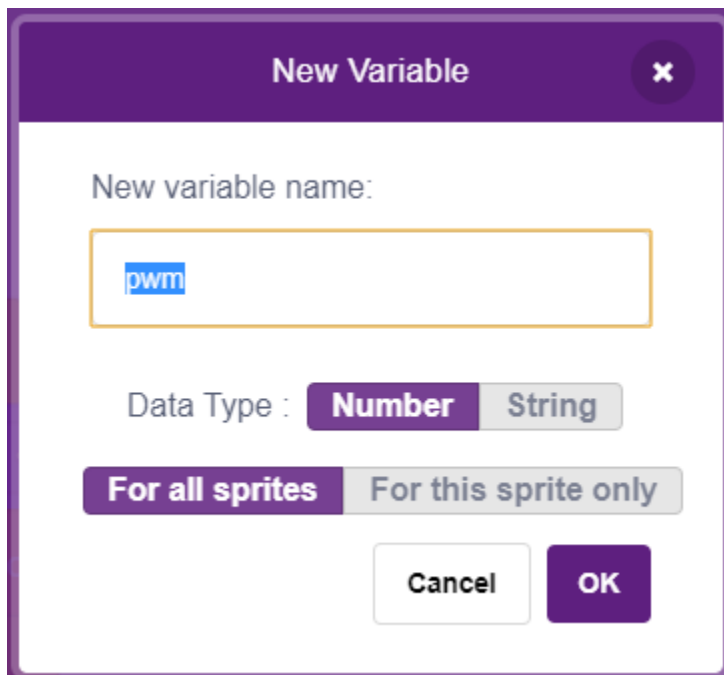
### 2. Creating a variable.

Create a variable called **pwm** to store the value of the pwm change.

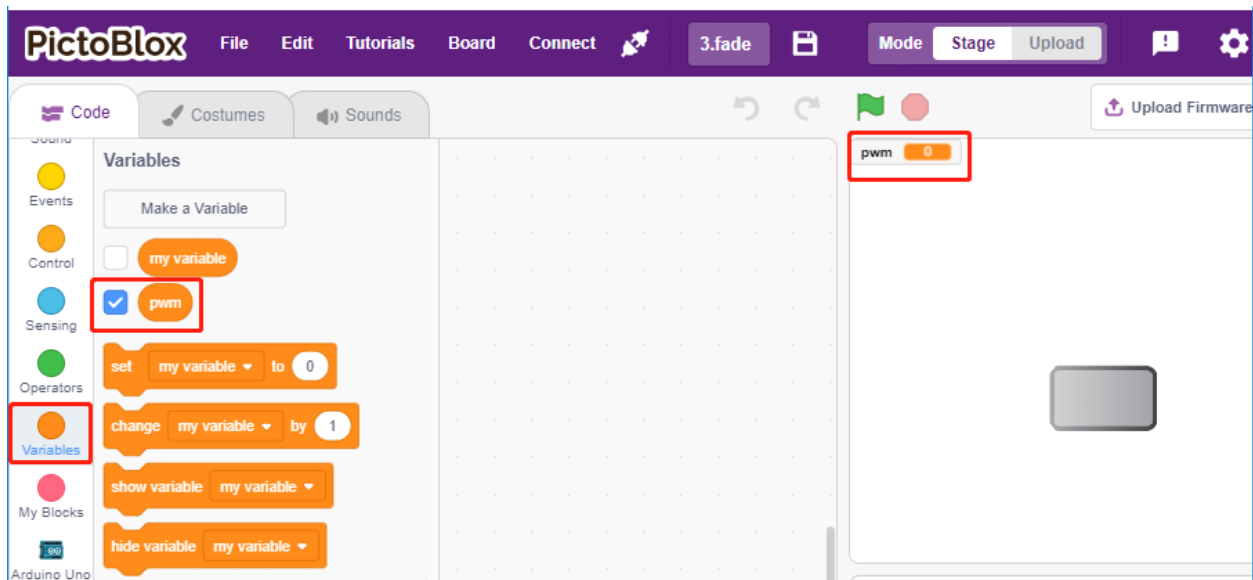
Click on the **Variables** palette and select **Make a Variable**.



Enter the name of the variable, it can be any name, but it is recommended to describe its function. The data type is number and For all sprites.



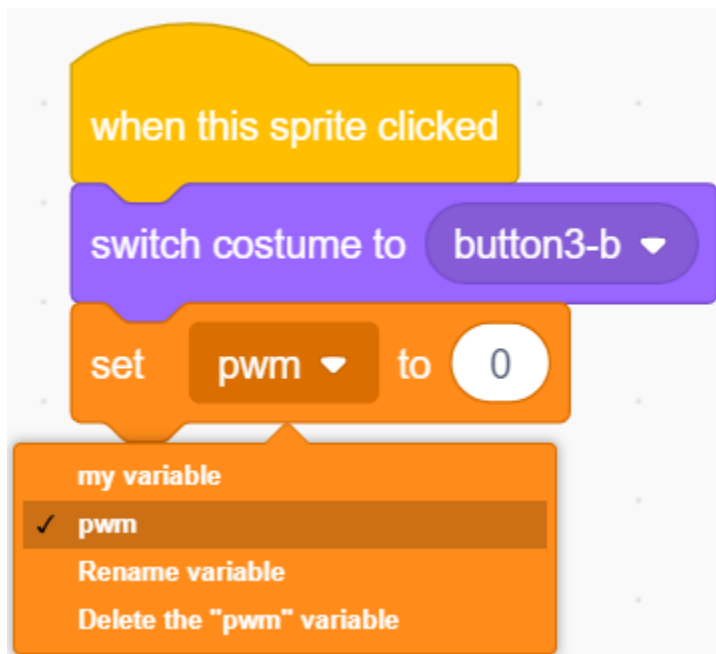
Once created, you will see **pwm** inside the **Variables** palette and in the checked state, which means this variable will appear on the stage. You can try unchecking it to see if pwm is still present on the stage.



### 3. Set the initial state

When the **button3** sprite is clicked, switch the costume to **button-b** (clicked state), and set the initial value of the variable **pwm** to 0.

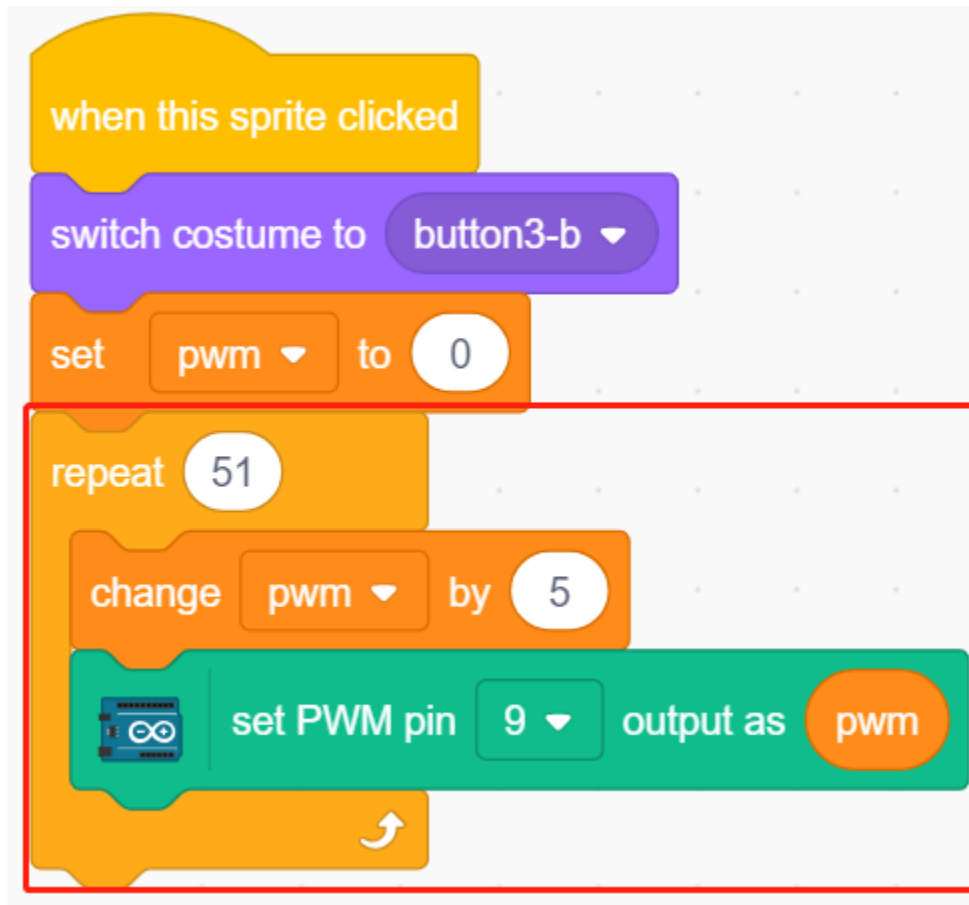
- [set pwm to 0]: from **Variables** palette, used to set the value of the variable.



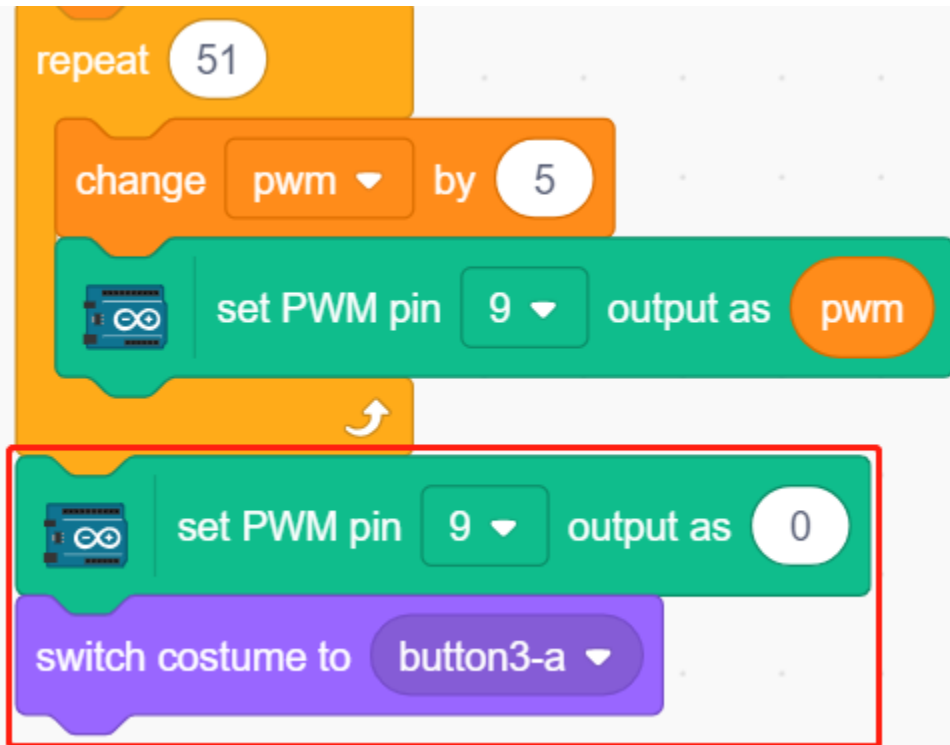
### 4. Make the LED brighter and brighter

Since the range of pwm is 255, so by [repeat] block, the variable **pwm** is accumulated to 255 by 5, and then put into [set PWM pin] block, so you can see the LED slowly light up.

- [change pwm by 5]: from **Variables** palette, let the variable change a specific number each time. It can be a positive or negative number, positive is increasing each time, negative is decreasing each time, for example, here the variable pwm is increased by 5 each time.
- [set PWM pin]: from the **Arduino Uno** palette, used to set the output value of the pwm pin.



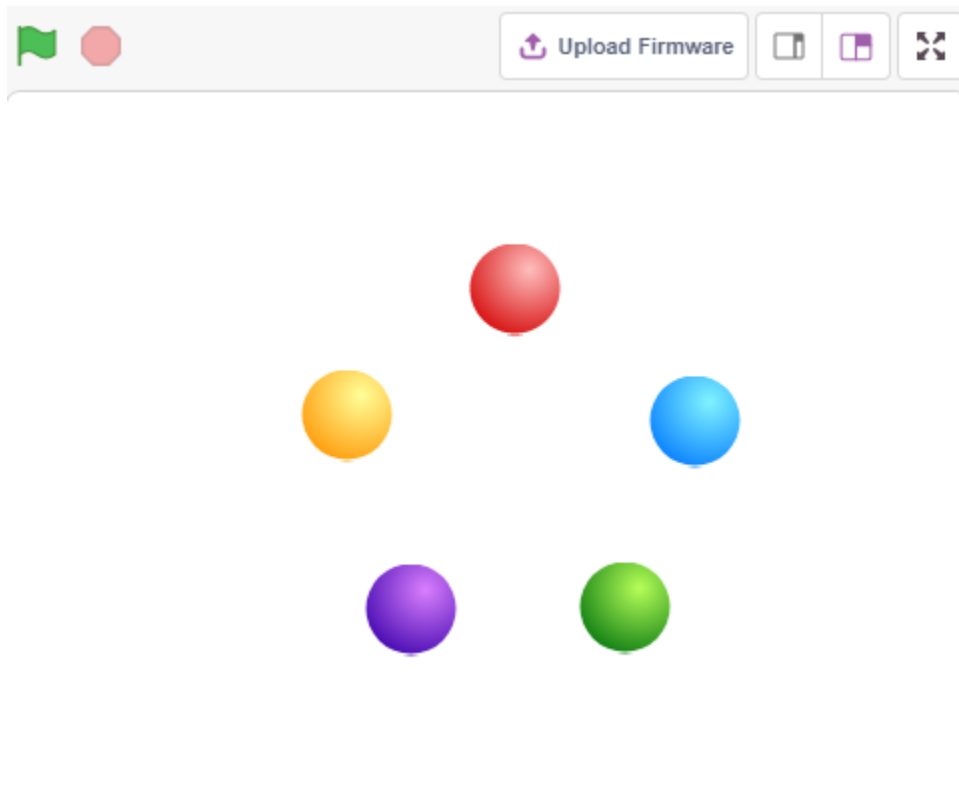
Finally, switch the costume of button3 back to **button-a** and make the PWM pin value 0, so that the LED will light up slowly and then turn off again.



## 7.6 2.3 Colorful Balls

In this project, we will make the RGB LEDs display different colors.

Clicking on different colored balls on the stage area will cause the RGB LED to light up in different colors.



### 7.6.1 You Will Learn

- The principle of RGB LED
- Copy sprites and select different costumes
- Three primary colors superimposed

### 7.6.2 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

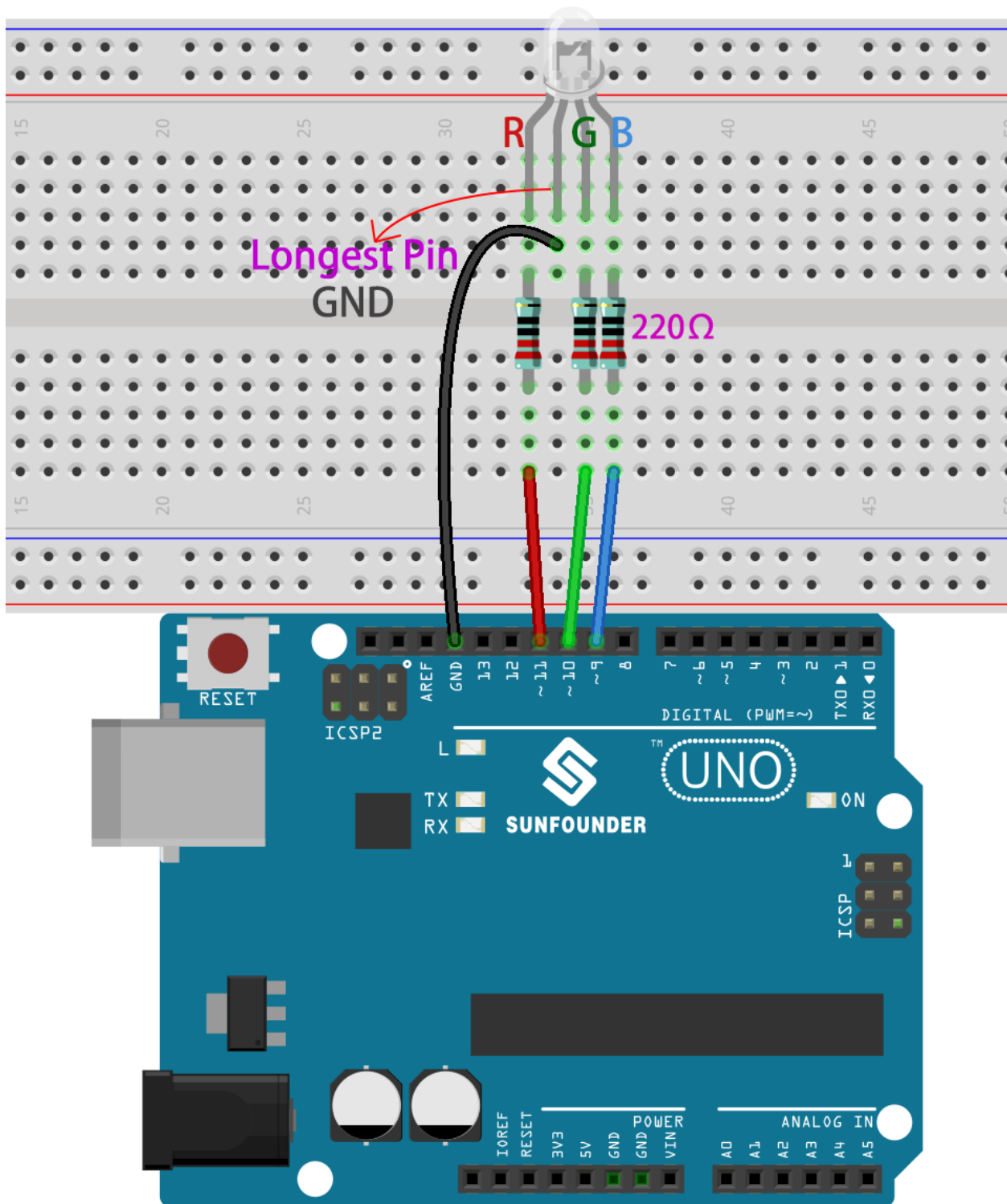
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>RGB LED</i>	

### 7.6.3 Build the Circuit

An RGB LED packages three LEDs of red, green, and blue into a transparent or semitransparent plastic shell. It can display various colors by changing the input voltage of the three pins and superimpose them, which, according to statistics, can create 16,777,216 different colors.



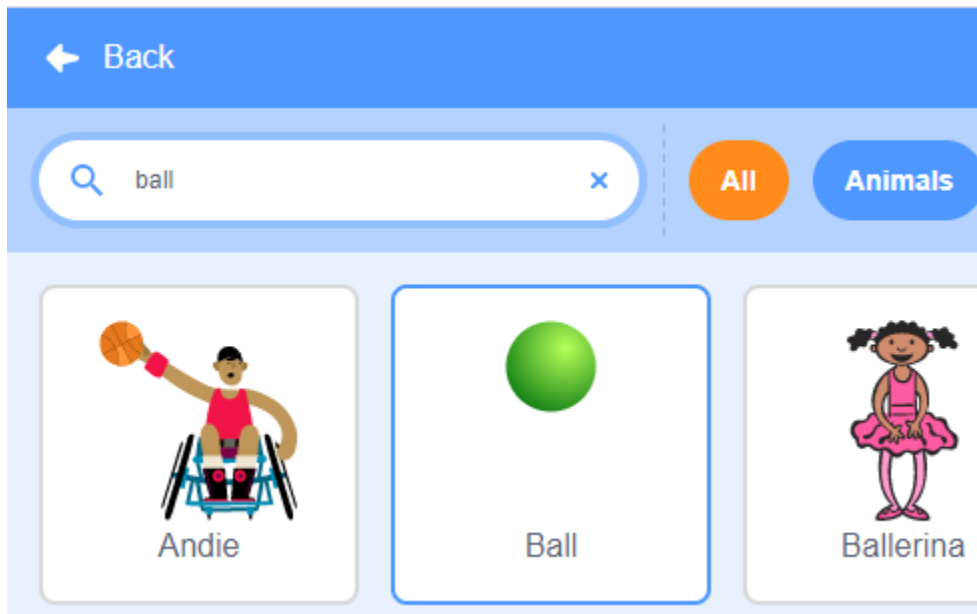




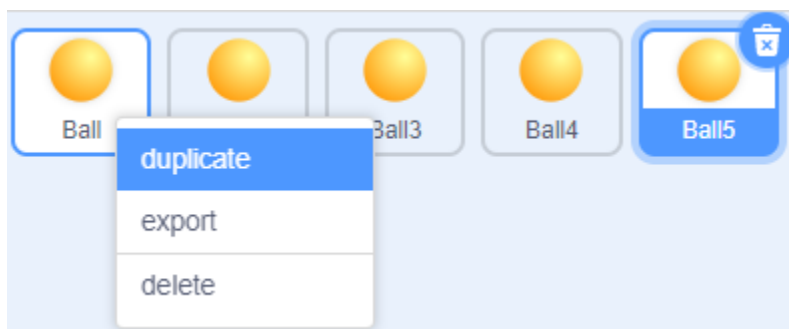
## 7.6.4 Programming

### 1. Select sprite

Delete the default sprite, then choose the **Ball** sprite.



And duplicate it 5 times.

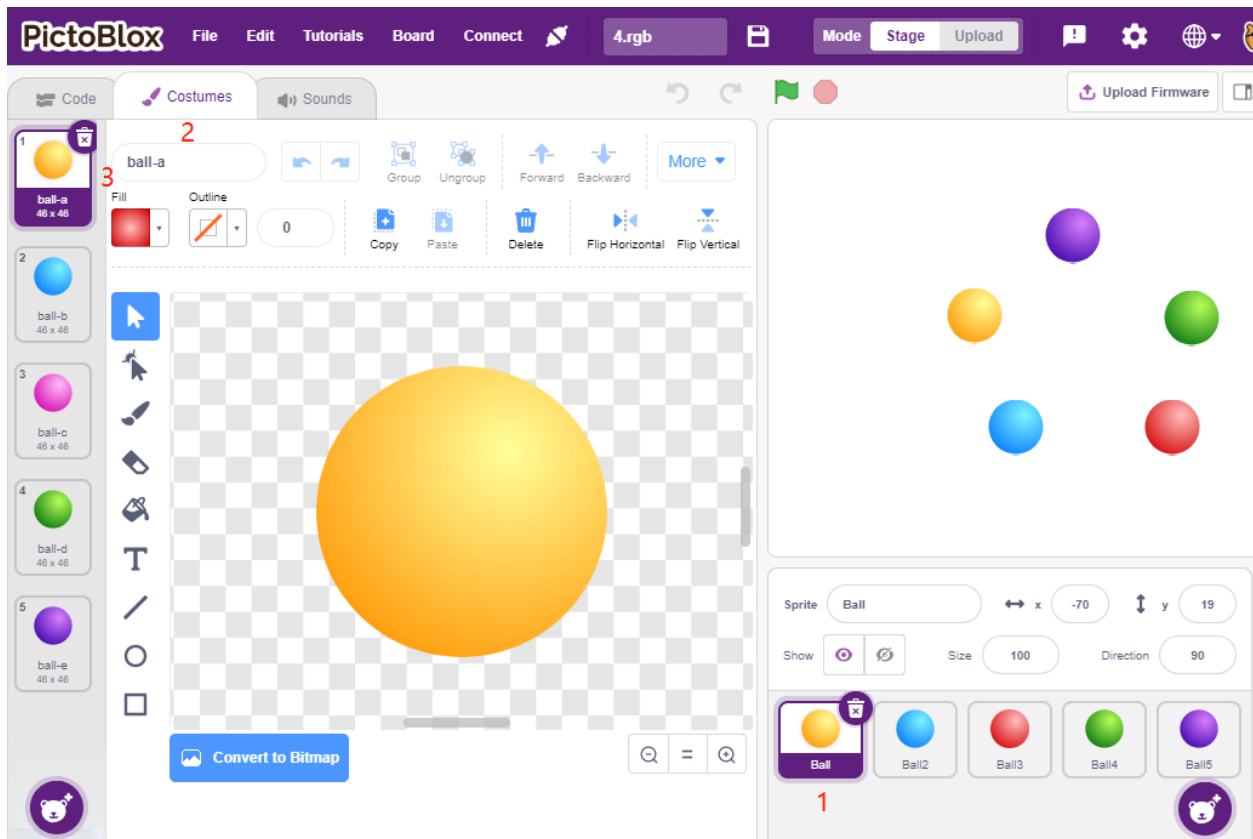


Choose different costumes for these 5 **Ball** sprites and move them to the corresponding positions.

---

**Note:** **Ball3** sprite costume color needs to be manually changed to red.

---

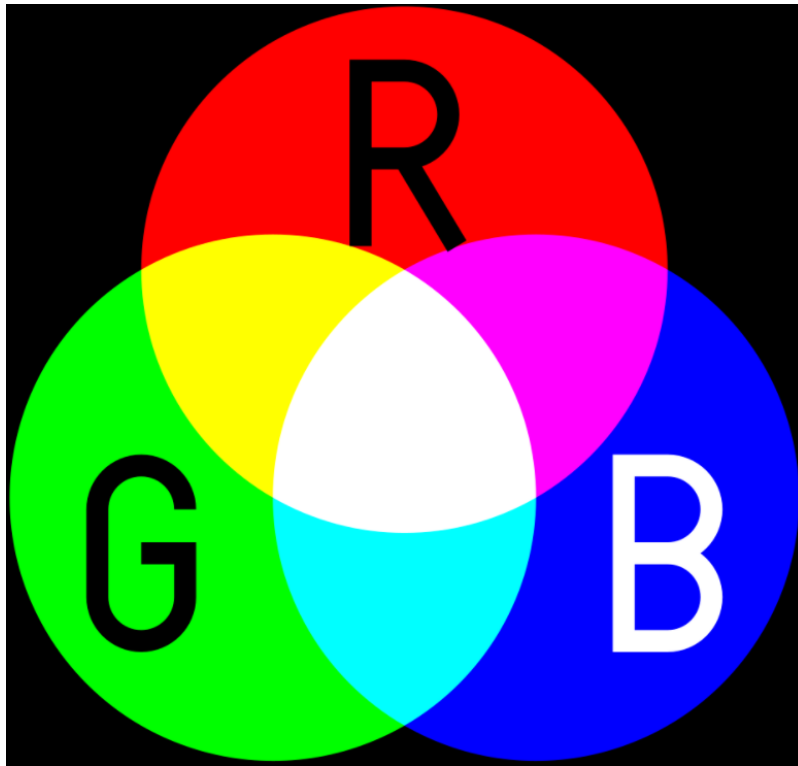


## 2. Make RGB LEDs light up in the appropriate color

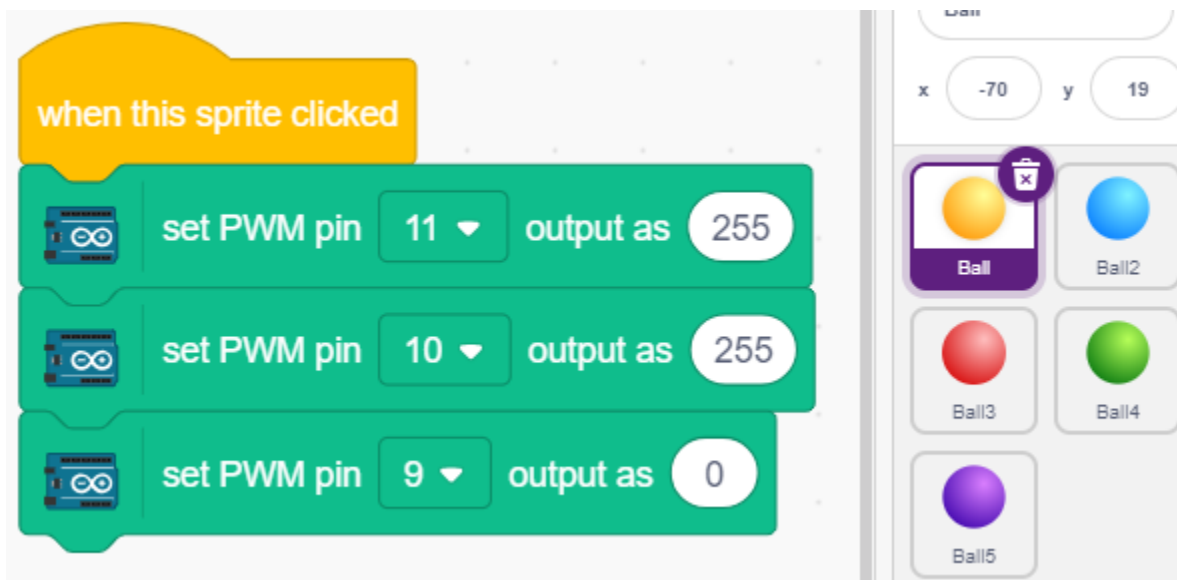
Before understanding the code, we need to understand the [RGB color model](#).

The RGB color model is an additive color model in which red, green, and blue light are added together in various ways to reproduce a broad array of colors.

Additive color mixing: adding red to green yields yellow; adding green to blue yields cyan; adding blue to red yields magenta; adding all three primary colors together yields white.



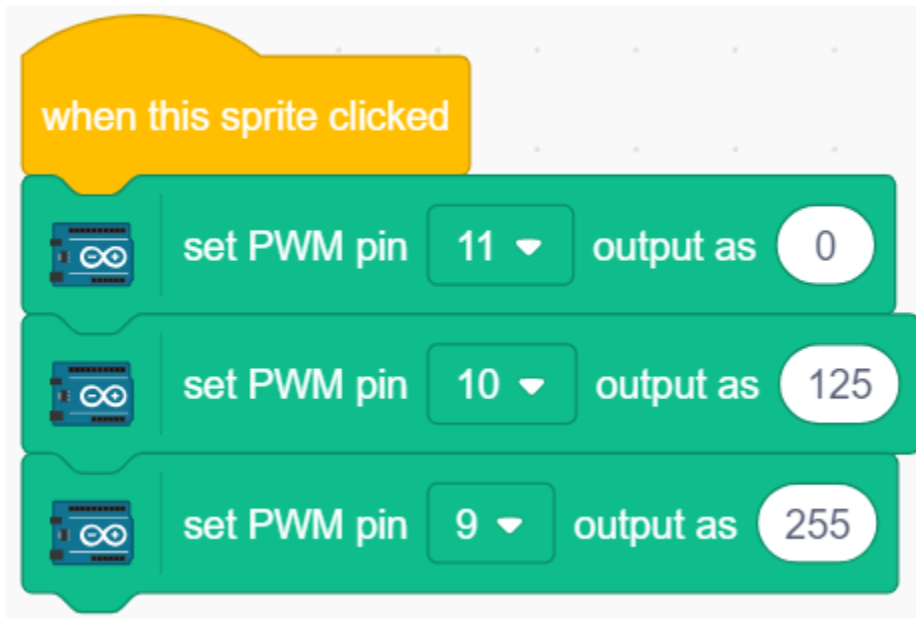
So the code to make the RGB LED light yellow is as follows.



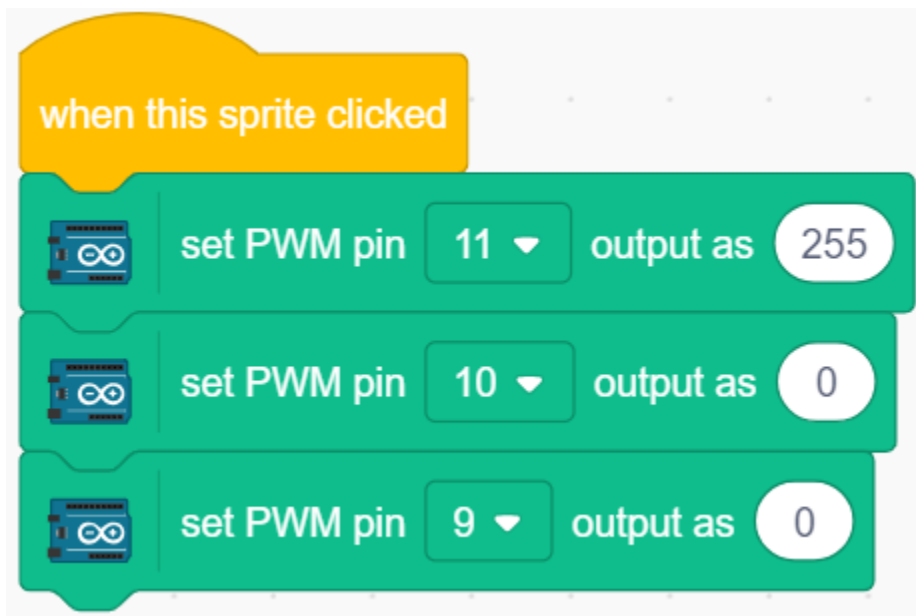
When the Ball sprite (yellow ball) is clicked, we set pin 11 high (red LED on), pin 10 high (green LED on) and pin 9 low (blue LED off) so that the RGB LED will light yellow.

You can write codes to other sprites in the same way to make the RGB LEDs light up in the corresponding colors.

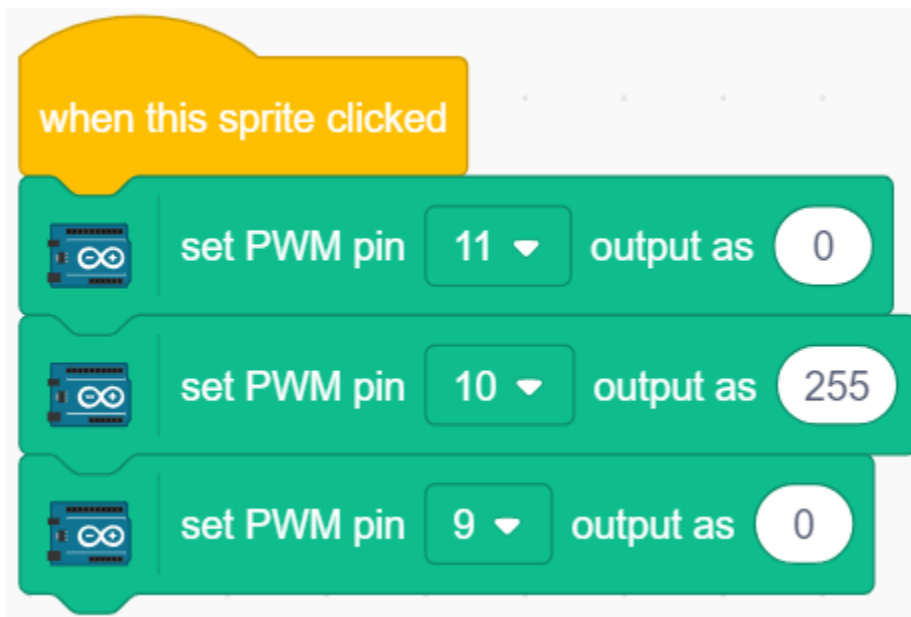
### 3. Ball2 sprite (light blue)



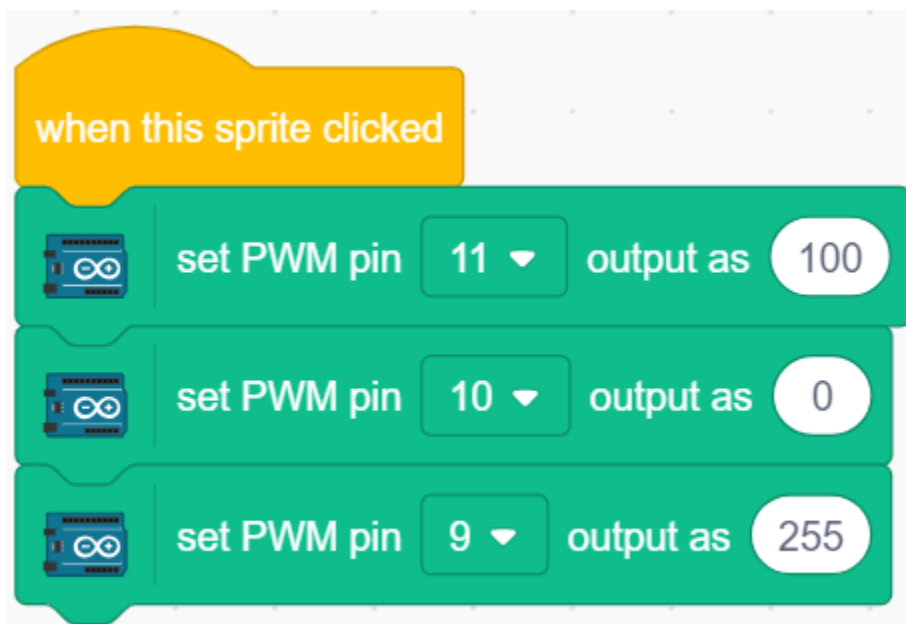
#### 4. Ball3 sprite (red)



#### 5. Ball4 sprite (green)



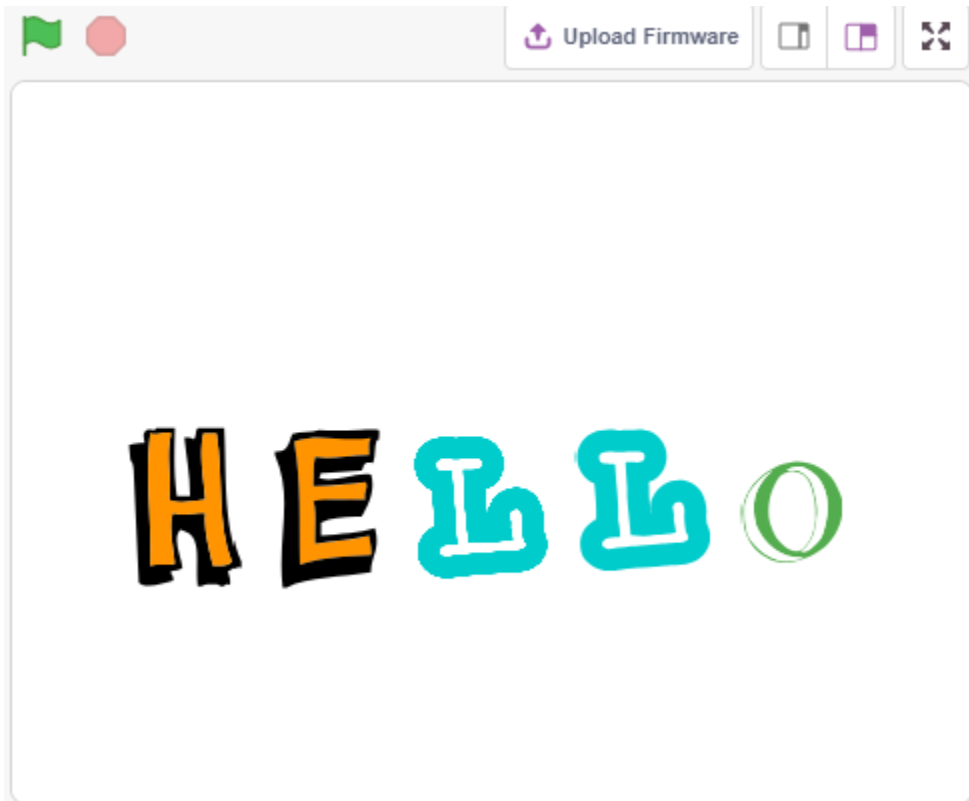
#### 6. Ball5 sprite (purple)



## 7.7 2.4 LCD1602

LCD1602 can be used to display 2x16 characters, now we let it display the corresponding characters with the character sprites on the stage.

When you click the Hello on the stage one by one, they will have different animation effects and the characters will be displayed on the LCD1602 at the same time.



### 7.7.1 You Will Learn

- Using the LCD1602
- Select multiple different sprites
- Change sprite size, rotation angle, color and show or hide.

### 7.7.2 Required Components

In this project, we need the following components.

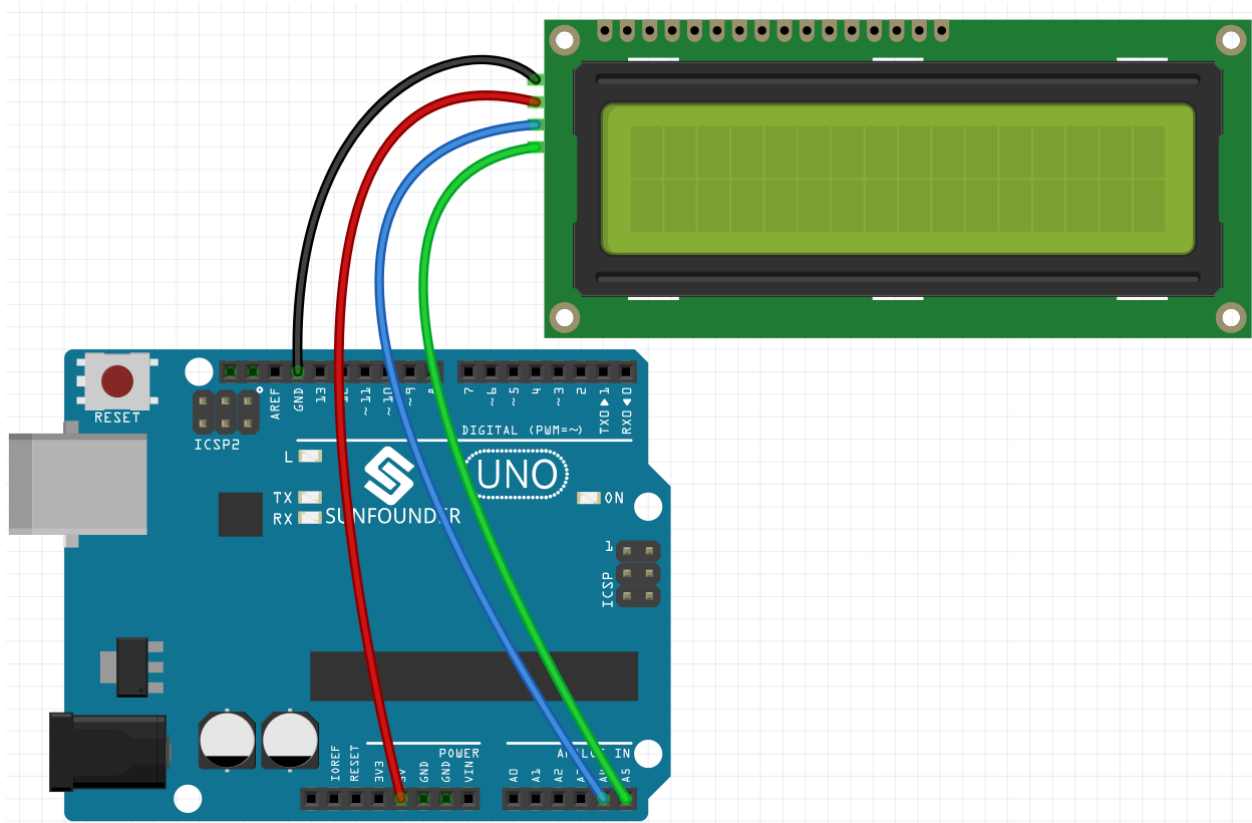
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>I2C LCD1602</i>	

### 7.7.3 Build the Circuit

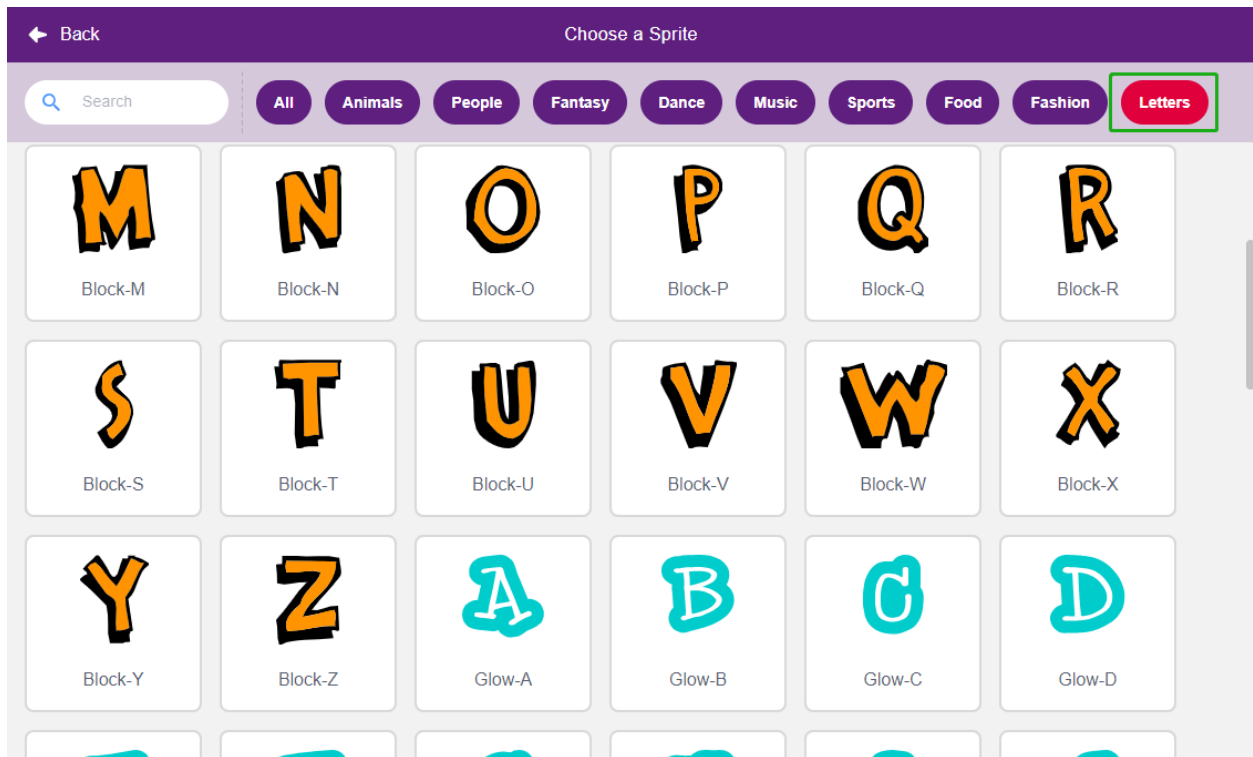


### 7.7.4 Programming

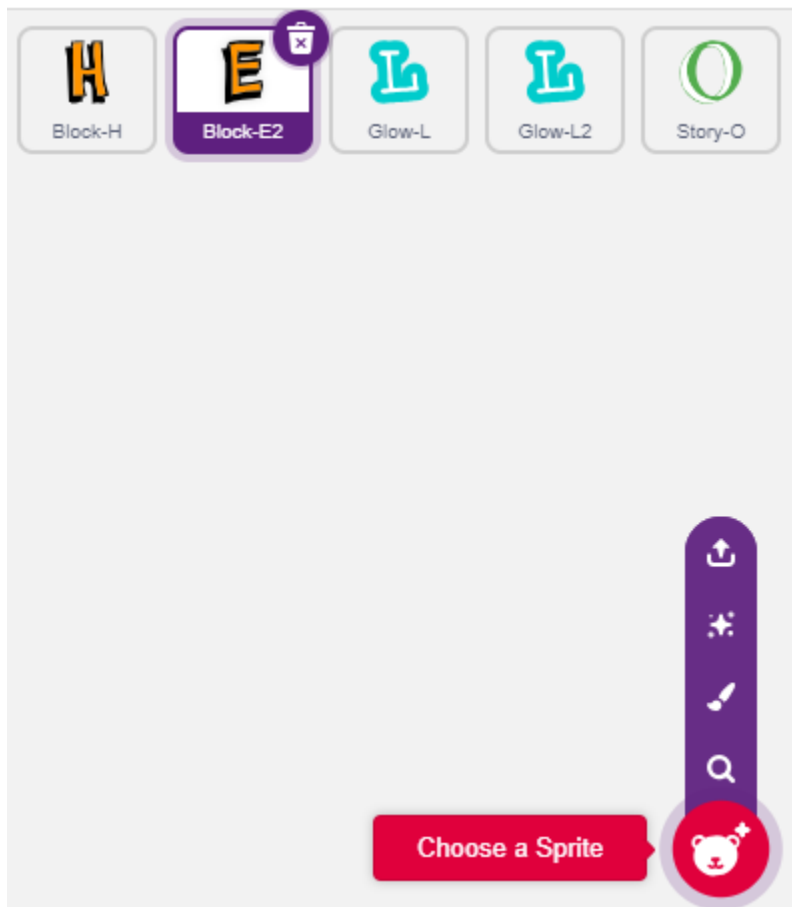
#### 1. Select sprite

Delete the default sprite, click **Choose a Sprite**, then click **letters** and select the sprite you want.





For example, I chose Hello, as shown below.



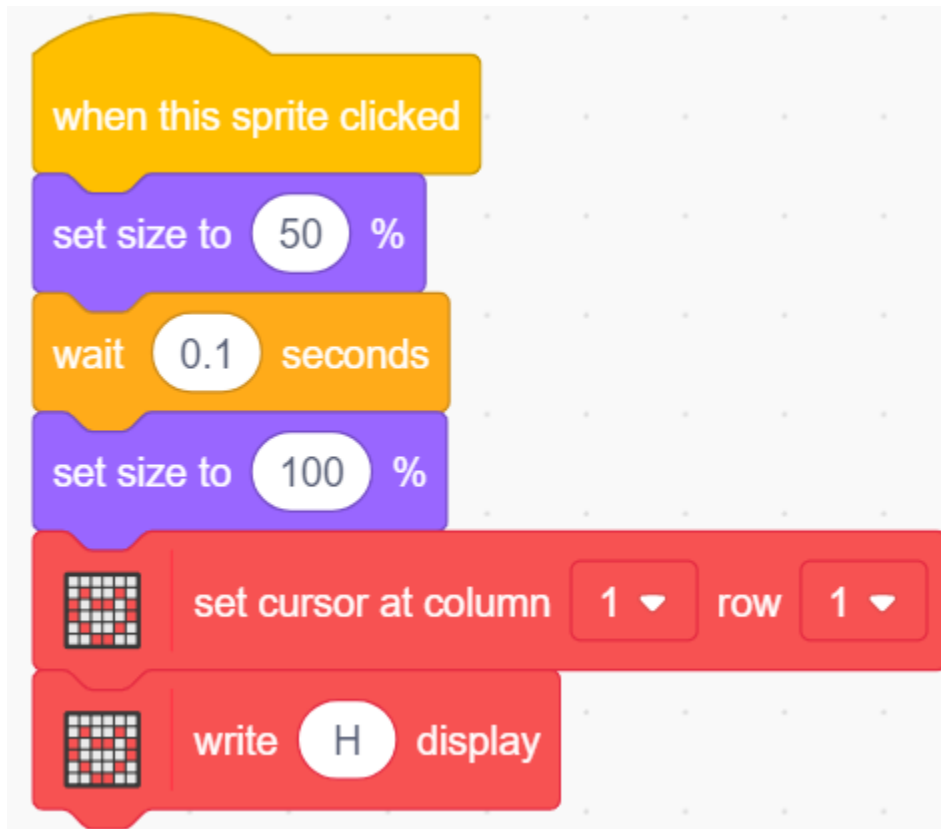
Now to set different effects for these sprites and display them on the LCD1602 while clicking.

## 2. H is zoom in and zoom out

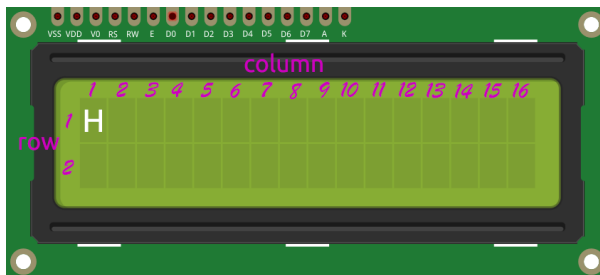
Click on the **H** sprite, and now write a script for it.

When the sprite **H** is clicked, make its size to 50%, then restore it; while displaying H on the first row and column of the LCD1602.

- [set size to]: From **Looks** palette, used to set the size of the sprite, from 0% to 100%.
- [set cursor at column row]: From **Display Modules** palette, used to set the cursor at a specific row of the LCD1602 to start displaying characters.
- [write display]: From the **Display Modules** palette, used to display characters or strings on the LCD1602.



The distribution of rows and columns on the LCD1602 is shown in the figure.

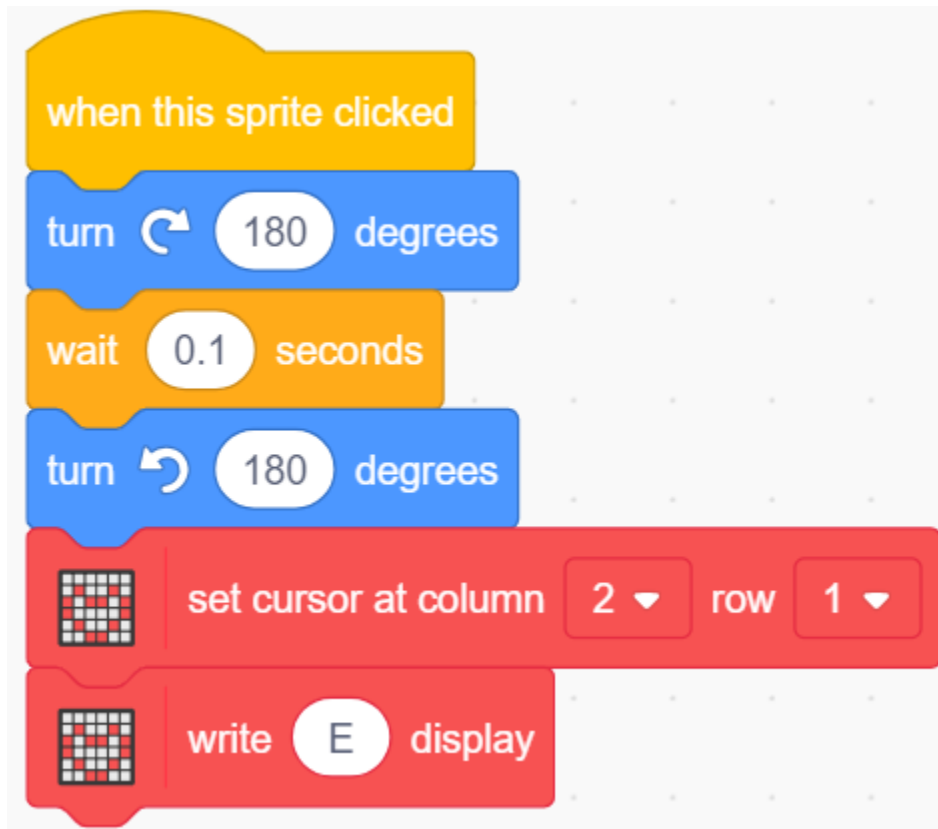


### 3. E is flipping left and right

Click on the **E** sprite, and now write a script for it.

When the sprite **E** is clicked, have it turn 180 degrees clockwise, then 180 degrees counterclockwise so you can see it flip left and right; and show H in the first row and column 2 of the LCD1602.

- [turn degrees]: From the **Motions** palette, used to turn the sprite clockwise or counterclockwise, the range is 0-360 degrees.

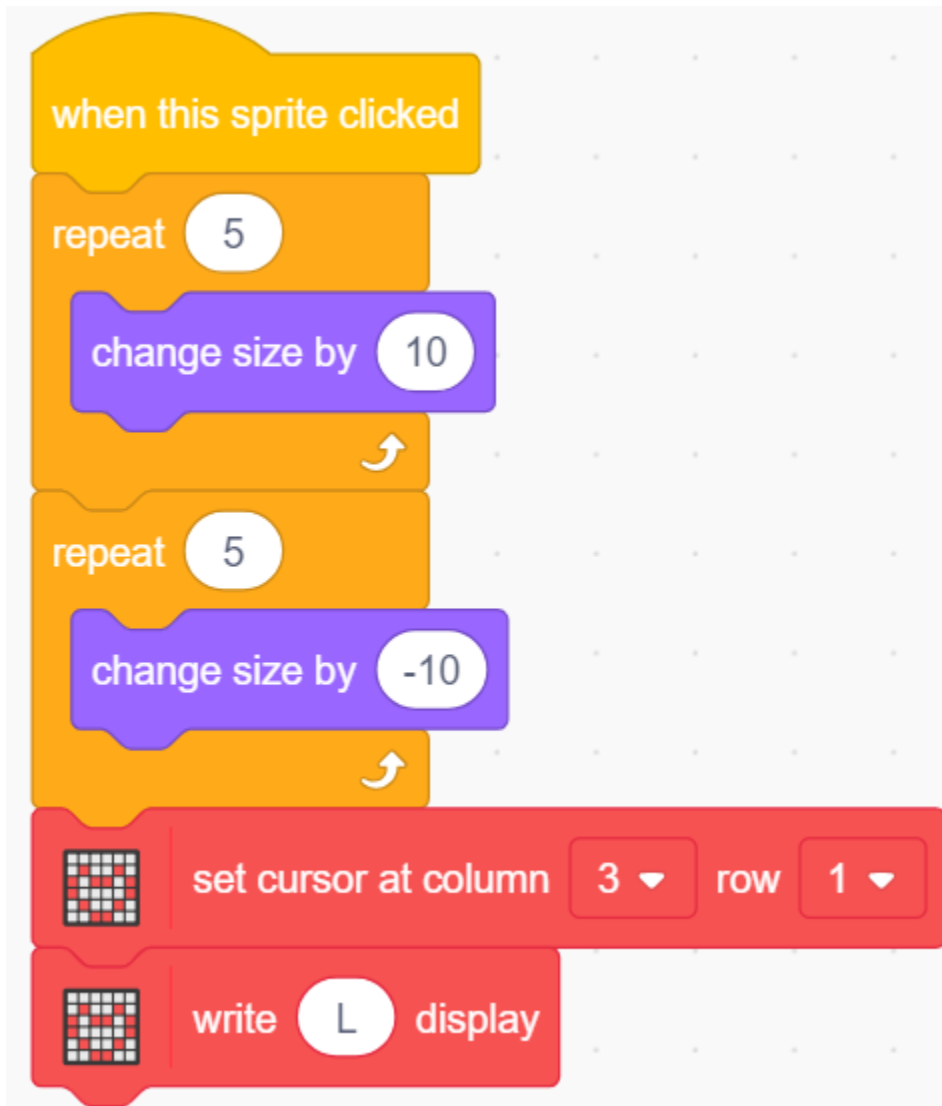


#### 4. L is slowly shrinking and zooming in

Click on the **first L** sprite and now write a script for it.

When the sprite **L** is clicked, use the [repeat] block to increase its size by 50% (5 times, 10 each time), then shrink it back to its original size in the same way, while displaying L in the first row and column 3 of the LCD1602.

- [change size by]: From the Motions palette, used to change the size of the sprite.

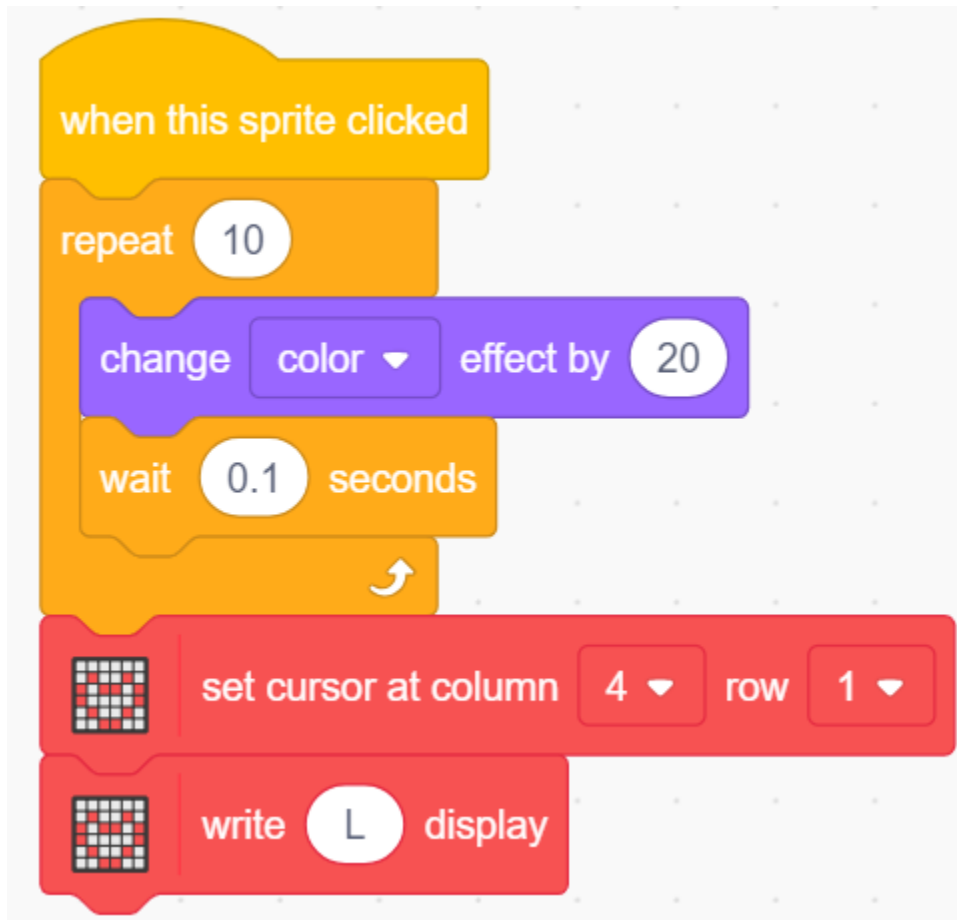


### 5. The second L is changing color

Click on the **second L** sprite and now write a script for it.

When the sprite **L** is clicked, use the [repeat] block to repeat 10 times at a rate of 20 increments to switch between colors and return to the original color. Also display L in the first row and column 4 of the LCD1602.

- [change color effect by]: Used to change the color Effect, one costume can take on 200 different color-schemes using the color effect, 0 and 200 are the same color.

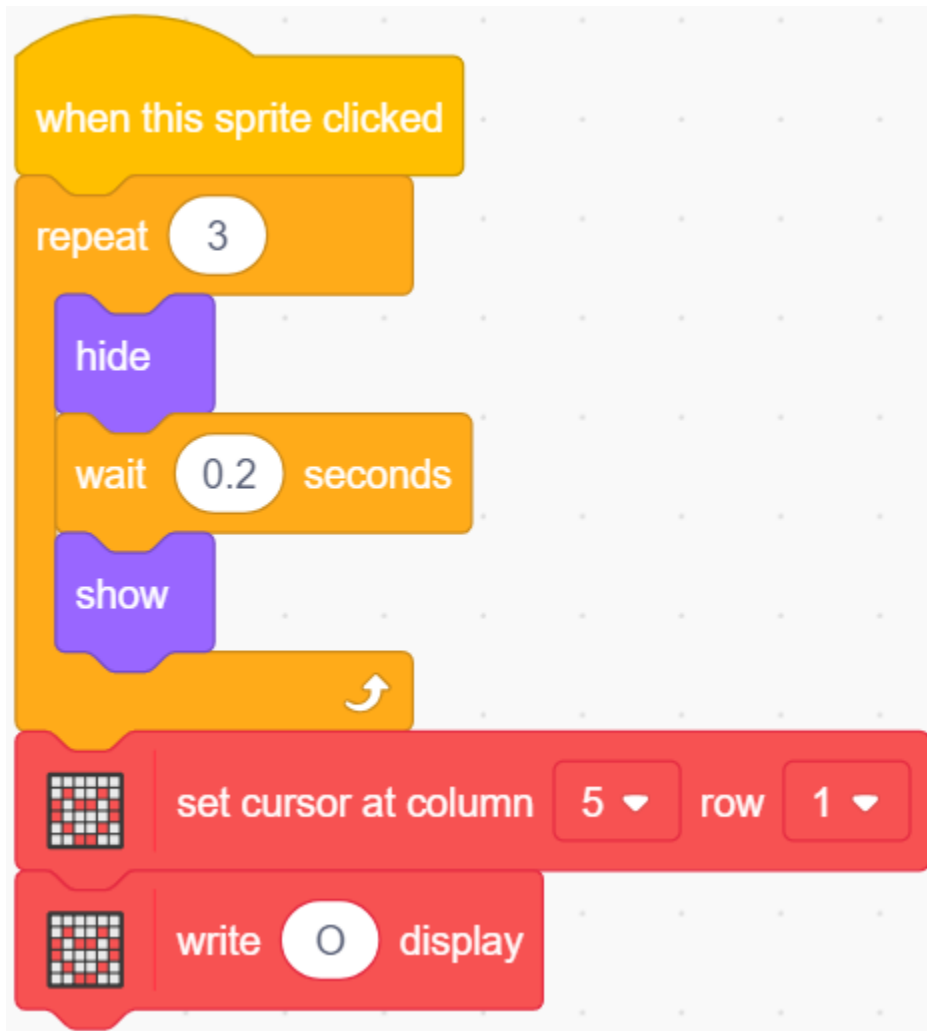


#### 6. O is hide and show

Click on the **O** sprite and now write a script for it.

When the **O** sprite is clicked, it repeats the hide and show process 3 times, while displaying O in the first row and column 5 of the LCD1602.

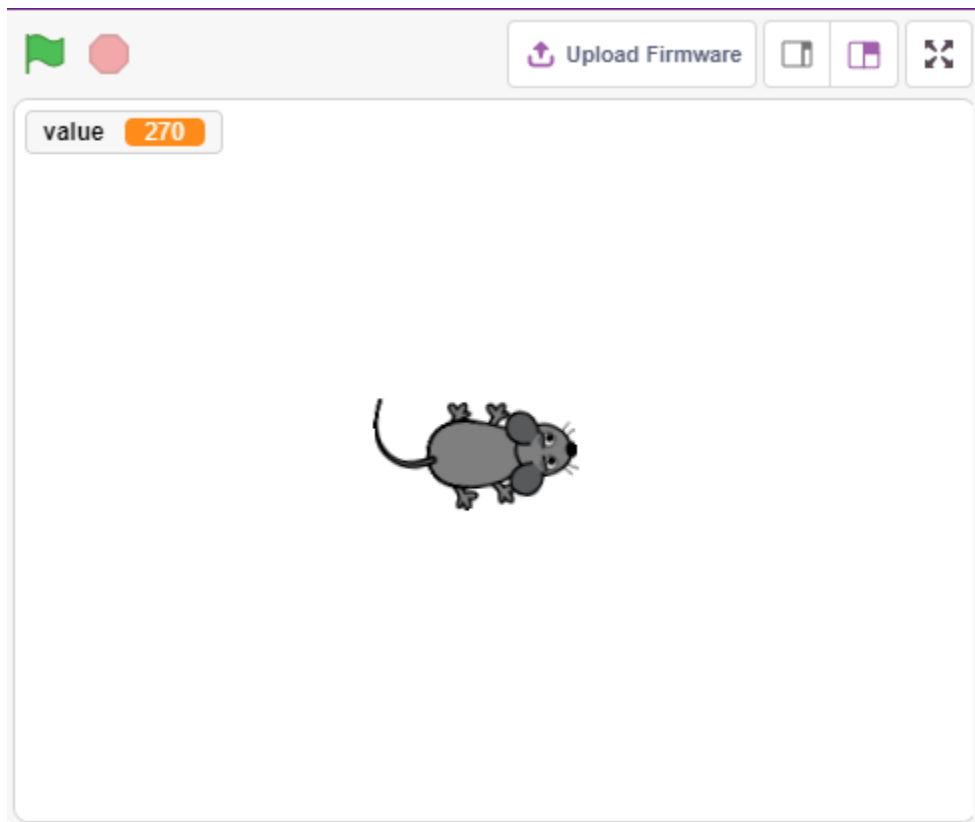
- [Hide] & [Show]: make the sprite hide and show.



## 7.8 2.5 Moving Mouse

Today we are going to make a mouse toy controlled by a potentiometer.

When the green flag is clicked, the mouse on the stage moves forward, and when you rotate the potentiometer, the mouse will change the direction of movement.



### 7.8.1 You Will Learn

- Potentiometer principle
- Read analog pin and ranges
- Mapping one range to another
- Moving and changing the direction of sprite

### 7.8.2 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

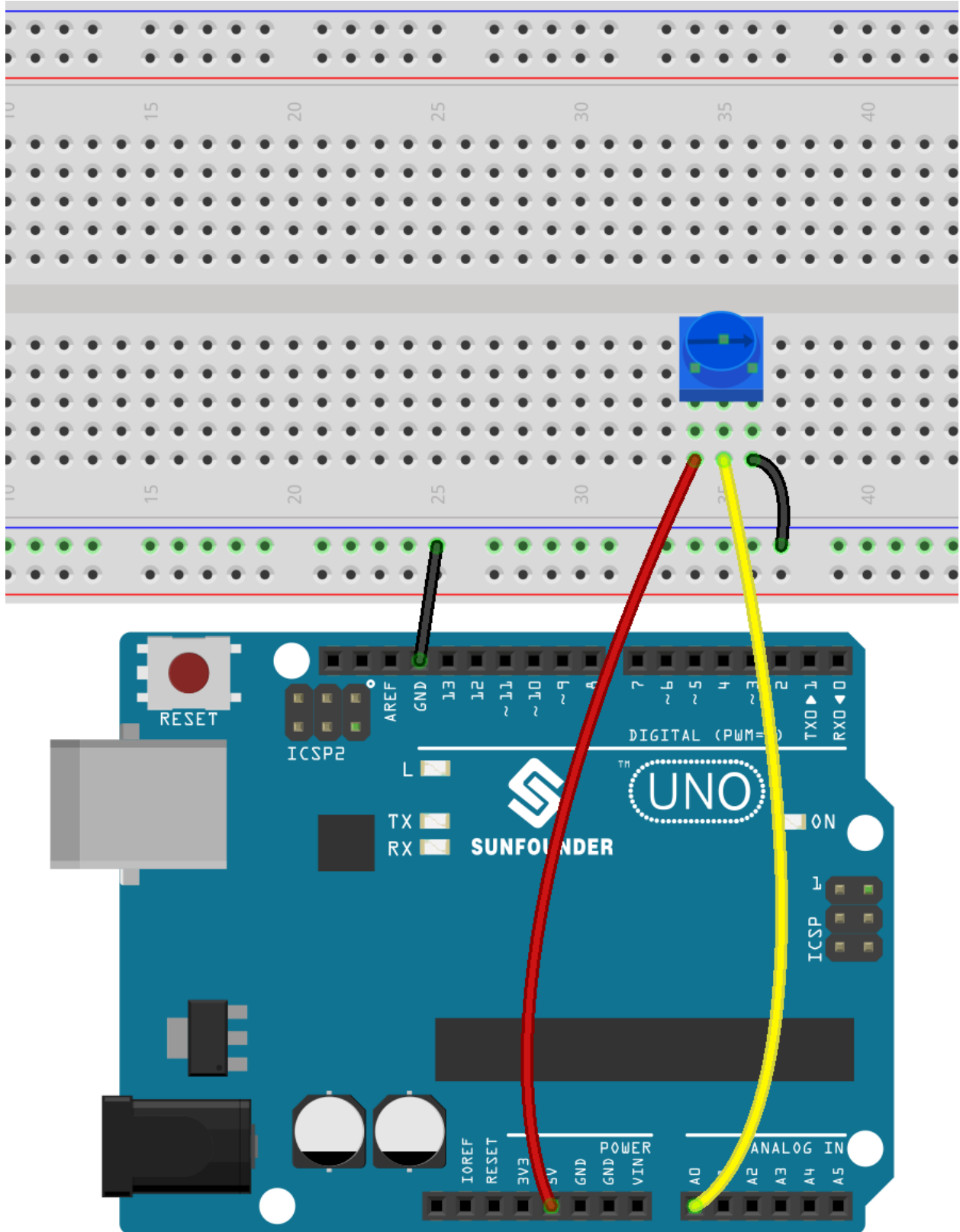
You can also buy them separately from the links below.



COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Potentiometer</i>	

### 7.8.3 Build the Circuit

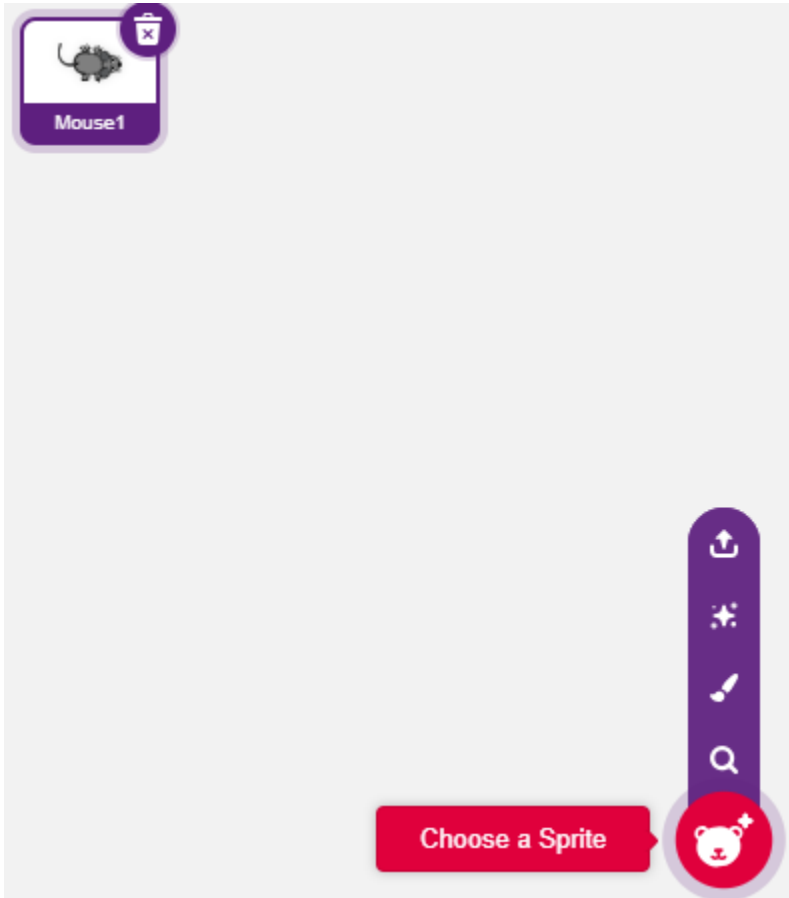
The potentiometer is a resistive element with 3 terminals, the 2 side pins are connected to 5V and GND, and the middle pin is connected to A0. After conversion by the ADC converter of the Arduino board, the value range is 0-1023.



## 7.8.4 Programming

### 1. Choose a sprite

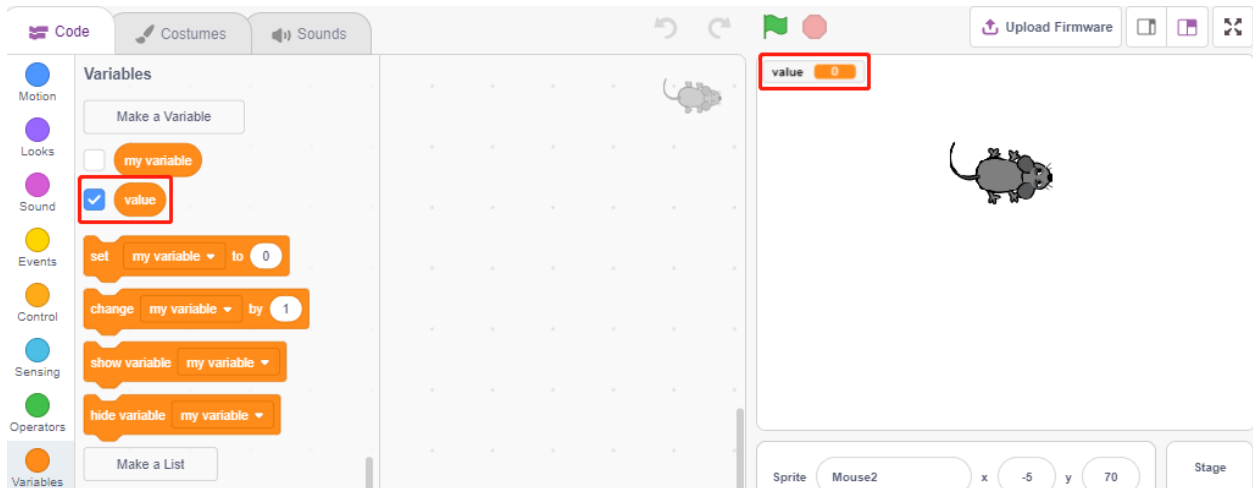
Delete the default sprite, click the **Choose a Sprite** button in the lower right corner of the sprite area, enter **mouse** in the search box, and then click to add it.



### 2. Creating a variable.

Create a variable called **value** to store the value of the potentiometer read.

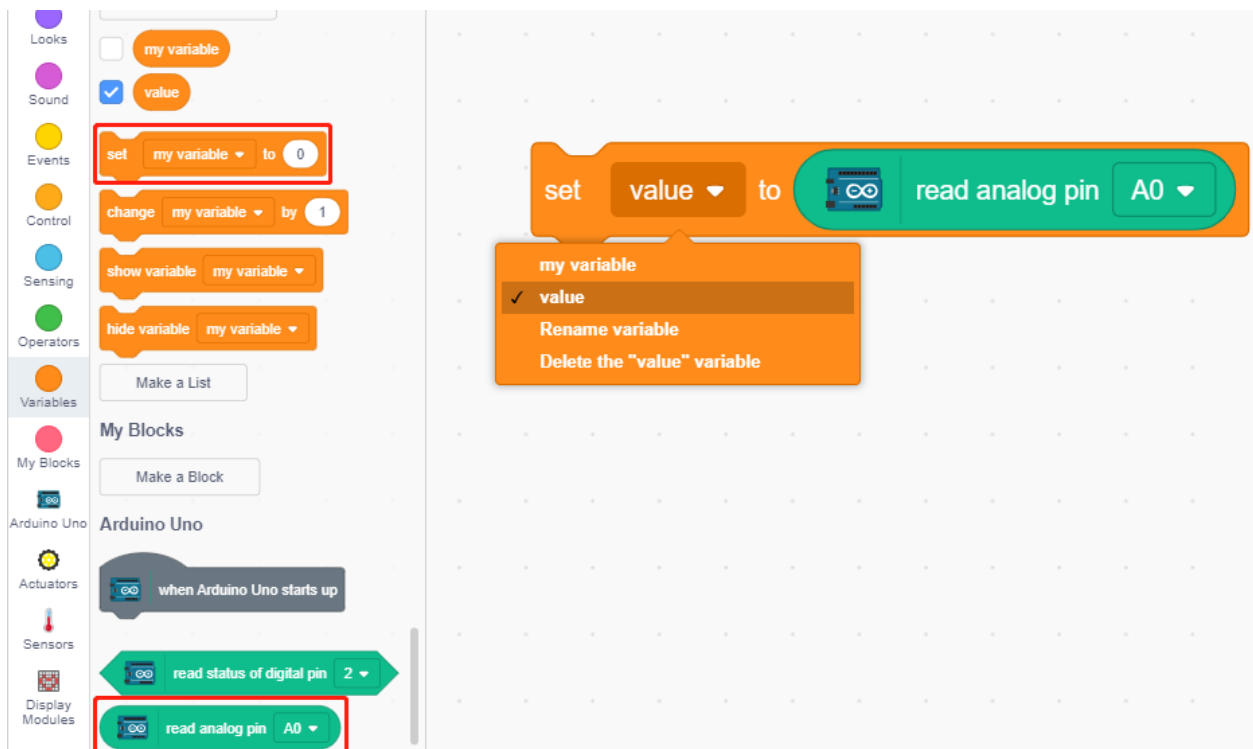
Once created, you will see **value** appear inside the **Variables** palette and in the checked state, which means this variable will appear on the stage.



### 3. Read the value of A0

Store the value of A0 read into the variable **value**.

- [set my variable to 0]: Set the value of the variable.
- [read analog pin A0]: Read the value of A0~A5 in the range of 0-1023.

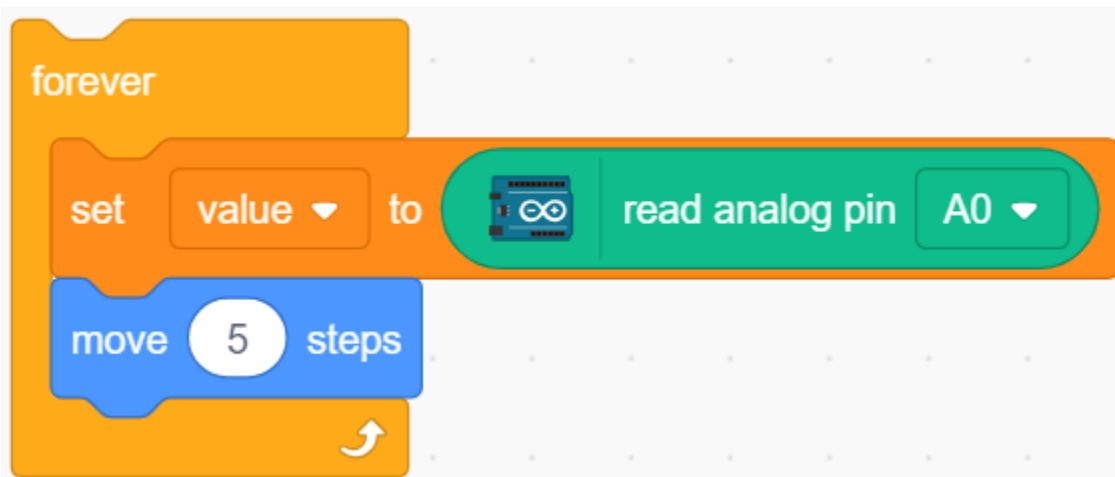


To be able to read all the way through, you need to use the [forever] block. Click on this script to run it, rotate the potentiometer in both directions, and you will see that the value range is 0-1023.



#### 4. Move the sprite

Use the [move steps] block to move the sprite, run the script and you will see the sprite move from the middle to the right.

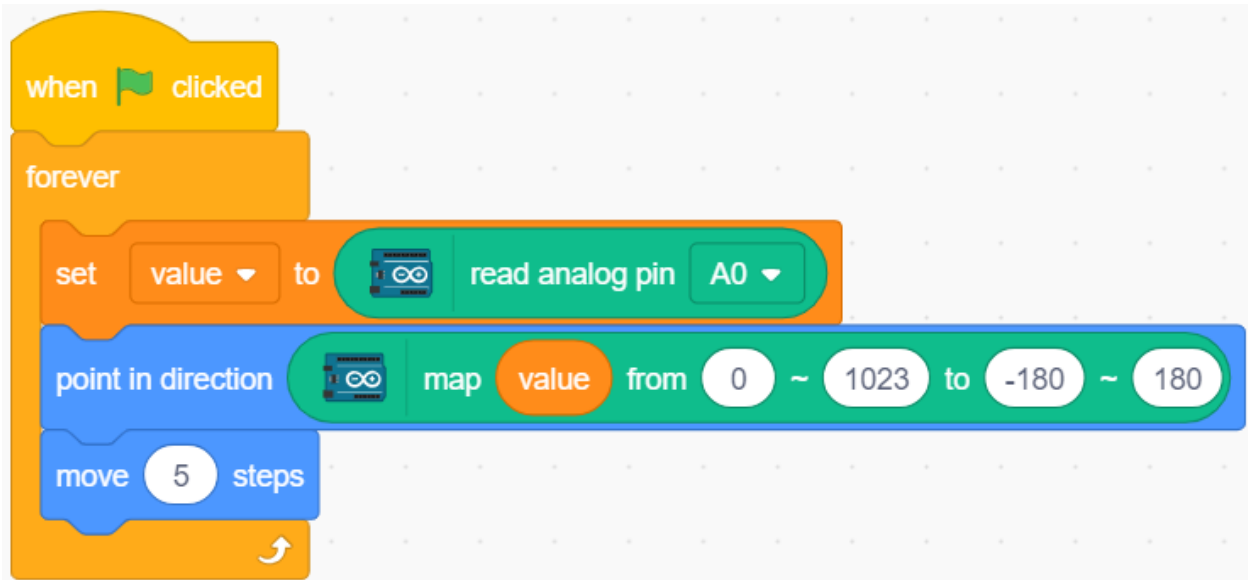


#### 5. Changing the sprite's direction

Now change the direction of the sprite's movement by the value of A0. Since the value of A0 ranges from 0-1023, but the sprite's rotation direction is -180~180, a [map] block needs to be used.

Also add [when green flag clicked] at the beginning to start the script.

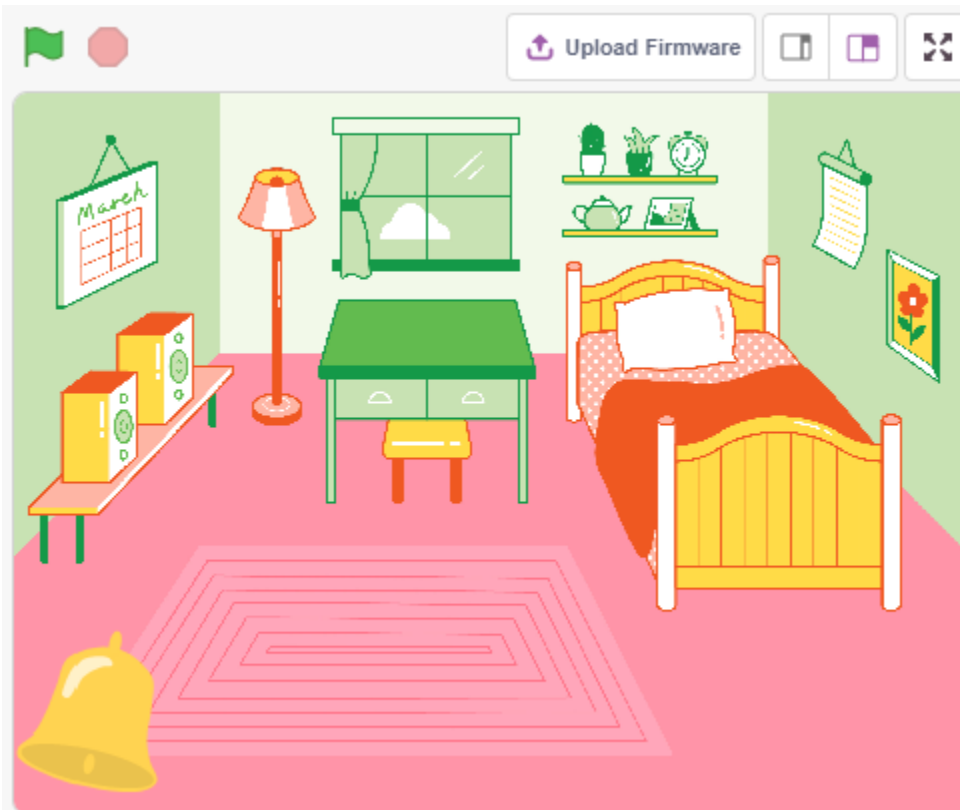
- [point in direction]: Set the steering angle of the sprite, from **Motion** palette.
- [map from to]: Map a range to another range.



## 7.9 2.6 Doorbell

Here, we will use the button and the bell on the stage to make a doorbell.

After the green flag is clicked, you can press the button and the bell on the stage will make a sound.



### 7.9.1 You Will Learn

- How the button work
- Reading digital pin and ranges
- Creating a conditional loop
- Adding a backdrop
- Playing sound

### 7.9.2 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

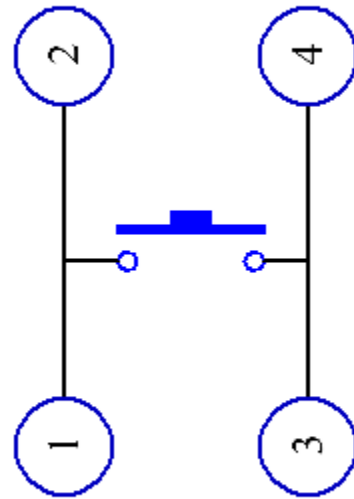
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Button</i>	
<i>Capacitor</i>	

### 7.9.3 Build the Circuit

The button is a 4-pin device, since the pin 1 is connected to pin 2, and pin 3 to pin 4, when the button is pressed, the 4 pins are connected, thus closing the circuit.



Button

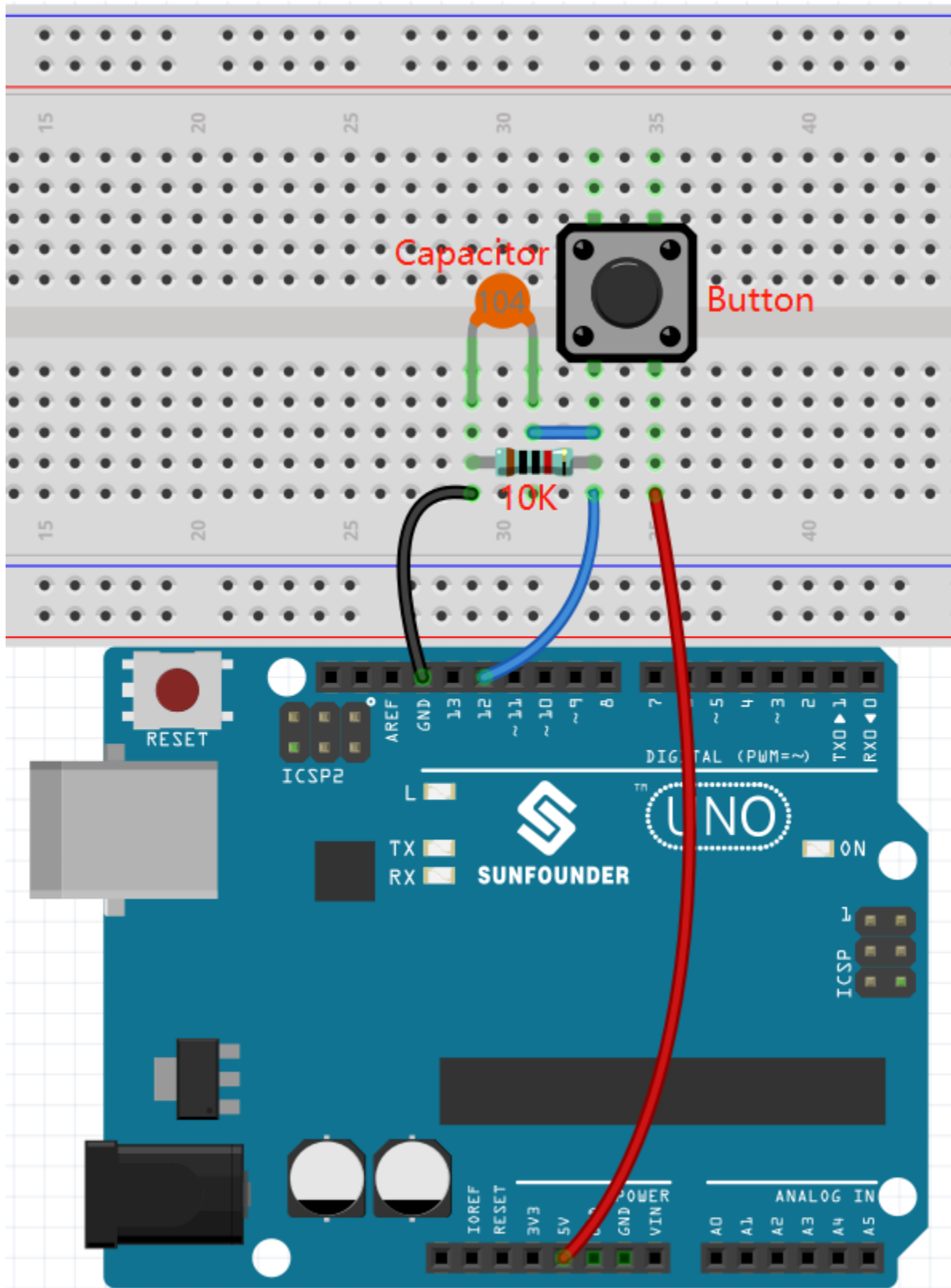


Internal Structure

Build the circuit according to the following diagram.

- Connect one of the pins on the left side of the button to pin 12, which is connected to a pull-down resistor and a 0.1 $\mu$ F (104) capacitor (to eliminate jitter and output a stable level when the button is working).
- Connect the other end of the resistor and capacitor to GND, and one of the pins on the right side of the button to 5V.

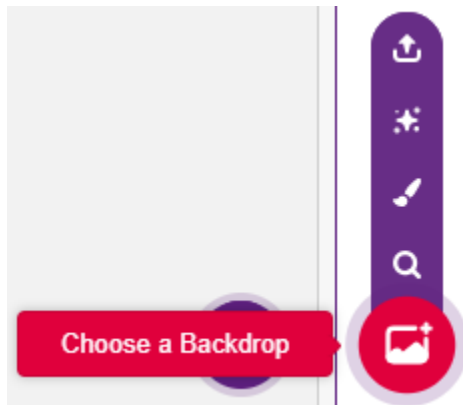




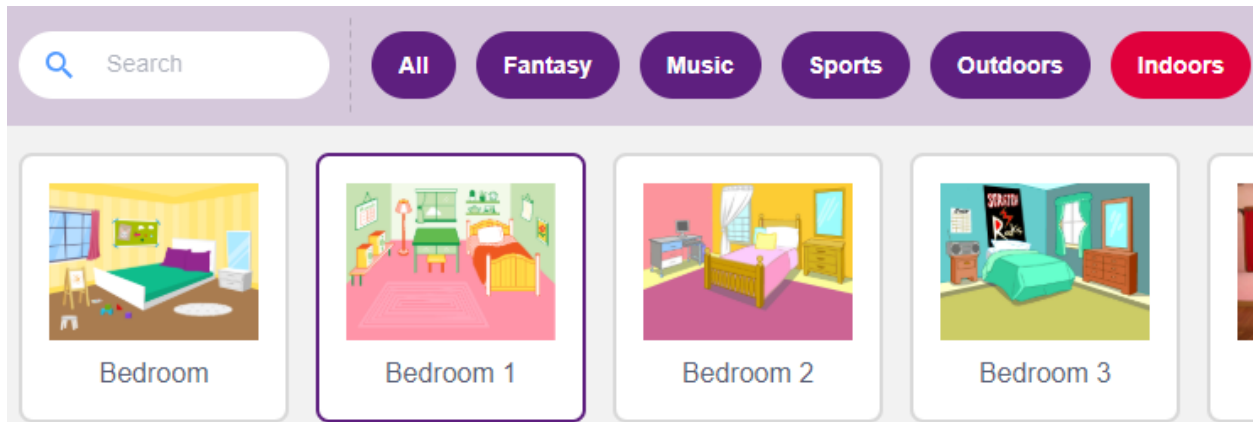
## 7.9.4 Programming

### 1. Add a Backdrop

Click the **Choose a Backdrop** button in the lower right corner.

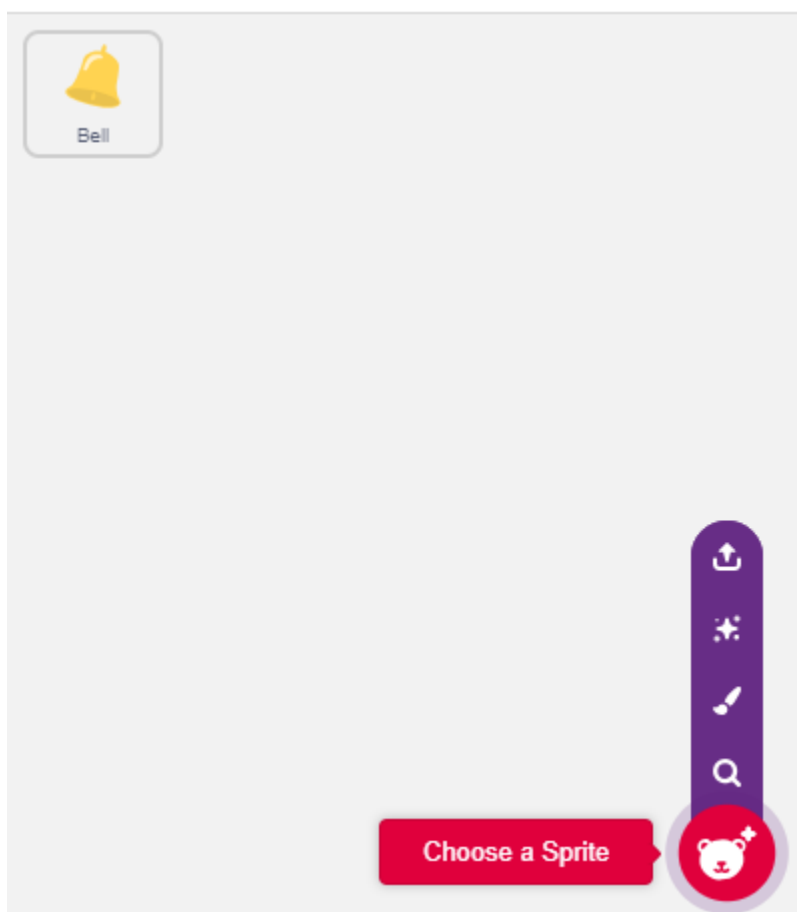


Choose **Bedroom 1**.

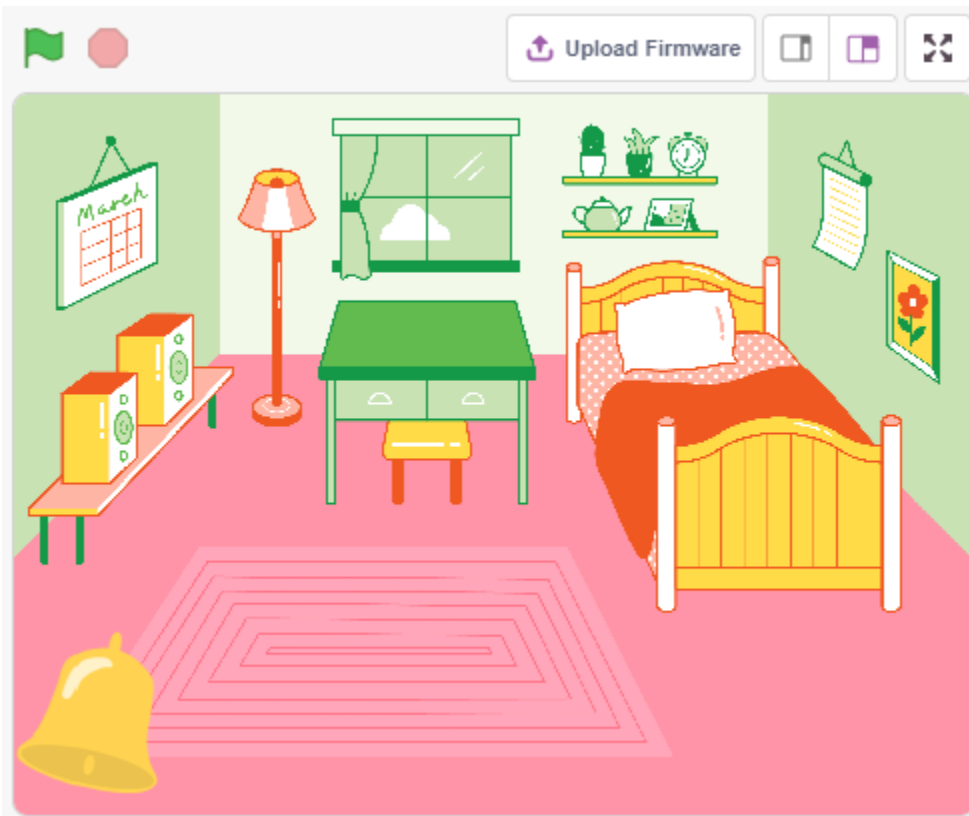


### 2. Select the sprite

Delete the default sprite, click the **Choose a Sprite** button in the lower right corner of the sprite area, enter **bell** in the search box, and then click to add it.



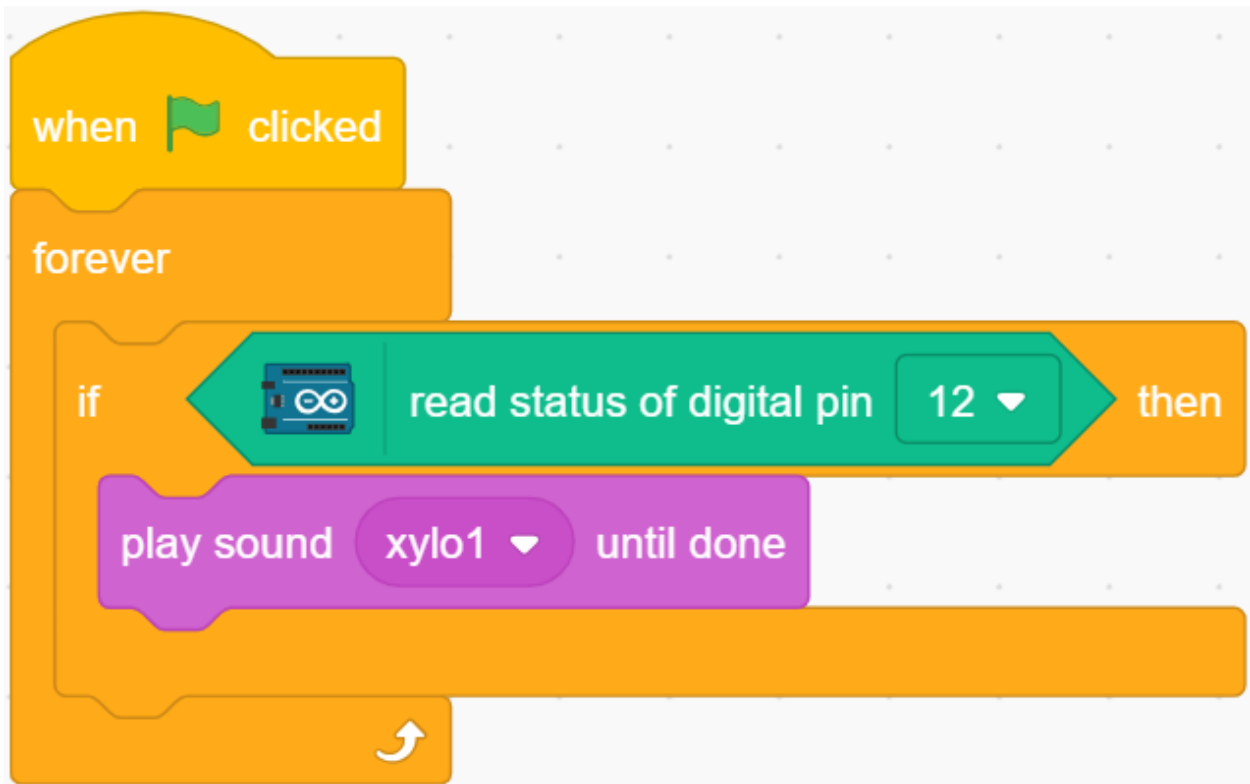
Then select the **bell** sprite on the stage and move it to the right position.



### 3. Press the button and the bell makes a sound

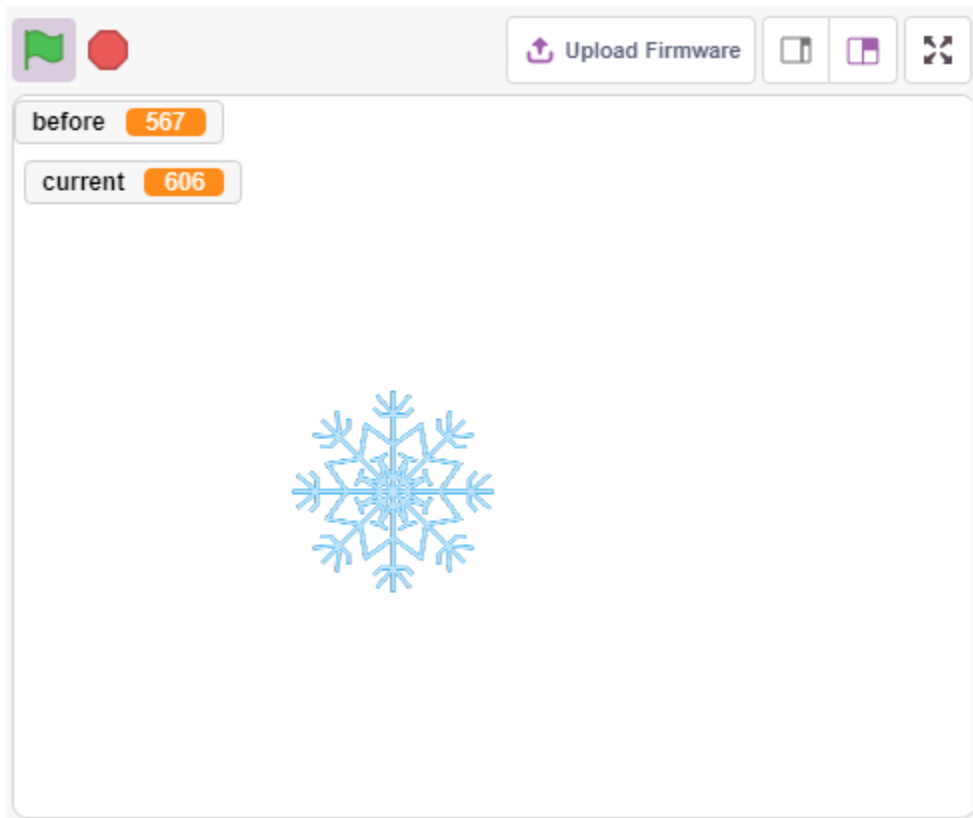
Use [if then] to make a conditional statement that when the value of the pin12 read is equal to 1 (the key is pressed), the sound **xylo1** will be played.

- [read status of digital pin]: This block is from the **Arduino Uno** palette and used to read the value of a digital pin, the result is 0 or 1.
- [if then]: This block is a control block and from **Control** palette. If its boolean condition is true, the blocks held inside it will run, and then the script involved will continue. If the condition is false, the scripts inside the block will be ignored. The condition is only checked once; if the condition turns to false while the script inside the block is running, it will keep running until it has finished.
- [play sound until done]: from the Sound palette, used to play specific sounds.



## 7.10 2.7 Low Temperature Alarm

In this project, we will make a low temperature alarm system, when the temperature is below the threshold, the **Snowflake** sprite will appear on the stage.



### 7.10.1 You Will Learn

- Thermistor working principle
- Multivariable and Subtractive Operations

### 7.10.2 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Thermistor</i>	

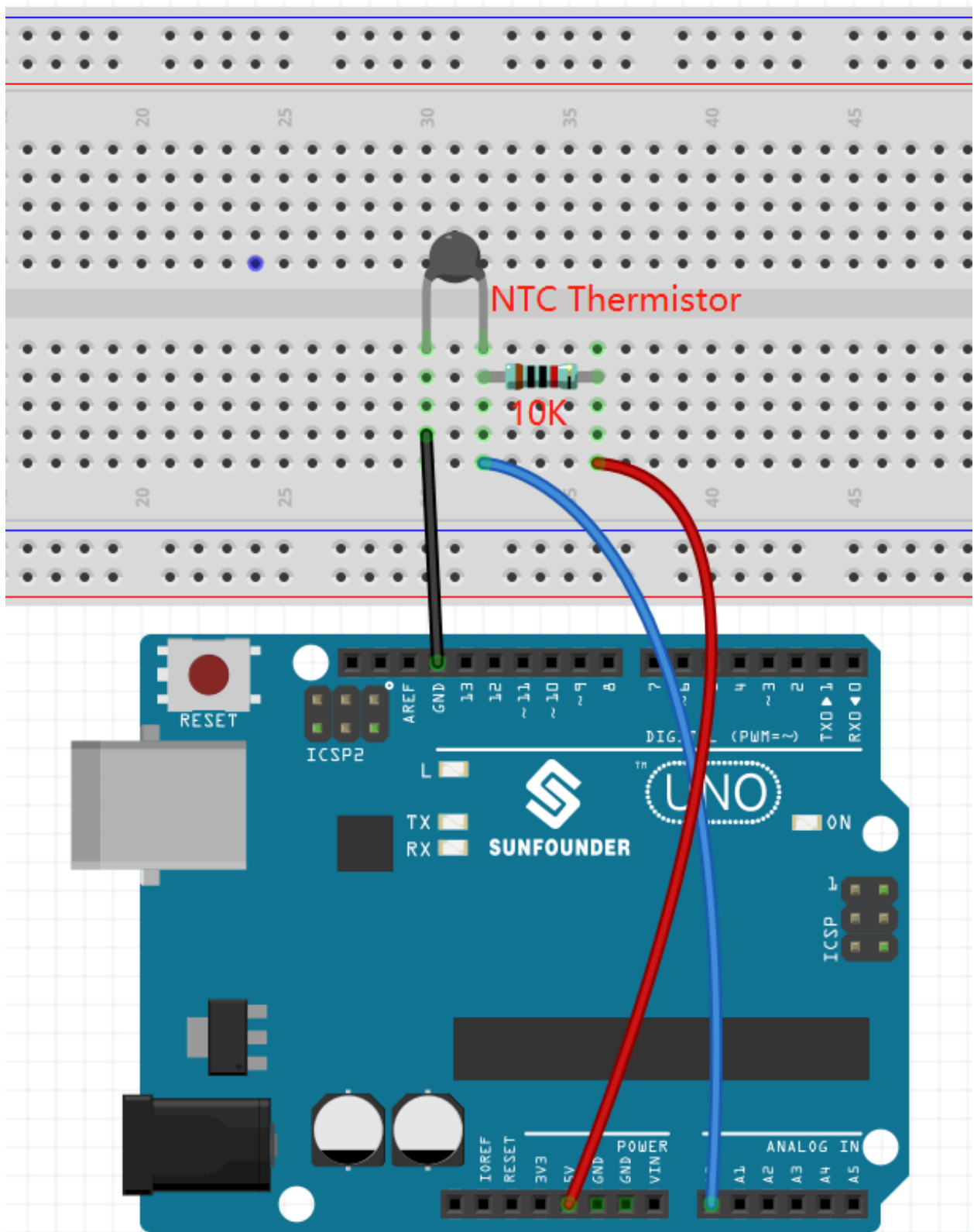
### 7.10.3 Build the Circuit

A thermistor is a type of resistor whose resistance is strongly dependent on temperature, more so than in standard resistors, and there are two types of resistors, PTC (resistance increases as temperature increases) and PTC (resistance decreases as temperature increases).

Build the circuit according to the following diagram.

One end of the thermistor is connected to GND, the other end is connected to A0, and a 10K resistor is connected in series to 5V.

The NTC thermistor is used here, so when the temperature rises, the resistance of the thermistor decreases, the voltage division of A0 decreases, and the value obtained from A0 decreases, and vice versa increases.

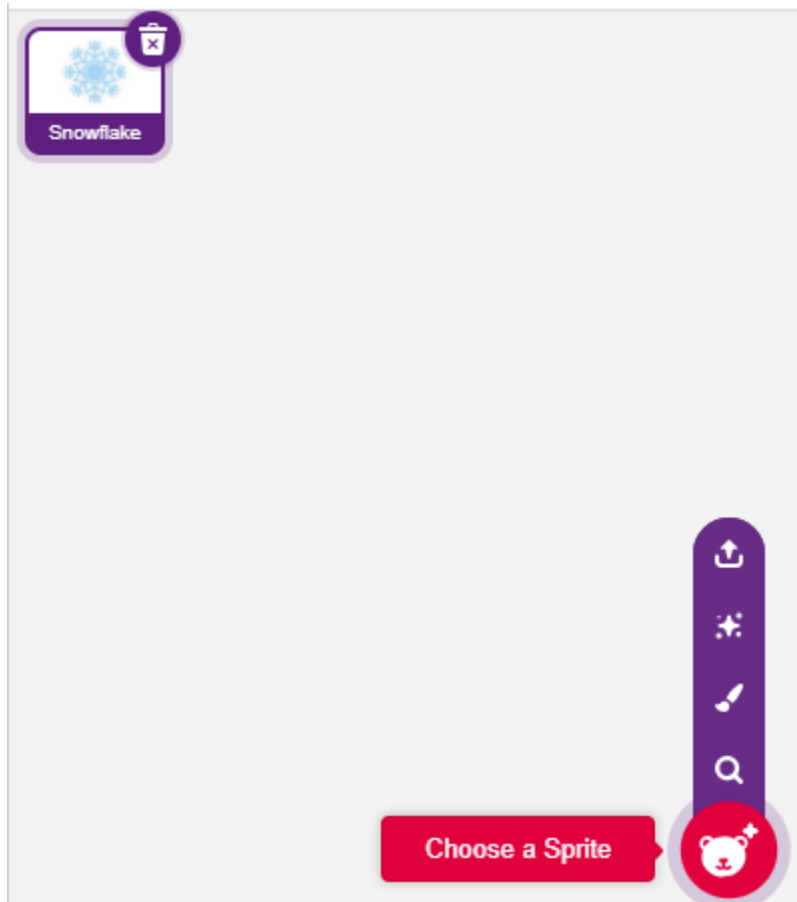




## 7.10.4 Programming

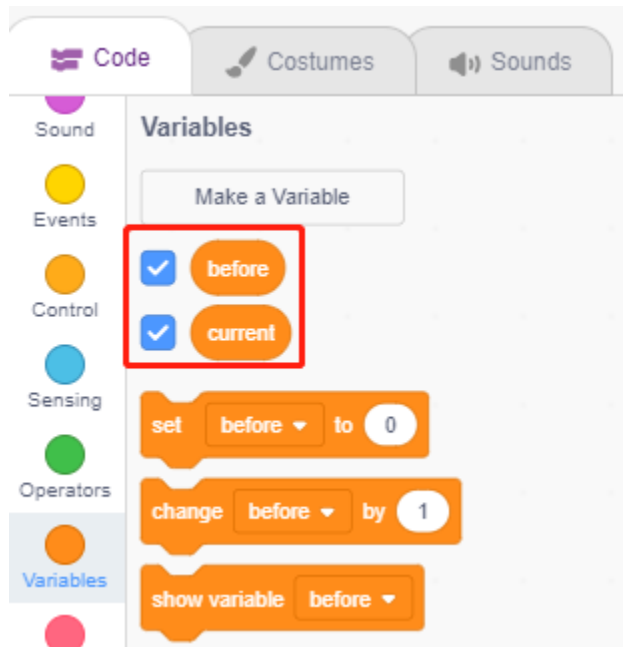
### 1. Select a sprite

Delete the default sprite, click the **Choose a Sprite** button in the lower right corner of the sprite area, enter **Snowflake** in the search box, and then click to add it.



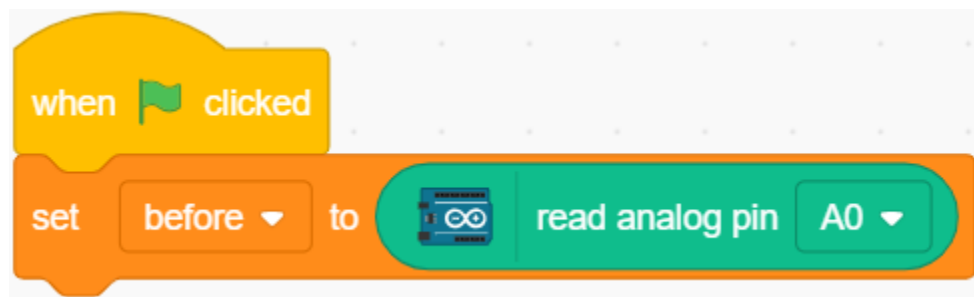
### 2. Create 2 variables

Create two variables, **before** and **current**, to store the value of A0 in different cases.



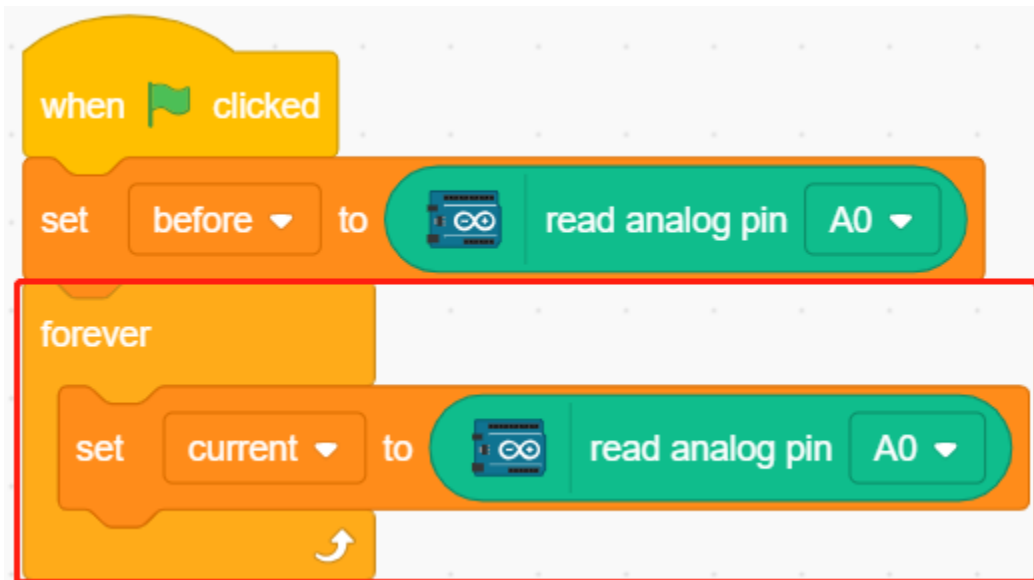
### 3. Read the value of A0

When the green flag is clicked, the value of A0 is read and stored in the variable **before**.



### 4. Read the value of A0 again

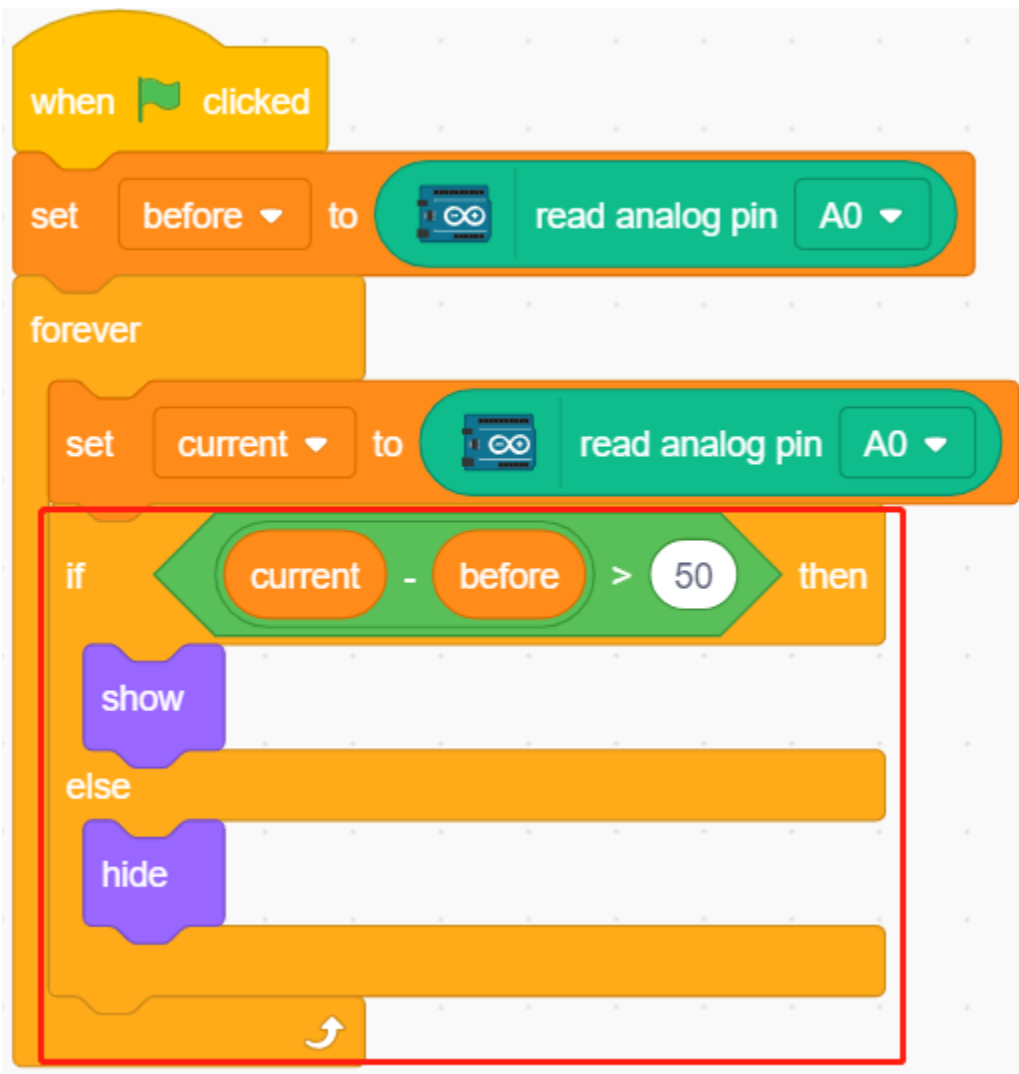
In [forever], read the value of A0 again and store it in the variable **current**.



### 5. Determining temperature changes

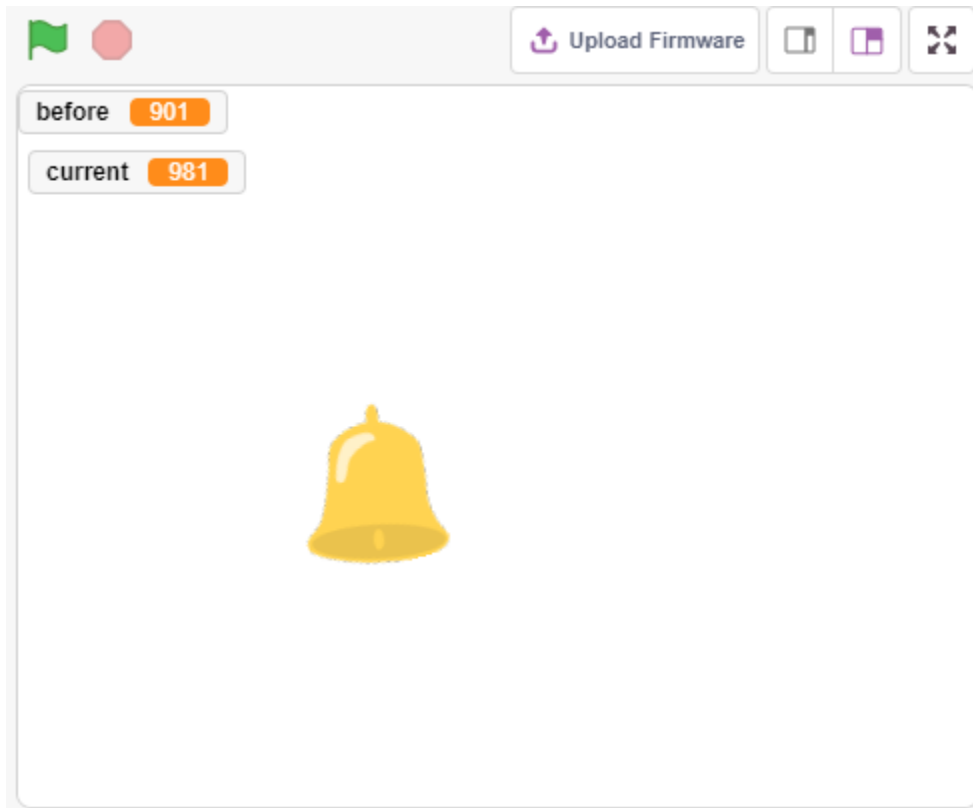
Using the [if else] block, determine if the current value of A0 is 50 greater than before, which represents a decrease in temperature. At this point let **Snowflake** sprite show, otherwise hide.

- [-] & [>]: subtraction and comparison operators from **Operators** palette.



## 7.11 2.8 Light Alarm Clock

In life, there are various kinds of time alarm clocks. Now let's make a light-controlled alarm clock. When morning comes, the brightness of light increases and this light-controlled alarm clock will remind you that it's time to get up.



### 7.11.1 You Will Learn

- Photoresistor working principle
- Stopping sound playback and stopping scripts from running

### 7.11.2 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Photoresistor</i>	

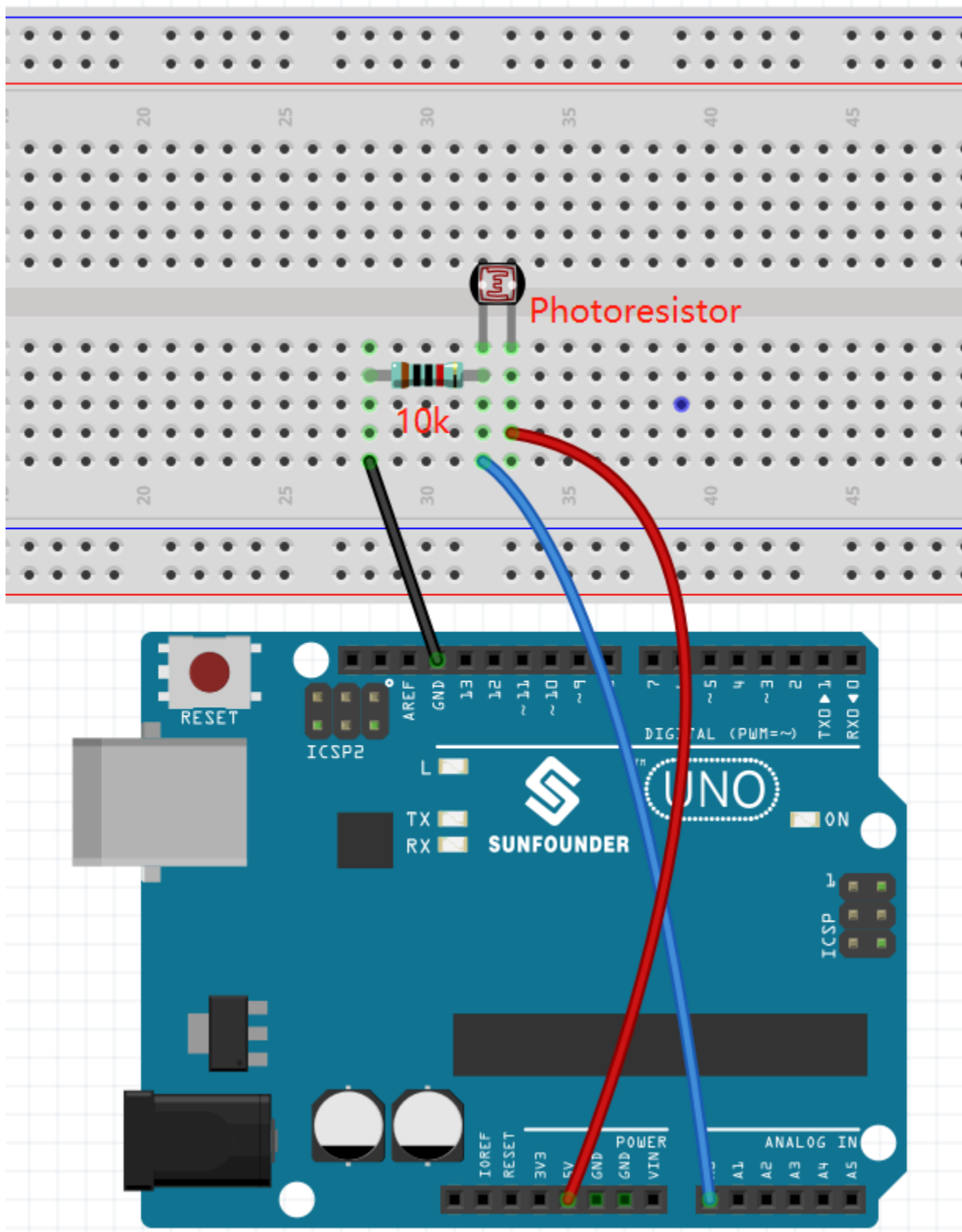
### 7.11.3 Build the Circuit

A photoresistor or photocell is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity.

Build the circuit according to the following diagram.

Connect one end of the photoresistor to 5V, the other end to A0, and connect a 10K resistor in series with GND at this end.

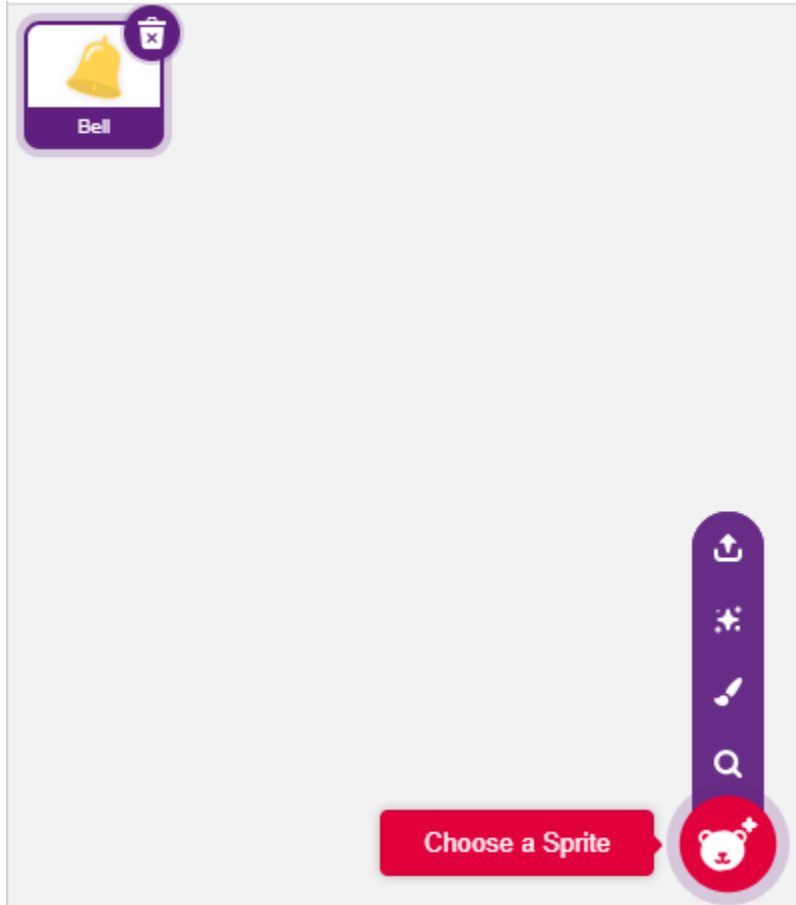
So when the light intensity increases, the resistance of a photoresistor decreases, the voltage division of the 10K resistor increases, and the value obtained by A0 becomes larger.



### 7.11.4 Programming

#### 1. Select a sprite

Delete the default sprite, click the **Choose a Sprite** button in the lower right corner of the sprite area, enter **bell** in the search box, and then click to add it.



#### 2. Read the value of A0

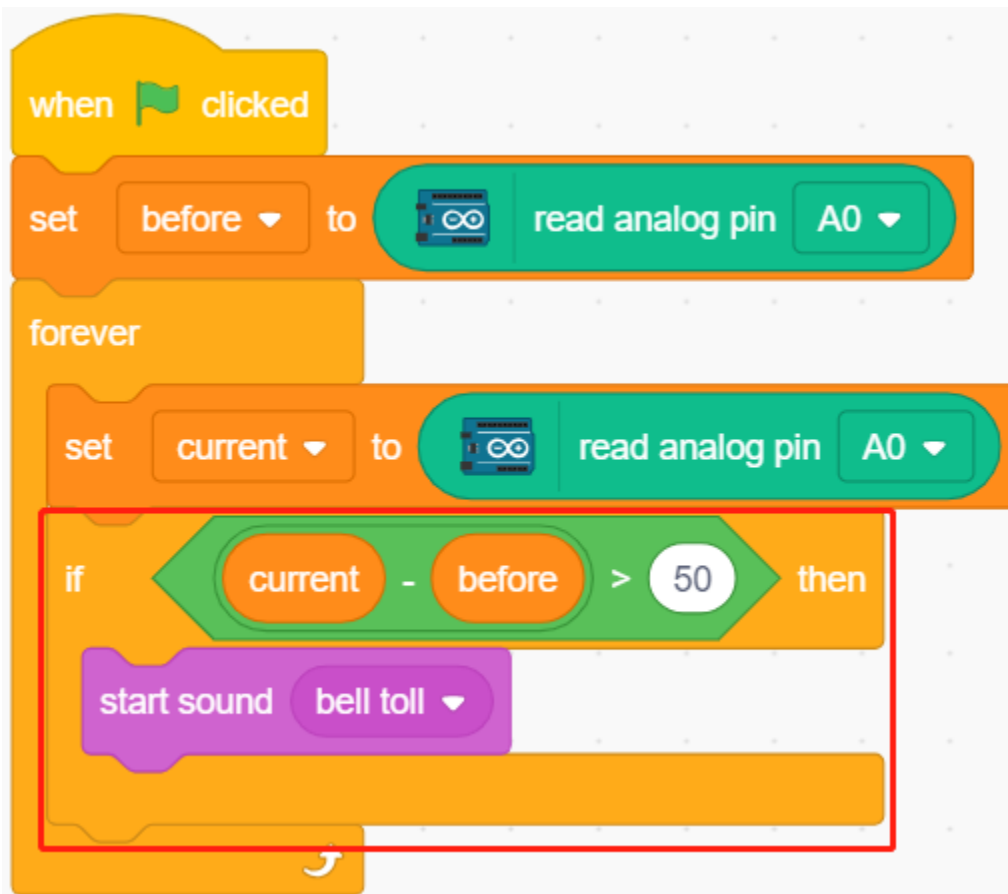
Create two variables **before** and **current**. When green flag is clicked, read the value of A0 and store it in variable **before** as a reference value. In [forever], read the value of A0 again, store it in the variable **current**.





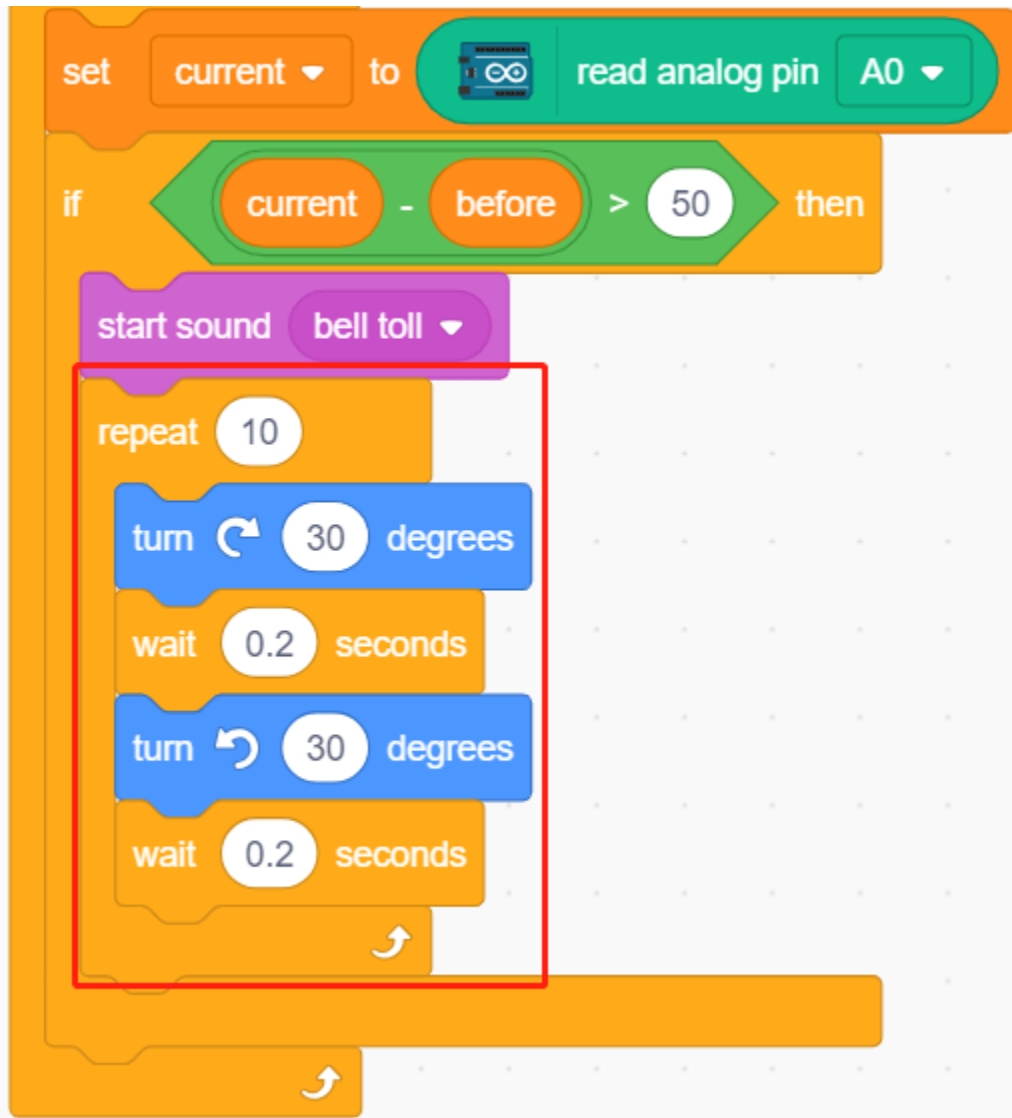
### 3. Make a sound

When the value of current A0 is greater than the previous 50, which represents the current light intensity is greater than the threshold, then let the sprite make a sound.



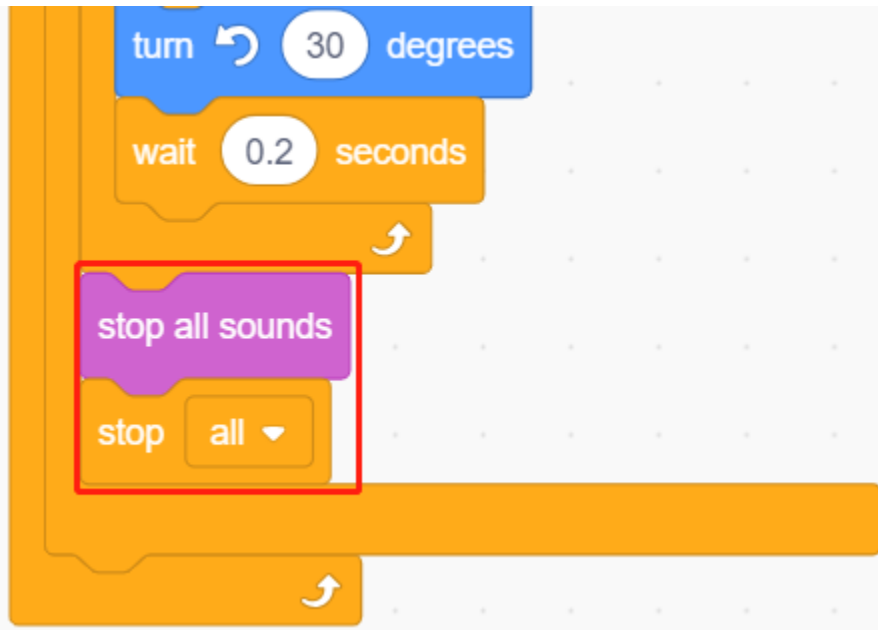
### 4. Turning the sprite

Use [turn block] to make the **bell** sprite turn left and right to achieve the alarm effect.



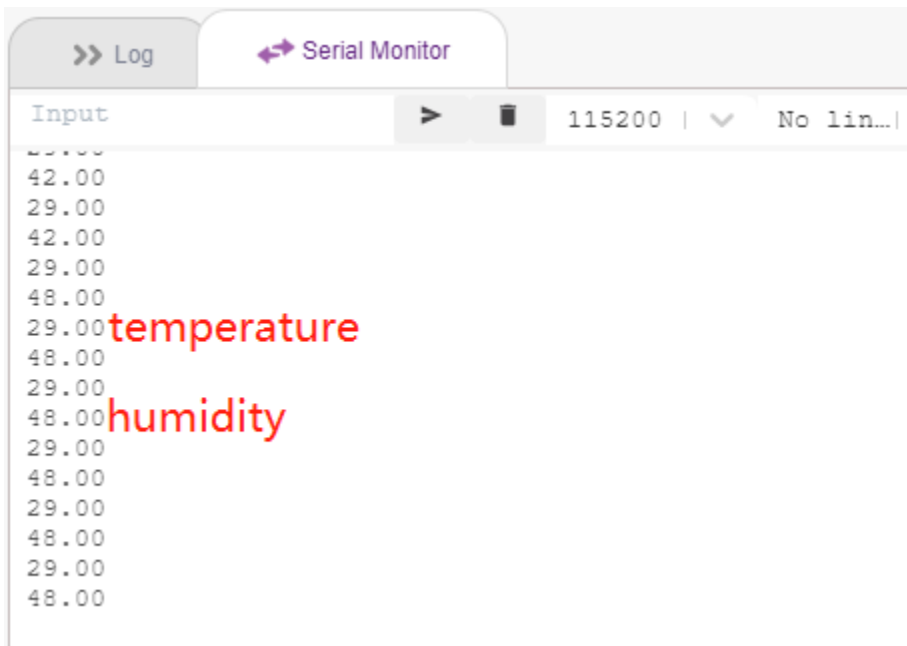
##### 5. stop all

Stops the alarm when it has been ringing for a while.



## 7.12 2.9 Read Temperature and Humidity

Previous projects have been using stage mode, but some functions are only available in upload mode, such as serial communication function. In this project, we will print the temperature and humidity of the DHT11 using the Serial Monitor in *Upload Mode*.



### 7.12.1 You Will Learn

- Get the temperature and humidity from the DHT11 module
- Serial Monitor for *Upload Mode*
- Add extension

### 7.12.2 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

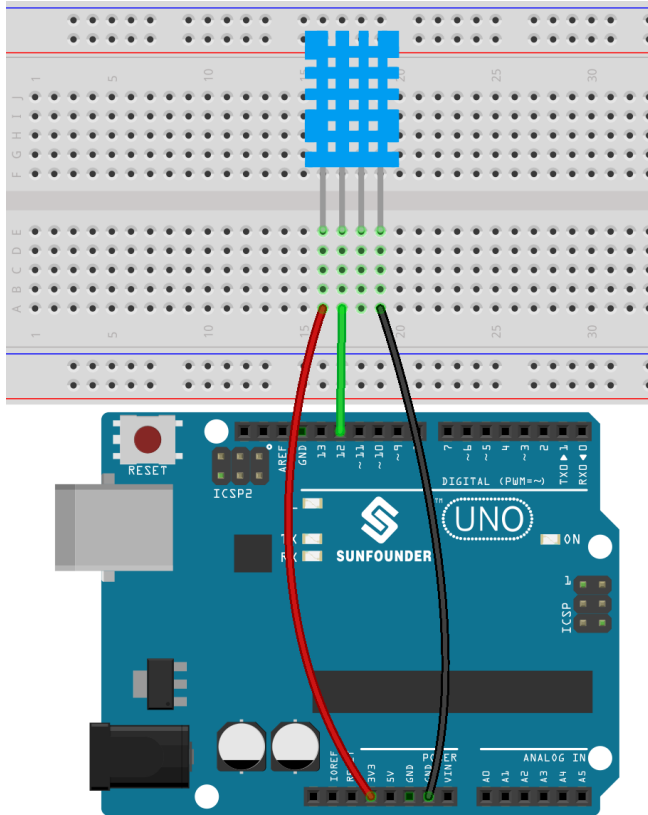
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>DHT11 Humiture Sensor</i>	-

### 7.12.3 Build the Circuit

The digital temperature and humidity sensor DHT11 is a composite sensor that contains a calibrated digital signal output of temperature and humidity.

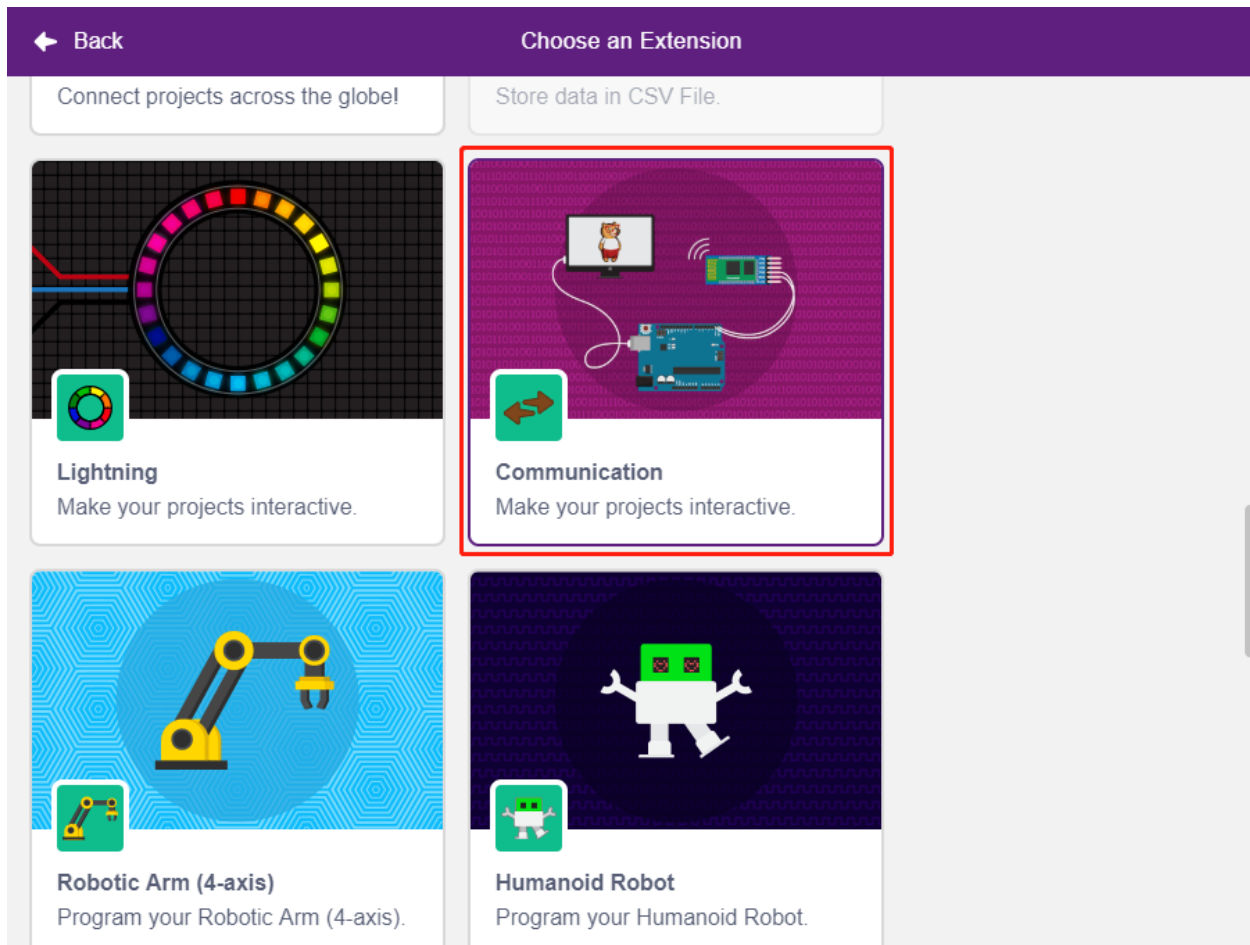
Now build the circuit according to the following diagram.



## 7.12.4 Programming

### 1. Adding Extensions

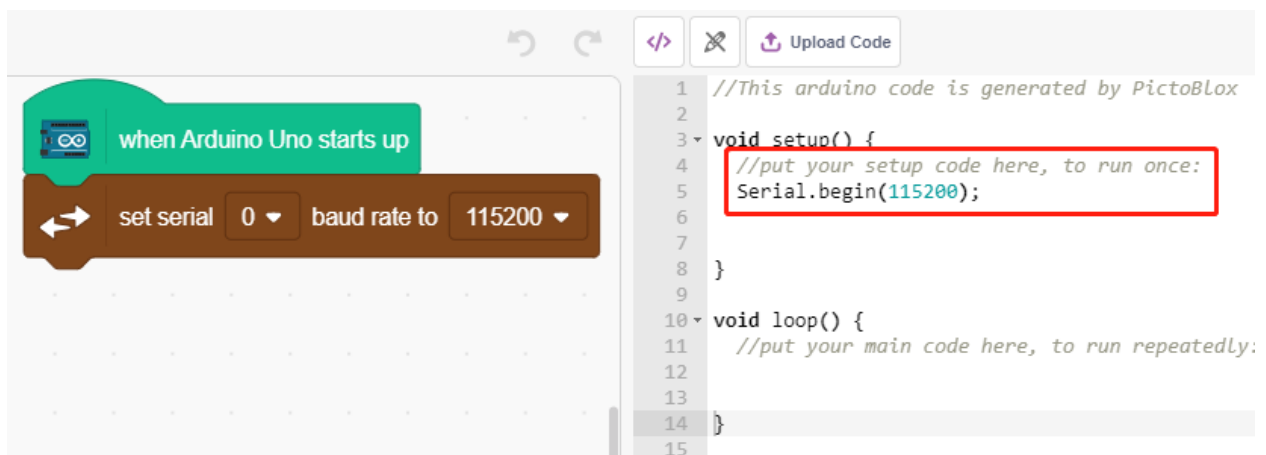
Switch to **Upload** mode, click the **Add Extension** button in the bottom left corner, then select **Communication** to add it, and it will appear at the end of the palette area.



## 2. Initializing the Arduino Uno and Serial Monitor

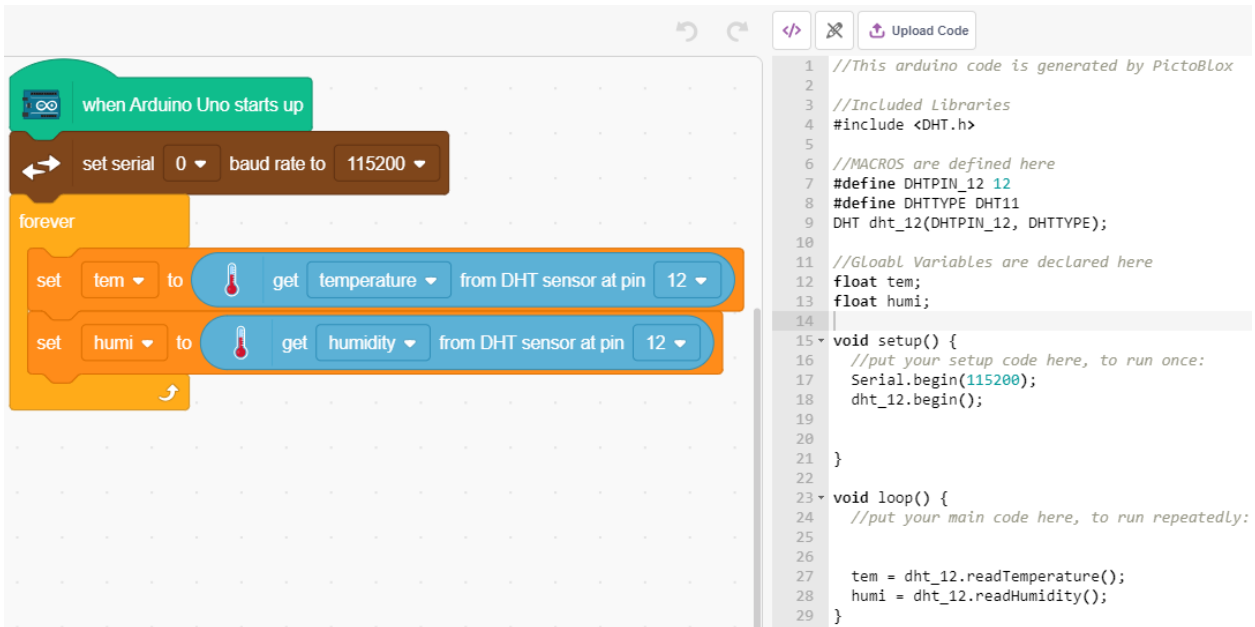
In **Upload** mode, start Arduino Uno and then set the serial port baud rate.

- [when Arduino Starts up]: In **Upload** mode, start Arduino Uno.
- [set serial baud rate to]: From the **Communications** palette, used to set the baud rate of serial port 0, default is 115200. If you are using Mega2560, then you can choose to set baud rate in serial port 0~3.



## 3. Read temperature and humidity

Create 2 variables **tem** and **humi** to store the temperature and humidity respectively, the code will appear on the right side while you drag and drop the block.



```

1 //This arduino code is generated by PictoBlox
2
3 //Included Libraries
4 #include <DHT.h>
5
6 //MACROS are defined here
7 #define DHTPIN_12 12
8 #define DHTTYPE DHT11
9 DHT dht_12(DHTPIN_12, DHTTYPE);
10
11 //Global Variables are declared here
12 float tem;
13 float humi;
14
15 void setup() {
16   //put your setup code here, to run once:
17   Serial.begin(115200);
18   dht_12.begin();
19 }
20
21
22
23 void loop() {
24   //put your main code here, to run repeatedly:
25
26
27   tem = dht_12.readTemperature();
28   humi = dht_12.readHumidity();
29 }

```

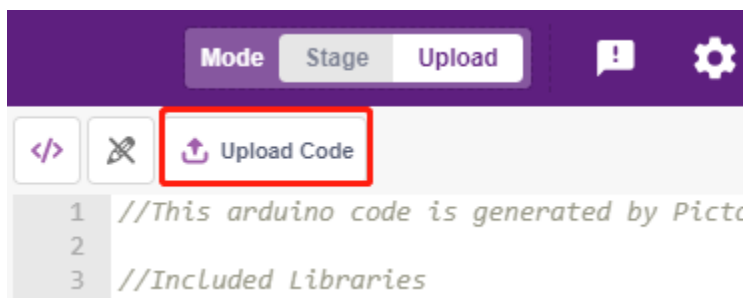
#### 4. Print them on the Serial Monitor

Write the read temperature and humidity to the Serial Monitor. To avoid transferring too fast and causing PictoBlox to jam, use the [wait seconds] block, to add some time interval for the next print.



### 5. Uploading code

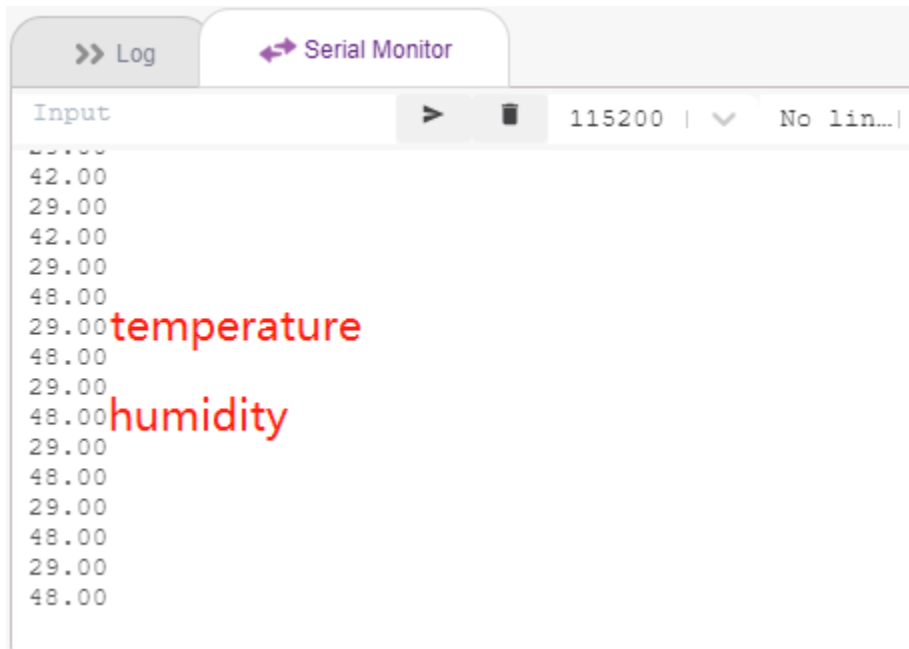
Unlike the **Stage** mode, the code in **Upload** mode needs to be uploaded to the Arduino board using the **Upload Code** button to see the effect. This also allows you to unplug the USB cable and still have the program running.



### 6. Turn on the serial monitor

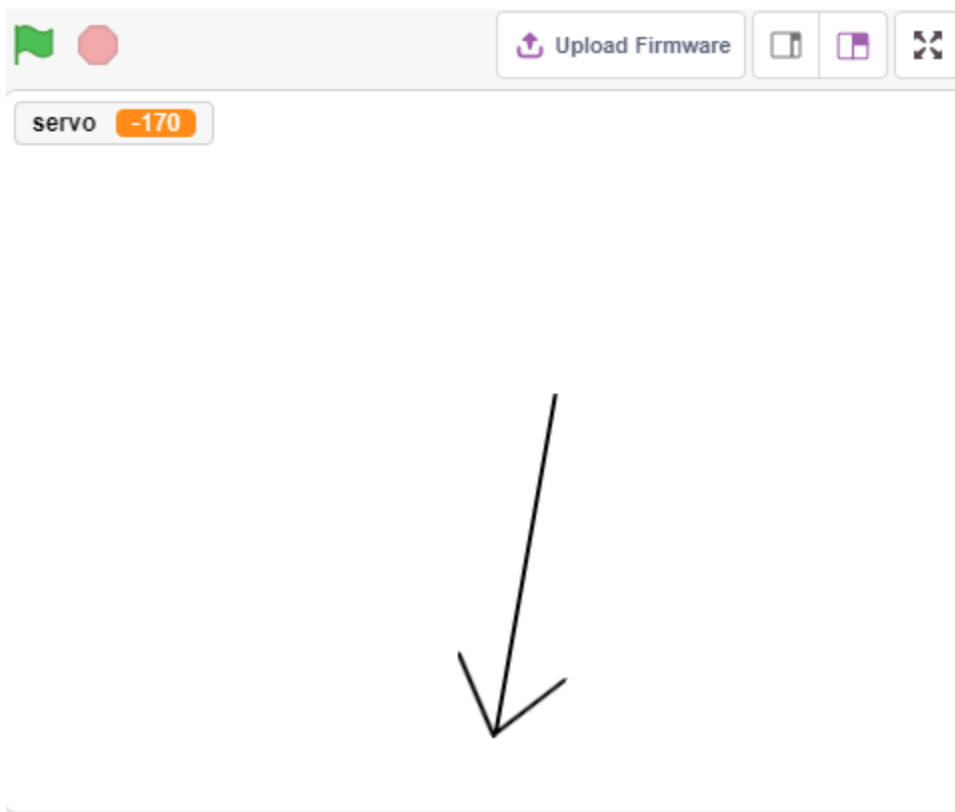
Now open the **Serial Monitor** to see the temperature and humidity.





## 7.13 2.10 Pendulum

In this project, we will make an arrow pendulum while the servo will follow the rotation.



### 7.13.1 You Will Learn

- How the servo works and the angle range
- Draw a sprite and put the center point on the tail.

### 7.13.2 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

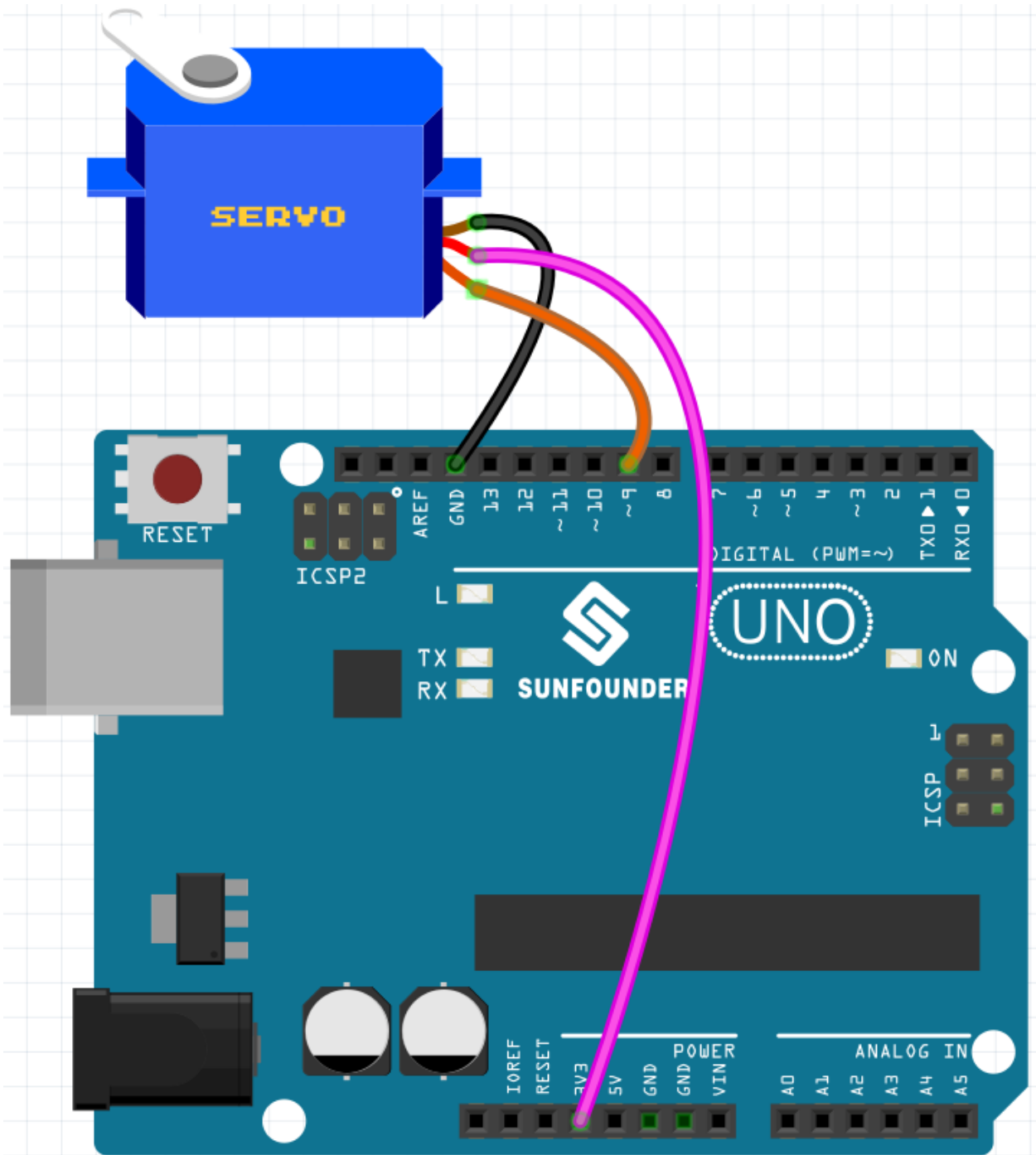
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>Servo</i>	

### 7.13.3 Build the Circuit

A servo is a geared motor that can only rotate 180 degrees. It is controlled by sending electrical pulses from your circuit board. These pulses tell the servo what position it should move to.

The servo has three wires: the brown wire is GND, the red one is VCC (connect to 3.3V), and the orange one is the signal wire. The angle range is 0-180.

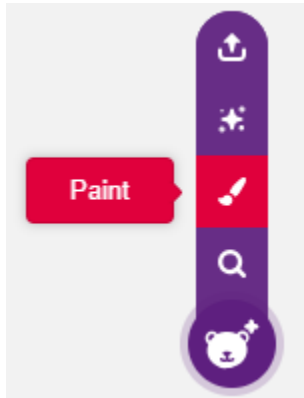
Now build the circuit according to the diagram below.



## 7.13.4 Programming

### 1. Paint a sprite

Delete the default sprite, select the Sprite button and click **Paint**, a blank sprite **Sprite1** will appear.

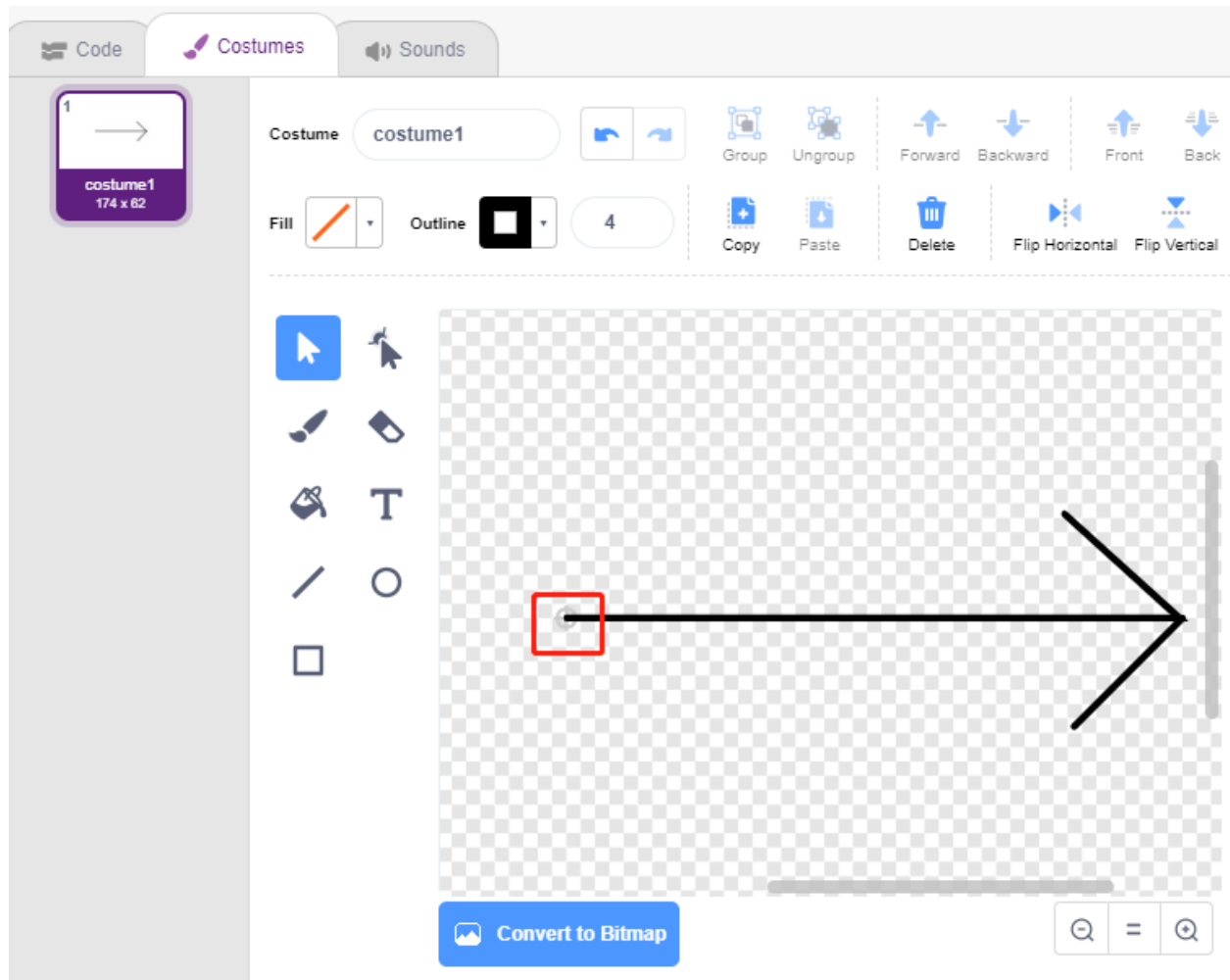


On the open **Costumes** page, use the **Line tool** to draw an arrow.

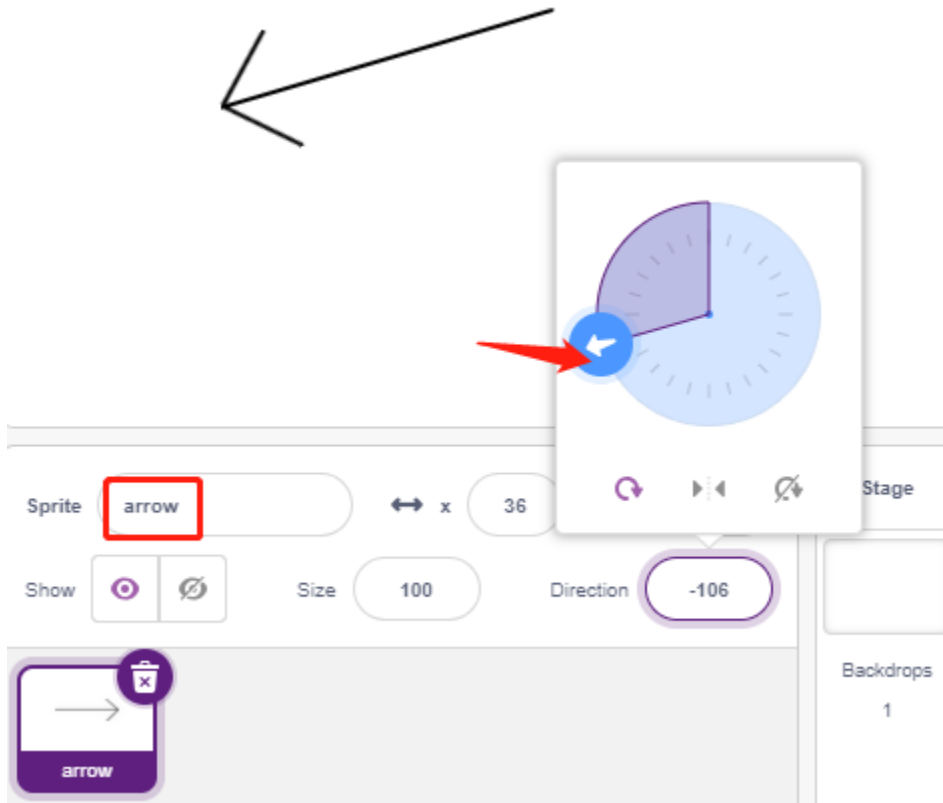
---

#### Note:

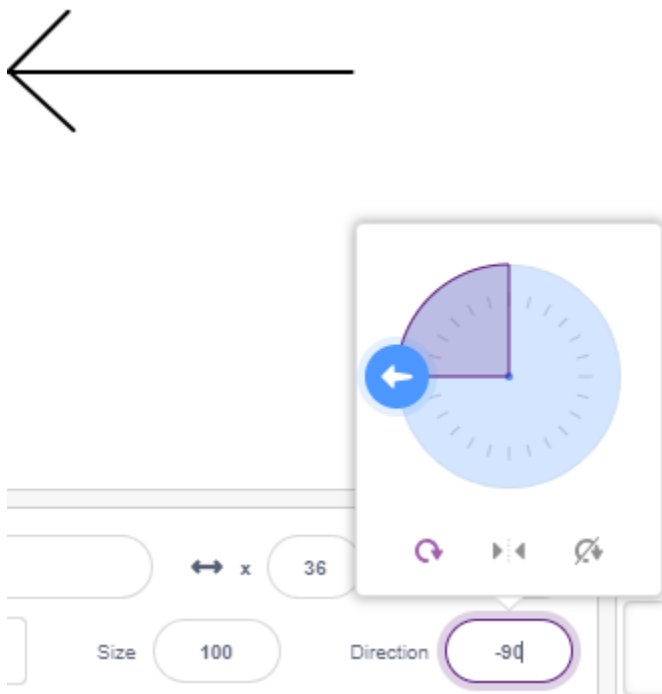
- Be sure to start drawing the arrow from the center of the canvas outward so that the arrow is turning in a circle with the center point as the origin.
  - Hold Shift to make the line angle straight or 45 degrees.
-

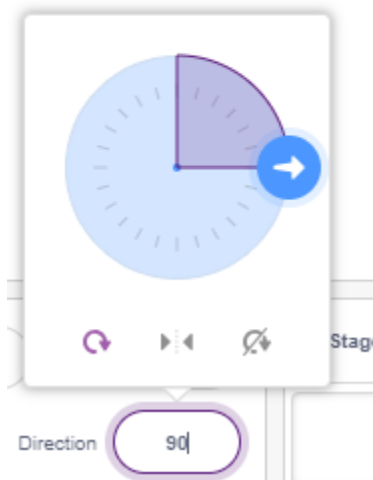
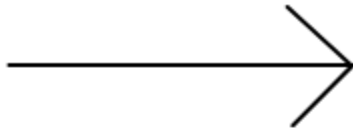


After drawing, the **arrow** sprite will be displayed on the stage, name it **arrow**. Then click on the number after **Direction**, a circular dial will appear, now drag this arrow and see if the **arrow** sprite on the stage turns with the tail as the origin.



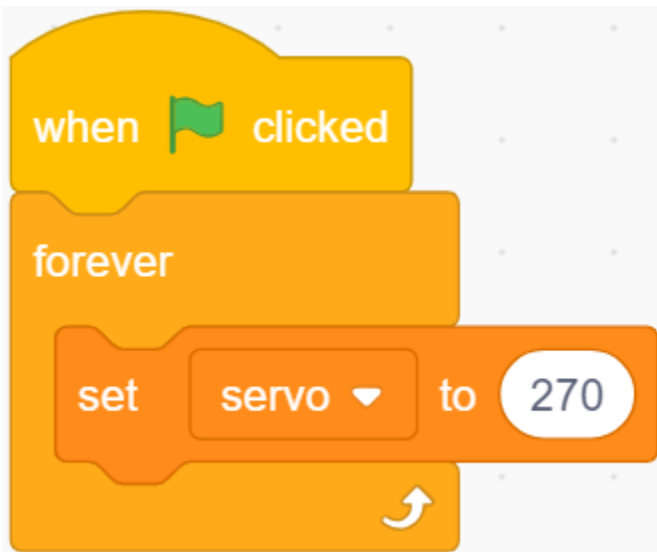
To make the **arrow** sprite swing from the left to the right, the angle range is -90 to -180, 180 to 90.





## 2. Creating a variable.

Create a variable called **servo**, which stores the angle value and sets the initial value to 270.



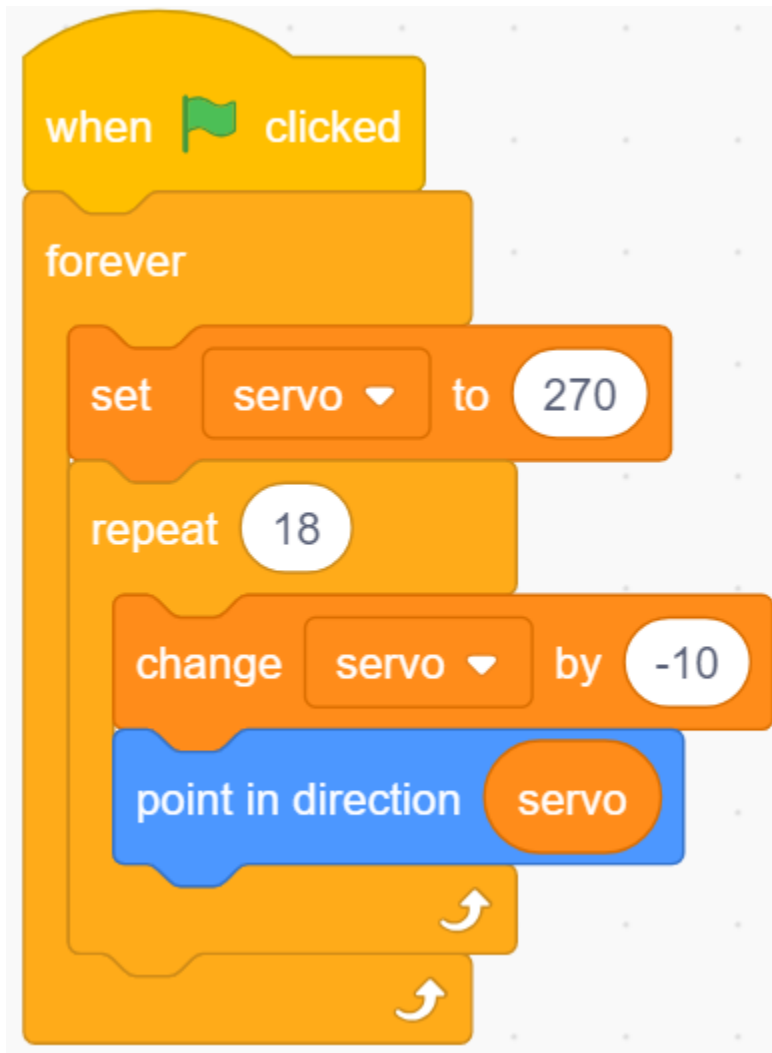
## 3. Swing from the left to the right

Now let the **arrow** sprite swing from the left -90 degree position to the right 90 degree position.

With [repeat] block, add -10 to the variable each time, and you'll get to 90 degrees in 18 passes. Then use [point in block] to make the arrow sprite turn to these angles.

Since the sprite rotation angle is -180 ~ 180, angles outside this range are converted by the following conditions.

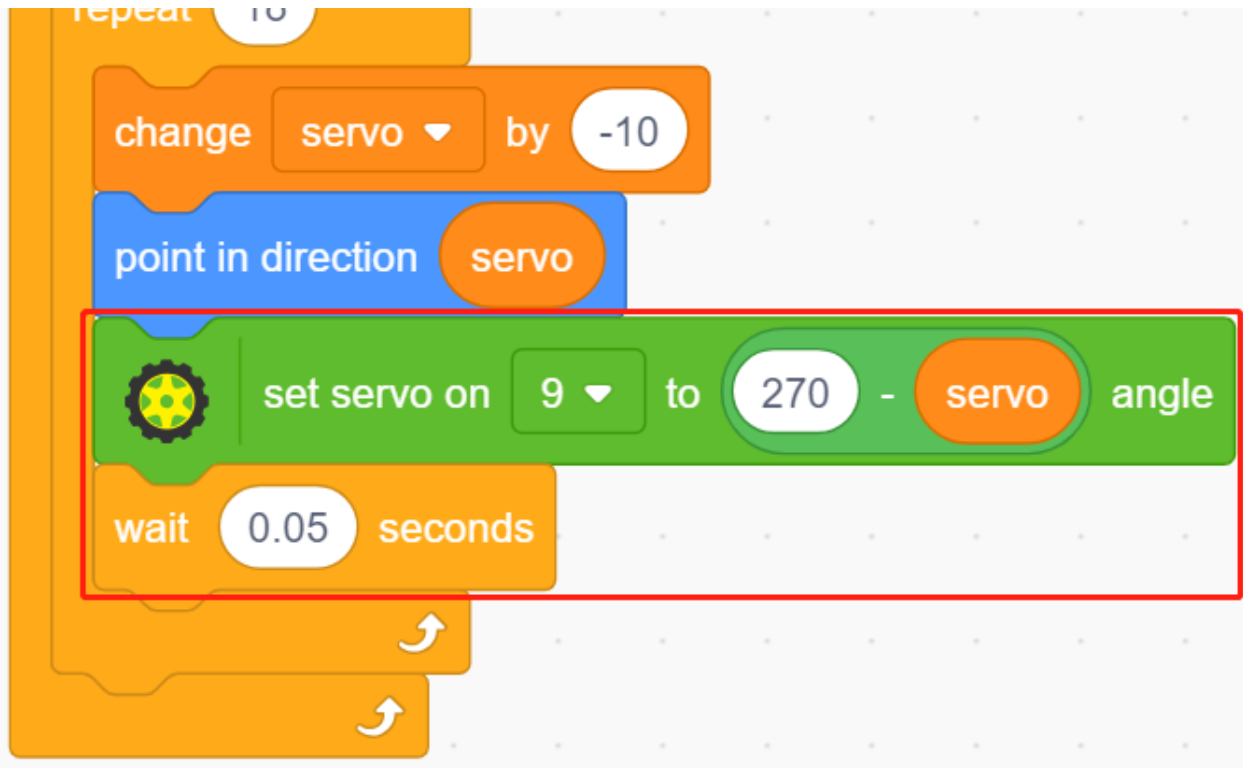
- If angle > 180, then angle -360.



#### 4. Turning the Servo

When you click on the green flag, you will see the arrow quickly turn to the right and then back to the left, so use a [wait seconds] block here to make the rotation slower. Also use the [set servo on to angle] block to make the servo connected to the Arduino board turn to a specific angle.

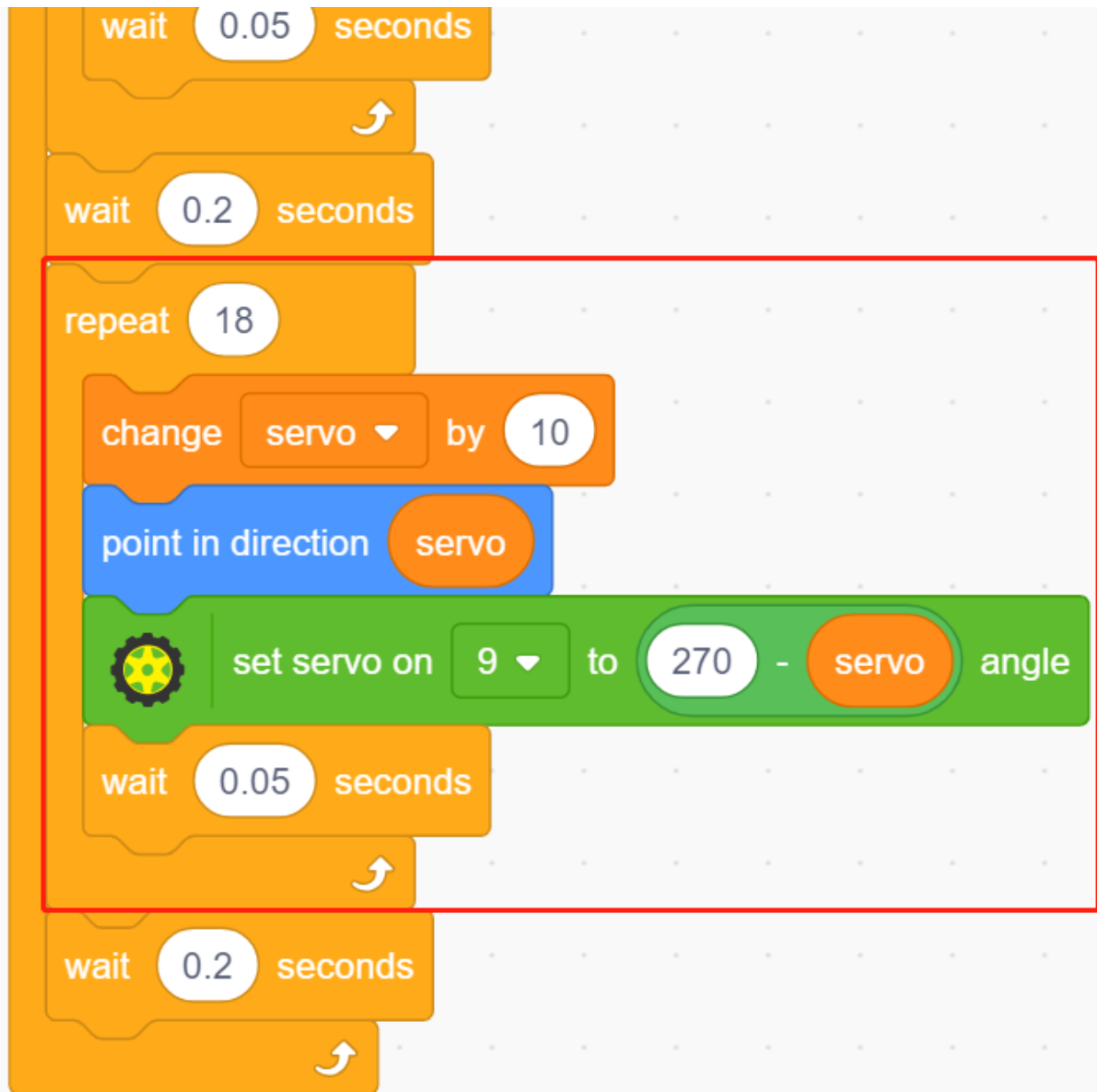




### 5. Swinging from right to left

By the same method, make the servo and **arrow** sprite slowly rotate from the right to the left.

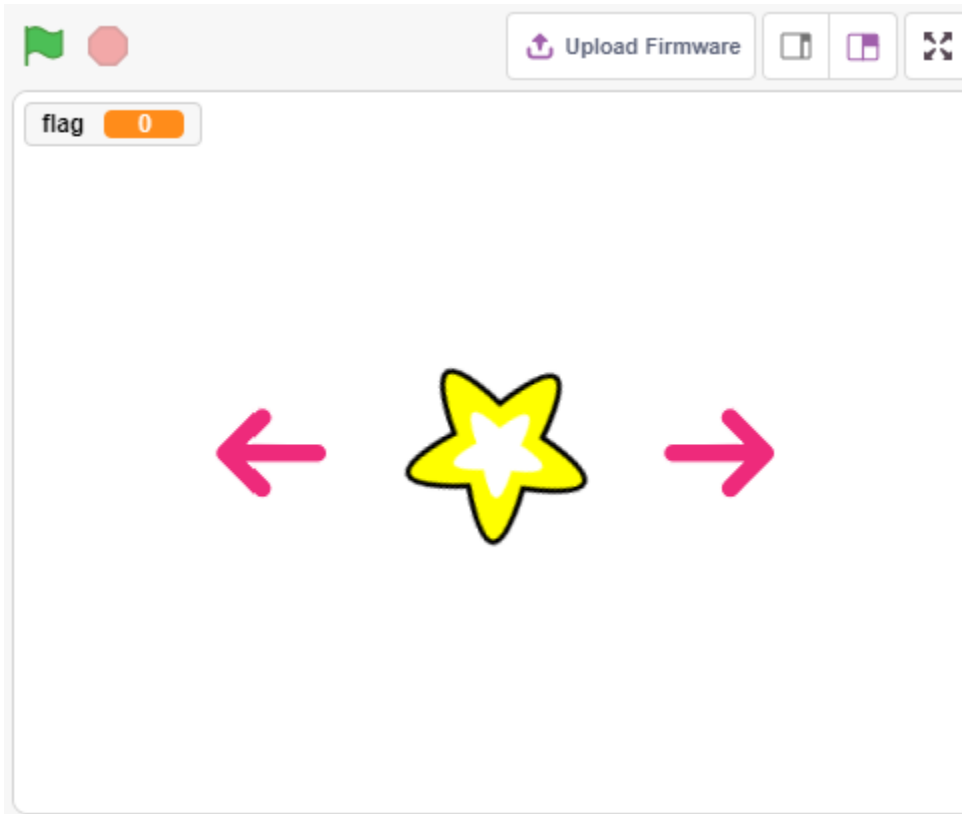
- If angle > 180, then angle -360.



## 7.14 2.11 Rotating Fan

In this project, we will make a spinning star sprite and fan.

Clicking on the left and right arrow sprites on the stage will control the clockwise and counterclockwise rotation of the motor and star sprite, click on the star sprite to stop the rotation.



### 7.14.1 You Will Learn

- Motor working principle
- Broadcast function
- Stop other script in sprite block

### 7.14.2 Required Components

In this project, we need the following components.

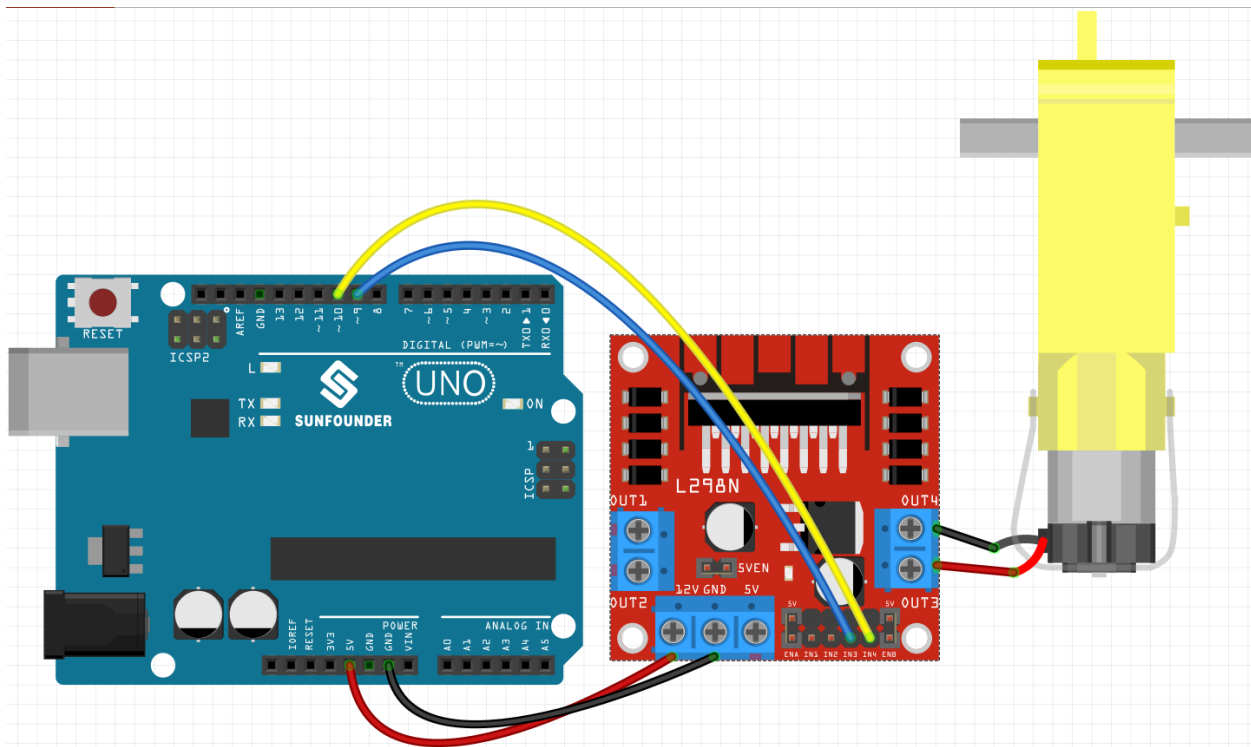
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>TT Motor</i>	-
<i>L298N Module</i>	

### 7.14.3 Build the Circuit

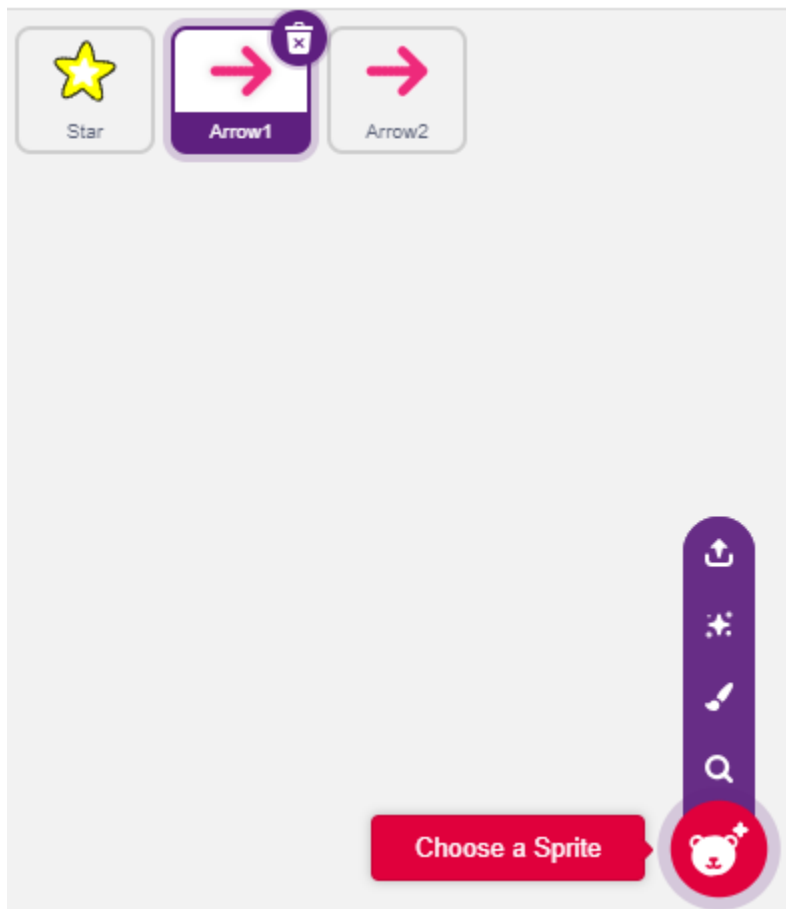


### 7.14.4 Programming

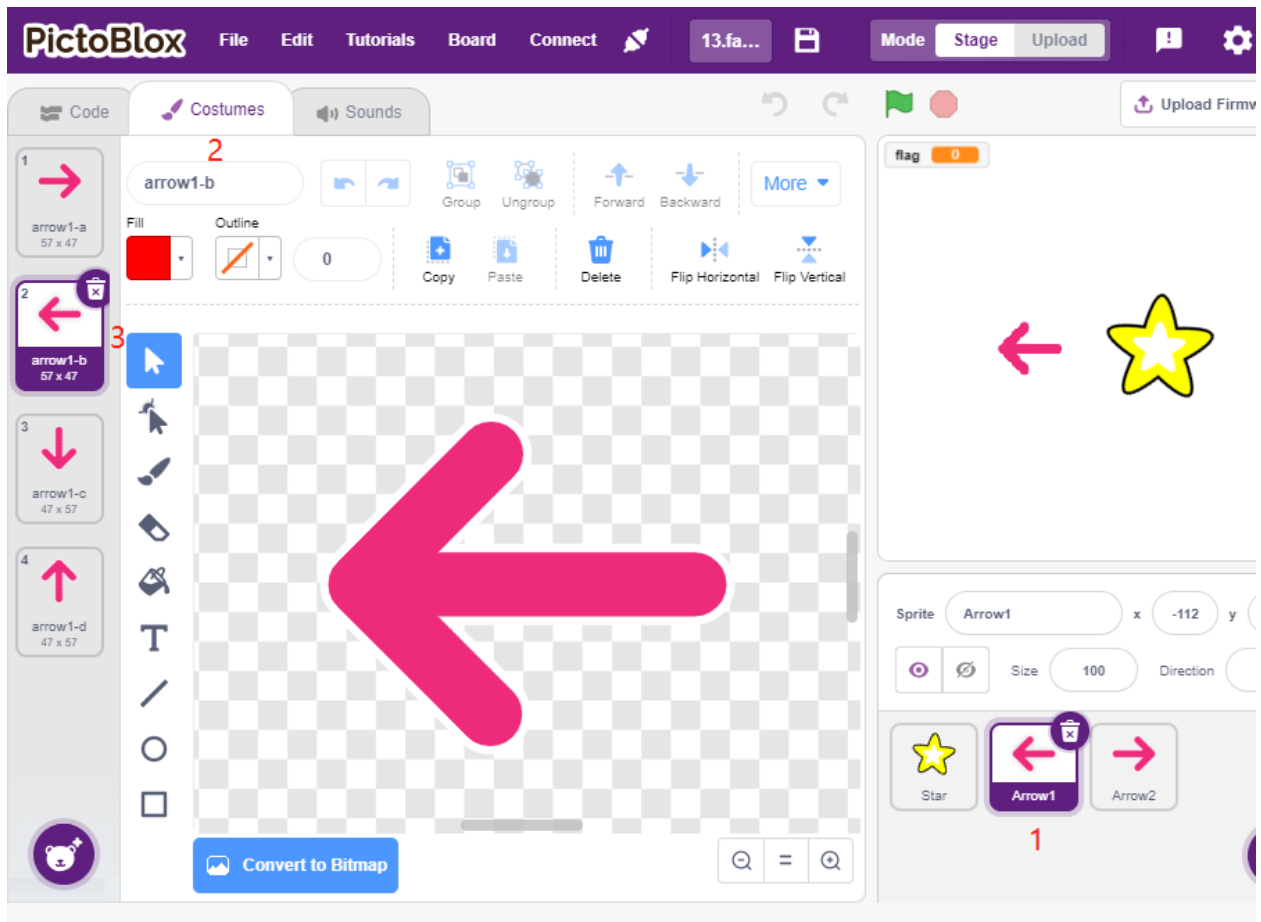
The effect we want to achieve is to use 2 arrow sprites to control the clockwise and counterclockwise rotation of the motor and the star sprite respectively, clicking on the star sprite will stop the motor from rotating.

#### 1. Add sprites

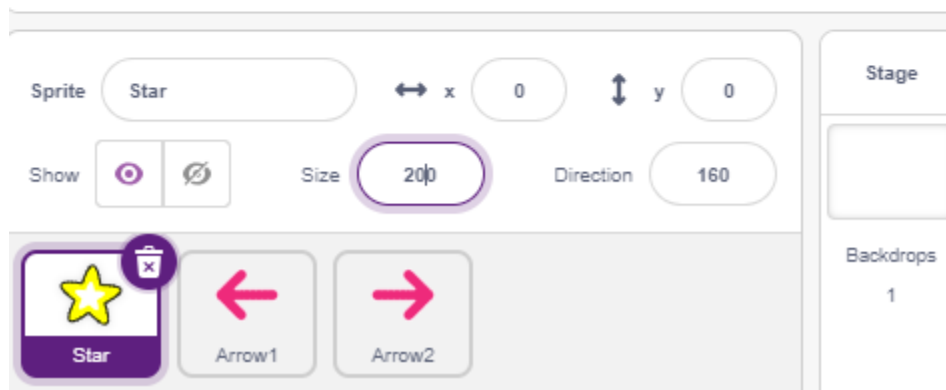
Delete the default sprite, then select the **Star** sprite and the **Arrow1** sprite, and copy **Arrow1** once.



In the **Costumes** option, change the **Arrow1** sprite to a different direction costume.



Adjust the size and position of the sprite appropriately.

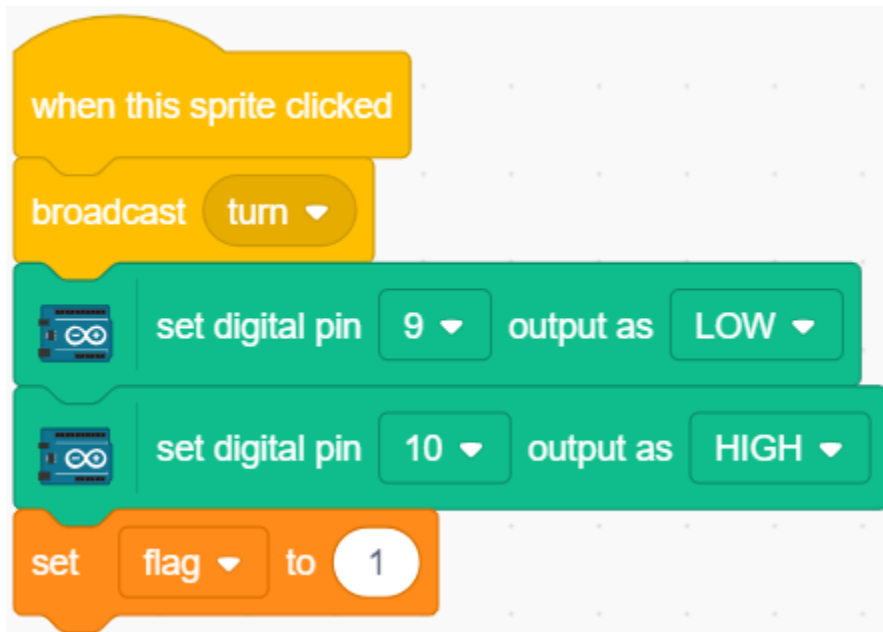


## 2. Left arrow sprite

When this sprite is clicked, it broadcasts a message - turn, then sets digital pin 9 to low and pin 10 to high, and sets the variable **flag** to 1. If you click the left arrow sprite, you will find that the motor turns counterclockwise, if your turn is clockwise, then you swap the positions of pin 9 and pin 10.

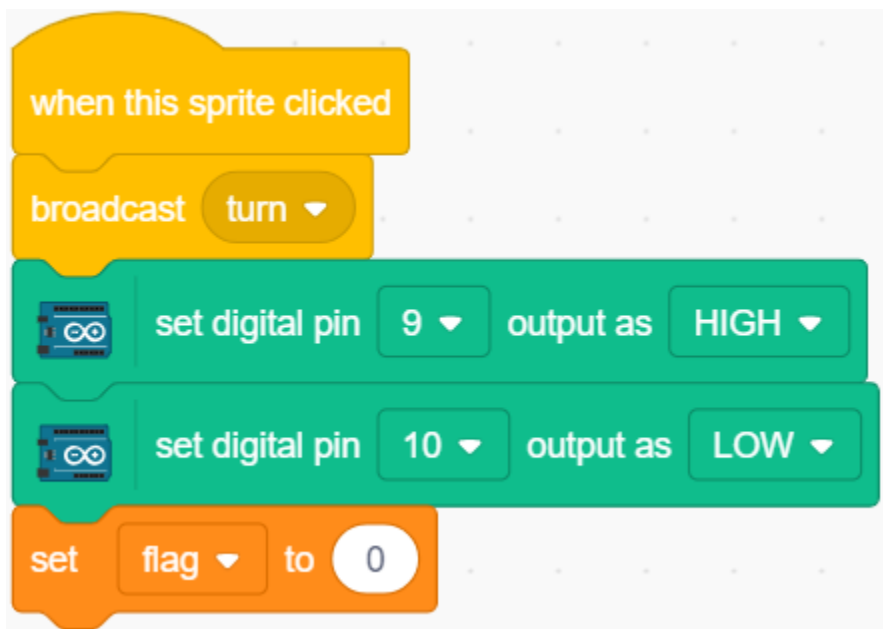
There are 2 points to note here.

- **[broadcast]**: from the **Events** palette, used to broadcast a message to the other sprites, when the other sprites receive this message, it will perform a specific event. For example, here is **turn**, when the **star** sprite receives this message, it executes the rotation script.
- **variable flag**: The direction of rotation of the star sprite is determined by the value of flag. So when you create the **flag** variable, you need to make it apply to all sprites.



### 3. right-arrow sprite

When this sprite is clicked, broadcast a message turn, then set digital pin 9 high and pin 10 low to make the motor turn clockwise and set the **flag** variable to 0.

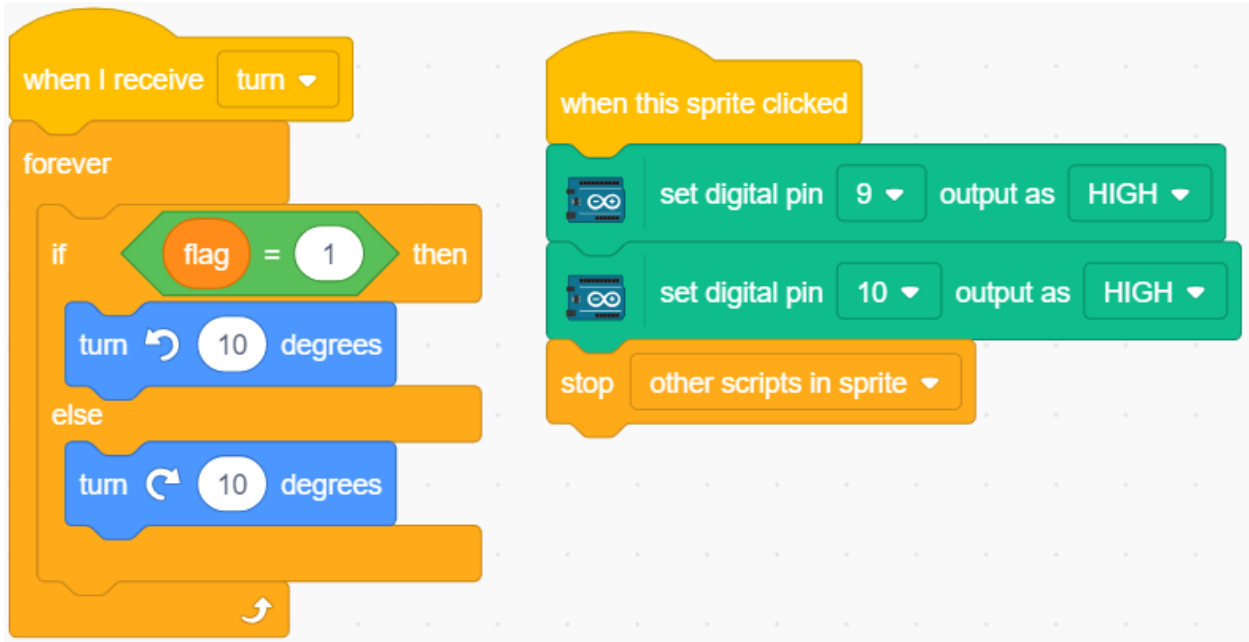


### 4. star sprite

There are 2 events included here.

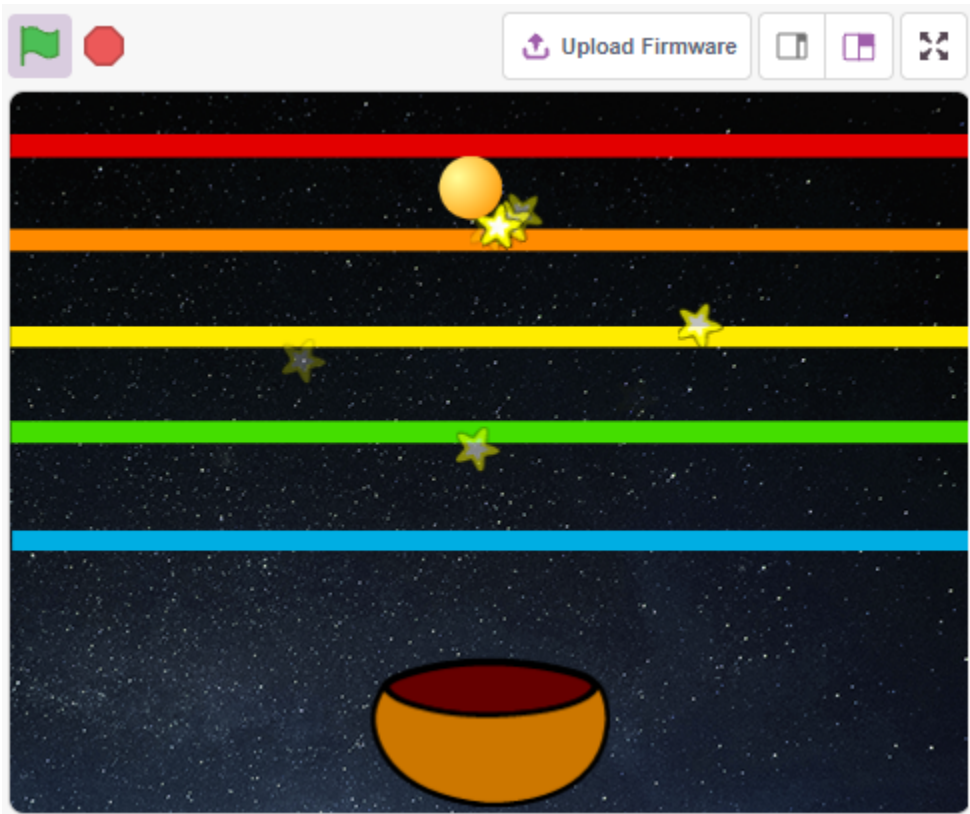
- When the **star** sprite receives the broadcasted message turn, it determines the value of flag; if flag is 1, it turns 10 degrees to the left, otherwise it reverses. Since it is in [FOREVER], it will keep turning.
- When this sprite is clicked, set both pins of the motor to high to make it stop rotating and stop the other scripts in this sprite.





## 7.15 2.12 Light Sensitive Ball

In this project, we use Photoresistor to make the ball on the stage fly upwards. Place your hand on top of the photoresistor to control the light intensity it receives. The closer your hand is to the photoresistor, the smaller its value and the higher the ball flies on the stage, otherwise it will fall. When the ball touches the string, it makes a nice sound as well as a twinkling starlight.



7.15.1 You Will Learn

- Fill the sprite with colors
- Touch between the sprites

7.15.2 Required Components

In this project, we need the following components.  
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Photoresistor</i>	

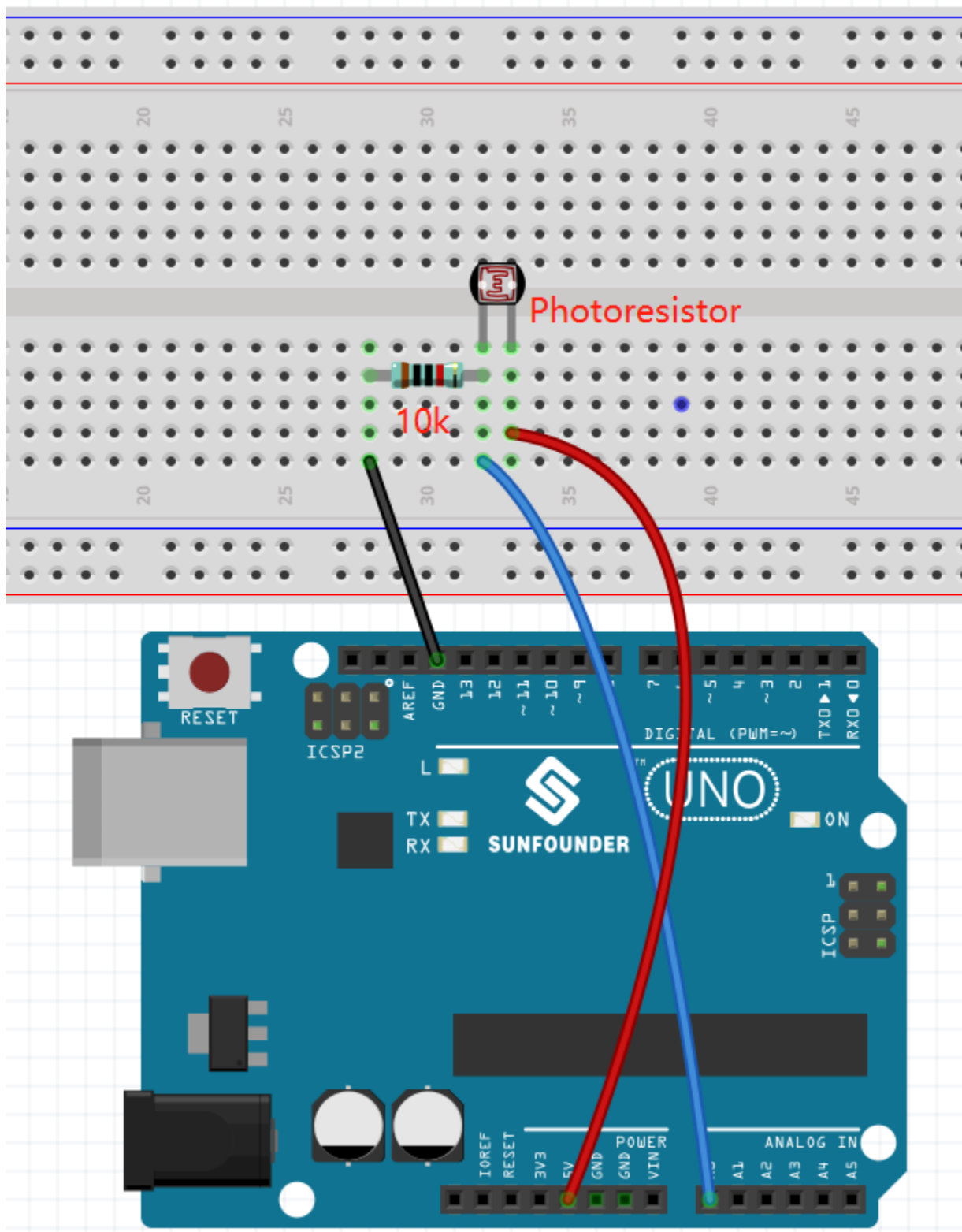
### 7.15.3 Build the Circuit

A photoresistor or photocell is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity.

Build the circuit according to the following diagram.

Connect one end of the photoresistor to 5V, the other end to A0, and connect a 10K resistor in series with GND at this end.

So when the light intensity increases, the resistance of a photoresistor decreases, the voltage division of the 10K resistor increases, and the value obtained by A0 becomes larger.

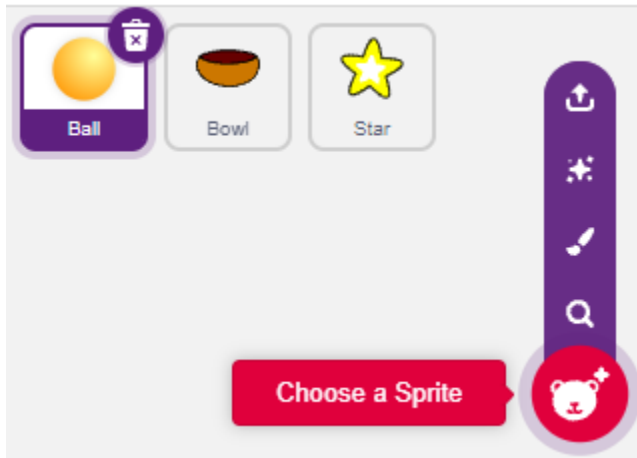


### 7.15.4 Programming

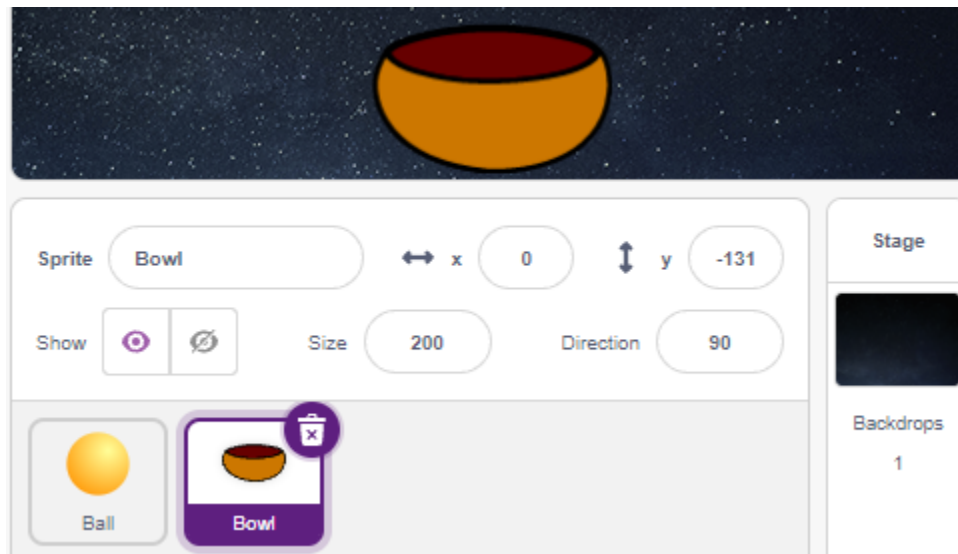
The effect we want to get is that the closer your hand is to the photoresistor, the ball sprite on the stage keeps going up, otherwise it will fall on the bowl sprite. If it touches the Line sprite while walking up or falling down, it will make a musical sound and emit star sprites in all directions.

#### 1. Select sprite and backdrop

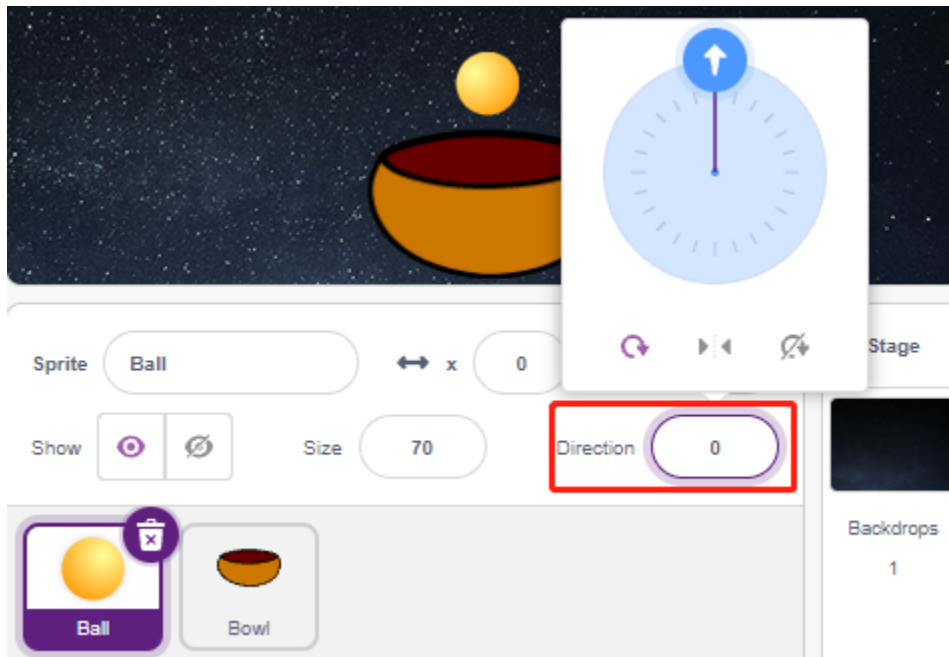
Delete the default sprite, select the **Ball**, **Bowl** and **Star** sprite.



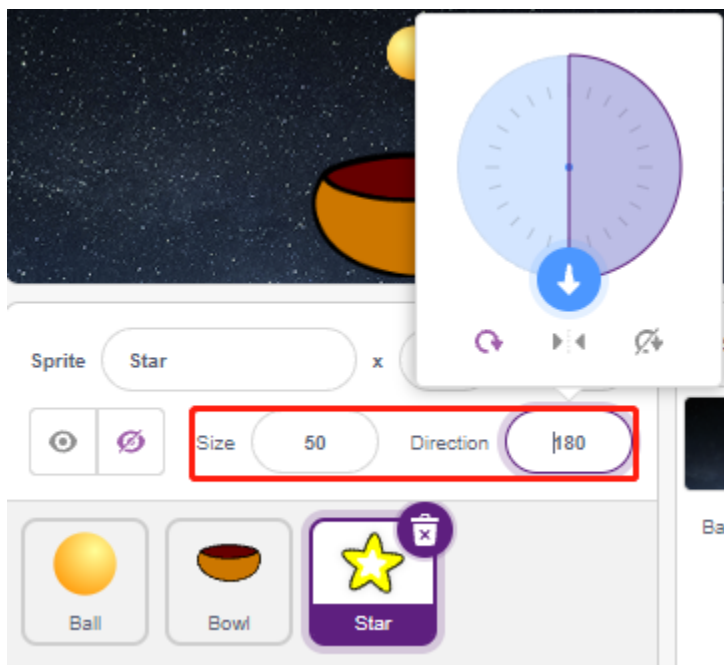
Move the **Bowl** sprite to the bottom center of the stage and enlarge its size.



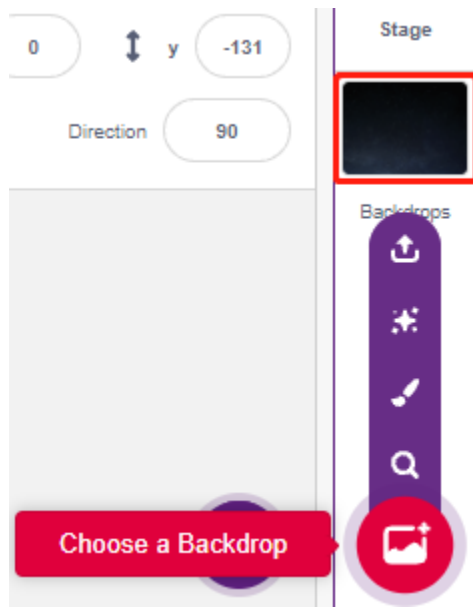
Because we need to move it upwards, so set direction of **Ball** sprite to 0.



Set the size and direction of the **Star** sprite to 180 because we need it to fall down, or you can change it to another angle.

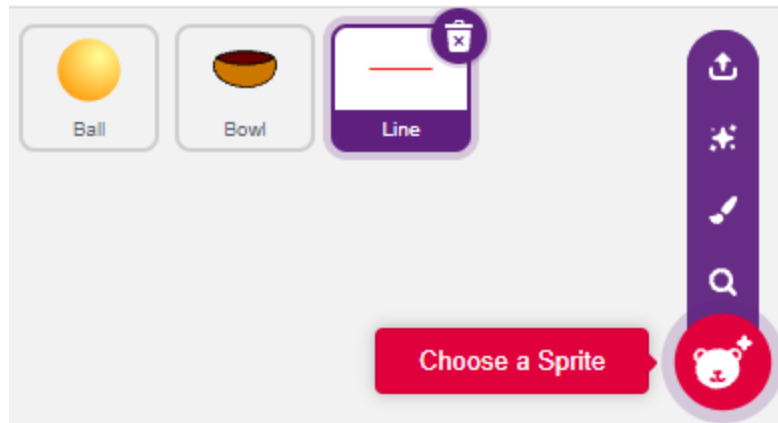


Now add the **Stars** backdrop.

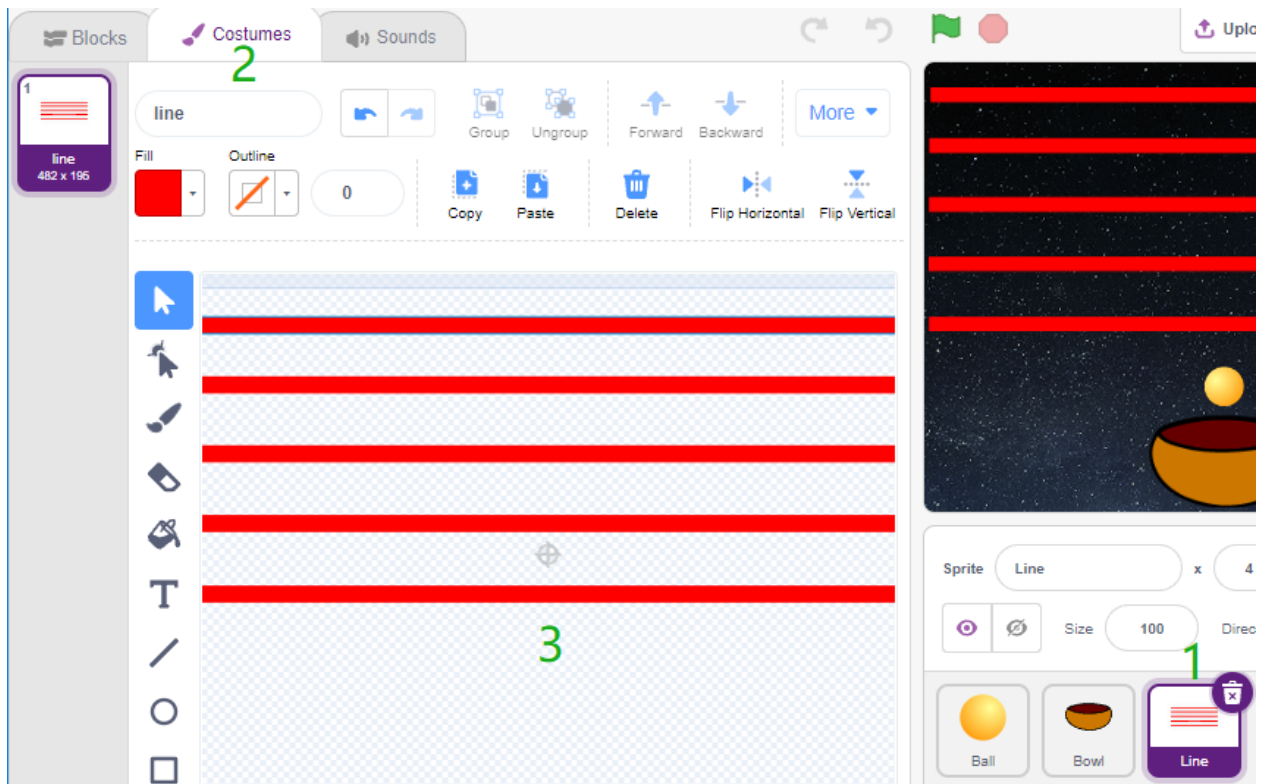


## 2. Draw a Line sprite

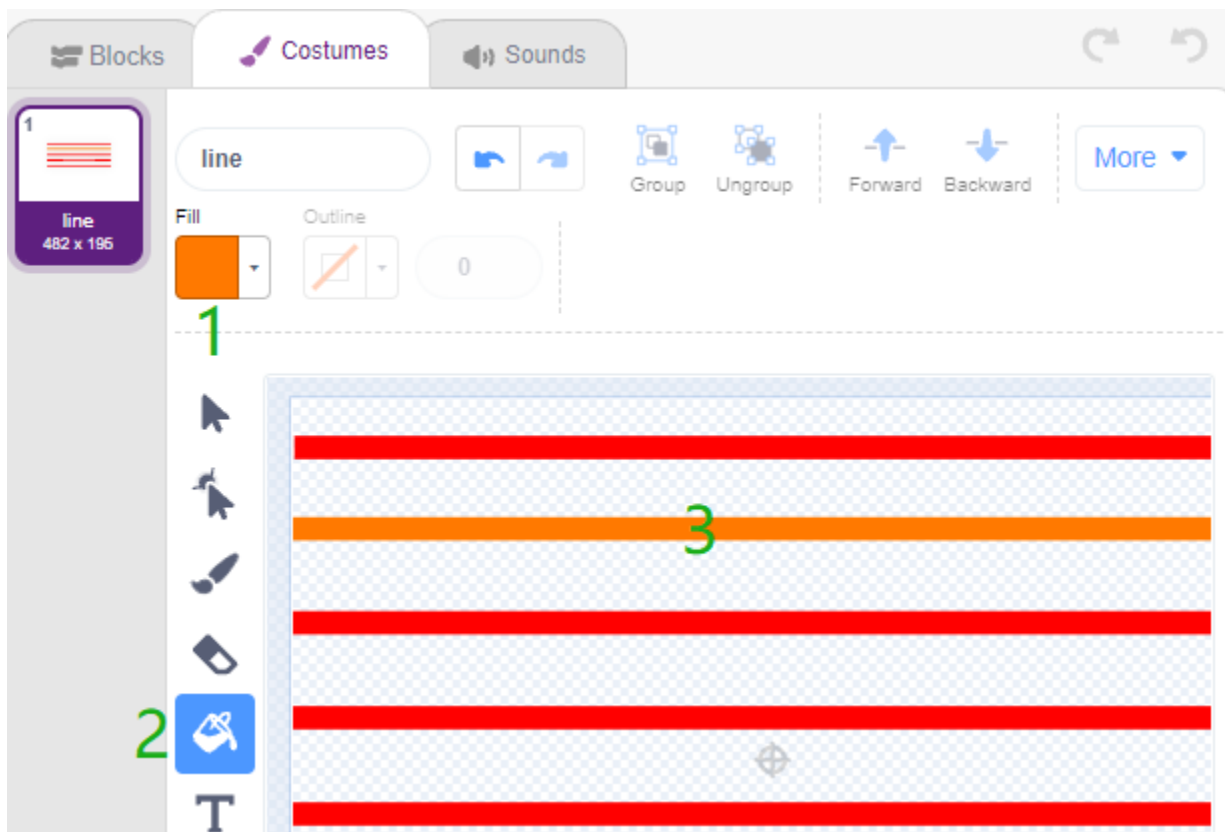
Add a Line sprite.



Go to the **Costumes** page of the **Line** sprite, reduce the width of the red line on the canvas slightly, then copy it 5 times and align the lines.

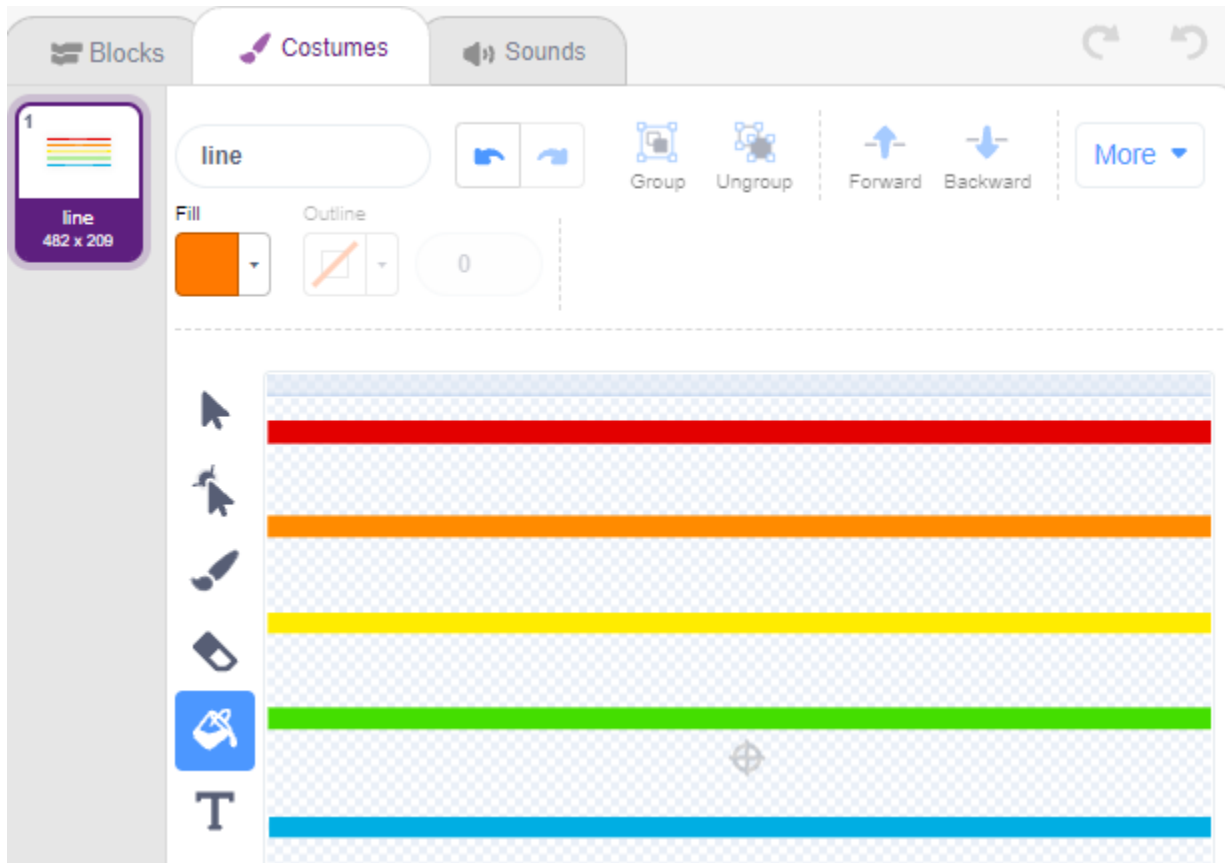


Now fill the lines with different colors. First choose a color you like, then click on the **Fill** tool and move the mouse over the line to fill it with color.





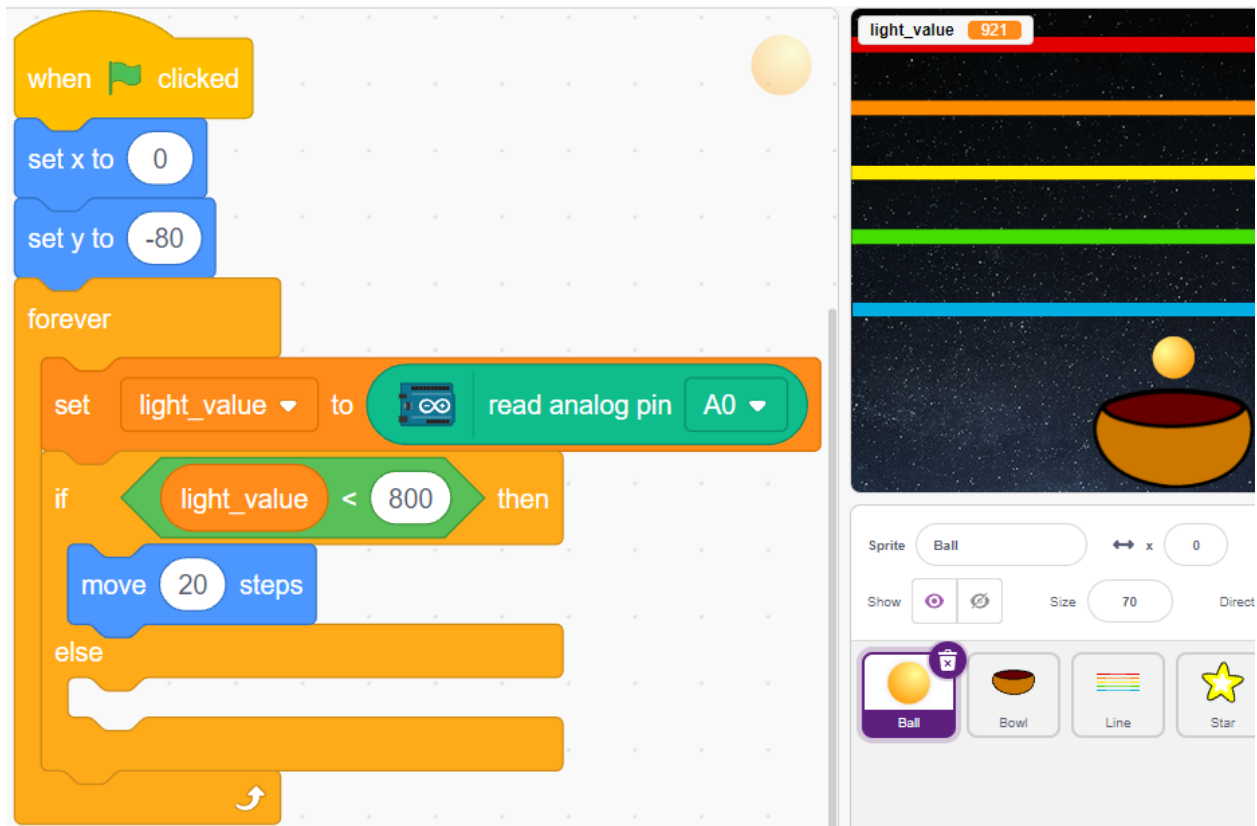
Follow the same method to change the color of the other lines.



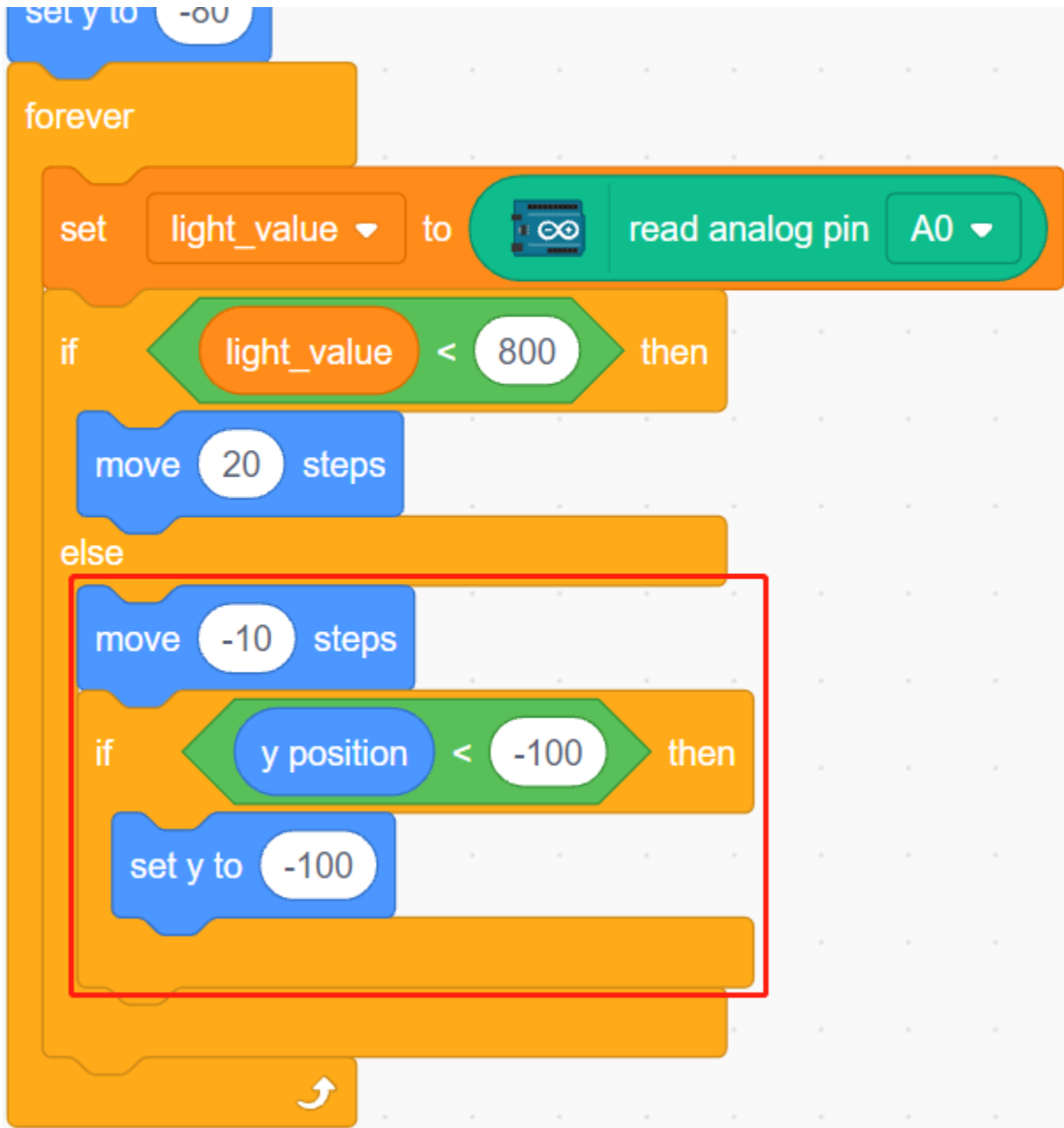
### 3. Scripting the Ball sprite

Set the initial position of the **Ball** sprite, then when the light value is less than 800 (it can be any other value, depending on your current environment.), let the Ball move up.

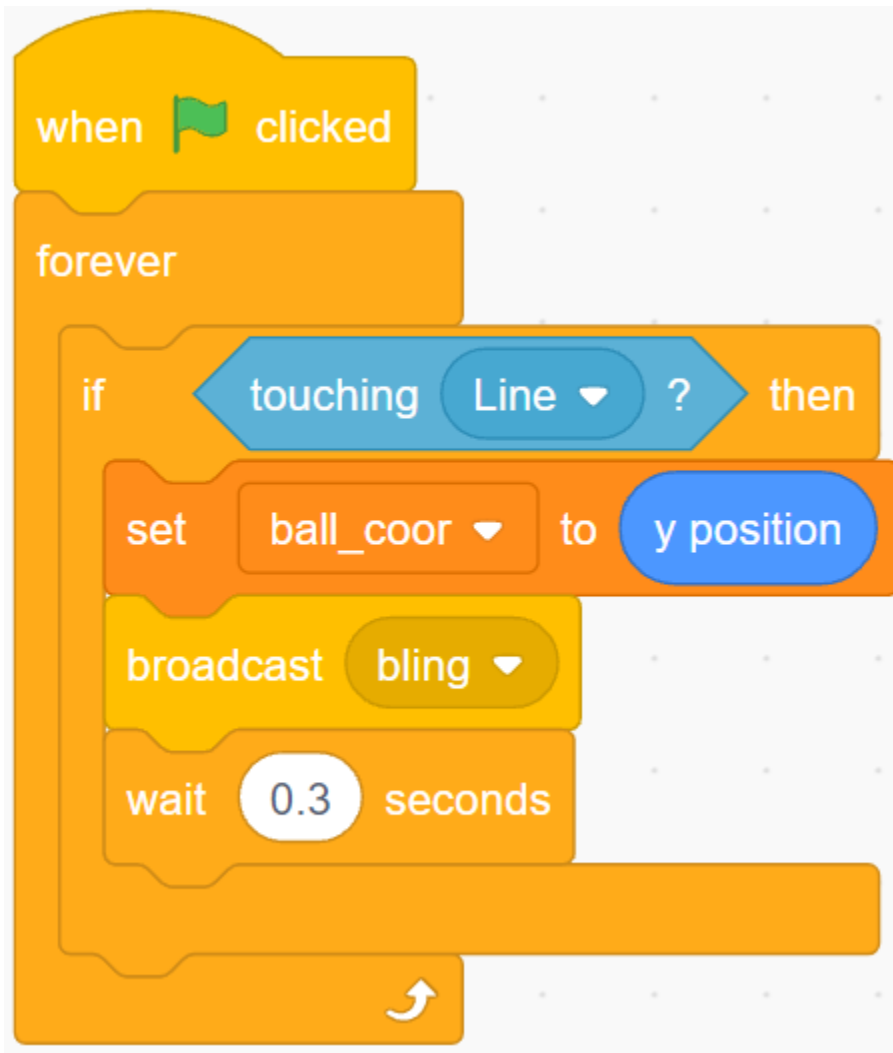
You can make the variable `light_value` show up on the stage to observe the change of light intensity at any time.



Otherwise, the **Ball** sprite will fall and limit its Y coordinate to a minimum of -100. This can be modified to make it look like it is falling on the **Bowl** sprite.

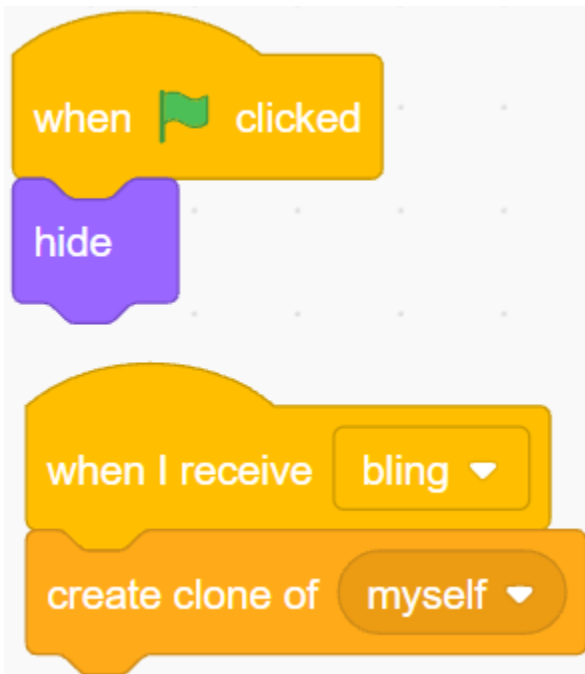


When the **Line** sprite is hit, the current Y coordinate is saved to the variable **ball\_coor** and a **Bling** message is broadcast.

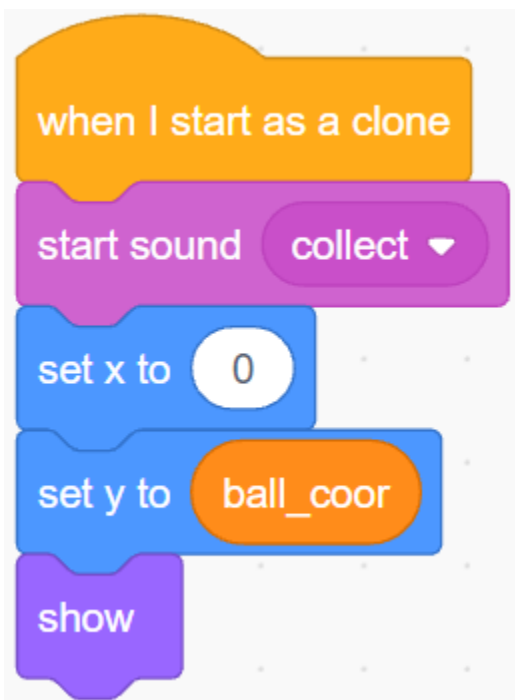


#### 4. Scripting the Star sprite

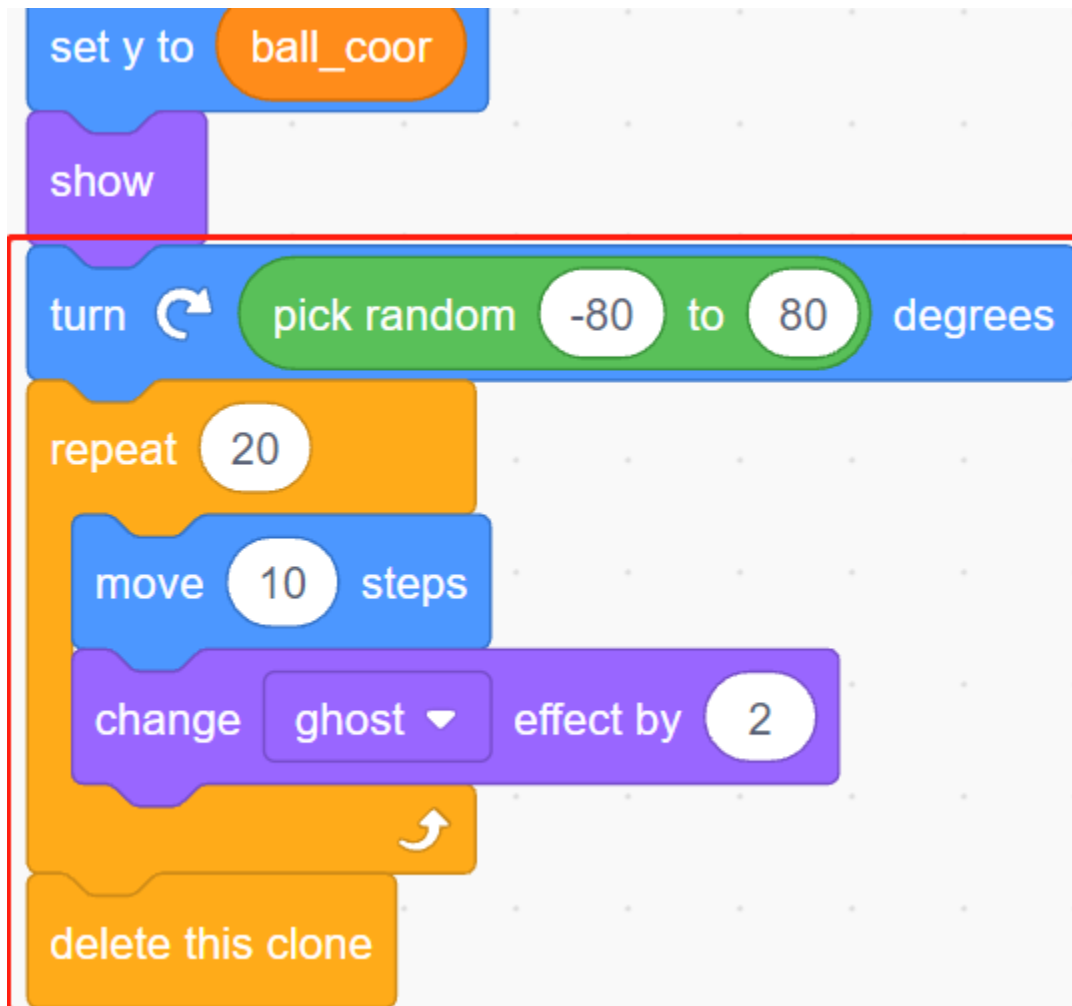
When the script starts, first hide the **Star** sprite. When the **Bling** message is received, clone the **Star** sprite.



When the **Star** sprite appears as a clone, play the sound effect and set its coordinates to be in sync with the **Ball** sprite.



Create the effect of the **Star** sprite appearing, and adjust it as needed.

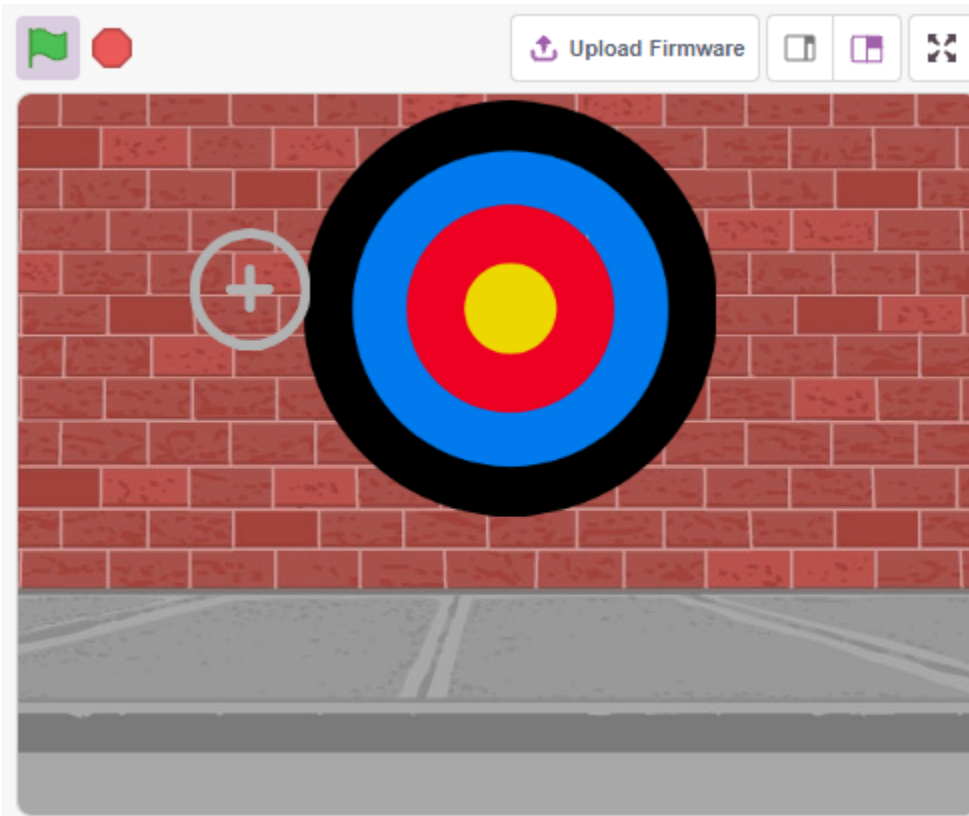


## 7.16 2.13 GAME - Shooting

Have you seen those shooting games on TV? The closer a contestant shoots a bullet on the target to the bullseye, the higher his score.

Today we are also doing a shooting game in Scratch. In the game, let the Crosshair shoot as far as possible to the bullseye to get a higher score.

Click on the green flag to start. Use the Obstacle Avoidance module to shoot an bullet.



### 7.16.1 You Will Learn

- How the Obstacle Avoidance module works and the angle range
- Paint different sprites
- Touch colors

### 7.16.2 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

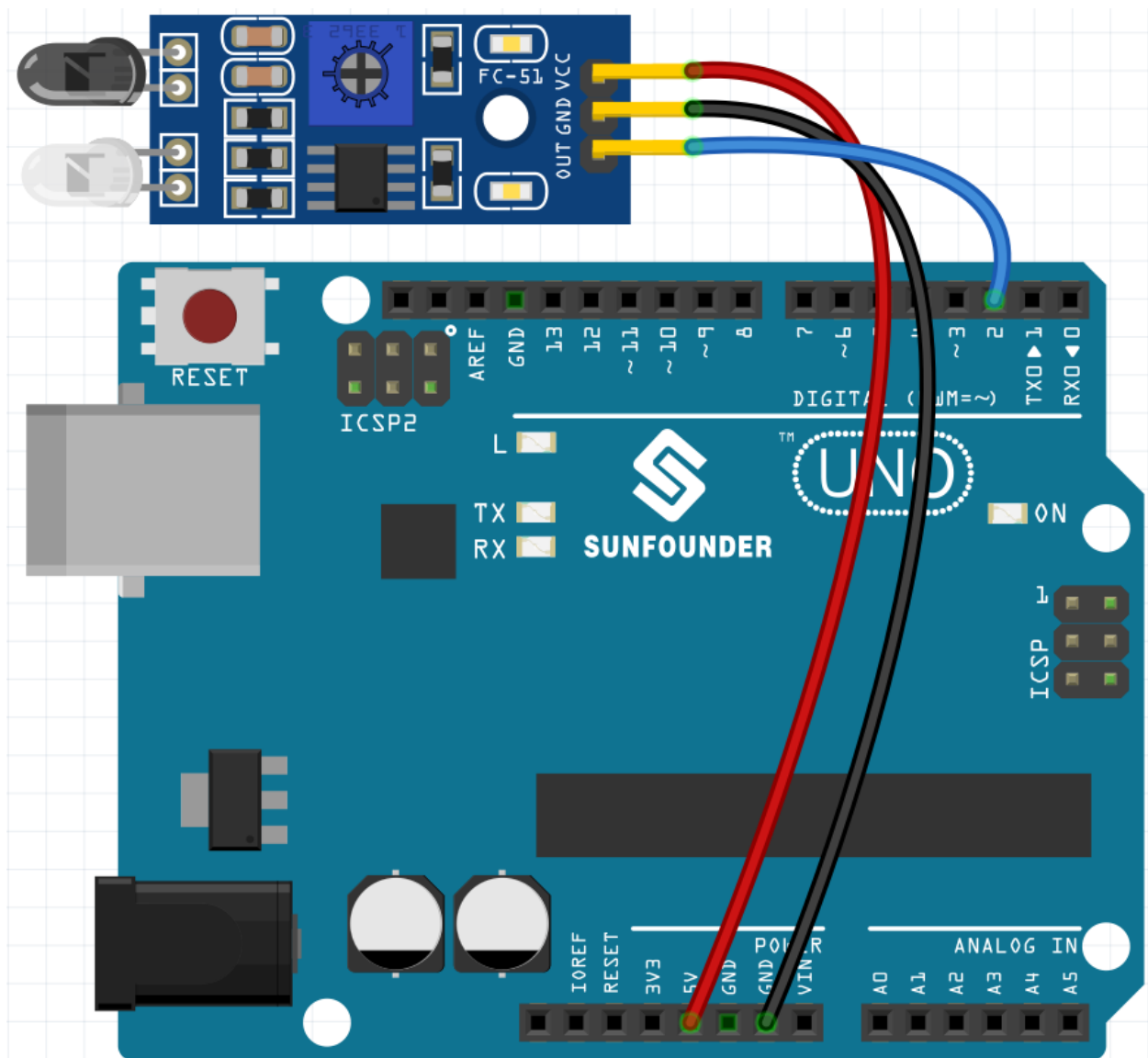
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>Obstacle Avoidance Module</i>	

### 7.16.3 Build the Circuit

The obstacle avoidance module is a distance-adjustable infrared proximity sensor whose output is normally high and low when an obstacle is detected.

Now build the circuit according to the diagram below.

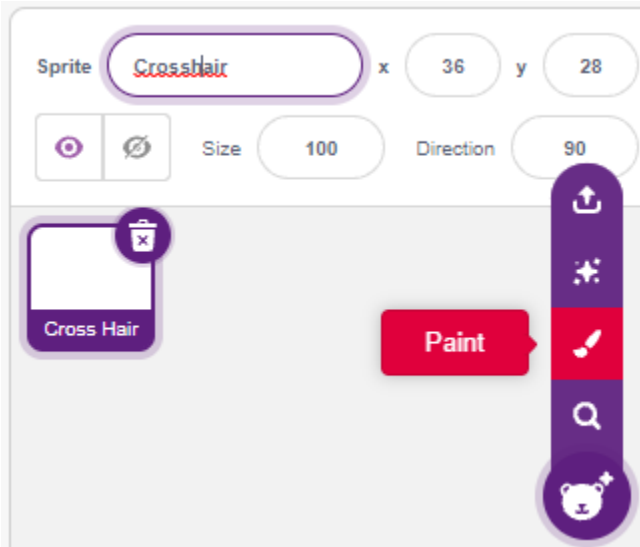




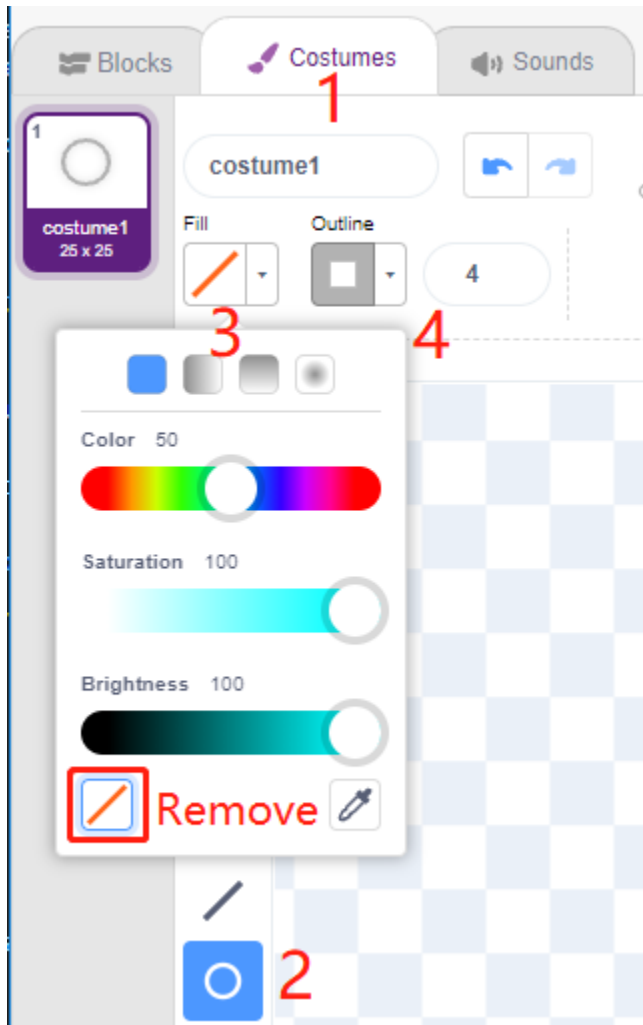
## 7.16.4 Programming

### 1. Paint the Crosshair sprite

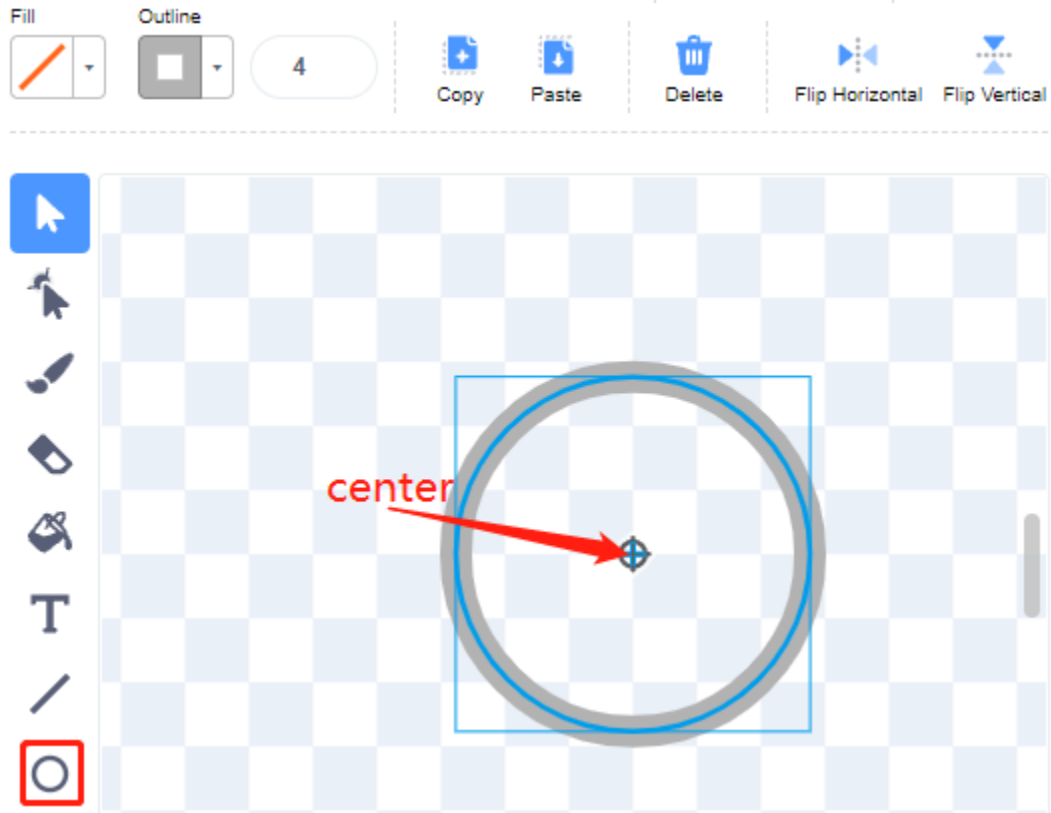
Delete the default sprite, select the **Sprite** button and click **Paint**, a blank sprite **Sprite1** will appear and name it **Crosshair**.



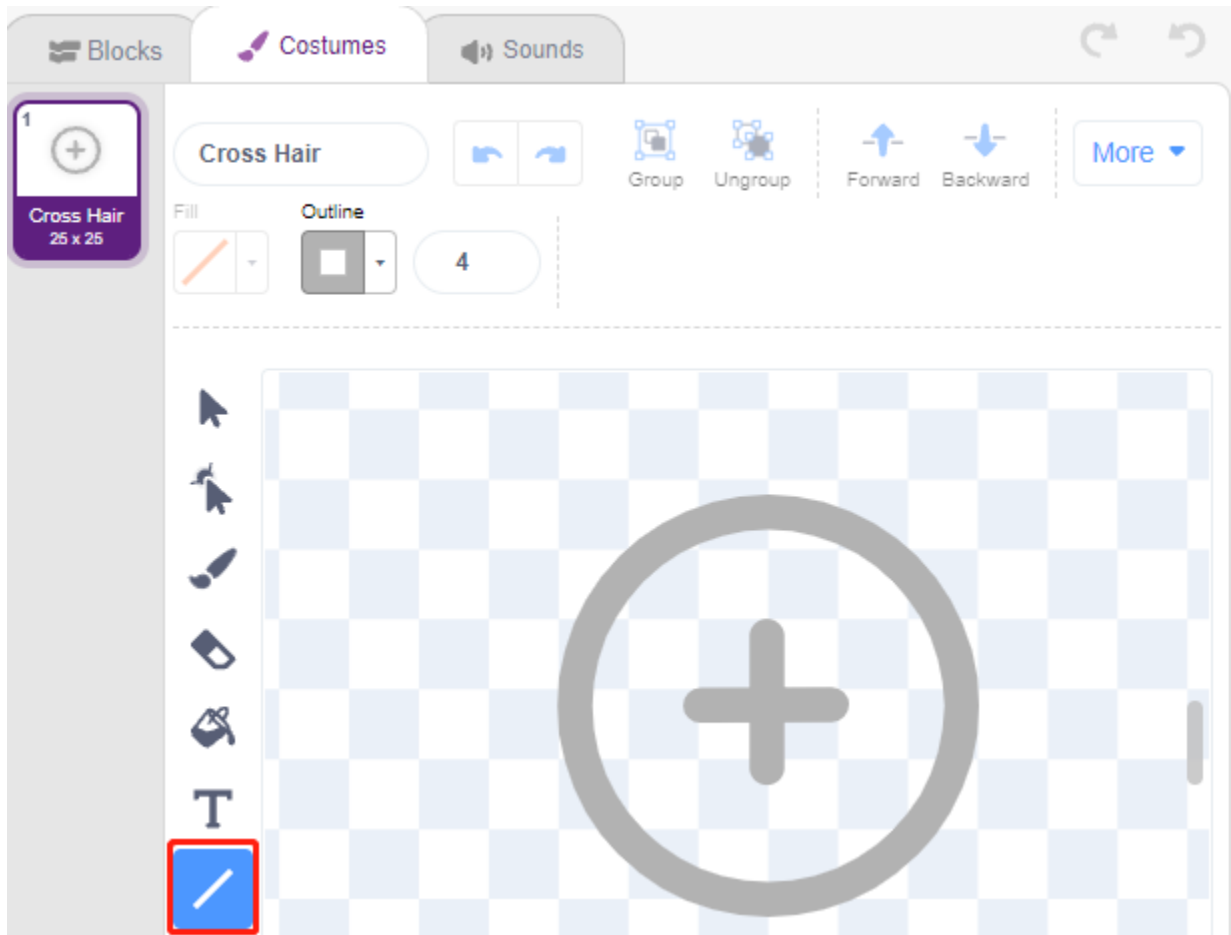
Go to the **Crosshair** sprite's **Costumes** page. Click on the **Circle** tool, remove the fill color, and set the color and width of the outline.



Now draw a circle with the **Circle** tool. After drawing, you can click to the **Select** tool and move the circle so that the original point is aligned with the center of the canvas.

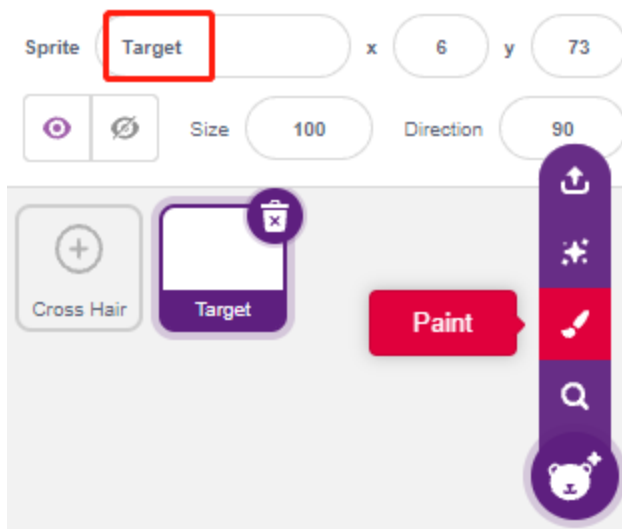


Using the **Line** tool, draw a cross inside the circle.

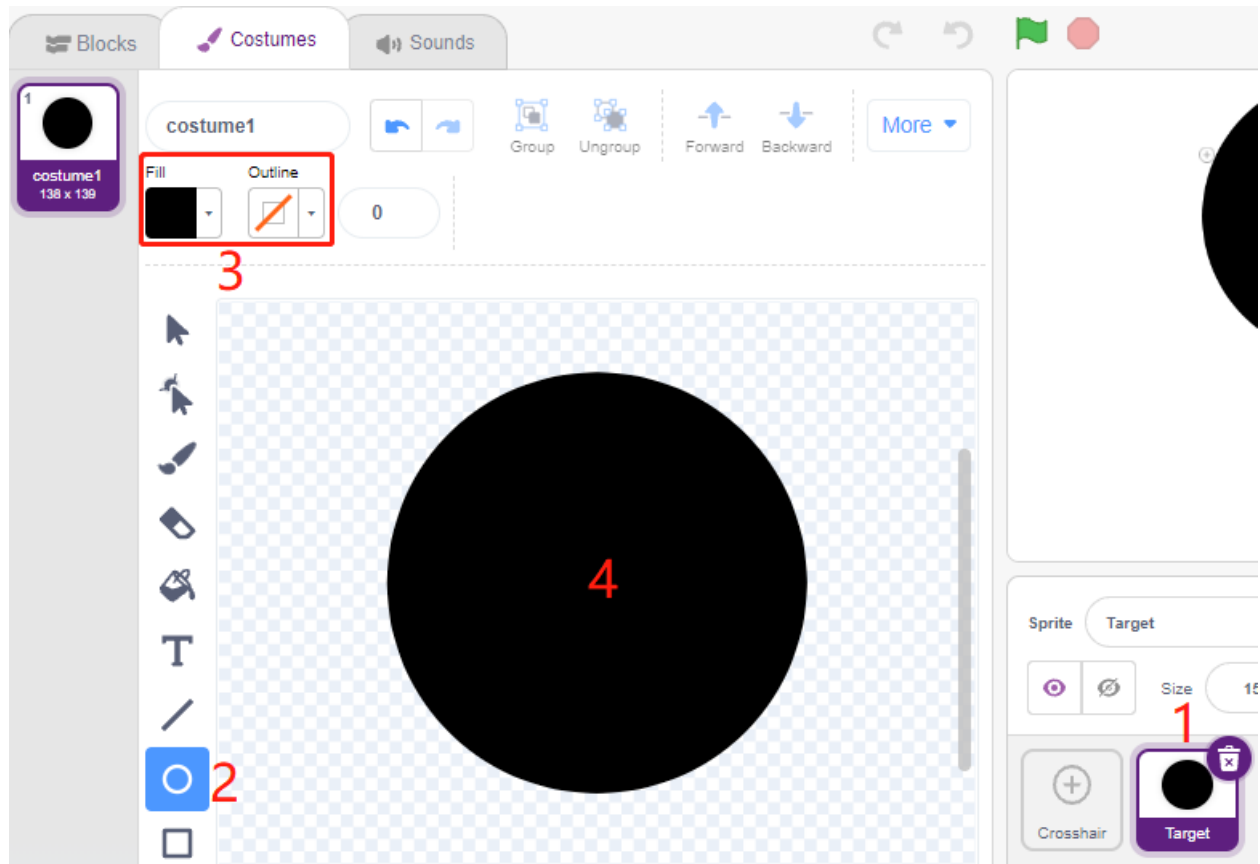


### Paint the Target sprite

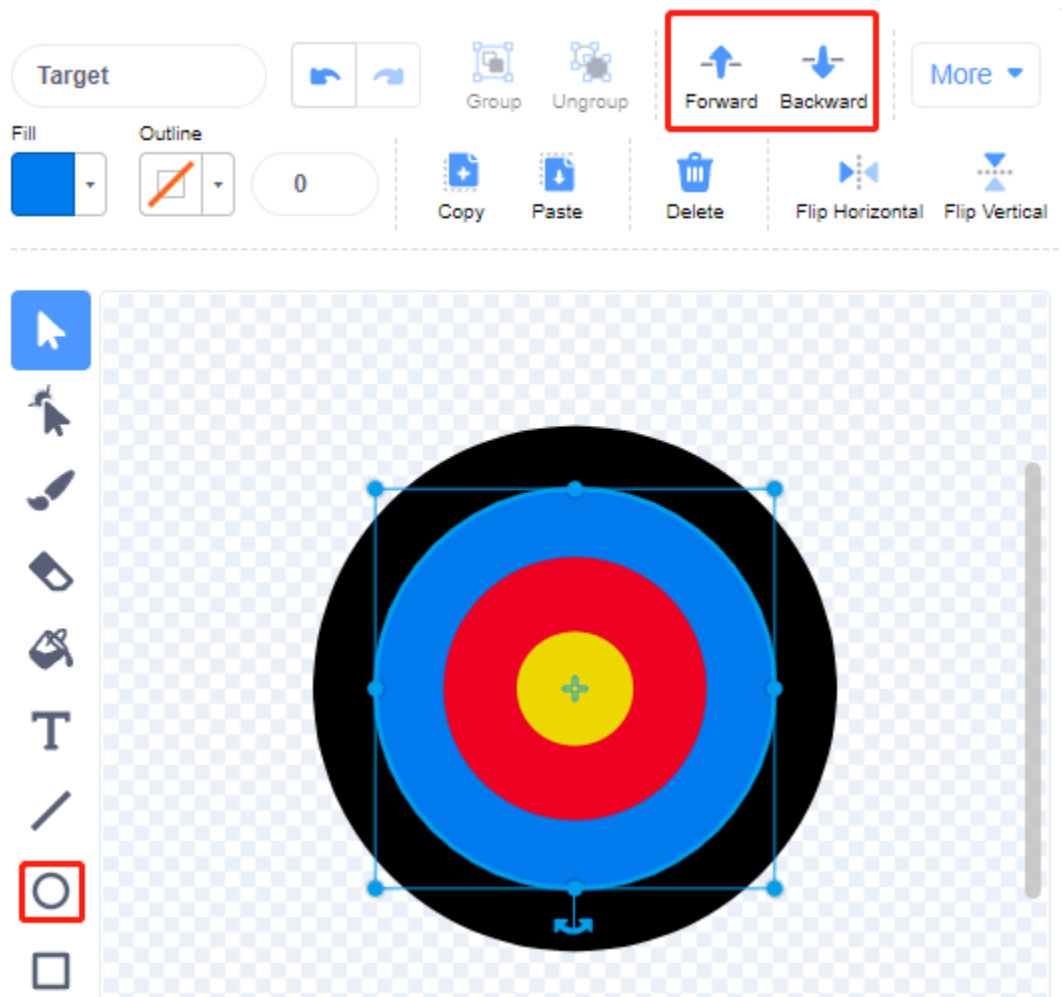
Create a new sprite called **Target** sprite.



Go to the Costumes page of the **Target** sprite, click on the **Circle** tool, select a fill color and remove the Outline and paint a large circle.

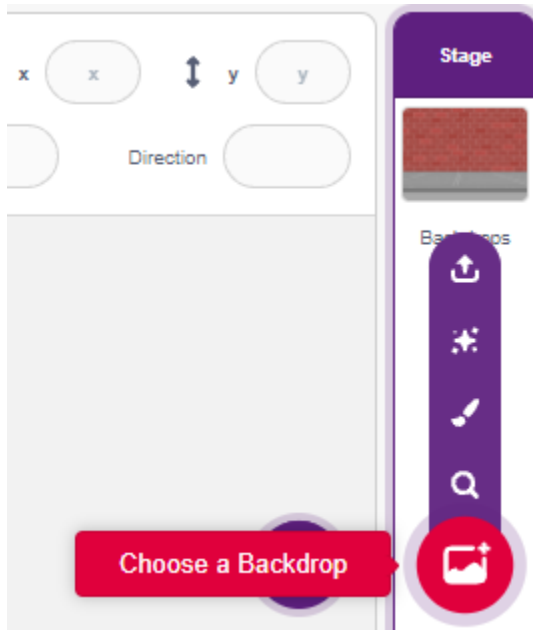


Use the same method to draw additional circles, each with a different color, and you can use the **Forward** or **Backbard** tool to change the position of the overlapping circles. Note that you also need to select the tool to move the circles, so that the origin of all the circles and the center of the canvas are aligned.



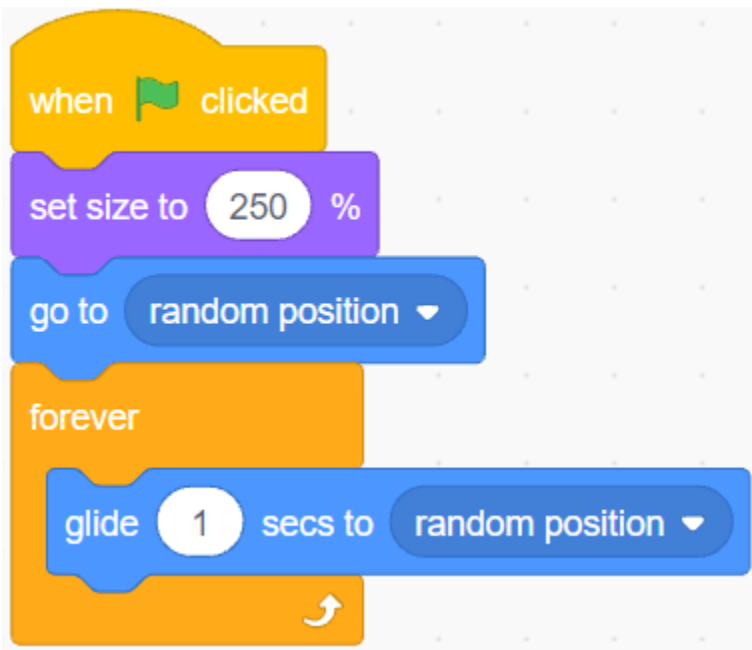
### 3. Add a backdrop

Add a suitable backdrop which preferably does not have too many colors and does not match the colors in the **Target** sprite. Here I have chosen **Wall1** backdrop.

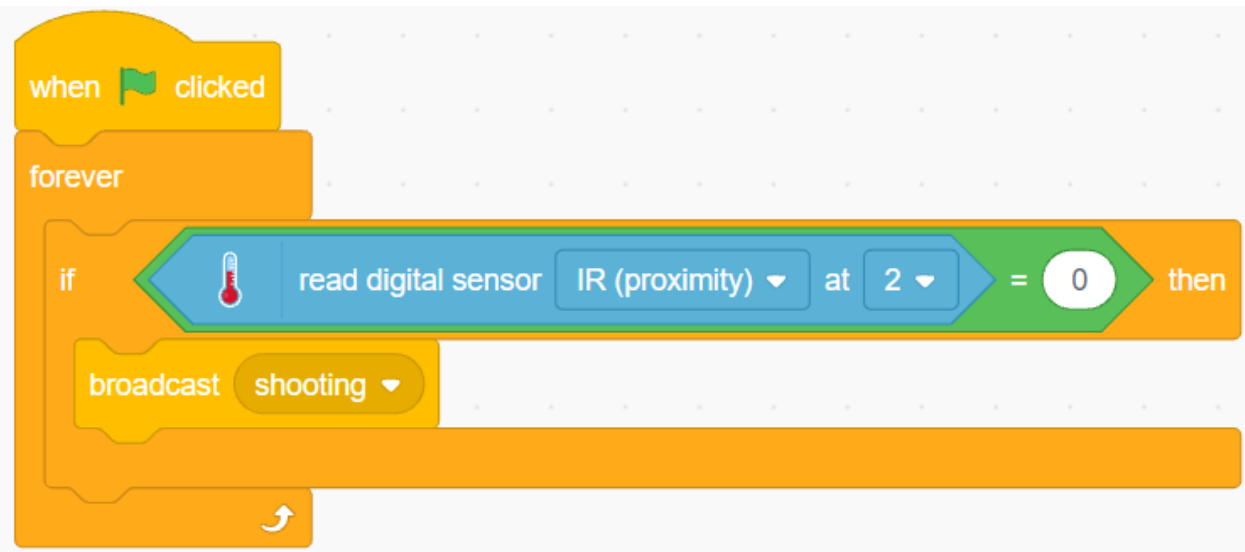


#### 4. Script the Crosshair sprite

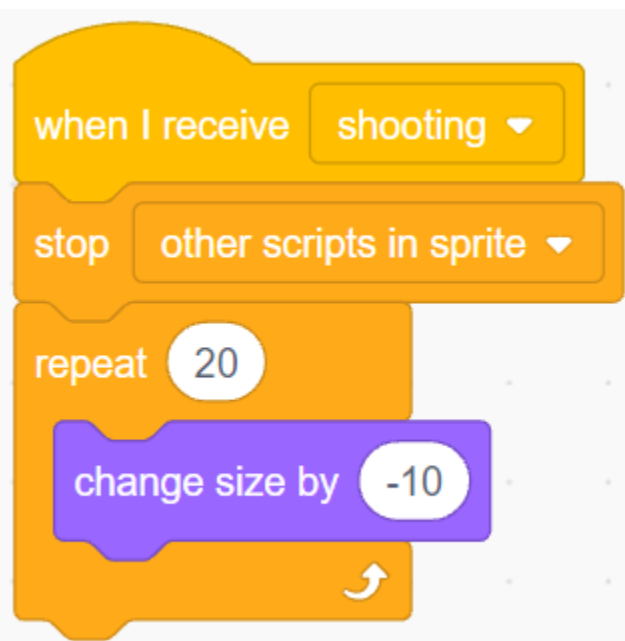
Set the random position and size of the **Crosshair** sprite, and let it move randomly.



When a hand is placed in front of the obstacle avoidance module, it will output a low level as a transmit signal.

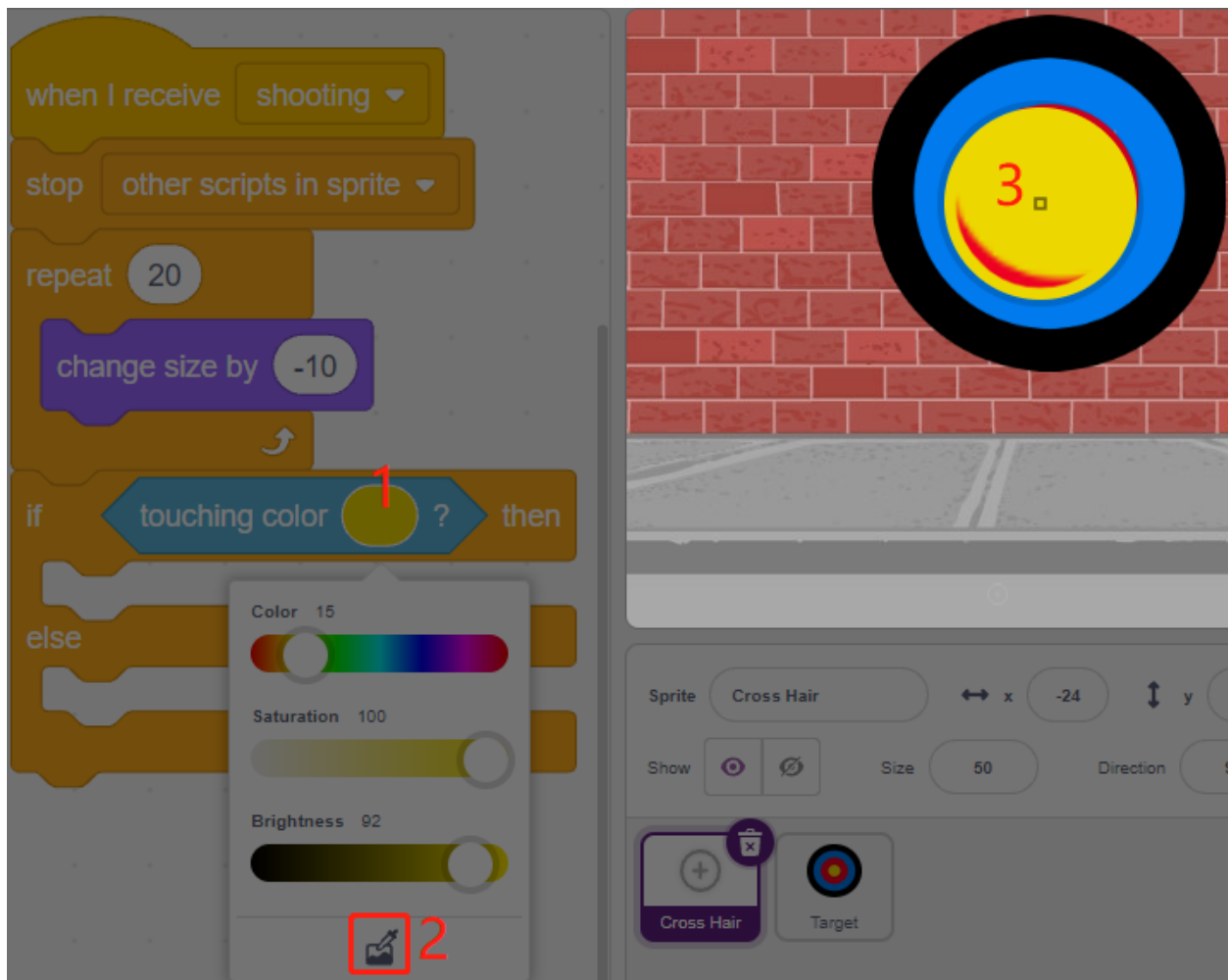


When the **shooting** message is received, the sprite stops moving and slowly shrinks, thus simulating the effect of a bullet being shot.

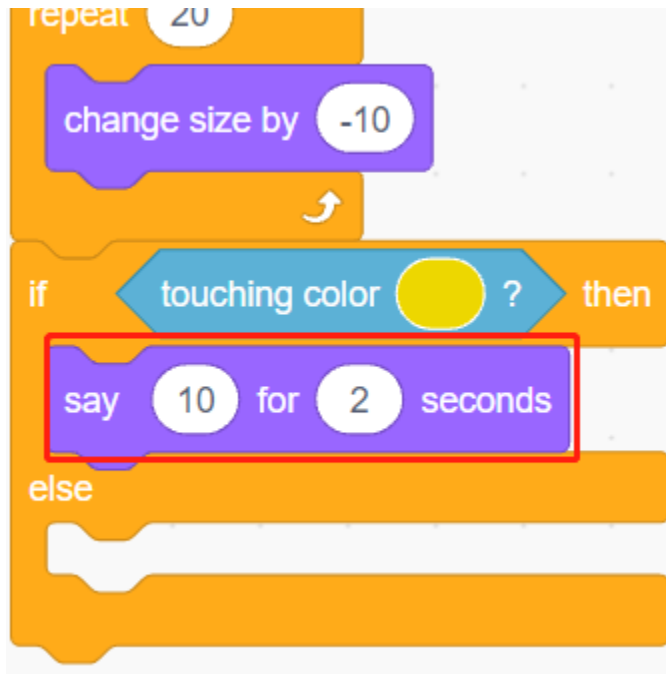


Use the [Touch color ()] block to determine the position of the shot.





When the shot is inside the yellow circle, 10 is reported.



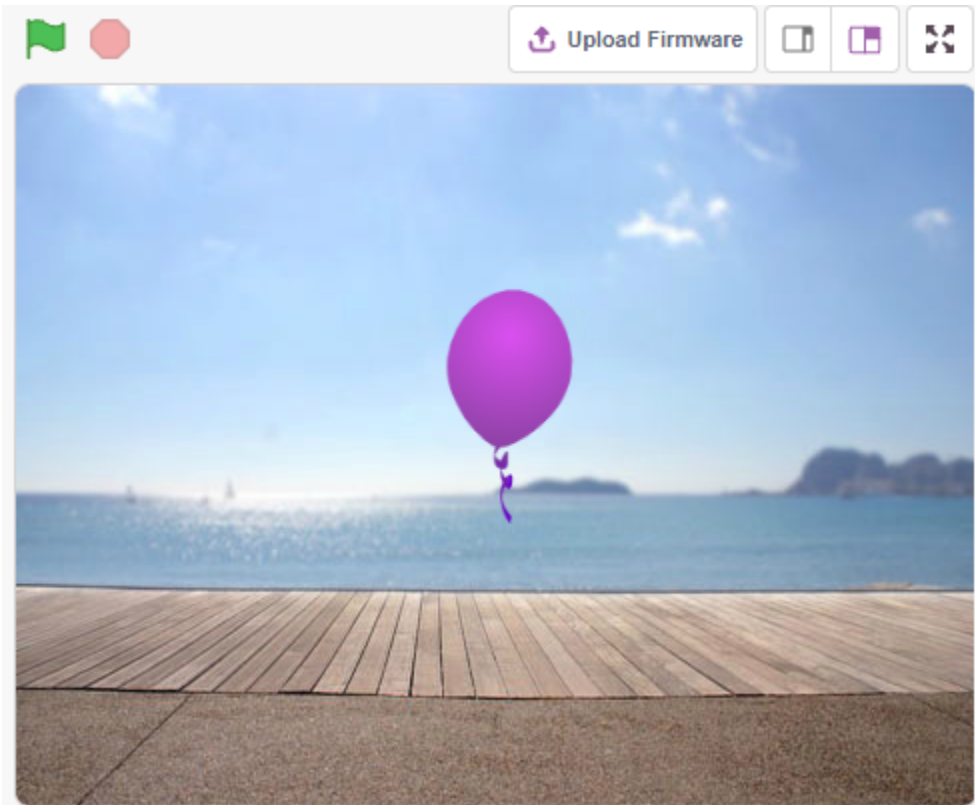
Use the same method to determine the position of the bullet shot, if it is not set on the **Target** sprite, it means it is out of the circle.



## 7.17 2.14 GAME - Inflating the Balloon

Here, we will play a game of ballooning.

After clicking the green flag, the balloon will become bigger and bigger. If the balloon is too big, it will be blown up; if the balloon is too small, it will fall down; you need to judge when to press the button to make it fly upwards.



### 7.17.1 You Will Learn

- Paint costume for the sprite

### 7.17.2 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

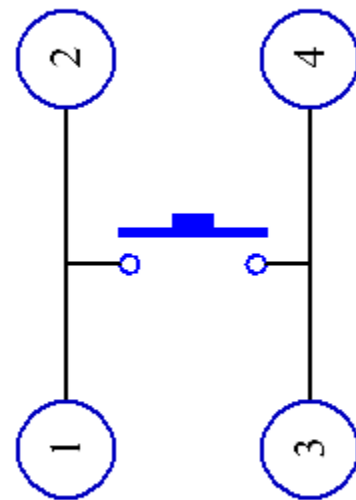
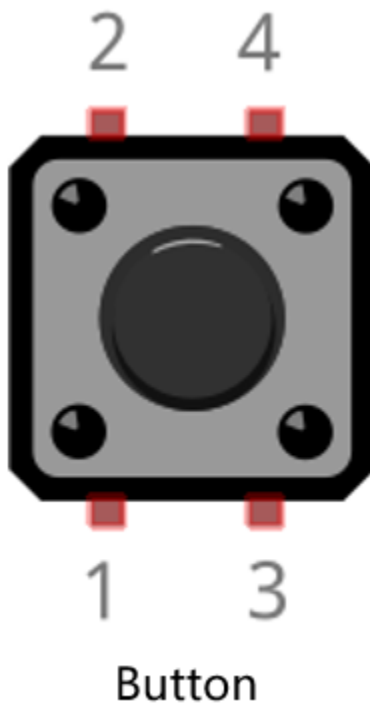
Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Capacitor</i>	
<i>Button</i>	

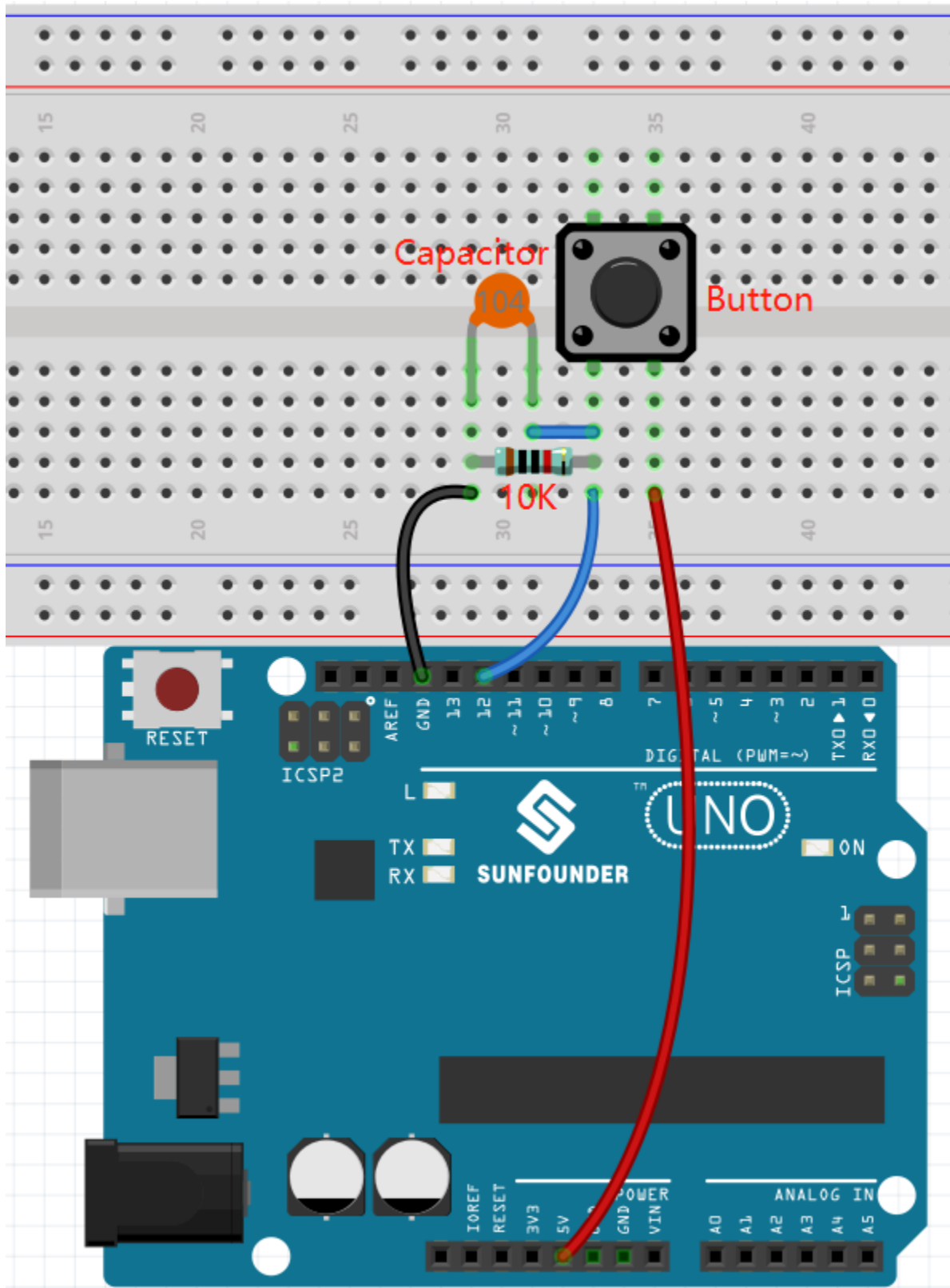
### 7.17.3 Build the Circuit

The button is a 4-pin device, since the pin 1 is connected to pin 2, and pin 3 to pin 4, when the button is pressed, the 4 pins are connected, thus closing the circuit.



Build the circuit according to the following diagram.

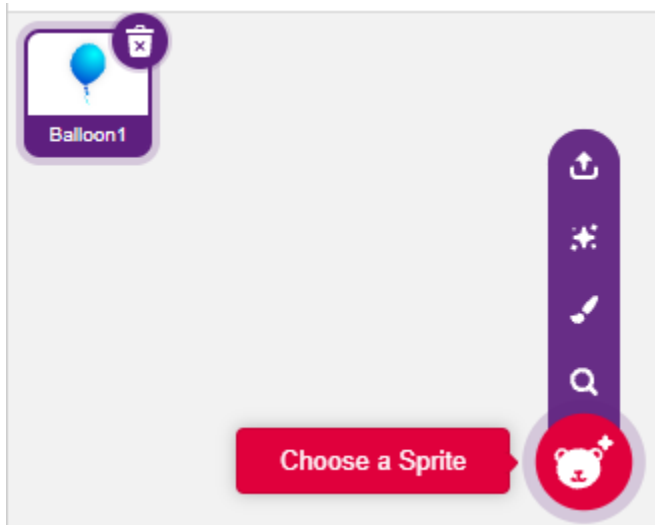
- Connect one of the pins on the left side of the button to pin 12, which is connected to a pull-down resistor and a 0.1uF (104) capacitor (to eliminate jitter and output a stable level when the button is working).
- Connect the other end of the resistor and capacitor to GND, and one of the pins on the right side of the button to 5V.



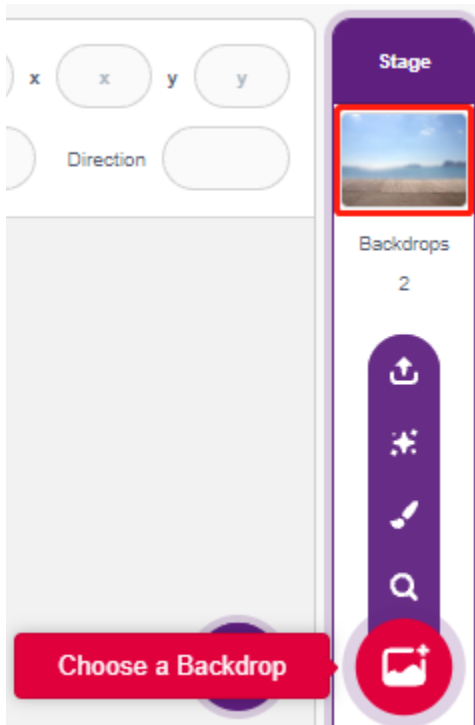
## 7.17.4 Programming

### 1. Add a sprite and a backdrop

Delete the default sprite, click the **Choose a Sprite** button in the lower right corner of the sprite area, then select the **Balloon1** sprite.



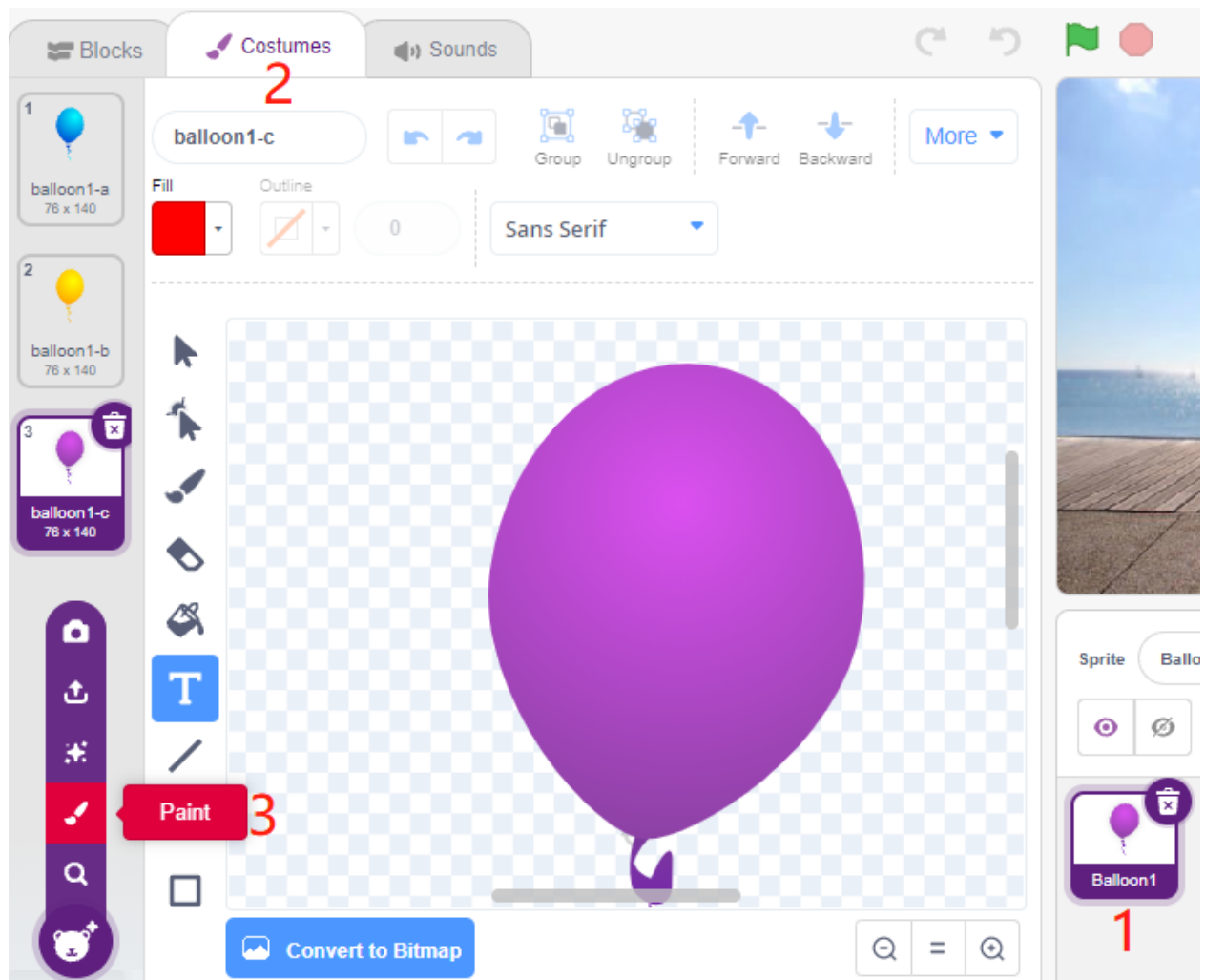
Add a **Boardwalk** backdrop via the **Choose a backdrop** button, or other backbackdrops you like.



### 2. Paint a costume for the Balloon1 sprite

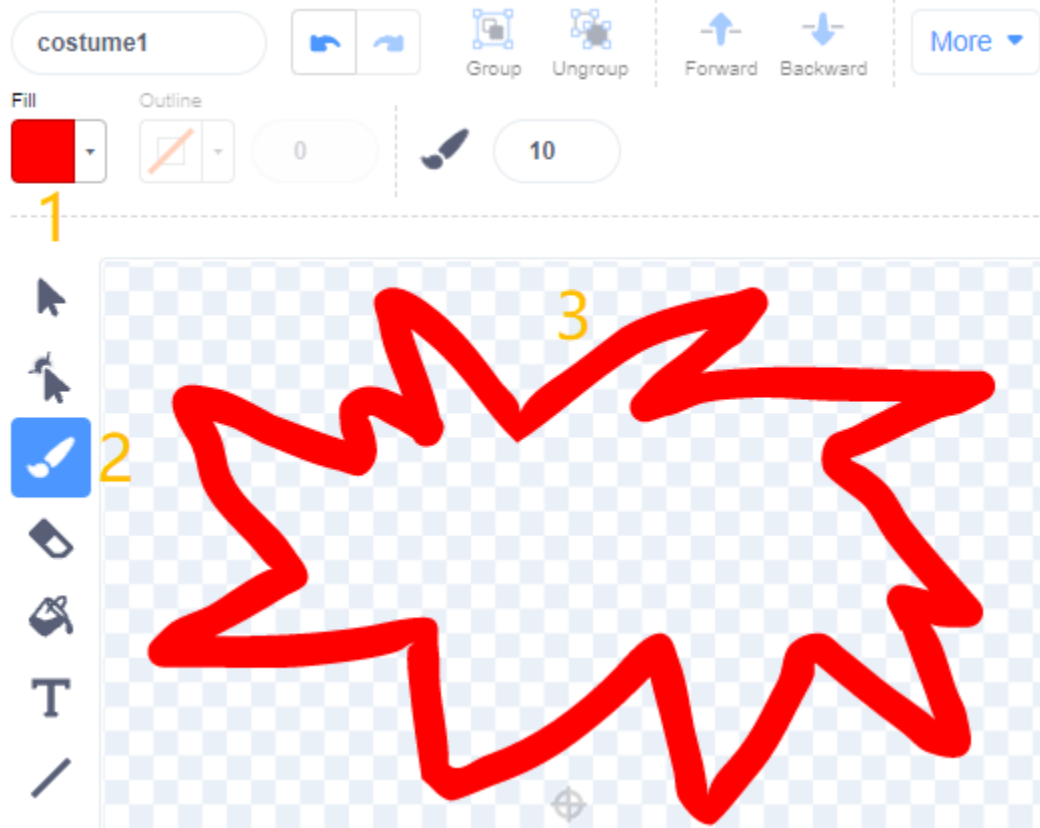
Now let's draw an exploding effect costume for the balloon sprite.

Go to the **Costumes** page for the **Balloon1** sprite, click the **Choose a Costume** button in the bottom left corner, and select **Paint** to bring up a blank **Costume**.

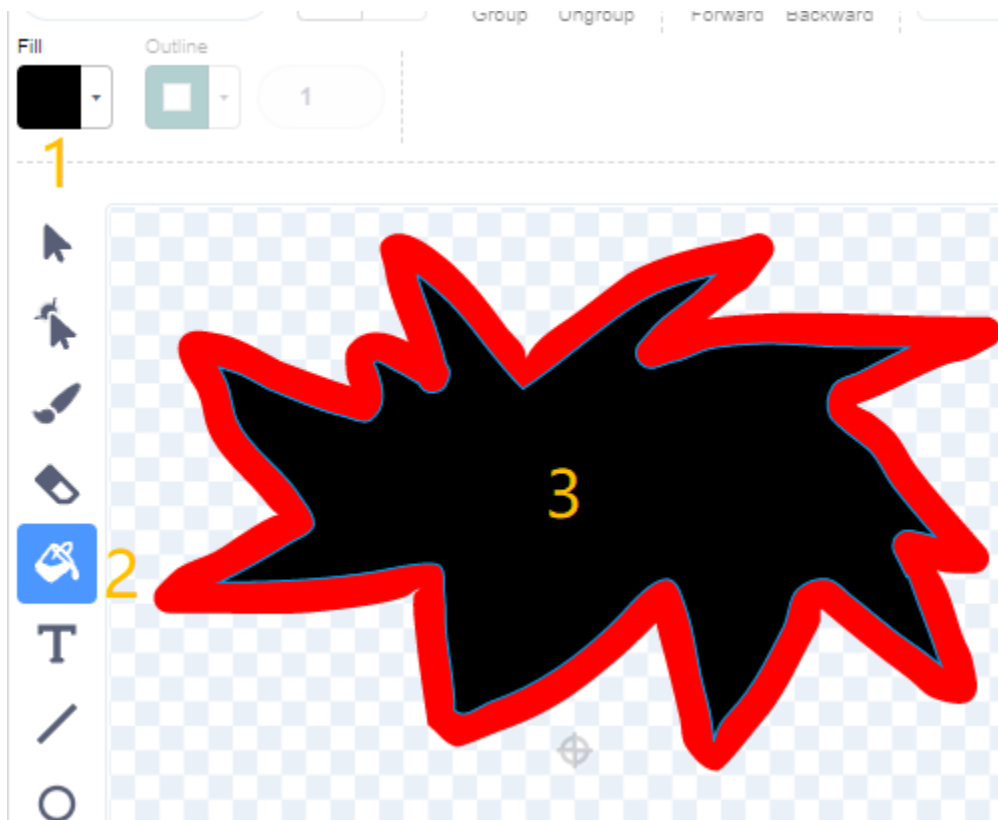


Select a color and then use the **Brush** tool to draw a pattern.

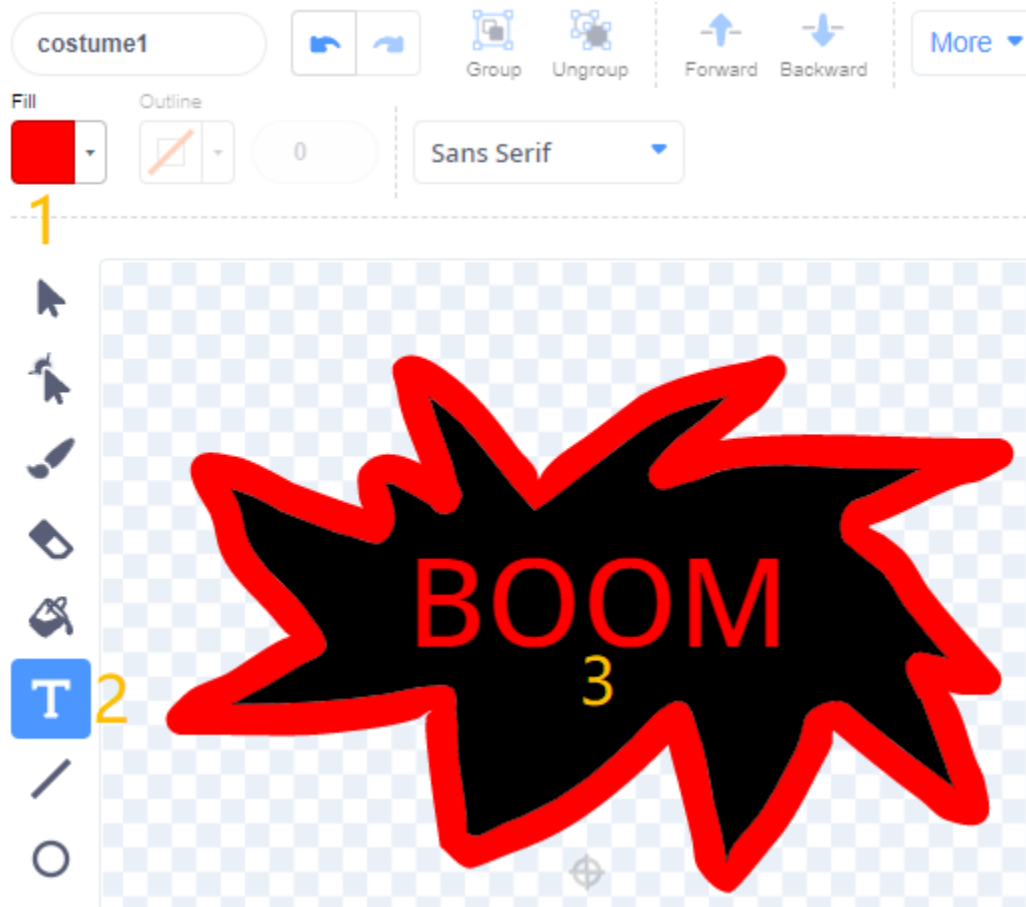




Select a color again, click the Fill tool, and move the mouse inside the pattern to fill it with a color.

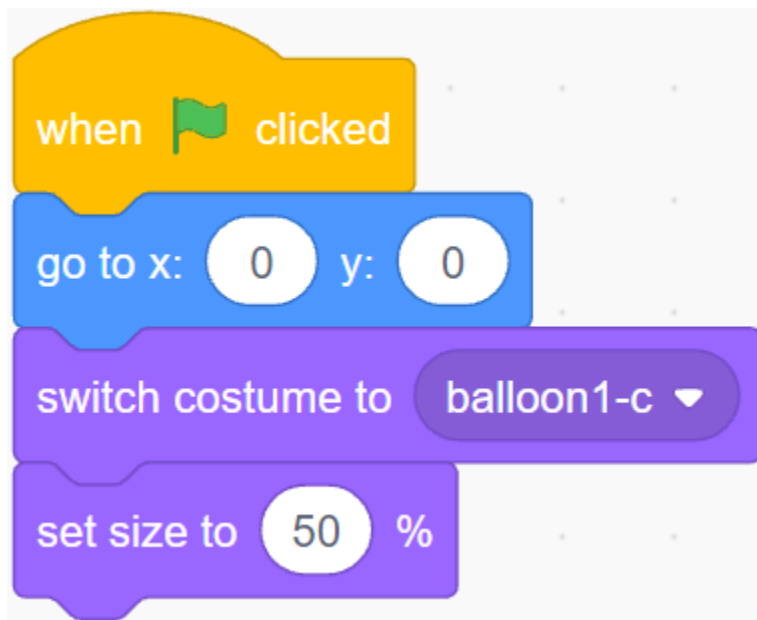


Finally, write the text BOOM, so that an explosion effect costume is complete.

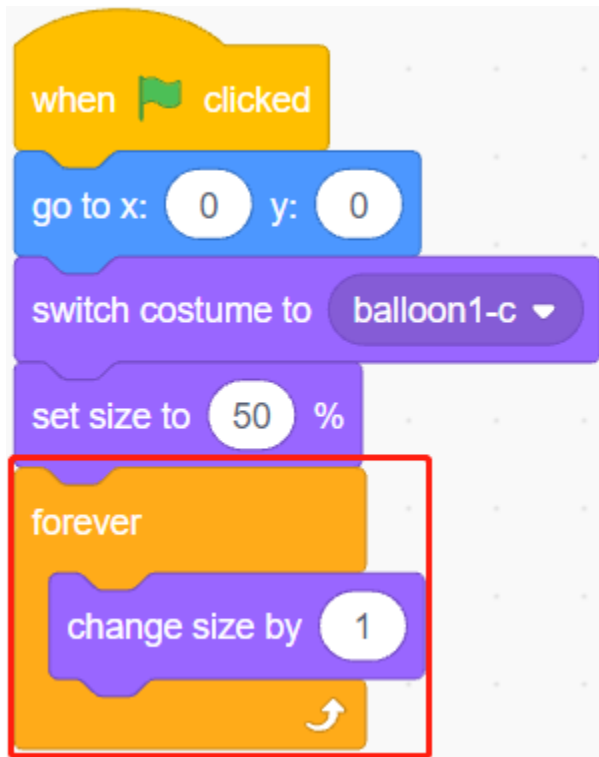


### 3. Scripting the Balloon sprite

Set the initial position and size of the **Balloon1** sprite.

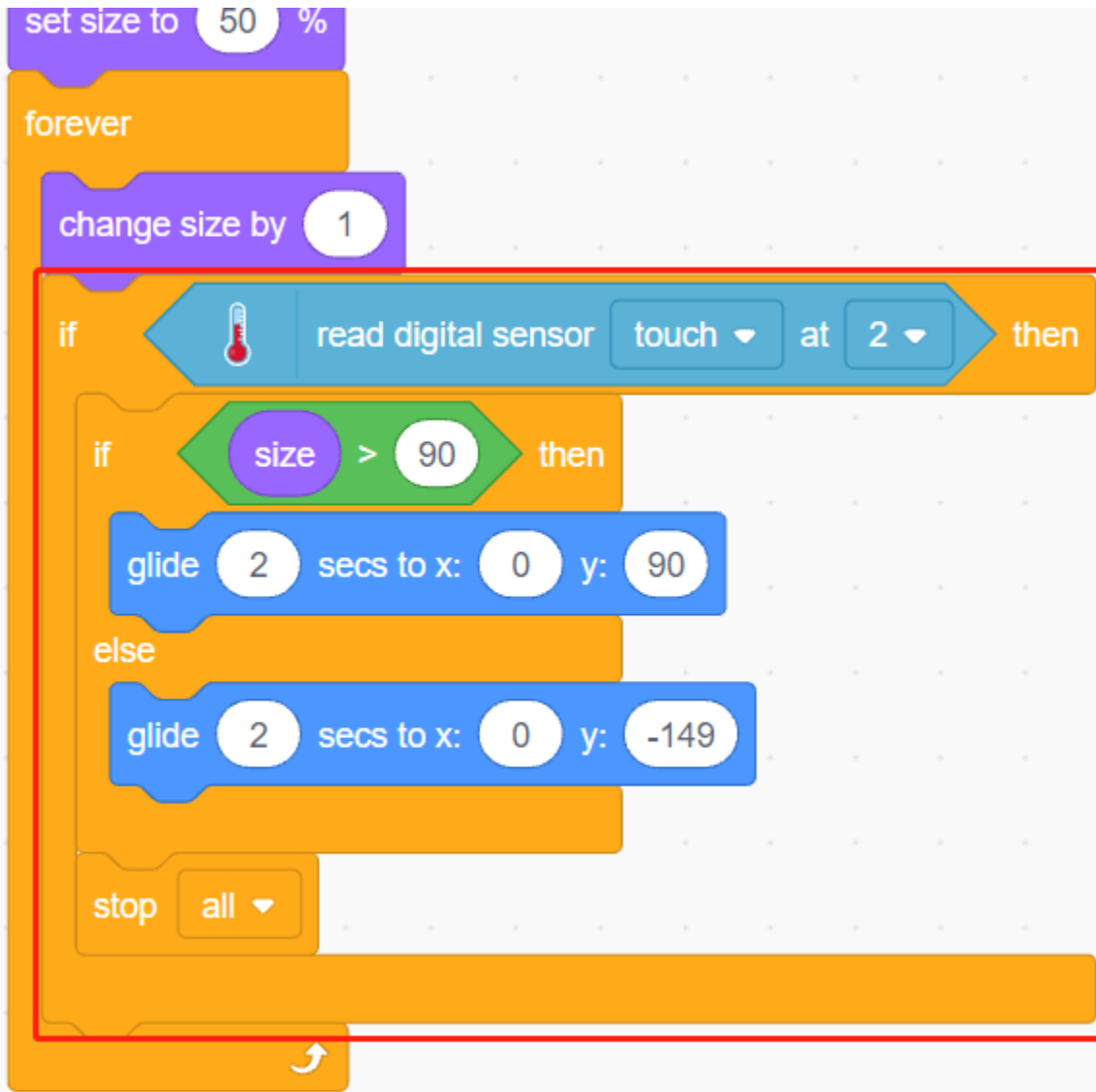


Then let the **Balloon** sprite slowly get bigger.

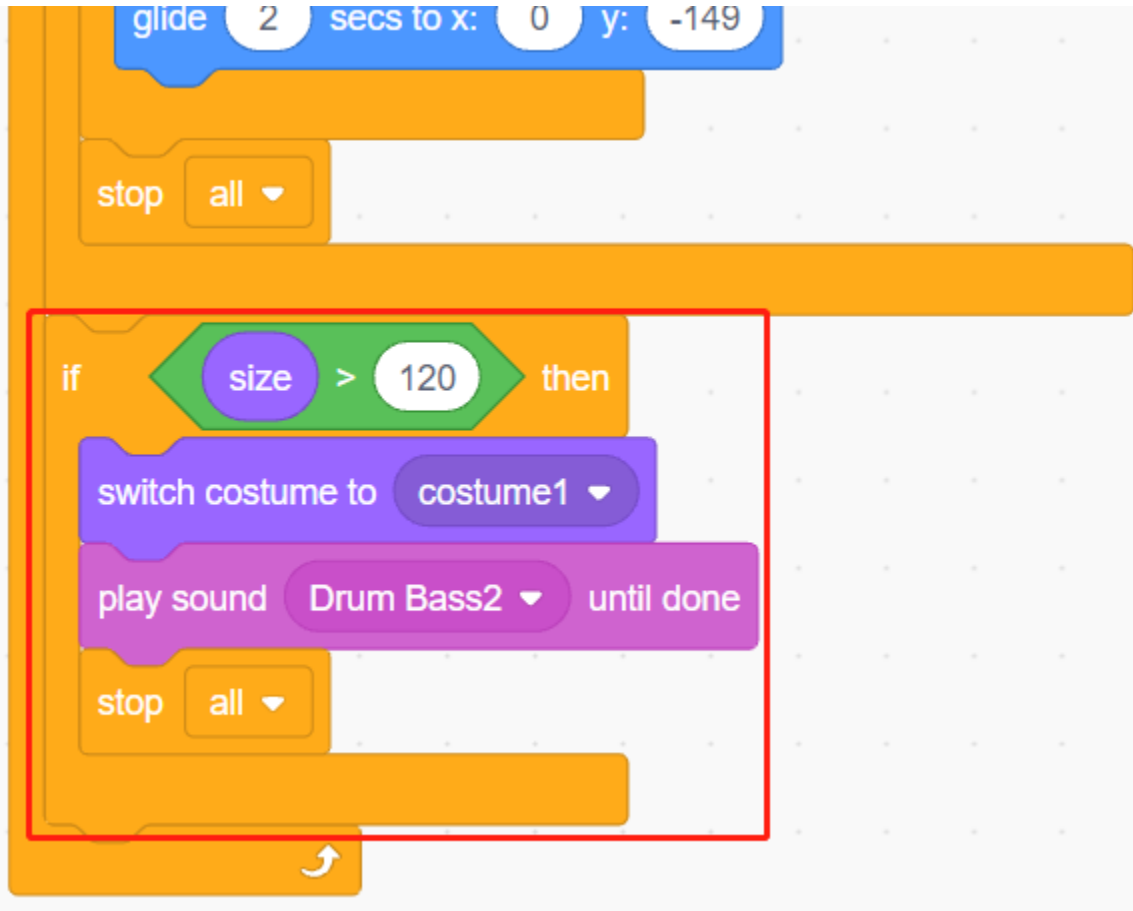


When the button is pressed (value is 1), the size of the **Balloon1** sprite stops getting bigger.

- When the size is less than 90, it will fall (y coordinate decreases).
- When the size is bigger than 90 and smaller than 120, it will fly to the sky (y coordinate increases).



If the button has not been pressed, the balloon slowly gets bigger and when the size is bigger than 120, it will explode (switch to the explode effect costume).

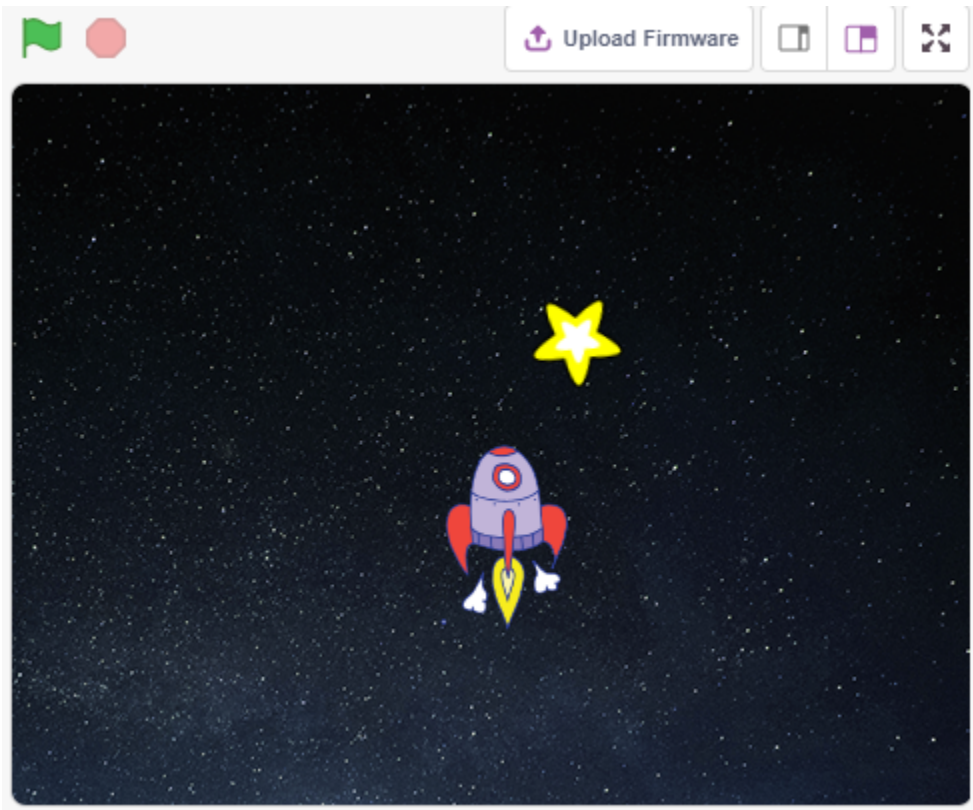


## 7.18 2.15 GAME - Star-Crossed

In the next projects, we will play some fun mini-games in PictoBlox.

Here we use Joystick module to play a Star-Crossed game.

After the script is run, stars will appear randomly on the stage, you need to use Joystick to control Rocketship to avoid the stars, if you touch it, the game will be over.



7.18.1 You Will Learn

- How Joystick module works
- Set the x and y coordinates of the sprite

7.18.2 Required Components

In this project, we need the following components.  
It’s definitely convenient to buy a whole kit, here’s the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>Joystick Module</i>	-

### 7.18.3 Build the Circuit

A joystick is an input device consisting of a stick that pivots on a base and reports its angle or direction to the device it is controlling. Joysticks are often used to control video games and robots.

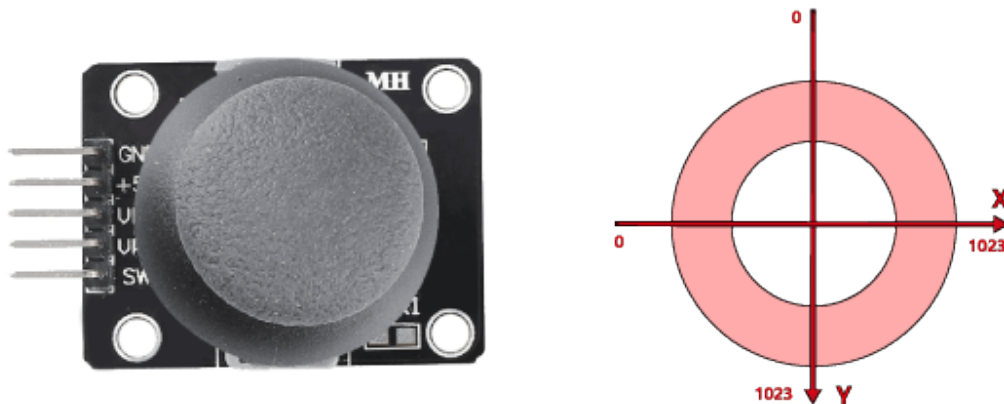
In order to communicate a full range of motion to the computer, a joystick needs to measure the stick's position on two axes – the X-axis (left to right) and the Y-axis (up and down).

The motion coordinates of the joystick are shown in the following figure.

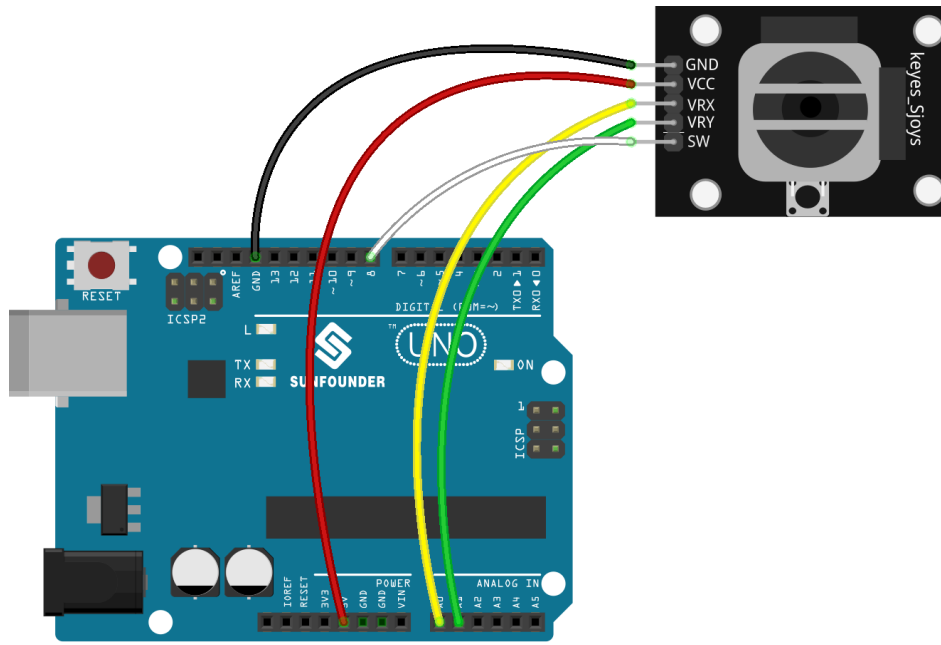
---

**Note:**

- The x coordinate is from left to right, the range is 0-1023.
  - y coordinate is from top to bottom, range is 0-1023.
- 



Now build the circuit according to the following diagram.



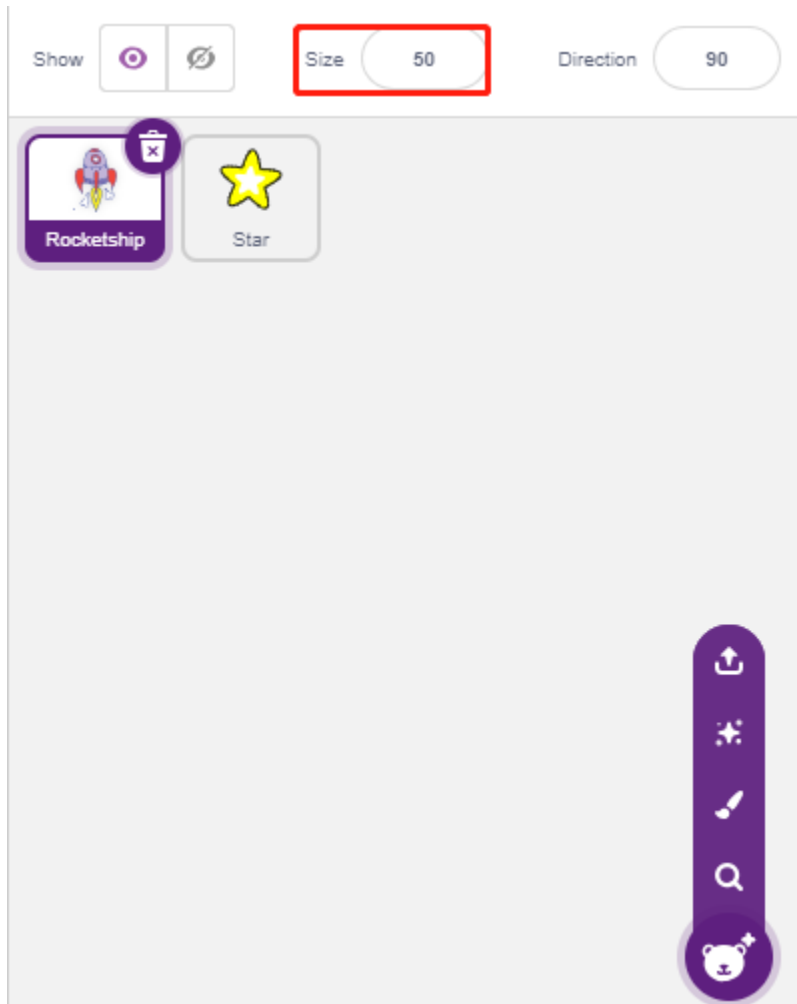
### 7.18.4 Programming

The whole script is to achieve the effect that when the green flag is clicked, the **Stars** sprite moves in a curve on the stage and you need to use the joystick to move the **Rocketship**, so that it will not be touched by the **Star** sprite.

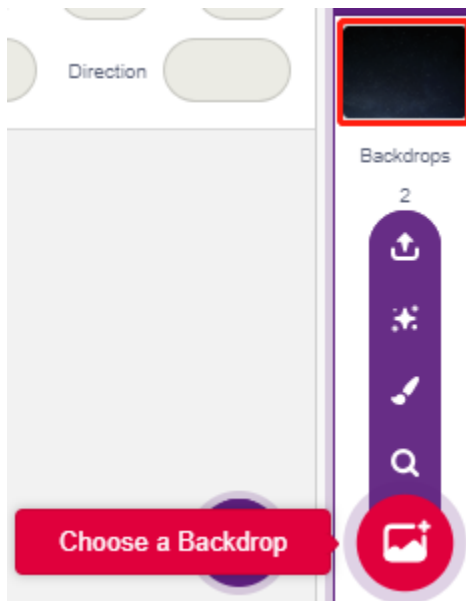
#### 1. Add sprites and backdrops

Delete the default sprite, and use the **Choose a Sprite** button to add the **Rocketship** sprite and the **Star** sprite. Note that the **Rocket** sprite size is set to 50%.





Now add the **Stars** backdrop by **Choose a Backdrop**.

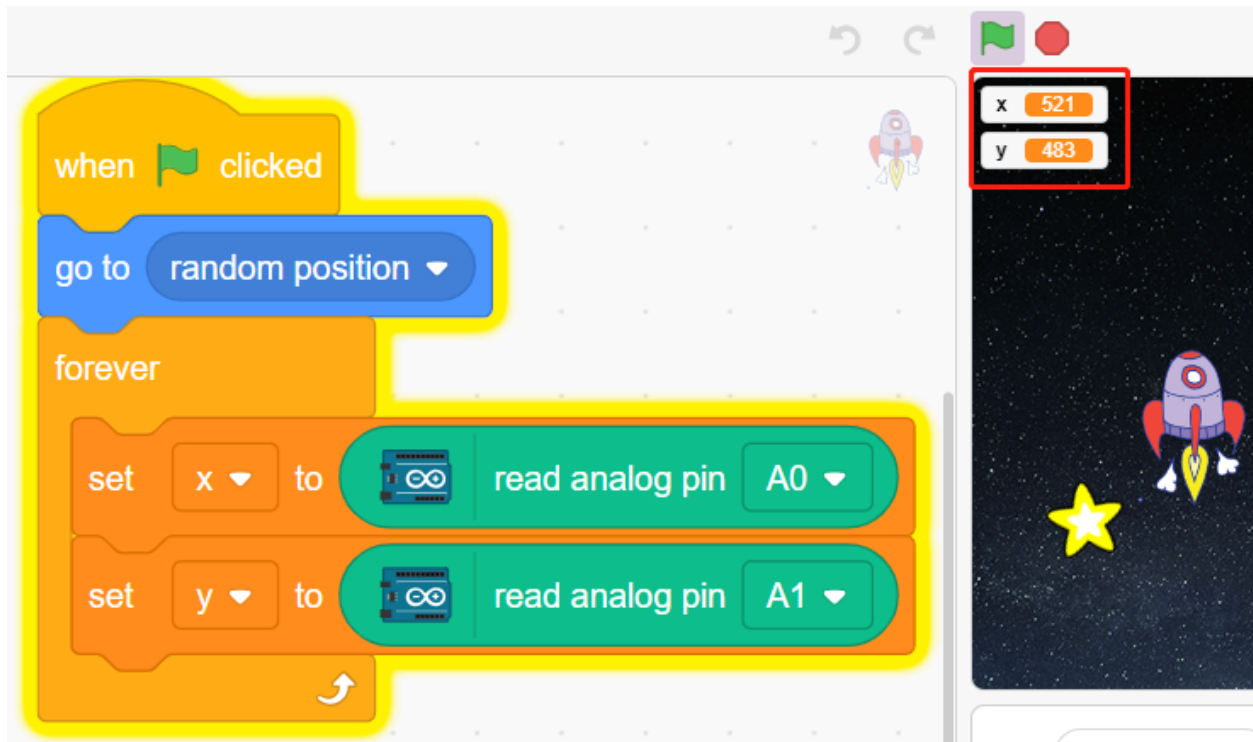


## 2. Scripting for Rocketship

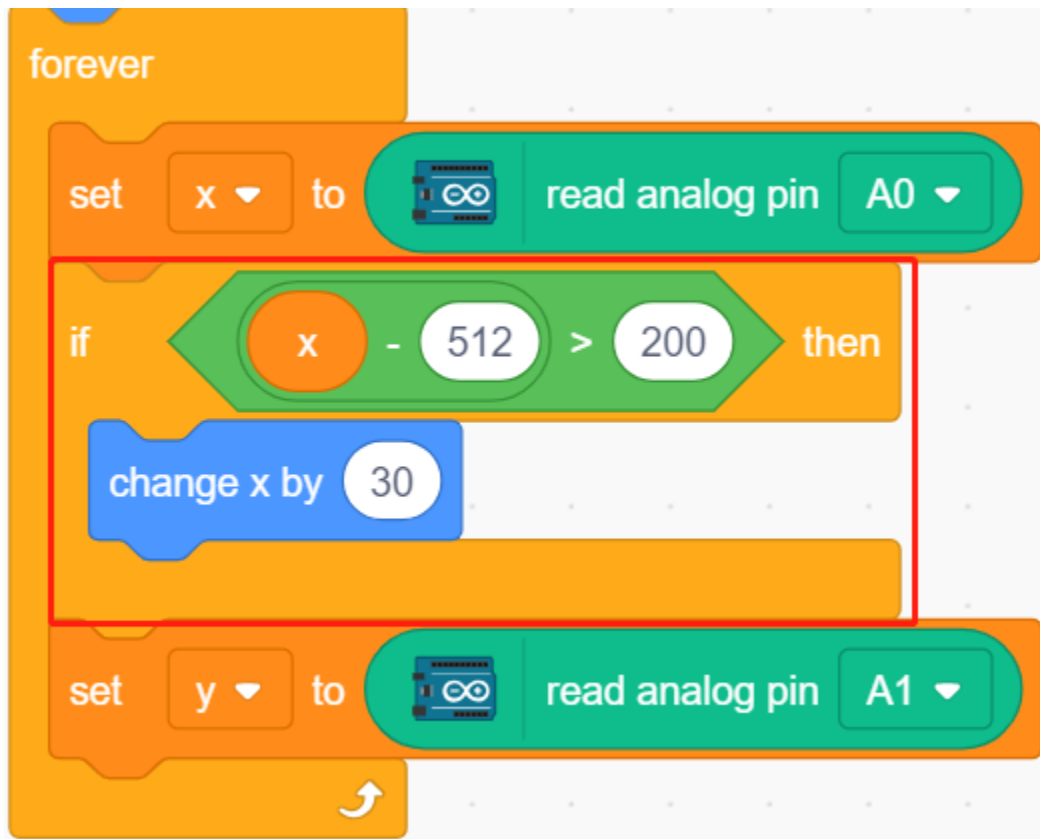
The **Rocketship** sprite is to achieve the effect that it will appear at a random position and then be controlled by the joystick to move it up, down, left, and right.

The workflow is as follows.

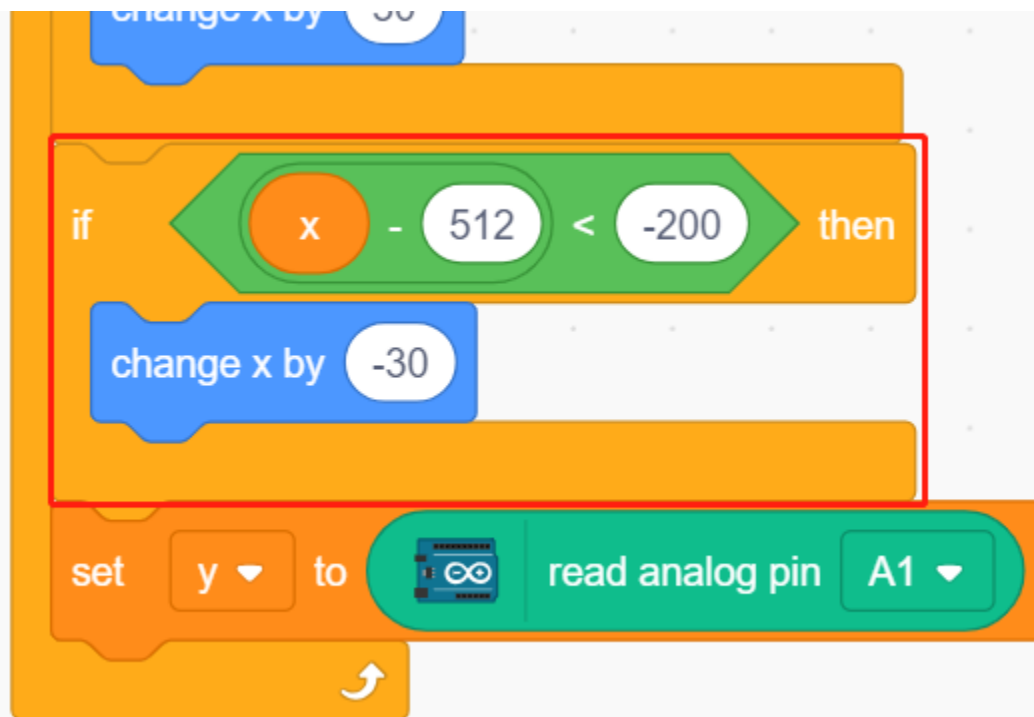
- When the green flag is clicked, have the sprite go to a random location and create 2 variables **x** and **y**, which store the values read from A0 (VRX of Joystick) and A1 (VRY of Joystick), respectively. You can let the script run, toggling the joystick up and down, left and right, to see the range of values for x and y.



- The value of A0 is in the range 0-1023 (the middle is about 512). Use  $x - 512 > 200$  to determine if Joystick is toggling to the right, and if so, make the x coordinate of the sprite +30 (to move the sprite to the right).

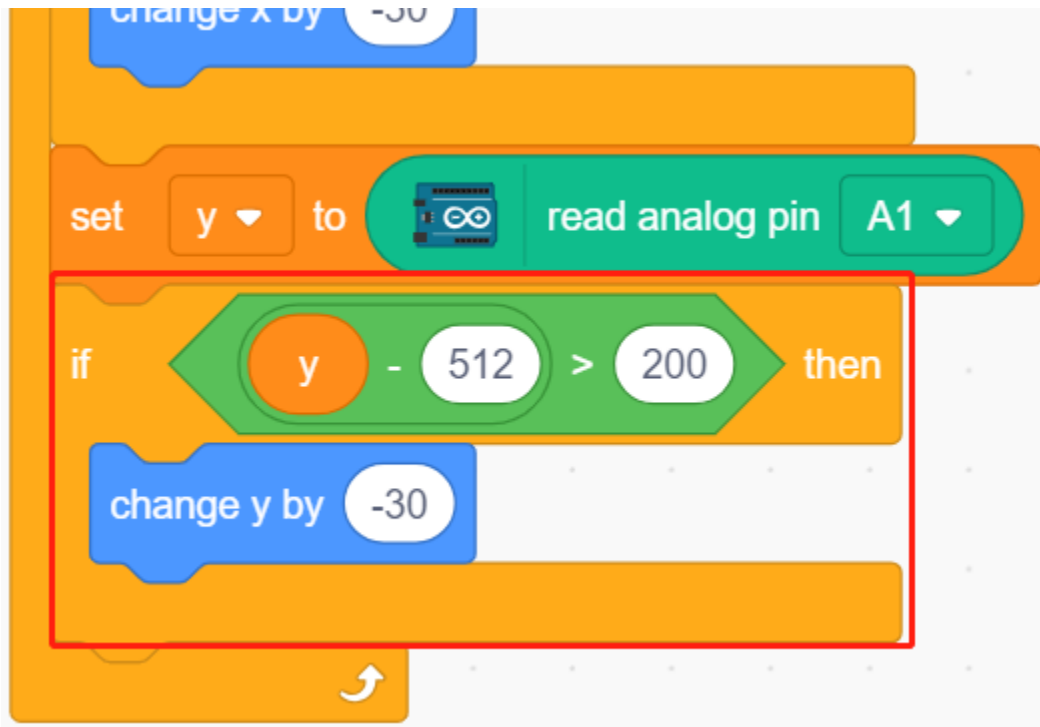


- If the Joystick is toggled to the left ( $x - 512 < -200$ ), let the x coordinate of the sprite be -30 (let the sprite move to the left).



- Since the Joystick's y coordinate is from up (0) to down (1023), and the sprite's y coordinate is from down to up.

So in order to move the Joystick upwards and the sprite upwards, the y-coordinate must be -30 in the script.



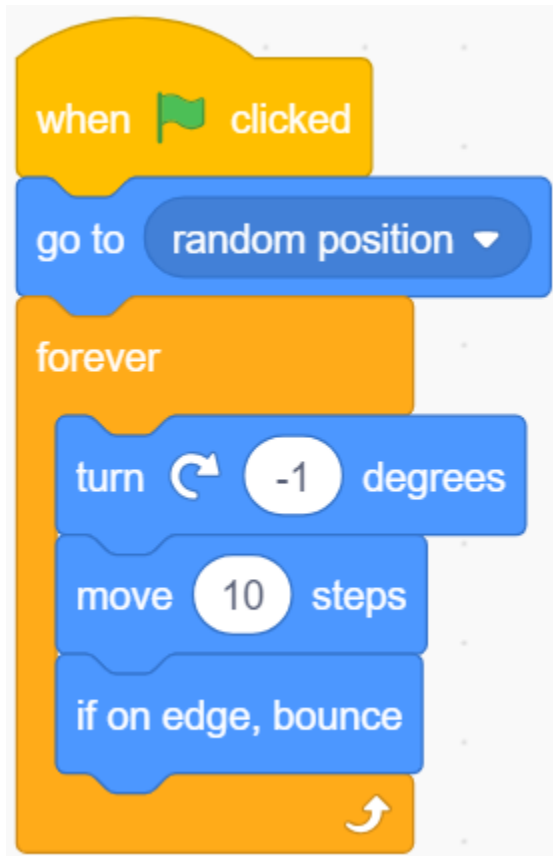
- If the joystick is flicked down, the y-coordinate of the sprite is +30.



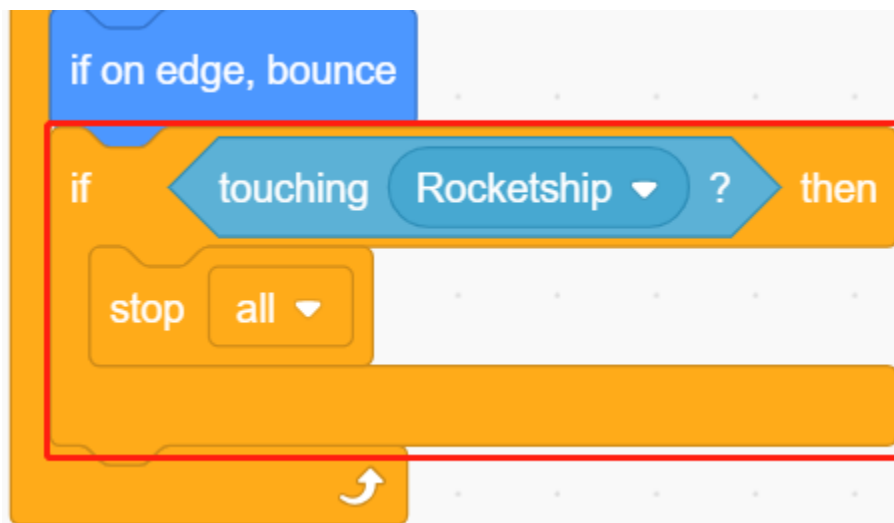
### 3. Scripting for Star

The effect to be achieved by the **Star** sprite is to appear at a random location, and if it hits **Rocketship**, the script stops running and the game ends.

- When the green flag is clicked and the sprite goes to a random location, the [turn degrees] block is to make the **Star** sprite move forward with a bit of an angle change so you can see that it is moving in a curve and if on edge, bounce.



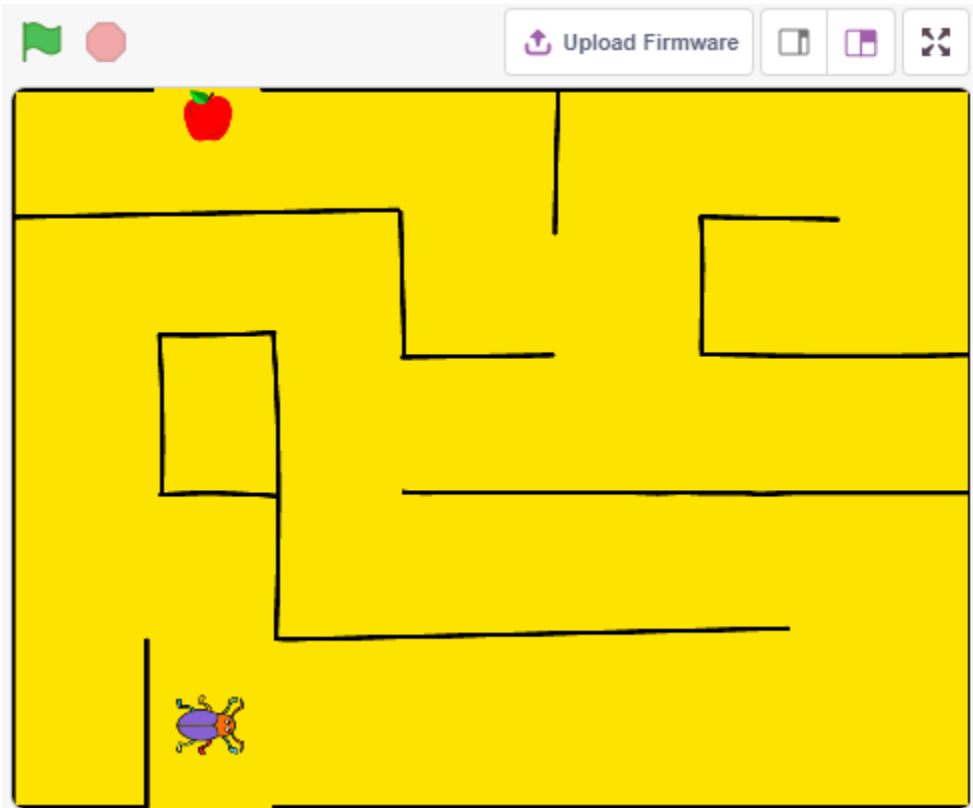
- If the sprite touches the **Rocketship** sprite while it's moving, stop the script from running.



## 7.19 2.16 GAME - Eat Apple

In this project, we play a game that uses button to control Beetle to eat apple.

When the green flag is clicked, press the button and Beetle will rotate, press the button again and Beetle stops running and goes forward at that angle. You need to control the angle of Beetle so that it moves forward without touching the black line on the map until it eats the apple. If it touches the black line, the game is over.



### 7.19.1 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

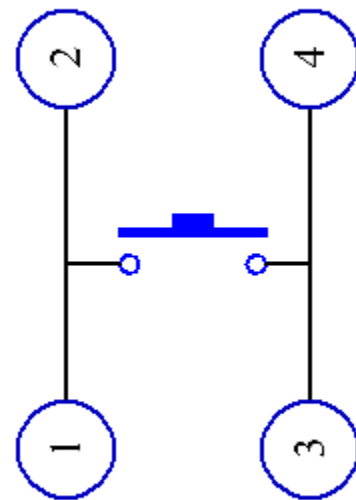
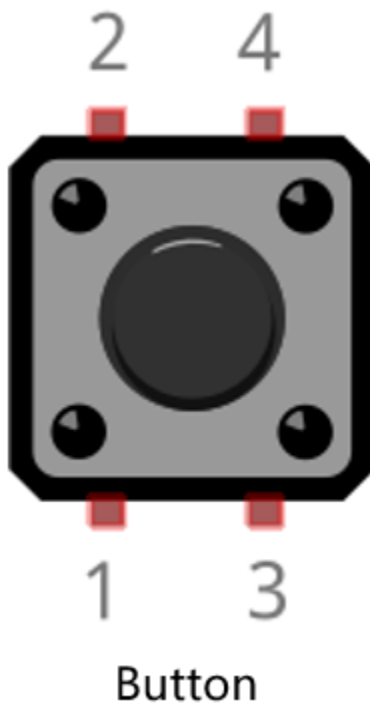
Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Capacitor</i>	
<i>Button</i>	

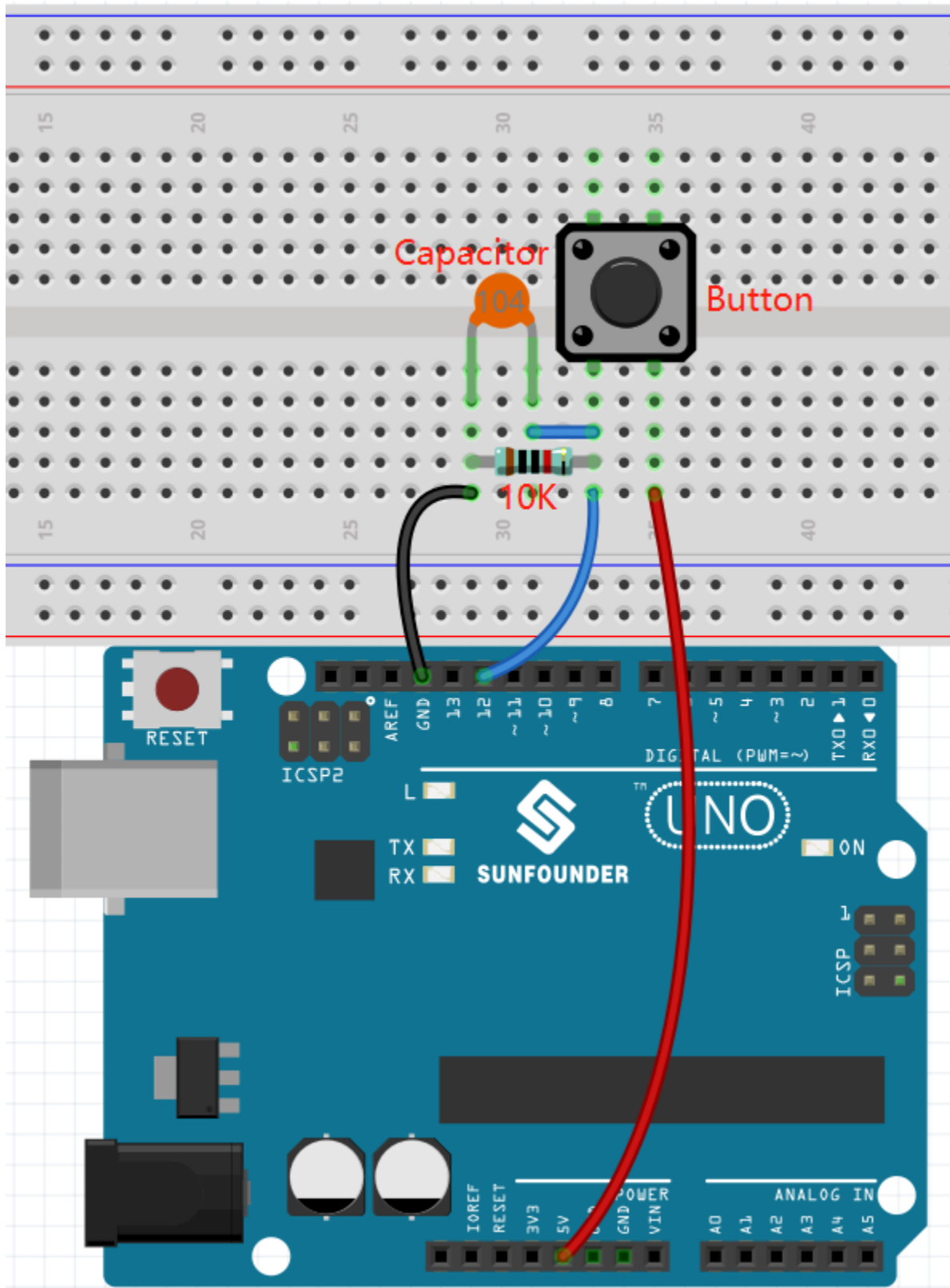
### 7.19.2 Build the Circuit

The button is a 4-pin device, since the pin 1 is connected to pin 2, and pin 3 to pin 4, when the button is pressed, the 4 pins are connected, thus closing the circuit.



Build the circuit according to the following diagram.

- Connect one of the pins on the left side of the button to pin 12, which is connected to a pull-down resistor and a 0.1uF (104) capacitor (to eliminate jitter and output a stable level when the button is working).
- Connect the other end of the resistor and capacitor to GND, and one of the pins on the right side of the button to 5V.





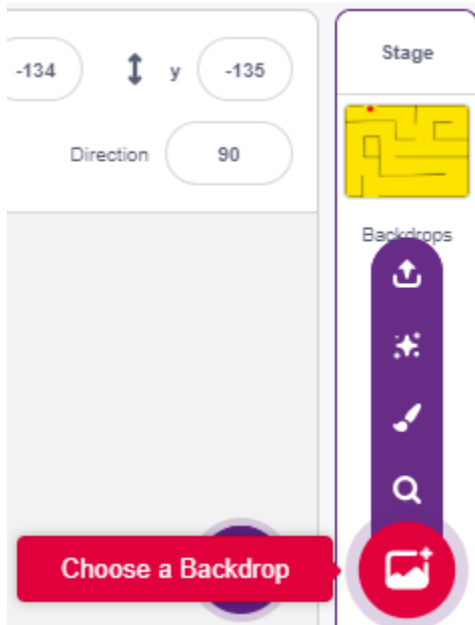
### 7.19.3 Programming

The effect we want to achieve is to use the button to control the direction of the **Beetle** sprite to move forward and eat the apple without touching the black line on the **Maze** backdrop, which will switch the backdrop when eaten.

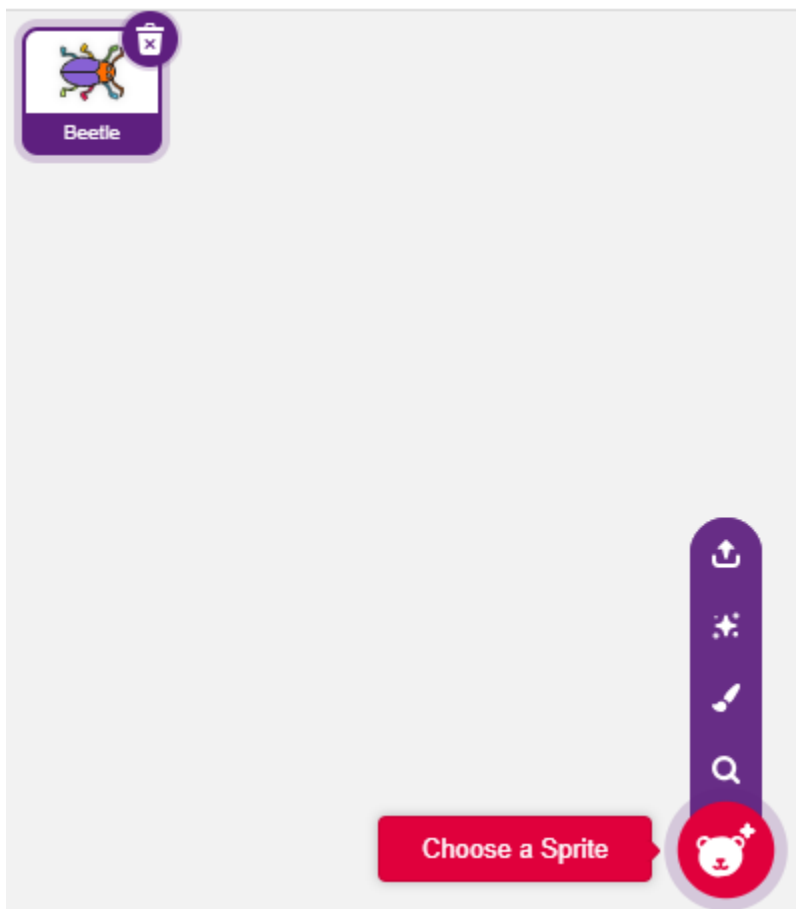
Now add the relevant backdrops and sprites.

#### 1. Adding backdrops and sprites

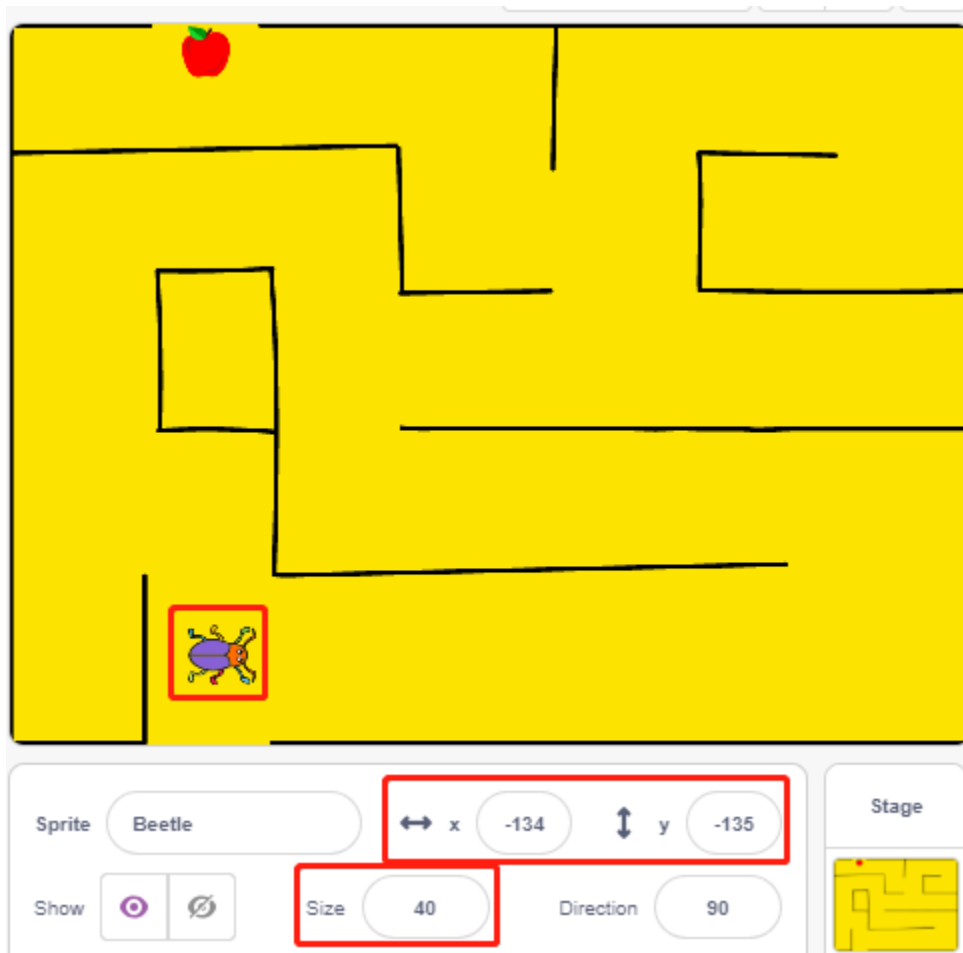
Add a **Maze** backdrop via the **Choose a backdrop** button.



Delete the default sprite, then select the **Beetle** sprite.



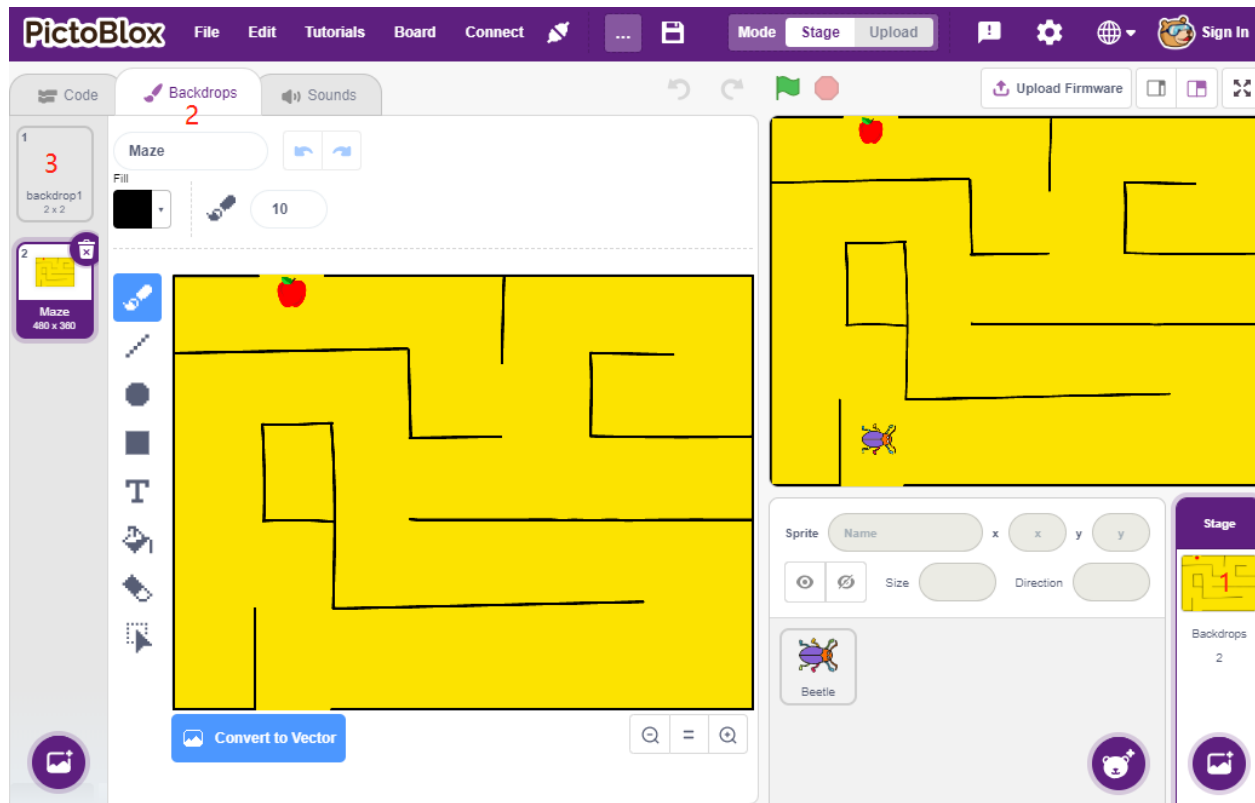
Place the **Beetle** sprite at the entrance of the **Maze** backdrop, remembering the x,y coordinate values at this point, and resize the sprite to 40%.



## 2. Draw a backdrop

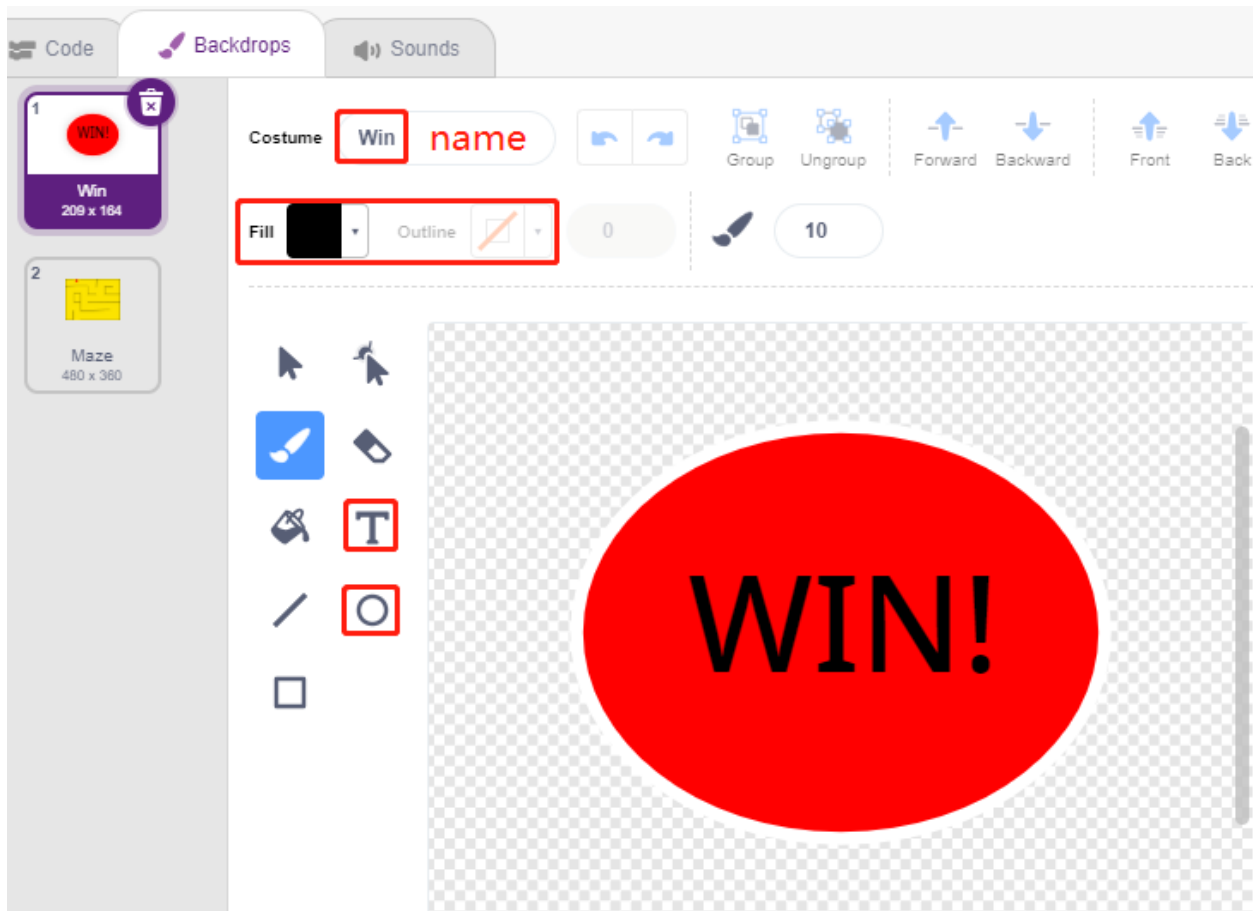
Now it's time to simply draw a backdrop with the WIN! character appearing on it.

First click on the backdrop thumbnail to go to the **Backdrops** page and click on the blank backdrop1.



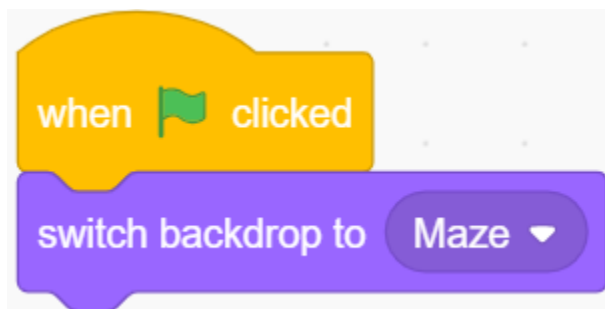
Now start drawing, you can refer to the picture below to draw, or you can draw a backdrop on your own, as long as the expression is winning.

- Using the **Circle** tool, draw an ellipse with the color set to red and no outline.
- Then use the **Text** tool, write the character "WIN!", set the character color to black, and adjust the size and position of the character.
- Name the backdrop as **Win**.



### 3. Scripting for the backdrop

The backdrop needs to be switched to **Maze** every time the game starts.



### 4. Writing scripts for the sprite Beetle

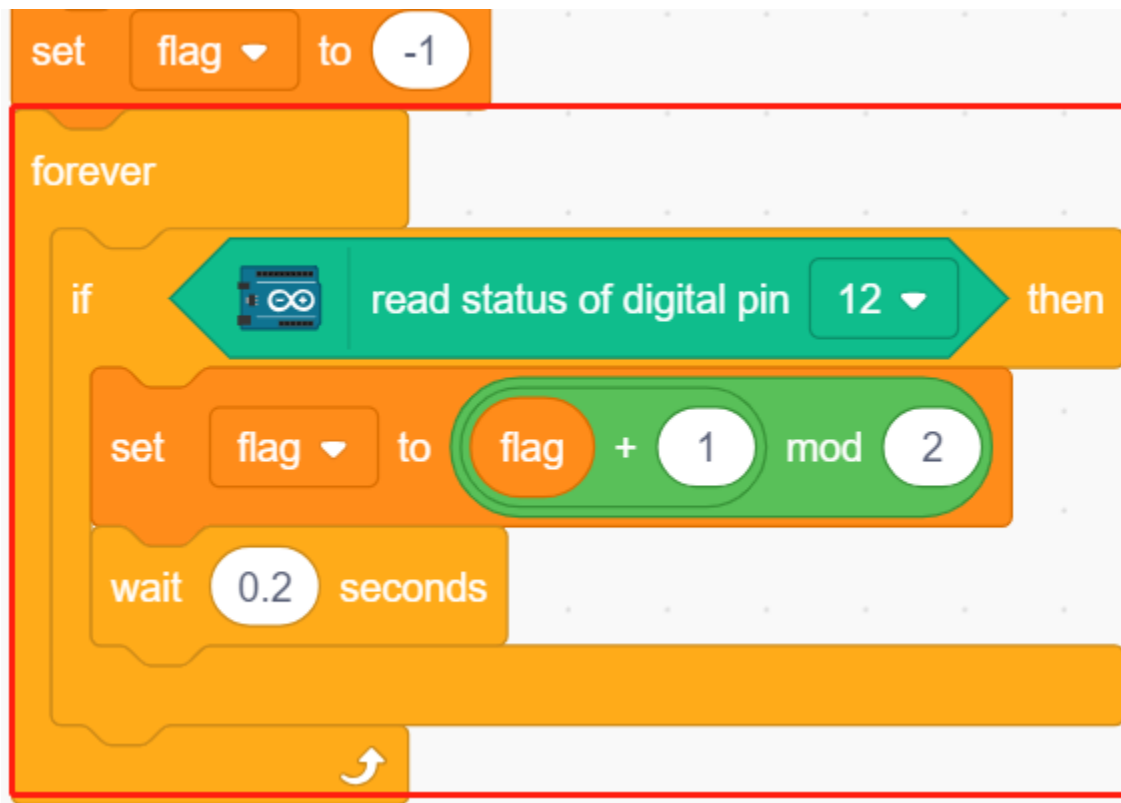
Now write a script for the sprite **Beetle** to be able to move forward and turn direction under the control of a button. The workflow is as follows.

- When the green flag is clicked, set the **Beetle** angle to 90, and the position to (-134, -134), or replace it with the coordinate value of your own placed position. Create the variable **flag** and set the initial value to -1.

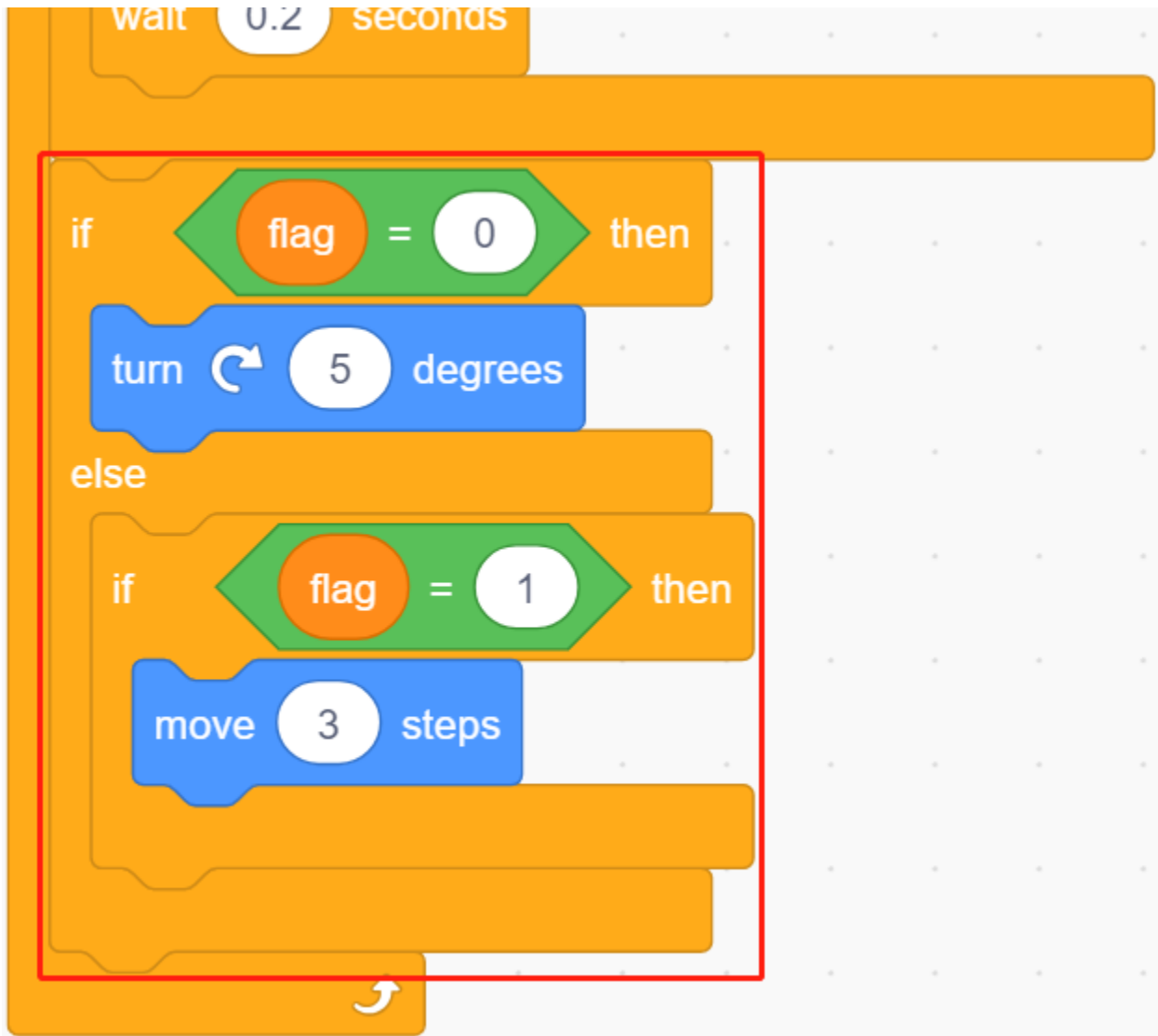


Next, in the [forever] block, four [if] blocks are used to determine various possible scenarios.

- If the key is 1 (pressed), use the [mod] block to toggle the value of the variable **flag** between 0 and 1 (alternating between 0 for this press and 1 for the next press).

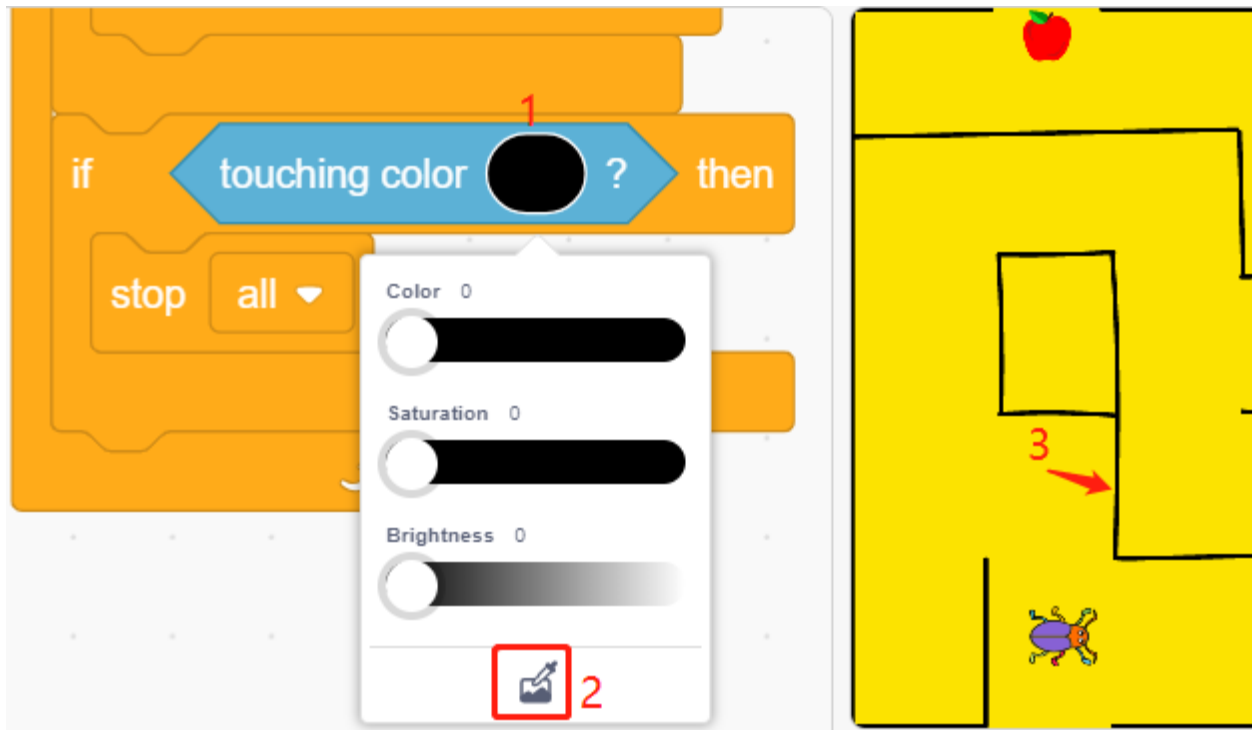


- If flag=0 (this key press), let the **Beetle** sprite turn clockwise. Then determine if flag is equal to 1 (key pressed again), the **Beetle** sprite moves forward. Otherwise, it keeps turning clockwise.



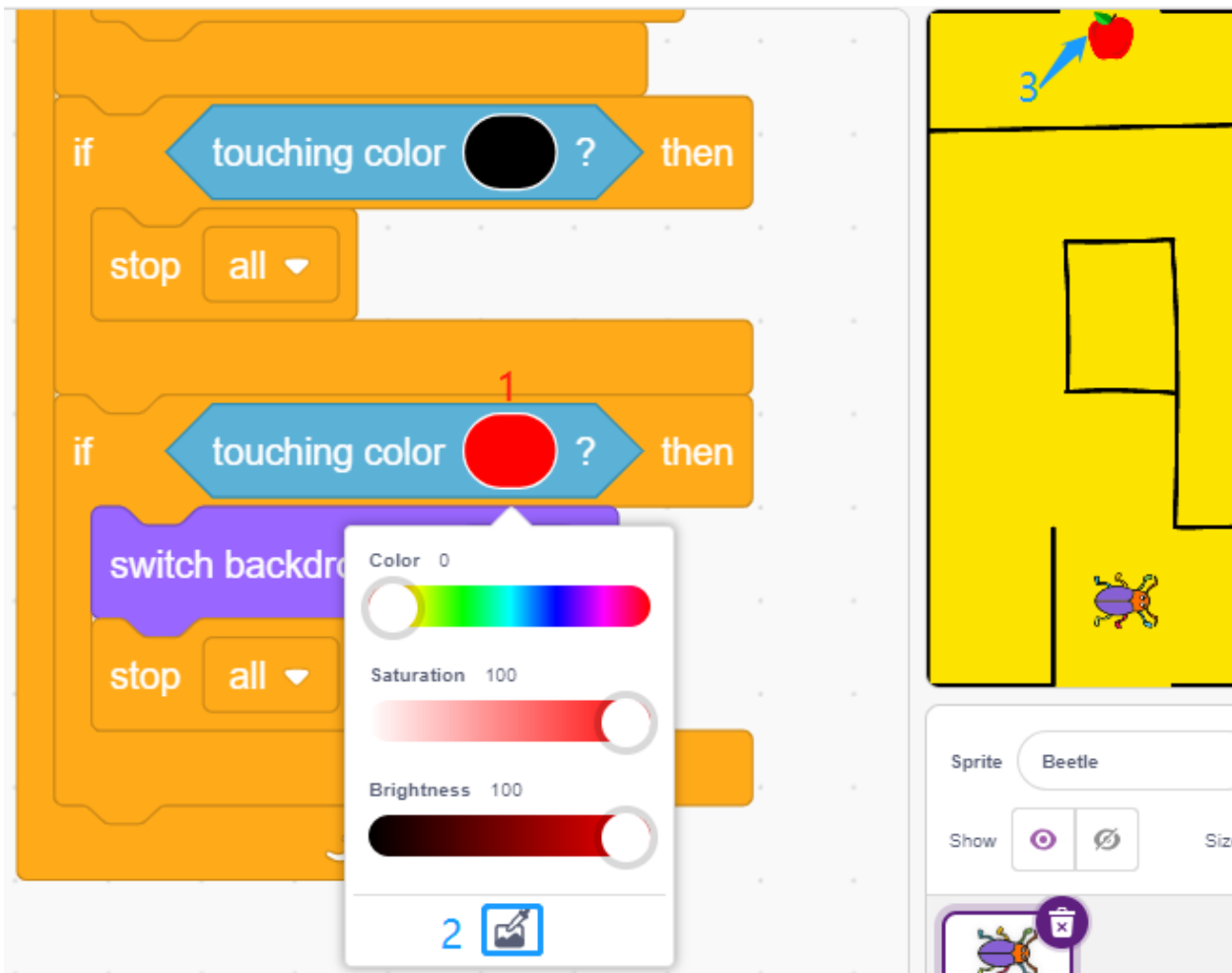
- If the Beetle sprite touches black (the black line on the **Maze** backdrop), the game ends and the script stops running.

**Note:** You need to click on the color area in the [Touch color] block, and then select the eyedropper tool to pick up the color of the black line on the stage. If you choose a black arbitrarily, this [Touch color] block will not work.



- If Beetle touches red (Also use the straw tool to pick up the red color of the apple), the backdrop will be switched to **Win**, which means the game succeeds and stops the script from running.

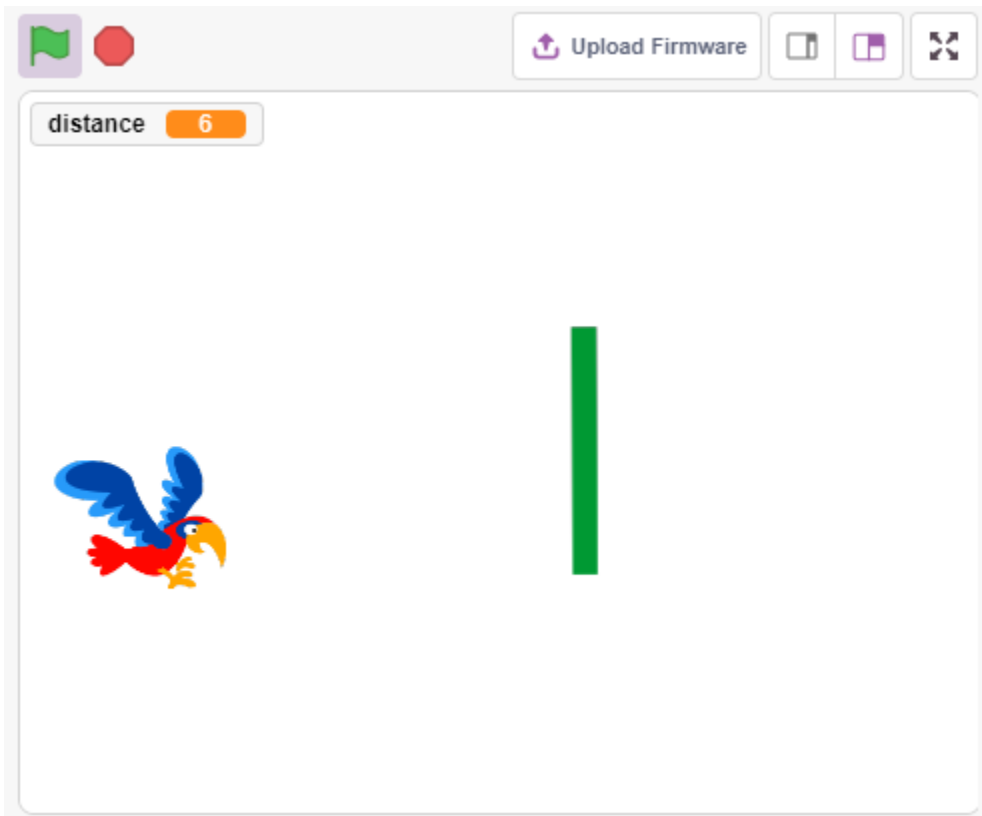




## 7.20 2.17 GAME - Flappy Parrot

Here we use the ultrasonic module to play a flappy parrot game.

After the script runs, the green bamboo will slowly move from the right to the left at a random height. Now place your hand on top of the ultrasonic module, if the distance between your hand and the ultrasonic module is less than 10, the parrot will fly upwards, otherwise it will fall downwards. You need to control the distance between your hand and the ultrasonic module so that the Parrot can avoid the green bamboo (Paddle), if it touches it, the game is over.



### 7.20.1 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

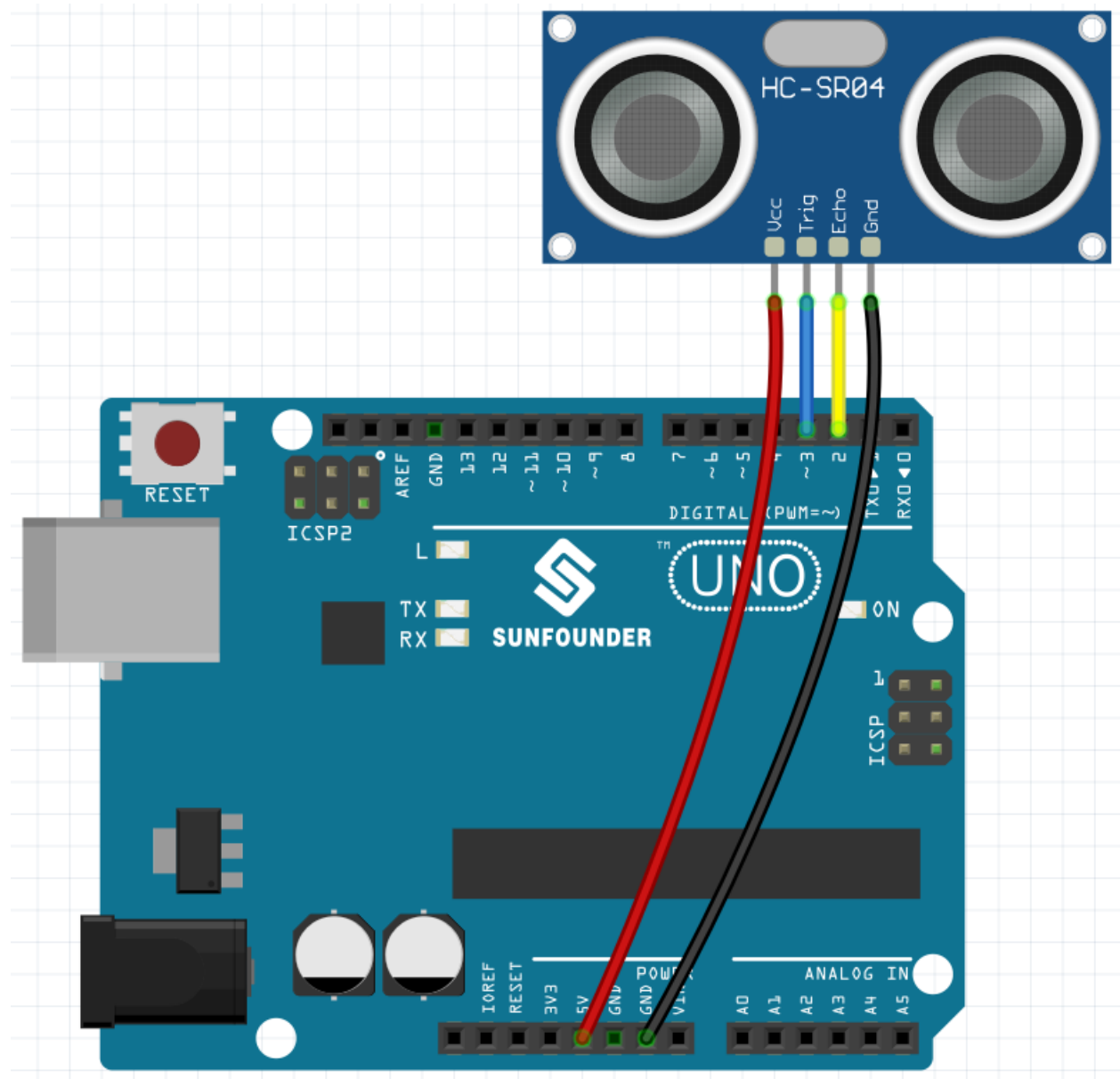
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>Ultrasonic Module</i>	

## 7.20.2 Build the Circuit

An ultrasonic sensor module is an instrument that measures the distance to an object using ultrasonic sound waves. It has two probes. One is to send ultrasonic waves and the other is to receive the waves and transform the time of sending and receiving into a distance, thus detecting the distance between the device and an obstacle.

Now build the circuit according to the following diagram.

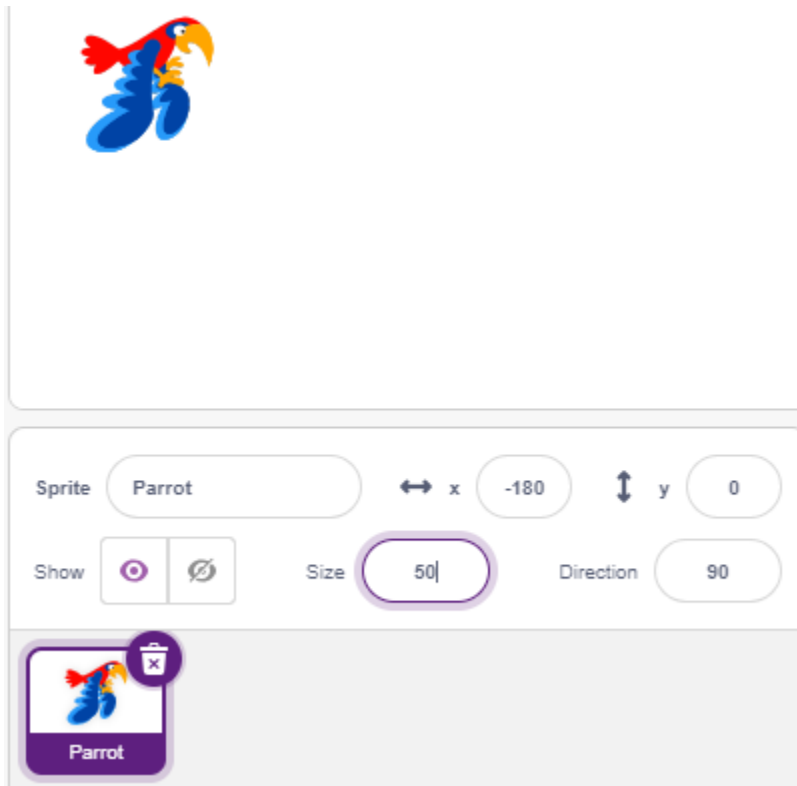


### 7.20.3 Programming

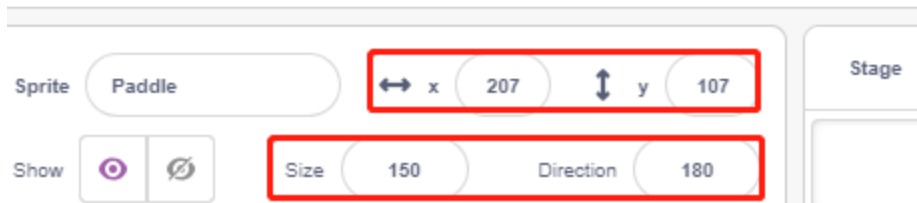
The effect we want to achieve is to use the ultrasonic module to control the flight height of the sprite **Parrot**, while avoiding the **Paddle** sprite.

#### 1. Add a sprite

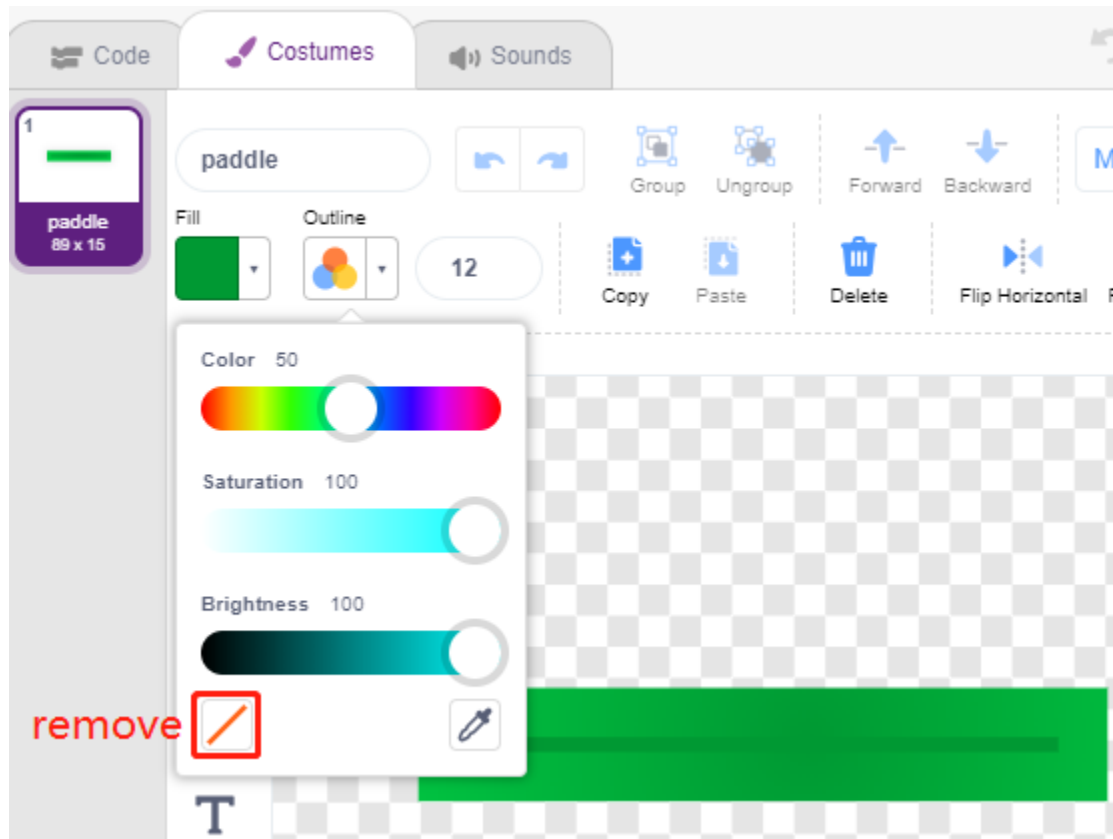
Delete the default sprite, and use the **Choose a Sprite** button to add the **Parrot** sprite. Set its size to 50%, and move its position to the left center.



Now add the **Paddle** sprite, set its size to 150%, set its angle to 180, and move its initial position to the top right corner.



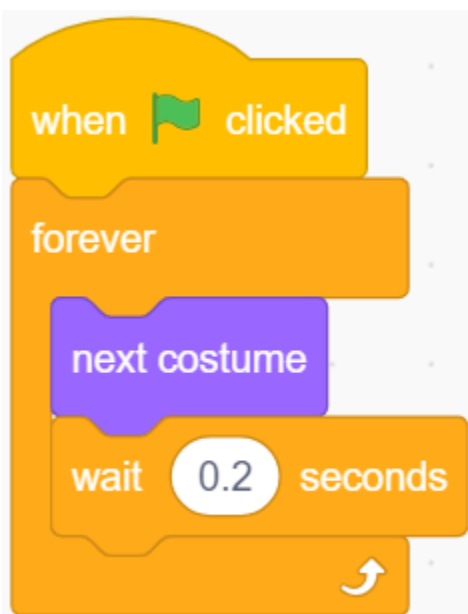
Go to the **Costumes** page of the **Paddle** sprite and remove the Outline.



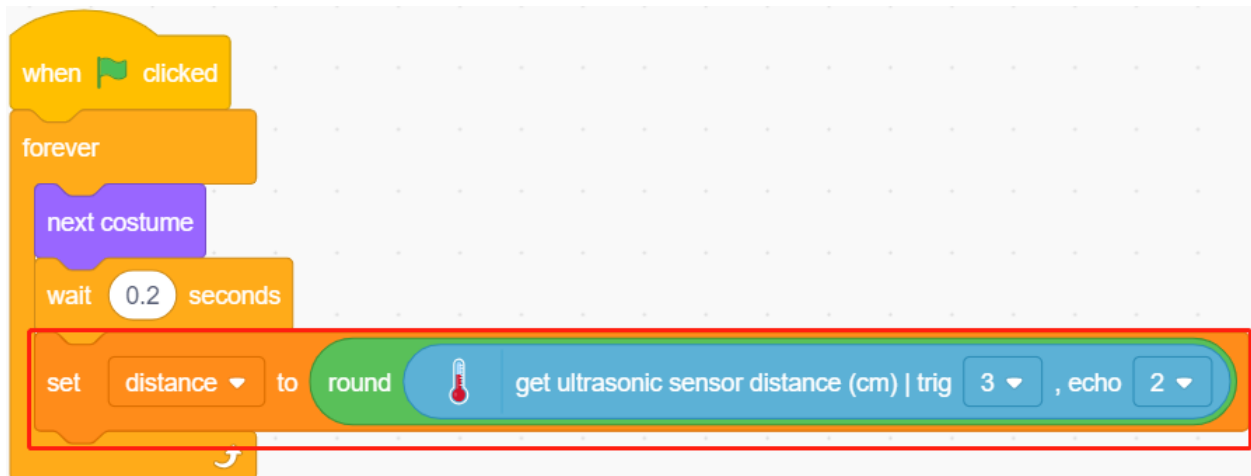
## 2. Scripting for the Parrot Sprite

Now script the **Parrot** sprite, which is in flight and the flight altitude is determined by the detection distance of the ultrasonic module.

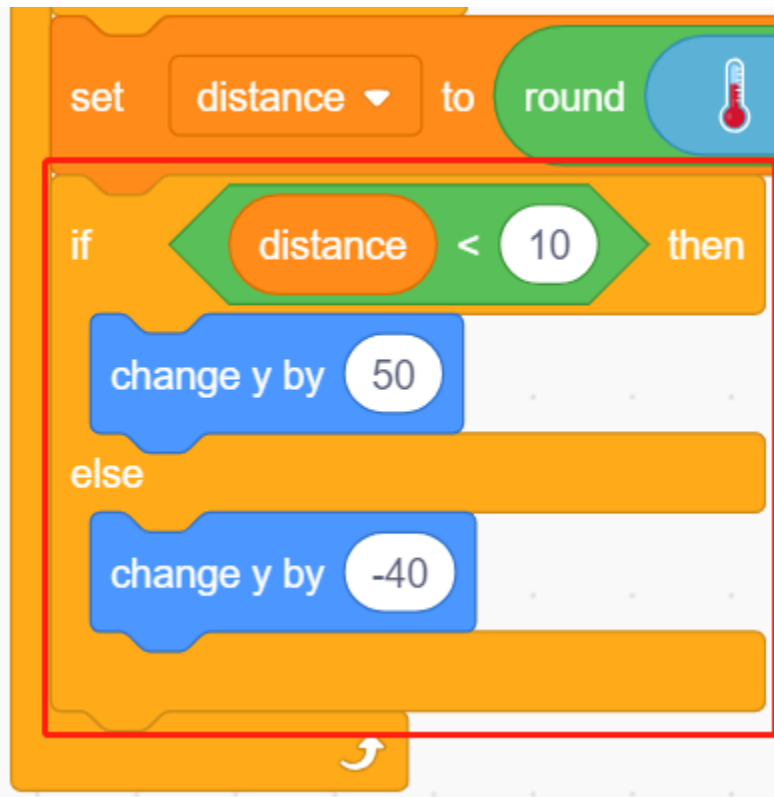
- When the green flag is clicked, switch the costume every 0.2s so that it is always in flight.



- Read the value of the ultrasonic module and store it in the variable **distance** after rounding it with the [round] block.



- If the ultrasonic detection distance is less than 10cm, let the y coordinate increase by 50, the **Parrot** sprite will fly upwards. Otherwise, the y-coordinate value is decreased by 40, **Parrot** will fall down.



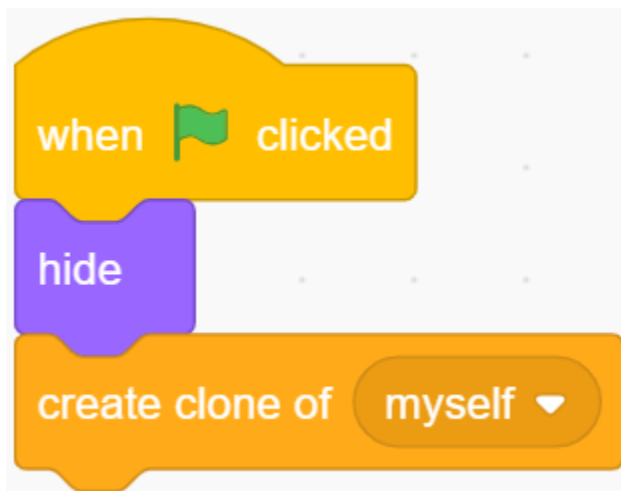
- If the **Parrot** sprite touches the **Paddle** sprite, the game ends and the script stops running.



### 3. Scripting for the Paddle sprite

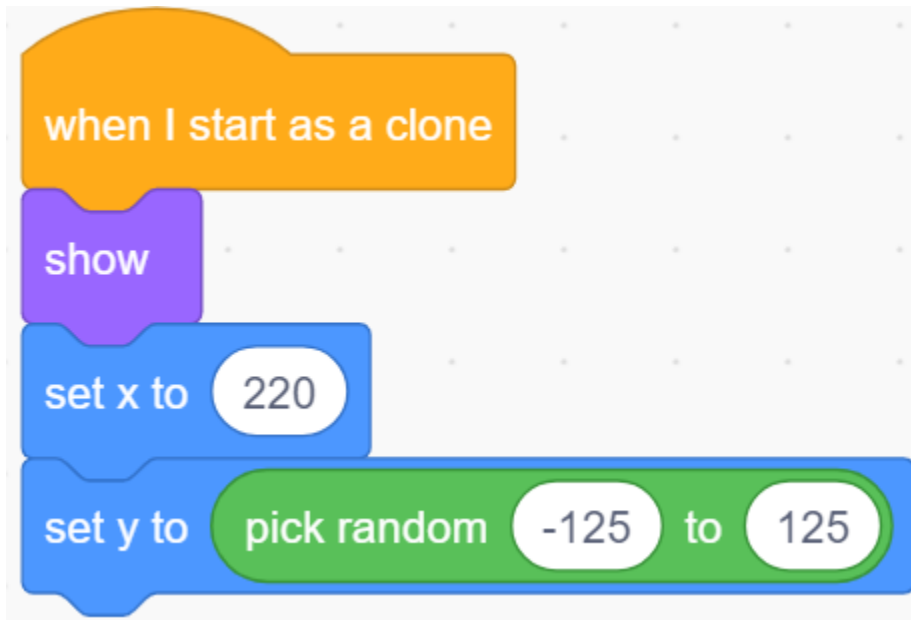
Now write the script for the **Paddle** sprite, which needs to appear randomly on the stage.

- Hide the sprite **Paddle** when the green flag is clicked, and clone itself at the same time. The [create clone of] block is a control block and a stack block. It creates a clone of the sprite in the argument. It can also clone the sprite it is running in, creating clones of clones, recursively.

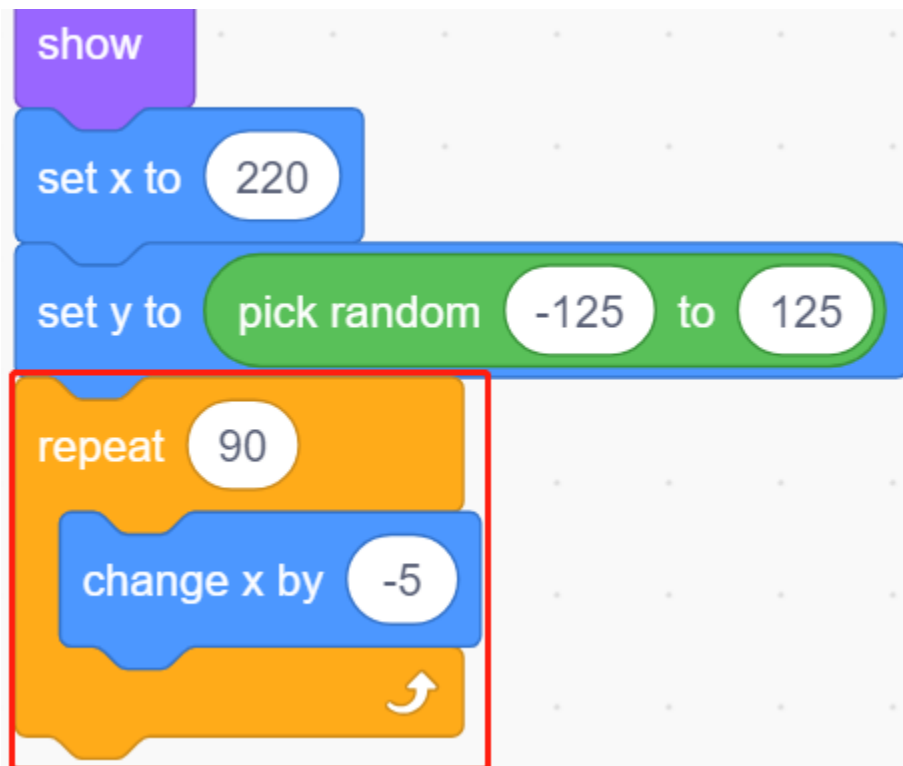


- When **Paddle** is presented as a clone, its position is 220 (rightmost) for the x-coordinate and its y-coordinate at (-125 to 125) random (height random).

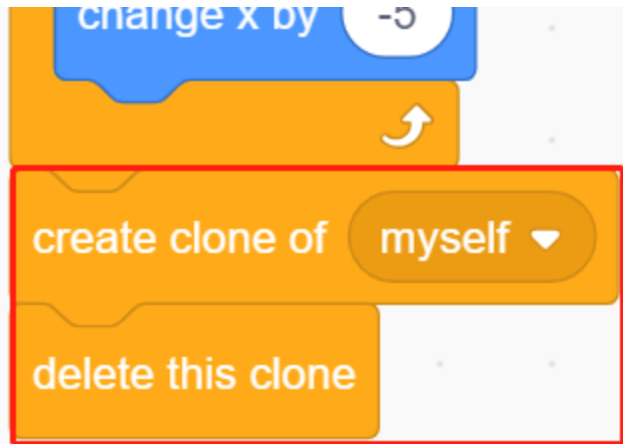




- Use the [repeat] block to make its x coordinate value slowly decrease, so you can see the clone of the **Paddle** sprite slowly move from the right to the left until it disappears.



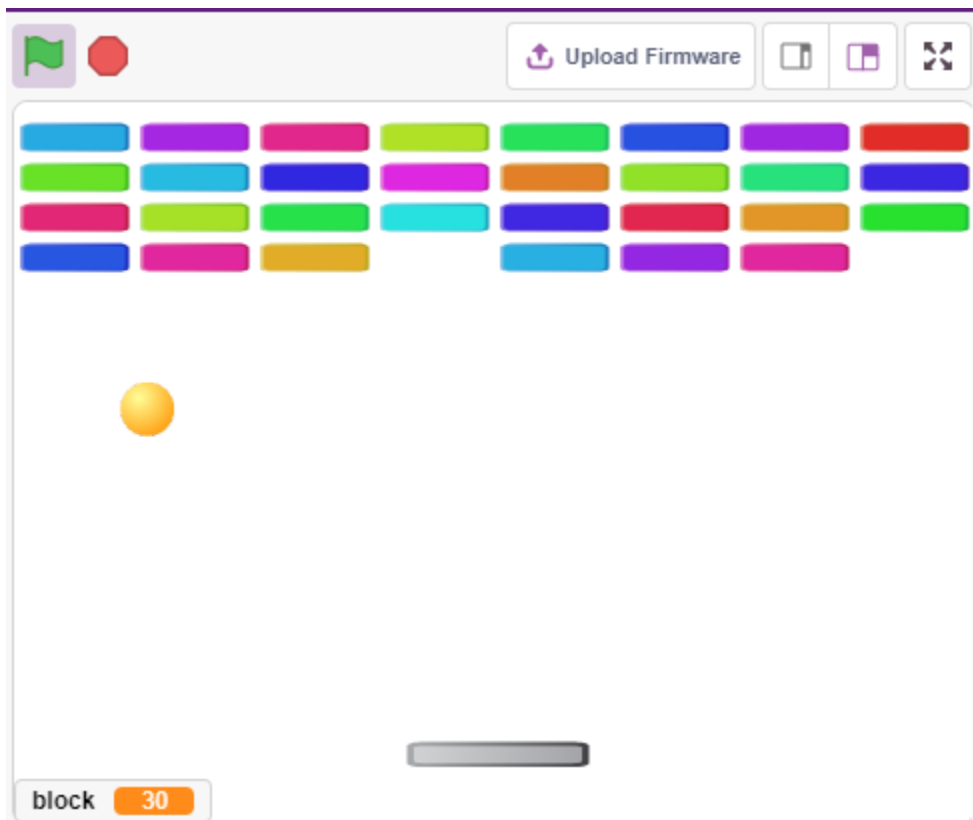
- Re-clone a new **Paddle** sprite and delete the previous clone.



## 7.21 2.18 GAME - Breakout Clone

Here we use the potentiometer to play a Breakout Clone game.

After clicking the green flag, you need to use the potentiometer to control the paddle on the stage to catch the ball so that it can go up and hit the bricks, all the bricks disappear then the game is won, if you don't catch the ball, the game is lost.



### 7.21.1 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

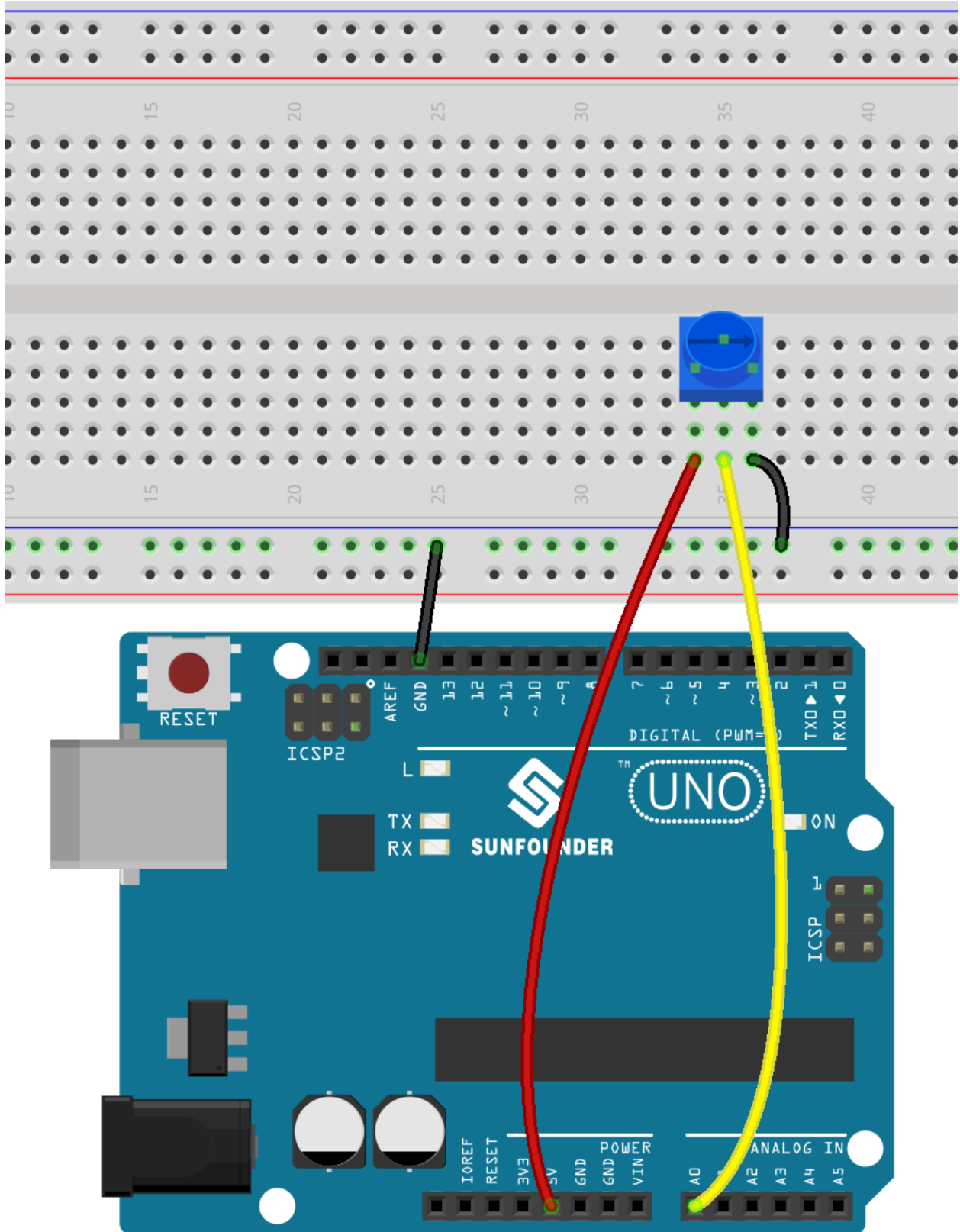
Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Potentiometer</i>	

### 7.21.2 Build the Circuit

The potentiometer is a resistive element with 3 terminals, the 2 side pins are connected to 5V and GND, and the middle pin is connected to A0. After the conversion by the ADC converter of the Arduino board, the value range is 0-1023.



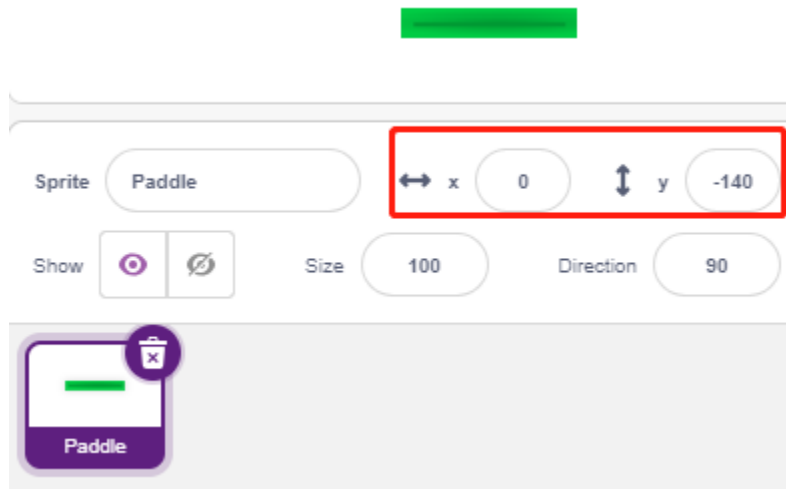
### 7.21.3 Programming

There are 3 sprites on the stage.

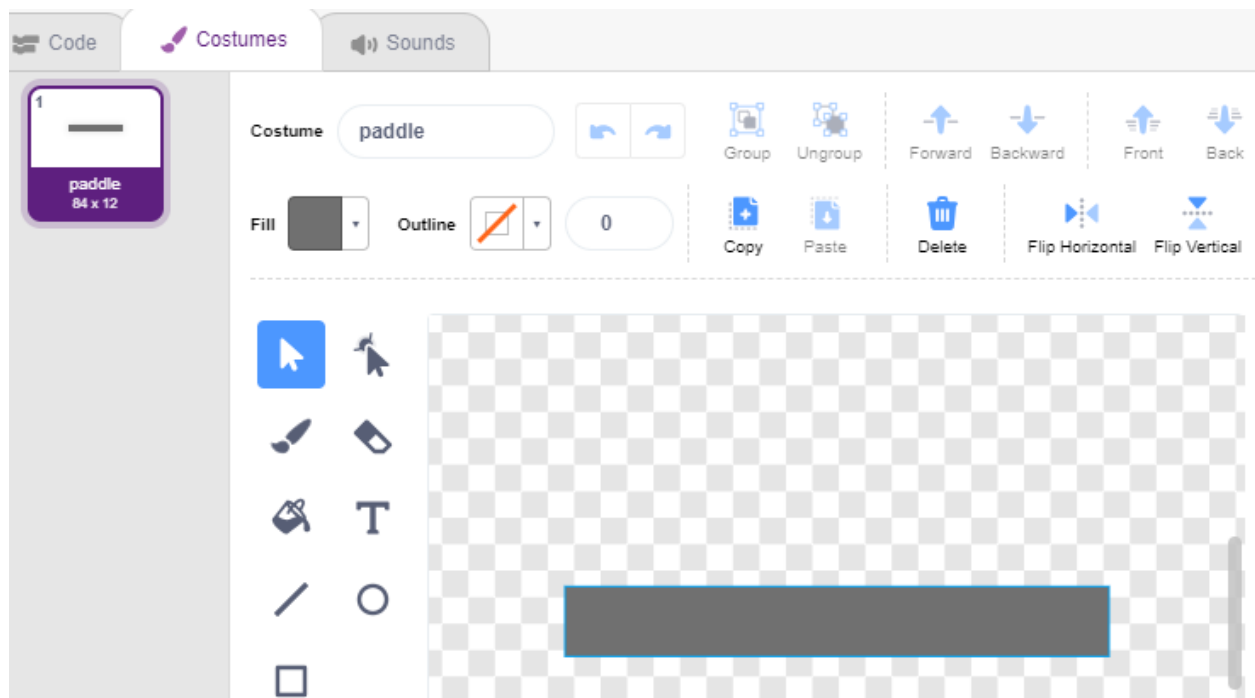
#### 1. Paddle sprite

The effect to be achieved by the **Paddle** is that the initial position is in the middle of the bottom of the stage, and it is controlled by a potentiometer to move it to the left or to the right.

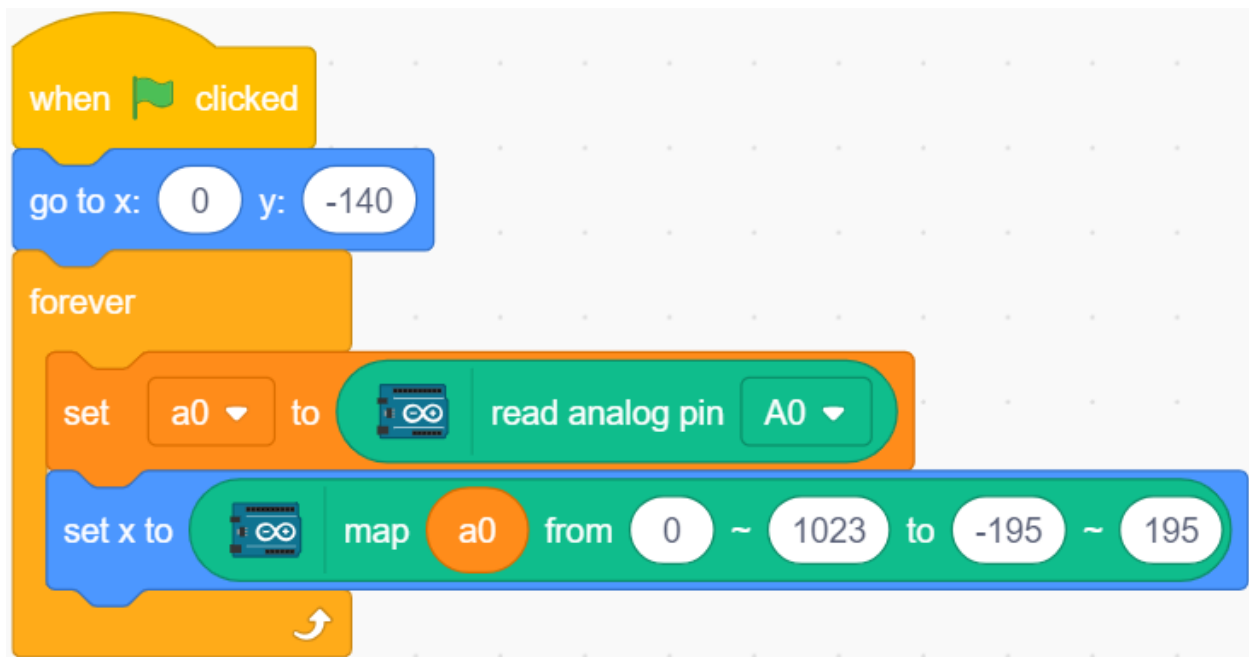
- Delete the default sprite, use the **Choose a Sprite** button to add the **Paddle** sprite, and set its x and y to (0, -140).



- Go to the **Costumes** page, remove the Outline and change its color to dark gray.



- Now script the **Paddle** sprite to set its initial position to (0, -140) when the green flag is clicked, and read the value of A0 (potentiometer) into the variable **a0**. Since the **Paddle** sprite moves from left to right on the stage at x-coordinates -195~195, you need to use the [map] block to map the variable **a0** range 0~1023 to -195~195.

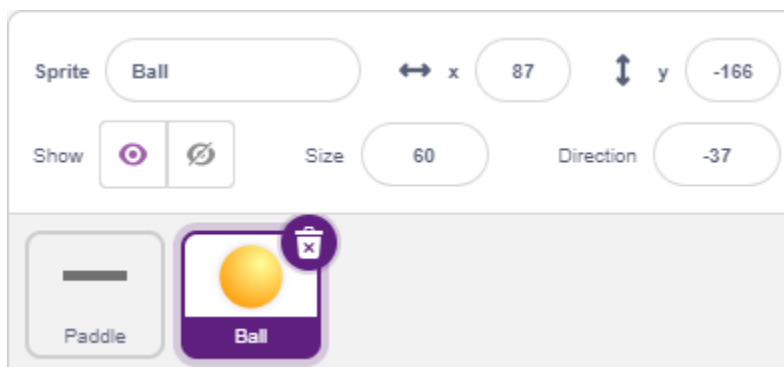


- Now you can rotate the potentiometer to see if the **Paddle** can move left and right on the stage.

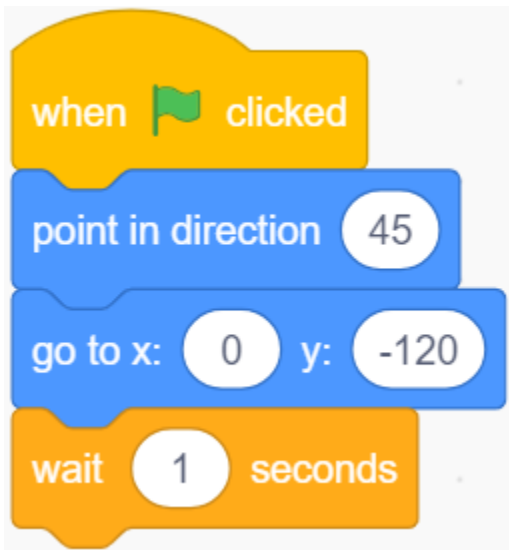
## 2. Ball sprite

The effect of the ball sprite is that it moves around the stage and bounces when it touches the edge; it bounces down if it touches the block above the stage; it bounces up if it touches the Paddle sprite during its fall; if it doesn't, the script stops running and the game ends.

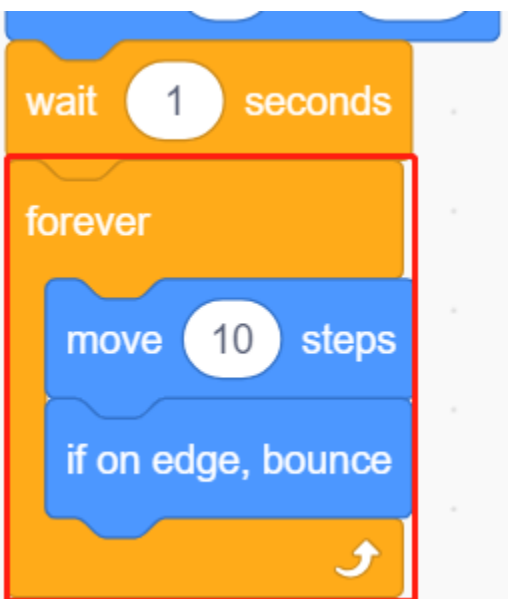
- Add **Ball** sprite.



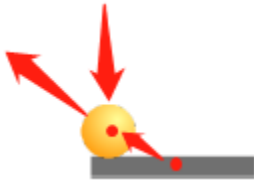
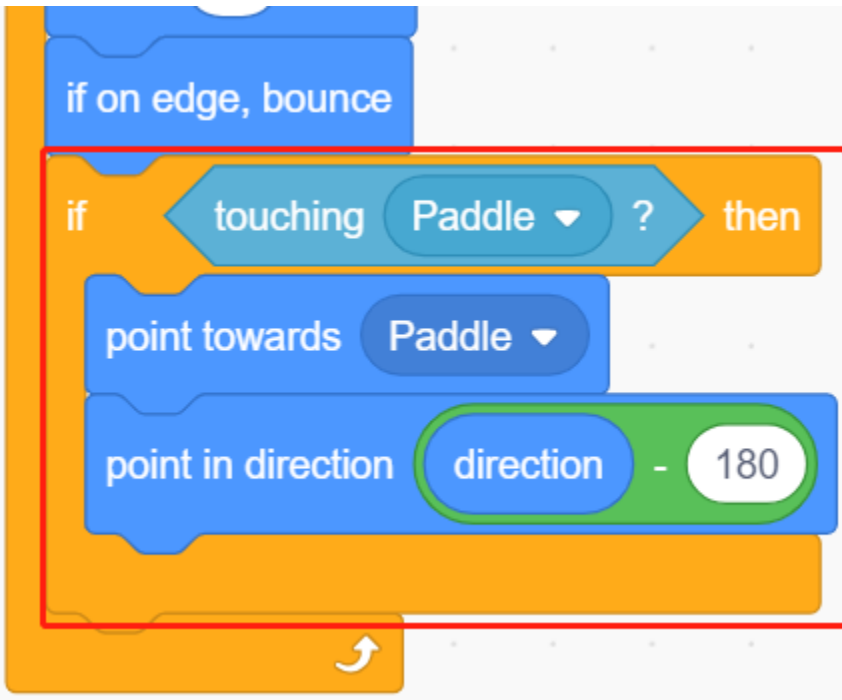
- When the green flag is clicked, set the angle of the **Ball** sprite to 45° and set the initial position to (0, -120).



- Now let the **Ball** sprite move around the stage and bounce when it touches the edge, and you can click on the green flag to see the effect.



- When the **Ball** sprite touches the **Paddle** sprite, do a reflection. The easy way to do this is to let the angle be directly inverted, but then you'll find that the path of the ball is completely fixed, which is too boring. Therefore, we use the center of the two sprites to calculate and make the ball bounce in the opposite direction of the center of the baffle.



- When the **Ball** sprite falls to the edge of the stage, the script stops running and the game ends.



### 3. Block1 sprite

The **Block1** sprite is to appear with the effect of cloning 4x8 of itself above the stage in a random color, and deleting a clone if it is touched by the **Ball** sprite.

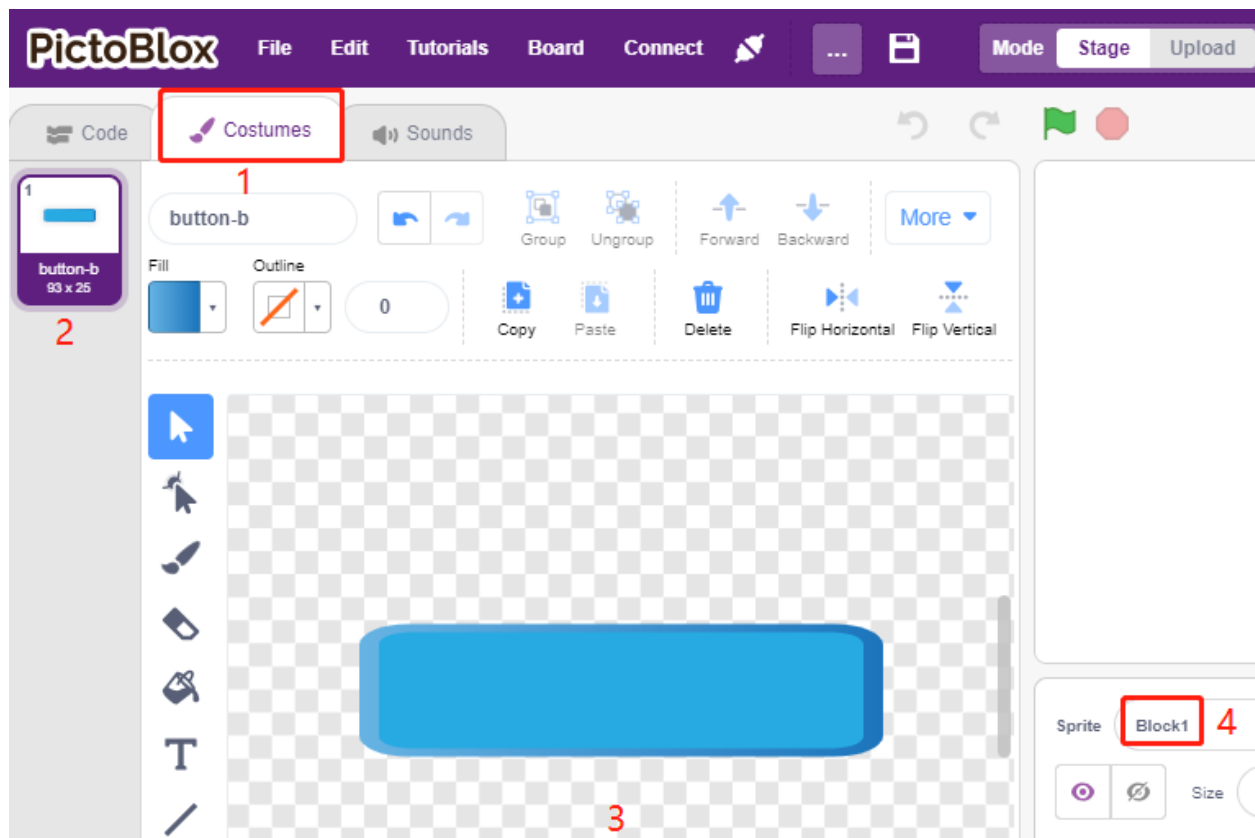


The **Block1** sprite is not available in the **PictoBlox** library, you need to draw it yourself or modify it with an existing sprite. Here we are going to modify it with the **Button3** sprite.

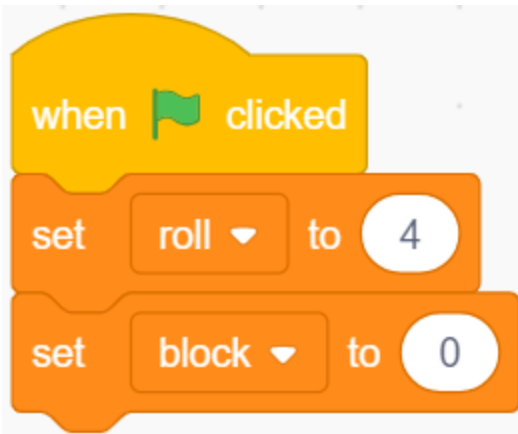
- After adding the **Button3** sprite, go to the **Costumes** page. Now delete **button-a** first, then reduce both the width and height of **button-b**, and change the sprite name to **Block1**, as shown in the following image.

**Note:**

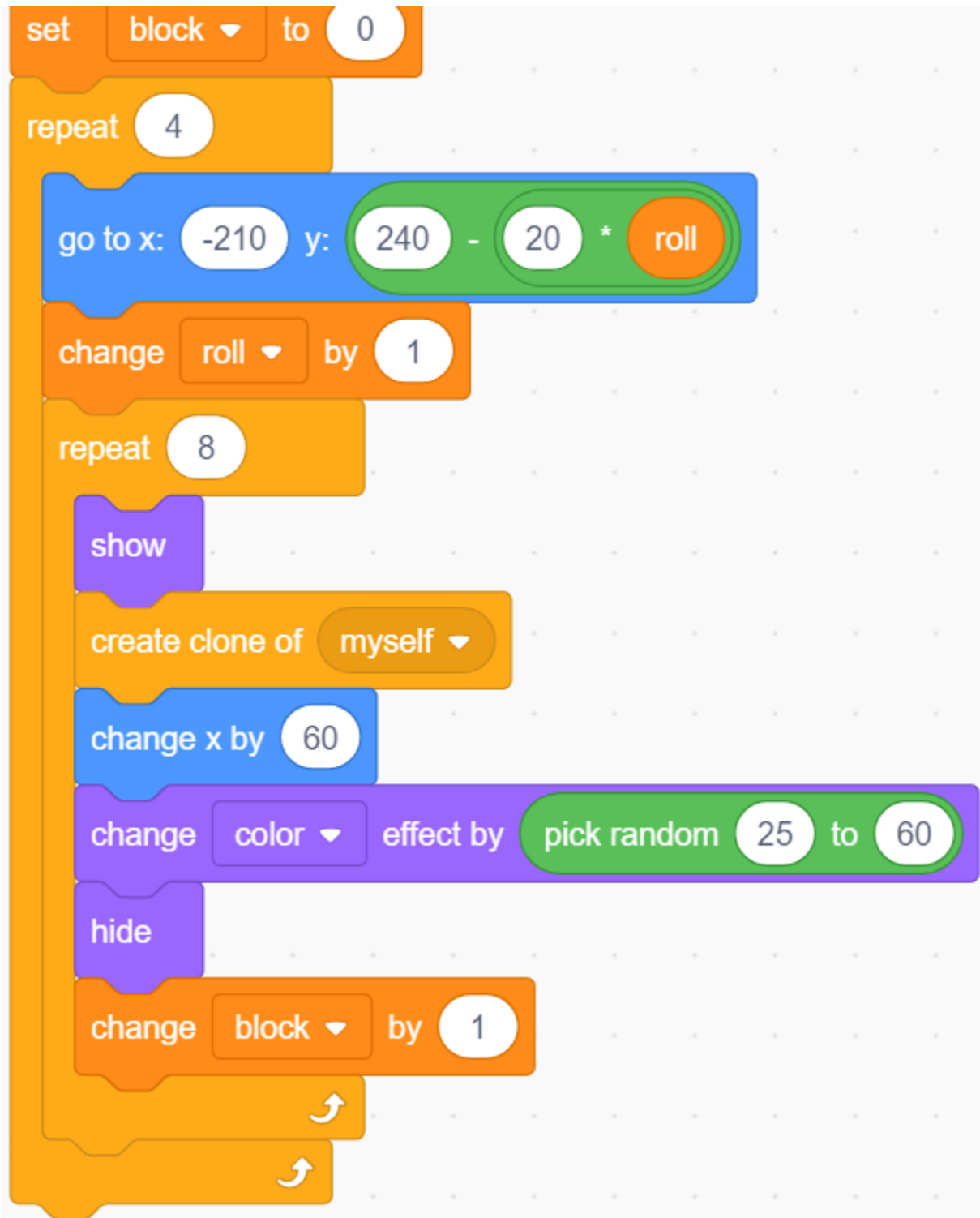
- For the width of **Block1**, you can probably simulate it on the screen to see if you can put down 8 in a row, if not, then reduce the width appropriately.
- In the process of shrinking the **Block1** sprite, you need to keep the center point in the middle of the sprite.



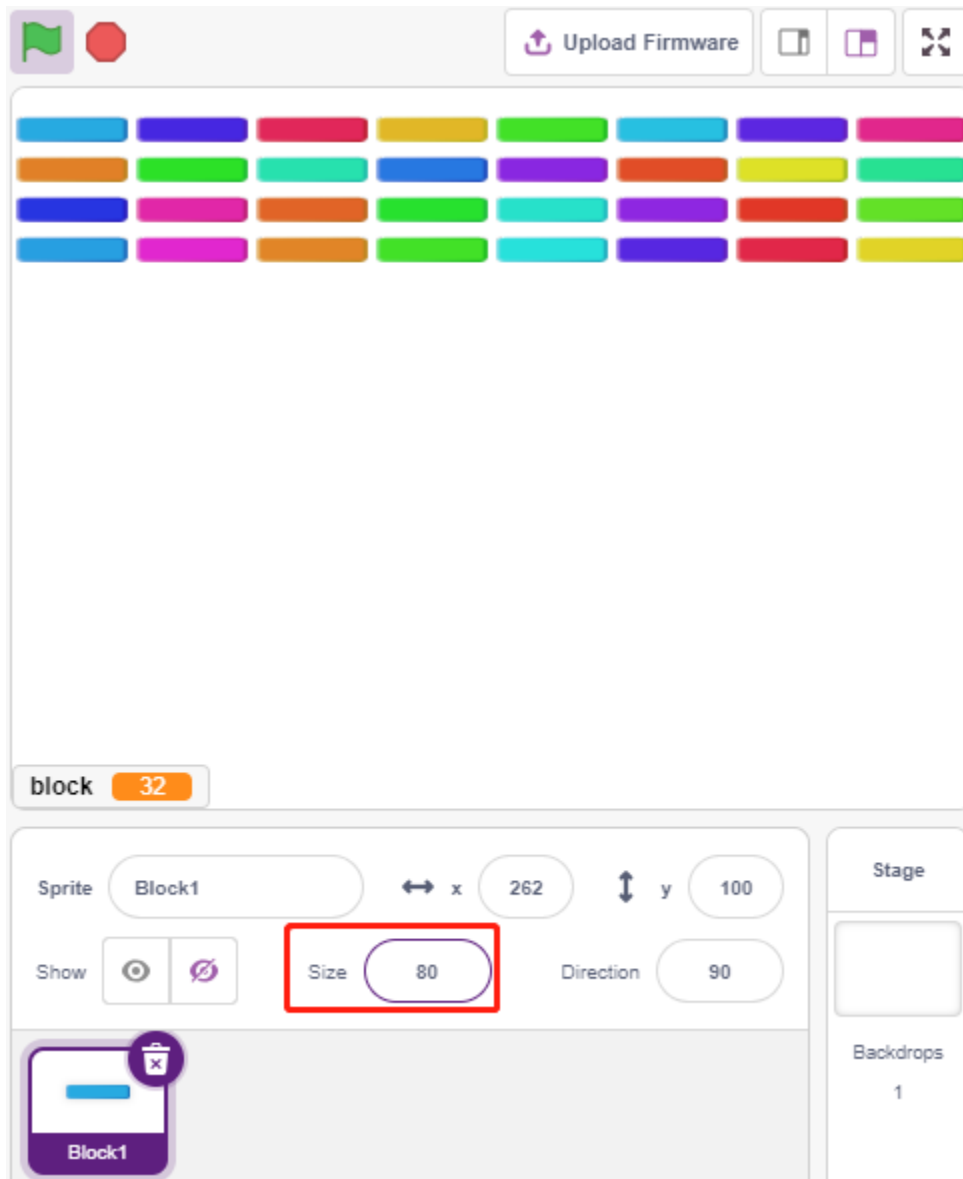
- Now create 2 variables first, **block** to store the number of blocks and **roll** to store the number of rows.



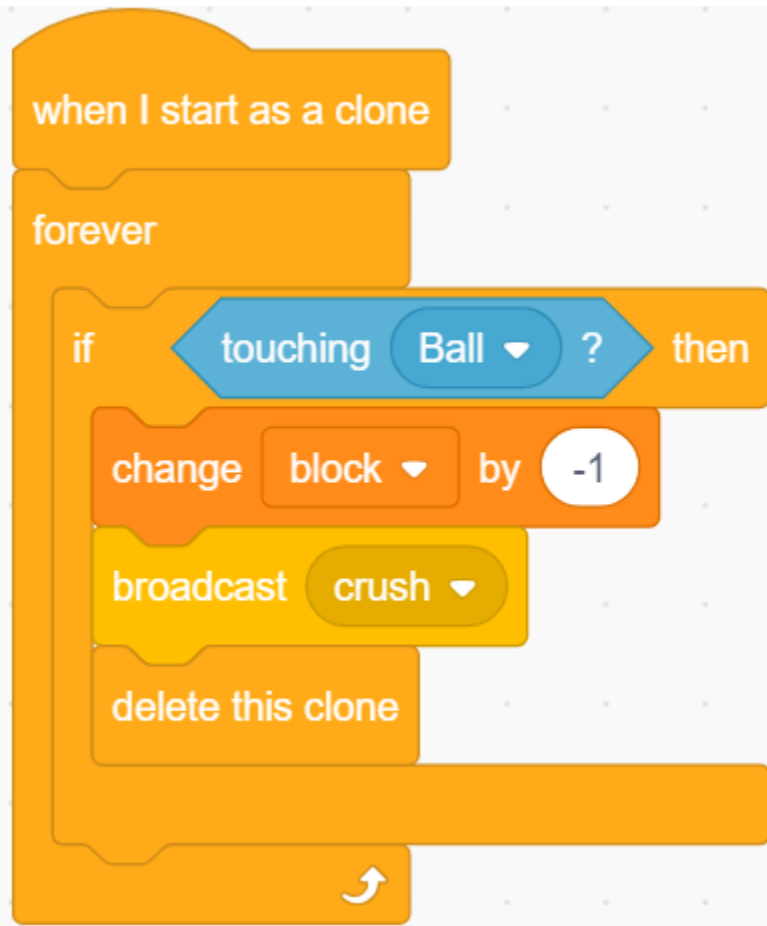
- We need to make a clone of the **Block1** sprite, so that it displays from left to right, top to bottom, one by one, 4x8 in total, with random colors.



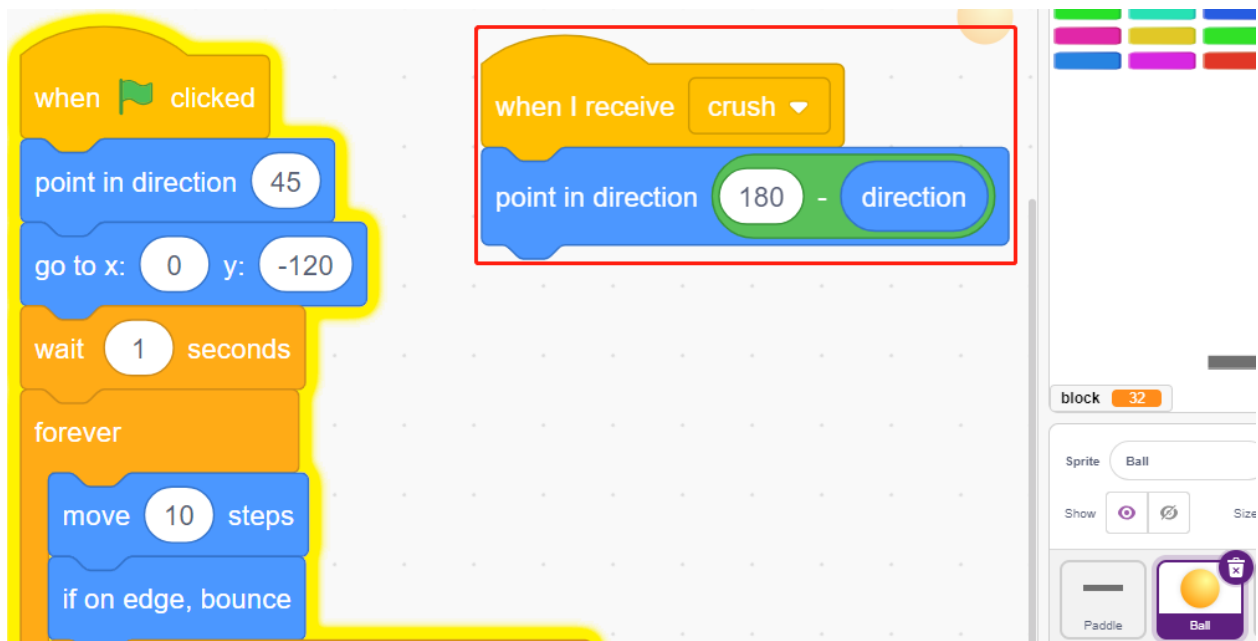
- After the script is written, click on the green flag and look at the display on the stage, if it is too compact or too small, you can change the size.



- Now write the trigger event. If the cloned **Block1** sprite touches the **Ball** sprite, delete the clone and broadcast the message **crush**.



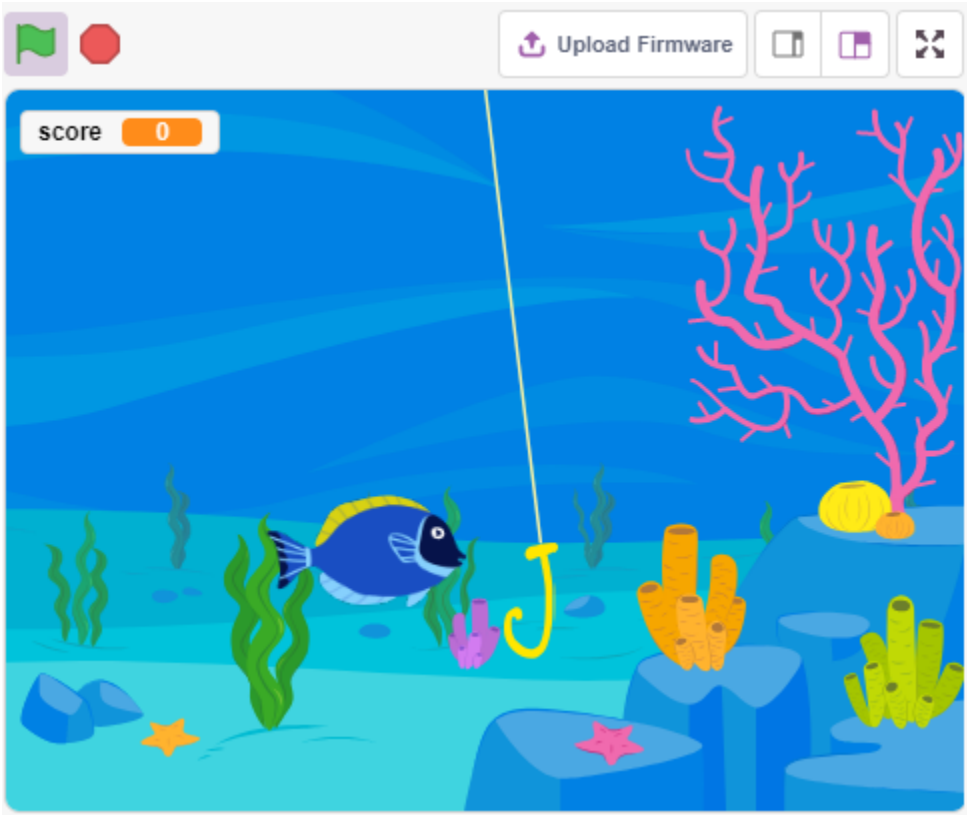
- Back to the **Ball** sprite, when the broadcast **crush** is received (the **Ball** sprite touches the clone of **Block1** sprite), the **Ball** is popped from the opposite direction.



## 7.22 2.19 GAME - Fishing

Here, we play a fishing game with a button.

When the script is running, the fish swim left and right on the stage, you need to press the button when the fish is almost close to the hook (it is recommended to press it for a longer time) to catch the fish, and the number of fish caught will be recorded automatically.



### 7.22.1 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

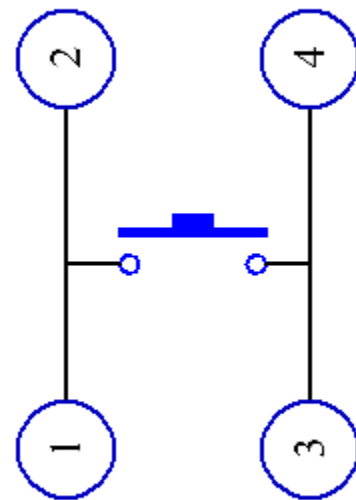
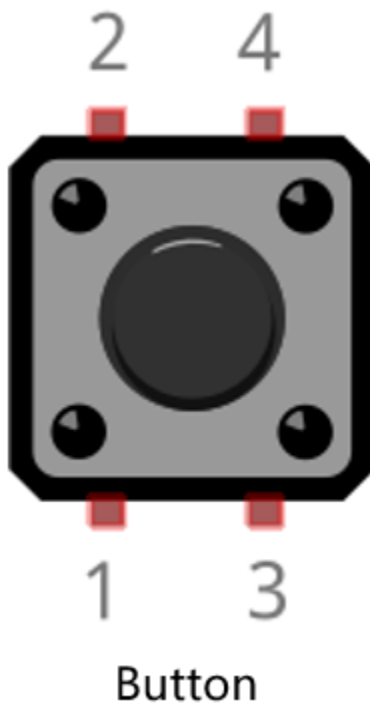
Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Resistor</i>	
<i>Capacitor</i>	
<i>Button</i>	

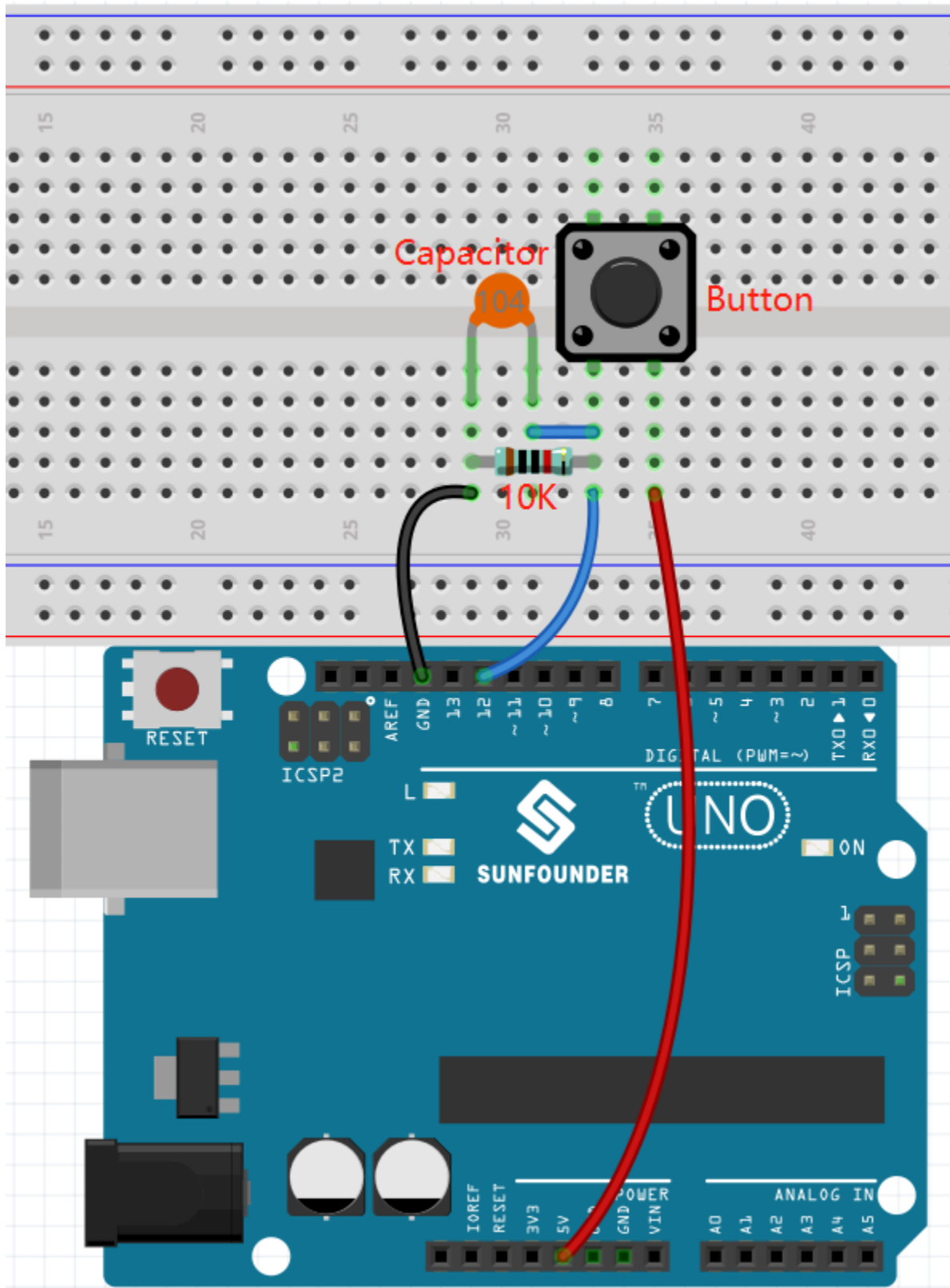
### 7.22.2 Build the Circuit

The button is a 4-pin device, since the pin 1 is connected to pin 2, and pin 3 to pin 4, when the button is pressed, the 4 pins are connected, thus closing the circuit.



Build the circuit according to the following diagram.

- Connect one of the pins on the left side of the button to pin 12, which is connected to a pull-down resistor and a 0.1uF (104) capacitor (to eliminate jitter and output a stable level when the button is working).
- Connect the other end of the resistor and capacitor to GND, and one of the pins on the right side of the button to 5V.



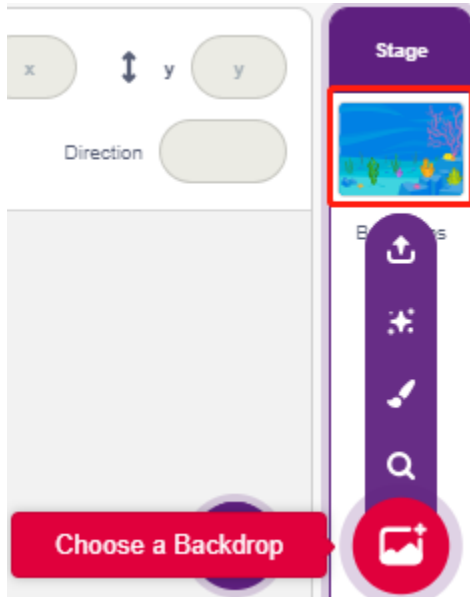


## 7.22.3 Programming

We need to select an **Underwater** backdrop first, then add a **Fish** sprite and let it swim back and forth on the stage. Then draw a **Fishhook** sprite and control it by a button to start fishing. When the **Fish** sprite touches the **Fishhook** sprite in the hooked state (turns red), it will be hooked.

### 1. Adding a backdrop

Use the **Choose a Backdrop** button to add an **Underwater** backdrop.

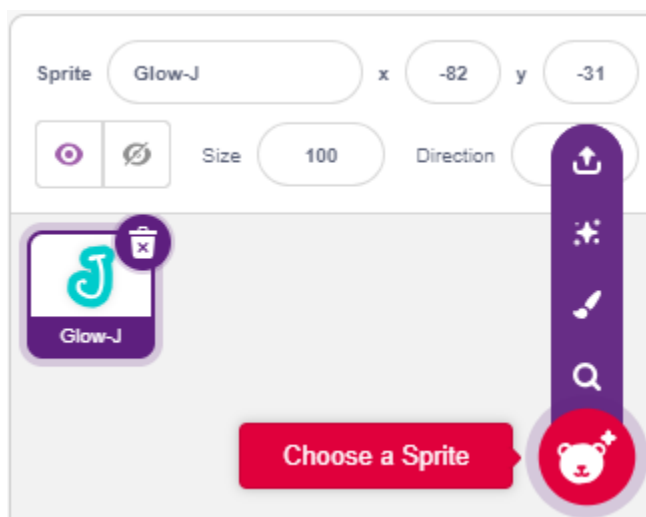


### 2. Fishhook sprite

The **Fishhook** sprite usually stays underwater in the yellow state; when the button is pressed, it is in the fishing state (red) and moves above the stage.

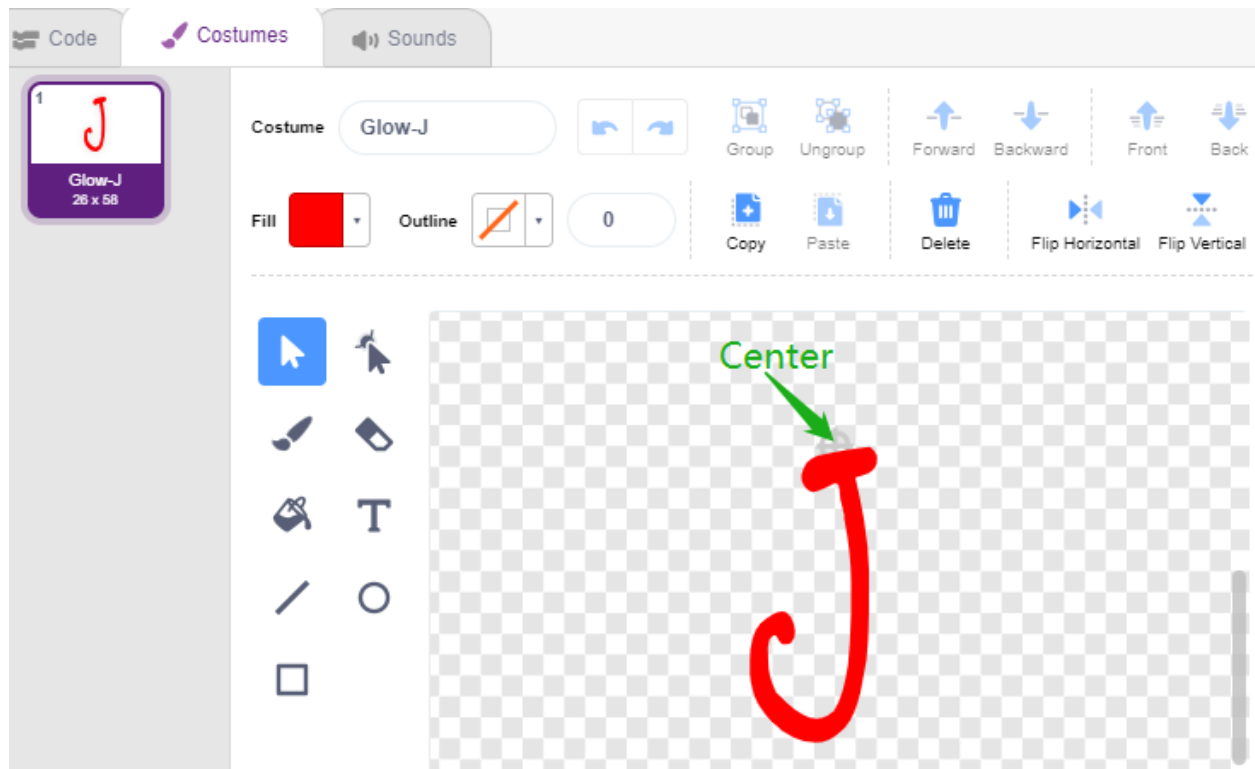
There is no **Fishhook** sprite in Pictoblox, we can modify the **Glow-J** sprite to look like a fishhook.

- Add the **Glow-J** sprite via **Choose a Sprite**.

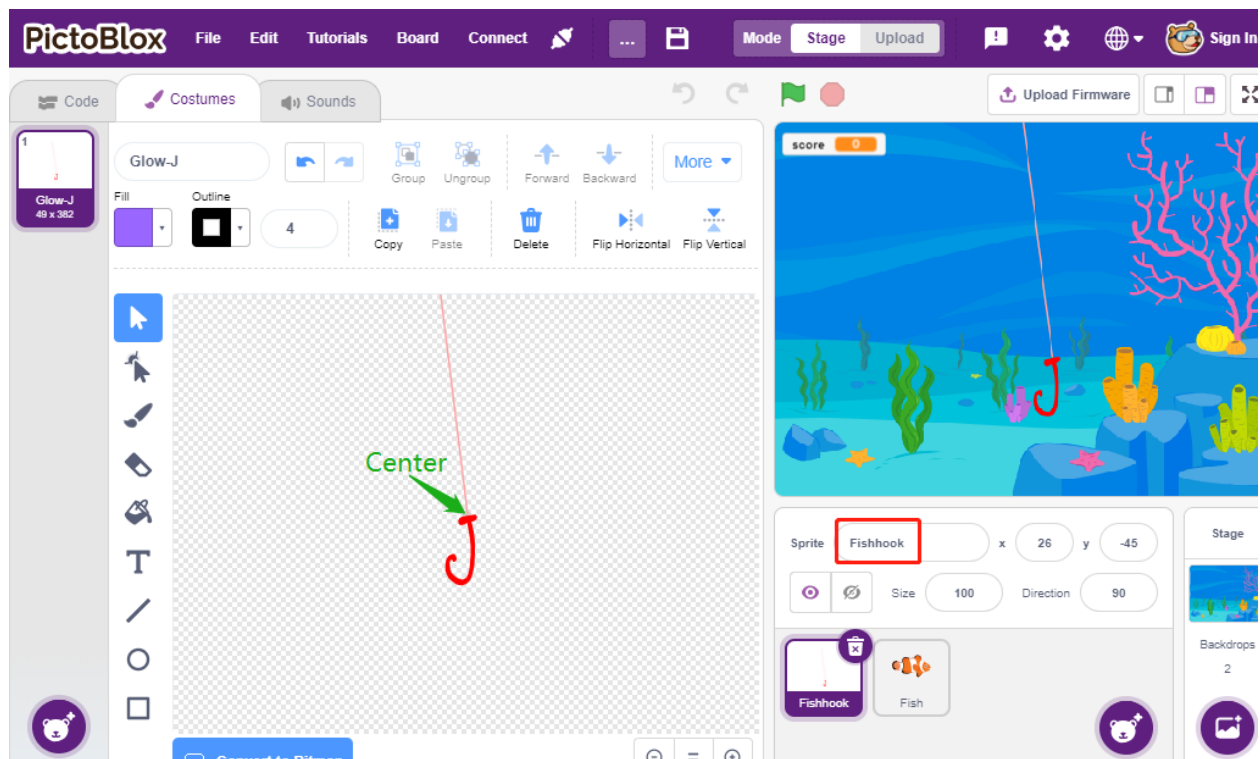


- Now go to the **Costumes** page of the **Glow-J** sprite, select Cyan's fill in the screen and remove it. Then change the J color to red and also reduce its width. The most important point to note is that you need to have the top of

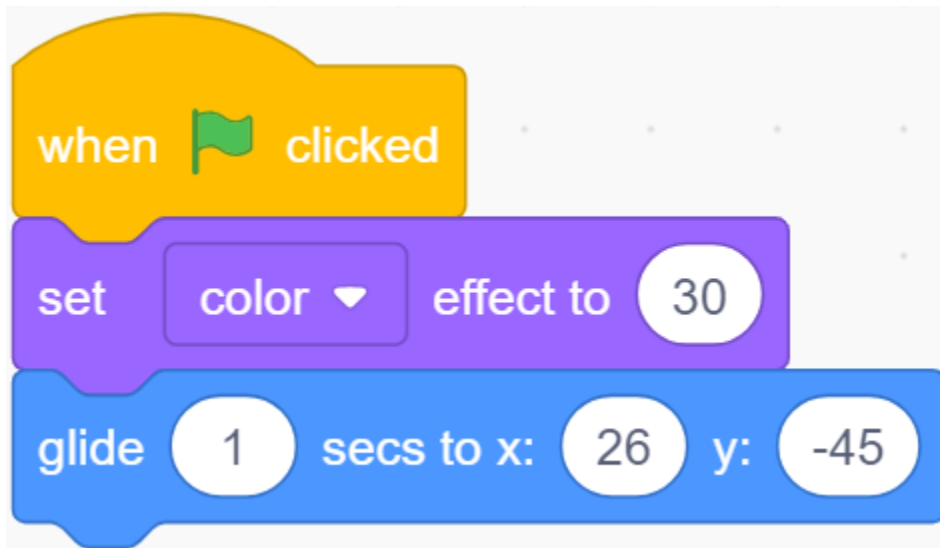
it just at the center point.



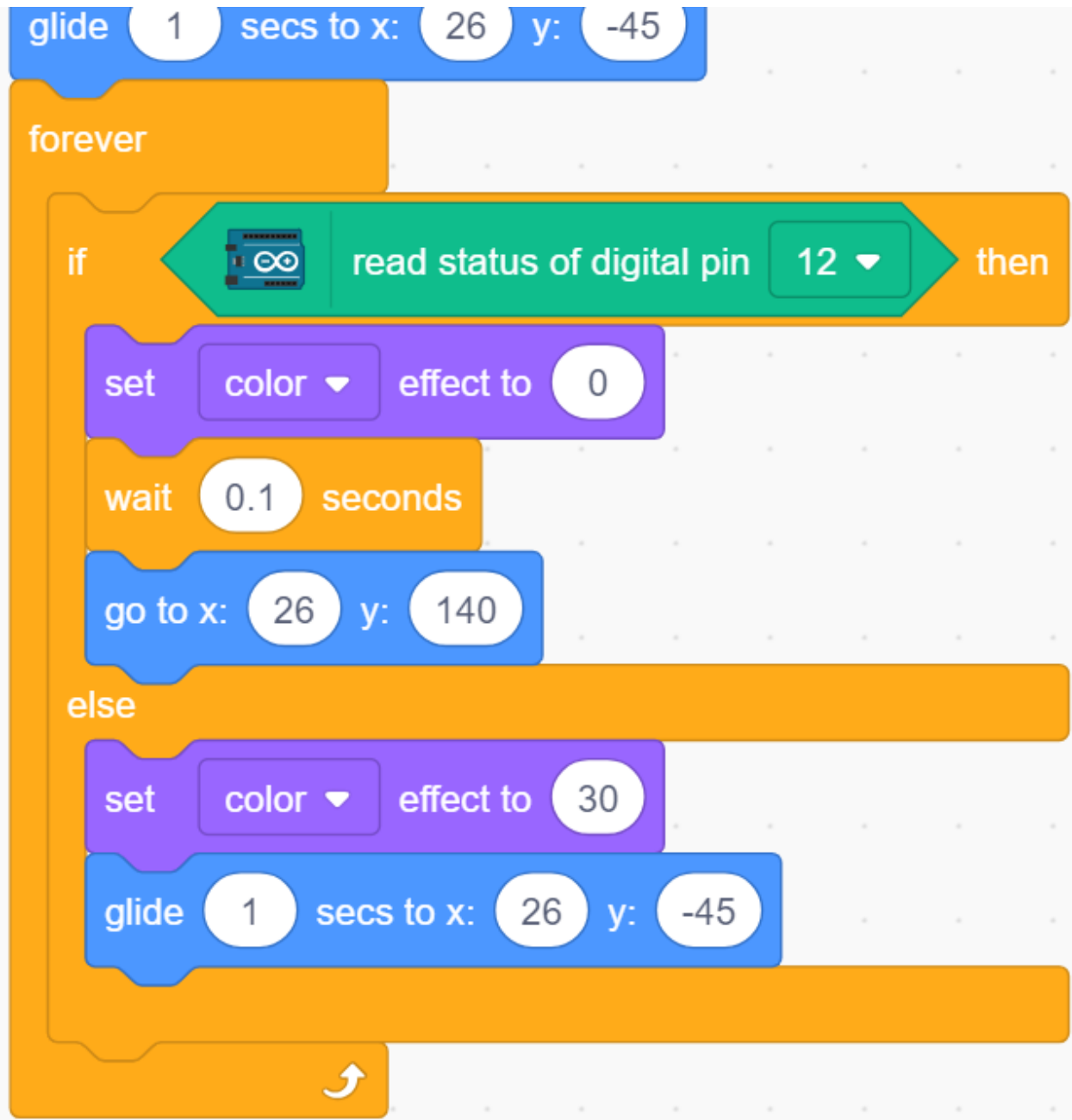
- Use the **Line tool** to draw a line as long as possible from the center point up (line out of the stage). Now that the sprite is drawn, set the sprite name to **Fishhook** and move it to the right position.



- When the green flag is clicked, set the sprite's color effect to 30 (yellow), and set its initial position.



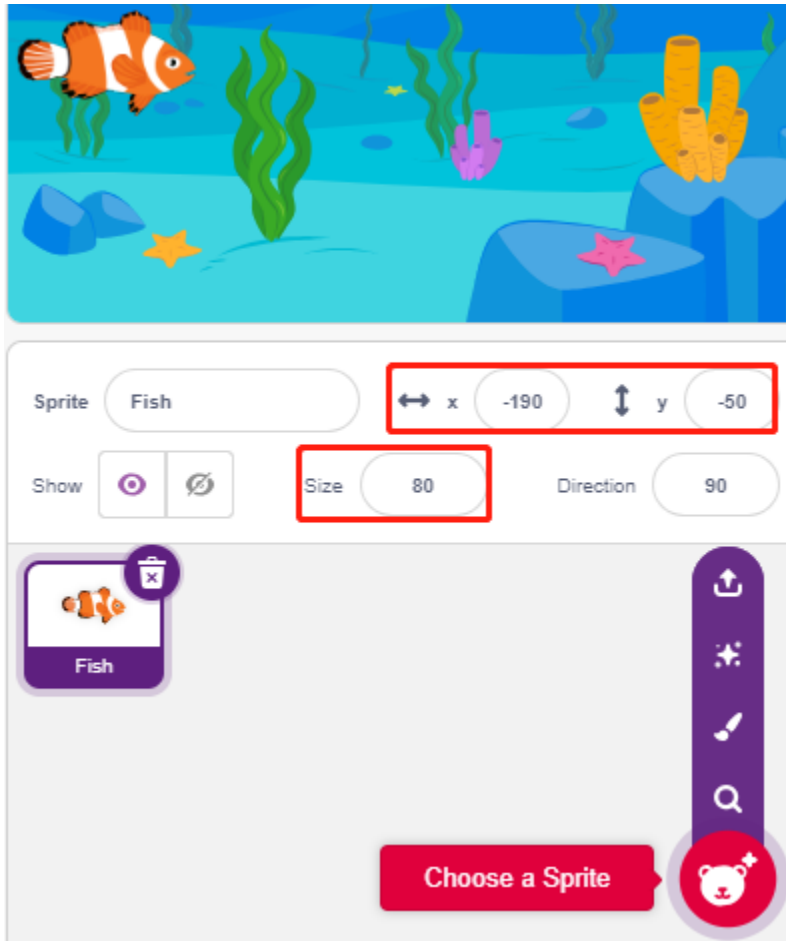
- If the button is pressed, set the color effect to 0 (red, start fishing state), wait for 0.1 and then move the **Fishhook** sprite to the top of the stage. Release the button and let the **Fishhook** return to its initial position.



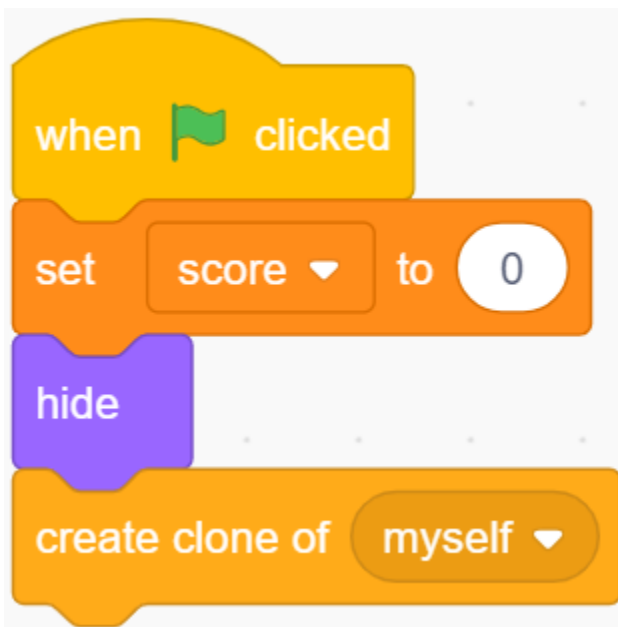
### 3. Fish sprite

The effect to be achieved by the **Fish** sprite is to move left and right on the stage, and when it encounters a **Fishhook** sprite in the fishing state, it shrinks and moves to a specific position and then disappears, and then clones a new **fish** sprite again.

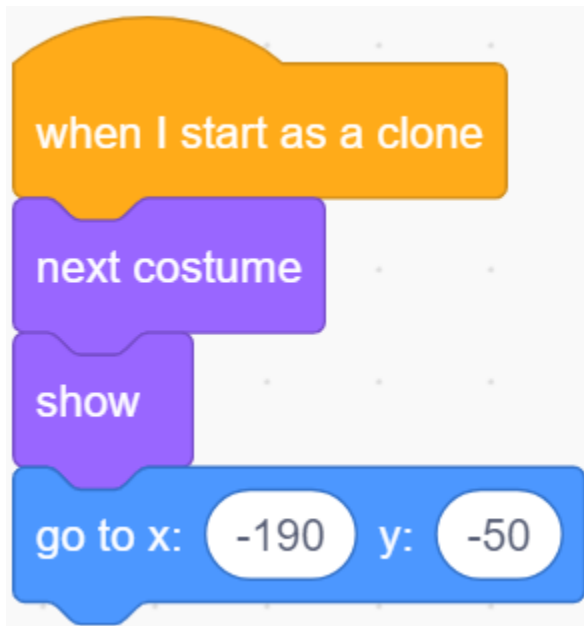
- Now add the **fish** sprite and adjust its size and position.



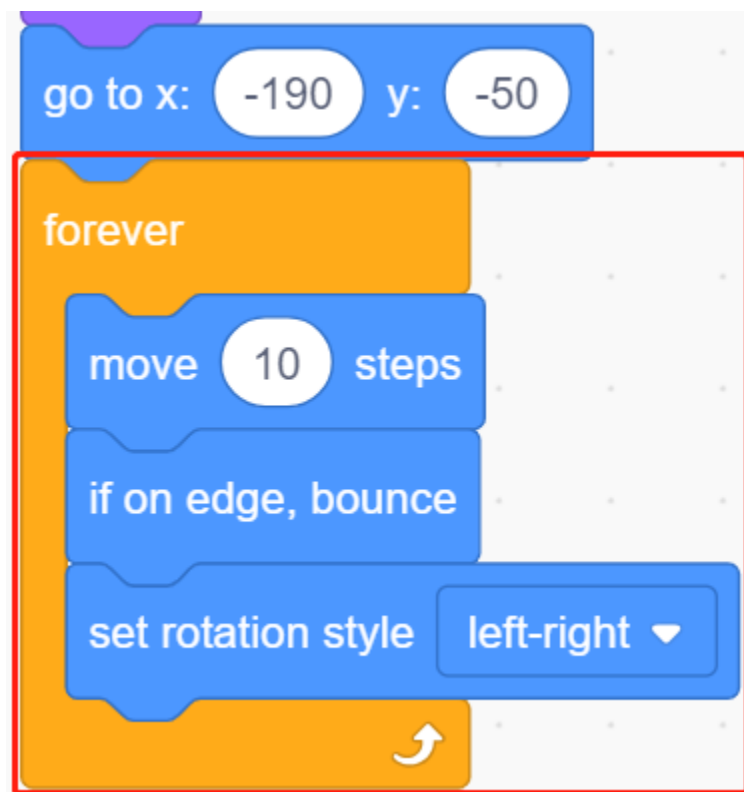
- Create a variable **score** to store the number of fish caught, hide this sprite and clone it.



- Show the clone of the **fish** sprite, switch its costume and finally set the initial position.



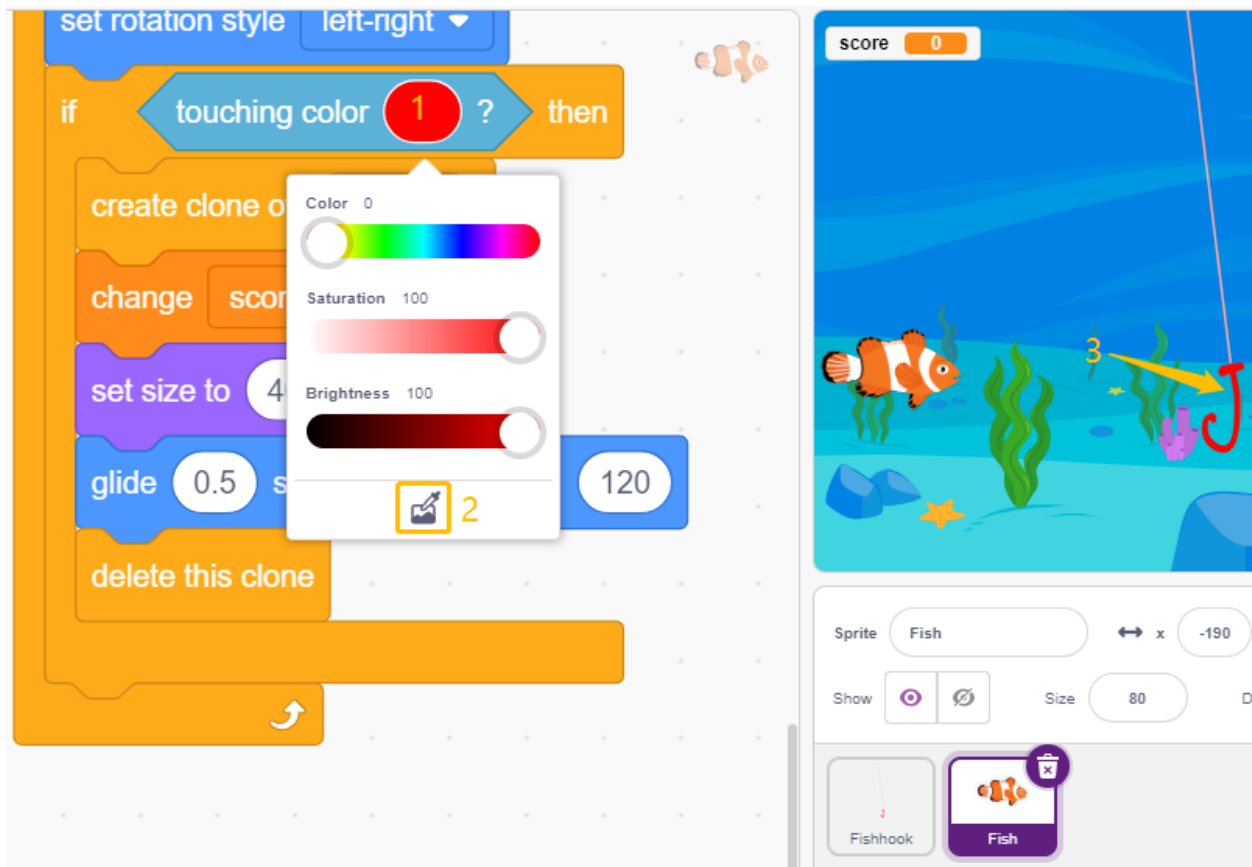
- Make the **fish** sprite's clone move left and right and bounce back when it touches the edge.



- The **fish** sprite (of the clone) will not react when it passes the **Fishhook** sprite; when it touches the **Fishhook** sprite in the fishing state (turns red), it will be caught, at which point the score (variable score) +1, and it will also show a score animation (shrinks 40%, quickly moves to the position of the scoreboard and disappears). At the same time, a new fish is created (a new fish sprite clone) and the game continues.

**Note:** You need to click on the color area in the [Touch color] block, and then select the eyedropper tool to pick up the

red color of the **Fishhook** sprite on the stage. If you choose a color arbitrarily, this [Touch color] block will not work.



## 7.23 2.20 GAME - Don't Tap on The White Tile

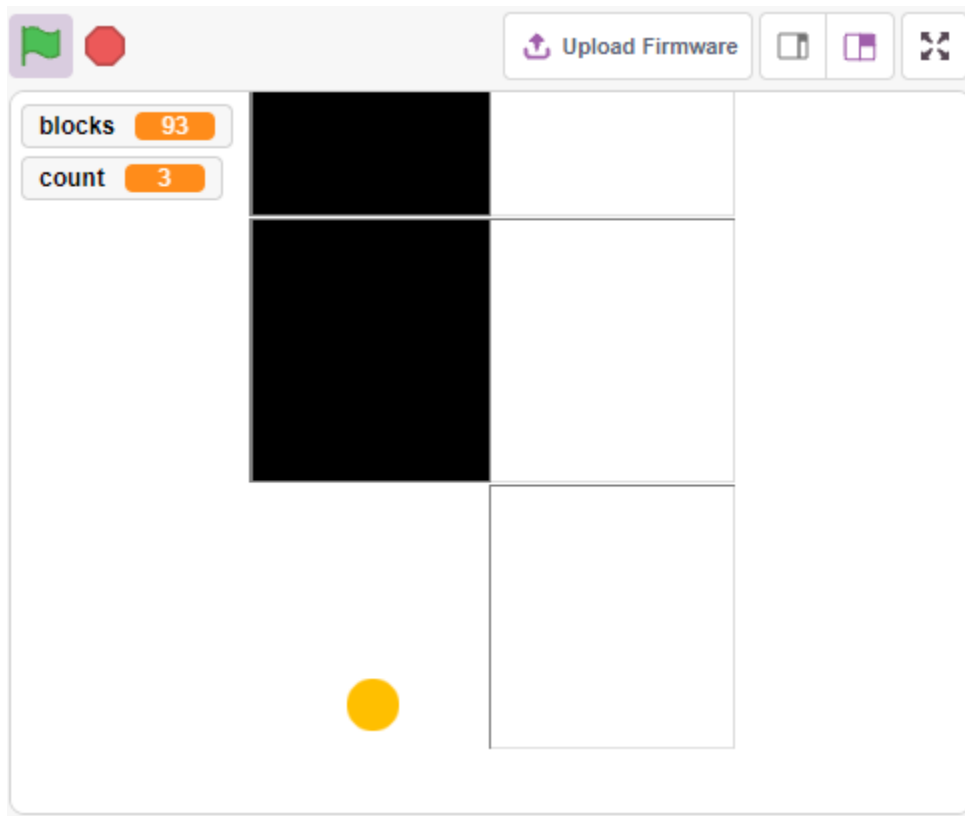
I'm sure many of you have played this game on your cell phones. This game is played by tapping on randomly appearing black to add points, the speed will get faster and faster, tap on white blocks or miss black blocks game over.

Now we use PictoBlox to replicate it.

Insert two IR obstacle avoidance modules vertically on the breadboard, when your hand is placed above one of the IR modules, a blink dot will appear on the stage, representing a tap was made.

If the tap to the black block, the score plus 1, touch the white block, the score minus 1.

You need to decide whether to place your hand on top of the IR module on the left or on top of the IR module on the right, depending on the position of the black block on the stage.



### 7.23.1 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

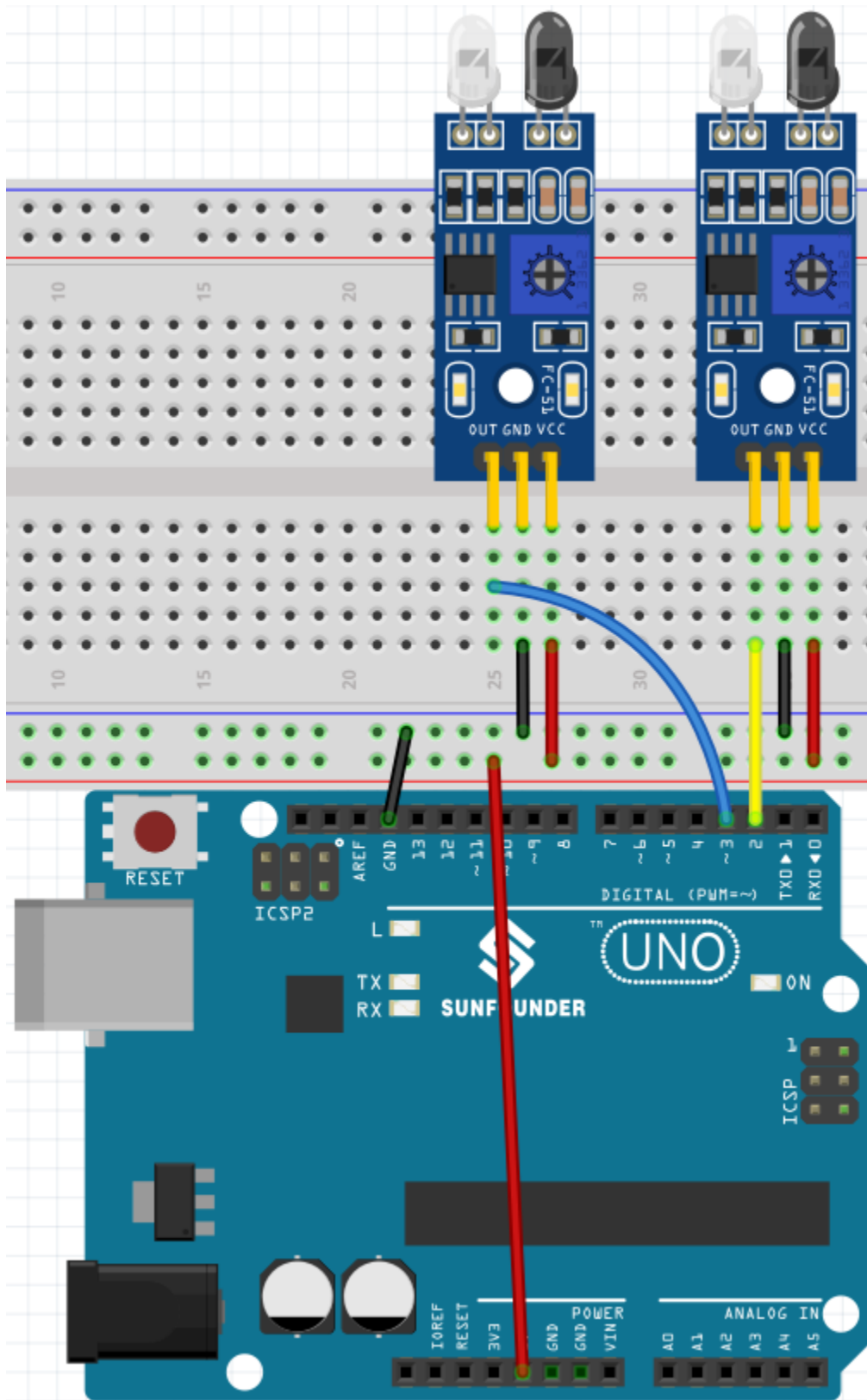
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Breadboard</i>	
<i>Jumper Wires</i>	
<i>Obstacle Avoidance Module</i>	



### 7.23.2 Build the Circuit

The obstacle avoidance module is a distance-adjustable infrared proximity sensor whose output is normally high and low when an obstacle is detected.

Now build the circuit according to the diagram below.



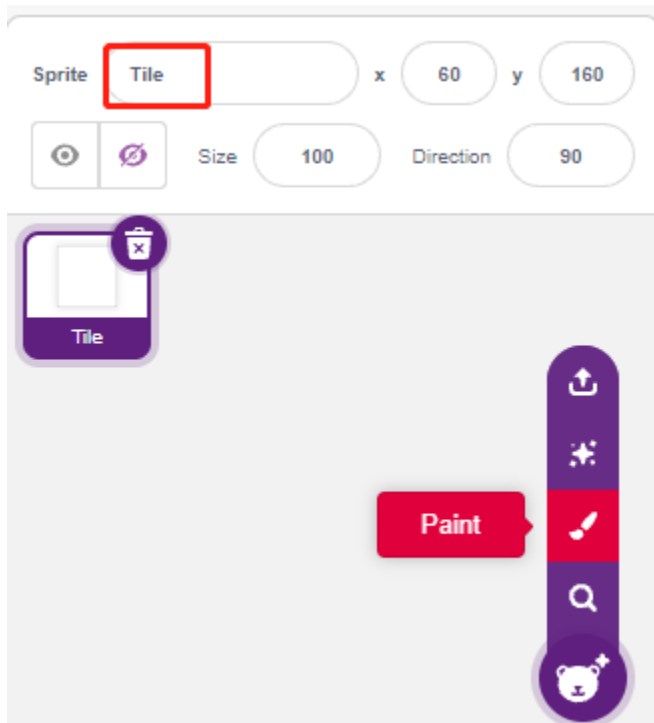
### 7.23.3 Programming

Here we need to have 3 sprites, **Tile** , **Left IR** and **Right IR**.

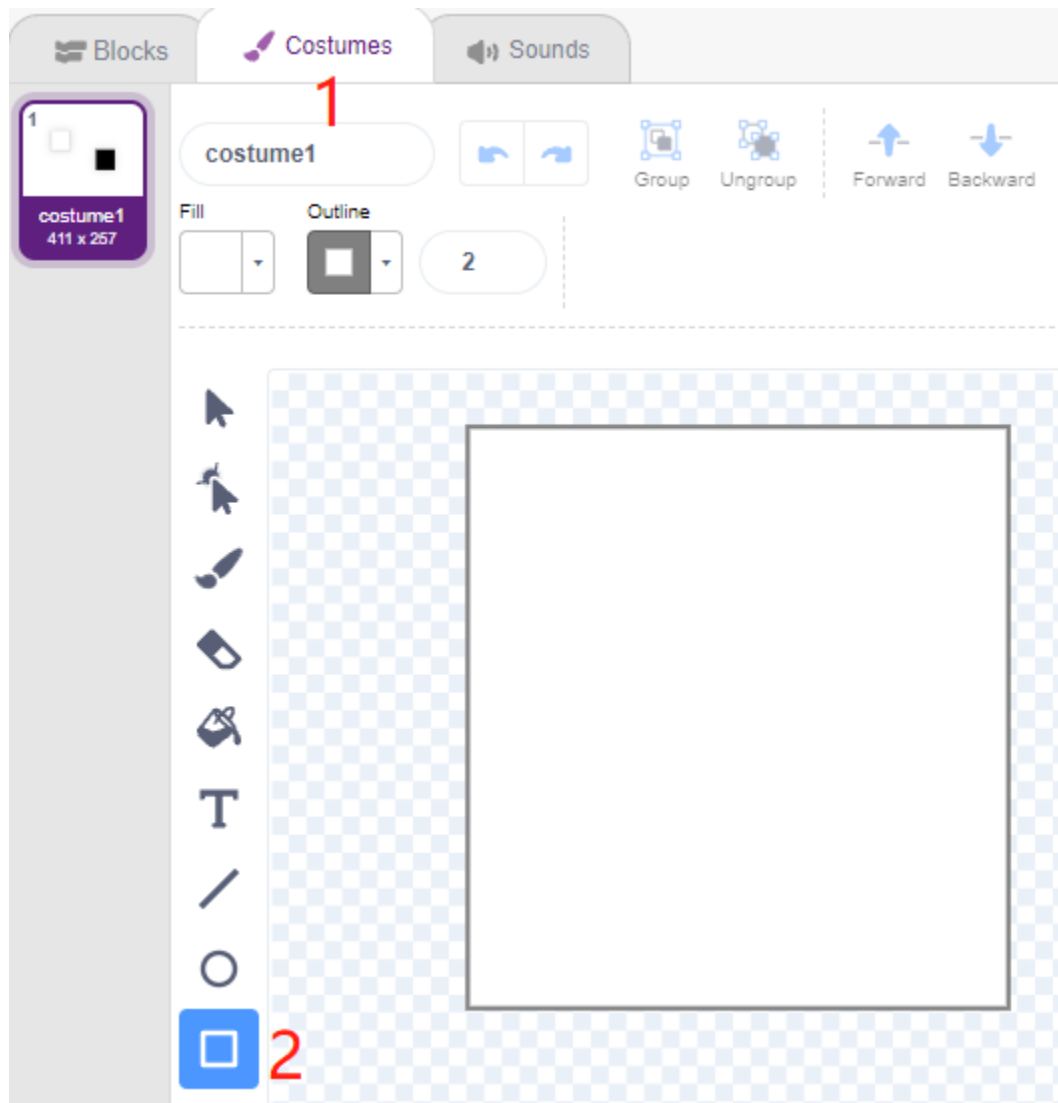
- **Tile** sprite: used to achieve the effect of alternating black and white tiles downward, in the cell phone this game is generally 4 columns, here we only do two columns.
- **Left IR** sprite: used to achieve the click effect, when the left IR module senses your hand, it will send a message - **left** to **Left IR** sprite, let it start working. If it touches the black tile on the stage, the score will be increased by 1, otherwise the score will be decreased by 1.
- **Right IR** sprite: The function is basically the same as **Left IR**, except that it receives **Right** information.

#### 1. Paint a Tile sprite.

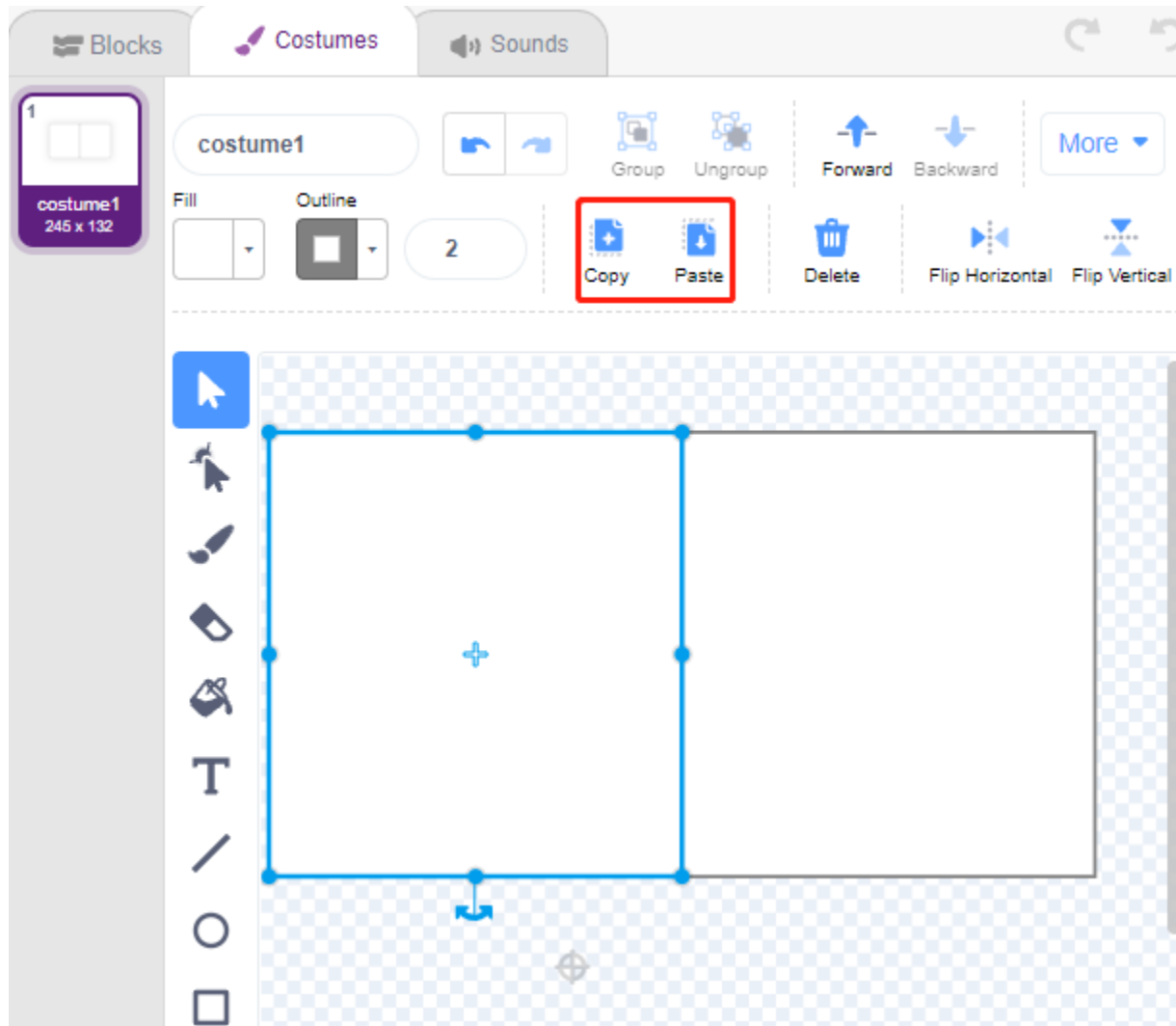
Delete the default sprite, mouse over the **Add Sprite** icon, select **Paint** and a blank sprite will appear and name it **Tile**.



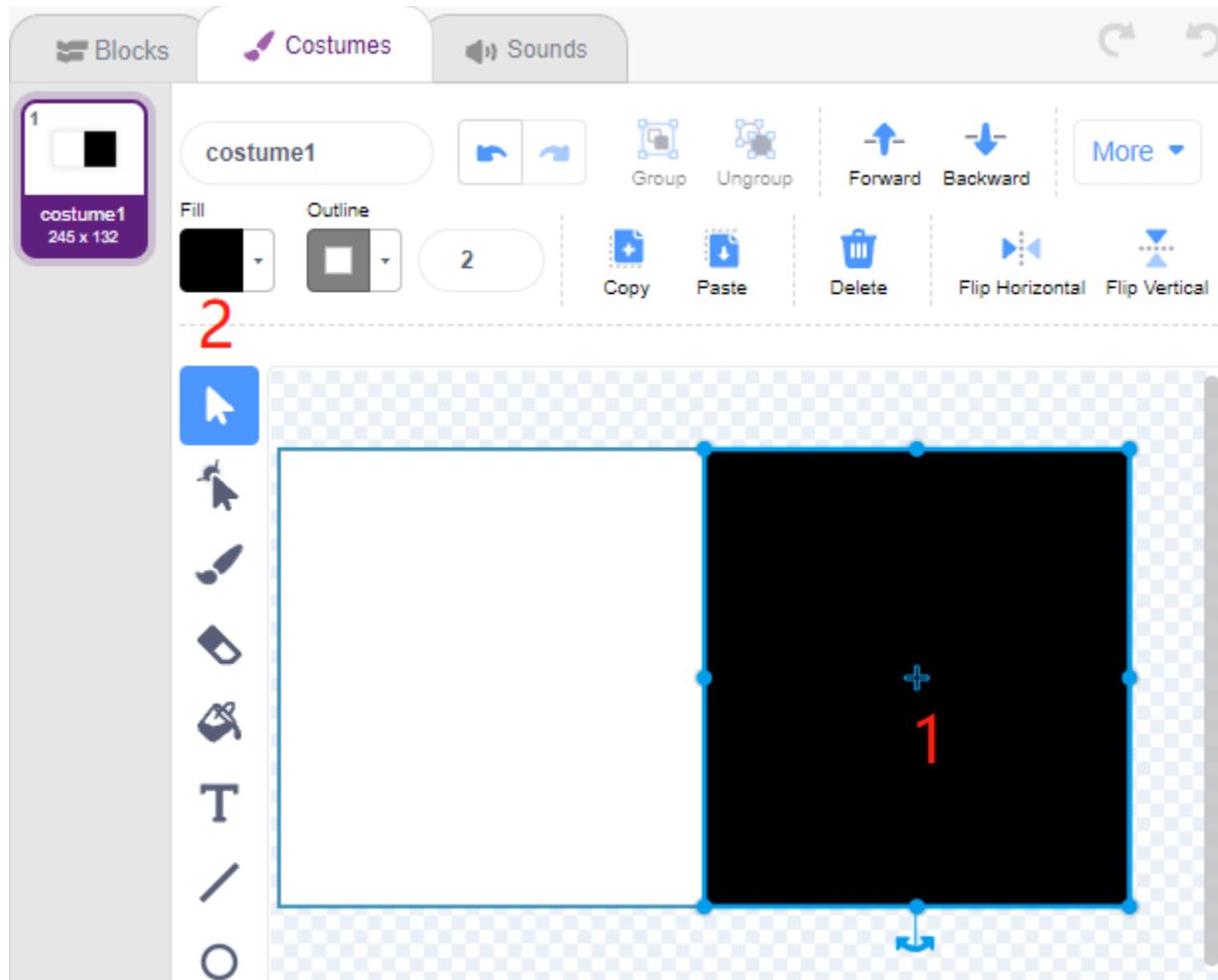
Go to the **Costumes** page and use the **Rectangle** tool to draw a rectangle.



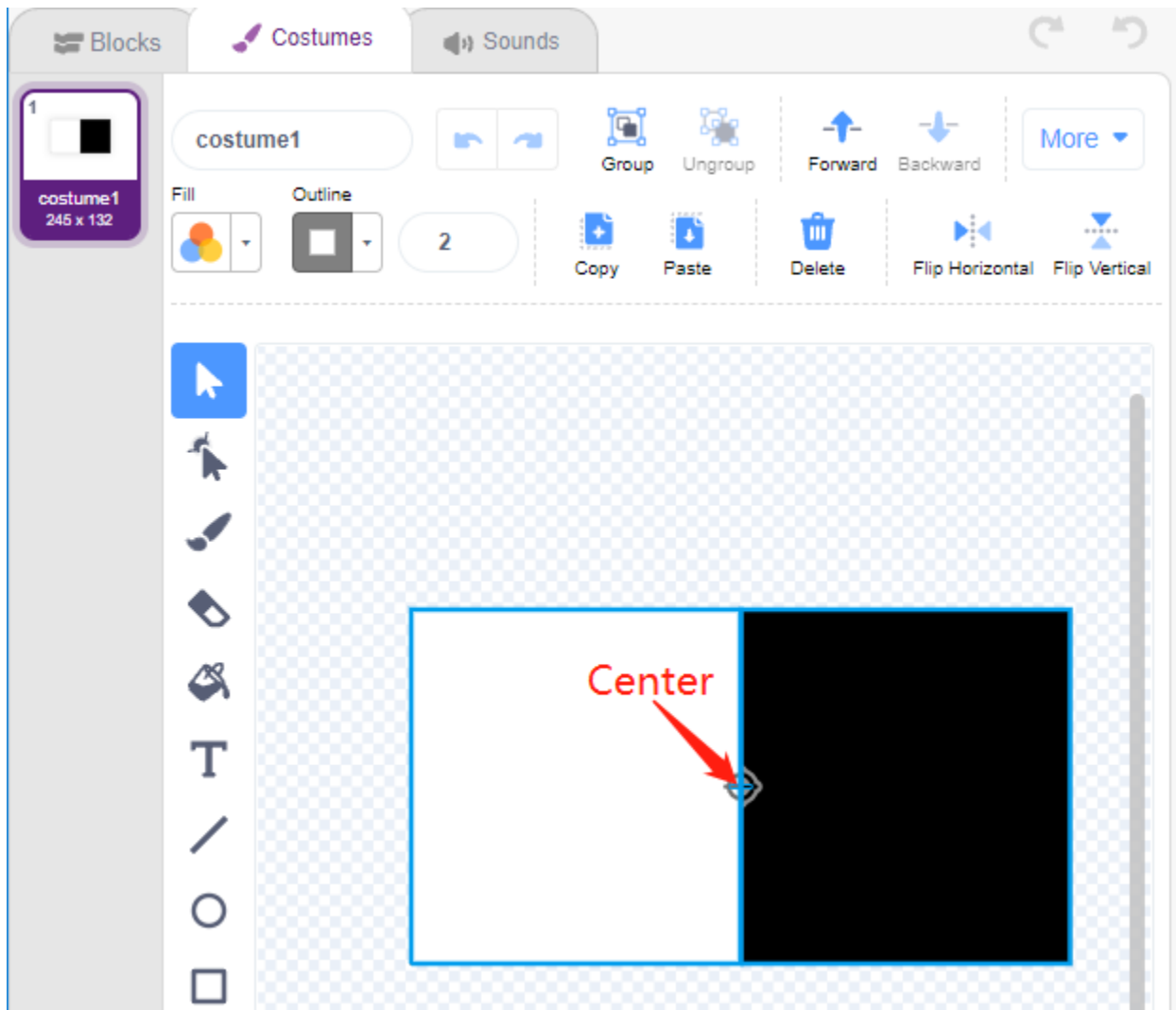
Select the rectangle and click **Copy** -> **Paste** to make an identical rectangle, then move the two rectangles to a flush position.



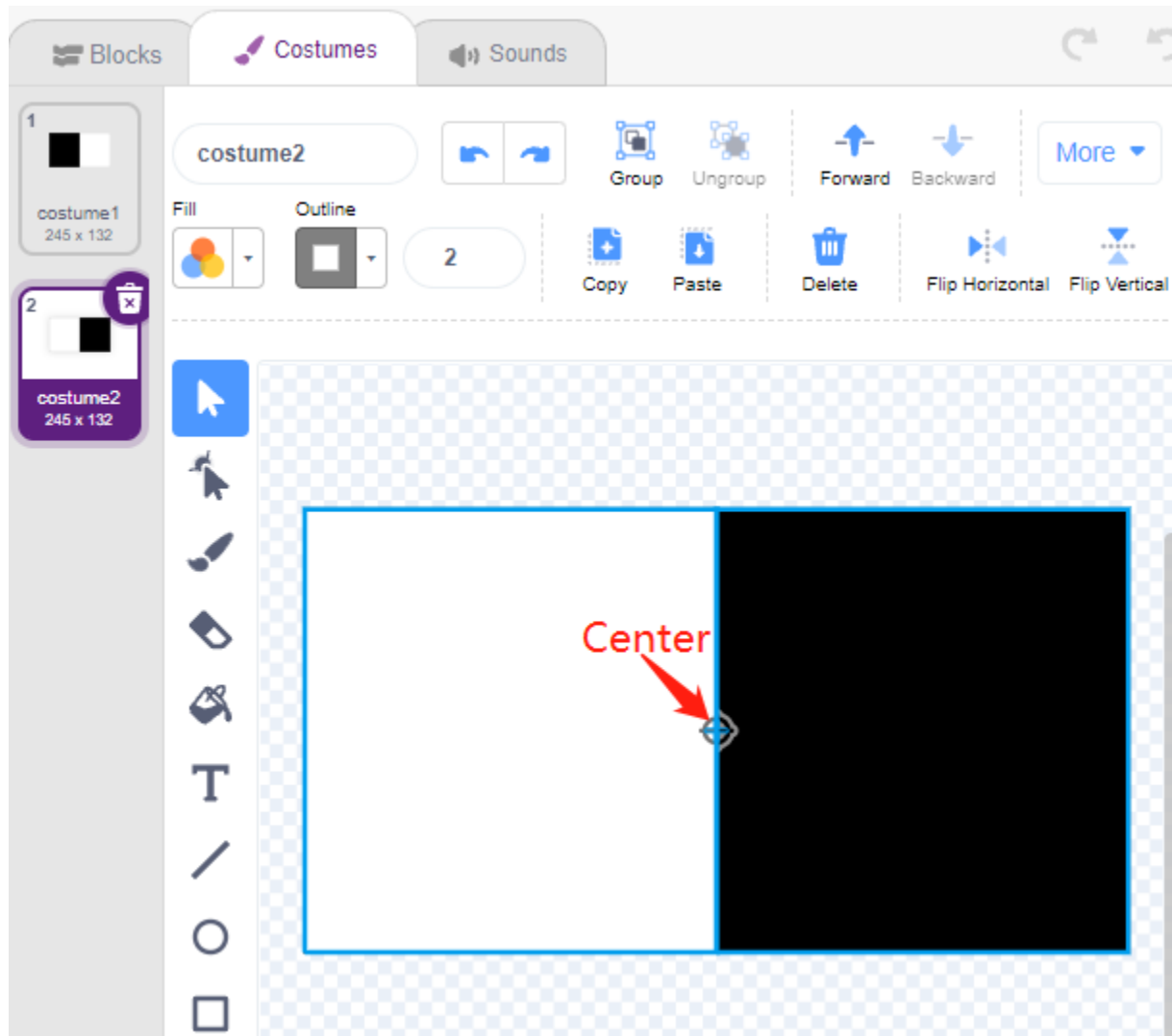
Select one of the rectangles and choose a fill color of black.



Now select both rectangles and move them so that their center points match the center of the canvas.



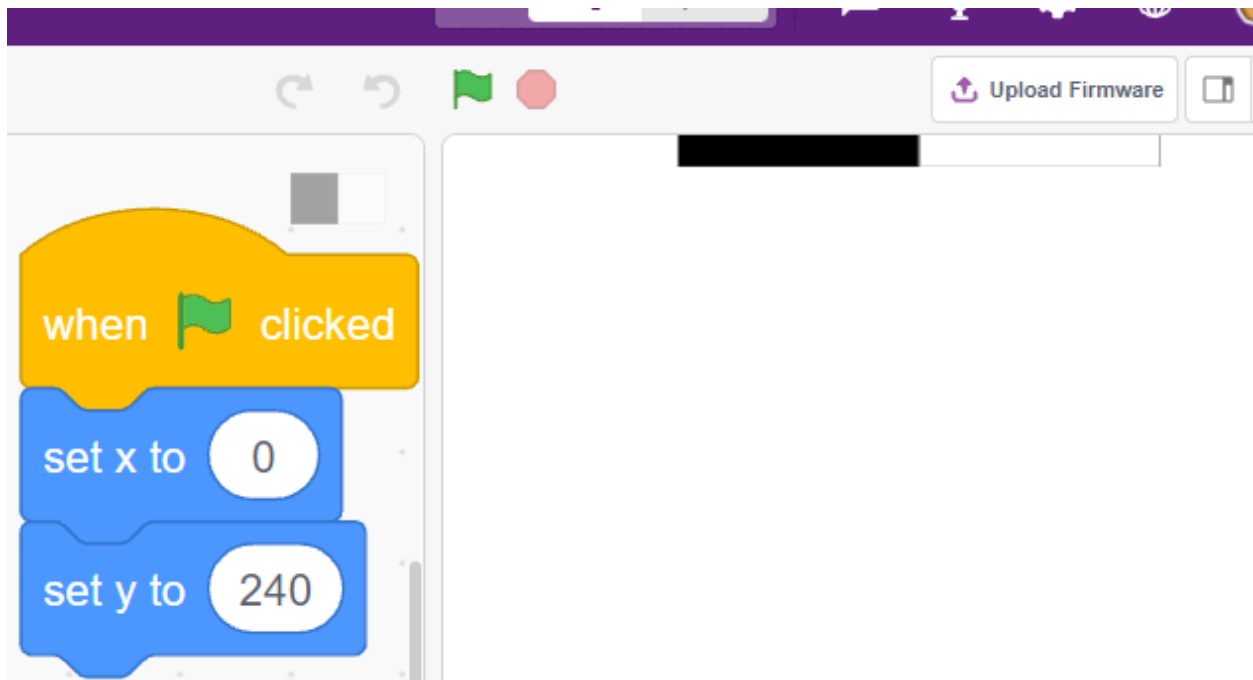
Duplicate costume1, alternating the fill colors of the two rectangles. For example, the fill color of costume1 is white on the left and black on the right, and the fill color of costume2 is black on the left and white on the right.



## 2. Scripting the Tile sprite

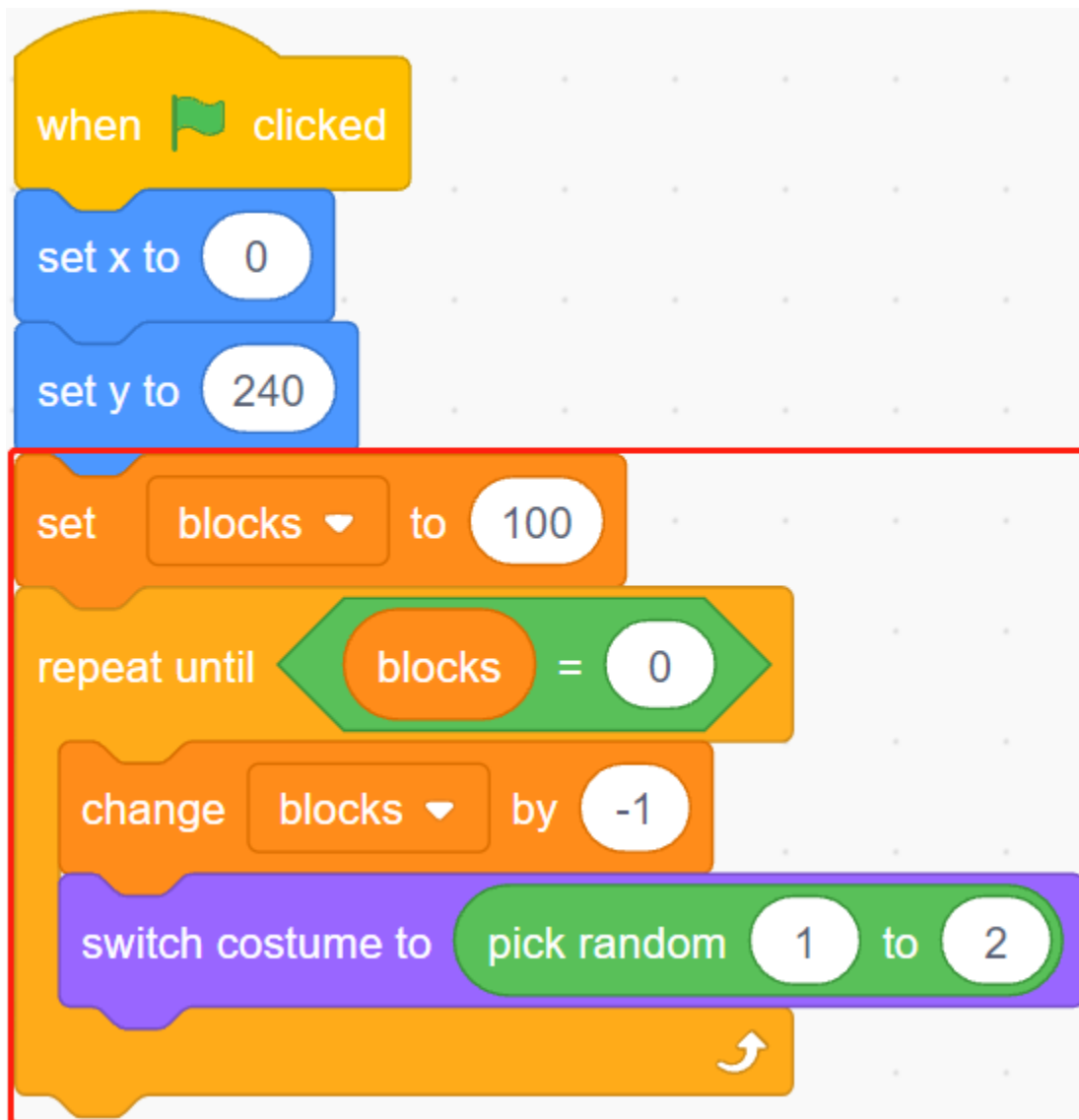
Now go back to the **Blocks** page and set the initial position of the **Tile** sprite so that it is at the top of the stage.



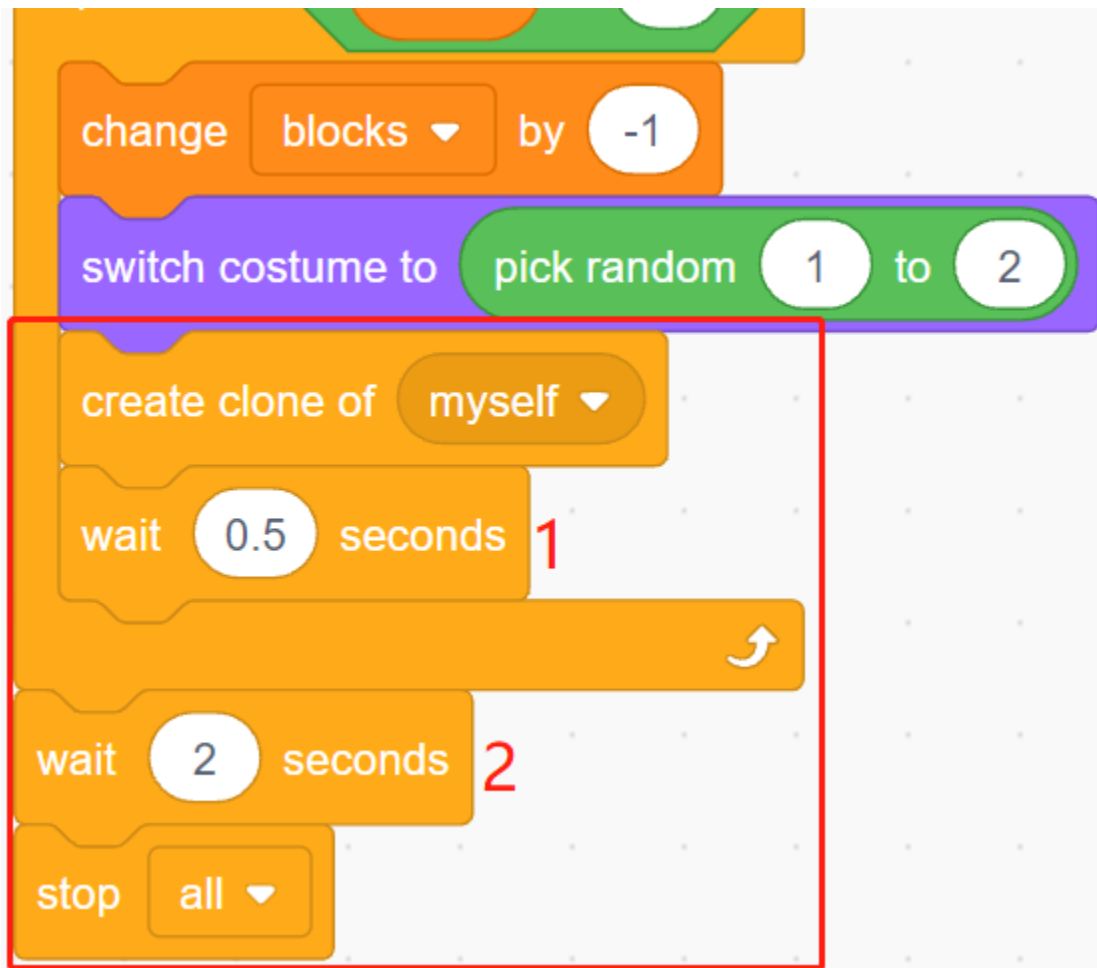


Create a variable -**blocks** and give it an initial value to determine the number of times the **Tile** sprite will appear. Use the [repeat until] block to make the variable **blocks** gradually decrease until **blocks** is 0. During this time, have the sprite **Tile** randomly switch its costume.

After clicking on the green flag, you will see the **Tile** sprite on the stage quickly switch costumes.



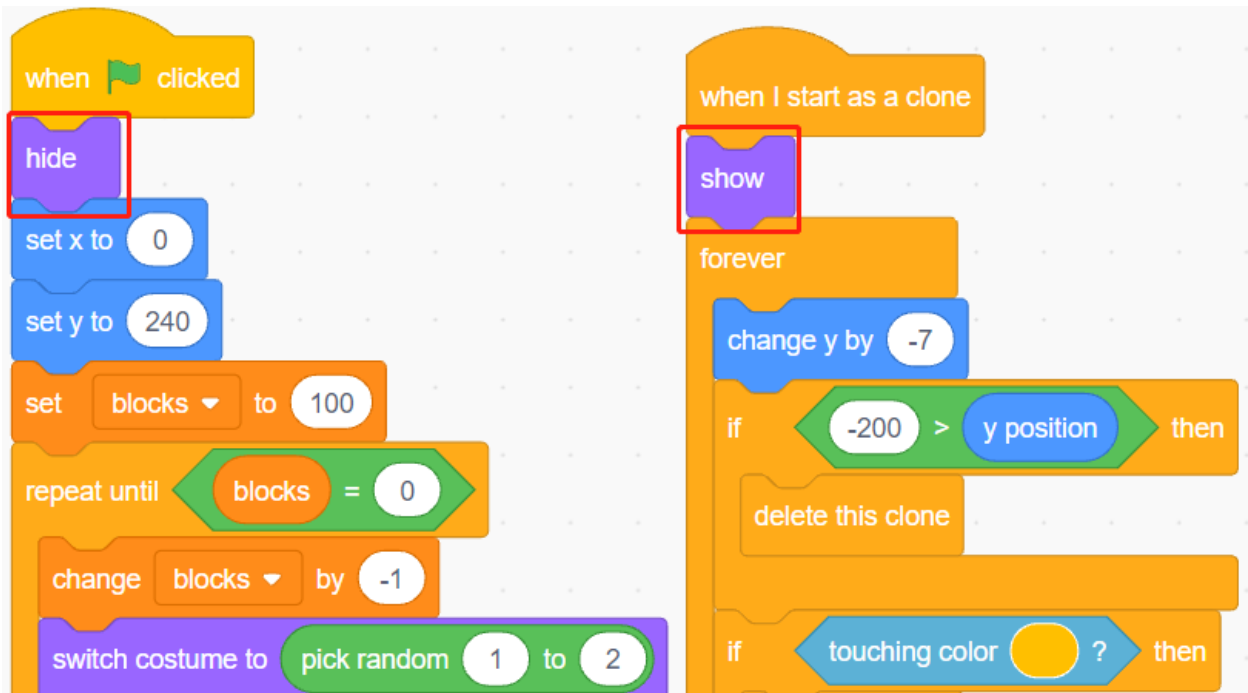
Create clones of the **Tile** sprite while the variable **blocks** is decreasing, and stop the script from running when blocks is 0. Two [wait () seconds] blocks are used here, the first to limit the interval between **Tile's** clones and the second is to let the variable blocks decrease to 0 without stopping the program immediately, giving the last tile sprite enough time to move.



Now script the clone of the **Tile** sprite to move down slowly and delete it when it reaches the bottom of the stage. The change in the y coordinate affects the drop speed, the larger the value, the faster the drop speed.



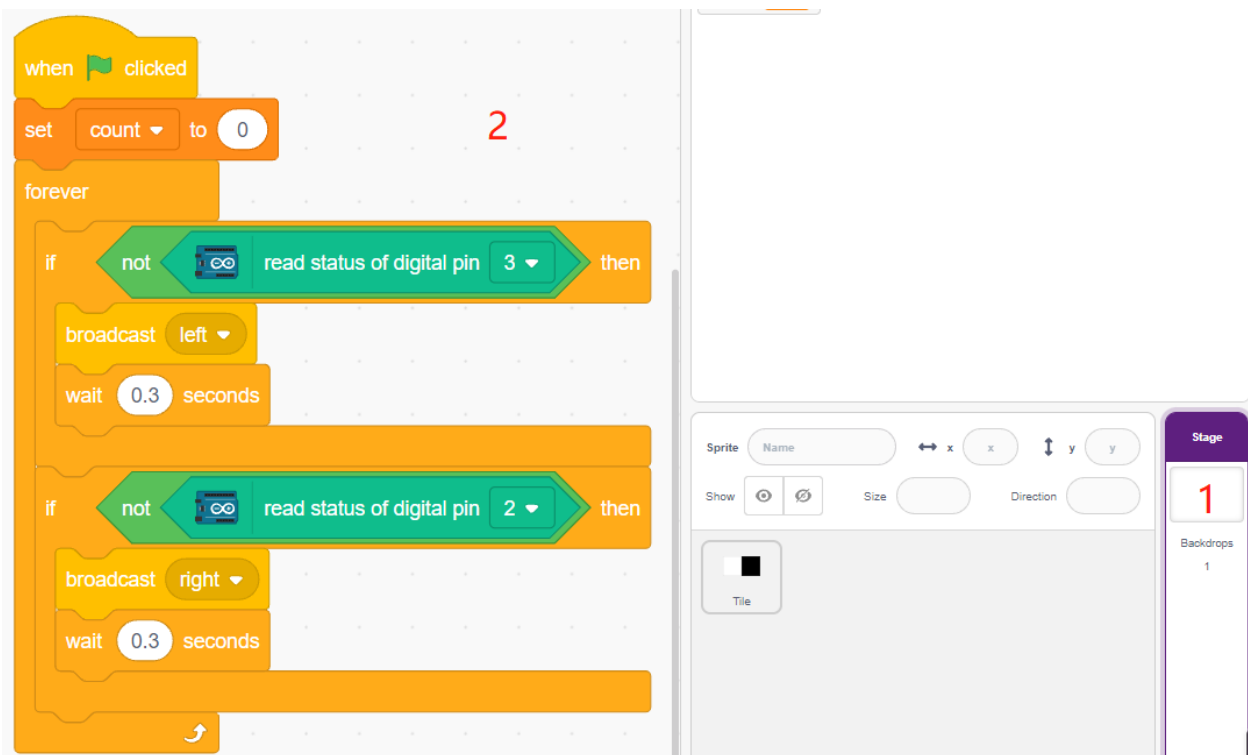
Hide the body and show the clone.



### 3. Read the values of the 2 IR modules

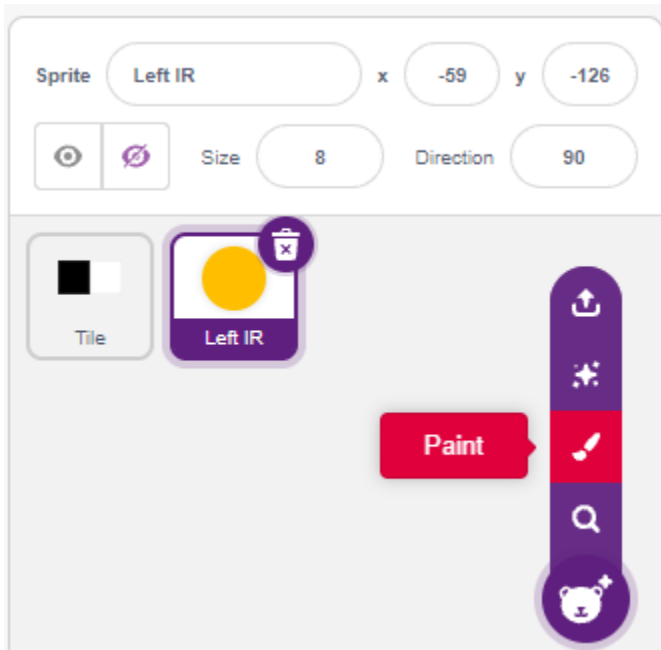
In the backdrop, read the values of the 2 IR modules and make the corresponding actions.

- If the left IR obstacle avoidance module senses your hand, broadcast a message - **left**.
- If the left IR avoidance module senses your hand, broadcast a message - **right**.

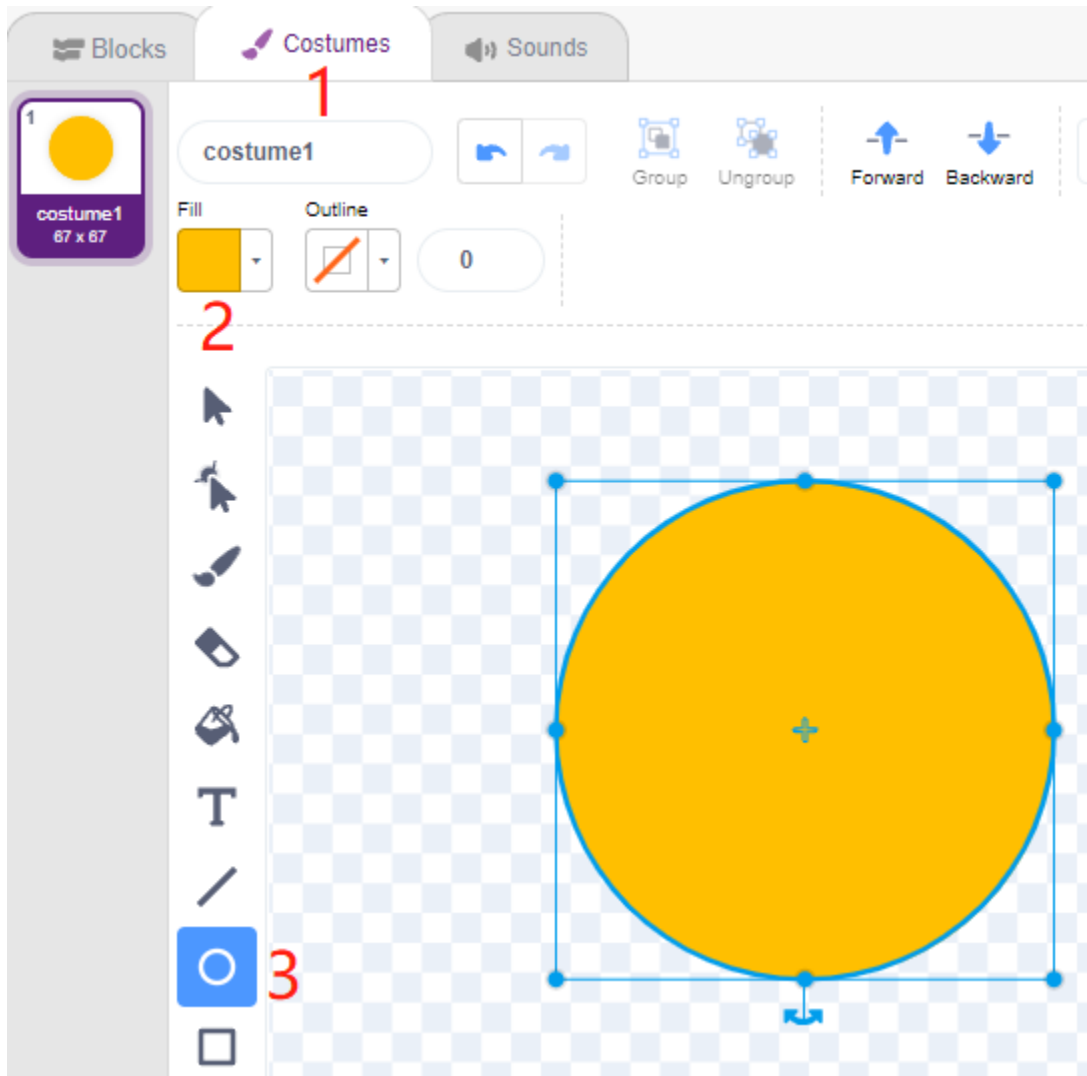


### 4. Left IR sprite

Again, mouse over the **Add sprite** icon and select **Paint** to create a new sprite called **Left IR**.



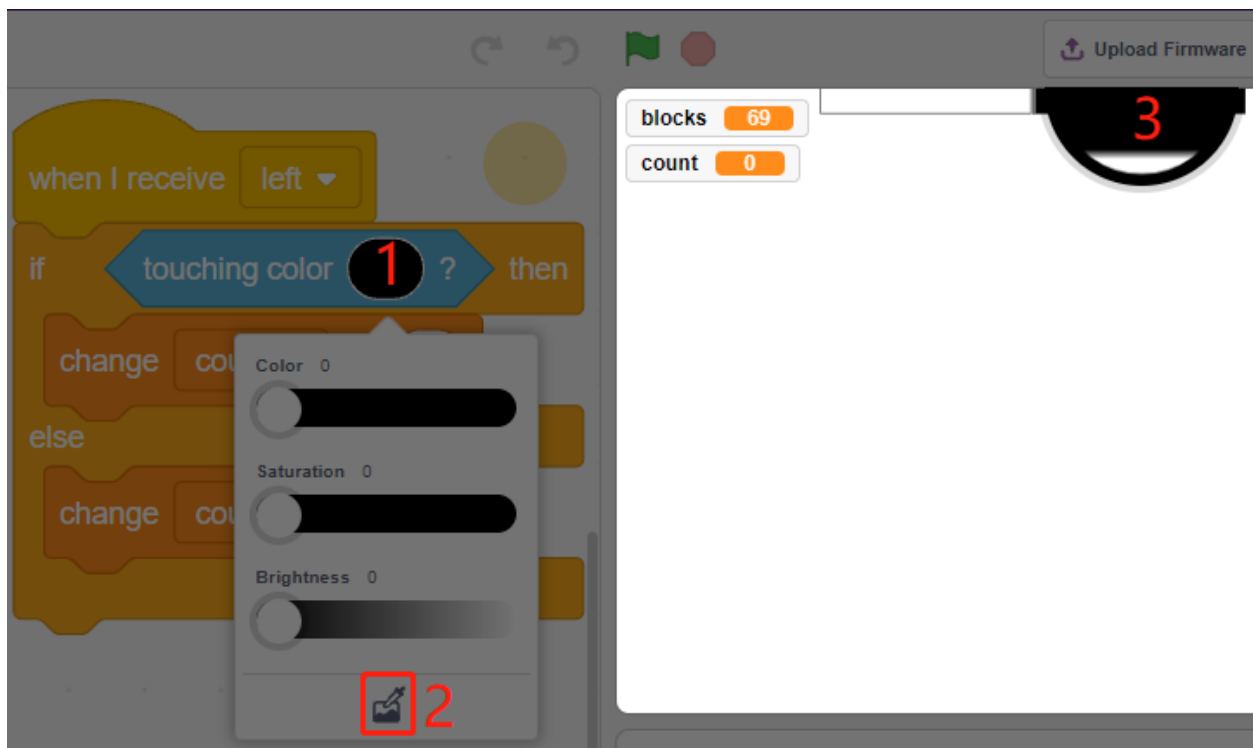
Go to the **Costumes** page of the **Left IR** sprite, select the fill color (any color out of black and white) and draw a circle.



Now start scripting the **Left IR** sprite. When the message - **left** is received (the IR receiver module on the left detects an obstacle), then determine if the black block of the **Tile** sprite is touched, and if it is, let the variable **count** add 1, otherwise subtract 1.

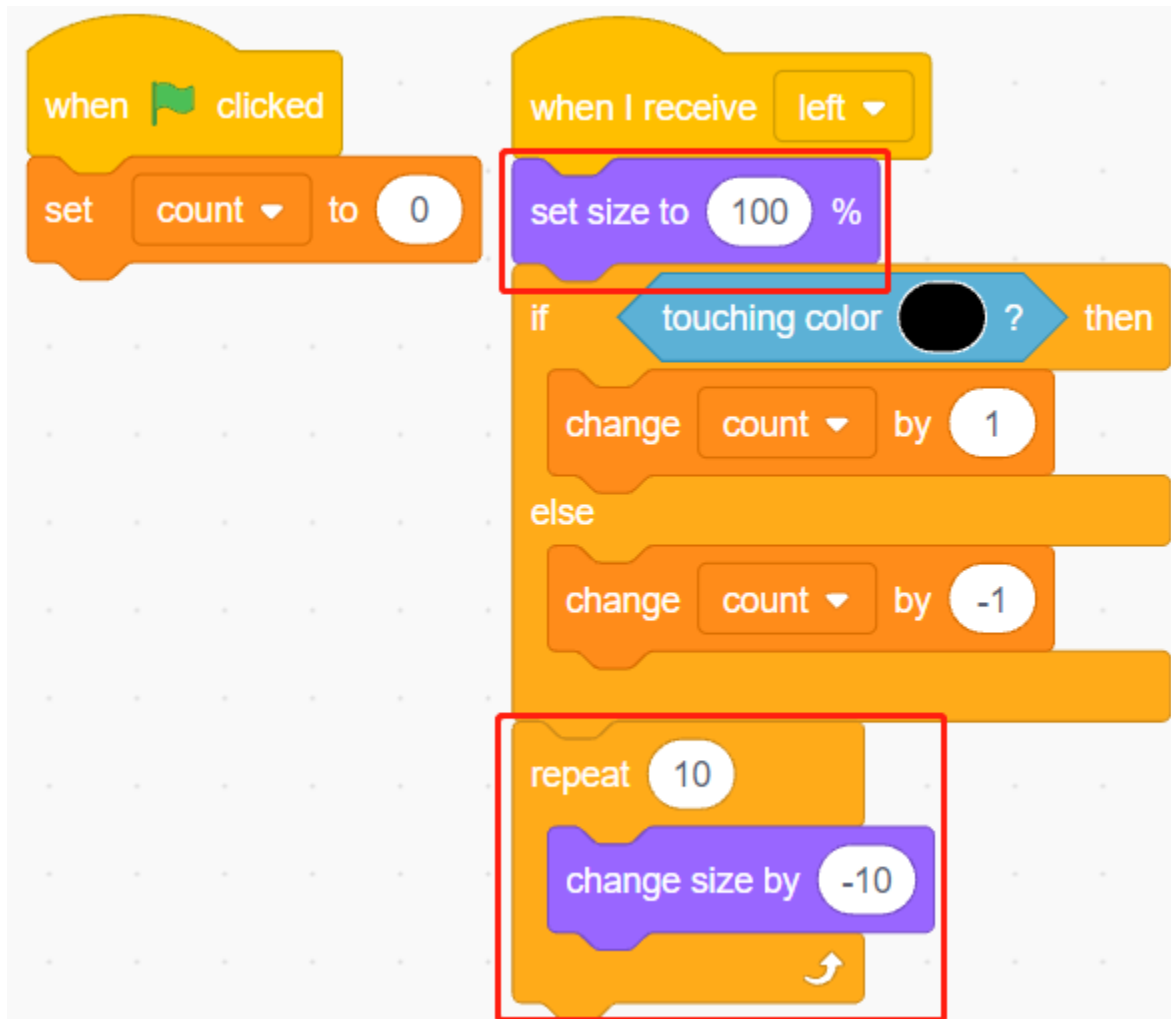


**Note:** You need to make the **Tile** sprite appear on the stage, and then absorb the color of the black block in the **Tile** sprite.

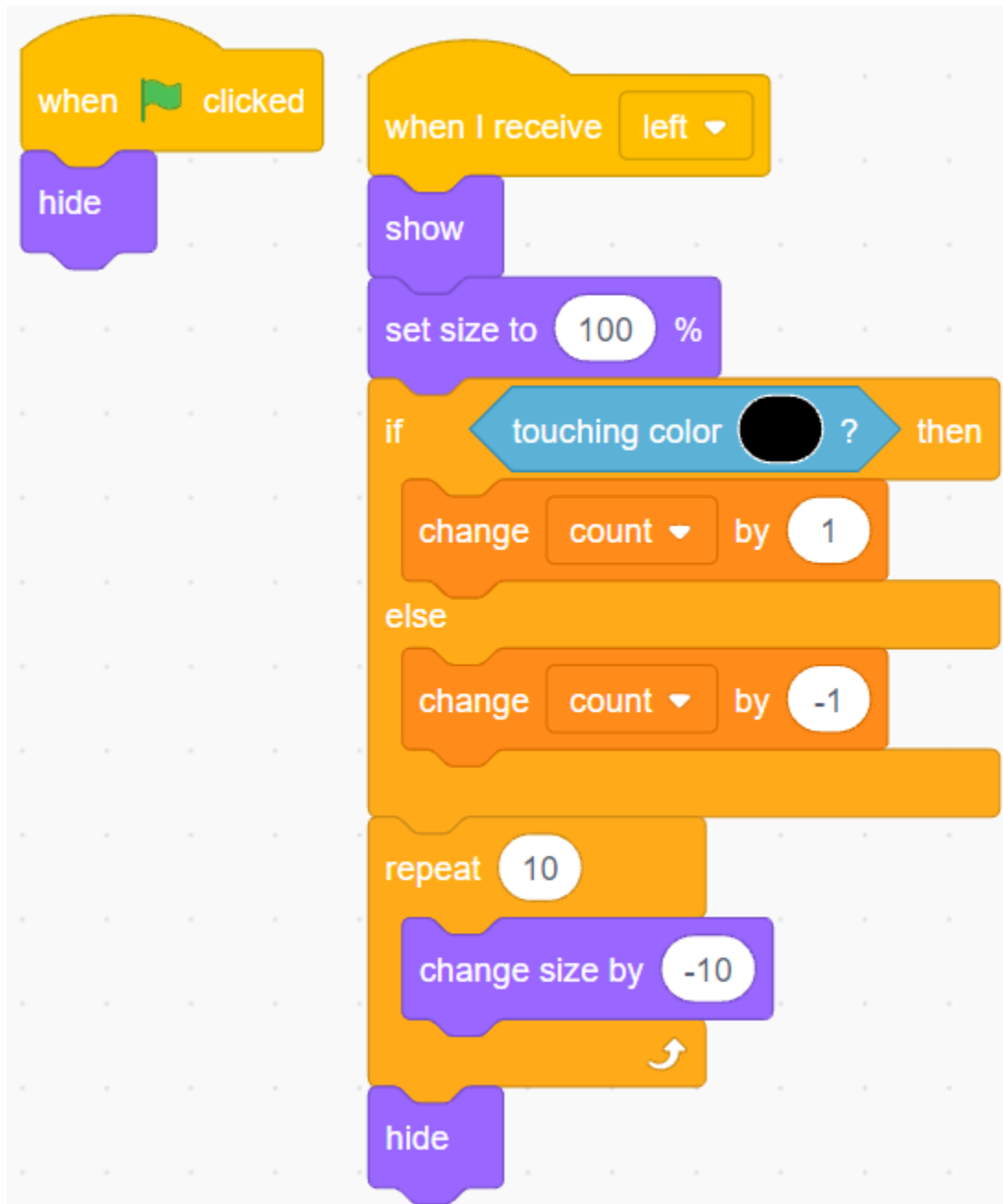


Now let's do the sensing effect (zoom in and out) for **Left IR**.



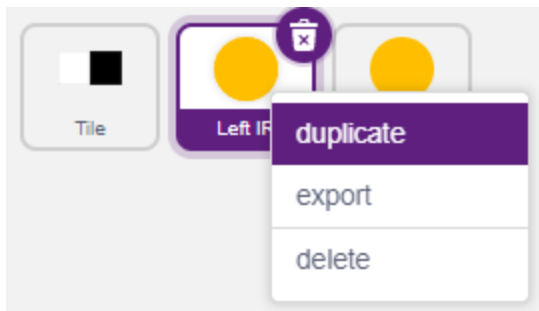


Make the **Left IR** sprite hide when the green flag is clicked, show when the message - **left** is received, and finally hide again.

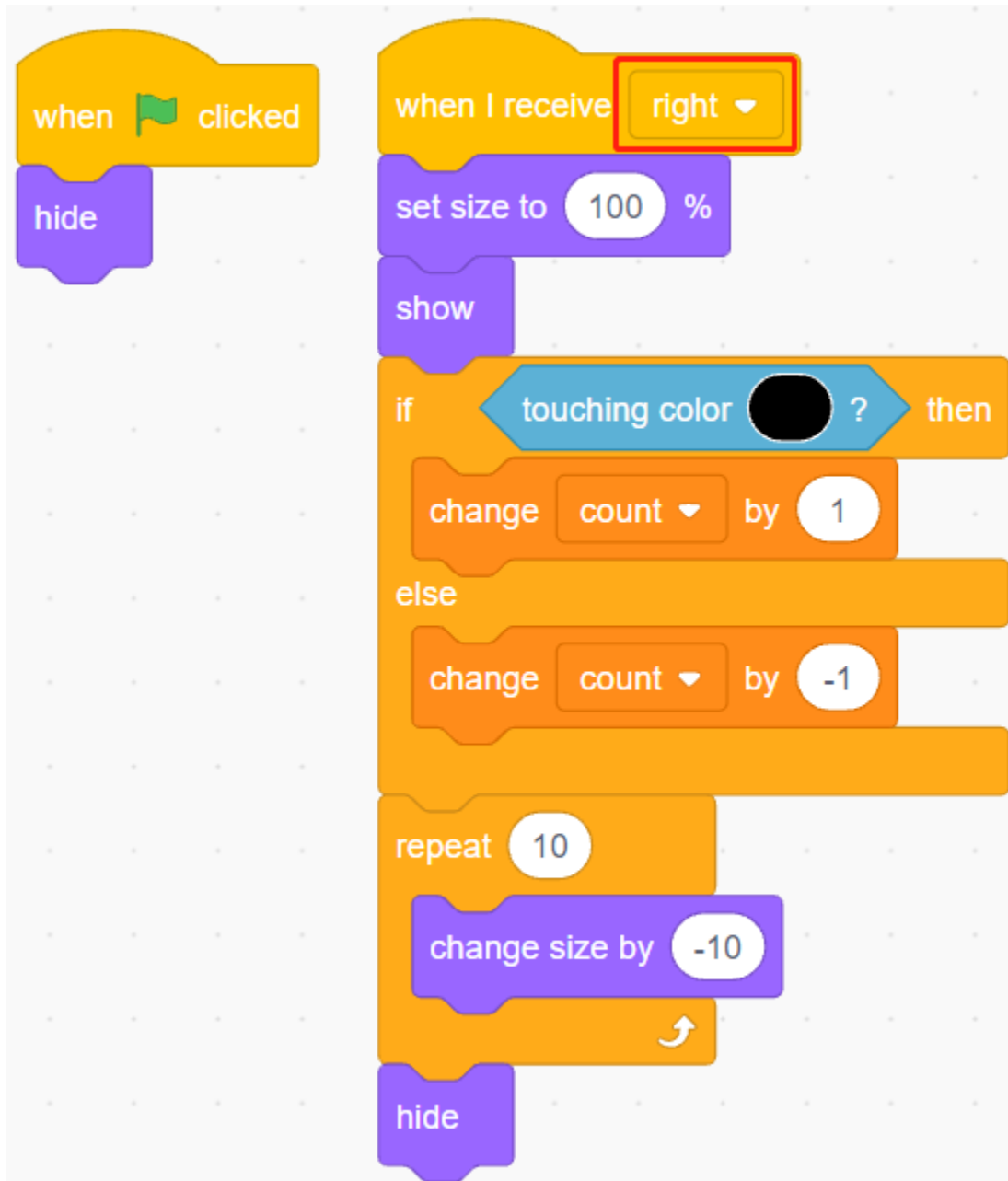


### 5. Right IR sprite

Copy the **Left IR** sprite and rename it to **Right IR**.



Then change the receive message to - **right**.



Now all the scripting is done and you can click on the green flag to run the script.

7.24 2.21 GAME - Protect Your Heart

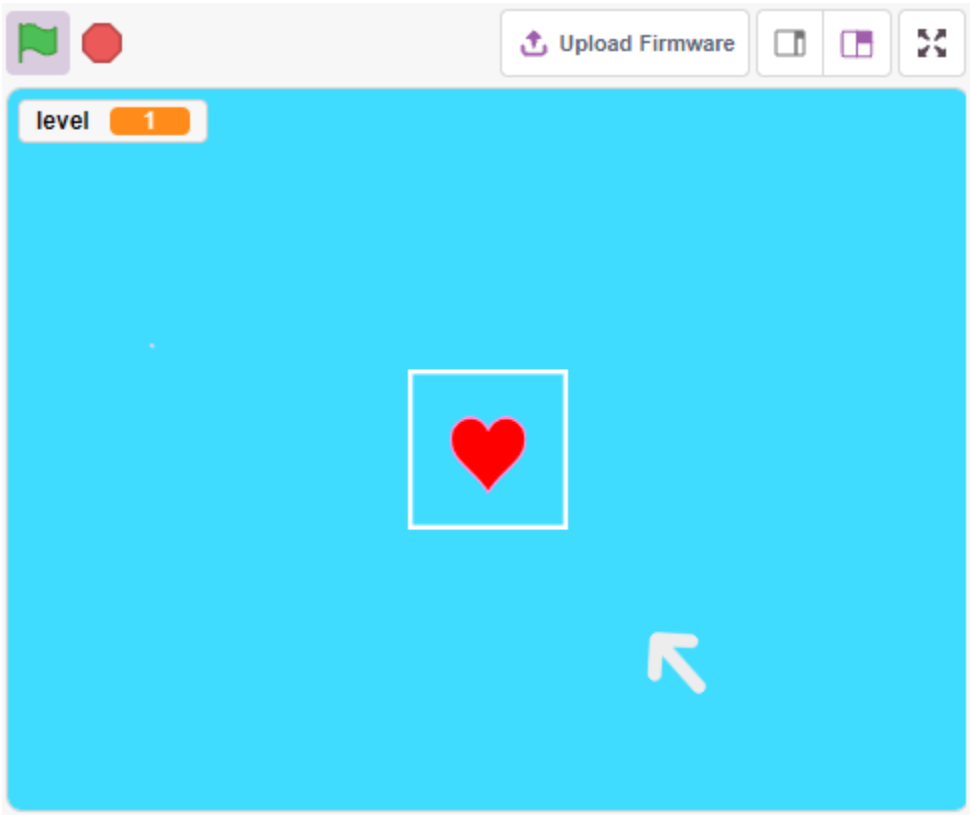
In this project, let’s make a game that tests reaction speed.

In the stage, there is a heart protected in a rectangular box, and there are arrows flying towards this heart from any position on the stage. The color of the arrow will alternate between black and white at random and the arrow will fly faster and faster.

If the color of the rectangular box and the arrow color are the same, the arrow is blocked outside and level is added 1; if the color of both is not the same, the arrow will shoot through the heart and the game is over.

Here the color of the rectangle box is controlled by the Line Tracking module. When the module is placed on a black surface (a surface that is reflective), the color of the rectangle box is black, otherwise it is white.

So you need to decide whether to put the Line Tracking module on a white surface or a black surface according to the arrow color.



7.24.1 Required Components

In this project, we need the following components.

It’s definitely convenient to buy a whole kit, here’s the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

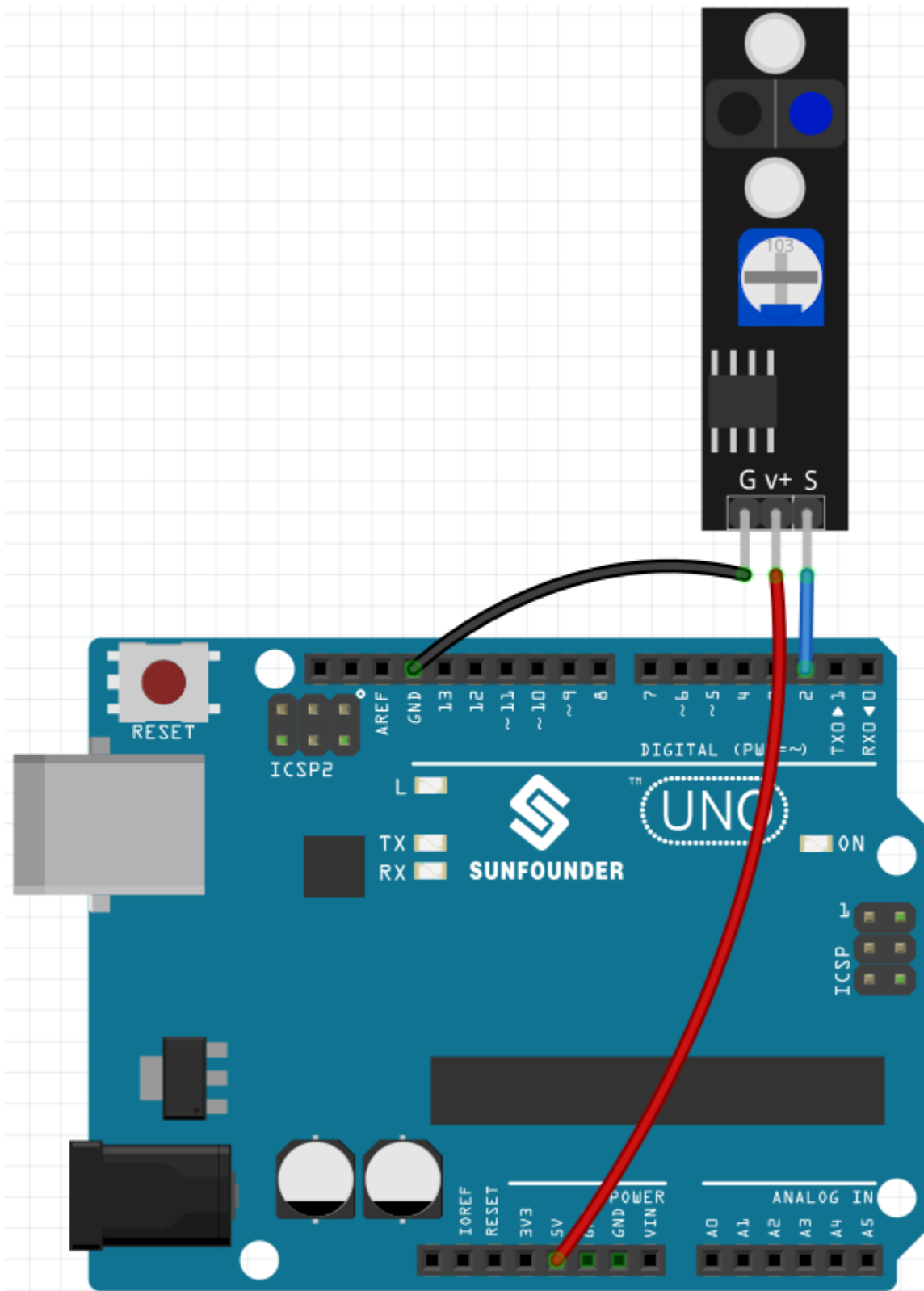
You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>Line Tracking Module</i>	

### 7.24.2 Build the Circuit

This is a digital Line Tracking module, when a black line is detected, it outputs 1; when a white line is detected, it outputs a value of 0. In addition, you can adjust its sensing distance through the potentiometer on the module.

Now build the circuit according to the diagram below.



**Note:** Before starting the project, you need to adjust the sensitivity of the module.

Wiring according to the above diagram, then power up the R3 board (either directly into the USB cable or the 9V

battery button cable), without uploading the code.

Now stick a black electrical tape on the desktop, put the Line Track module at a height of 2cm from the desktop.

With the sensor facing down, observe the signal LED on the module to make sure it lights up on the white table and goes off on the black tape.

If not, you need to adjust the potentiometer on the module, so that it can do the above effect.

### 7.24.3 Programming

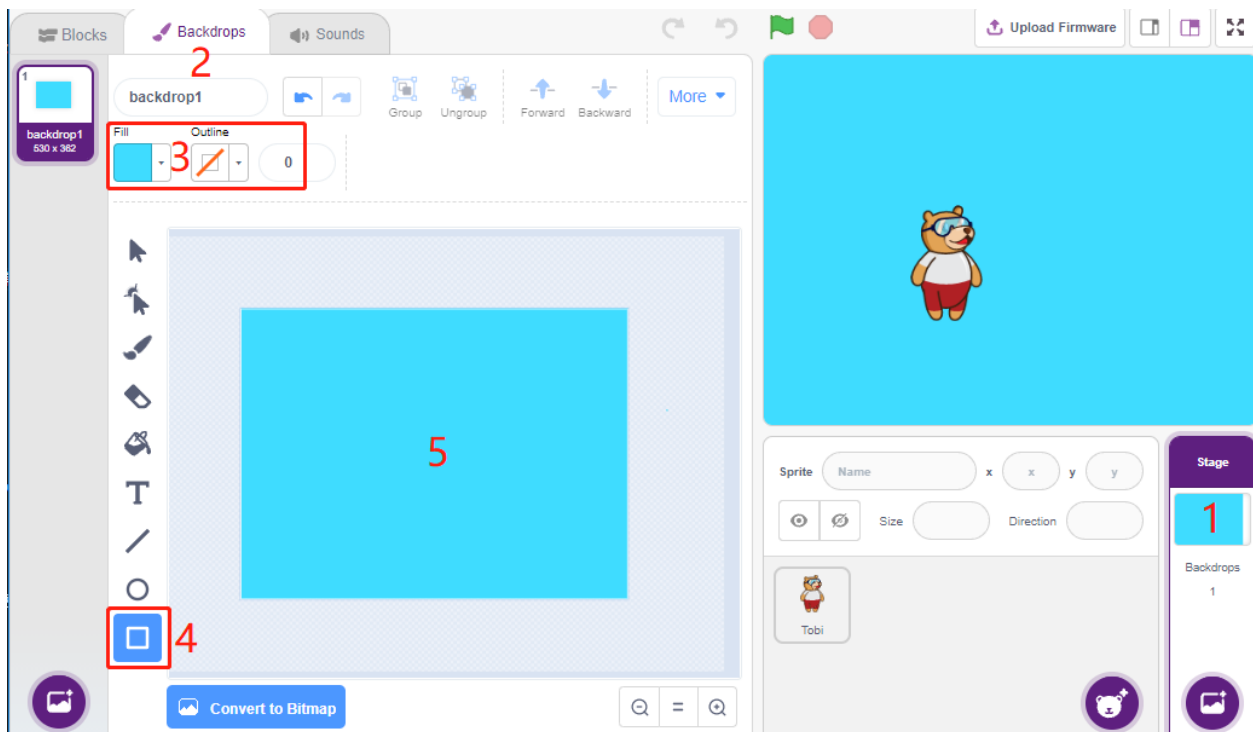
Here we need to create 3 sprites, **Heart**, **Square Box** and **Arrow1**.

- **Heart**: stops in the middle of the stage, if touched by **Arrow1** sprite, the game is over.
- **Square Box**: There are two types of costumes, black and white, and will switch costumes according to the value of Line Tracking module.
- **Arrow**: flies towards the middle of the stage from any position in black/white; if its color matches the color of the **Square Box** sprite, it is blocked and re-flies towards the middle of the stage from a random position; if its color does not match the color of the **Square Box** sprite, it passes through the **Heart** sprite and the game is over.

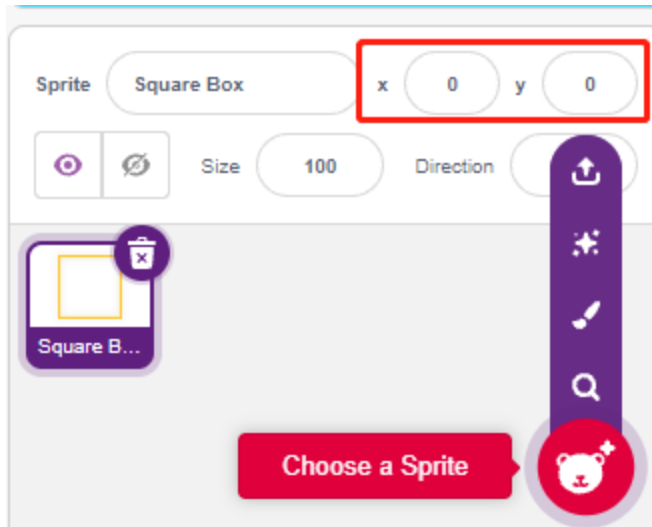
#### 1. Add Square Box sprite

Since the Arrow1 and Square Box sprite both have white costumes, in order for them to be displayed on the stage, now fill the background with a color that can be any color except black, white, and red.

- Click on **Backdrop1** to go to its **Backdrops** page.
- Select the color you want to fill.
- Use the **Rectangle** tool to draw a rectangle the same size as the drawing board.



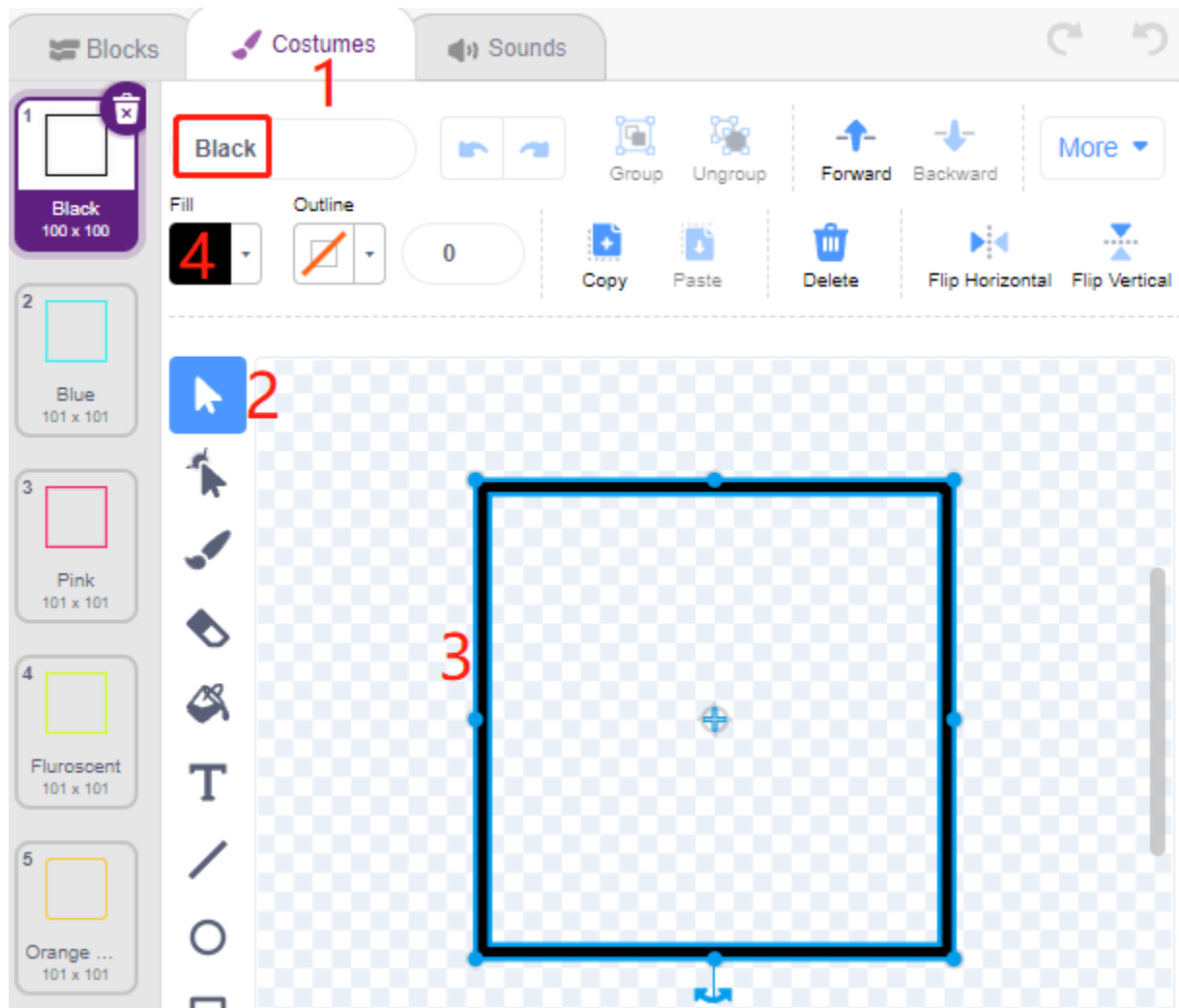
Delete the default sprite, use the **Choose a Sprite** button to add the **Square Box** sprite, and set its x and y to (0, 0).



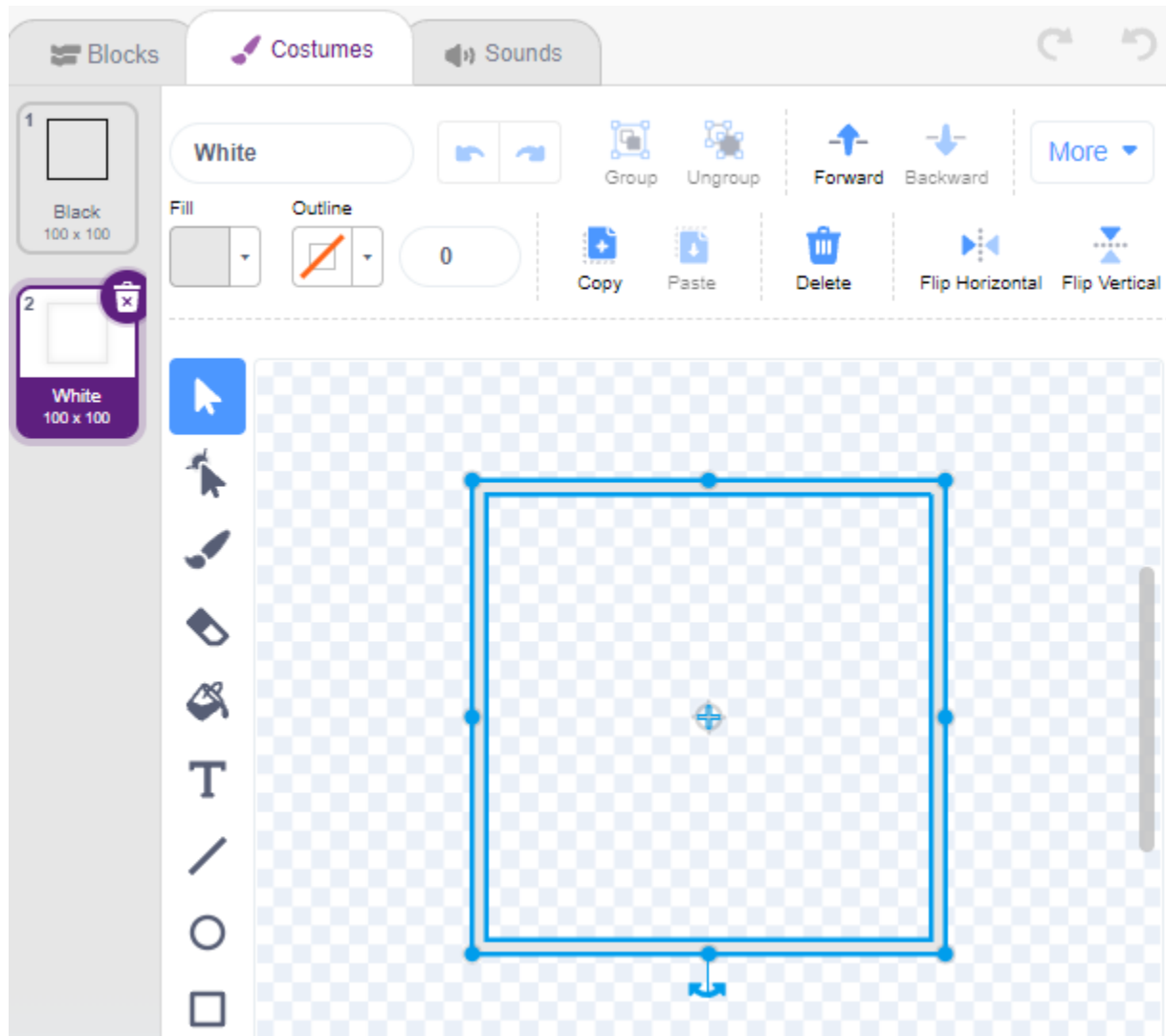
Go to the **Square Box** sprite's **Costumes** page and set the black and white costumes.

- Click the selection tool
- Select the rectangle on the canvas
- Select the fill color as black
- and name the costume **Black**



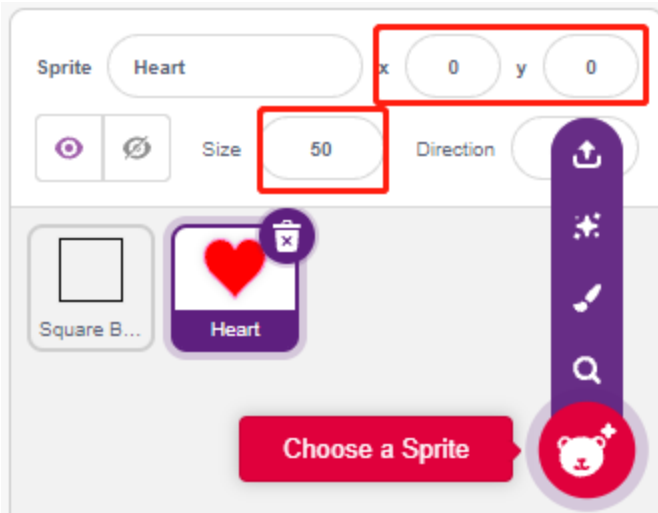


Select the second costume, set the fill color to white, name it White, and delete the rest of the costume.

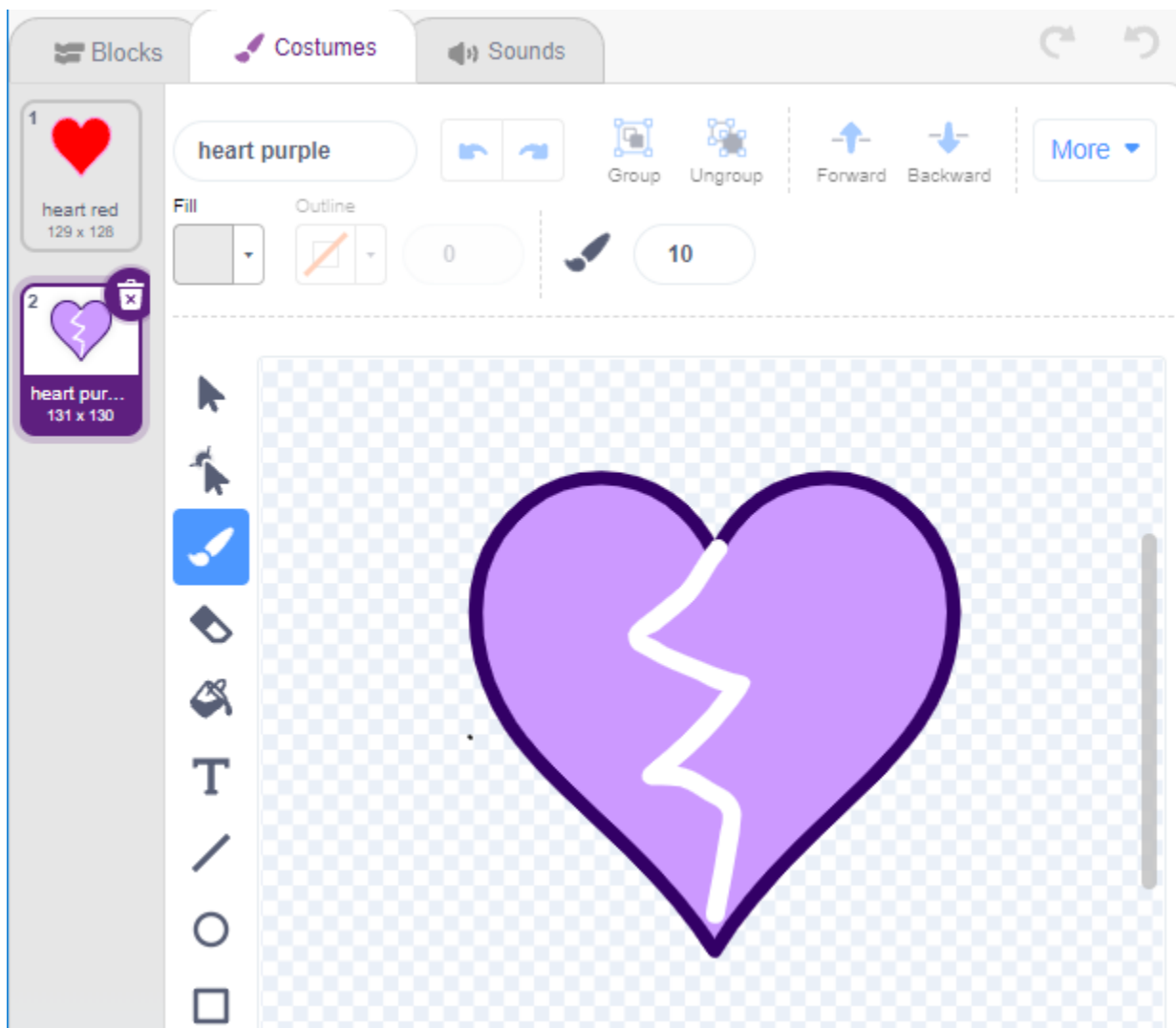


## 2. Add Heart sprite

Also add a **Heart** sprite, set its position to (0, 0), and shrink its size so that it appears to be located inside the Square Box.

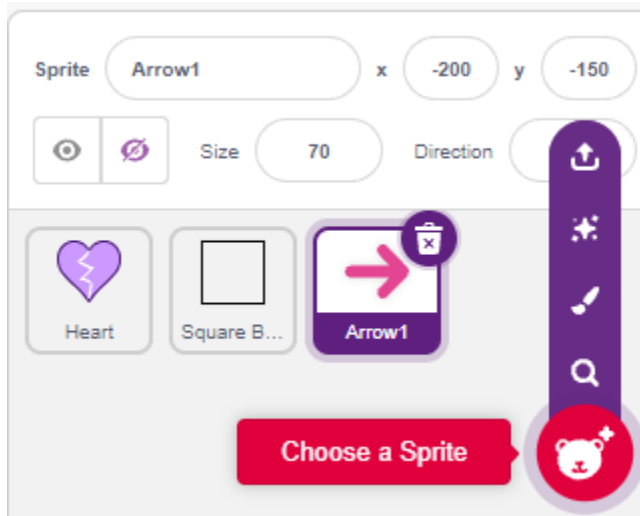


On the **Costumes** page, adjust the heart purple costume so that it appears to be broken.

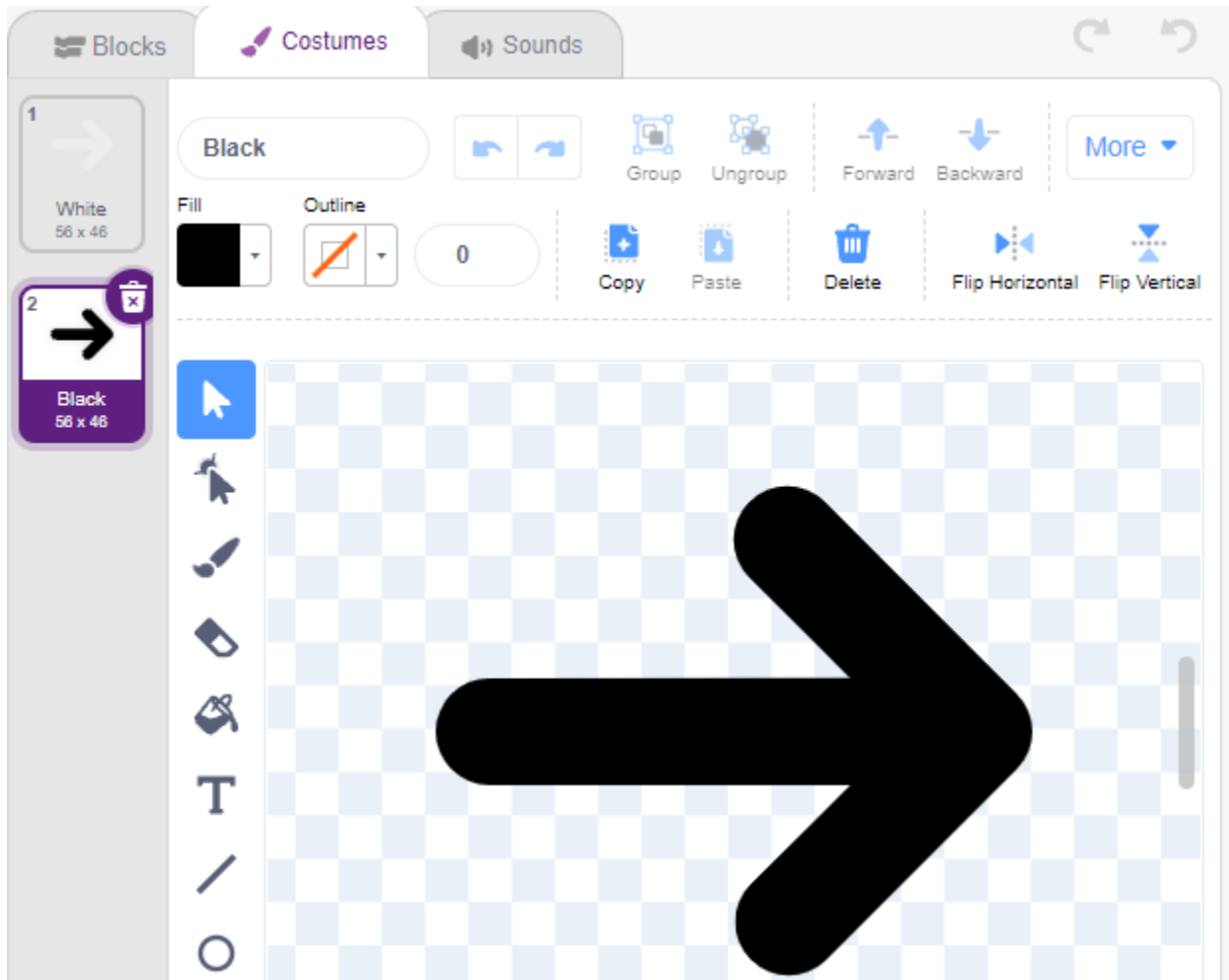


### 3. Add Arrow1 sprite

Add an **Arrow1** sprite.



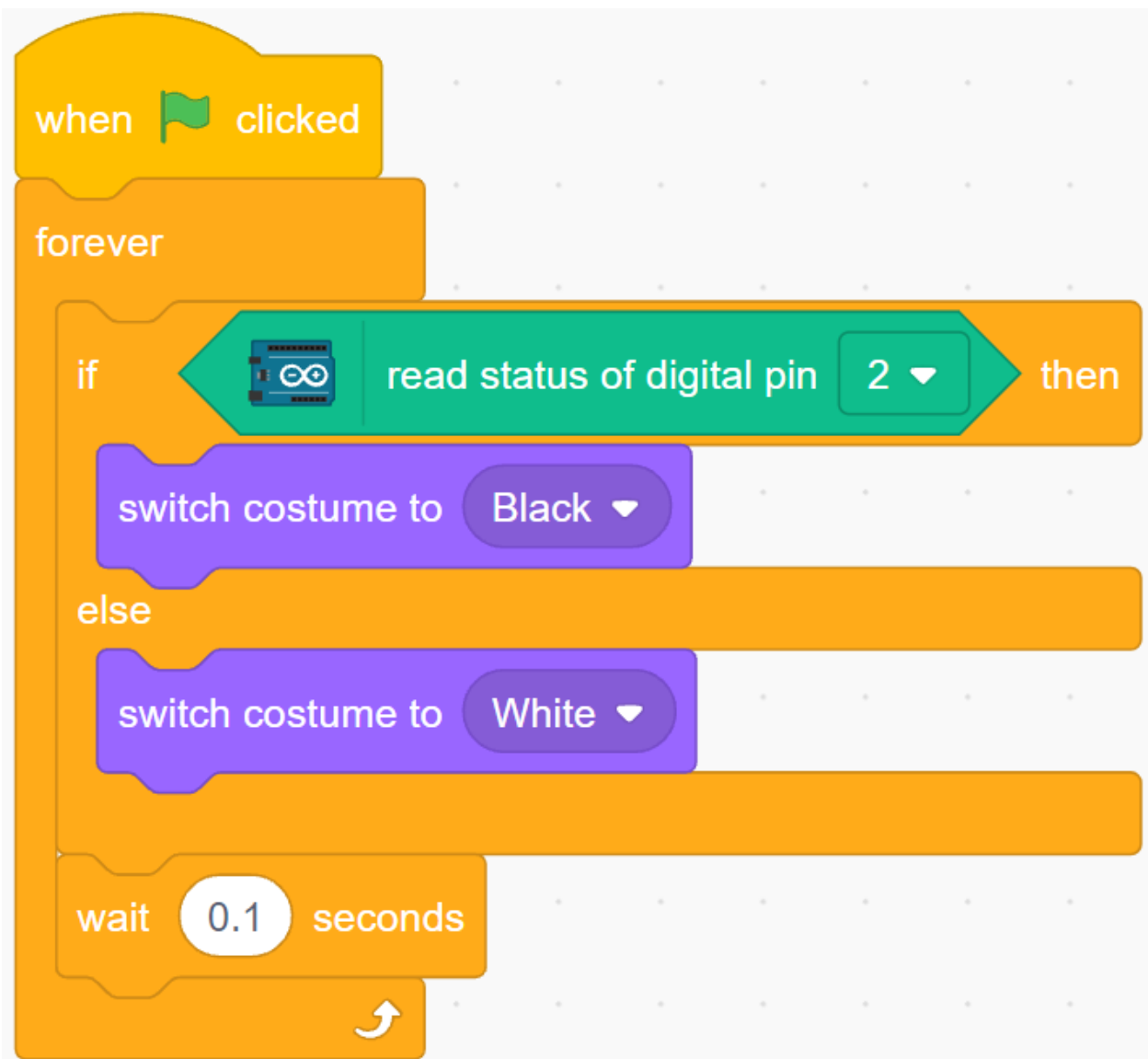
On the **Costumes** page, keep and copy the rightward facing costume and set its color to black and white.



#### 4. Scripting for Square Box sprite

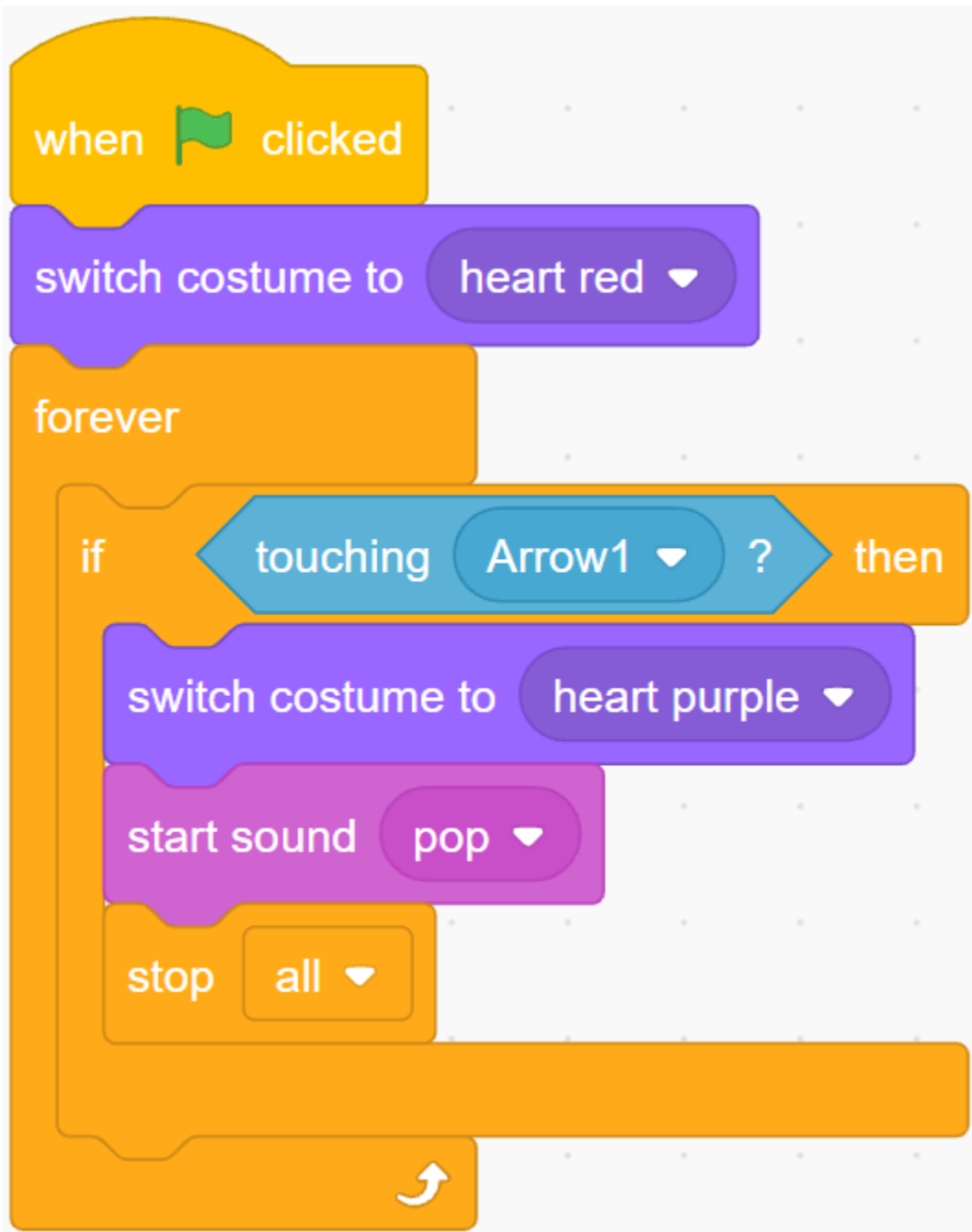
Go back to the **Blocks** page and script **Square Box** sprite.

- So when the value of the digital pin 2 (Line Following module) is 1 (black line detected), then switch the costume to **Black**.
- Otherwise toggle the costume to **White**.



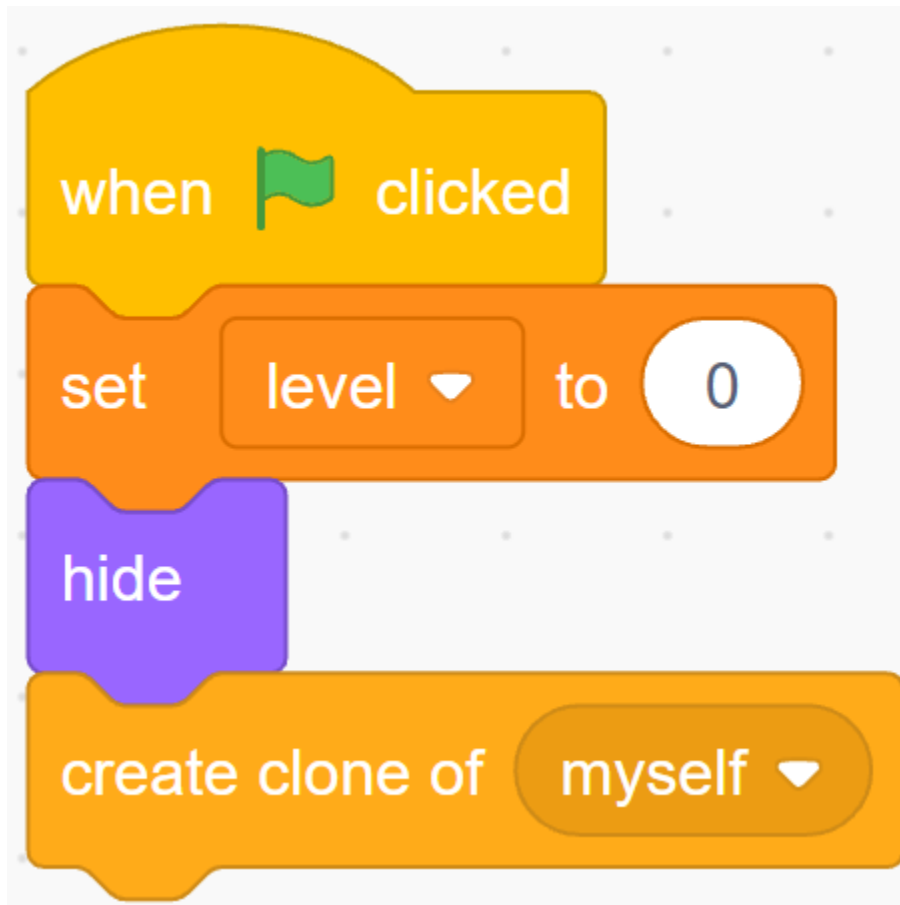
### 5. Scripting for Heart sprite

**Heart** sprite is protected inside **Square Box**, and by default is a red costume. When the Arrow1 sprite is touched, the game ends.



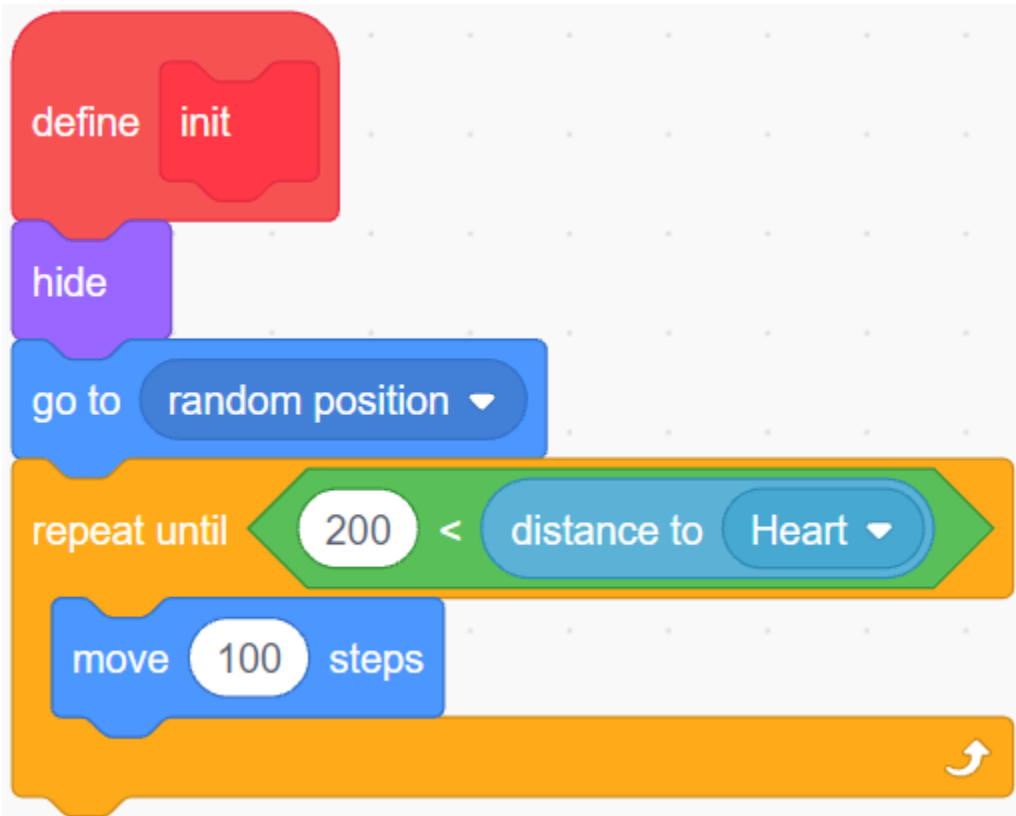
## 6. Scripting for Arrow1 sprite

Make the **Arrow1** sprite hide and create a clone when the green flag is clicked.



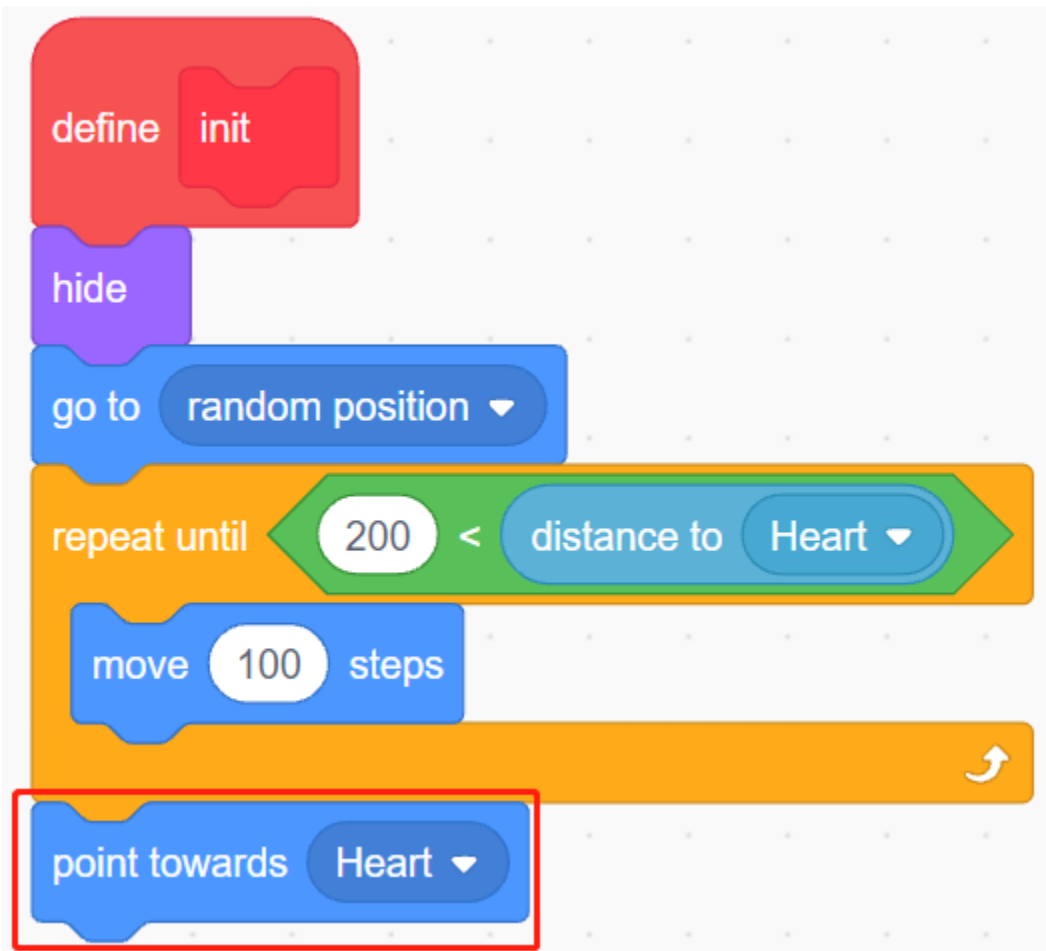
Create an [init] block to initialize the **Arrow1** sprite's position, orientation and color.

It appears at a random location, and if the distance between it and the **Heart** sprite is less than 200, it moves outward until the distance is greater than 200.



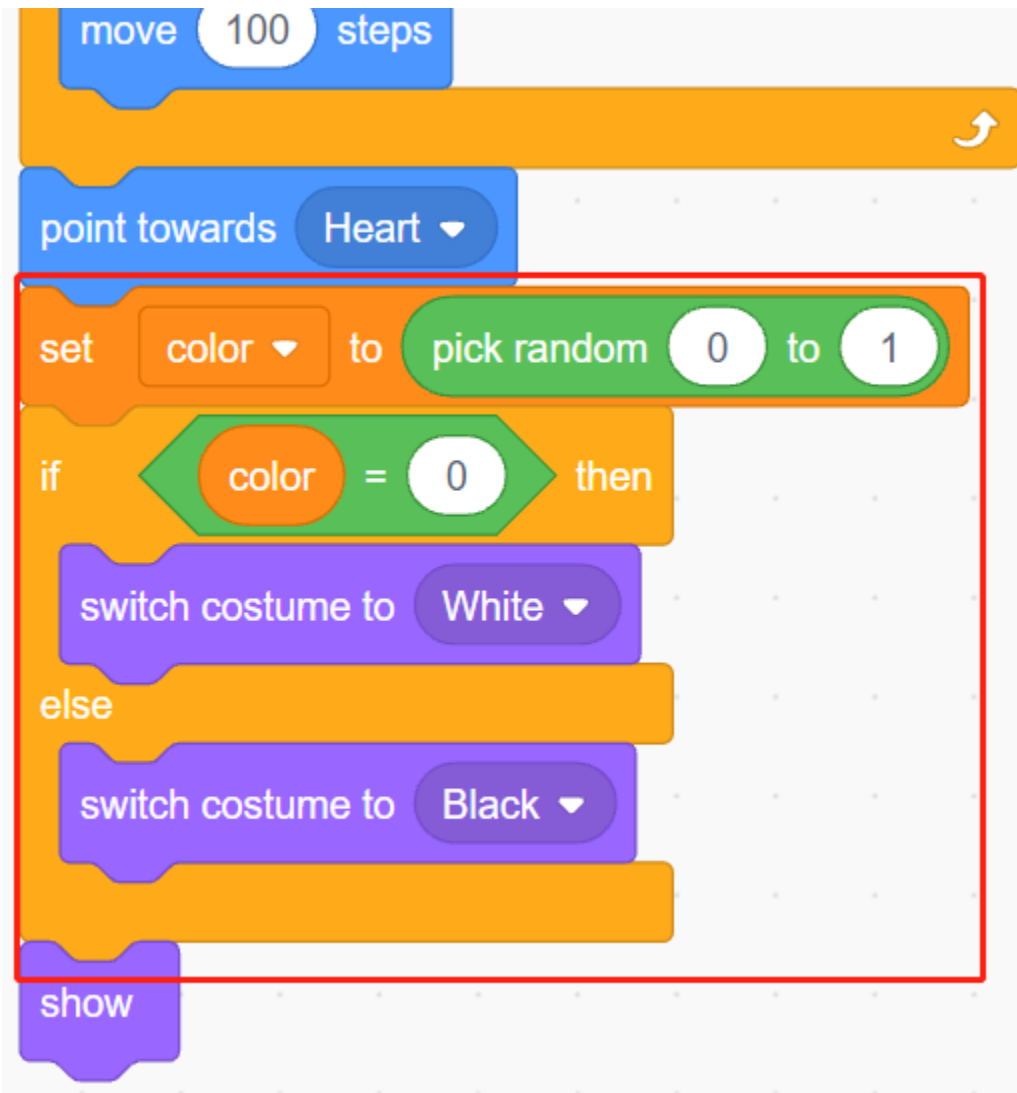
Set its direction to face the **Heart** sprite.



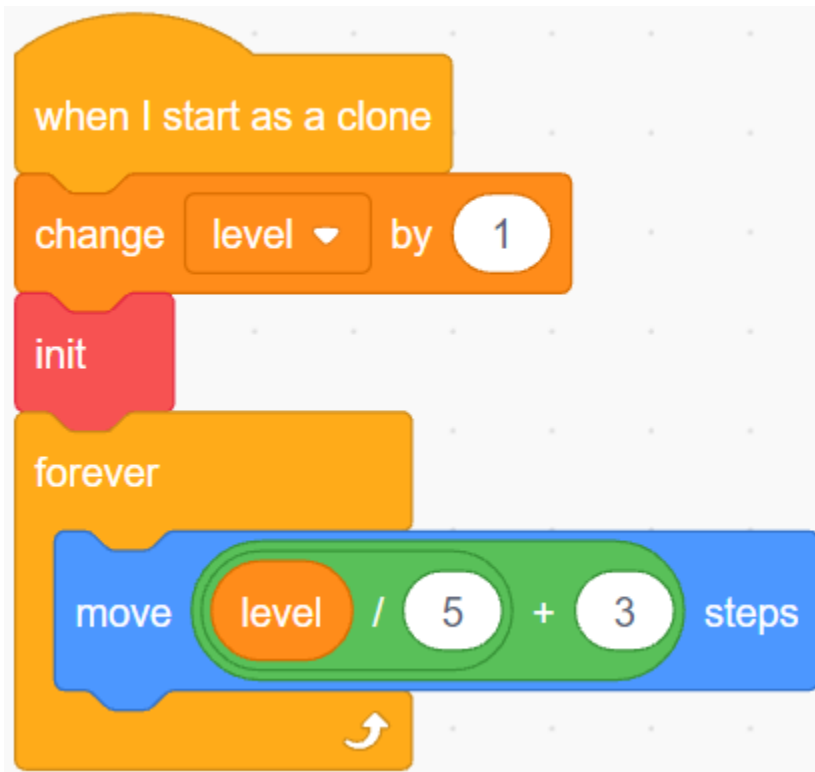


Make its color alternate randomly between black/white.

- Variable color is 0, toggle costume to **White**.
- Variable color is 1, toggles the outfit to **Black**.

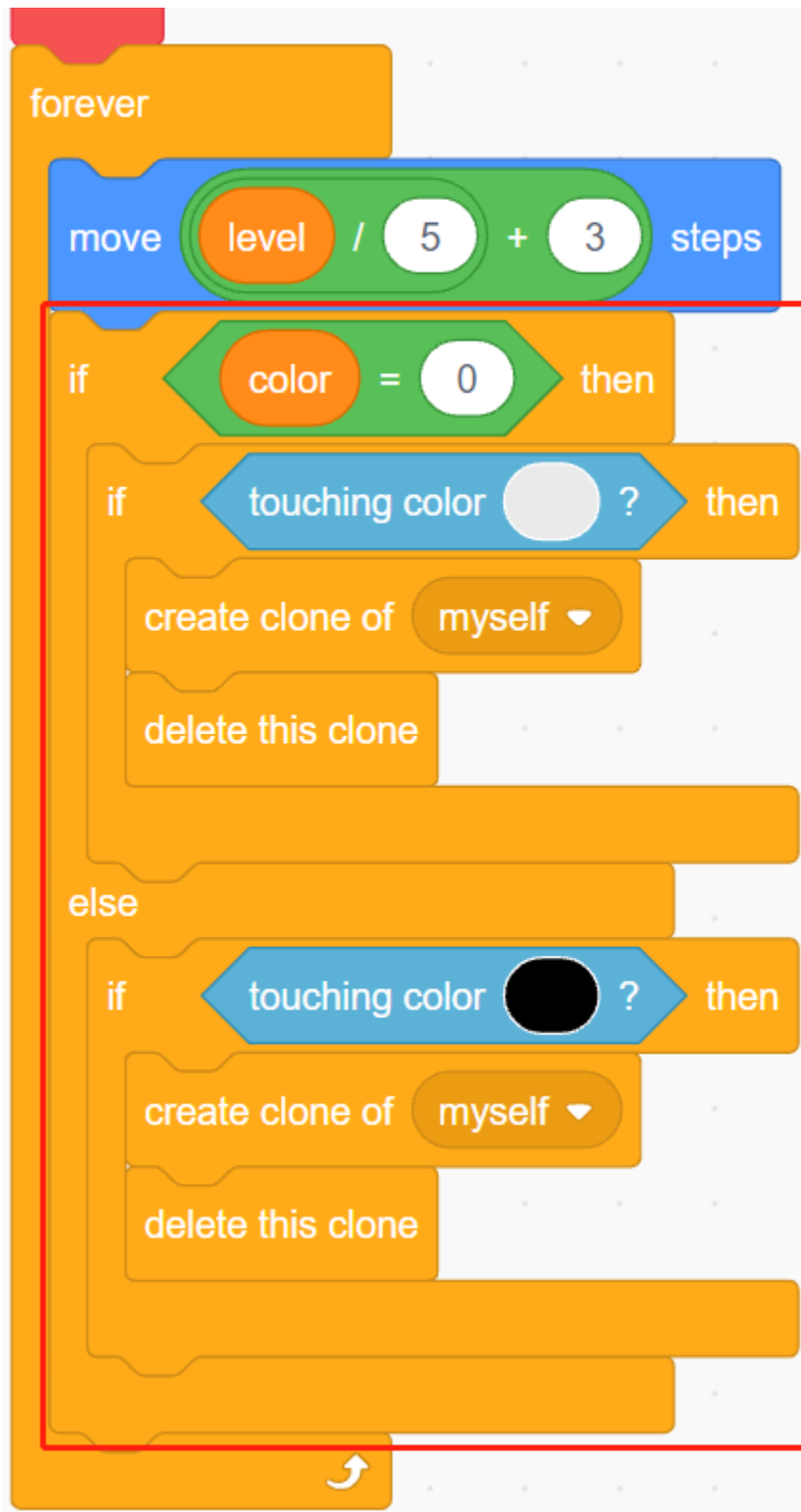


Now let it start moving, it will move faster as the value of the variable **level** increases.

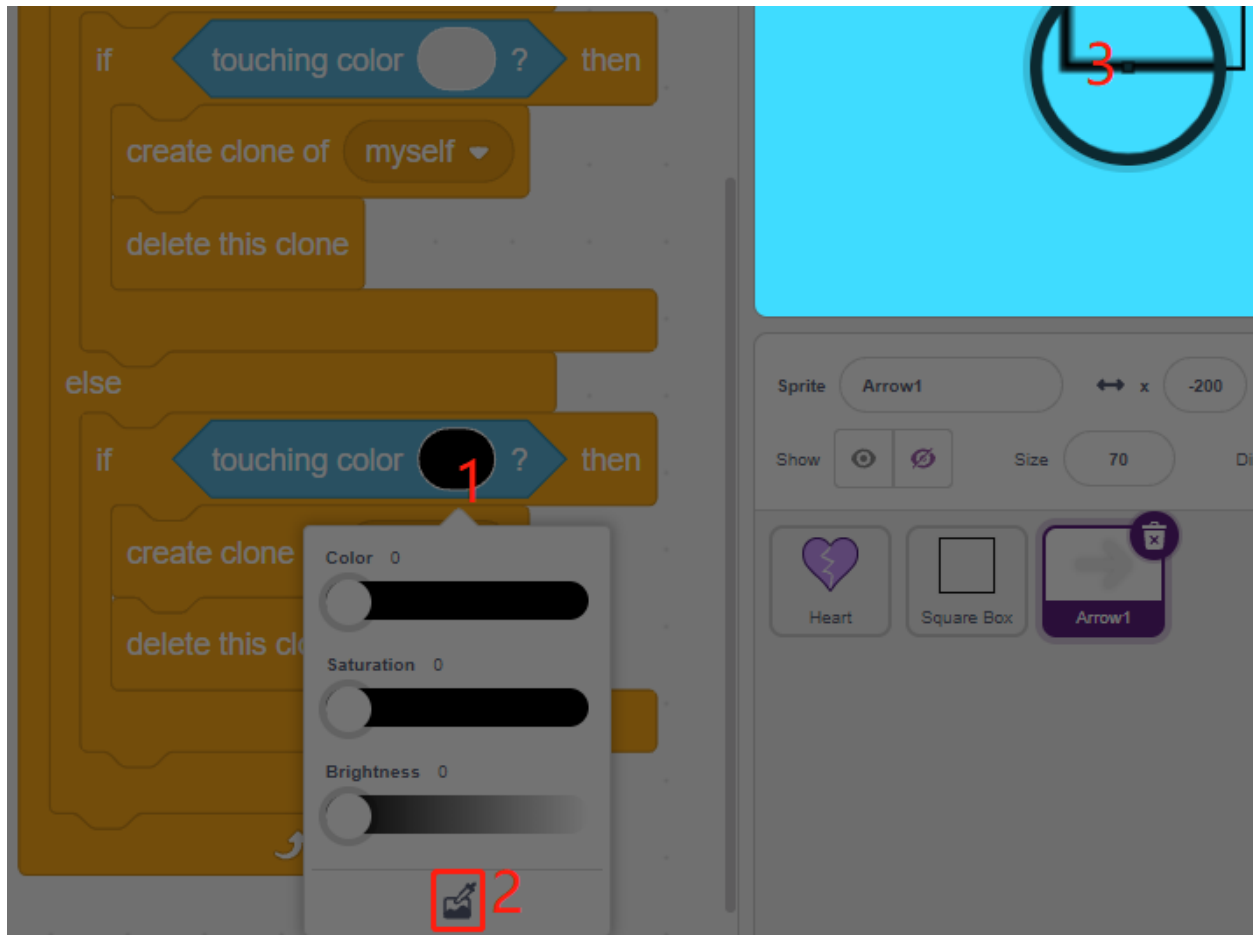


Now set its collision effect with the **Square Box** sprite.

- If the **Arrow1** sprite and the **Square Box** sprite have the same color (which will be modified according to the value of the Line Track module), either black or white, a new clone is created and the game continues.
- If their colors do not match, the **Arrow1** sprite continues to move and the game ends when it hits the **Heart** sprite.



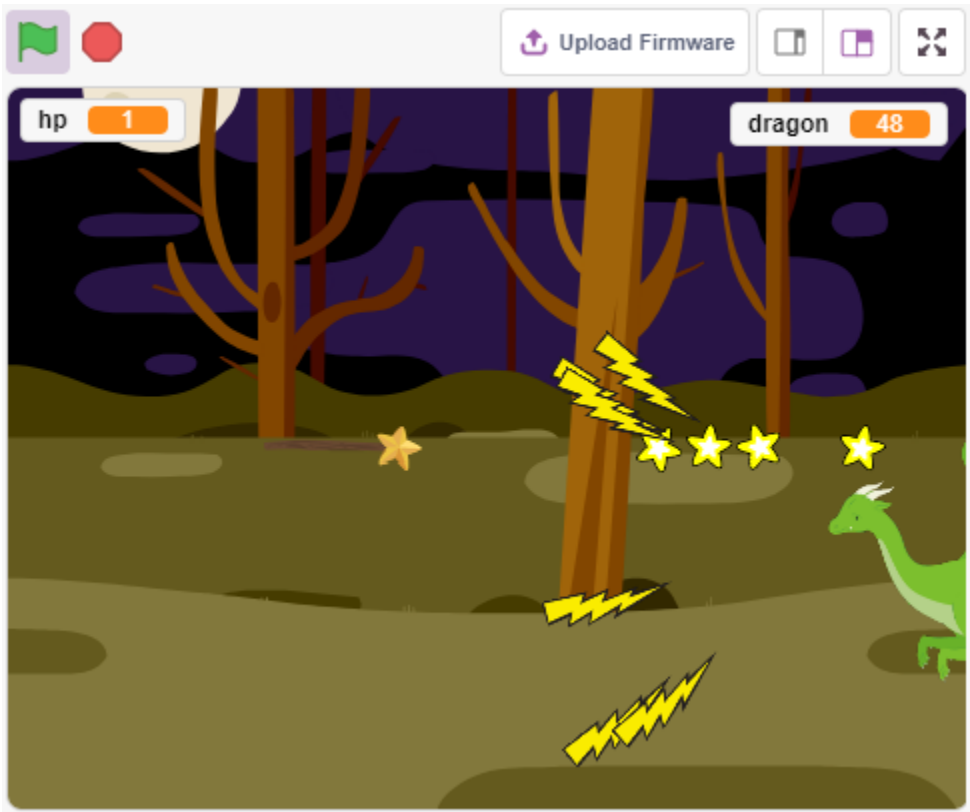
**Note:** The two [touch color()] blocks need to pick up the black/white costumes of Square Box separately.



## 7.25 2.22 GAME - Kill Dragon

Here, we use the joystick to play a game of dragon killing.

When clicking on green, the dragon will float up and down on the right side and blow fire intermittently. You need to use the joystick to control the movement of the magic wand and launch star attacks at the dragon, while avoiding the flames it shoots, and finally defeat it.



7.25.1 Required Components

In this project, we need the following components.  
It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>Jumper Wires</i>	
<i>Joystick Module</i>	-

### 7.25.2 Build the Circuit

A joystick is an input device consisting of a stick that pivots on a base and reports its angle or direction to the device it is controlling. Joysticks are often used to control video games and robots.

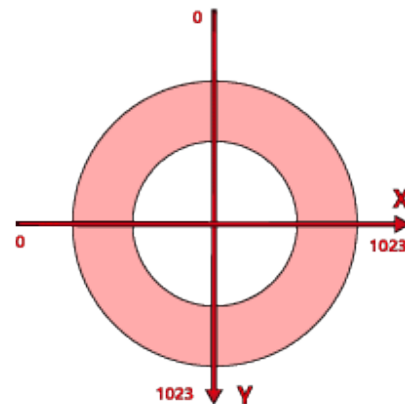
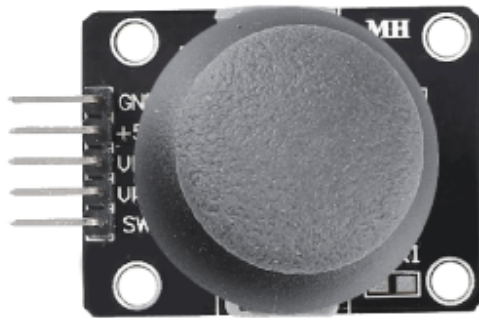
In order to communicate a full range of motion to the computer, a joystick needs to measure the stick's position on two axes – the X-axis (left to right) and the Y-axis (up and down).

The motion coordinates of the joystick are shown in the following figure.

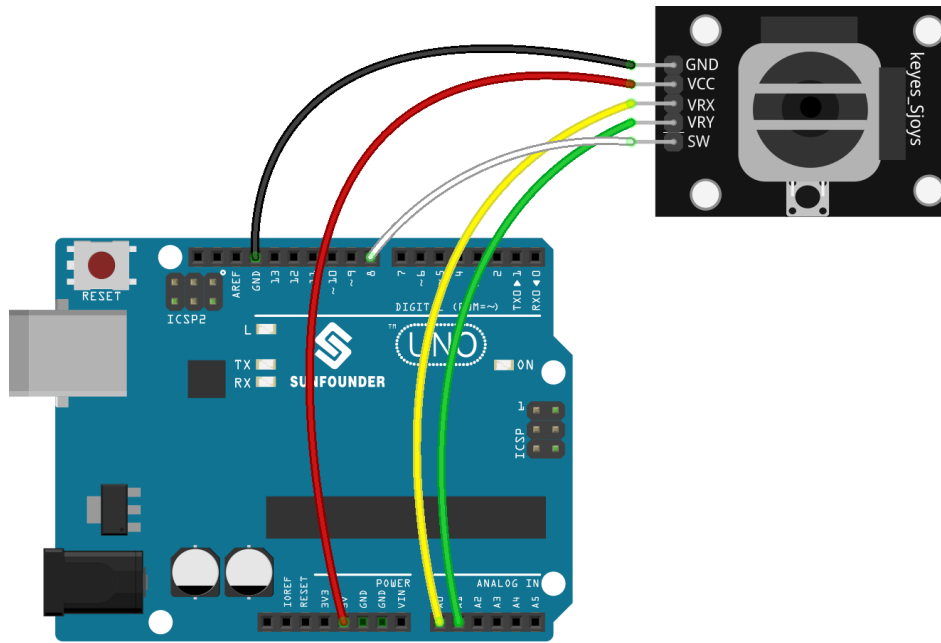
---

**Note:**

- The x coordinate is from left to right, the range is 0-1023.
  - y coordinate is from top to bottom, range is 0-1023.
- 



Now build the circuit according to the following diagram.

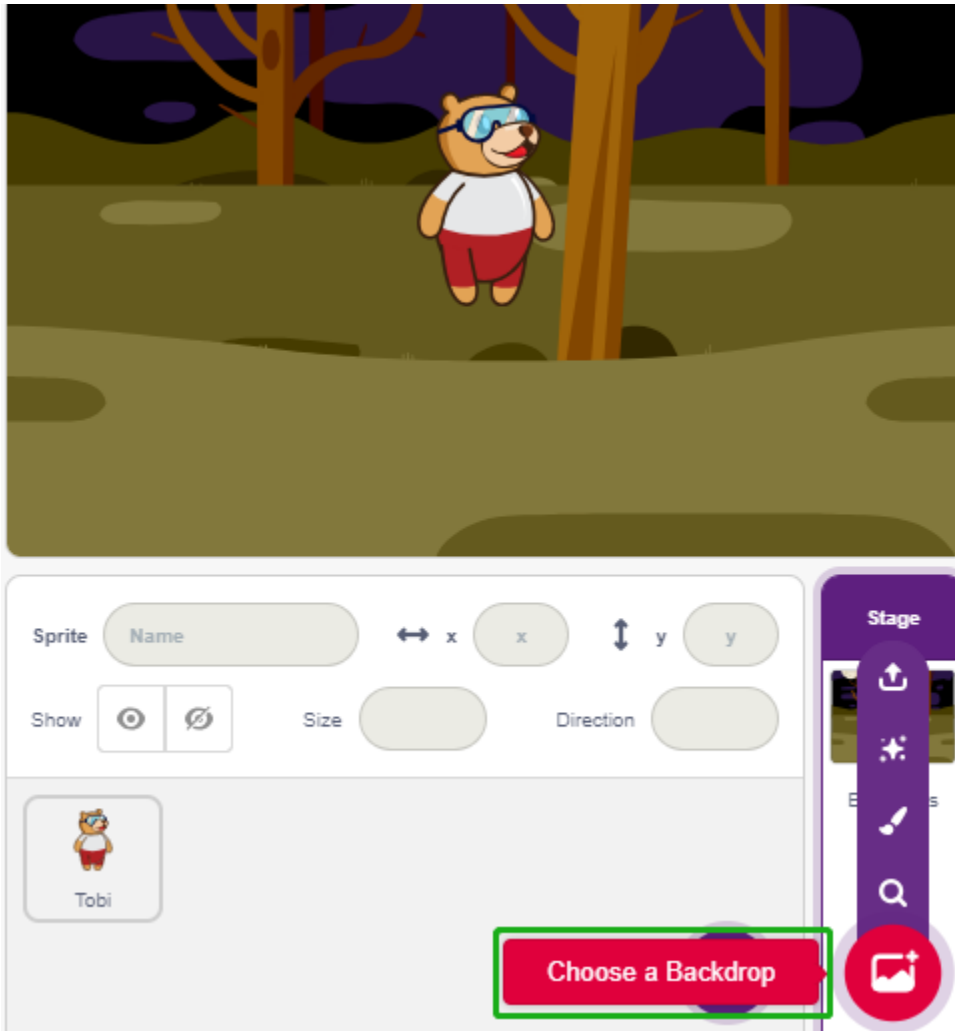


### 7.25.3 Programming

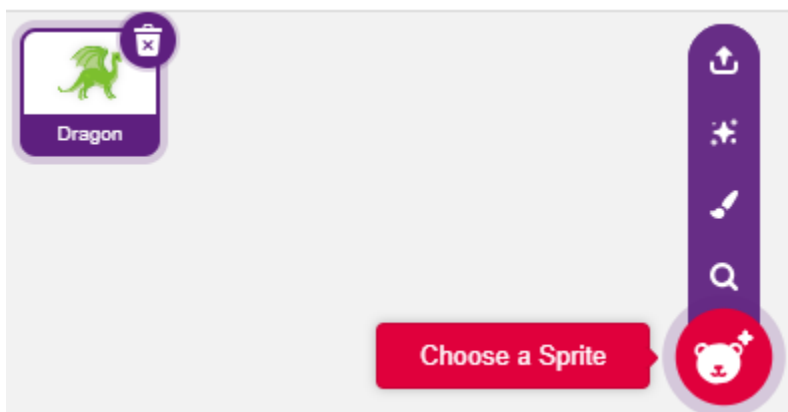
#### 1. Dragon

Woods backdrop added via the **Choose a Backdrop** button.

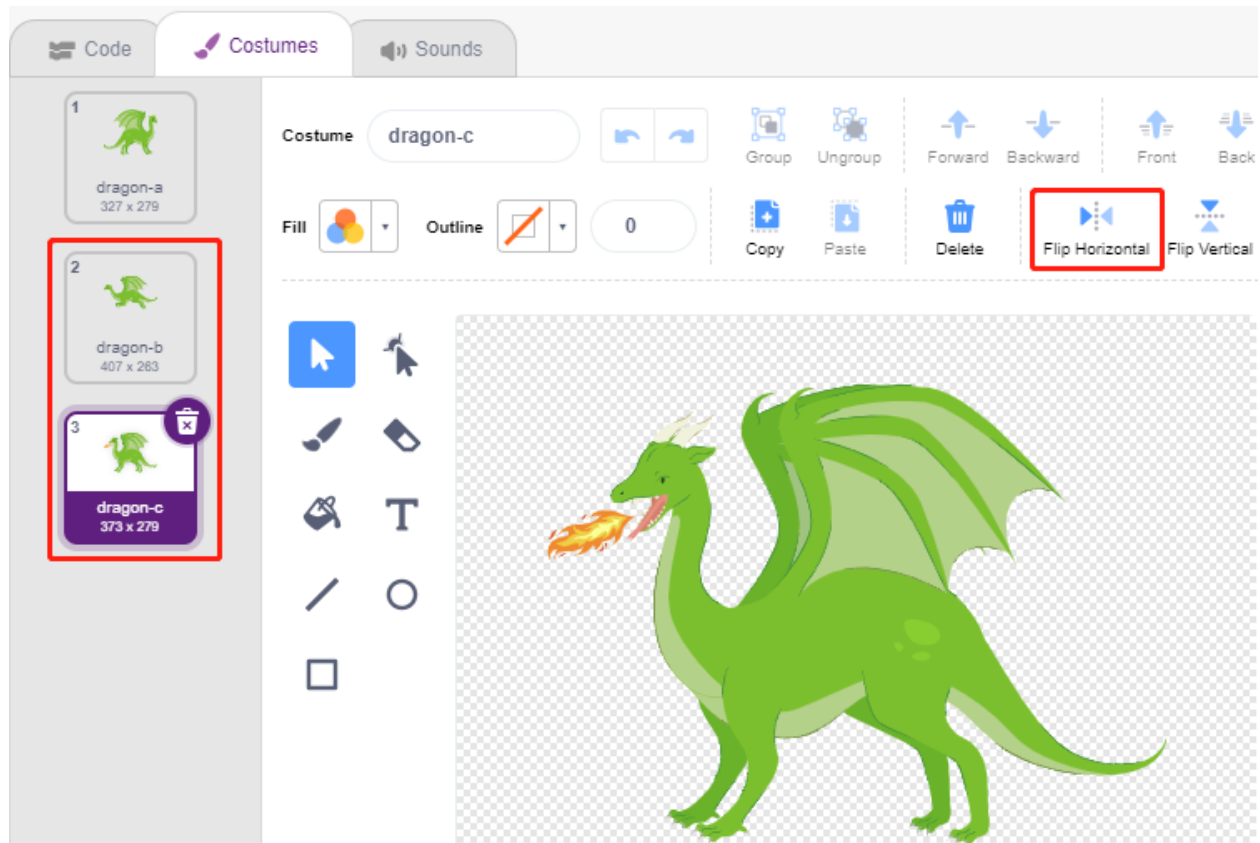




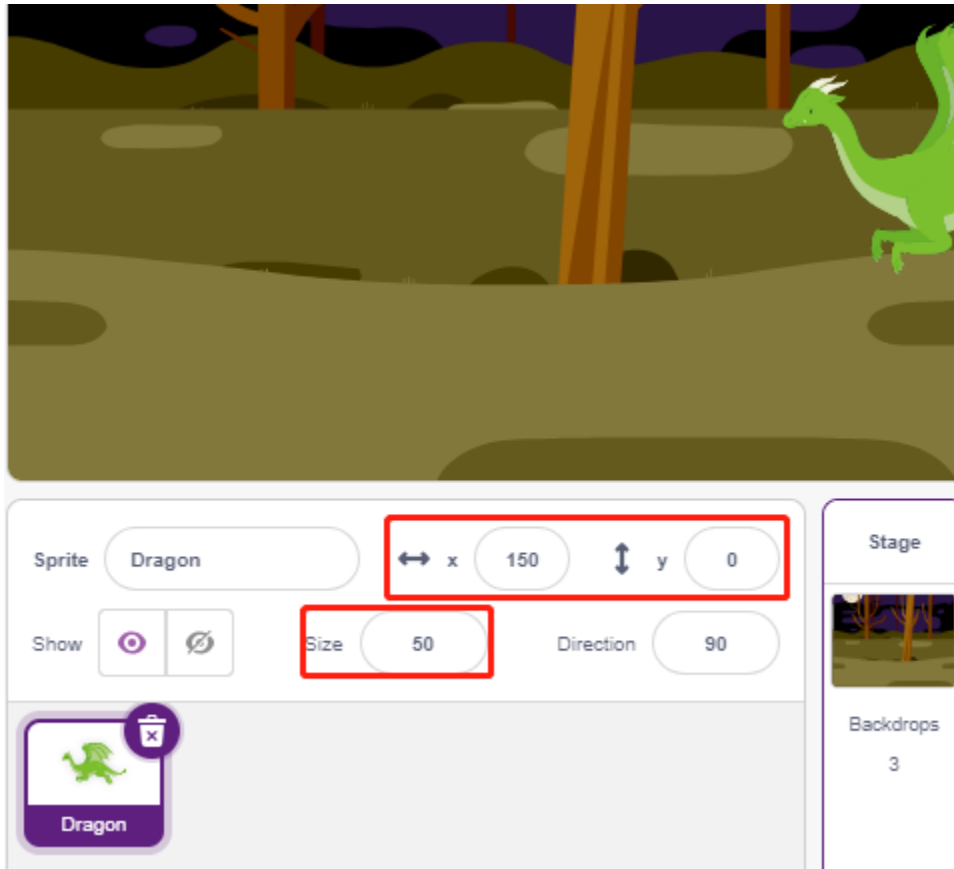
- Delete the default sprite and add the **Dragon** sprite.



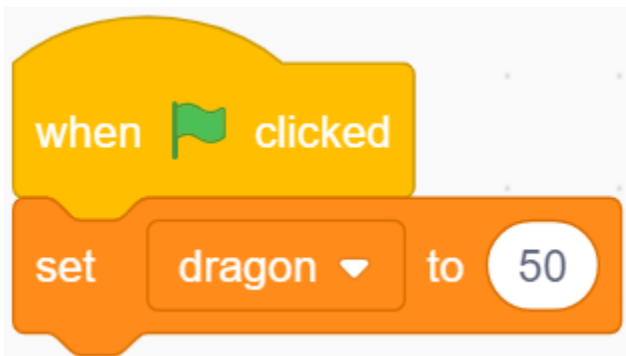
- Go to the **Costumes** page and flip the dragon-b and dragon-c horizontally.



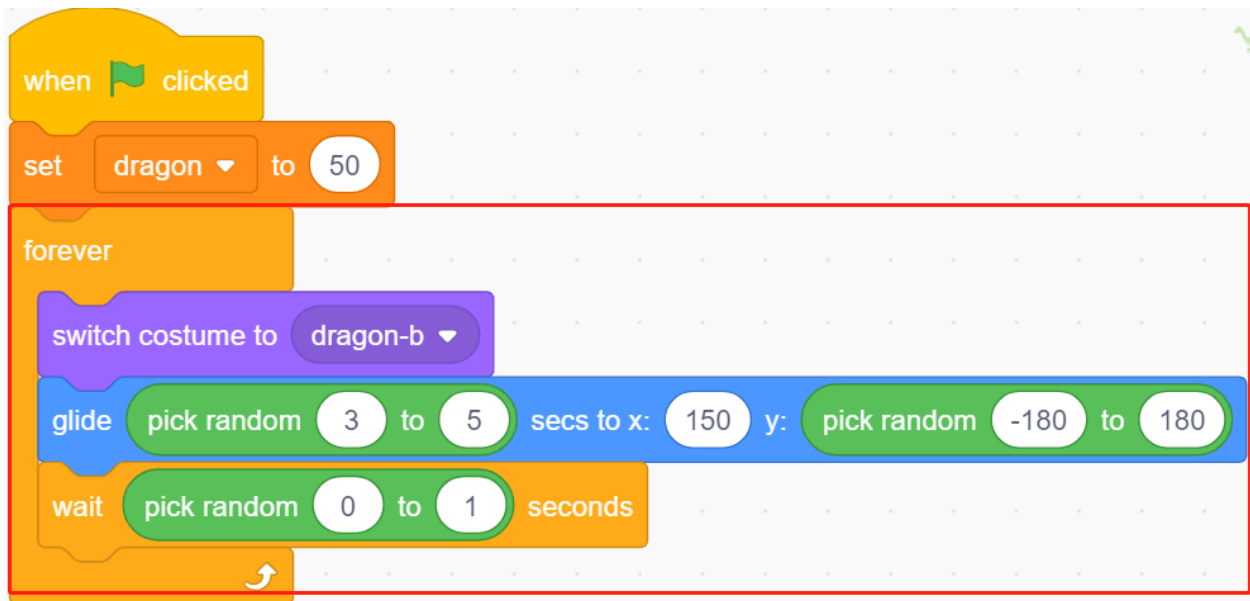
- Set the size to 50%.



- Now create a variable - **dragon** to record the dragon's life points, and set the initial value to 50.

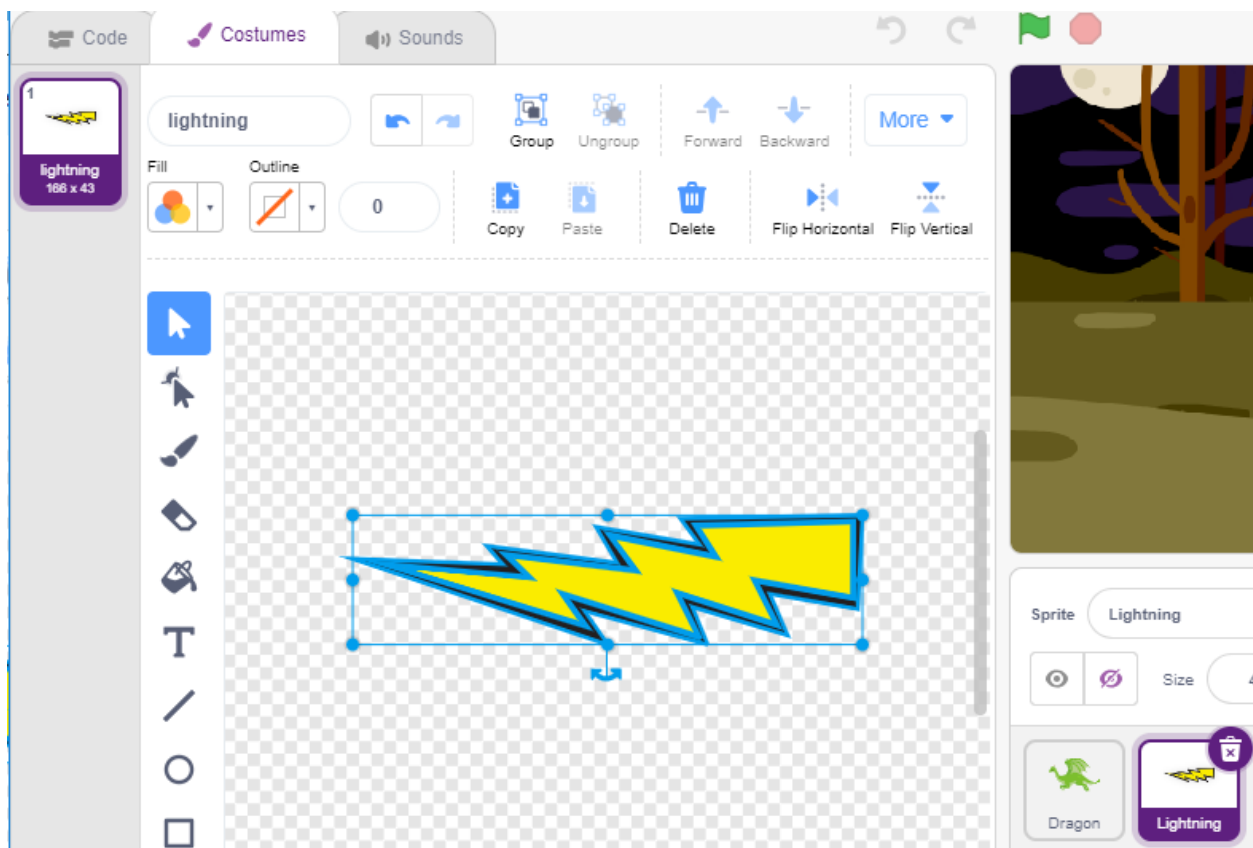


- Next, switch the sprite costume to **dragon-b** and have the **Dragon** sprite up and down in a range.

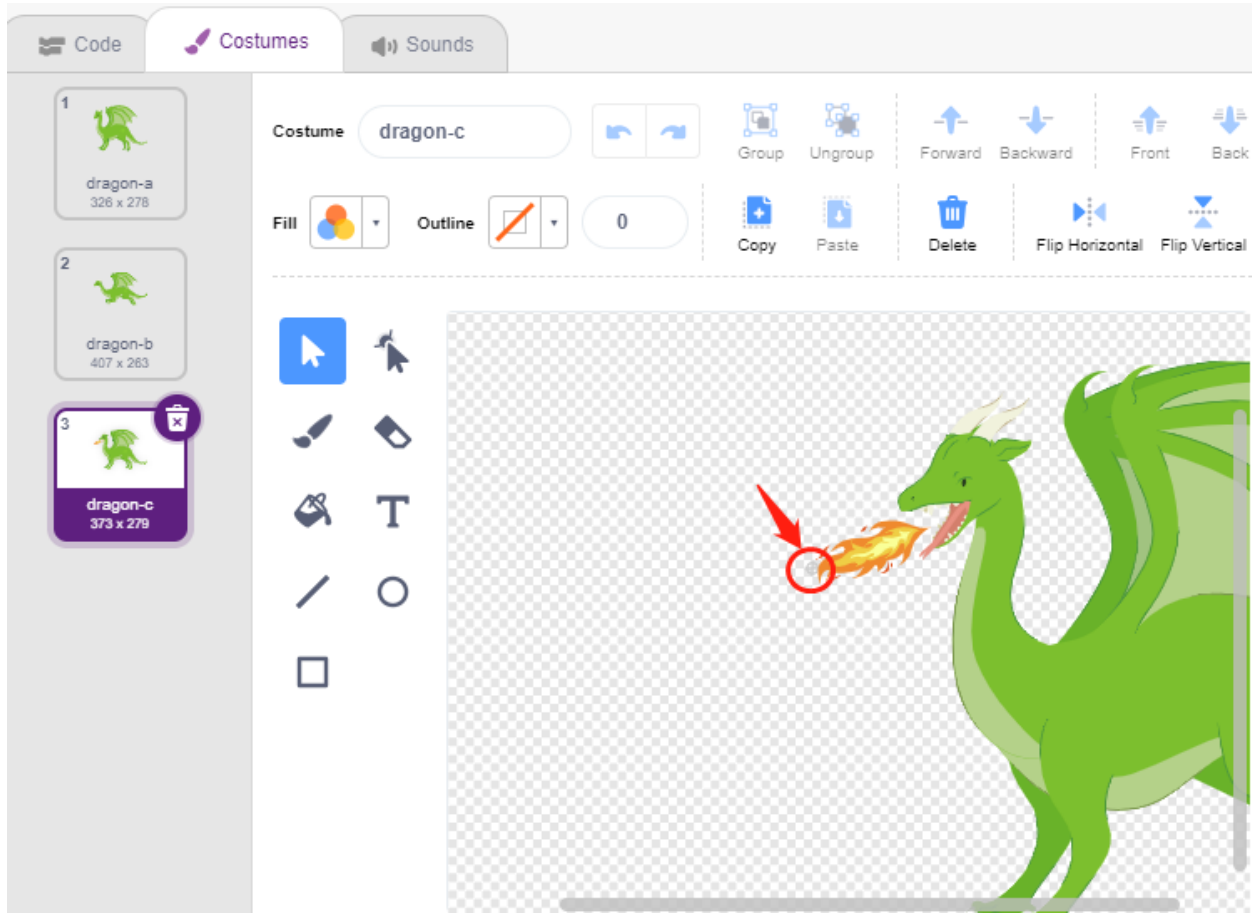


- Add a **Lightning** sprite as the fire blown by the **Dragon** sprite. You need to rotate it 90° clockwise in the Costumes page, this is to make the **Lightning** sprite move in the right direction.

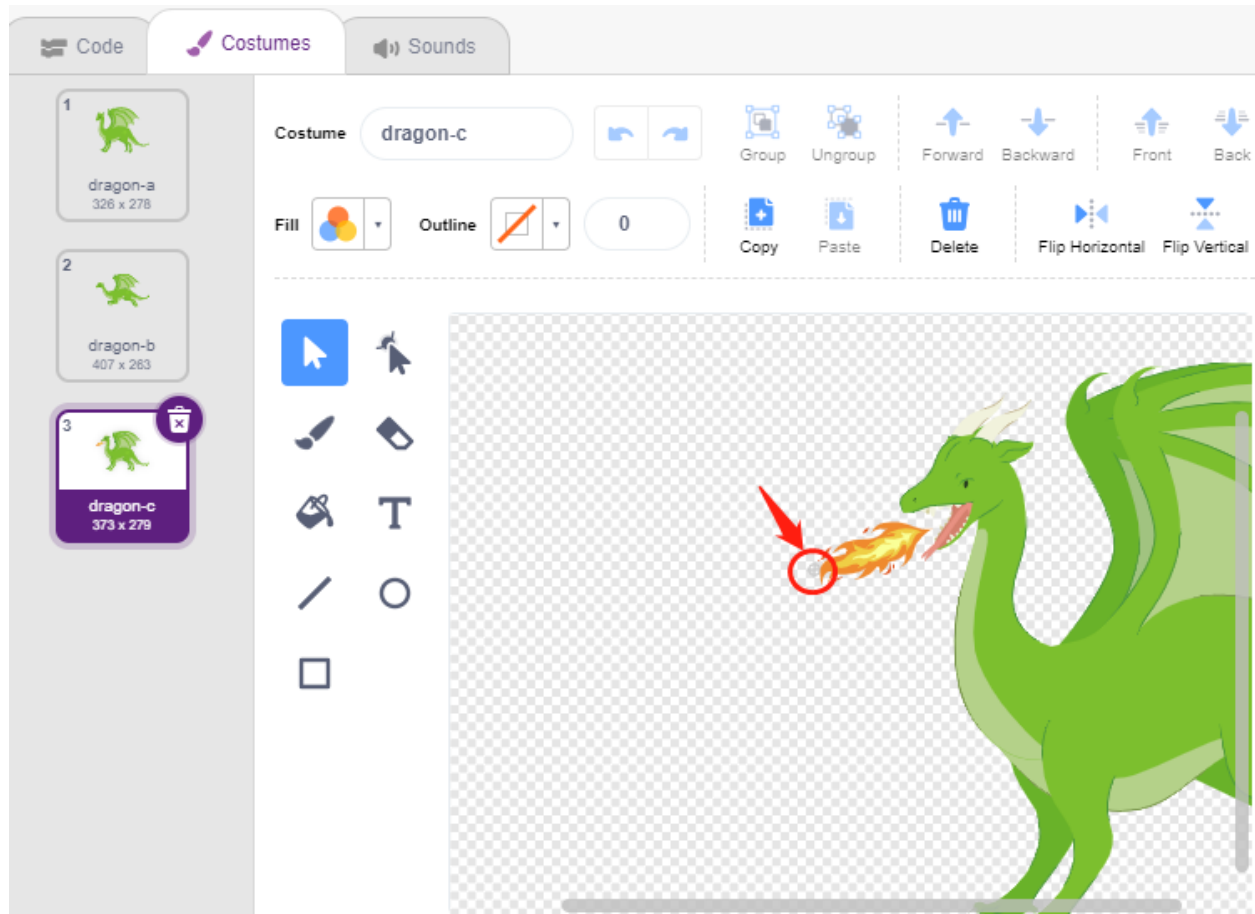
**Note:** When adjusting the **Lightning** sprite's costume, you may move it off-center, which must be avoided! The center point must be right in the middle of the sprite!



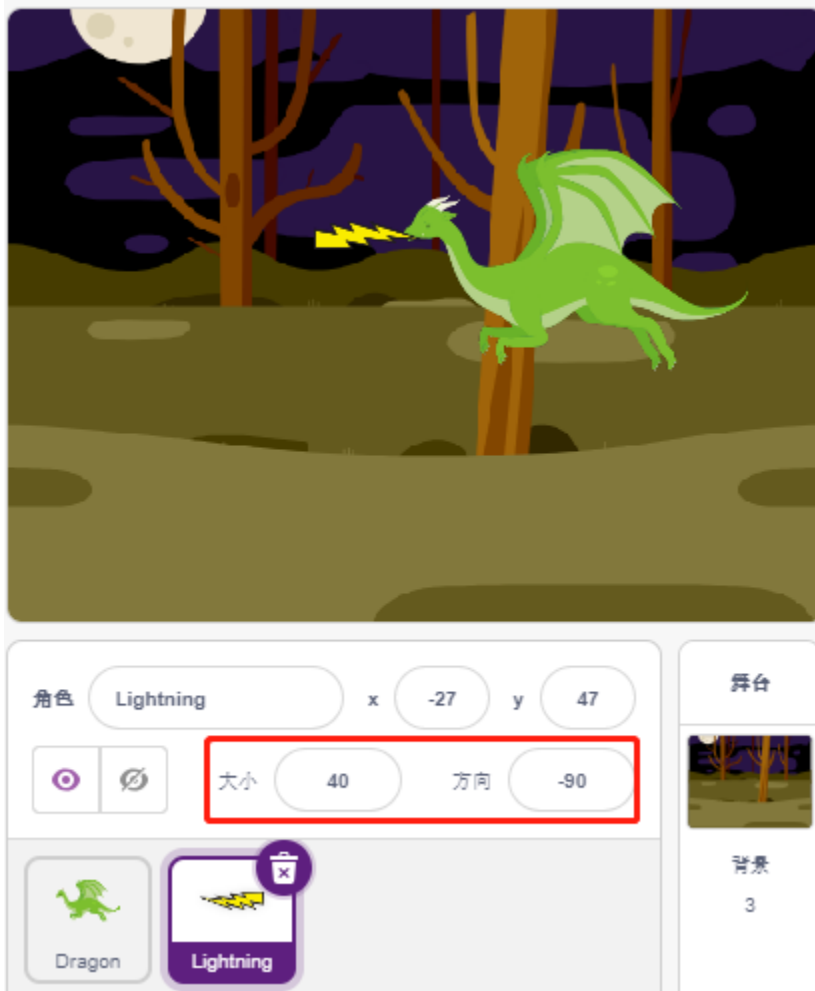
- Then adjust the **dragon-c** costume of the **Dragon** sprite so that its center point should be at the tail of the fire. This will make the positions of the **Dragon** sprite and the **Lightning** sprite correct, and prevent **Lightning** from launching from the dragon's feet.



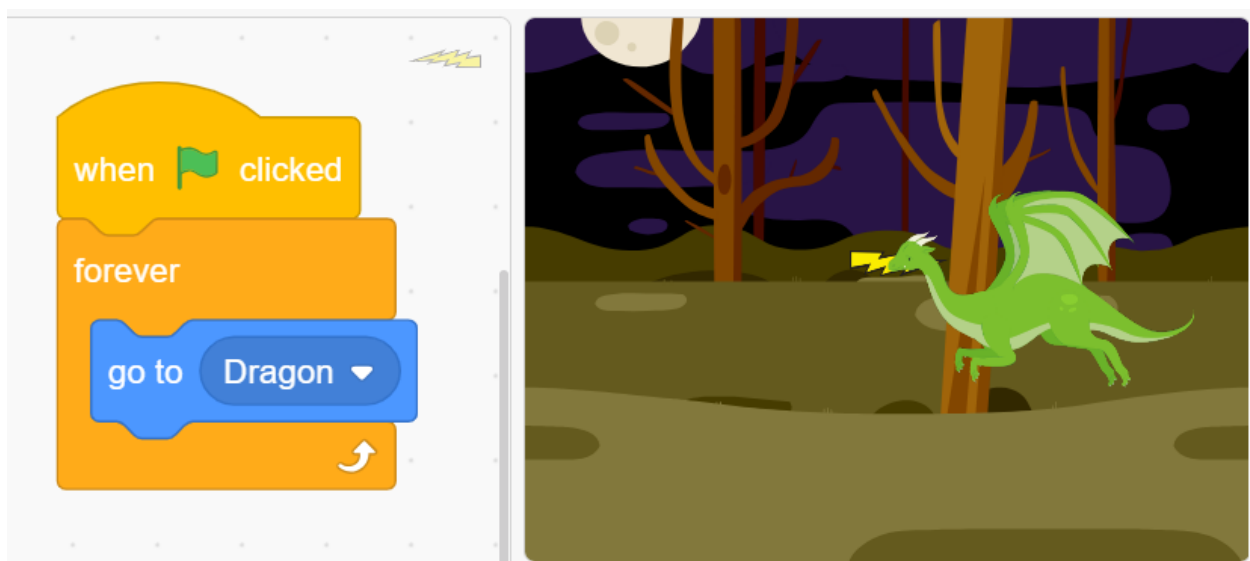
- Correspondingly, **dragon-b** needs to make the head of the dragon coincide with the center point.



- Adjust the size and orientation of the **Lightning** sprite to make the image look more harmonious.

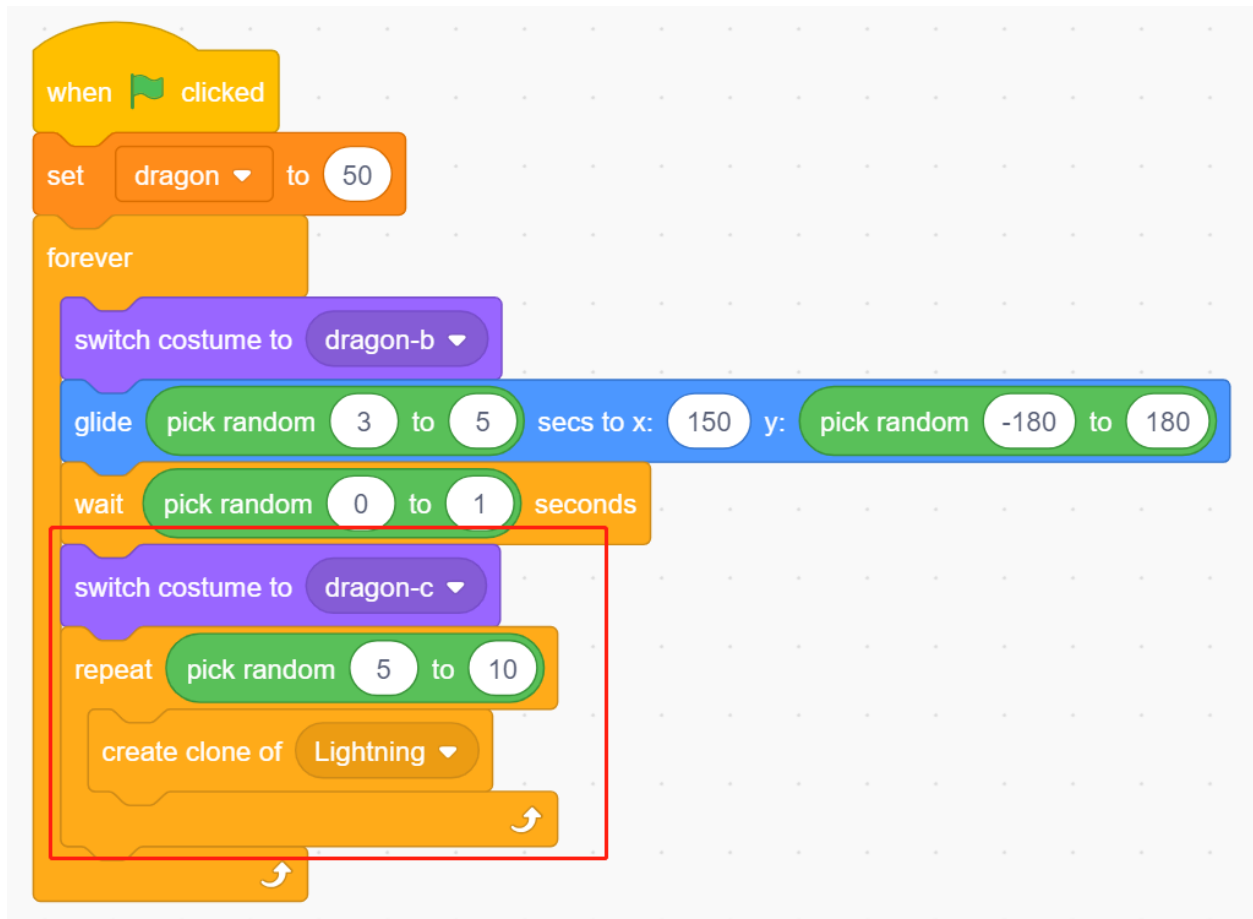


- Now script the **Lightning** sprite. This is easy, just have it follow the **Dragon** sprite all the time. At this point, click on the green flag and you will see **Dragon** moving around with lightning in its mouth.



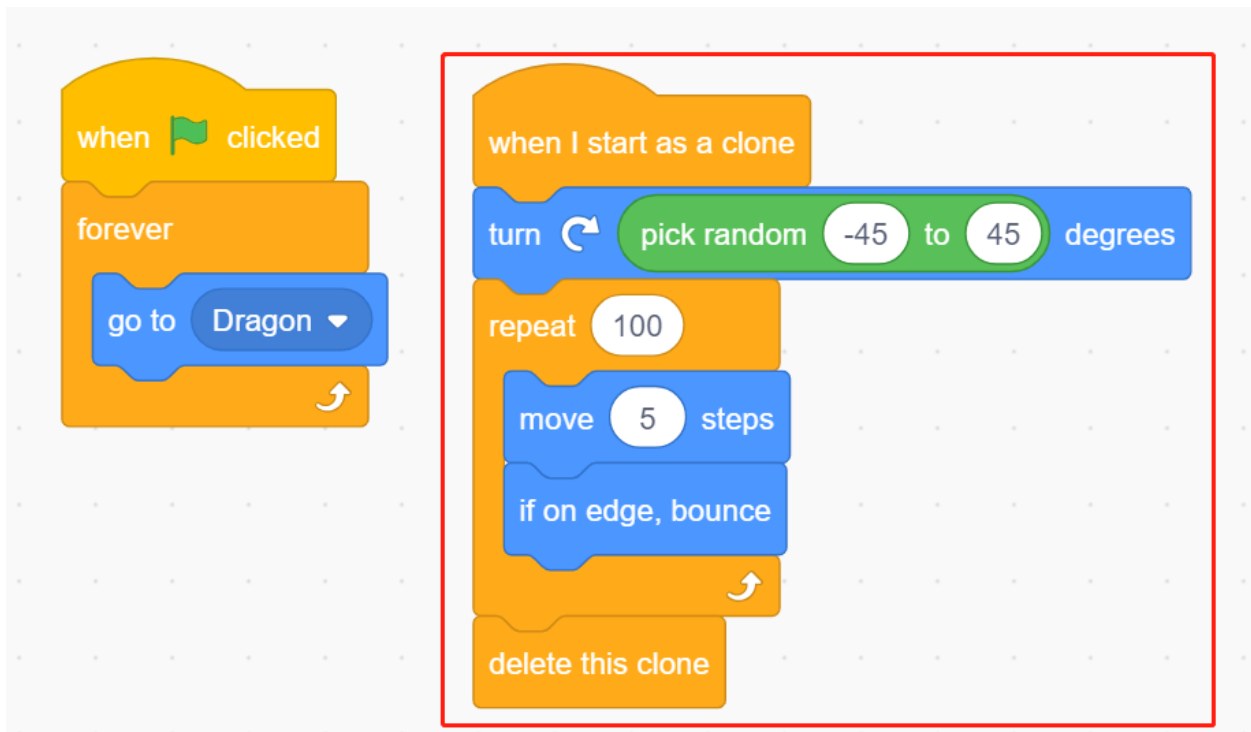
- Back to the **Dragon** sprite, now have it blow out fire, being careful not to let the fire in its mouth shoot out, but

to create a clone for the **Lightning** sprite.

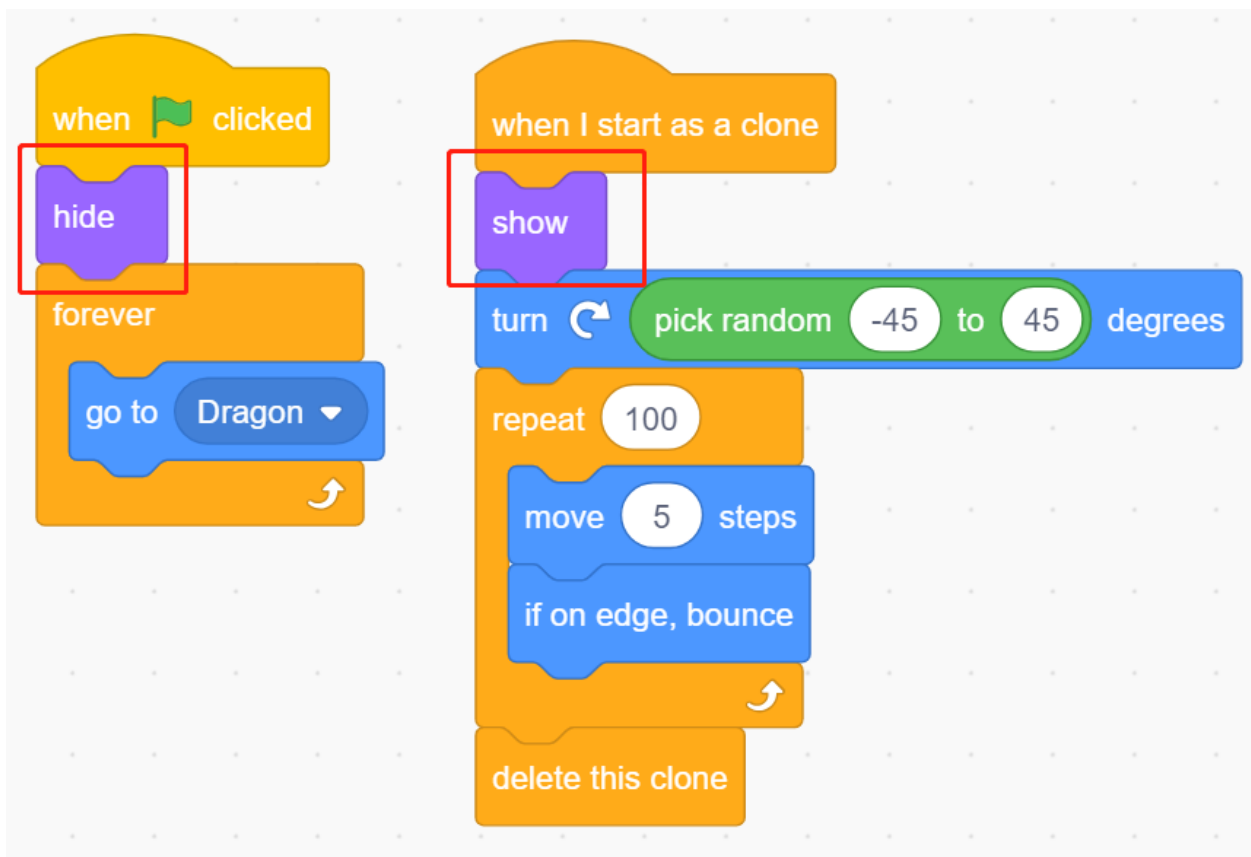


- Click on the **Lightning** sprite and let the **Lightning** clone shoot out at a random angle, it will bounce off the wall and disappear after a certain amount of time.





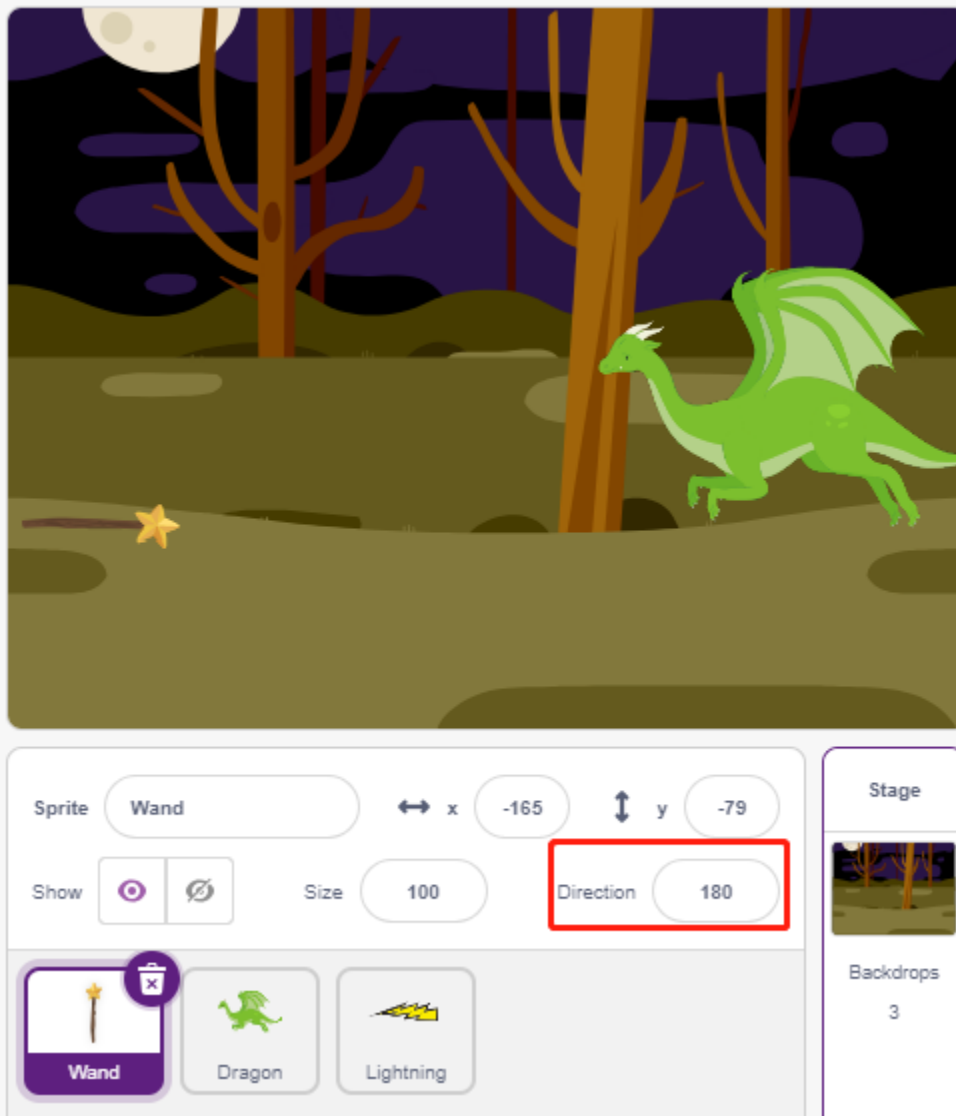
- In the **Lightning** sprite, hide its body and show the clone.



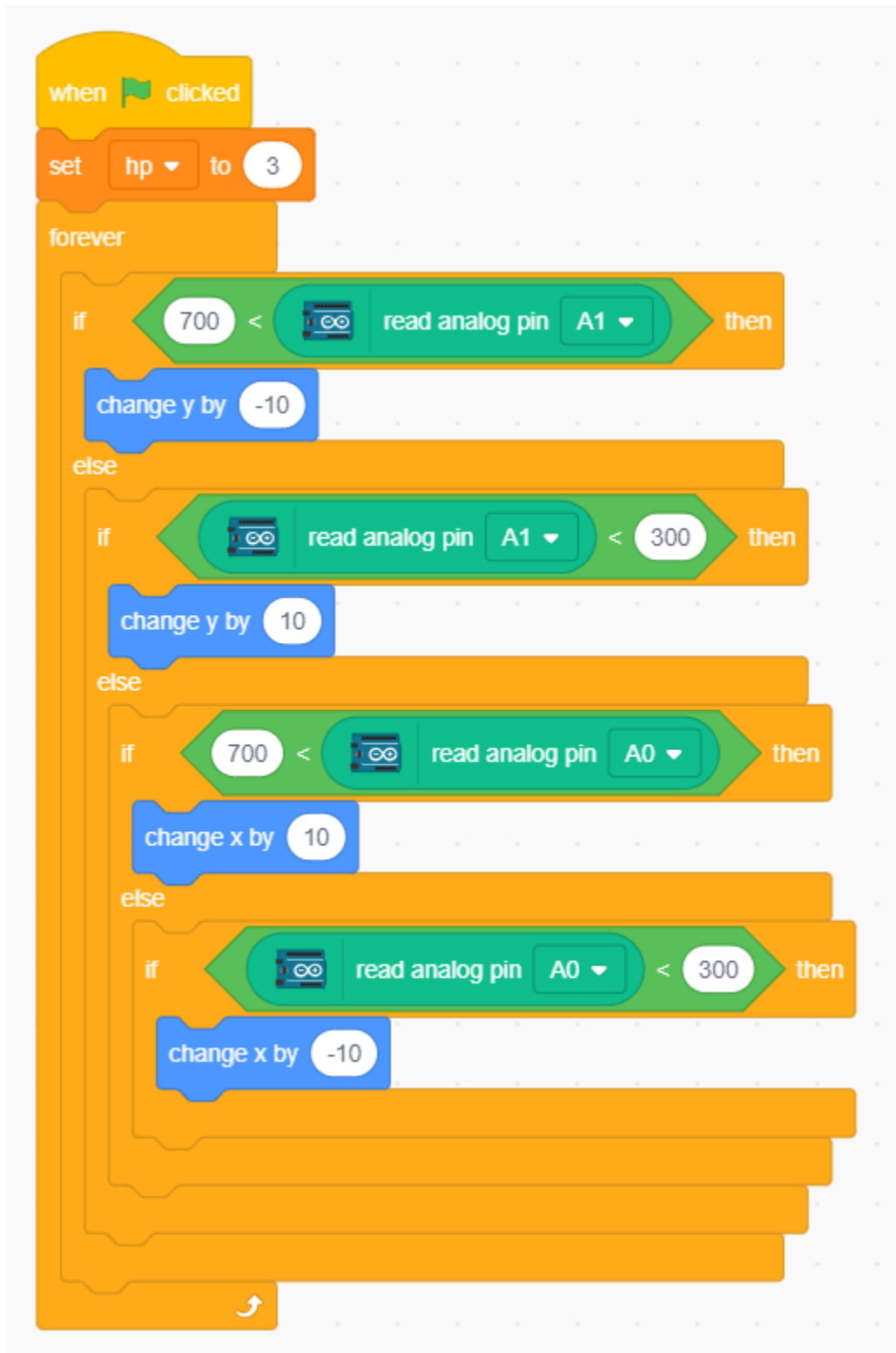
Now the dragon can move up and down and blow out fire.

## 2.Wand

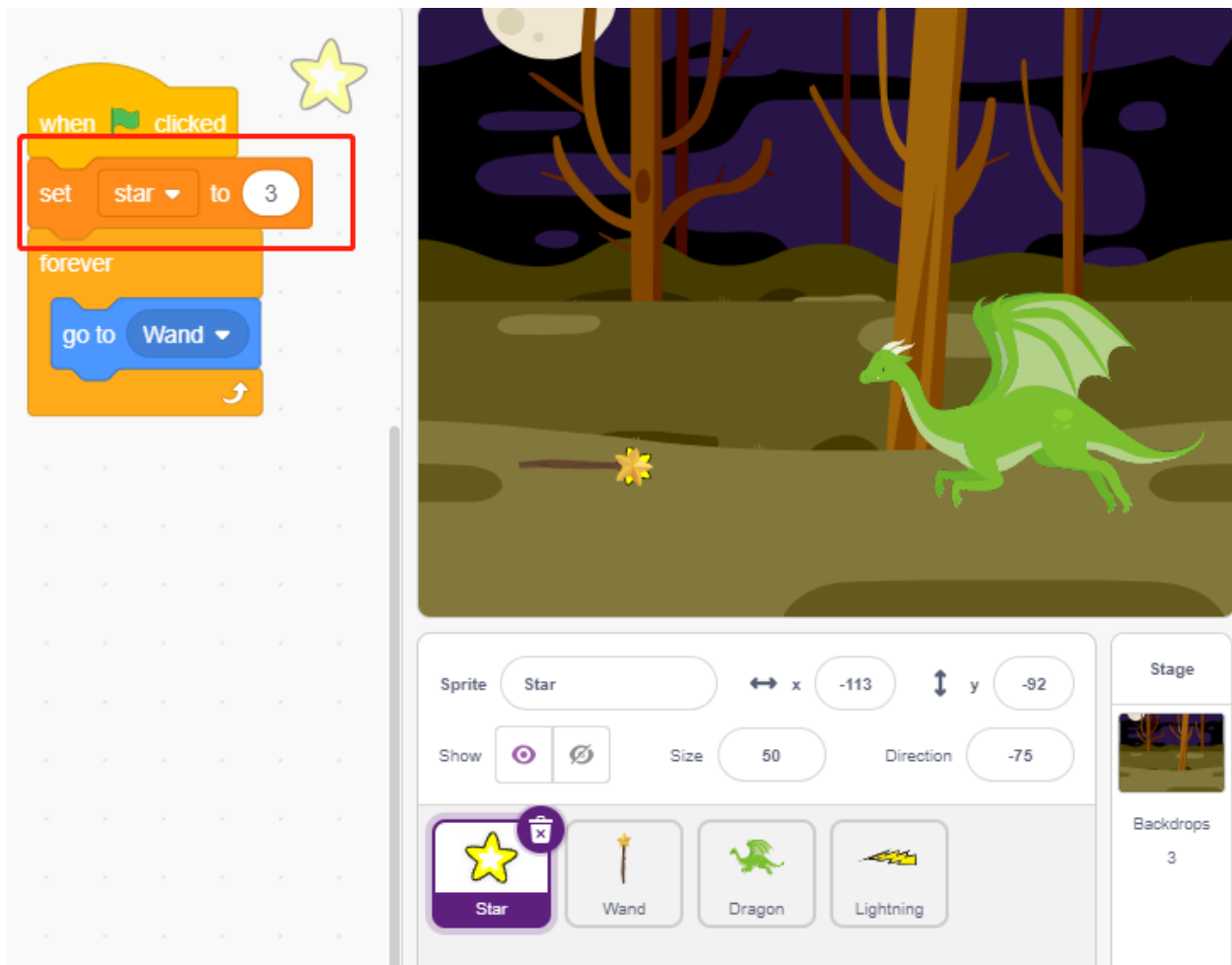
- Create a **Wand** sprite and rotate its direction to 180 to point to the right.



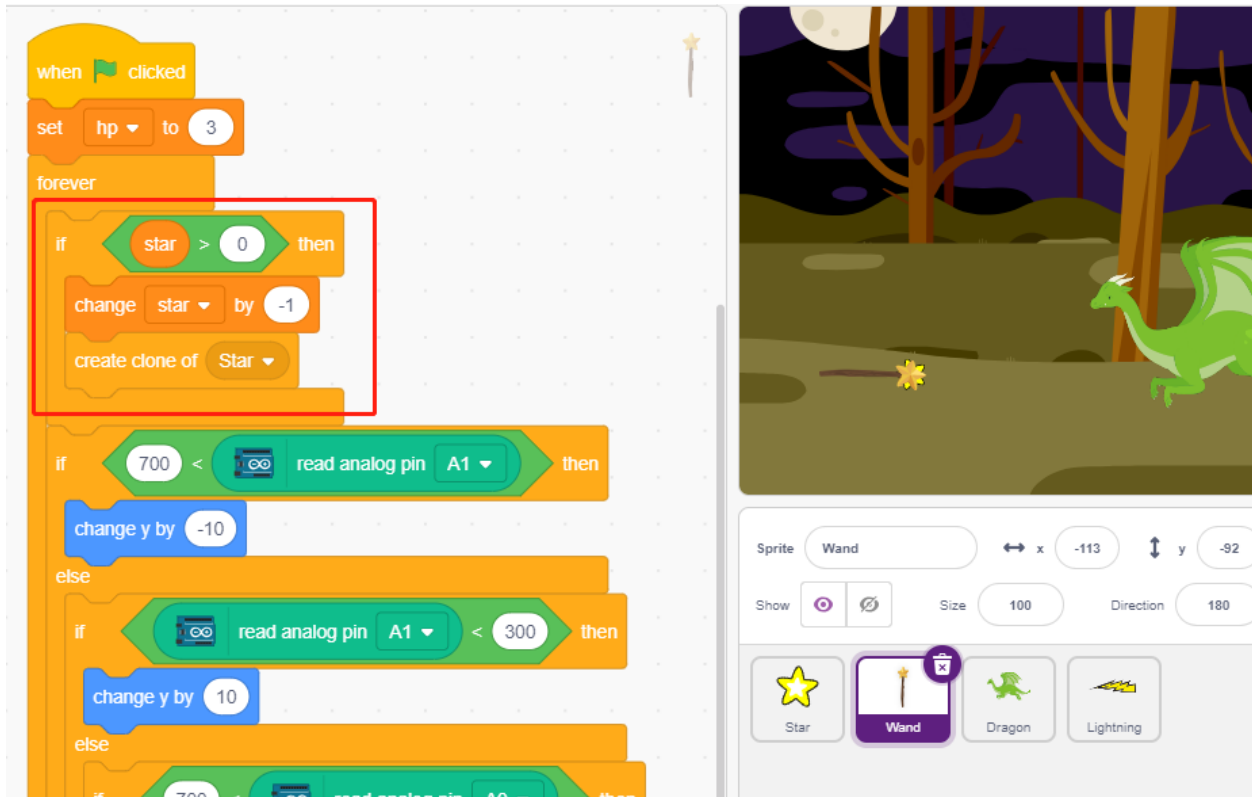
- Now create a variable **hp** to record its life value, initially set to 3. Then read the Joystick's value, which is used to control the wand's movement.



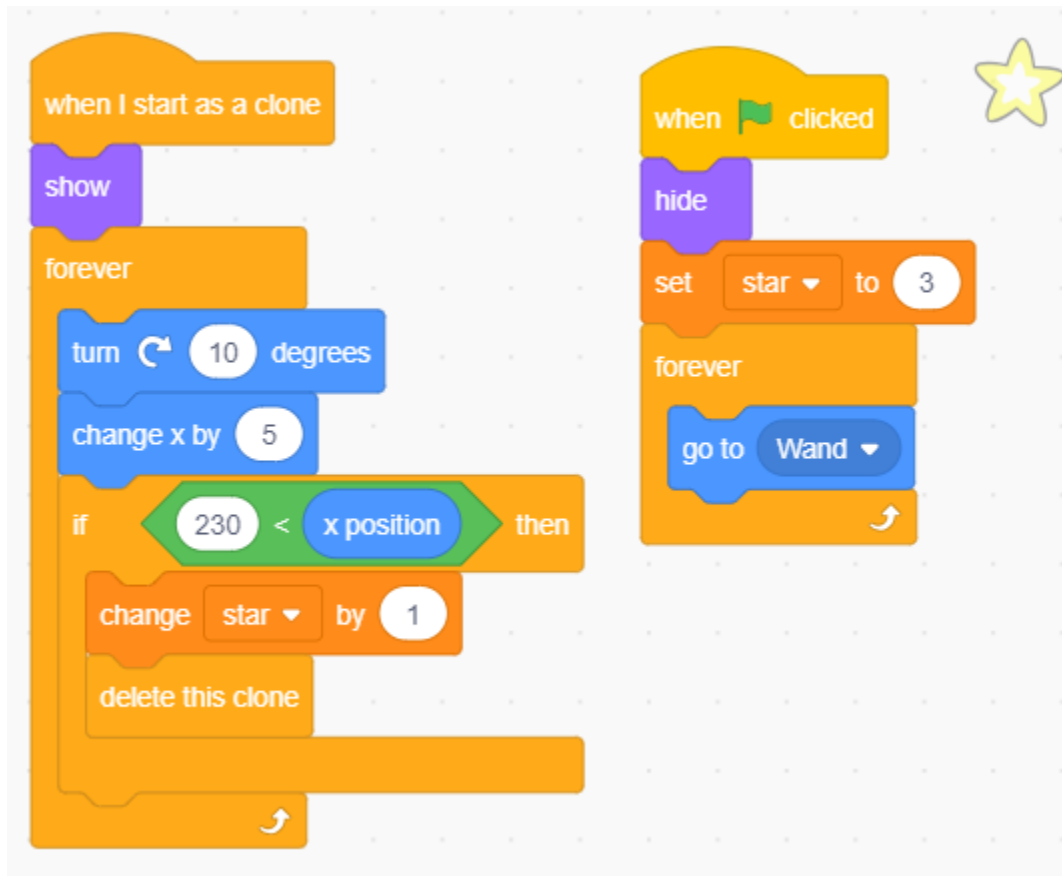
- The dragon has lightning, and the wand that crushes it has its “magic bullet”! Create a **Star** sprite, resize it, and script it to always follow the **Wand** sprite, and limit the number of stars to three.



- Make the **Wand** sprite shoot stars automatically. The **Wand** sprite shoots stars the same way the dragon blows fire – by creating clones.



- Go back to the **Star** sprite and script its clone to spin and shoot to the right, disappear after going beyond the stage and restoring the number of stars. Same as **Lightning** sprite, hide the body and show the clone.



Now we have a wand that shoots star bullets.

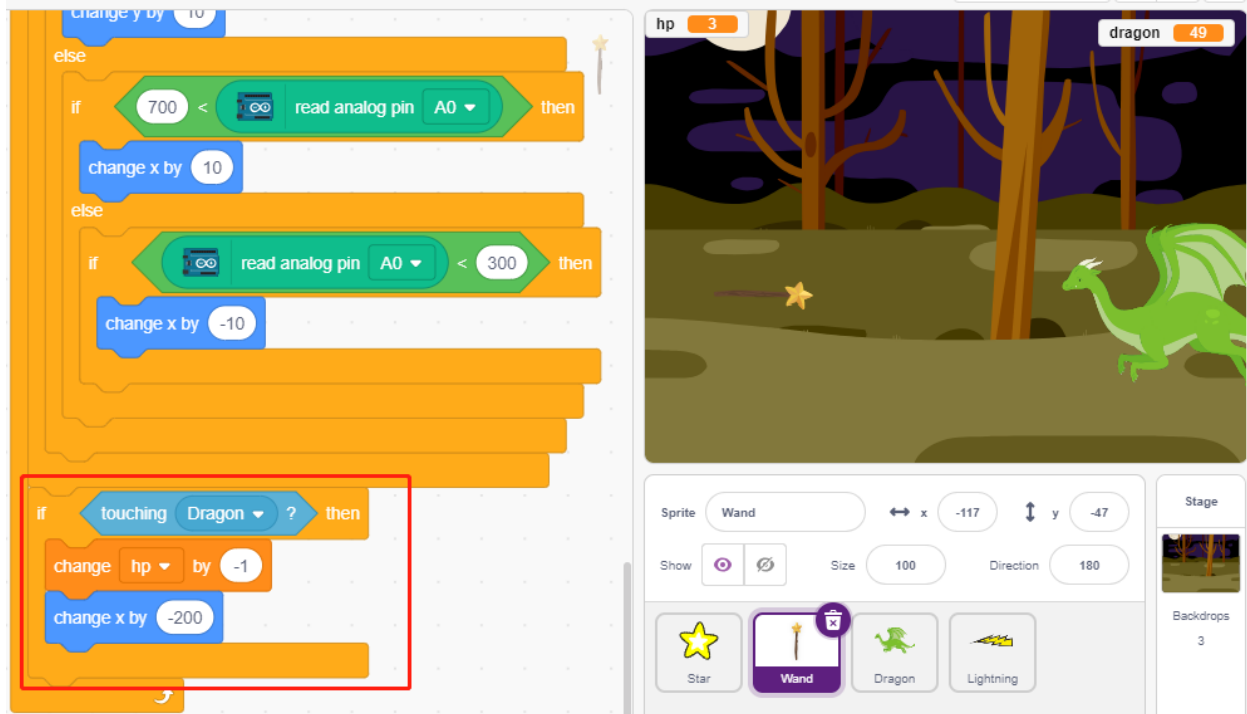
### 3. Fight!

The wand and the dragon are currently still at odds with each other, and we're going to make them fight. The dragon is strong, and the wand is the brave man who crusades against the dragon. The interaction between them consists of the following parts.

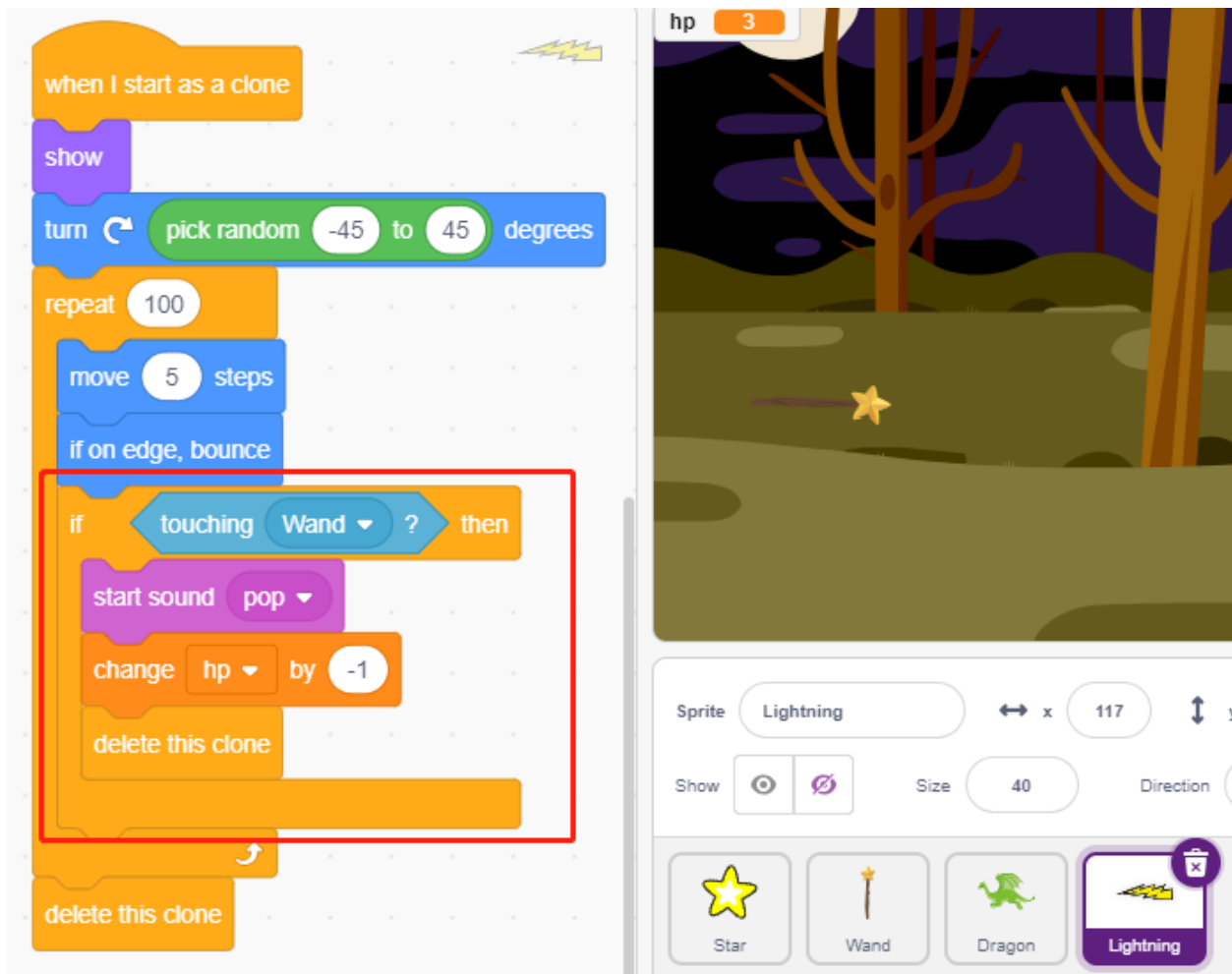
1. if the wand touches the dragon, it will be knocked back and lose life points.
2. if lightning strikes the wand, the wand will lose life points.
3. if the star bullet hits the dragon, the dragon will lose life points.

Once that's sorted out, let's move on to changing the scripts for each sprite.

- If the **Wand** hits the **Dragon**, it will be knocked back and lose life points.

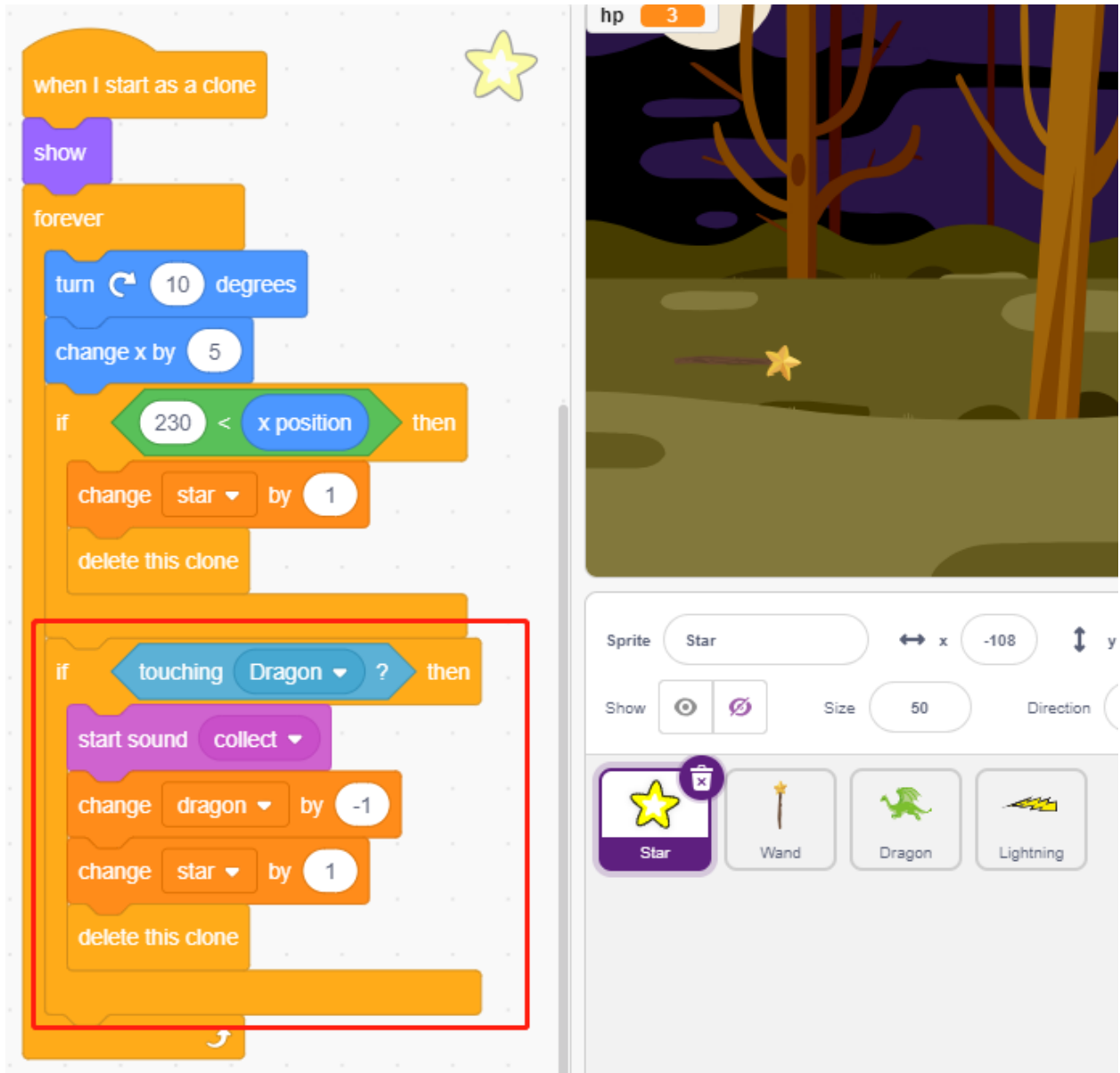


- If **Lightning** (a **Lightning** sprite clone) hits the **Wand** sprite, it will make a pop sound and disappear, and the **Wand** will lose life points.



- If a **Star** (clone of the **Star** sprite) hits the **Dragon**, it will emit a collect sound and disappear, while restoring the **Star** count, and the **Dragon** will lose life points.

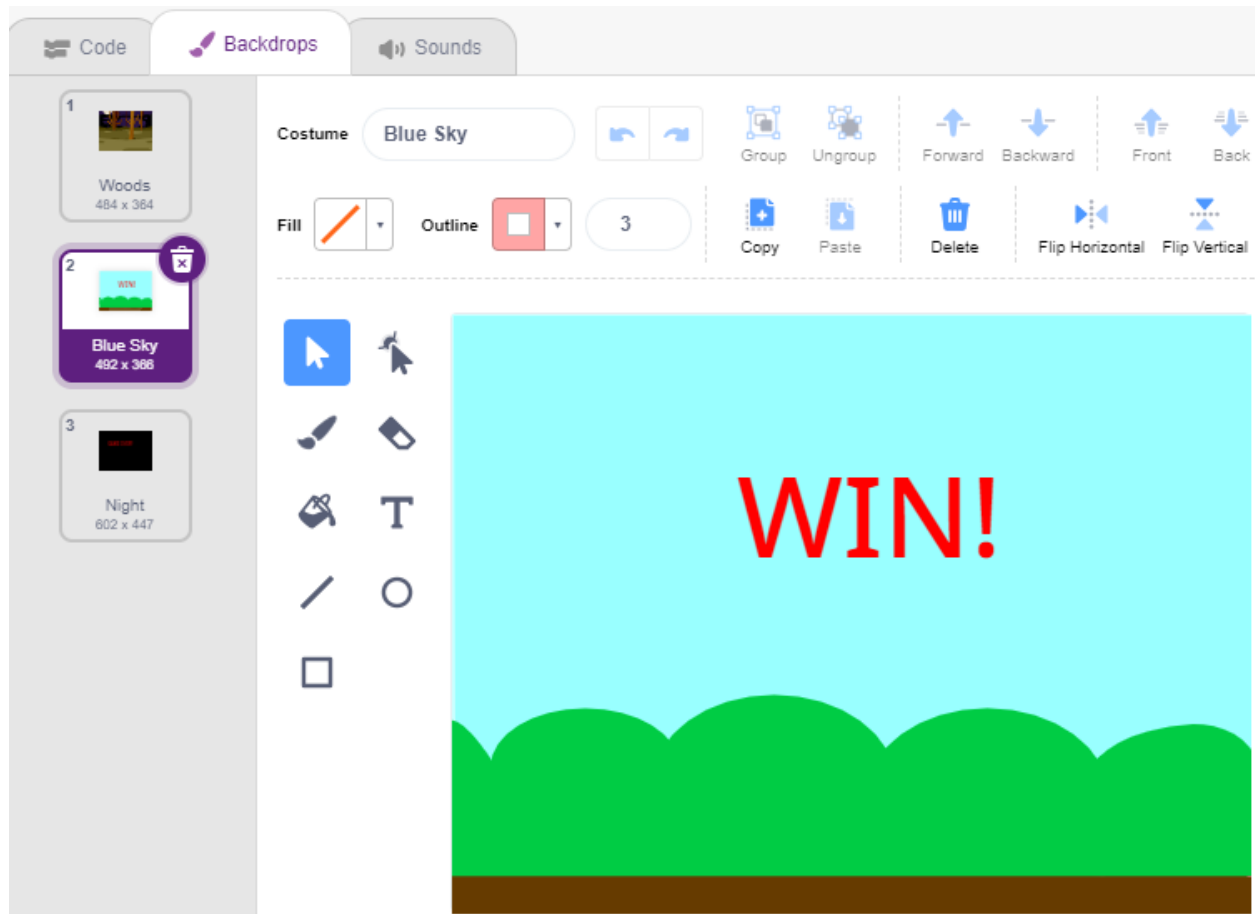




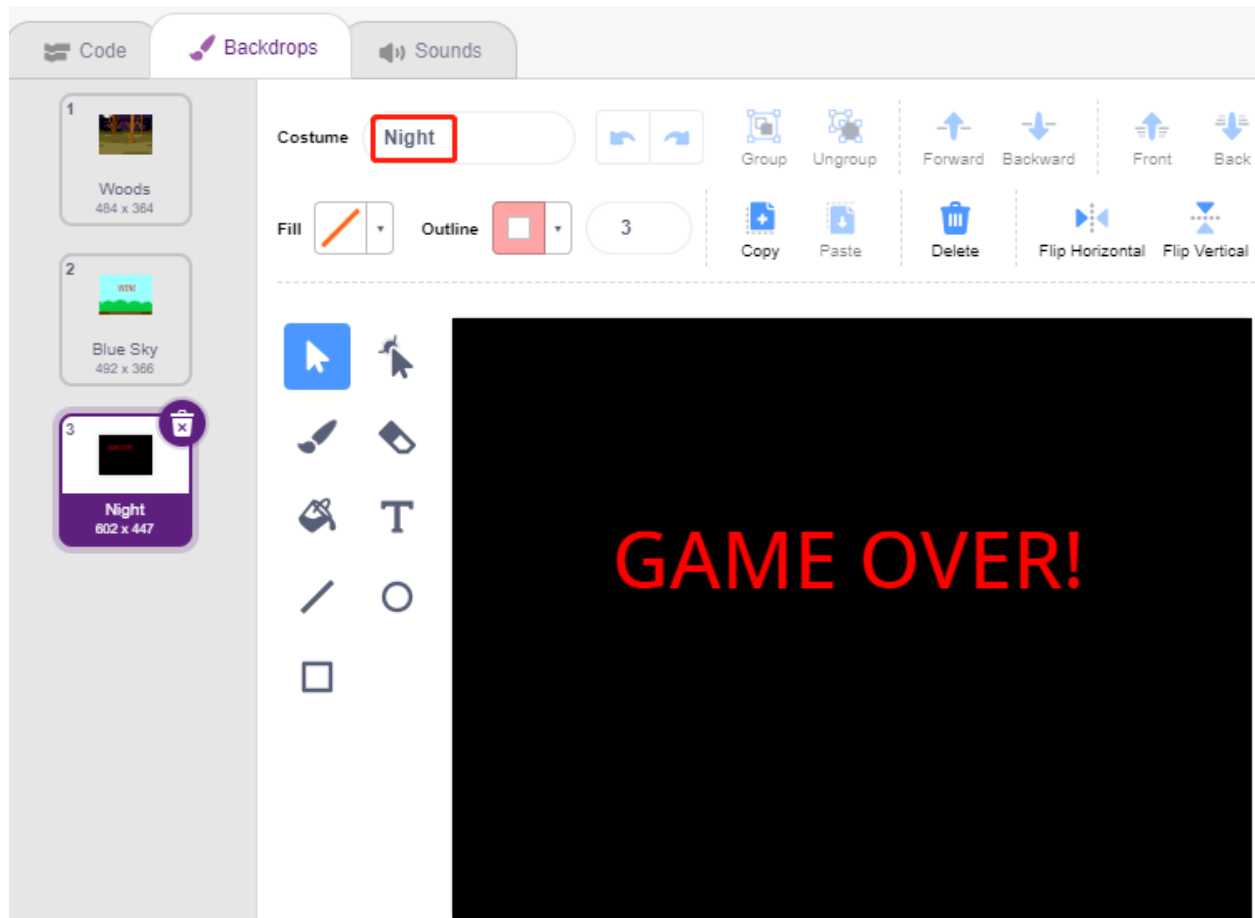
#### 4. stage

The battle between the **Wand** and the **Dragon** will eventually be divided into winners and losers, which we represent with the stage.

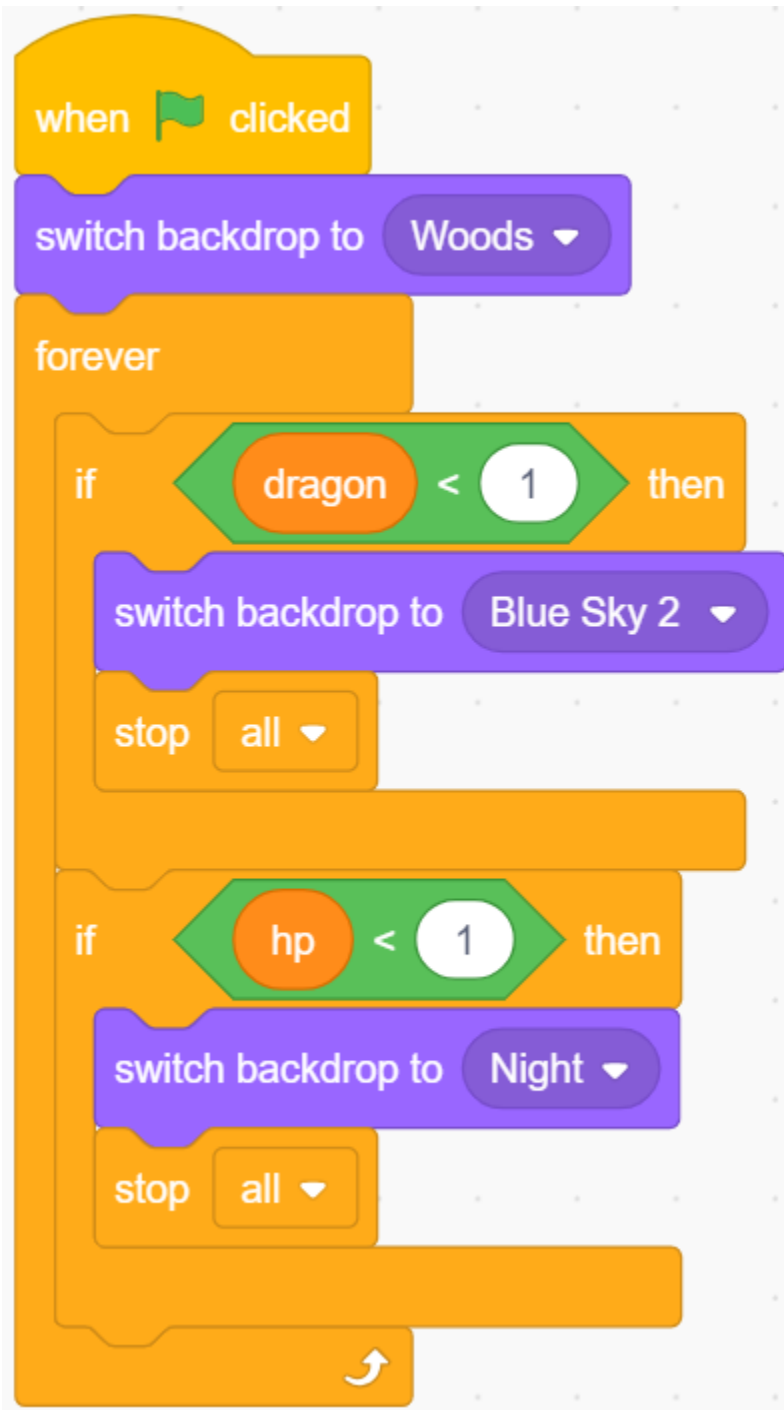
- Add **Blue Sky** backdrop, and write the character “WIN!” on it to represent that the dragon has been defeated and the dawn has come.



- And modify the blank backdrop as follows, to represent that the game has failed and everything will be in darkness.



- Now write a script to switch these backdrops, when the green flag is clicked, switch to **Woods** backdrop; if the dragon's life point is less than 1, then the game succeeds and switch the backdrop to **Blue Sky**; if the life value point of the **Wand** is less than 1, then switch to **Night** backdrop and the game fails.



### 3. Play Car with Scratch

The following projects are written in order of programming difficulty, it is recommended to read these books in order. In each project, there are very detailed steps to teach you how to build the circuit and how to program it step by step to achieve the final result.

Of course, you can also open the script directly to run it, but you need to make sure you have downloaded the relevant material from [github](#).

Once the download is complete, unzip it. Refer to *Upload Mode* to run individual scripts directly.

## 7.26 3.1 Test the Car

Here, you will learn how to write scripts to make the car go forward, but you need to refer to *Car Projects* to assemble the car and to get a basic understanding of it.

But before you start the project, you need to know the steps to use PictoBlox in *Upload Mode*.

### 7.26.1 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>L298N Module</i>	
<i>TT Motor</i>	-

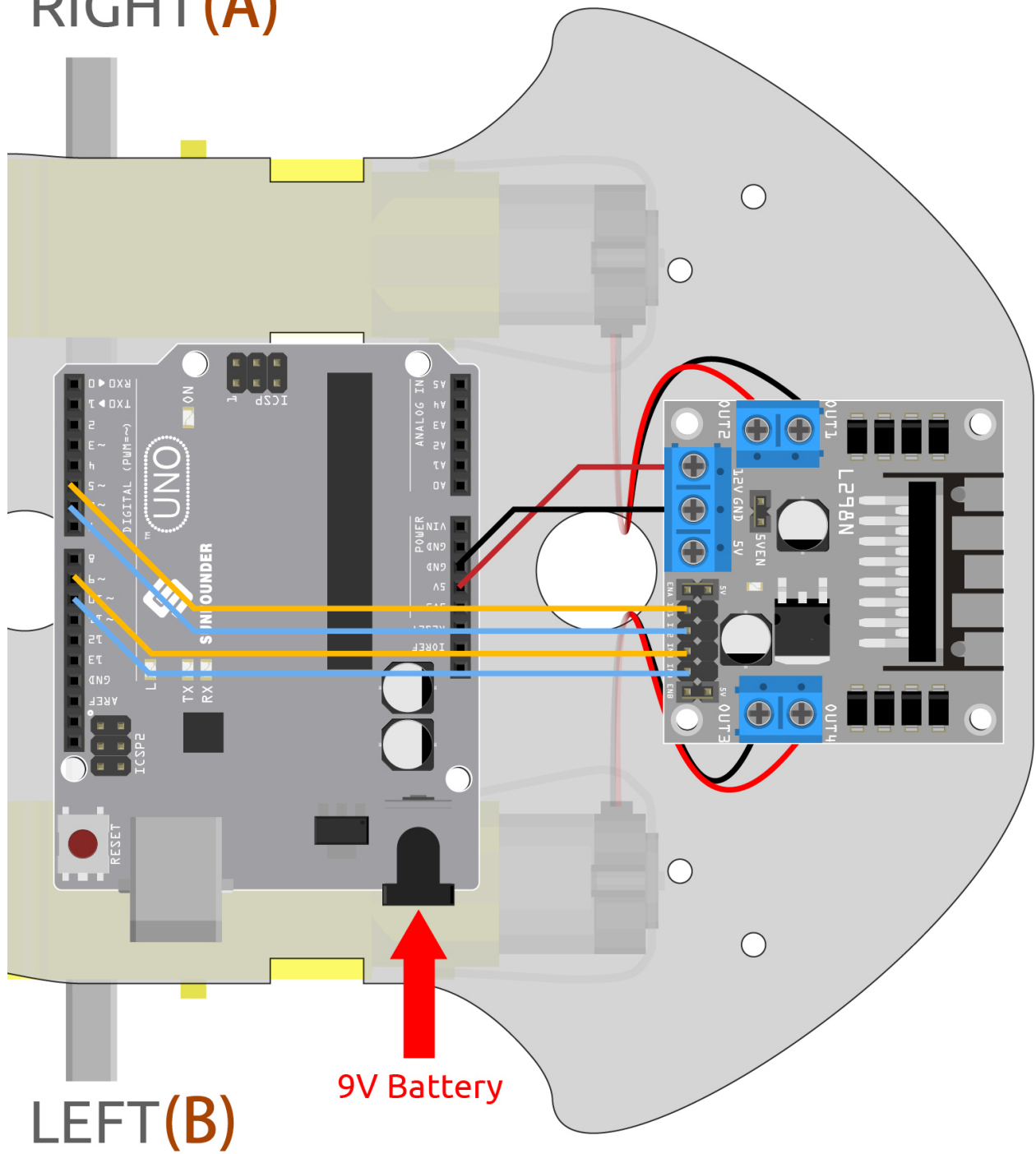
### 7.26.2 Build the Circuit

The L298N motor driver module is a high power motor driver module for driving DC and stepper motors. The L298N module can control up to 4 DC motors, or 2 DC motors with direction and speed control.

Connect the wires between the L298N module and the R3 board according to the diagram below.

L298N	R3 Board	Motor
IN1	5	
IN2	6	
IN3	9	
IN4	10	
OUT1		Black wire of right motor
OUT2		Red wire of right motor
OUT3		Black wire of left motor
OUT4		Red wire of left motor

RIGHT(A)



## 7.26.3 Programming

### 1. Let the car go forward

Based on the above wiring, we know that pins 5 and 6 are used to control the right motor rotation and pins 9 and 10 are used for the left motor rotation. Now let's write a script to make the car go forward.

After selecting Board as Arduino Uno, switch to *Upload Mode* and write the script according to the following diagram.

The image shows the Arduino IDE interface. On the left, a Scratch-style block script is visible. It starts with a 'when Arduino Uno starts up' block, followed by a 'forever' loop. Inside the loop, there are four 'set PWM pin' blocks: 'set PWM pin 5 output as 0', 'set PWM pin 6 output as 255', 'set PWM pin 9 output as 255', and 'set PWM pin 10 output as 0'. On the right, the corresponding C++ code is shown. The 'Upload Code' button is highlighted with a red box.

```

1 //This c++ code is gene
2
3 void setup() {
4   //put your setup code
5   pinMode(5, OUTPUT);
6   pinMode(6, OUTPUT);
7   pinMode(9, OUTPUT);
8   pinMode(10, OUTPUT);
9
10 }
11
12
13 void loop() {
14   //put your main code
15
16   analogWrite(5, 0);
17   analogWrite(6, 255);
18   analogWrite(9, 255);
19   analogWrite(10, 0);
20 }
21
22

```

Click the **Upload Code** button to upload the code to the R3 board. When it's done, you will see the two motors of the car moving forward (if you put the car on the ground, it will move forward in a straight line, but maybe the car will go in a curve because the speed of the two motors is a bit different).

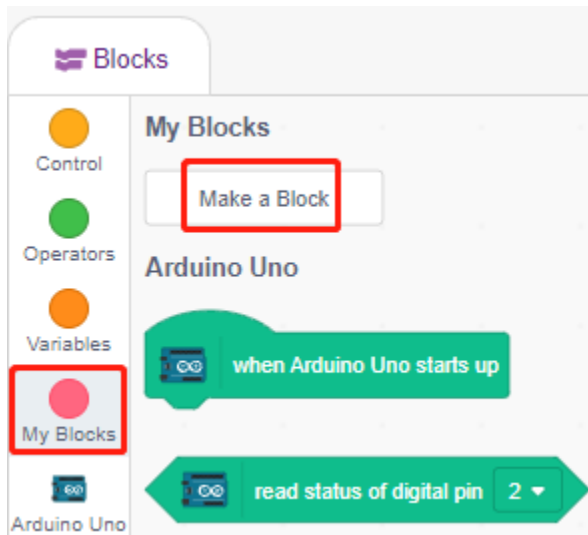
If not both turn forward, but the following situations occur, you need to readjust the wiring of the two motors.

- If both motors turn backward at the same time (left motor turns clockwise, right motor turns counterclockwise), swap the wiring of the left and right motors at the same time, OUT1 and OUT2 swap, OUT3 and OUT4 swap.
- If the left motor turns backward (clockwise rotation), exchange the wiring of OUT3 and OUT4 of the left motor.
- If the right motor turns backward (counterclockwise rotation), swap the wiring of OUT1 and OUT1 of the right motor.

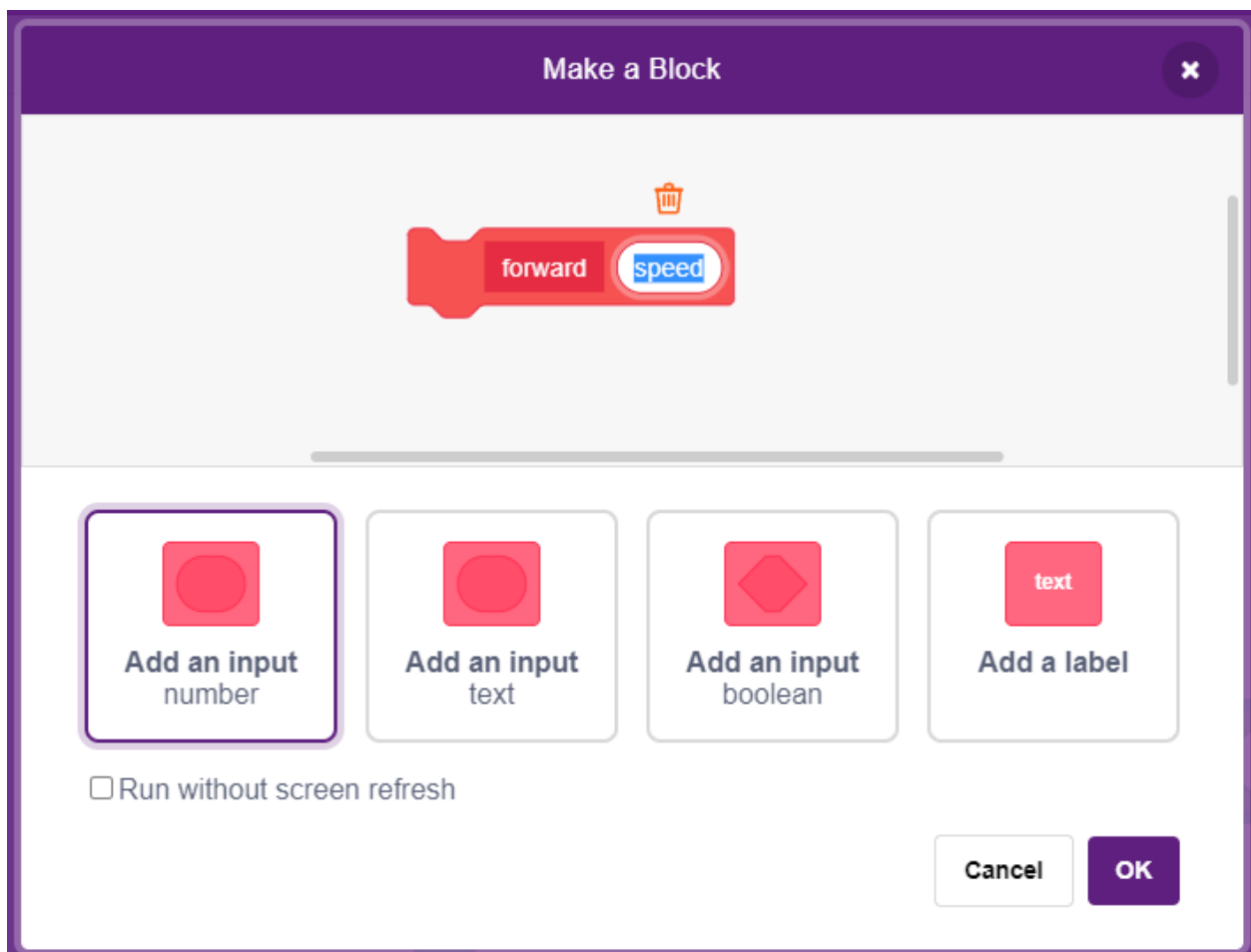
### 2. Creating block

In order to make the script more clean and easy to use, here we put all the blocks that control the forward movement into a block, and when using it, just call this block directly.

Click **Make a Block** in the **My Blocks** palette.

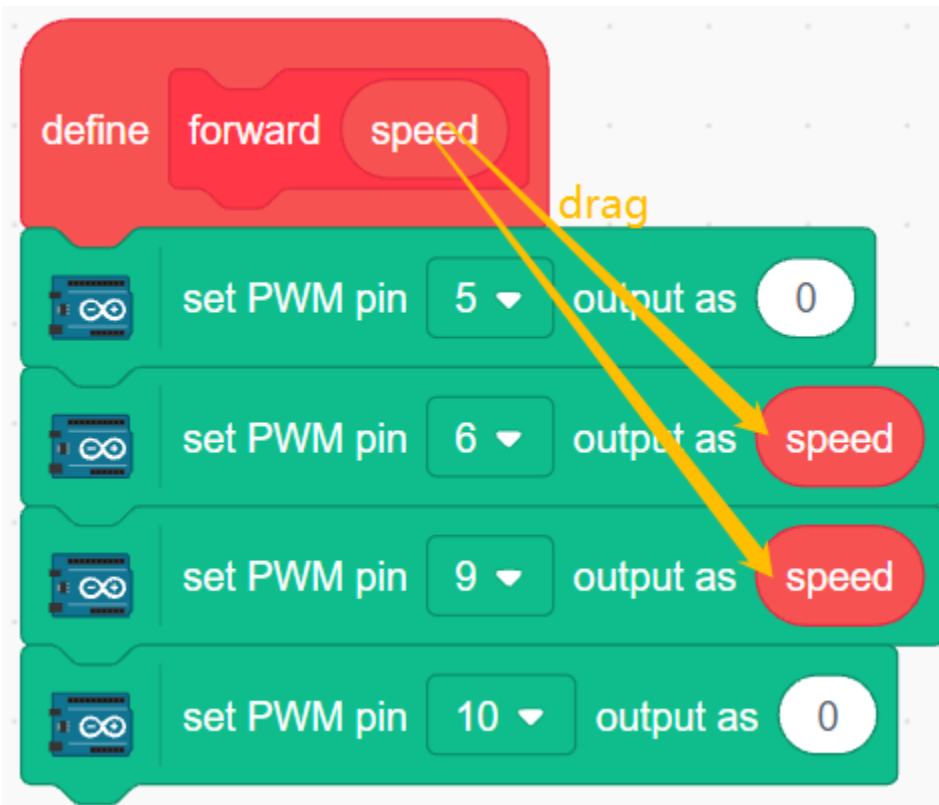


Enter the name of the block - **forward** and check **Add an input**, set the input name to **speed**.



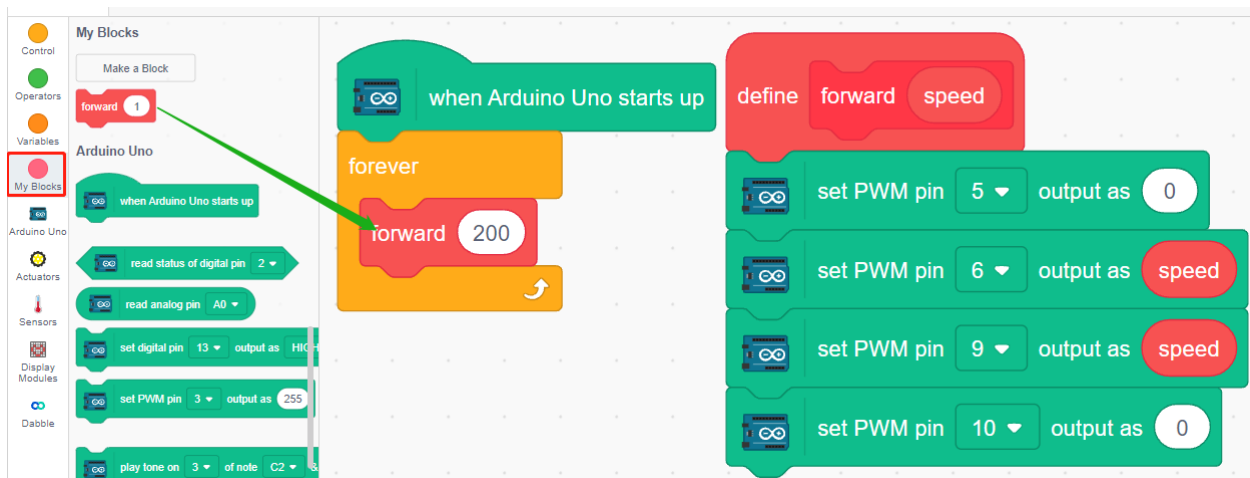
Drag and drop the blocks that control the cars forward into **forward**, note that you need to add the parameter - **speed** to pin6 and pin9.





Call the created block in the [Forward] block - **forward**. In Upload mode, the [When Arduino Uno starts up] block must be added at the beginning.

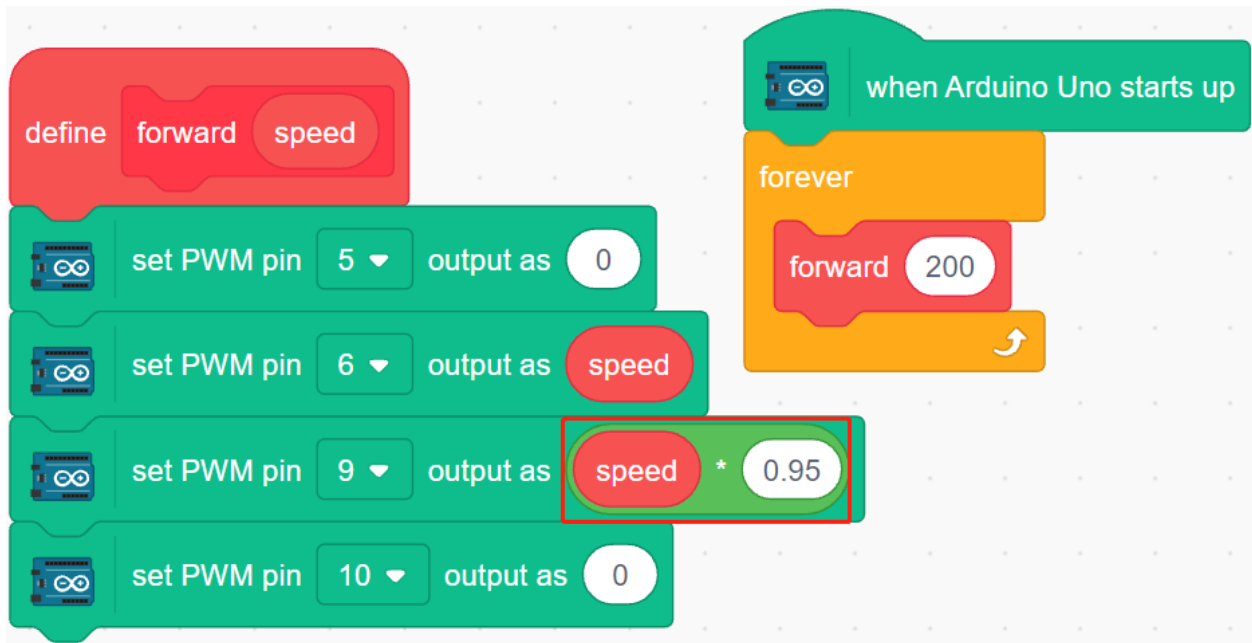
- The motor rotation speed range is 100 ~ 255.



### 3. Adjusting the speed of motors

Since there may be a slight difference in the speed of the 2 motors, resulting in the car not being able to move along a straight line, we can give the left and right motors different speeds to keep the car moving along a straight line as much as possible.

Since my car will move slowly to the right front, so here reduce the speed of the left motor.



## 7.27 3.2 Movement

This project is based on *3.1 Test the Car* to make the car move in all directions.

Before we start programming, let's review the working principle of L298N.

The working relationship between ENA and IN1,IN2 is as follows.

ENA	IN1	IN2	The state of right motor(A)
0	X	X	Stop
1	0	0	Brake
1	0	1	Rotate clockwise
1	1	0	Rotate counterclockwise
1	1	1	Brake

The working relationship between ENB and IN3,IN4 is as follows.

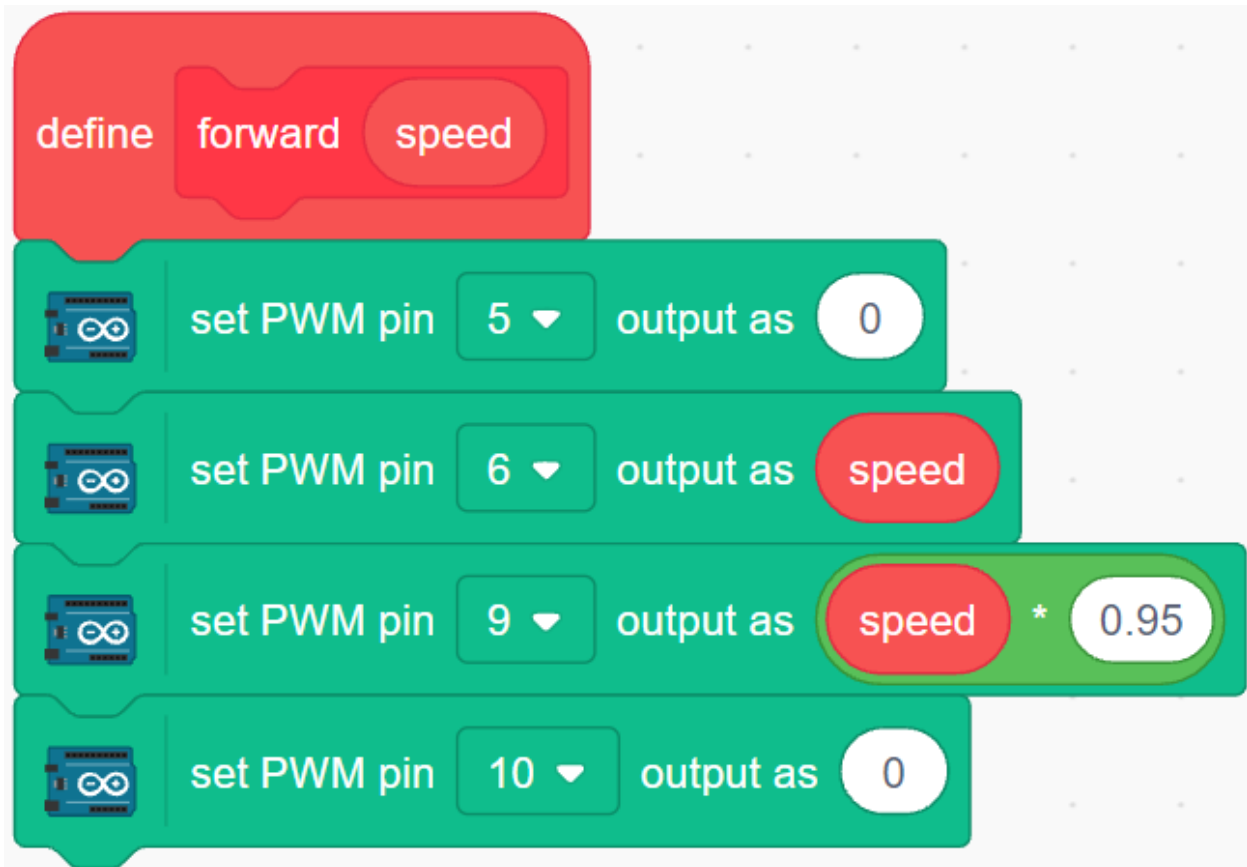
ENB	IN3	IN4	The state of left motor(B)
0	X	X	Stop
1	0	0	Brake
1	0	1	Rotate clockwise
1	1	0	Rotate counterclockwise
1	1	1	Brake

### 7.27.1 Programming

Now create blocks to make the car, forward, backward, left and right rotation and stop respectively.

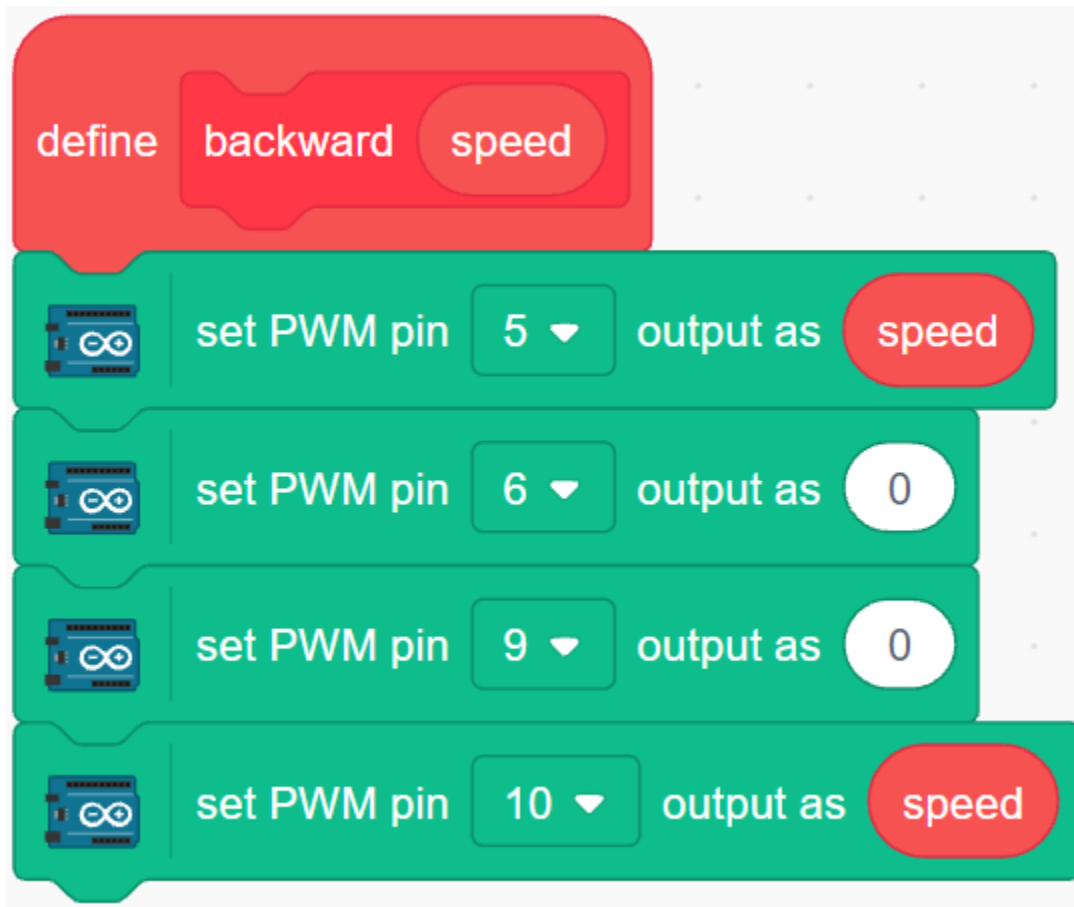
#### 1. Move Forward

The right motor turns clockwise and the left motor turns counterclockwise to move the car forward.



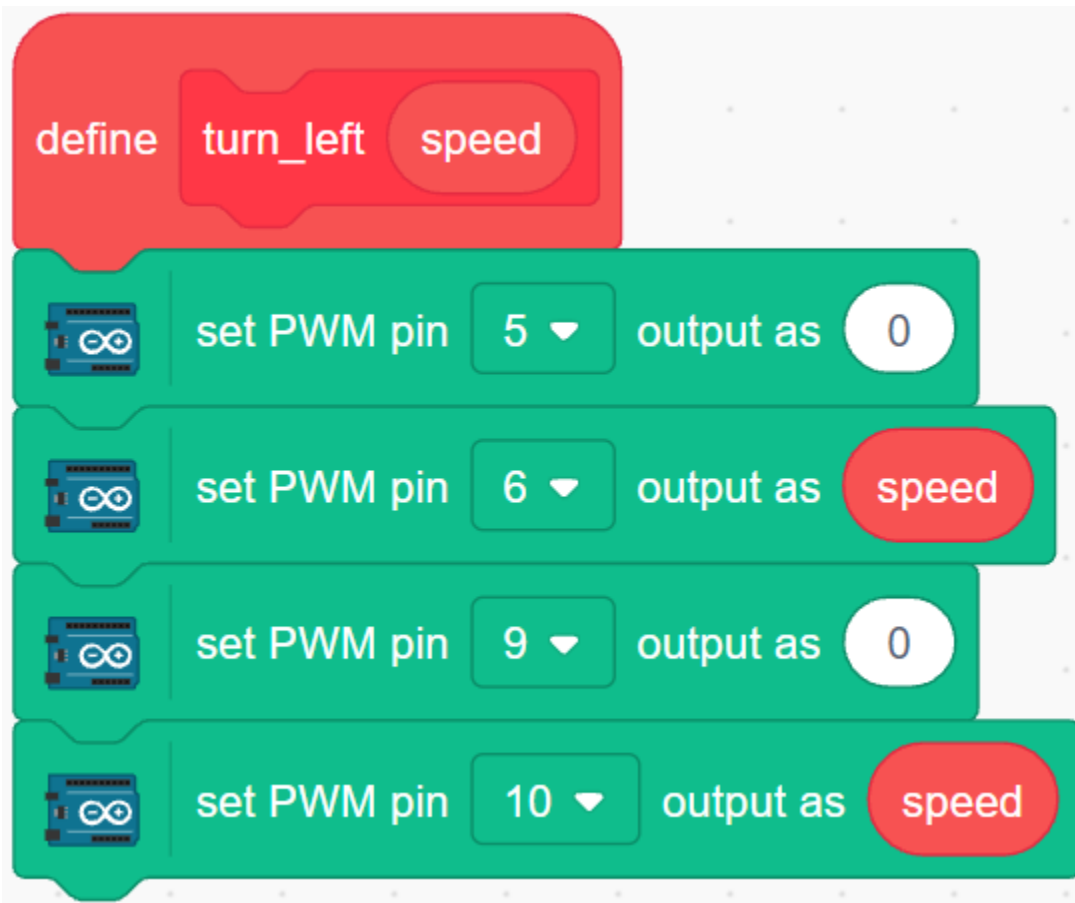
#### 2. Move Backward

Backward is just the opposite, the right motor needs to turn counterclockwise, the left motor clockwise.



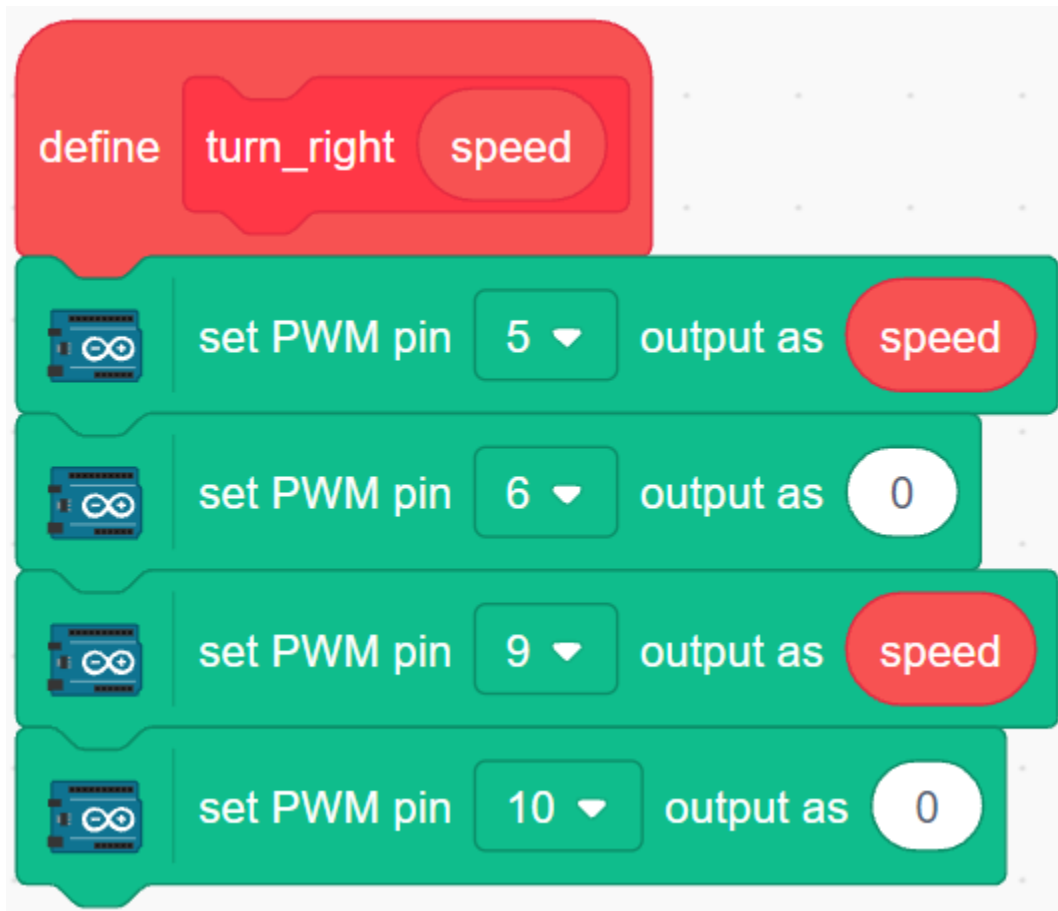
### 3. Turn Left

The left and right motors turn clockwise at the same time to make the car turn left.



#### 4. Turn Right

Similarly, turn the left and right motors counterclockwise to turn the car to the right.



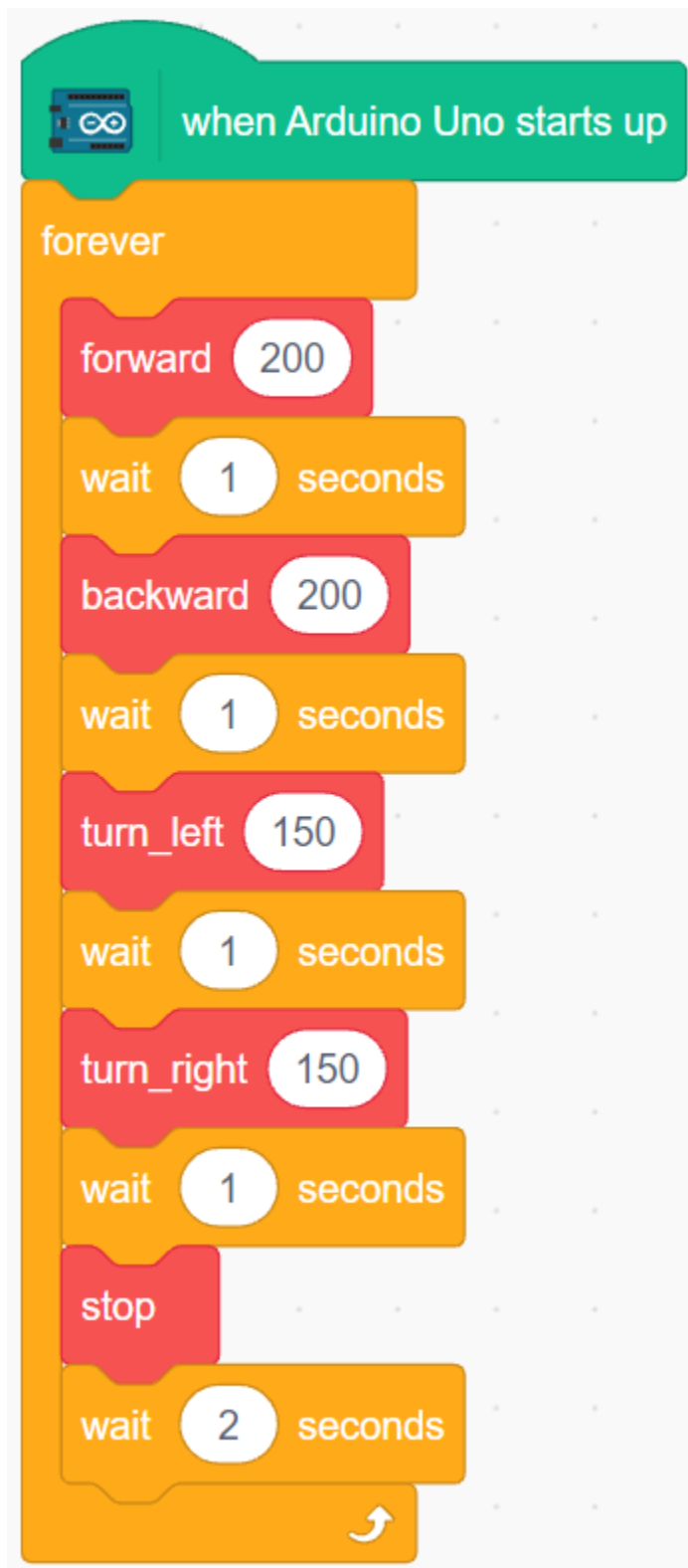
### 5. Stop

Stop the car by setting all motors to 0.



#### 6. Make the car move

Make the car move forward, backward, left and right for 1 second, then stop. Since all blocks are placed in the [Forever] block, you will see that the car repeats the above actions.





## 7.28 3.3 Follow the line

The car is equipped with a Line Track module, which can be used to make the car follow the black line.

Before starting the project, you need to build a curve map with black line tape, the recommended line width is between 0.8-1.5cm and the angle of the turn should not be less than 90 degrees.

### 7.28.1 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

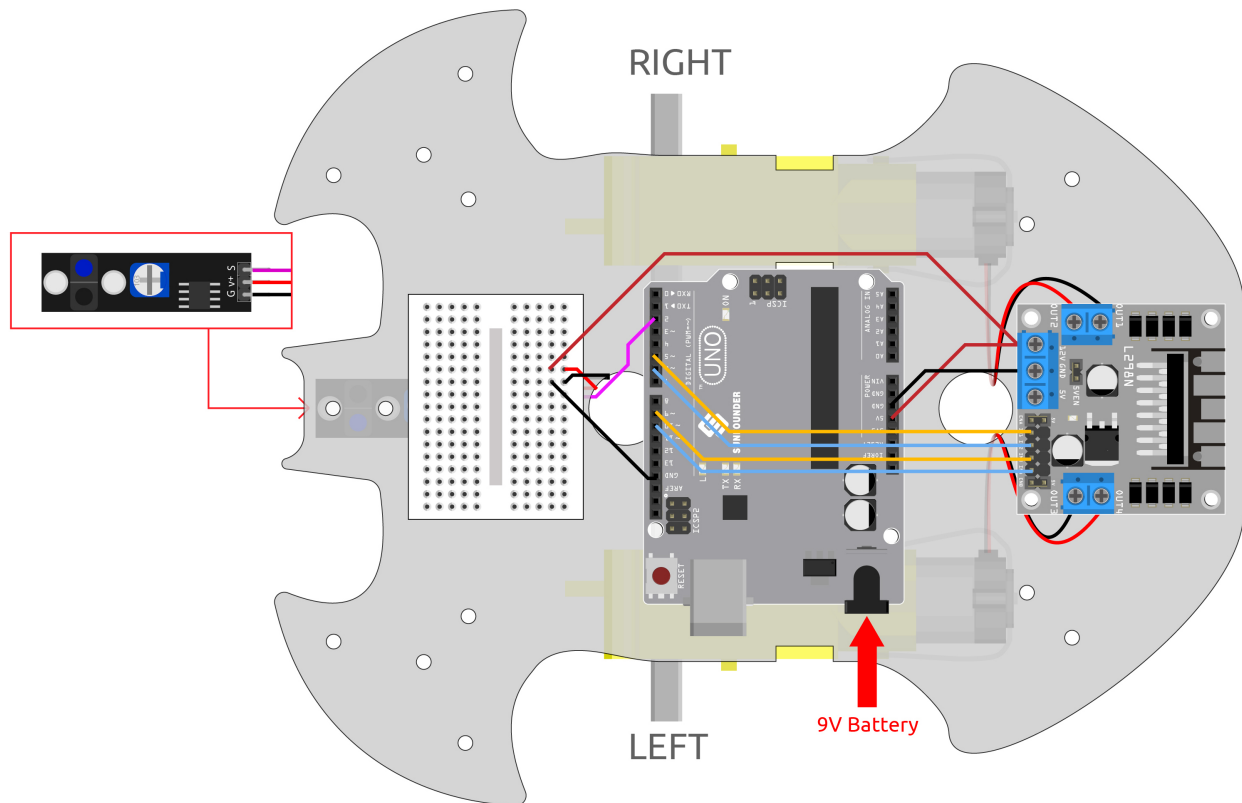
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>L298N Module</i>	
<i>TT Motor</i>	-
<i>Line Tracking Module</i>	

### 7.28.2 Build the Circuit

This is a digital Line Tracking module, when a black line is detected, it outputs 1; when a white line is detected, it outputs a value of 0. In addition, you can adjust its sensing distance through the potentiometer on the module.

Build the circuit according to the following diagram.

Line Tracking Module	R3 Board
S	2
V+	5V
G	GND



### 7.28.3 Adjust the Module

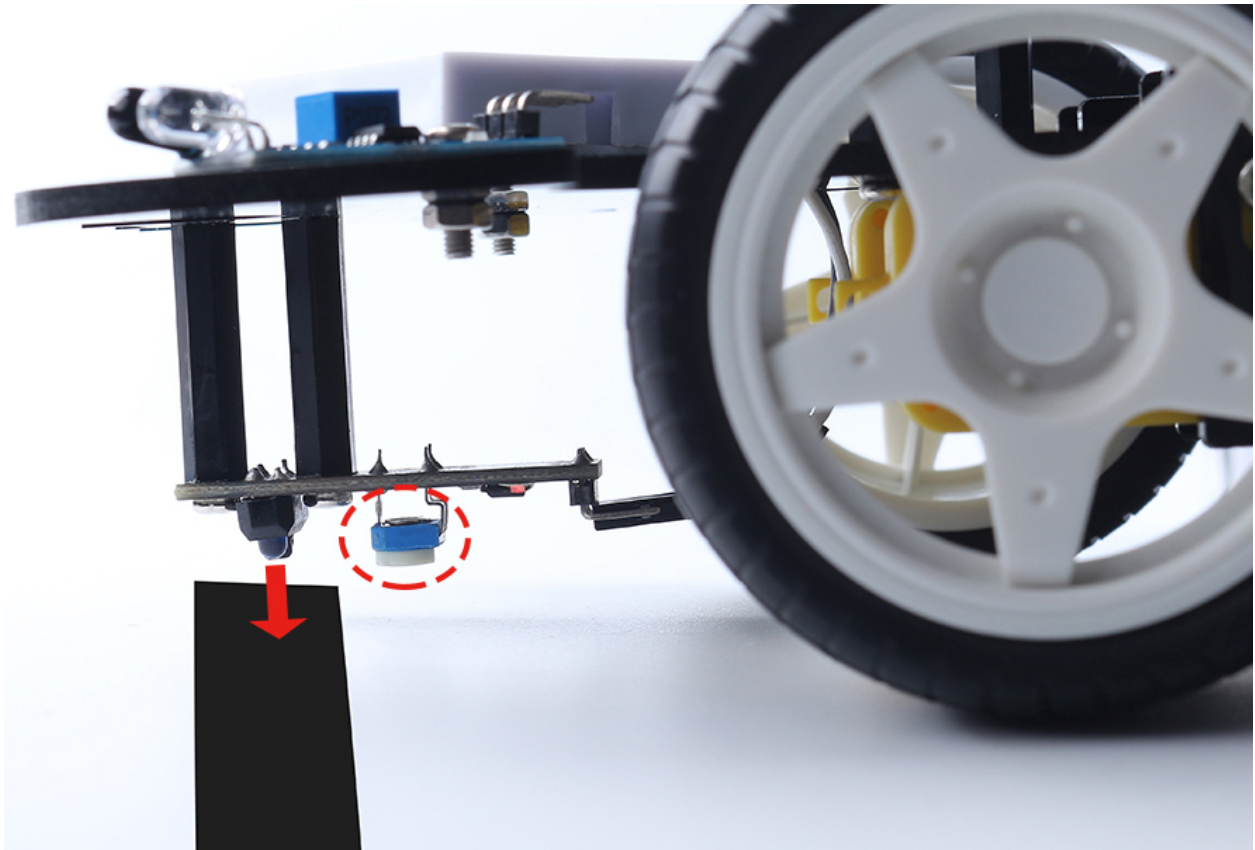
Before starting the project, you need to adjust the sensitivity of the module.

Wiring according to the above diagram, then power up the R3 board (either directly into the USB cable or the 9V battery button cable), without uploading the code.

Stick a black electrical tape on the table and put the cart on it.

Observe the signal LED on the module to make sure it lights up on the white table and goes off on the black tape.

If not, you need to adjust the potentiometer on the module, so that it can do the above effect.

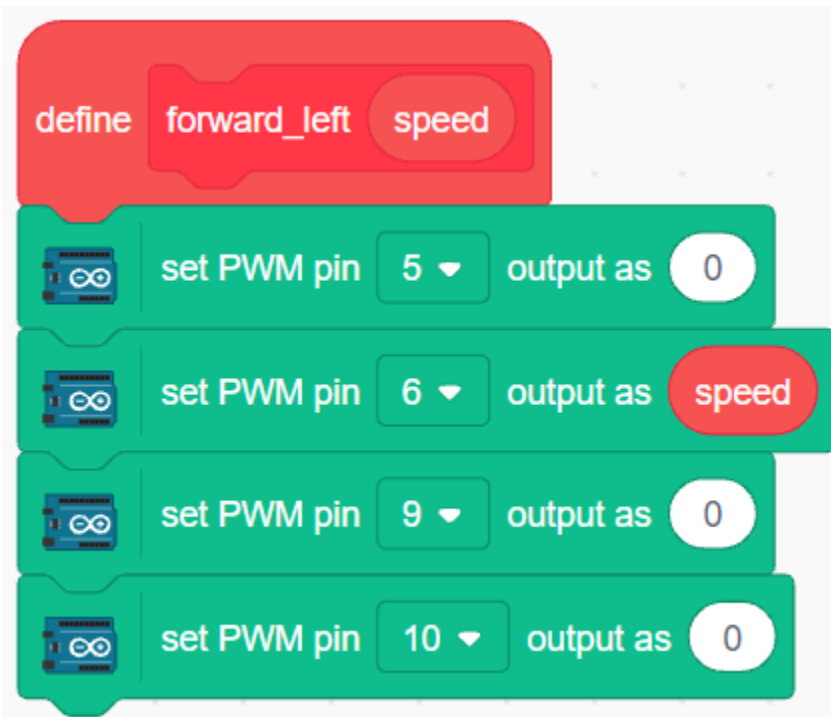


### 7.28.4 Programming

Now create 2 blocks that allow the car to move either to the left front or to the right front.

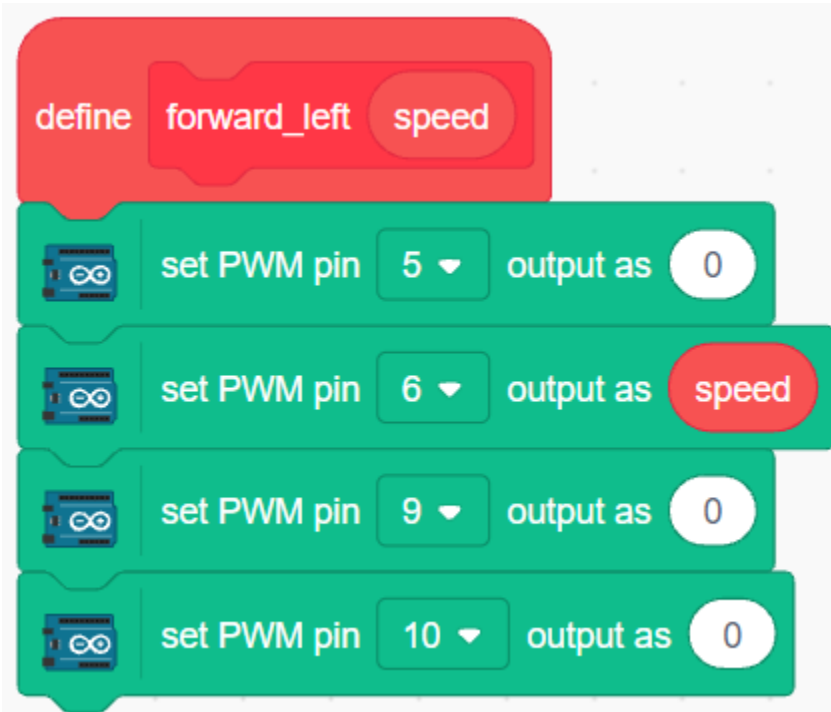
#### 1. Move to the left front

When the right motor is turned clockwise and the left motor is left unmoved, the car is moved slightly to the left front.



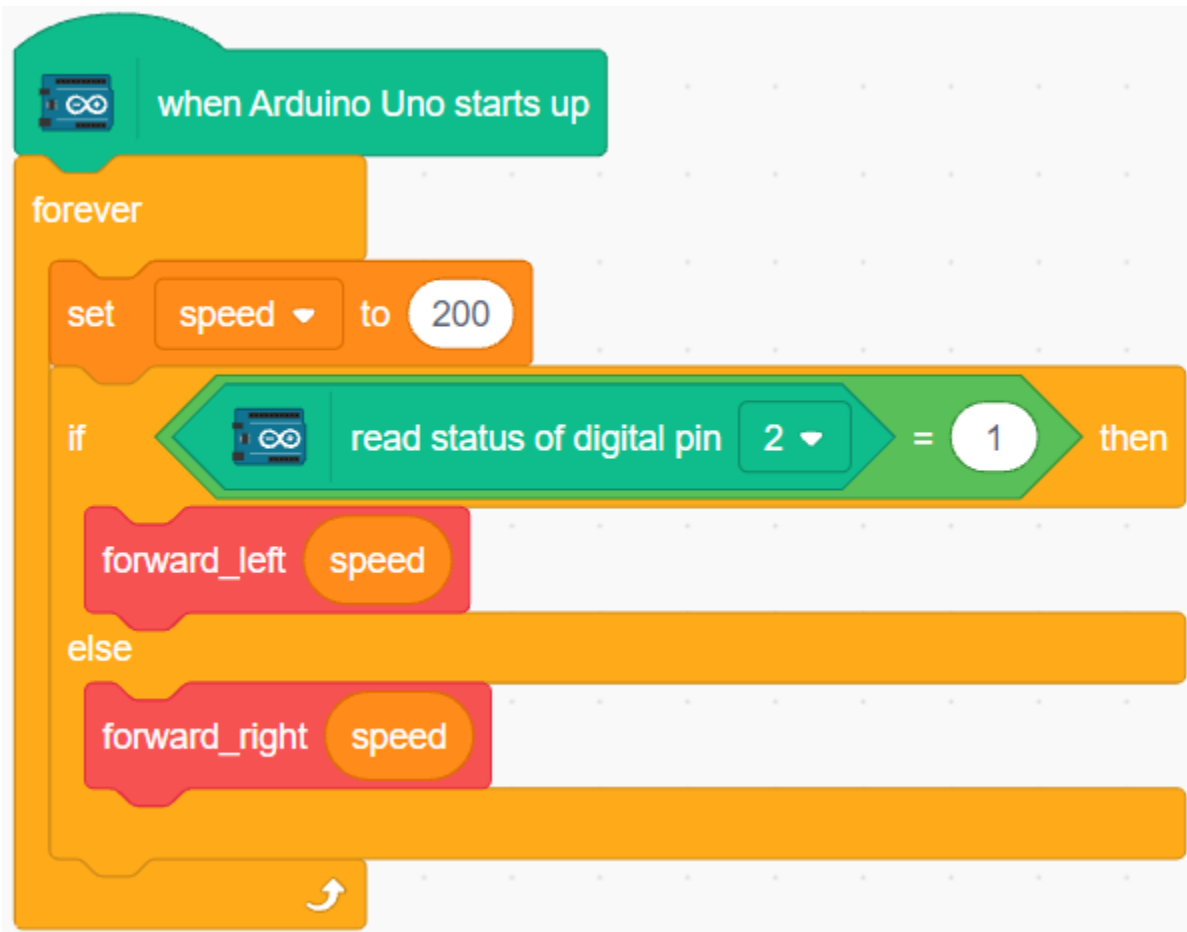
## 2. Moving to the right front

Similarly, when the left motor is turned counterclockwise and the left motor does not move, the car moves slightly to the right.



## 3. Line Tracking

Read the value of Line Tracking module, if it is 1, it means black line has been detected, let the car move forward to the left, otherwise move forward to the right.



After uploading the code to the R3 board, then align the Line Tracking module under the car with the black line, and you will see the car following the line.

## 7.29 3.4 Follow Your Hand

Think of this car as your pet here, and when you will wave to him, it comes running to you.

### 7.29.1 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

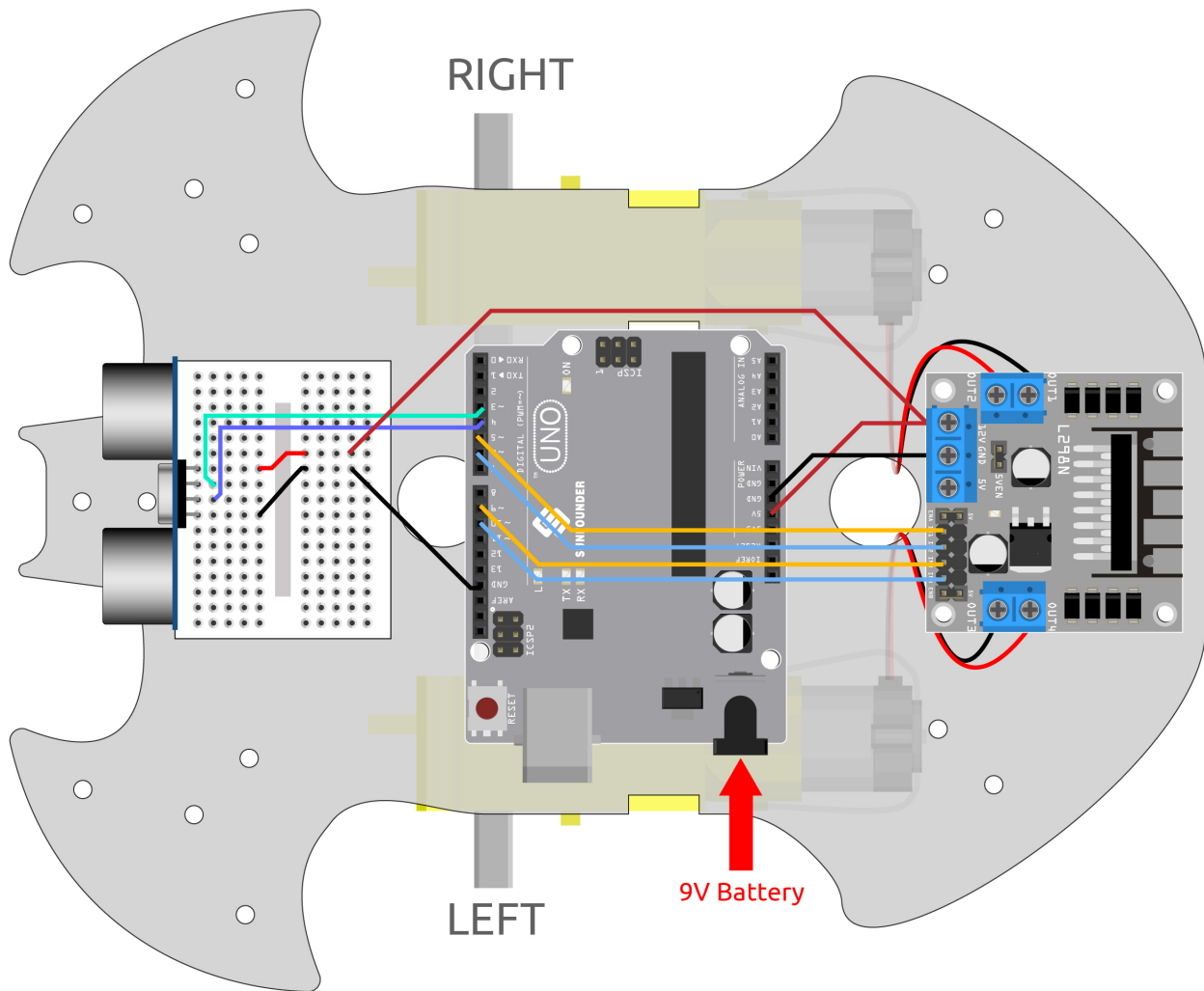
COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>L298N Module</i>	
<i>TT Motor</i>	-
<i>Ultrasonic Module</i>	

### 7.29.2 Build the Circuit

An ultrasonic sensor module is an instrument that measures the distance to an object using ultrasonic sound waves. It has two probes. One is to send ultrasonic waves and the other is to receive the waves and transform the time of sending and receiving into a distance, thus detecting the distance between the device and an obstacle.

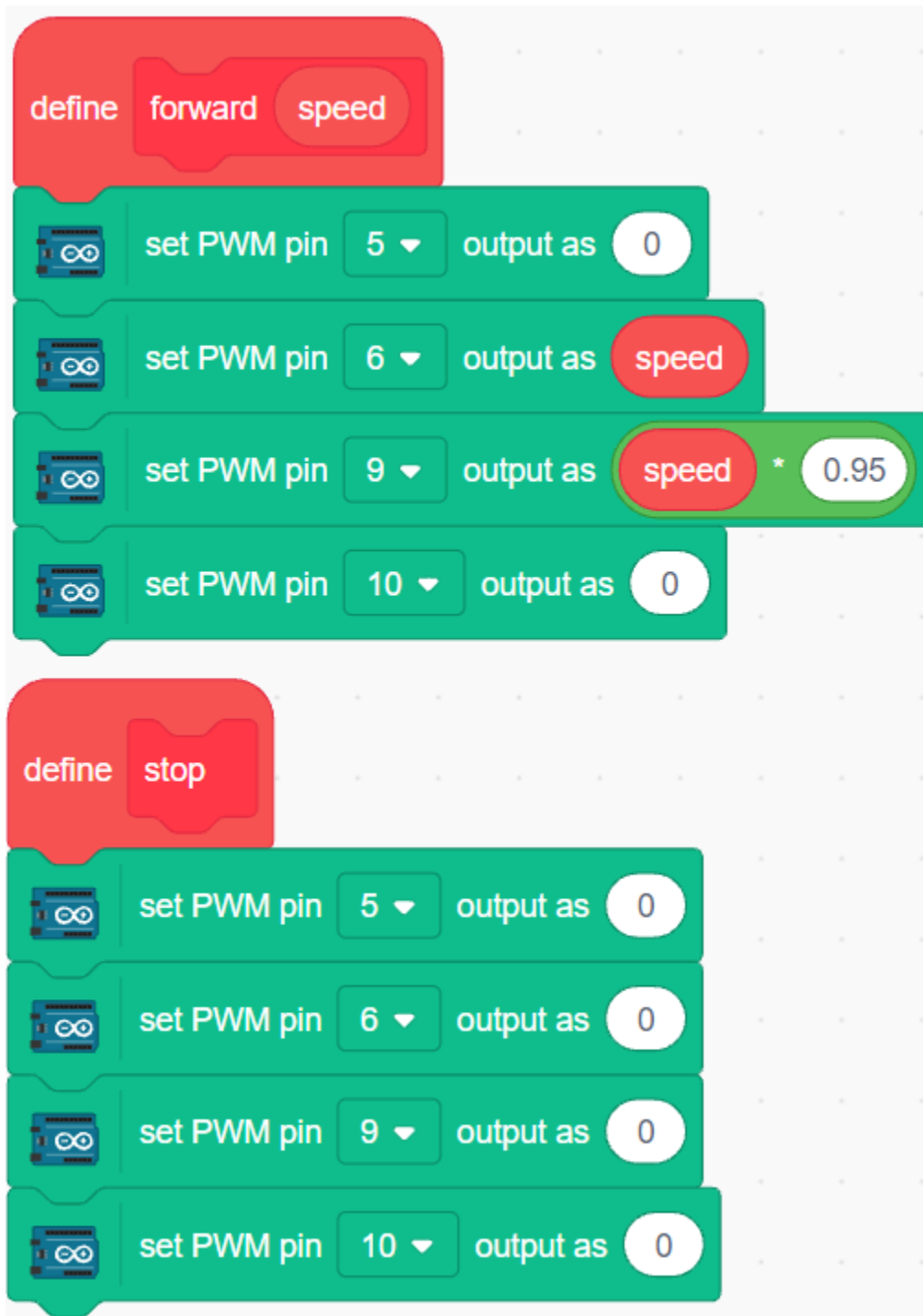
Now build the circuit according to the following diagram.

Ultrasonic Module	R3 Board
Vcc	5V
Trig	3
Echo	4
Gnd	GND



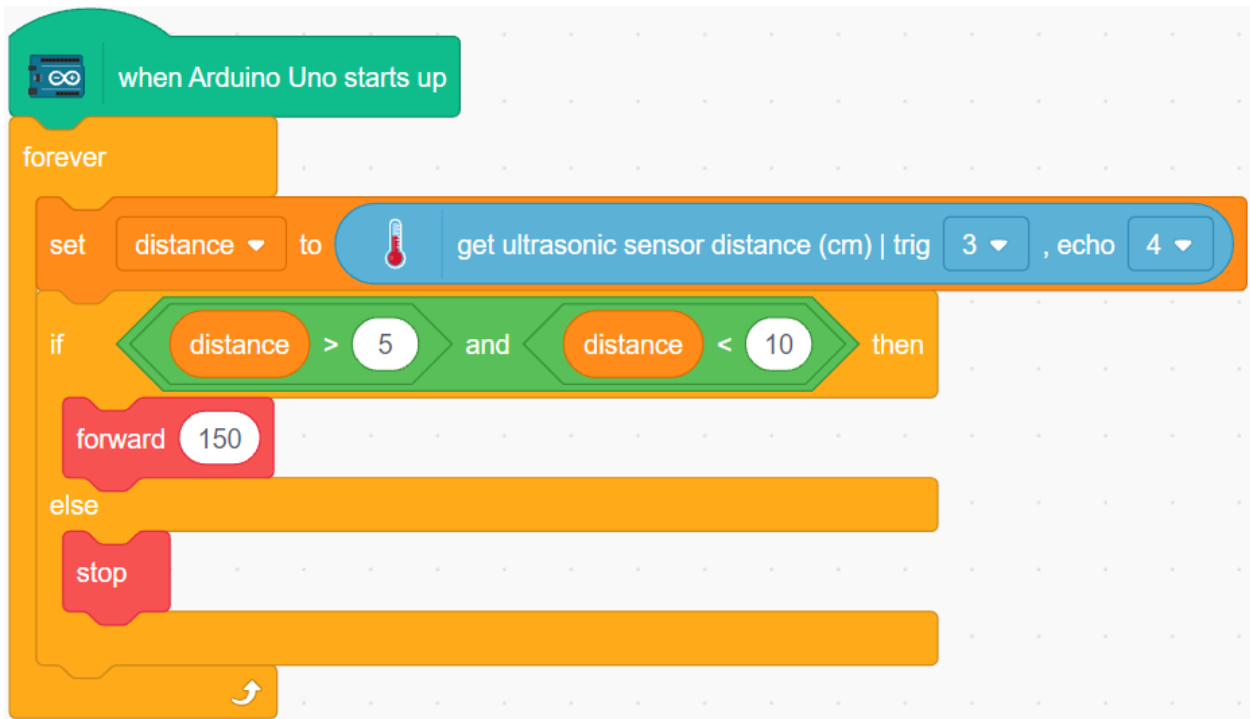
### 7.29.3 Programming

Create blocks to make the car go forward and stop.



Put your hand in front of the car, then read the value of the ultrasonic module, if the detected distance of your hand is 5-10cm, then let the car go forward, otherwise stop.





## 7.30 3.5 Obstacle avoidance

Two infrared obstacle avoidance modules are mounted on the front of the car, which can be used to detect some close obstacles.

In this project, the car is allowed to move forward freely, and when it encounters an obstacle it is able to avoid it and continue to move in other directions.

### 7.30.1 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>L298N Module</i>	
<i>TT Motor</i>	-
<i>Obstacle Avoidance Module</i>	

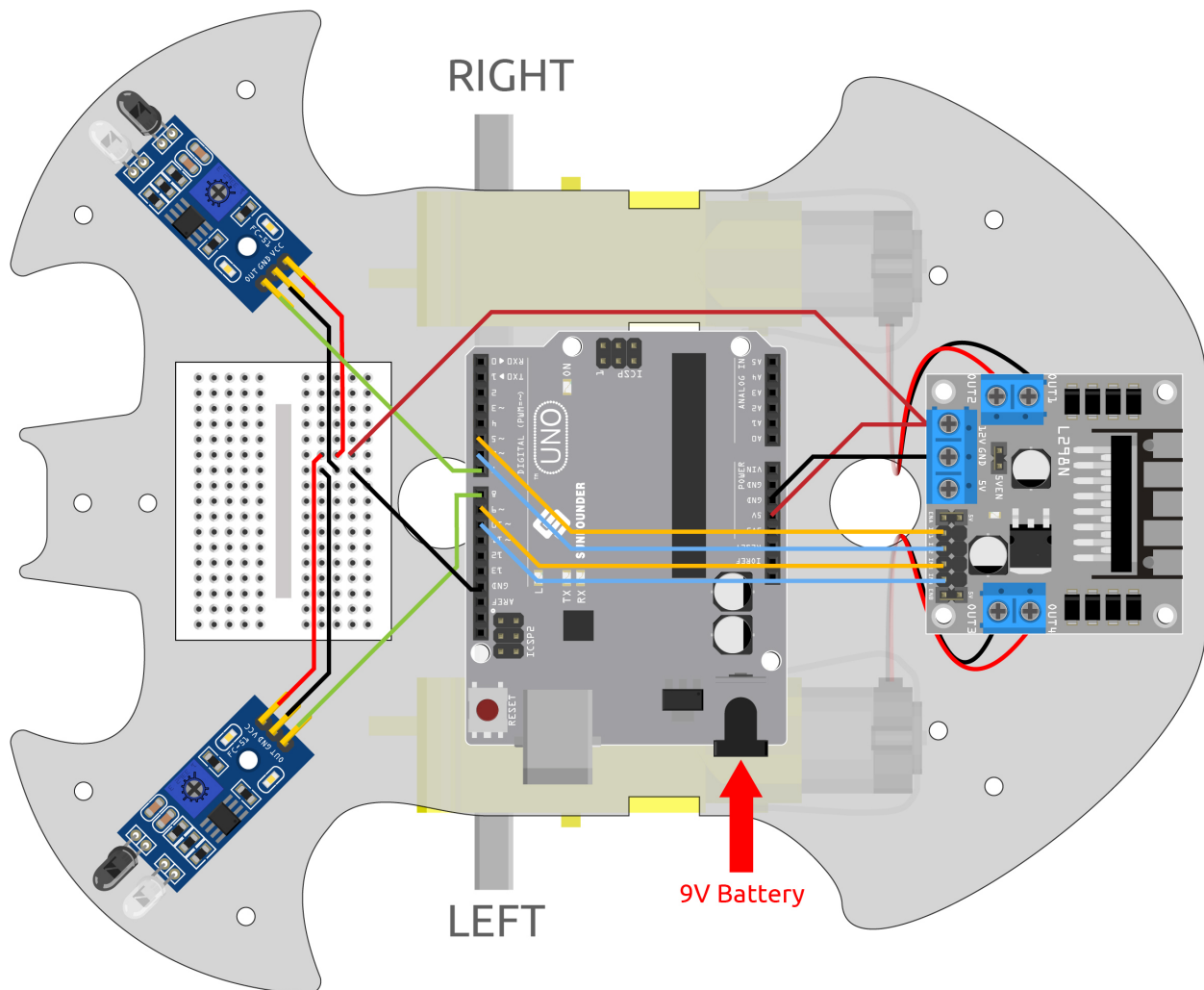
### 7.30.2 Build the Circuit

The obstacle avoidance module is a distance-adjustable infrared proximity sensor whose output is normally high and low when an obstacle is detected.

Now build the circuit according to the diagram below.

Left IR Module	R3 Board
OUT	8
GND	GND
VCC	5V

Right IR Module	R3 Board
OUT	7
GND	GND
VCC	5V



### 7.30.3 Adjust the Module

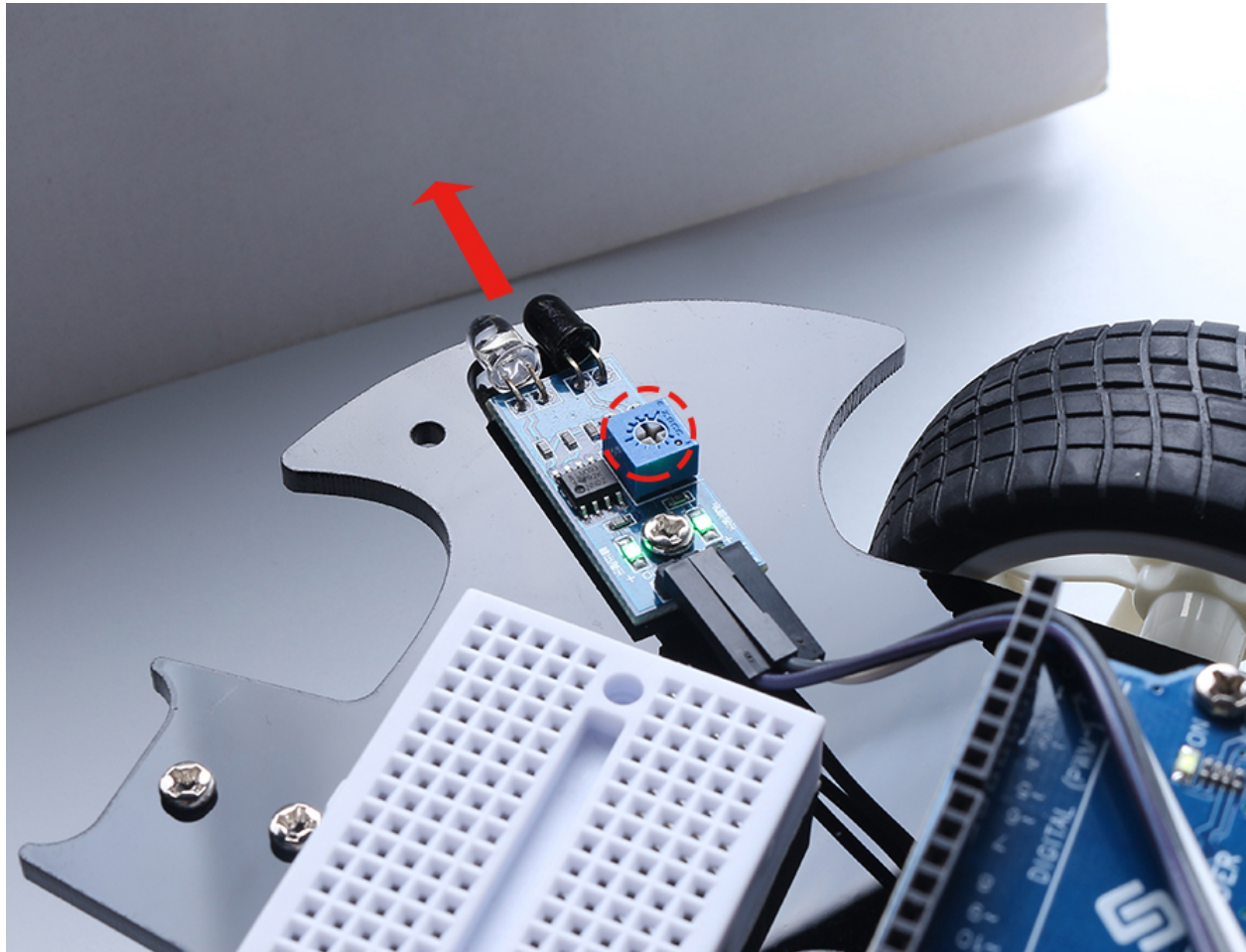
Before starting the project, you need to adjust the detection distance of the module.

Wiring according to the above diagram, power up the R3 board (either by plugging in the USB cable directly or by snapping the 9V battery cable), without uploading the code.

Place a notebook or any other flat object about 5cm in front of the IR obstacle avoidance.

Then use a screwdriver to rotate the potentiometer on the module until the signal indicator on the module just lights up, so as to adjust its maximum detection distance of 5cm.

Follow the same method to adjust another infrared module.



### 7.30.4 Programming

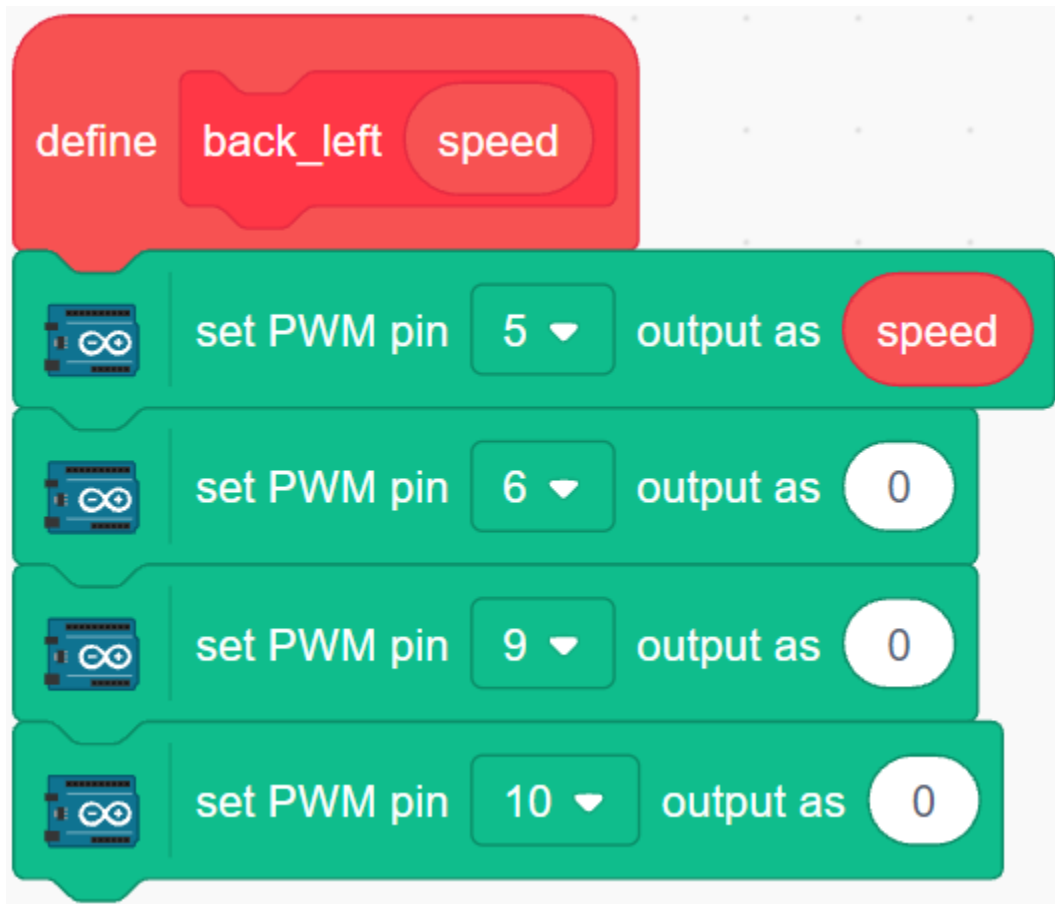
The effect we want to achieve.

- When the left IR module detects an obstacle, the car goes backward to the left
- When the right IR module detects an obstacle, the car goes backward to the right.
- If both IR modules detect the obstacle, the car will go back directly.
- Otherwise the car will go forward.

Now create the corresponding blocks.

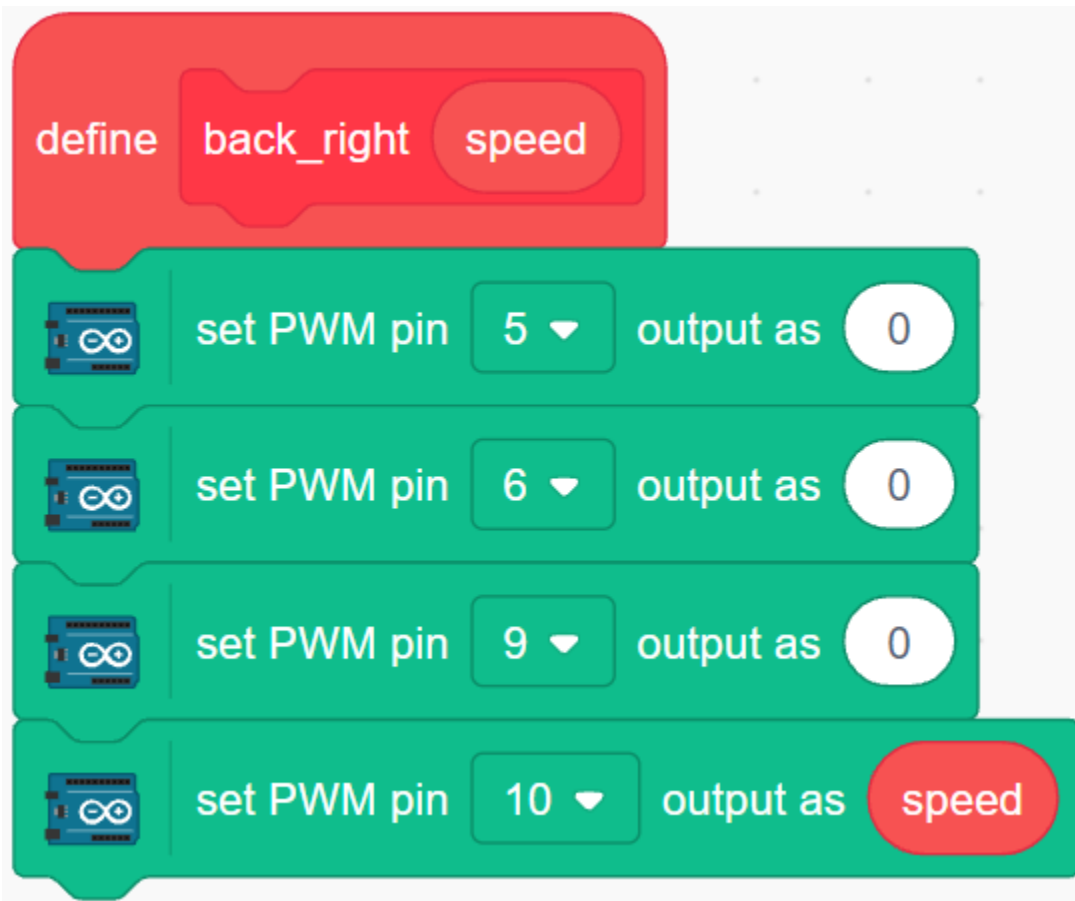
### 1. The car goes backward to the left

When the right motor is turning counterclockwise and the left motor is not turning, the car will go backward to the left.

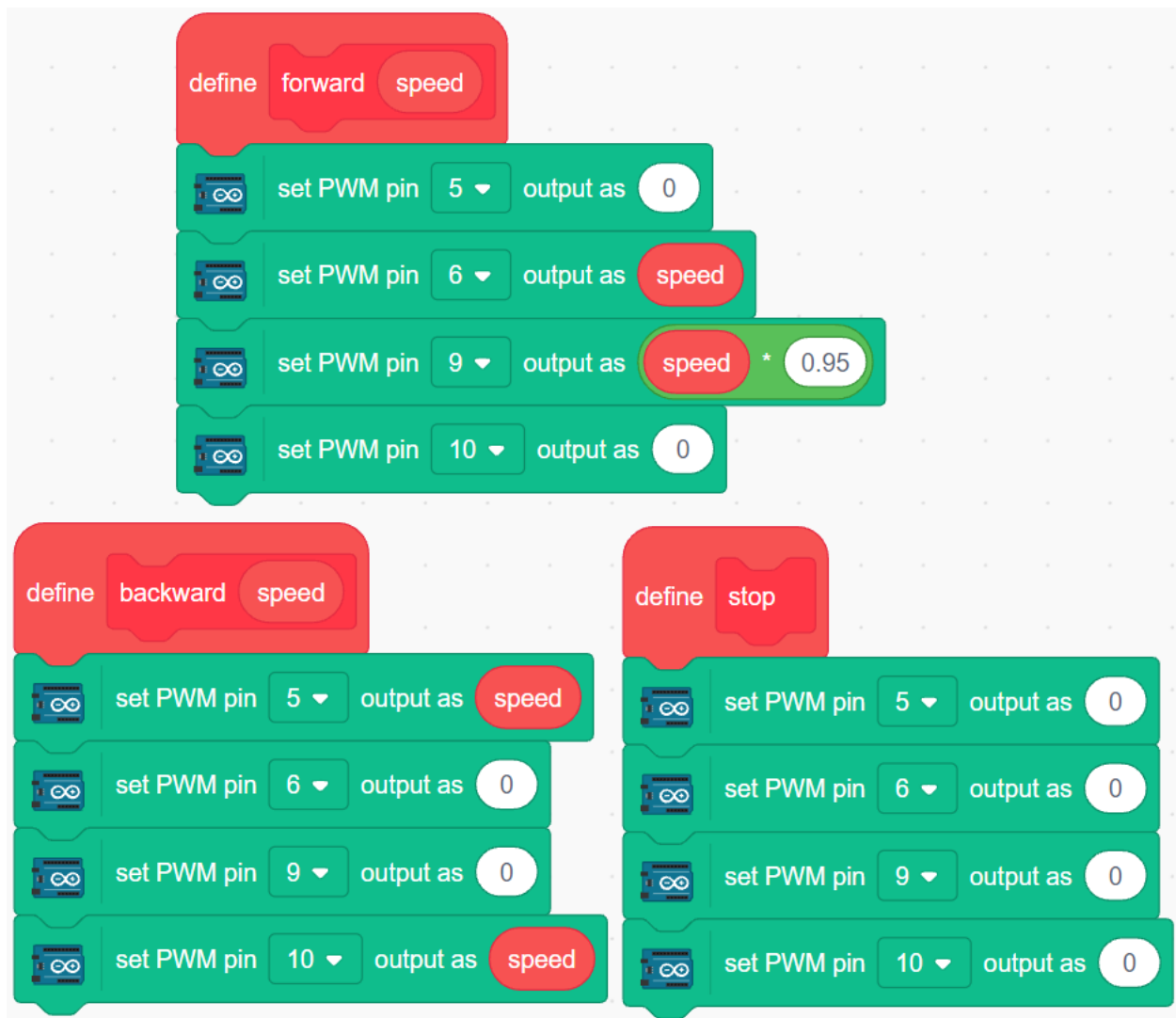


### 2. The car goes backward to the right

When the left motor is turning clockwise and the right motor is not turning, the car will go backward to the right.

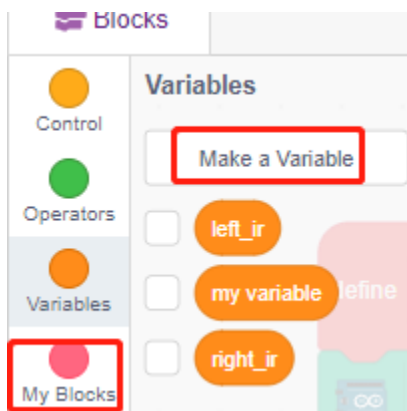


3. The car moves forward, backward and stops

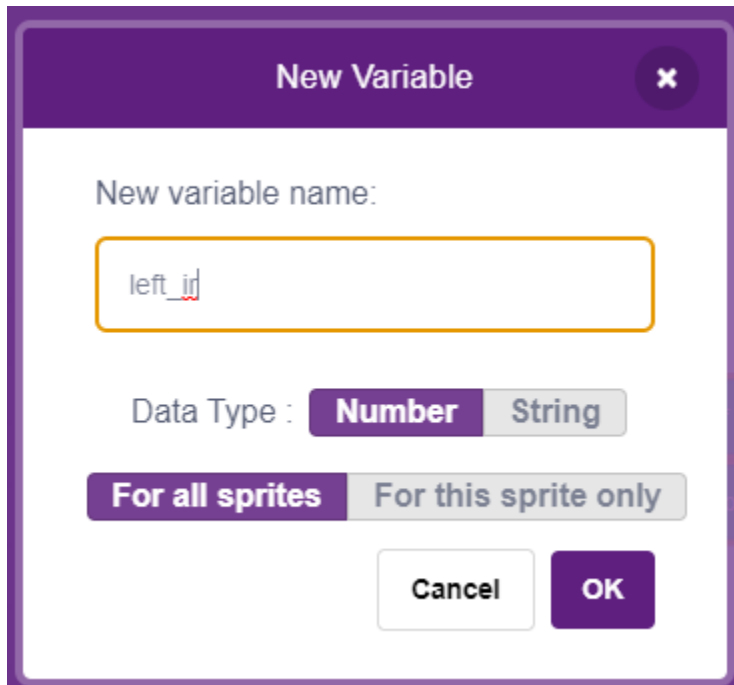


#### 4. Read the values of the 2 IR modules

Click **Make a variable** in the **Variables** palette.



Enter the variable name and click **OK** to create a new variable.

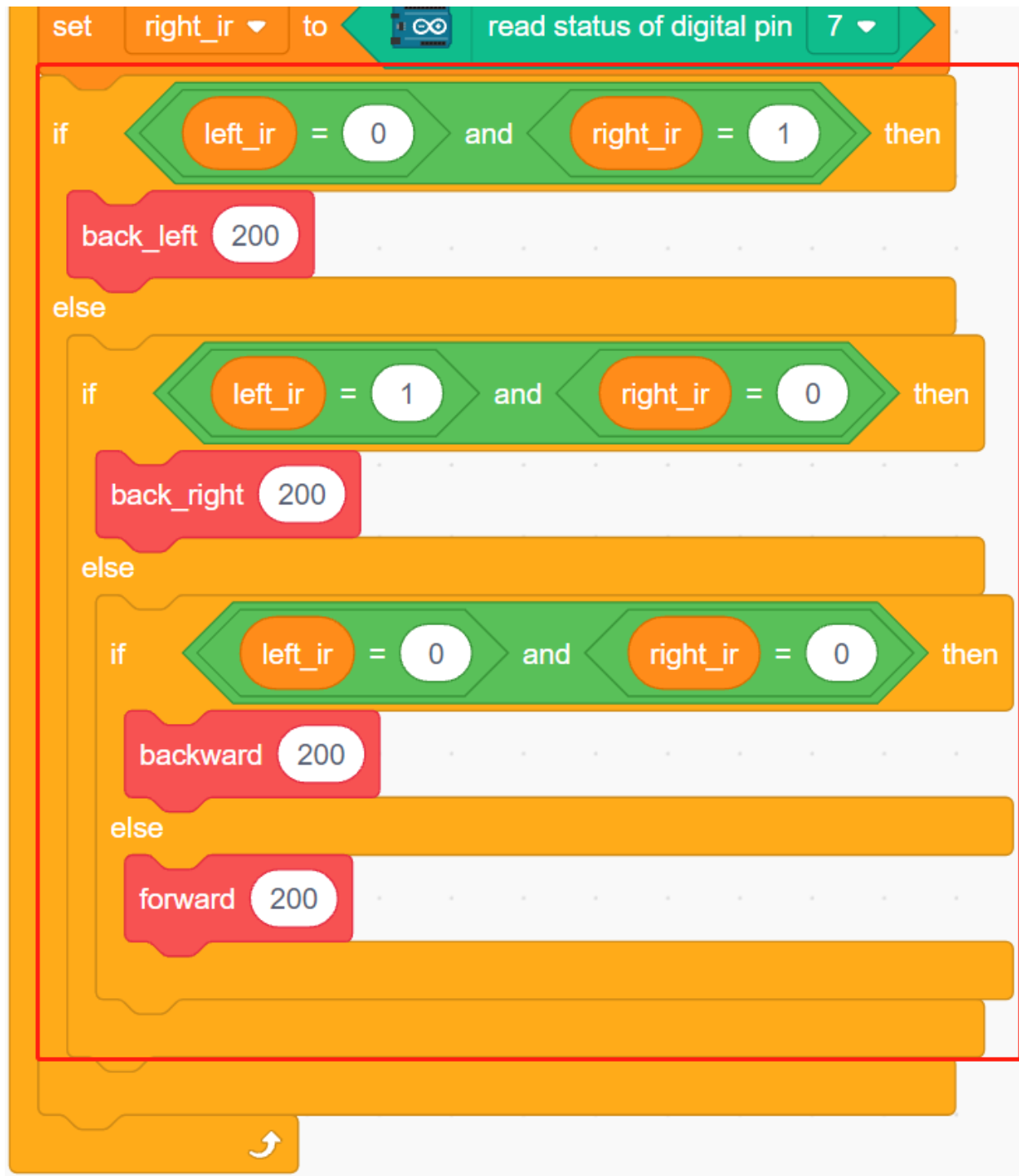


Read the values of the left and right IR obstacle avoidance modules and store them in the 2 new variables.



## 5. obstacle avoidance

- When the left IR module is 0 (obstacle detected) and the right IR module is 1, let the car back up to the left.
- When the right IR module is 0 (obstacle detected), let the car go back up to the right.
- If 2 IR modules detect the obstacle at the same time, the car will go backward.
- Otherwise the car will keep going forward.





## 7.31 3.6 Follow Your Hand 2

In the *3.4 Follow Your Hand* project only the ultrasonic module is used, it can only follow your hand forward.

In this project, we use 2 IR obstacle avoidance modules at the same time, so that the car can follow your hand left or right.

### 7.31.1 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>L298N Module</i>	
<i>TT Motor</i>	-
<i>Ultrasonic Module</i>	
<i>Obstacle Avoidance Module</i>	

### 7.31.2 Build the Circuit

Connect the ultrasonic module and the two IR obstacle avoidance modules at the same time.

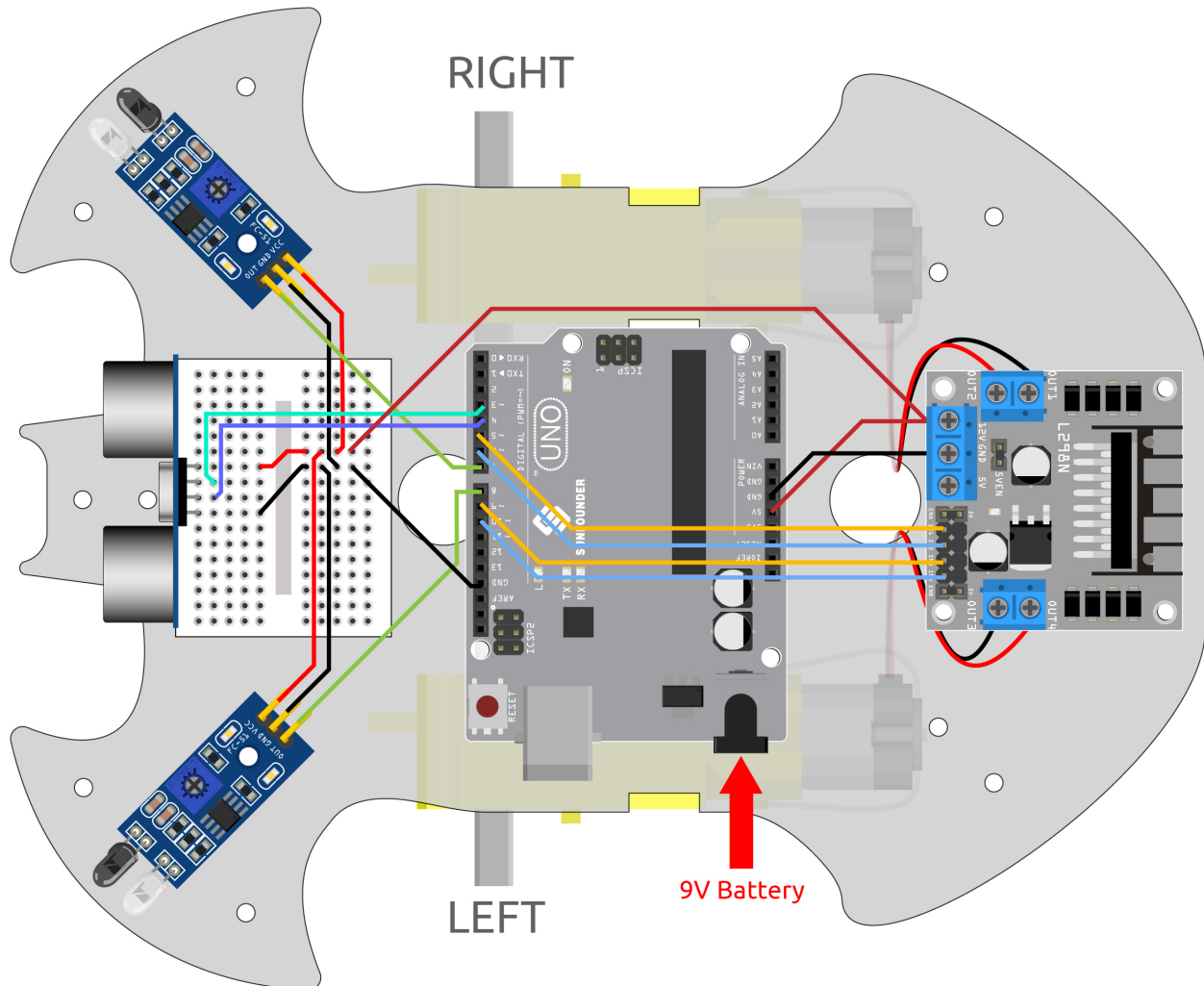
The wiring between the ultrasonic and the R3 board is as follows.

Ultrasonic Module	R3 Board
Vcc	5V
Trig	3
Echo	4
Gnd	GND

The wiring of the 2 IR obstacle avoidance modules to the R3 board is as follows.

Left IR Module	R3 Board
OUT	8
GND	GND
VCC	5V

Right IR Module	R3 Board
OUT	7
GND	GND
VCC	5V



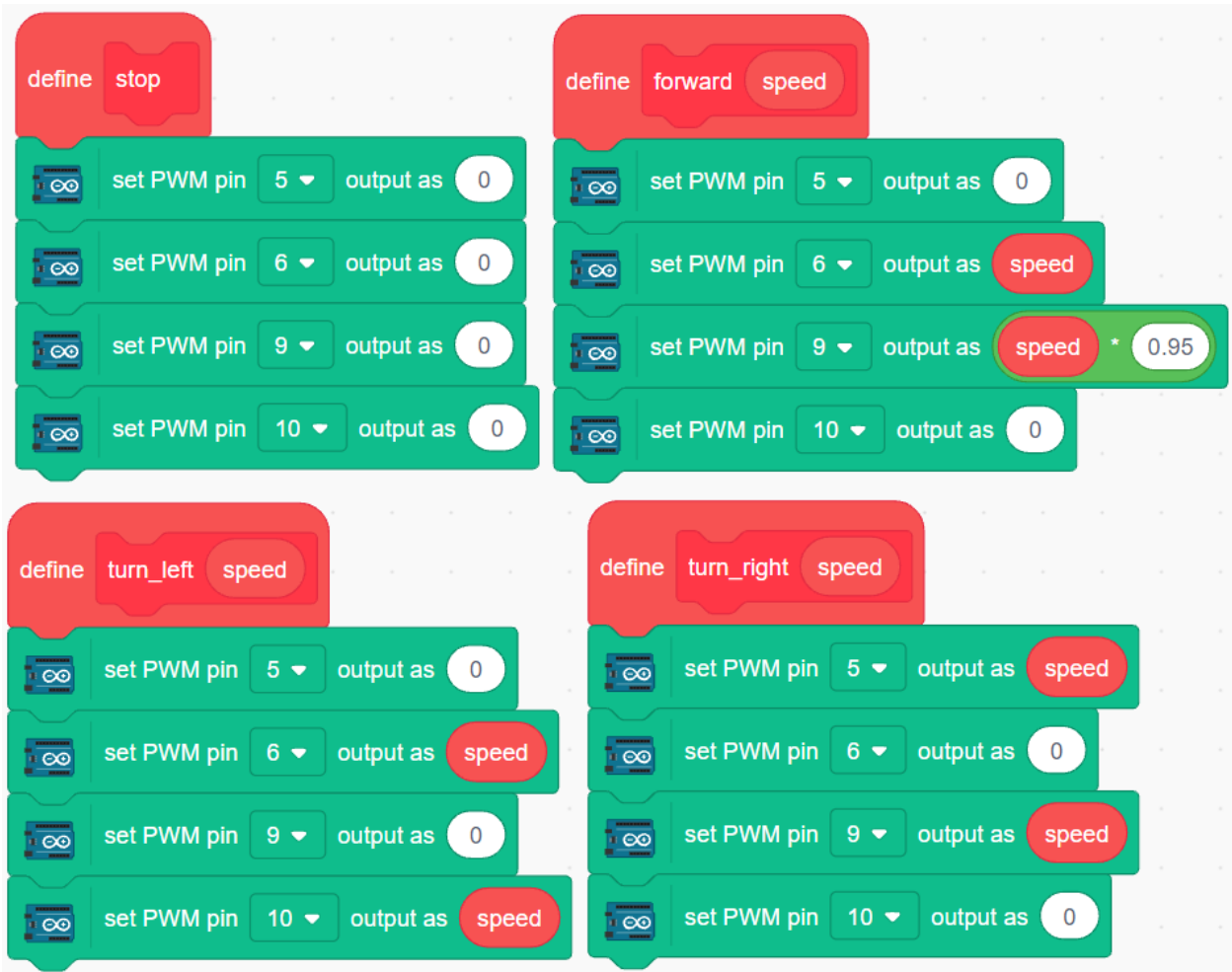
### 7.31.3 Programming

The effect to be achieved by this project is as follows

- Ultrasonic detects your hand about 5-10cm in front and let the car follow.
- The infrared module on the left detects your hand and turns to the left.
- The right IR module detects your hand and turns to the right.

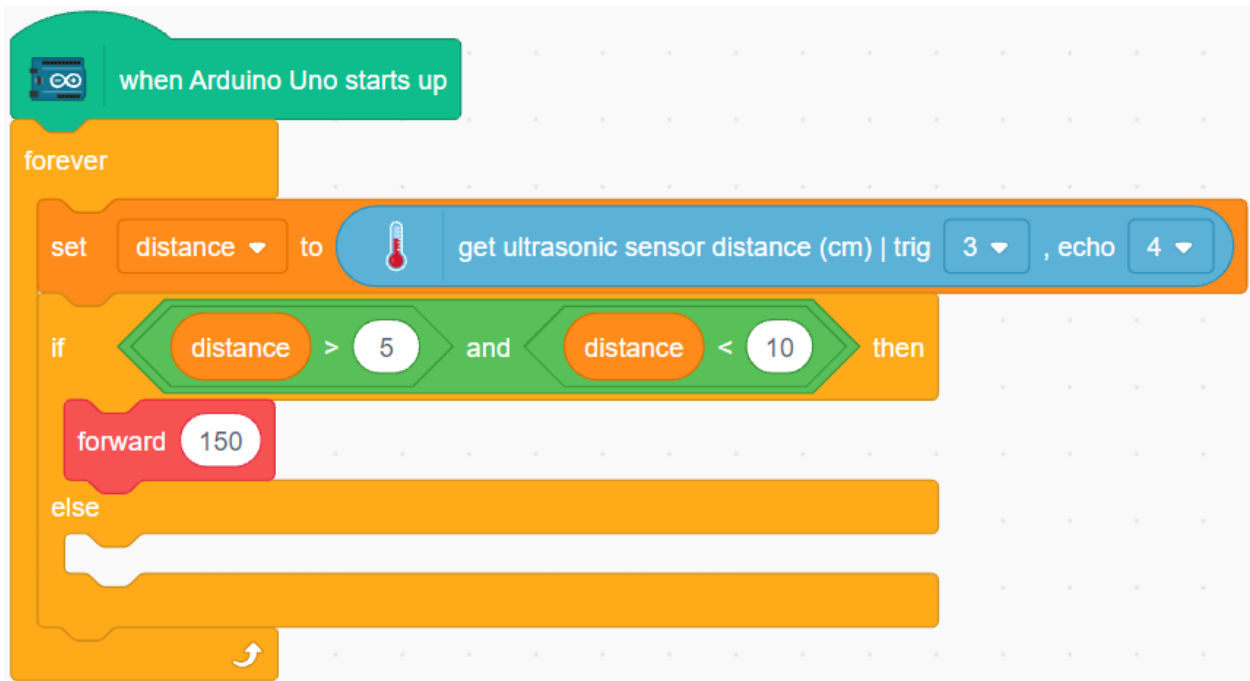
#### 1. Create a block

Create blocks that allow the car to move forward, turn left, turn right and stop.



## 2. Follow to move forward

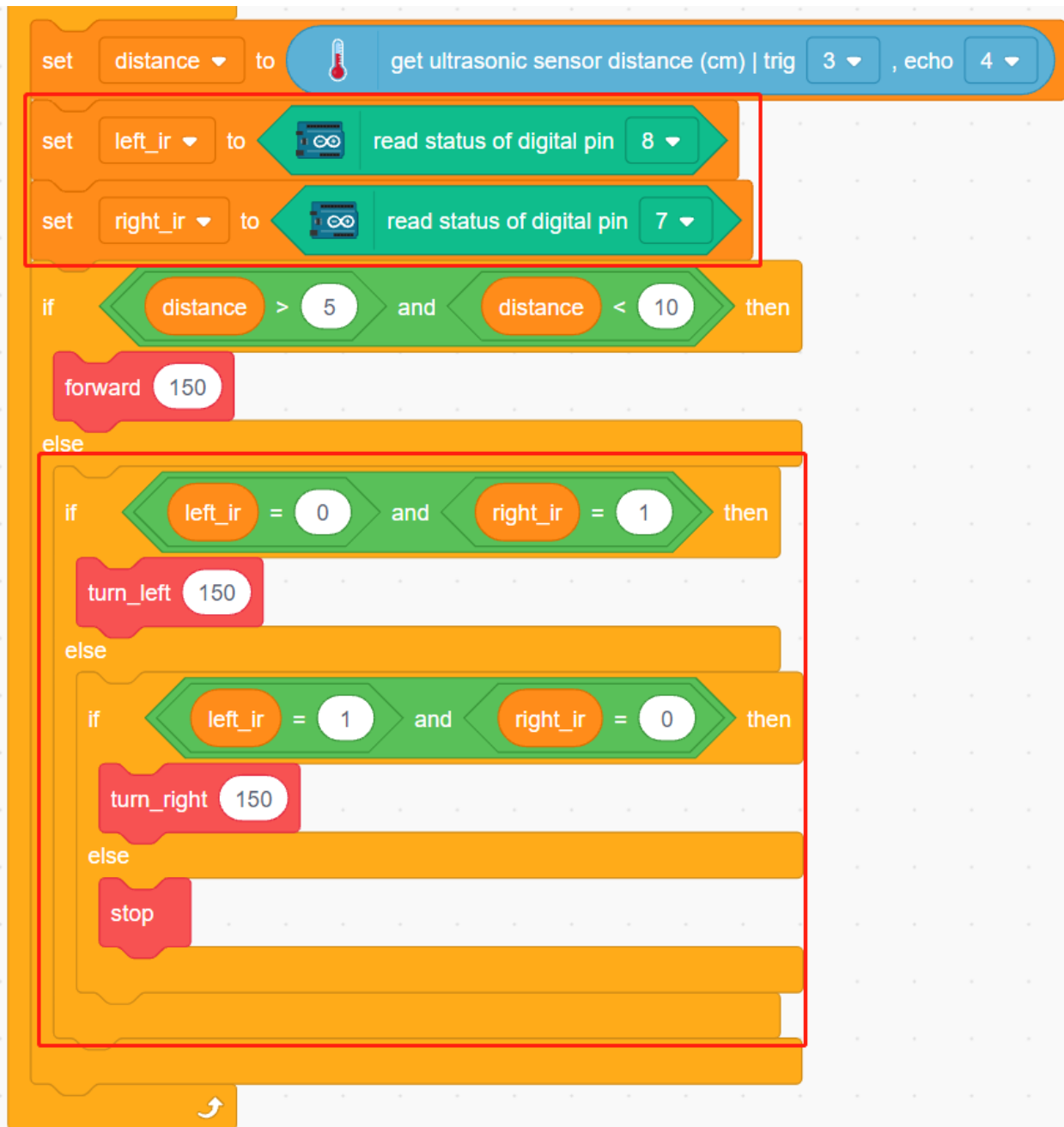
Read the ultrasonic value and if your hand is detected at a distance of 5-10cm, then let the car follow.



### 3. Follow to turn left and right

Read the values of the left and right IR modules.

- If the left IR module detects your hand, turn left.
- If the right IR module detects your hand, turn right.
- If neither IR module and ultrasonic module detect your hand, make the car stop.



## 7.32 3.7 Obstacle avoidance 2

In [3.5 Obstacle avoidance](#) project, only 2 IR obstacle avoidance modules are used for obstacle avoidance, but the detection distance of IR obstacle avoidance module is short, which may make the car too late to avoid the obstacles.

In this project, we also add ultrasonic module to do some long-distance detection, so that the car can sense obstacles at a farther distance to make a judgment.

### 7.32.1 Required Components

In this project, we need the following components.

It's definitely convenient to buy a whole kit, here's the link:

Name	ITEMS IN THIS KIT	LINK
3 in 1 Starter Kit	380+	

You can also buy them separately from the links below.

COMPONENT INTRODUCTION	PURCHASE LINK
<i>SunFounder R3 Board</i>	
<i>L298N Module</i>	
<i>TT Motor</i>	-
<i>Ultrasonic Module</i>	
<i>Obstacle Avoidance Module</i>	

### 7.32.2 Build the Circuit

Connect the ultrasonic module and the 2 IR obstacle avoidance modules at the same time.

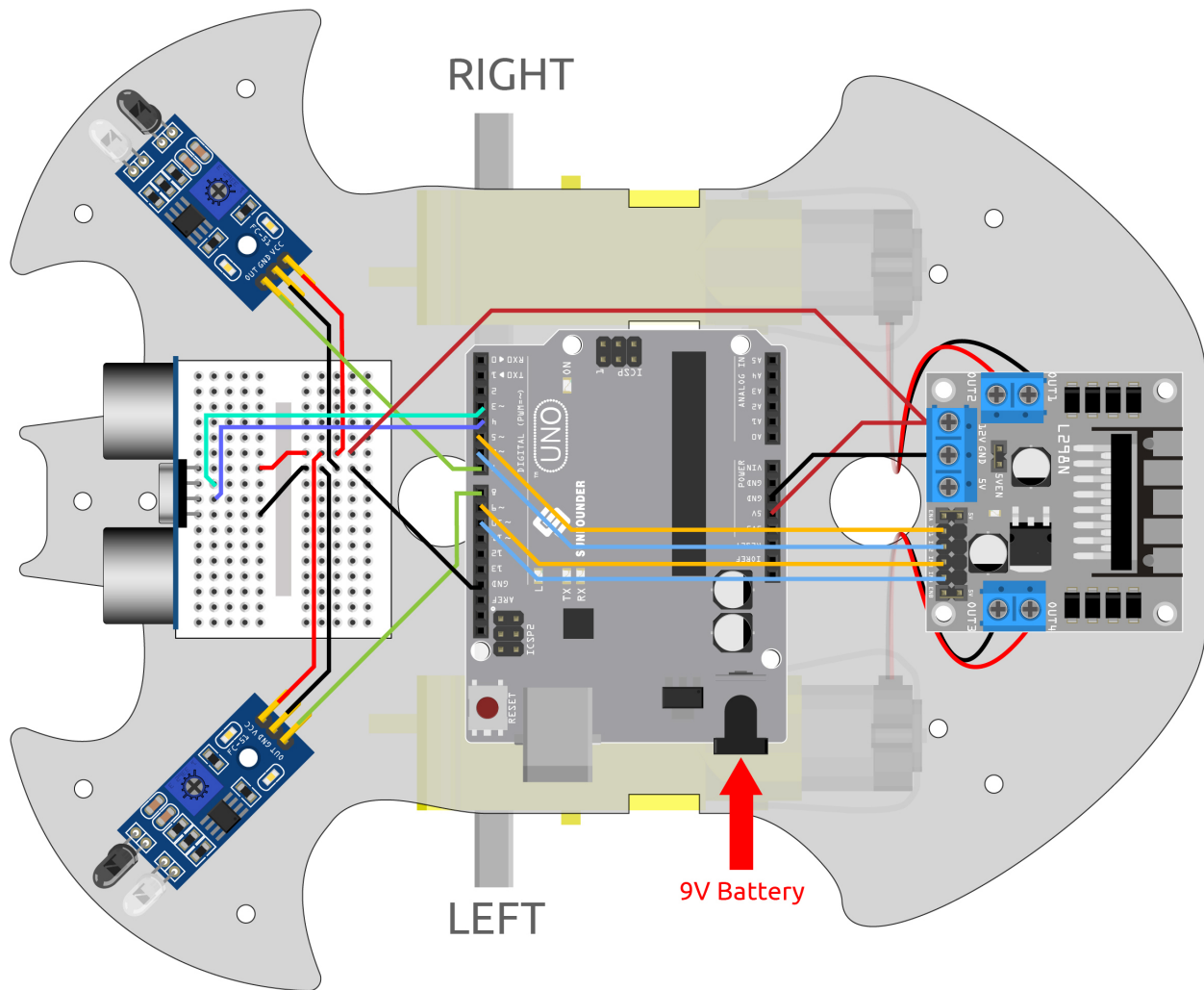
Wire the ultrasonic to the R3 board as follows.

Ultrasonic Module	R3 Board
Vcc	5V
Trig	3
Echo	4
Gnd	GND

The wiring of the 2 IR obstacle avoidance modules to the R3 board is as follows.

Left IR Module	R3 Board
OUT	8
GND	GND
VCC	5V

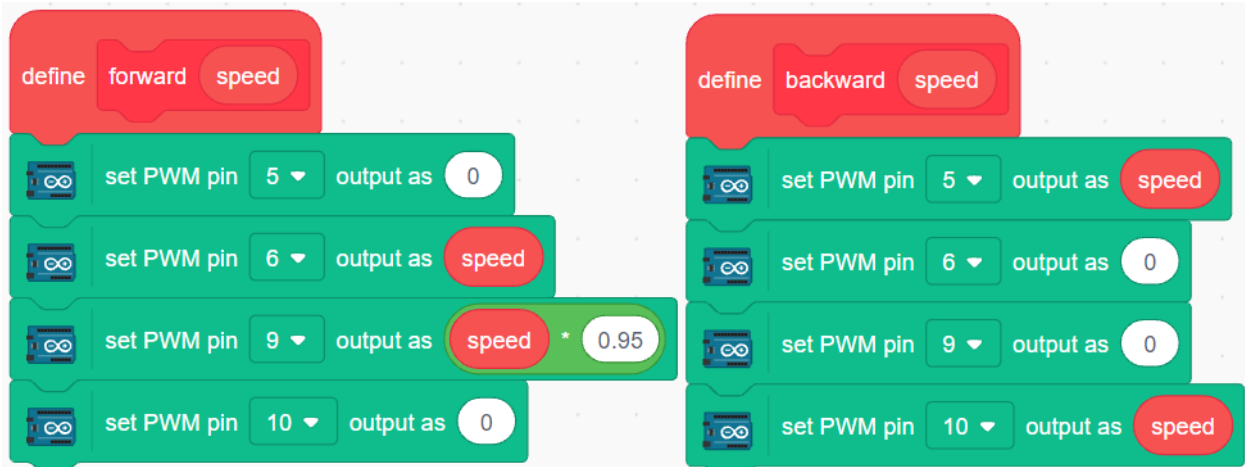
Right IR Module	R3 Board
OUT	7
GND	GND
VCC	5V



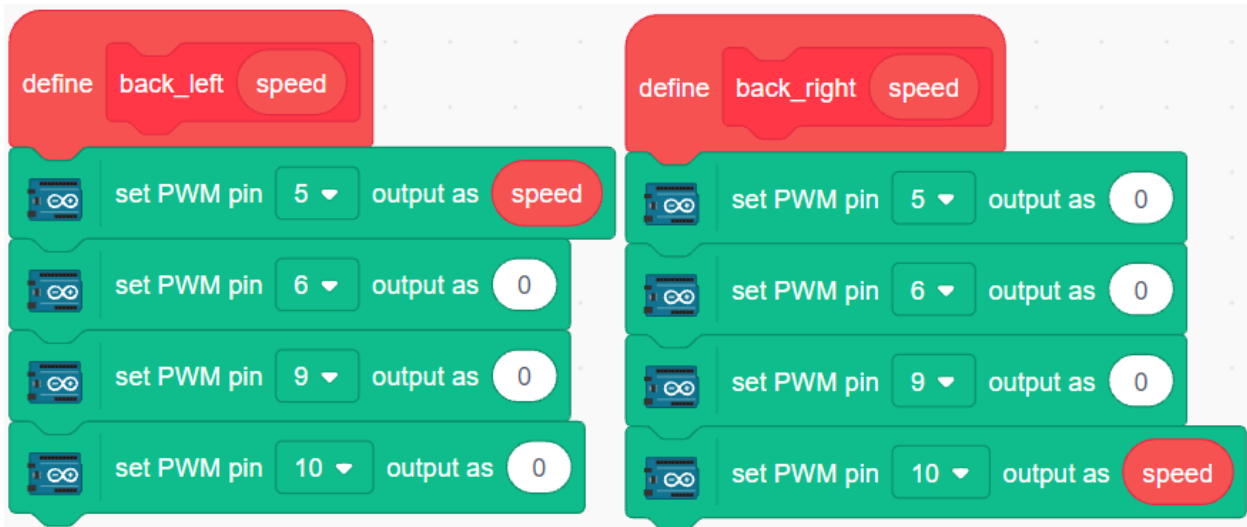
### 7.32.3 Programming

#### 1. Create function

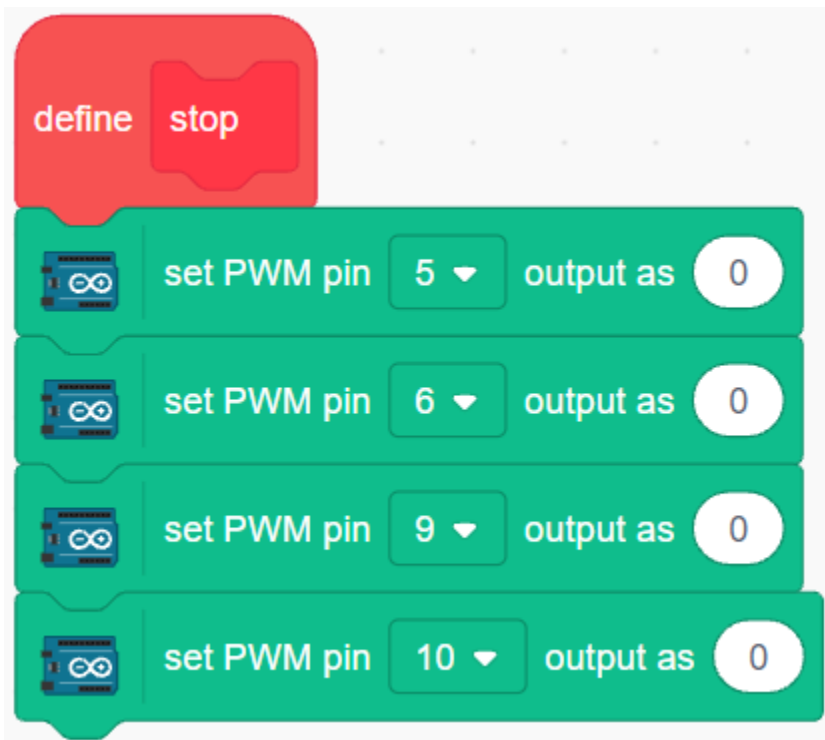
Make the car go forward and backward.



Make the car to go backward to the left and backward to the right.



Make the car stop.

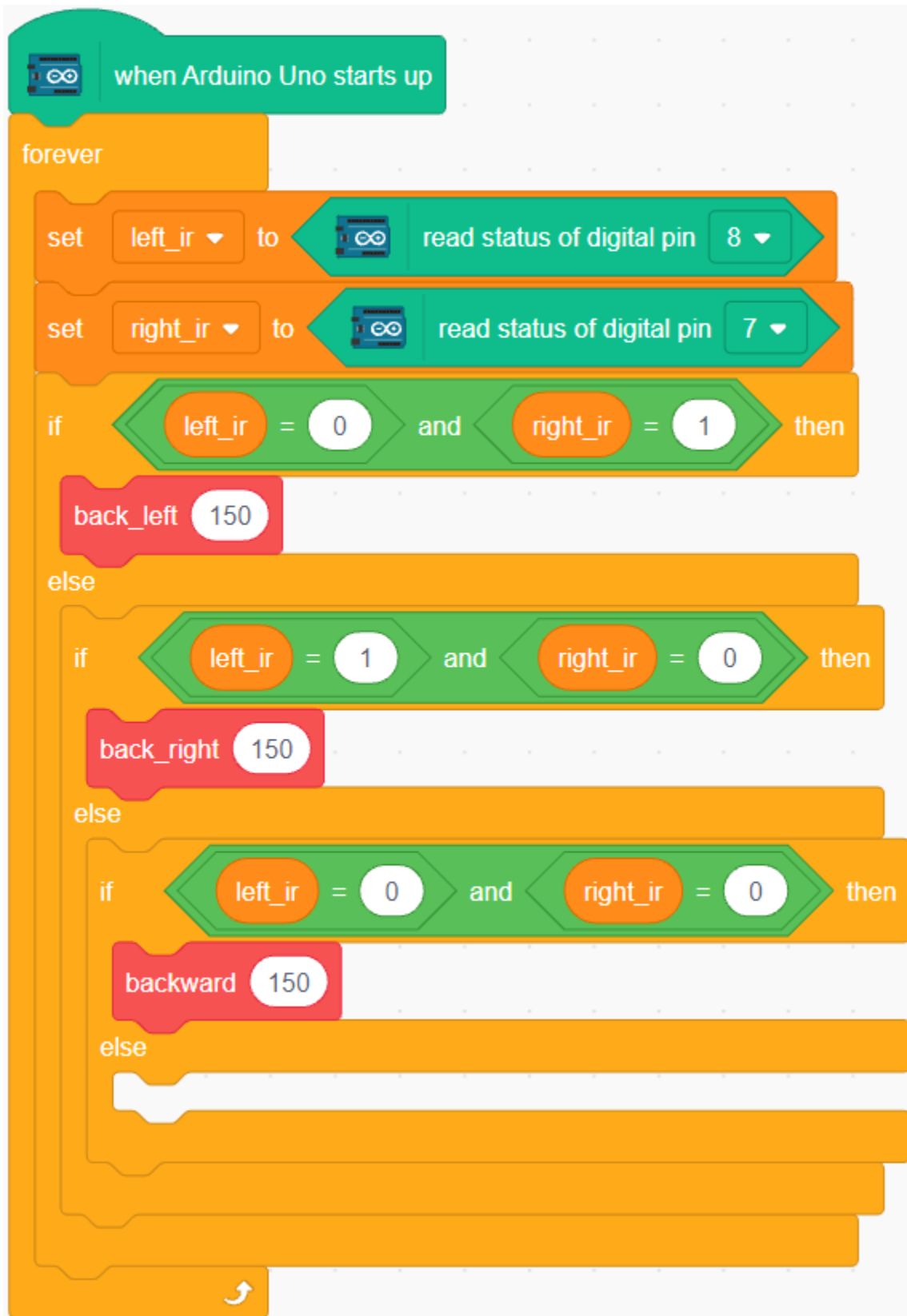


## 2. Emergency obstacle avoidance

The 2 infrared obstacle avoidance modules on the car are used for emergency obstacle avoidance, detecting obstacles at short distances, corners or relatively small obstacles.

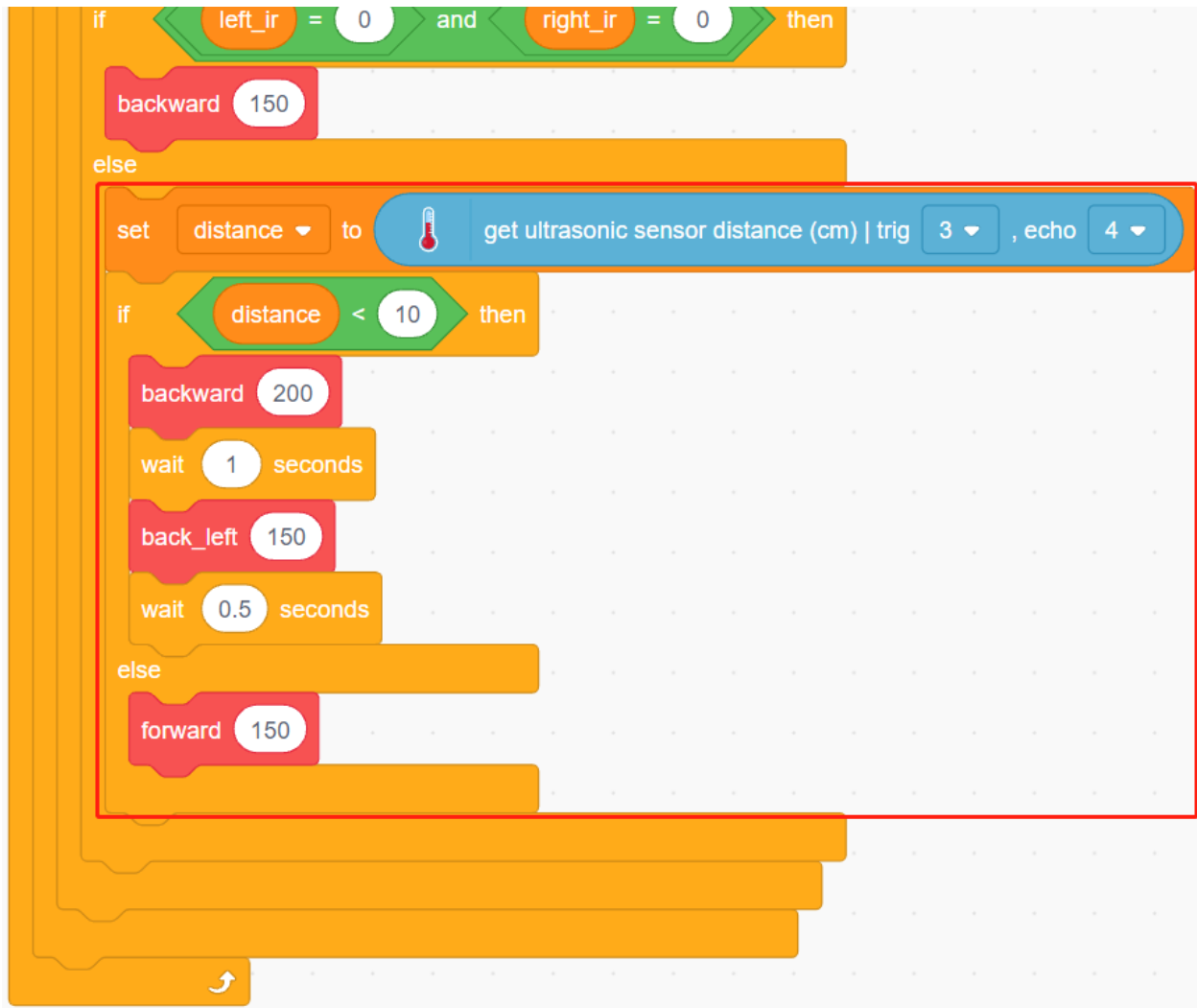
- If the left infrared module detects an obstacle, the car backs up to the left.
- If the right IR module detects an obstacle, the car recedes to the right rear.
- If 2 modules detect the obstacle at the same time, the car goes backward directly.





### 3. Long range obstacle avoidance

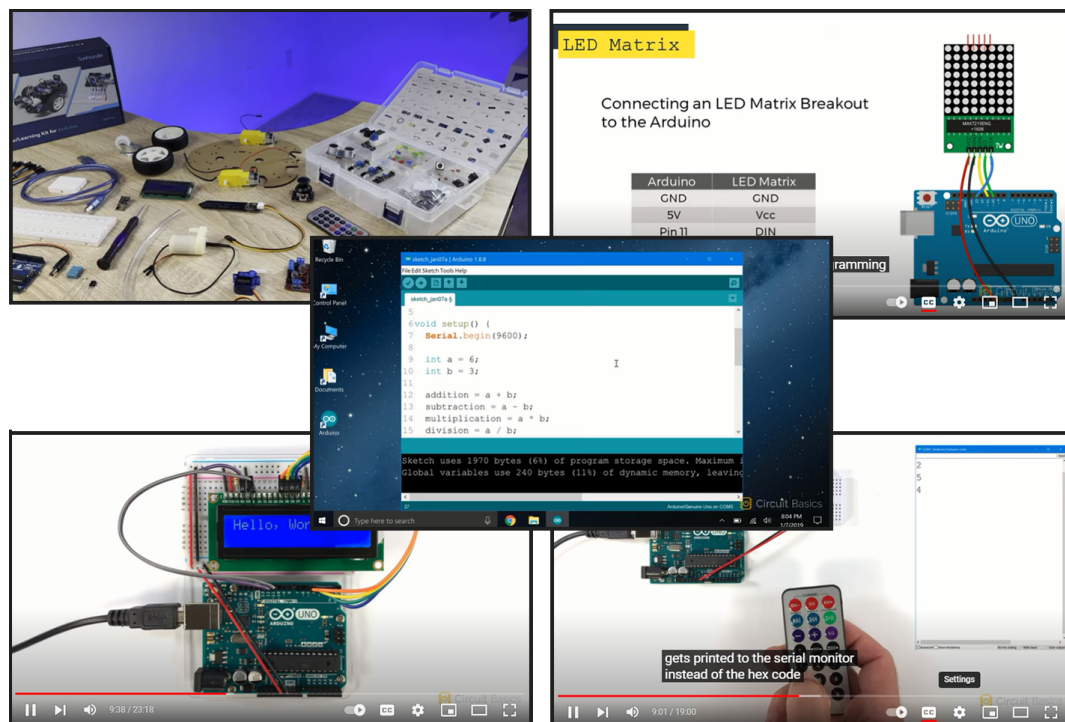
Read the value of ultrasonic module, when the detected value is less than 10, the car will go backward; otherwise it keeps going forward.



## VIDEO COURSES

- For *Basic Projects* Sections

If you find the content in the online documentation difficult to comprehend, you can enhance your learning experience by following a progressive video course. These videos will make Arduino more engaging and visually appealing for you.

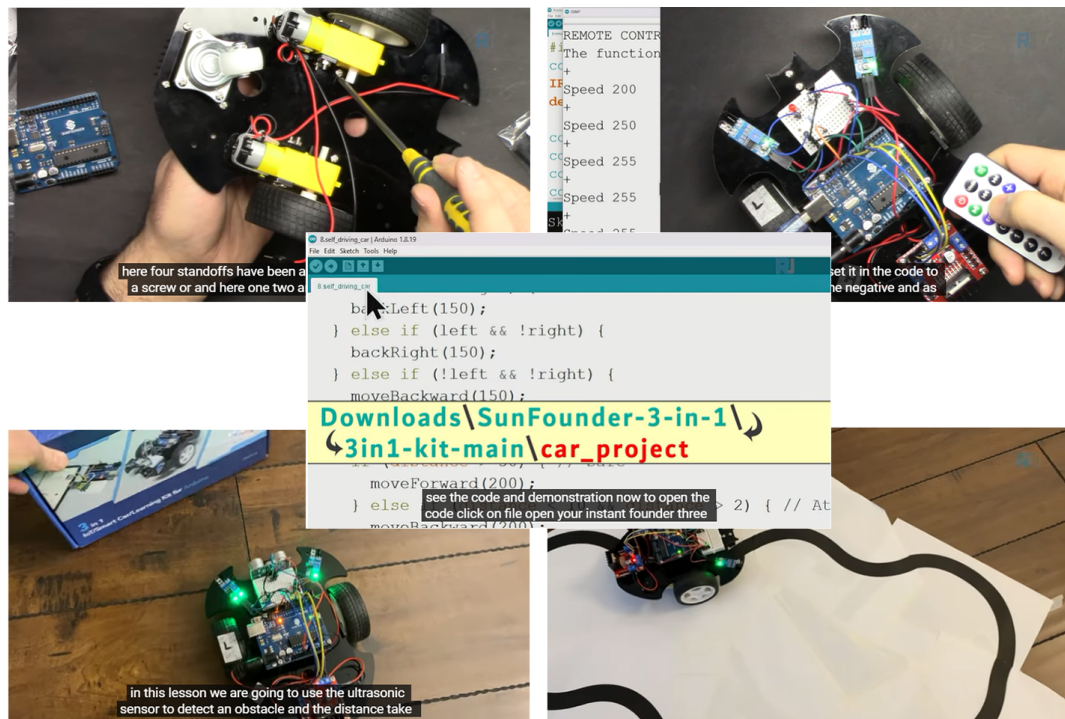


You can access the video course at: .

In these videos, you'll discover fascinating experiments and projects that present Arduino concepts and principles in a fun and interactive manner. By watching the videos and participating in hands-on activities, you'll have an exciting and enjoyable learning experience with Arduino.

- For the *Car Projects* Sections

I recommend watching the following YouTube playlists to gain more guidance and hands-on experience: .

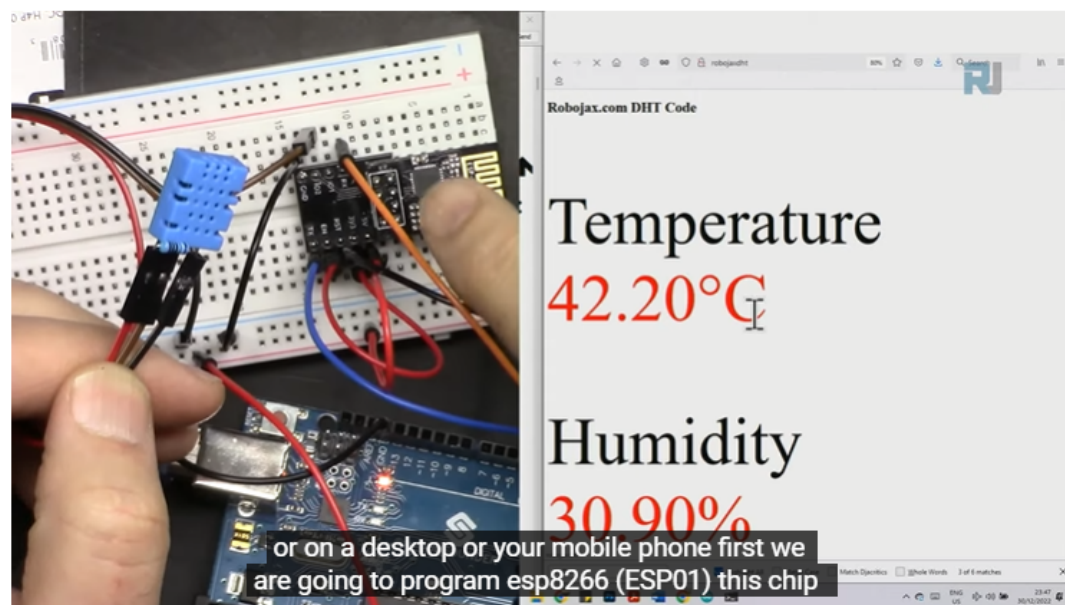


In these video, you will learn the fundamentals of robotics and Arduino through captivating video lessons. Step-by-step, you'll assemble a robot car while understanding the workings of motors, obstacle avoidance modules, line tracking modules, and infrared receivers. Explore how the car achieves various functions and unleash your creativity in the world of robotics and technology.

- About the WiFi Function

In the *IoT Projects* section of our online tutorial, you will learn how to communicate with the IoT platform Blynk.

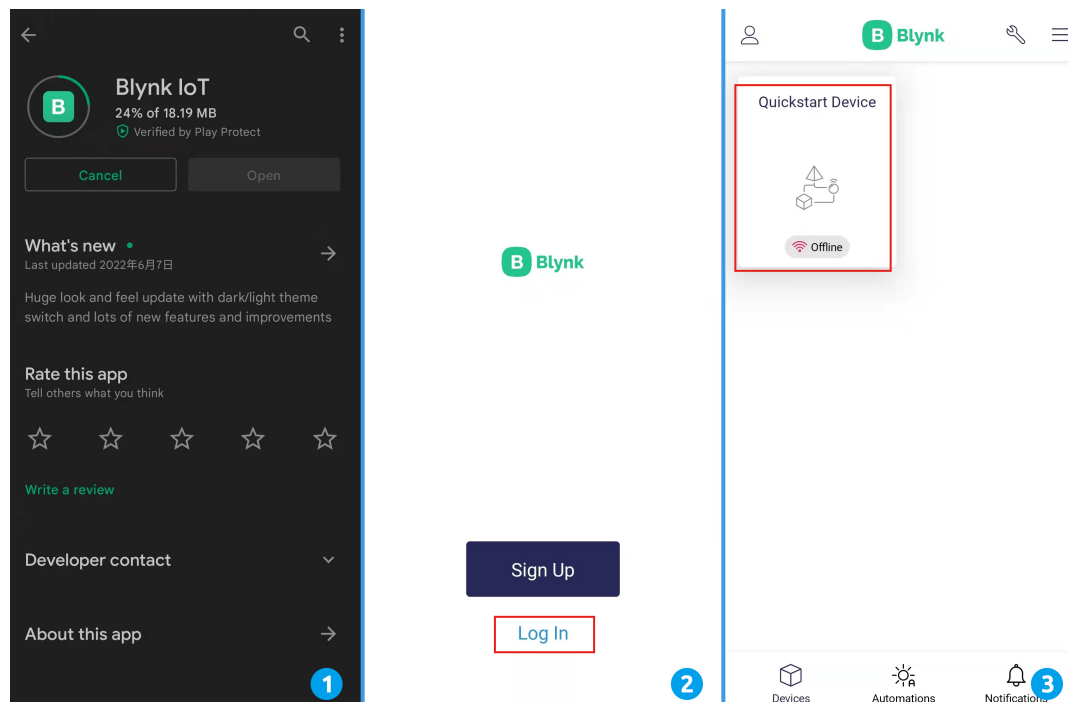
In , you will be guided on writing a web server and uploading sensor data to it. This tutorial will teach you how to establish a connection between your Arduino project and a web server using WiFi.



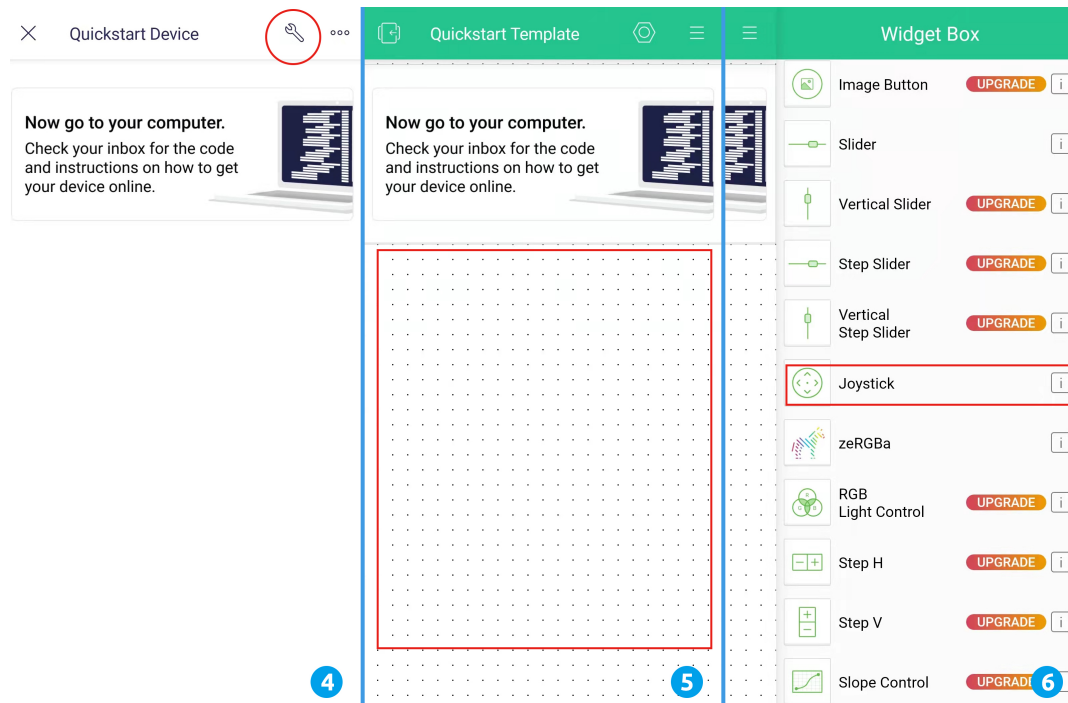
## 9.1 How to use Blynk on mobile device?

**Note:** As datastreams can only be created in Blynk on the web, you will need to reference different projects to create datastreams on the web, then follow the tutorial below to create widgets in Blynk on your mobile device.

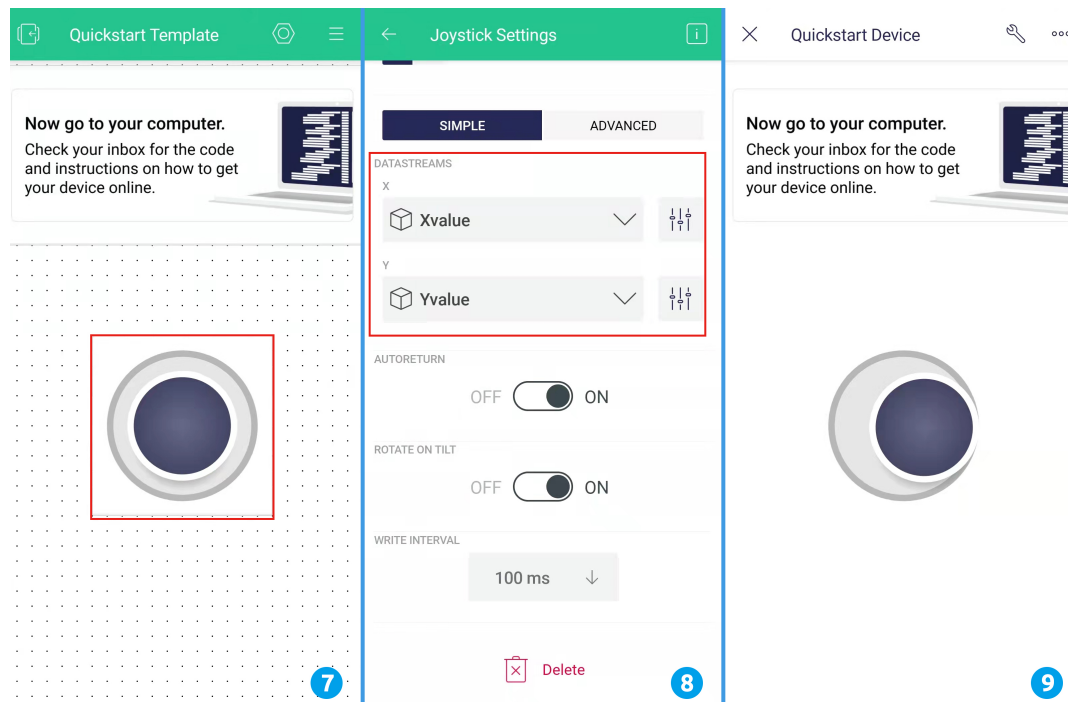
1. Open Google Play or APP Store on your mobile device and search for “Blynk IoT” (not Blynk(legacy)) to download.
2. After opening the APP, login in, this account should be the same as the account used on the web client.
3. Then go to **Dashboard** (if you don’t have one, create one) and you will see that the **Dashboard** for mobile and web are independent of each other.



4. Click **Edit** Icon.
5. Click on the blank area.
6. Choose the same widget as on the web page, such as select a **Joystick** widget.



7. Now you will see a **Joystick** widget appear in the blank area, click on it.
8. **Joystick** Settings will appear, select the **Xvalue** and **Yvalue** datastreams you just set in the web page. Note that each widget corresponds to a different datastream in each project.
9. Go back to the **Dashboard** page and you can operate the **Joystick** when you want.



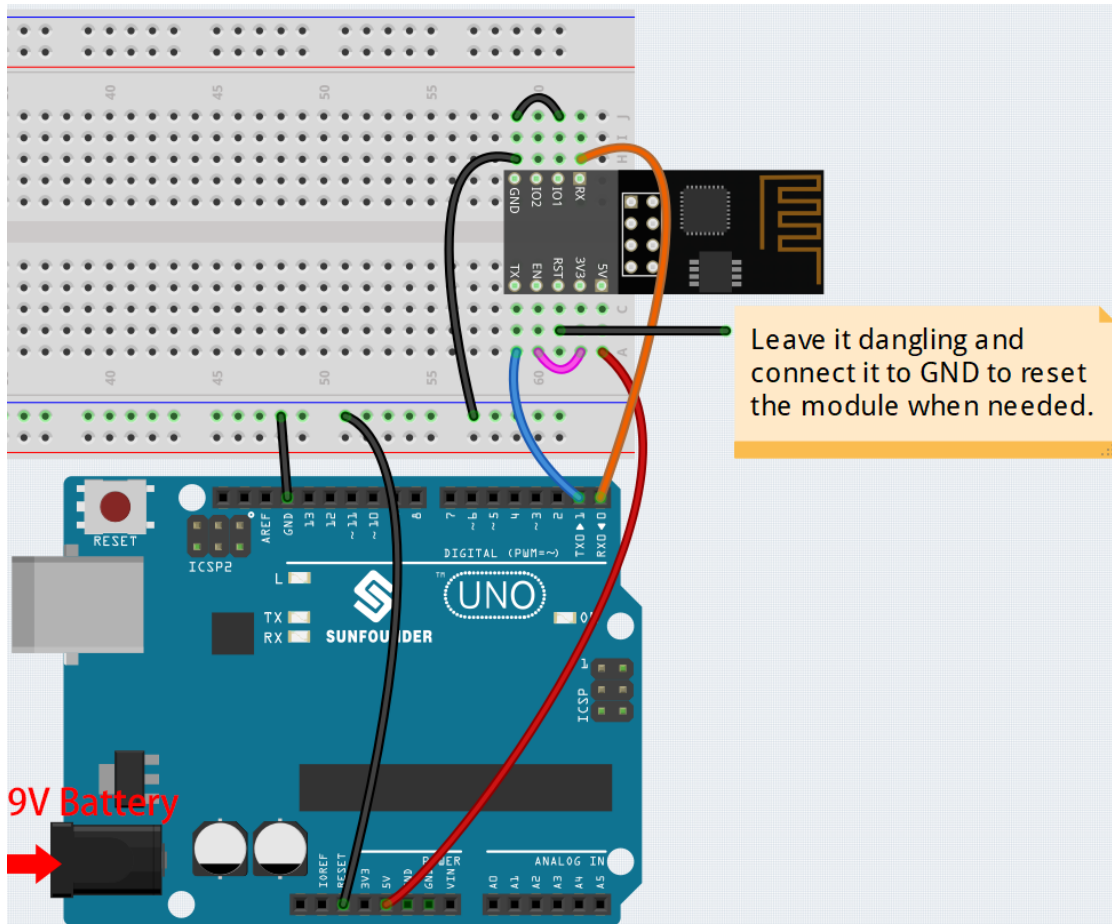


## 9.2 How to re-burn the firmware for ESP8266 module?

### 9.2.1 Re-brun the Firmware with R3

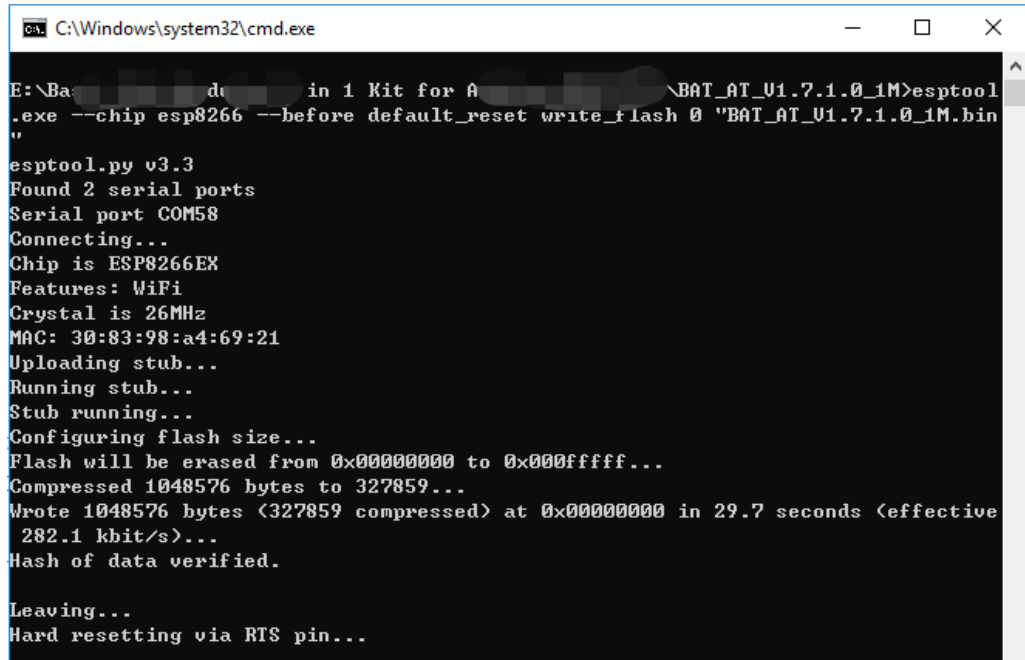
#### 1. Build the circuit

Connect ESP8266 and SunFounder R3 board.



#### 2. Burning the firmware

- Follow the steps below to burn the firmware if you are using **Windows**.
  1. Download firmware and burn-in tool.
    - ESP8266 Firmware
  2. After unzipping, you will see 4 files.
    - BAT\_AT\_V1.7.1.0\_1M.bin: The firmware to burn to the ESP8266 module.
    - esptool.exe: This is a command-line utility for Windows.
    - install\_r3.bat: This is the command package for Windows system, double click this file will run all the commands inside the file.
    - install\_r4.bat: Same as install\_r3.bat, but dedicated to UNO R4 board.
  3. Double click install\_r3.bat to start the firmware burning. If you see the following prompt, the firmware has been installed successfully.



```

C:\Windows\system32\cmd.exe

E:\Ba... in 1 Kit for A... \BAT_AT_V1.7.1.0_1M>esptool
.exe --chip esp8266 --before default_reset write_flash 0 "BAT_AT_V1.7.1.0_1M.bin"

esptool.py v3.3
Found 2 serial ports
Serial port COM58
Connecting...
Chip is ESP8266EX
Features: WiFi
Crystal is 26MHz
MAC: 30:83:98:a4:69:21
Uploading stub...
Running stub...
Stub running...
Configuring flash size...
Flash will be erased from 0x00000000 to 0x000fffff...
Compressed 1048576 bytes to 327859...
Wrote 1048576 bytes (327859 compressed) at 0x00000000 in 29.7 seconds (effective
282.1 kbit/s)...
Hash of data verified.

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

```

**Note:** If the burn-in fails, please check the following points.

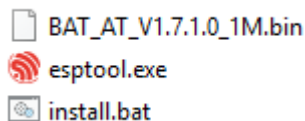
- Reset the ESP8266 module by inserting the RST on the ESP8266 Adapter to GND and then unplugging it.
- Check if the wiring is correct.
- Whether the computer has recognized your board properly, and make sure the port is not occupied.
- Reopen the install.bat file.

- To burn the firmware, follow these steps if you are using a **Mac OS** system.

1. Use the following commands to install Esptool. Esptool is a Python-based, open-source, platform-independent utility to communicate with the ROM bootloader in Espressif chips.

```
python3 -m pip install --upgrade pip
python3 -m pip install esptool
```

2. If esptool is properly installed, it will output a message such as [usage: esptool] if you run `python3 -m esptool`.
3. Download firmware.
  - ESP8266 Firmware
4. After unzipping, you will see 3 files.



BAT\_AT\_V1.7.1.0\_1M.bin  
esptool.exe  
install.bat

- BAT\_AT\_V1.7.1.0\_1M.bin: The firmware to burn to the ESP8266 module.



- esptool.exe: This is a command-line utility for Windows.
  - install\_r3.bat: This is the command package for Windows system.
  - install\_r4.bat: Same as install\_r3.bat, but dedicated to UNO R4 board.
5. Open a terminal and use the cd command to go into the firmware folder you just downloaded, then run the following command to erase the existing firmware and re-burn the new firmware.

```
python3 -m esptool --chip esp8266 --before default_reset erase_flash
python3 -m esptool --chip esp8266 --before default_reset write_flash 0
↪ "BAT_AT_V1.7.1.0_1M.bin"
```

6. If you see the following prompt, the firmware has been installed successfully.

```
MacdeMacBook-Pro:BAT_AT_V1.7.1.0_1M mac$ python3 -m esptool --chip esp8266 --before default_reset w
rite_flash 0 "BAT_AT_V1.7.1.0_1M.bin"
esptool.py v4.3
[Found 3 serial ports
Serial port /dev/cu.usbmodem143401
Connecting...
Chip is ESP8266EX
Features: WiFi
Crystal is 26MHz
MAC: 30:83:98:a4:69:21
Uploading stub...
Running stub...
Stub running...
Configuring flash size...
Flash will be erased from 0x00000000 to 0x000fffff...
Compressed 1048576 bytes to 327859...
Wrote 1048576 bytes (327859 compressed) at 0x00000000 in 29.6 seconds (effective 283.0 kbit/s)...
Hash of data verified.

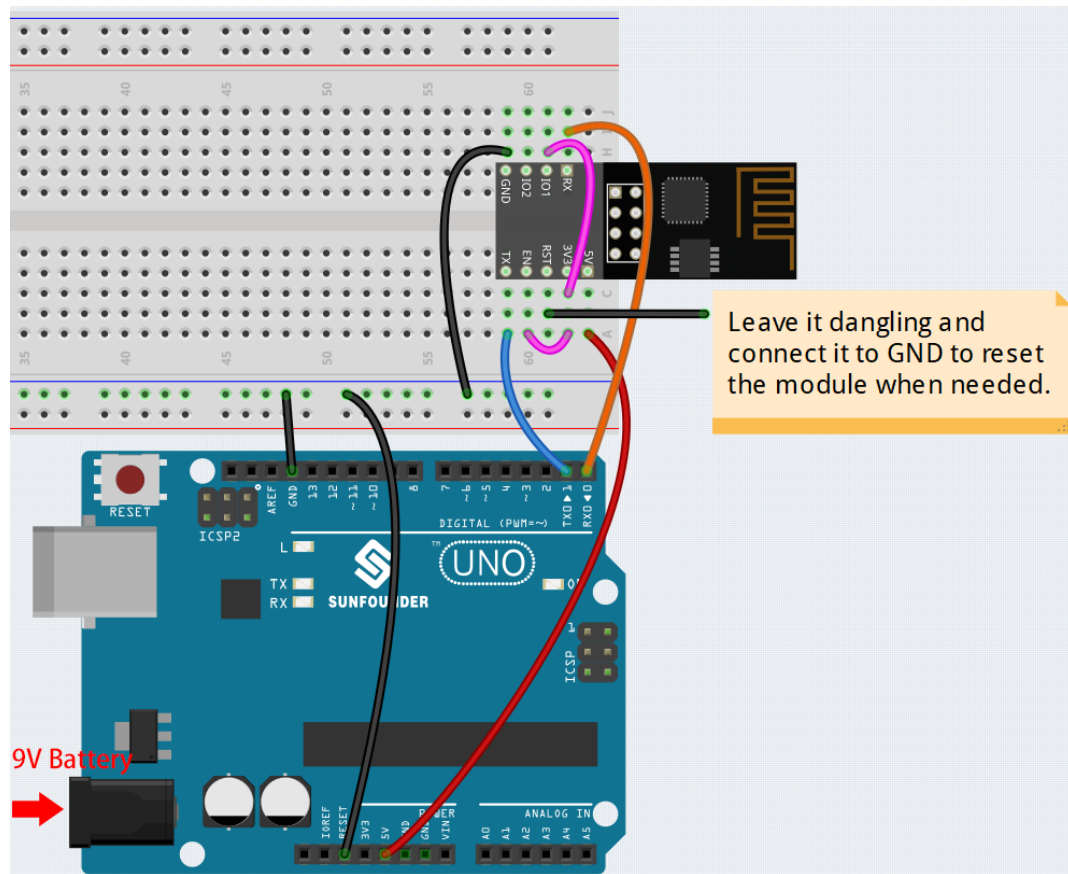
Leaving...
Hard resetting via RTS pin...
MacdeMacBook-Pro:BAT_AT_V1.7.1.0_1M mac$
```

**Note:** If the burn-in fails, please check the following points.

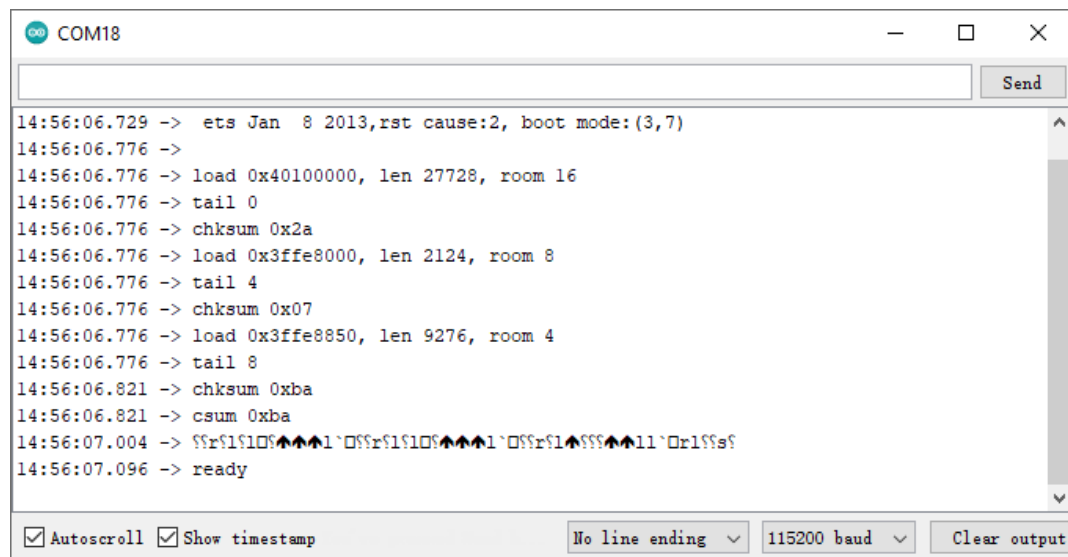
- Reset the ESP8266 module by inserting the RST on the ESP8266 Adapter to GND and then unplugging it.
- Check if the wiring is correct.
- Whether the computer has recognized your board properly, and make sure the port is not occupied.
- Reopen the install.bat file.

### 3. Test

1. On the basis of the original wiring, connect IO1 to 3V3.



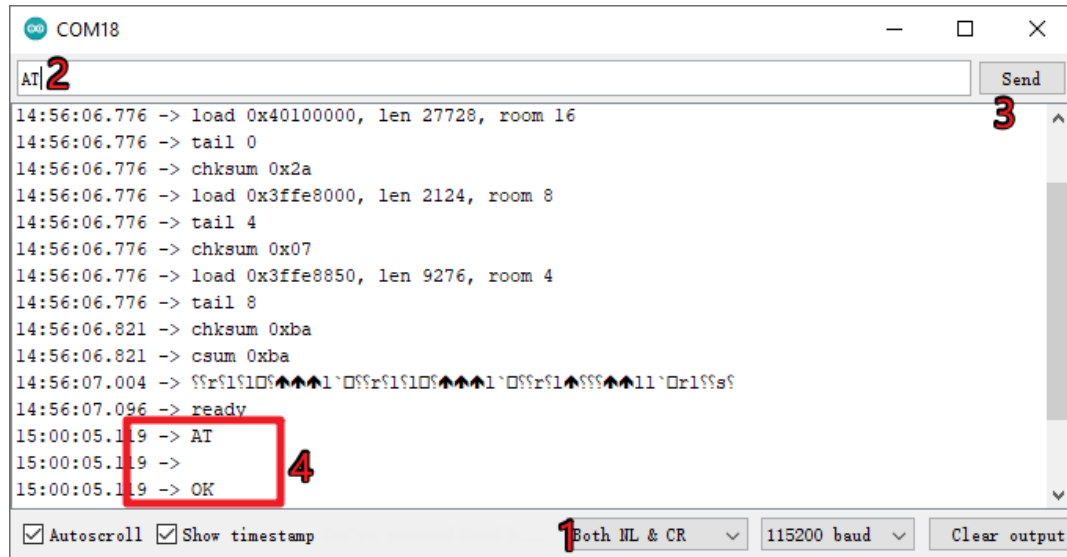
2. You will be able to see information about the ESP8266 module if you click the magnifying glass icon(Serial Monitor) in the upper right corner and set the baud rate to **115200**.



**Note:**

- If ready doesn't appear, you can try to reset the ESP8266 module(connect RST to GND) and re-open the Serial Monitor.

- Click on **NEWLINE DROPDOWN BOX**, select both NL & CR in the drop down option, enter AT, if it returns OK, it means ESP8266 has successfully established connection with R3 board.

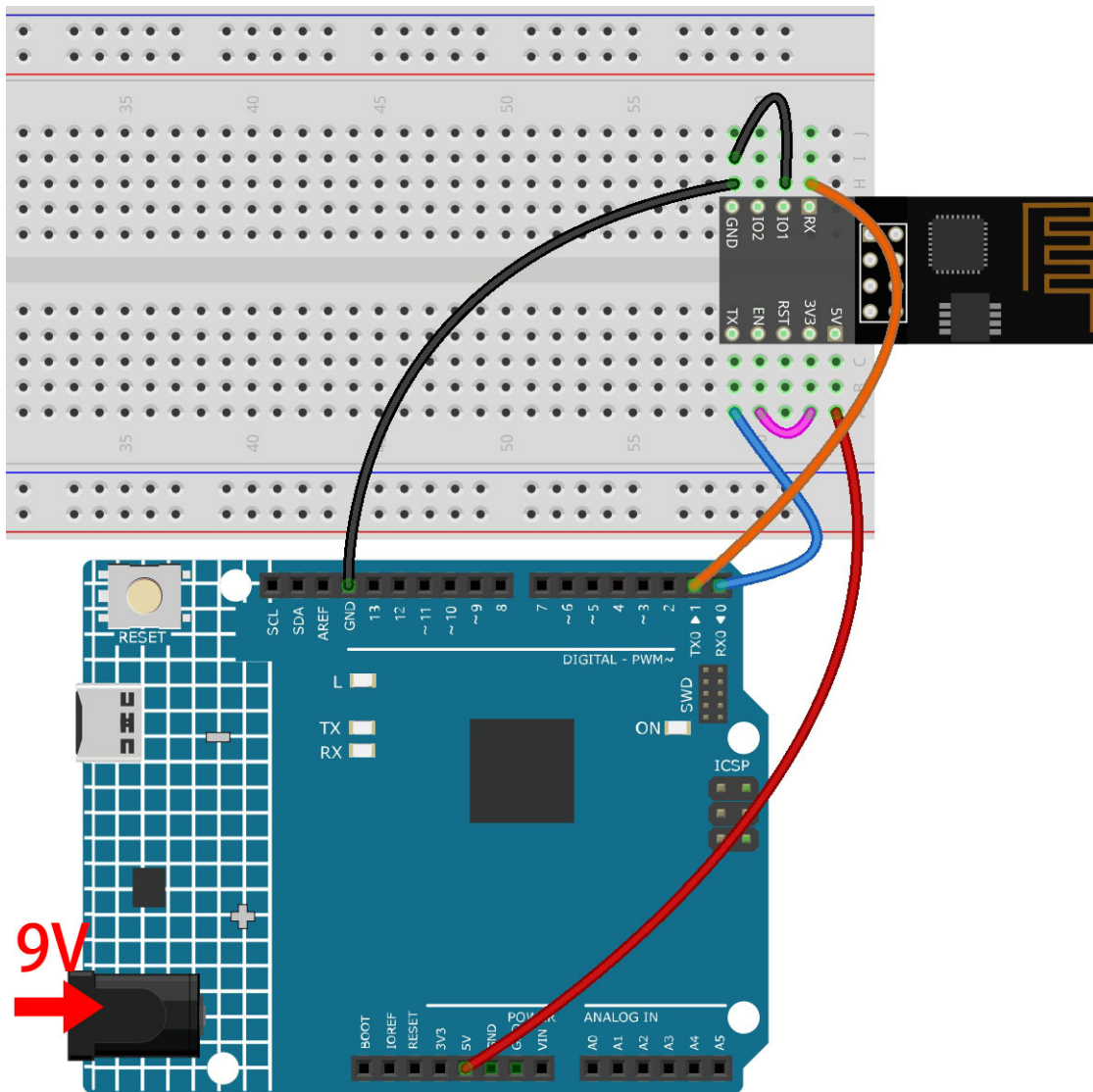


Now you can continue to follow [1.1 Configuring the ESP8266](#) to set the working mode and baud rate of the ESP8266 module.

## 9.2.2 Re-brun the Firmware with R4

### 1. Build the circuit

Connect ESP8266 and Arduino UNO R4 board.



## 2. Upload the Following Code to R4

```
void setup() {
  Serial.begin(115200);
  Serial1.begin(115200);
}

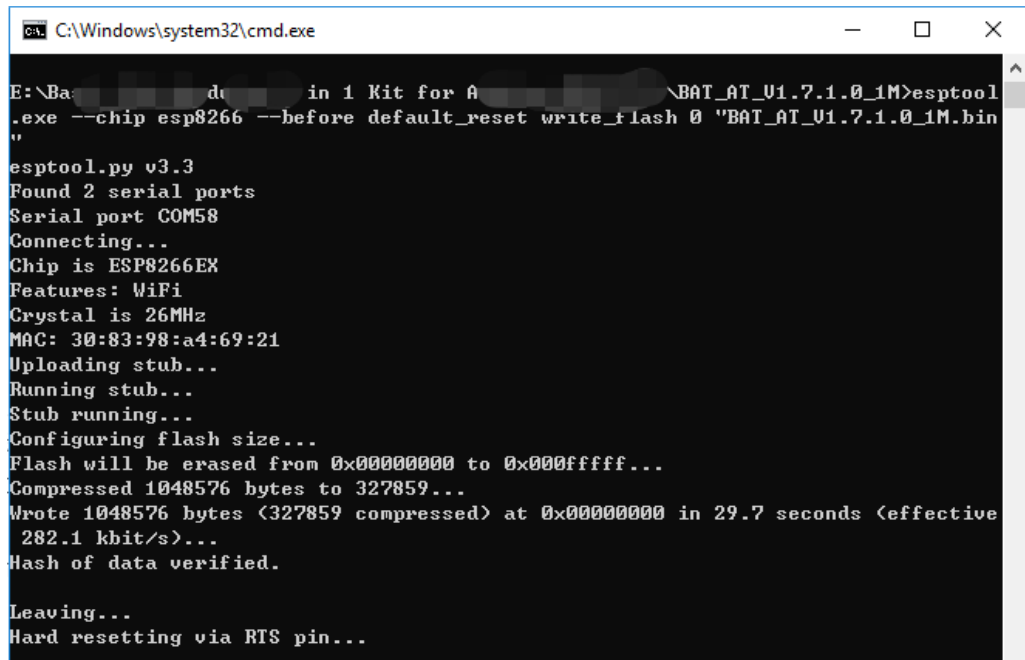
void loop() {
  if (Serial.available()) {      // If anything comes in Serial (USB),
    Serial1.write(Serial.read()); // read it and send it out Serial1 (pins 0 & 1)
  }

  if (Serial1.available()) {    // If anything comes in Serial1 (pins 0 & 1)
    Serial.write(Serial1.read()); // read it and send it out Serial (USB)
  }
}
```

## 3. Burning the firmware

- Follow the steps below to burn the firmware if you are using **Windows**.

1. Download firmware and burn-in tool.
  - ESP8266 Firmware
2. After unzipping, you will see 4 files.
  - BAT\_AT\_V1.7.1.0\_1M.bin: The firmware to burn to the ESP8266 module.
  - esptool.exe: This is a command-line utility for Windows.
  - install\_r3.bat: This is the command package for Windows system, double click this file will run all the commands inside the file.
  - install\_r4.bat: Same as install\_r3.bat, but dedicated to UNO R4 board.
3. Double click install\_r4.bat to start the firmware burning. If you see the following prompt, the firmware has been installed successfully.



```

C:\Windows\system32\cmd.exe

E:\Ba... du... in 1 Kit for A... \BAT_AT_V1.7.1.0_1M>esptool
.exe --chip esp8266 --before default_reset write_flash 0 "BAT_AT_V1.7.1.0_1M.bin
"
esptool.py v3.3
Found 2 serial ports
Serial port COM58
Connecting...
Chip is ESP8266EX
Features: WiFi
Crystal is 26MHz
MAC: 30:83:98:a4:69:21
Uploading stub...
Running stub...
Stub running...
Configuring flash size...
Flash will be erased from 0x00000000 to 0x000fffff...
Compressed 1048576 bytes to 327859...
Wrote 1048576 bytes (327859 compressed) at 0x00000000 in 29.7 seconds (effective
282.1 kbit/s)...
Hash of data verified.

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

**Note:** If the burn-in fails, please check the following points.

- Reset the ESP8266 module by inserting the RST on the ESP8266 Adapter to GND and then unplugging it.
- Check if the wiring is correct.
- Whether the computer has recognized your board properly, and make sure the port is not occupied.
- Reopen the install.bat file.

- To burn the firmware, follow these steps if you are using a **Mac OS** system.


1. Use the following commands to install Esptool. Esptool is a Python-based, open-source, platform-independent utility to communicate with the ROM bootloader in Espressif chips.

```
python3 -m pip install --upgrade pip
python3 -m pip install esptool
```

2. If esptool is properly installed, it will output a message such as [usage: esptool] if you run `python3 -m esptool`.
3. Download firmware.
  - ESP8266 Firmware
4. After unzipping, you will see 4 files.
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  - esptool.exe: This is a command-line utility for Windows.
  - install\_r3.bat: This is the command package for Windows system.
  - install\_r4.bat: Same as install\_r3.bat, but dedicated to UNO R4 board.
5. Open a terminal and use the `cd` command to go into the firmware folder you just downloaded, then run the following command to erase the existing firmware and re-burn the new firmware.

```
python3 -m esptool --chip esp8266 --before no_reset_no_sync erase_flash
python3 -m esptool --chip esp8266 --before no_reset_no_sync write_flash
↪ 0 "BAT_AT_V1.7.1.0_1M.bin"
```

6. If you see the following prompt, the firmware has been installed successfully.



```
BAT_AT_V1.7.1.0_1M — -bash — 99x22
MacdeMacBook-Pro:BAT_AT_V1.7.1.0_1M mac$ python3 -m esptool --chip esp8266 --before default_reset w
rite_flash 0 "BAT_AT_V1.7.1.0_1M.bin"
esptool.py v4.3
[Found 3 serial ports
Serial port /dev/cu.usbmodem143401
Connecting...
Chip is ESP8266EX
Features: WiFi
Crystal is 26MHz
MAC: 30:83:98:a4:69:21
Uploading stub...
Running stub...
Stub running...
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Hash of data verified.

Leaving...
Hard resetting via RTS pin...
MacdeMacBook-Pro:BAT_AT_V1.7.1.0_1M mac$
```

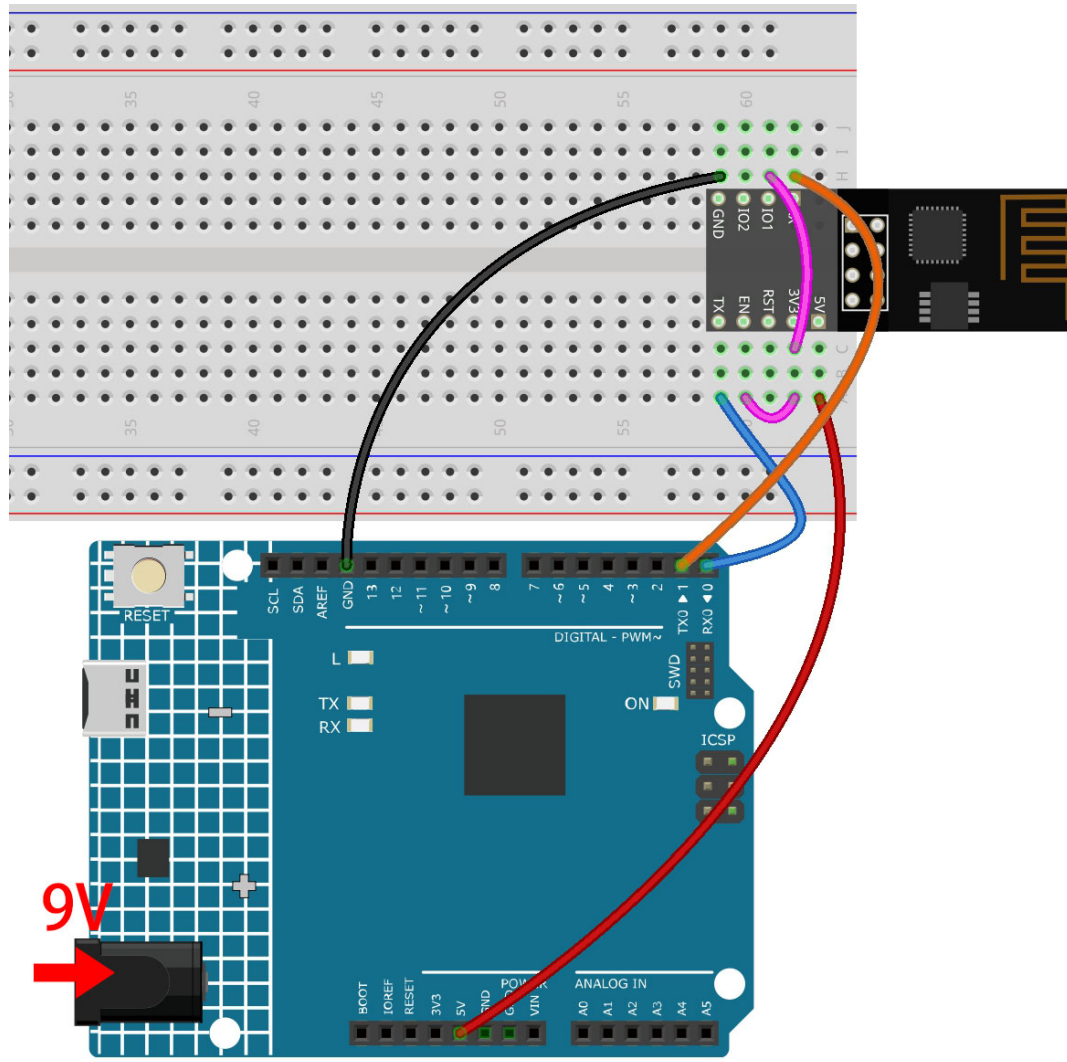
---

**Note:** If the burn-in fails, please check the following points.

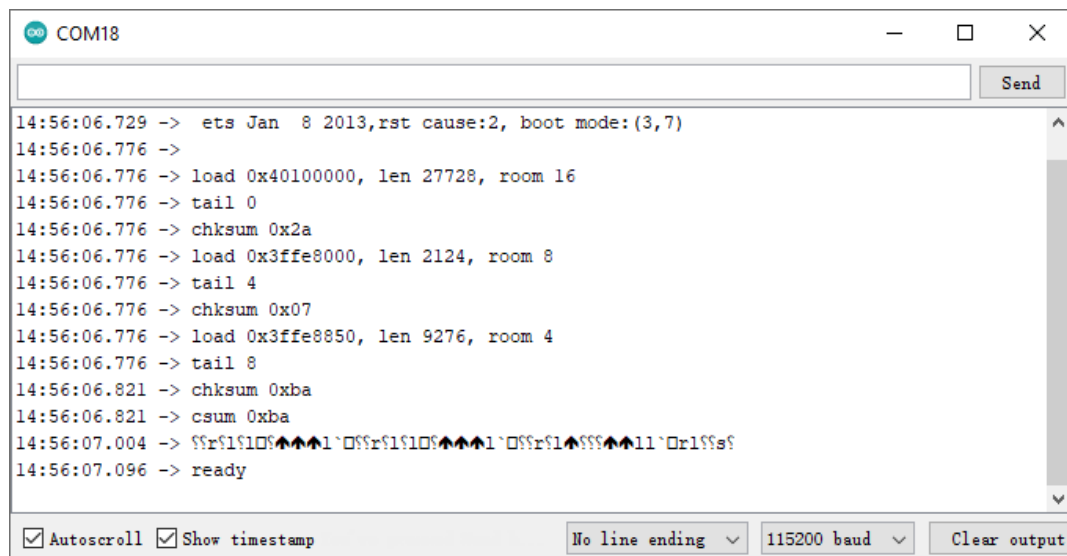
- Reset the ESP8266 module by inserting the RST on the ESP8266 Adapter to GND and then unplugging it.
  - Check if the wiring is correct.
  - Whether the computer has recognized your board properly, and make sure the port is not occupied.
  - Reopen the install.bat file.
- 

#### 4. Test

1. On the basis of the original wiring, connect IO1 to 3V3.



2. You will be able to see information about the ESP8266 module if you click the magnifying glass icon(Serial Monitor) in the upper right corner and set the baud rate to **115200**.

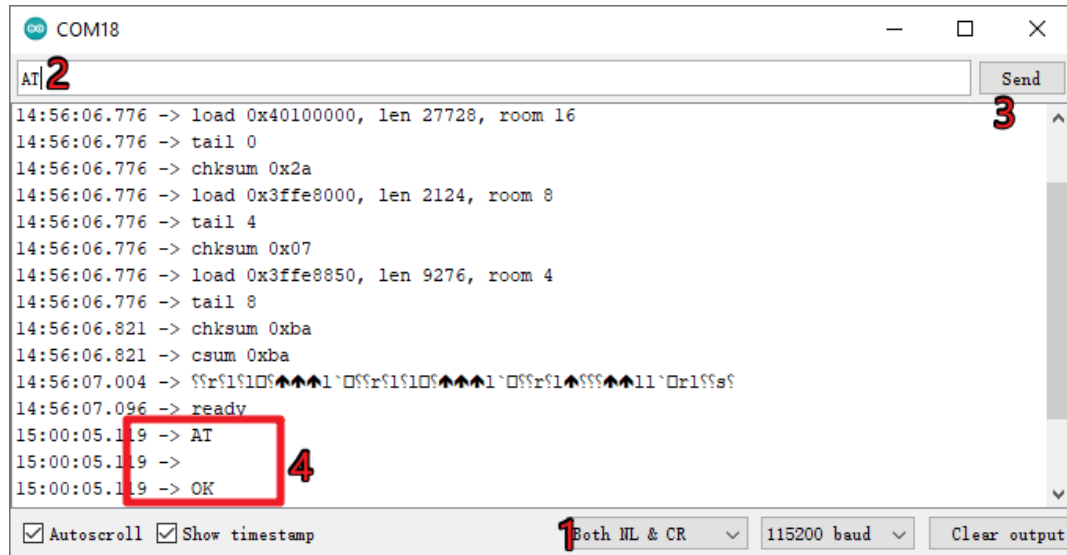




**Note:**

- If ready doesn't appear, you can try to reset the ESP8266 module(connect RST to GND) and re-open the Serial Monitor.

3. Click on **NEWLINE DROPDOWN BOX**, select both NL & CR in the drop down option, enter AT, if it returns OK, it means ESP8266 has successfully established connection with your board.



Now you can continue to follow [1.1 Configuring the ESP8266](#) to set the working mode and baud rate of the ESP8266 module.



## THANK YOU

Thanks to the evaluators who evaluated our products, the veterans who provided suggestions for the tutorial, and the users who have been following and supporting us. Your valuable suggestions to us are our motivation to provide better products!

### Particular Thanks

- Len Davisson
- Kalen Daniel
- Juan Delacosta

Now, could you spare a little time to fill out this questionnaire?

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**Note:** After submitting the questionnaire, please go back to the top to view the results.

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