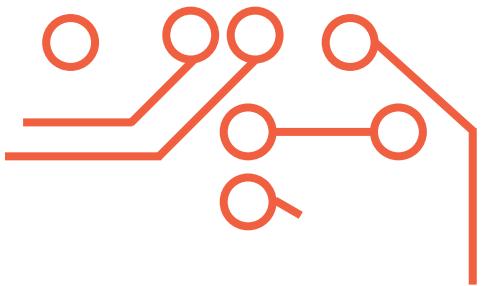


STAGE ONE EDUCATION

Hands-on Engineering Workshops

ROBOTICS WORKSHOP

ELECTRONICS & CODING

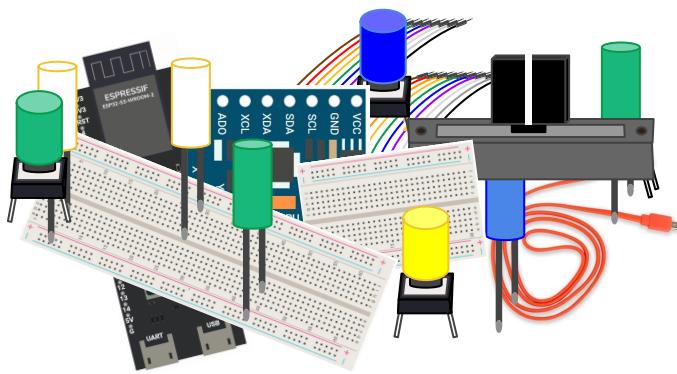


with
ARDUINO
&
ESP32

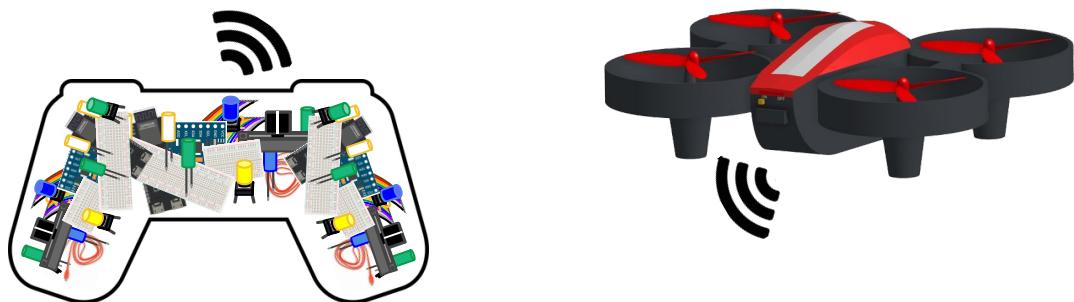


Background

Get ready to build a controller using simple electrical components!



You'll use this controller to send signals to your drone, allowing you to control its flight both manually and autonomously.



Along the way we will build, program, and optimize our circuit and drones flight.

Parts that we'll use today

On your desk



Laptop

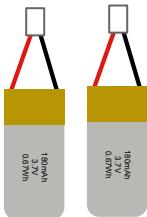
Open your laptop and connect to power



Instructions



Safety Glasses



Drone Batteries

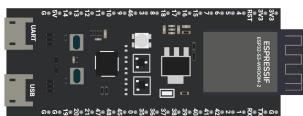


Electronics Box

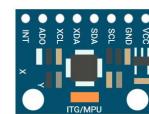
Check that you have all the parts we will use today



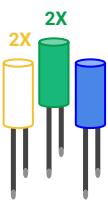
Drone



ESP32 Development Board



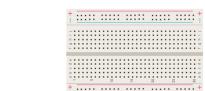
GY-521 Accelerometer



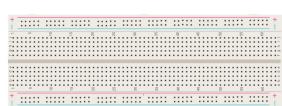
LED's



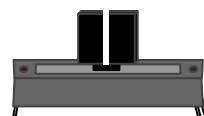
Wires



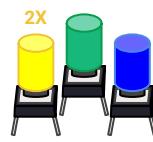
Small Breadboard



Large Breadboard



Slider Variable Resistors



Buttons



Drone Battery Charging Cable



USB to Micro USB

Start-Up



SAFETY GLASSES REQUIRED



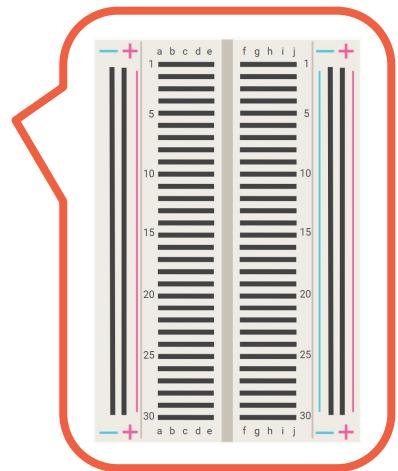
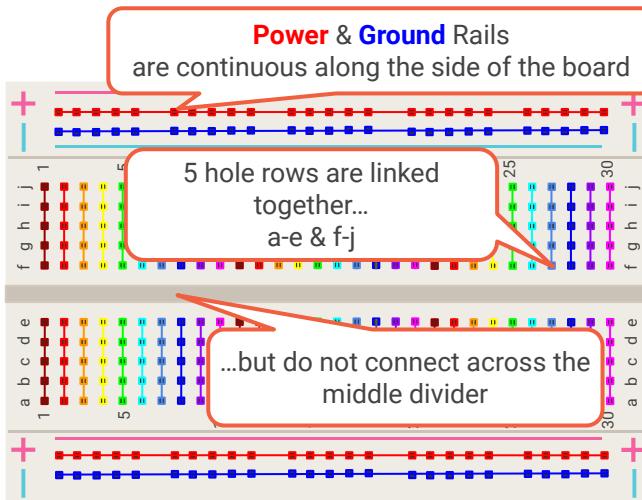
Put on your safety glasses

BREADBOARDS

NEVER twist wires



ALWAYS connect wires using the breadboard!



GOOD TO KNOW

Ohm's Law

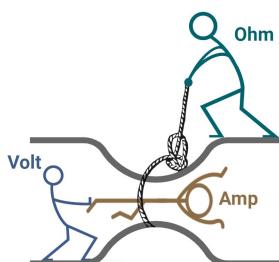
Voltage = Current × Resistance

Current (Amperage)

measure the flow of electrical current in a circuit. It indicates how many electrons are passing a point in the circuit per second.

Voltage

the electrical potential difference between two points in a circuit. It is measured in volts (V)



Resistance (Ω)

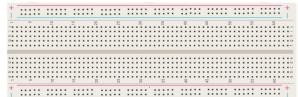
measures how much a component resists the flow of current. It's measured in ohms (Ω)

STAGE ONE EDUCATION

Hands-on Engineering Workshops

Drone Control Board Assembly

Parts we need



Large Breadboard



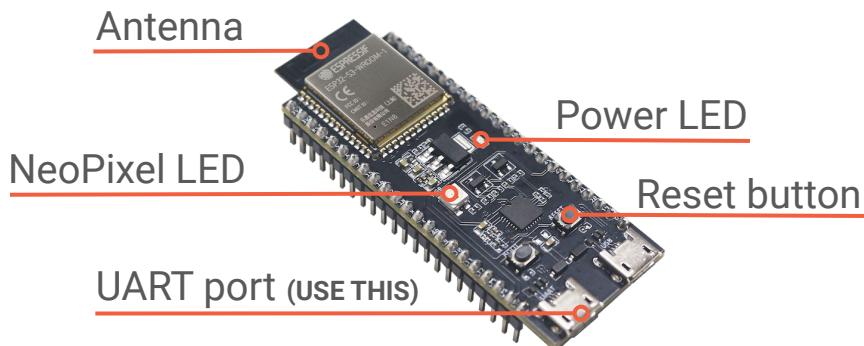
ESP32



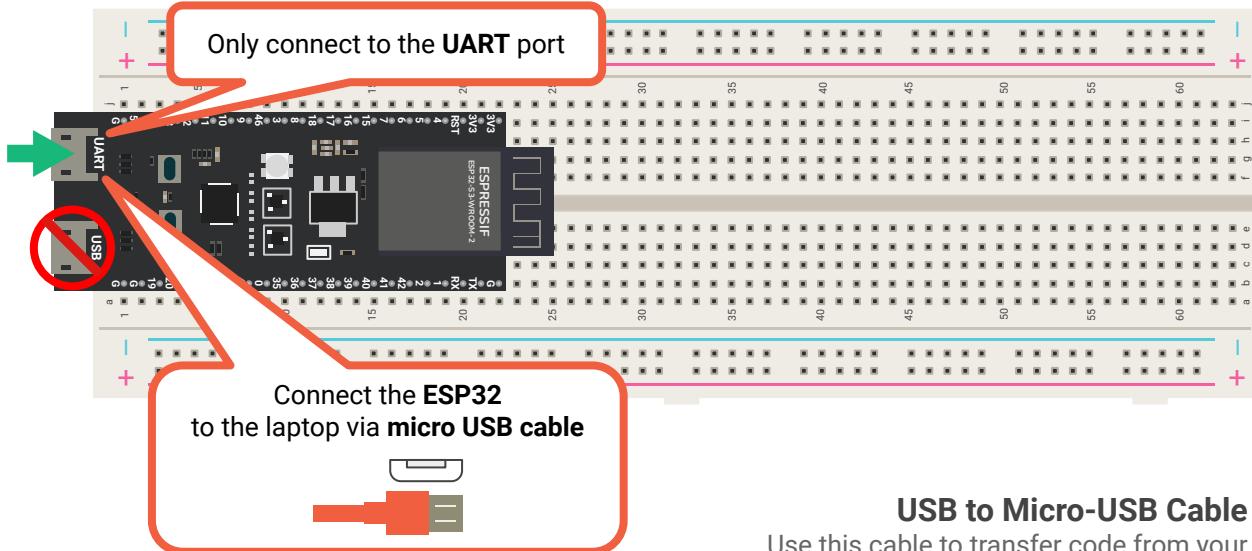
USB to Micro-USB

ESP32-S3-WROOM Development Module

This component is like a small computer that lets devices communicate. We'll use it to link to our drone's WiFi and create a controller to pilot the drone!

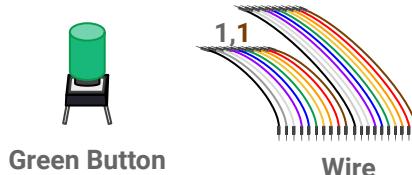


The **ESP32** will be installed on the **breadboard**



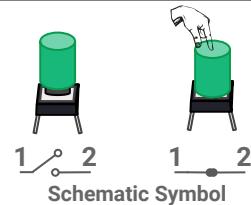
Takeoff Button Assembly

Parts we need

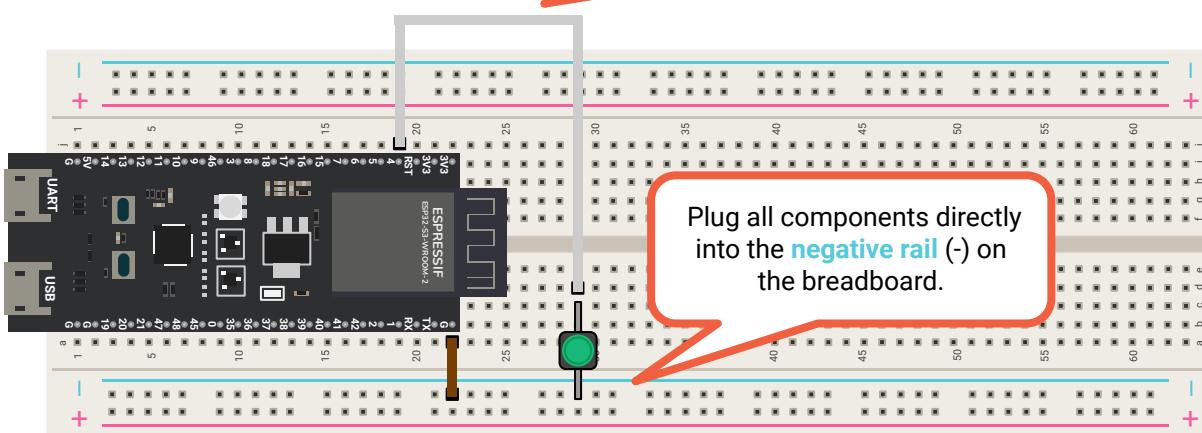


Two-Pin Button

- When the button is pressed, pins 1 and 2 connect
- Pressing the button can cause a bouncy connection, sending multiple signals.
- Two-pin buttons are used as on/off switches and triggers in various projects.



Let's use a **White** wire to link **pin 4** of the ESP32 to the **Green** button.



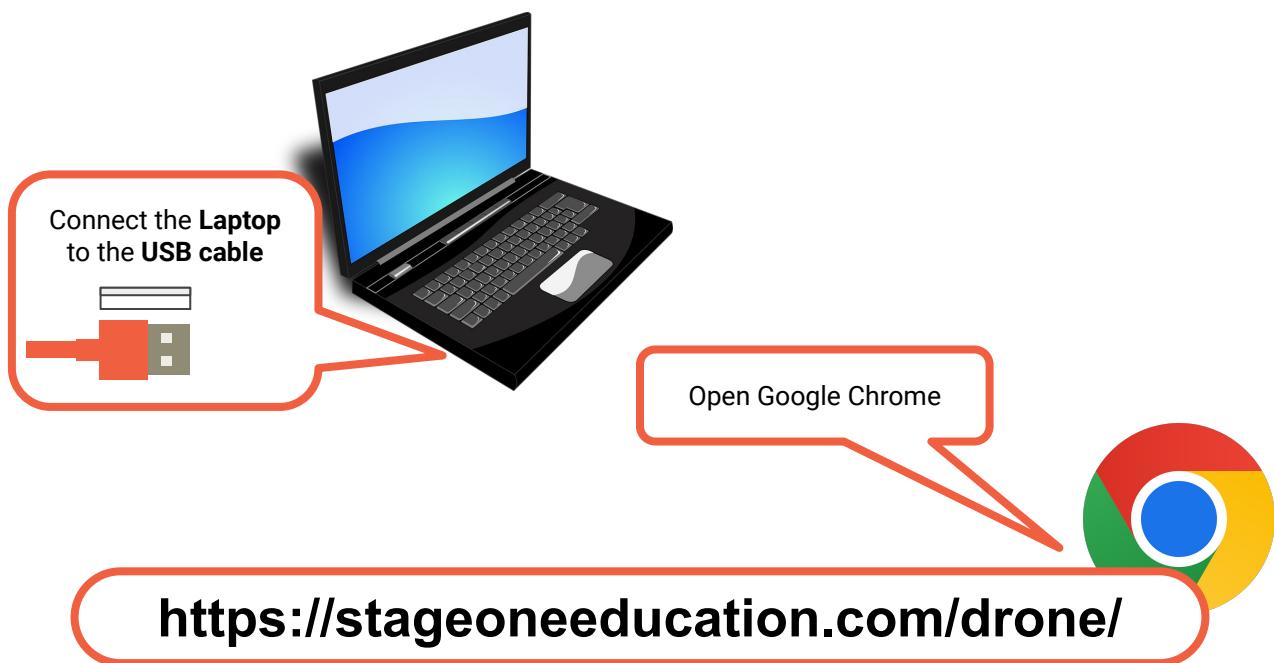
Connect the **ESP32** to ground by using a **Brown** wire to link **pinG** to the **negative rail** (-) on the breadboard.

Grounding

- Prevents shocks and protects components by safely redirecting excess electricity.
- Ensures correct voltage levels by providing a common reference point.
- Reduces noise and interference for accurate readings and stable operation.



Connect to Serial



Drone Workshop | Stage One Education

The screenshot shows the Drone Workshop interface with the following elements:

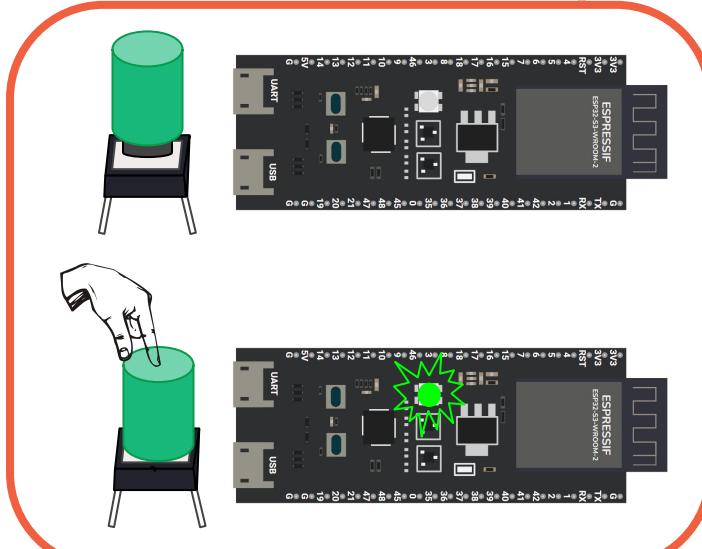
- A blue button labeled "Connect to Serial" is highlighted with a red box and a callout "Select Connect to Serial".
- An "Upload" button is located next to the "Connect to Serial" button.
- A vertical list of line numbers from 1 to 24 is on the left side.
- A modal window titled "StageOneEducation.com wants to connect to a serial port" lists "USB to UART Bridge Controller (COM#) - Paired" and includes "Connect" and "Cancel" buttons.
- A red box highlights the "Select COM Port #" step in the modal, with a callout "Select Connect".
- A red box highlights the "Select" step in the main interface, with a callout "Select Connect".

Upload

Drone Workshop | Stage One Education

Connected  **Upload**

1
2
3
Select
4 Upload to send the software to the ESP32
5
6
7
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41



Serial Monitor:

Autoscroll

Green button pressed
Green button released
Green button pressed
Green button released
Green button pressed
Green button released
Green button pressed
Green button released

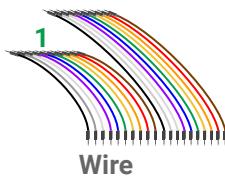
Observe the Serial Monitor when the green button is pressed

Serial Monitor

works like a chat window that lets you see messages between your computer and the ESP32, helping you understand and control what's happening inside your project.

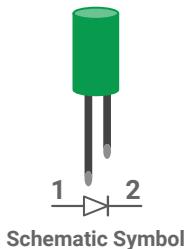
Takeoff LED

Parts we need

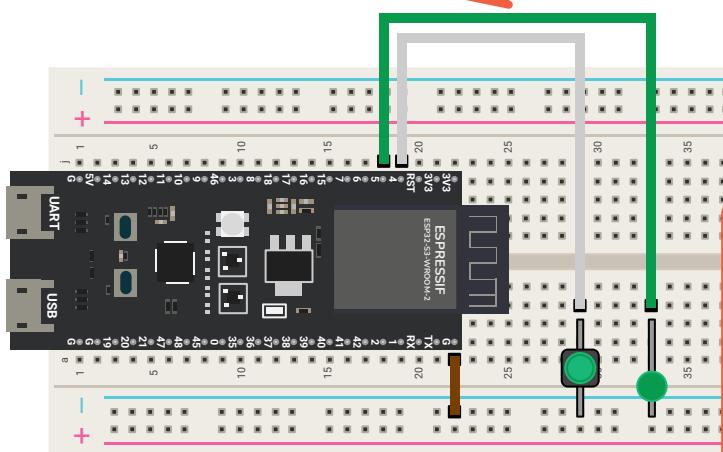


Light Emitting Diode - LED

- Short leg = Negative (cathode)
- Long leg = Positive (anode)
- LEDs require different voltages
 - Green, White, Blue: 2.8 - 3.6 volts
 - Red, Yellow: 1.8 - 2.3 volts
- The color of an LED depends on the materials it is made from.
 - EX: Green LEDs use indium gallium nitride (InGaN).

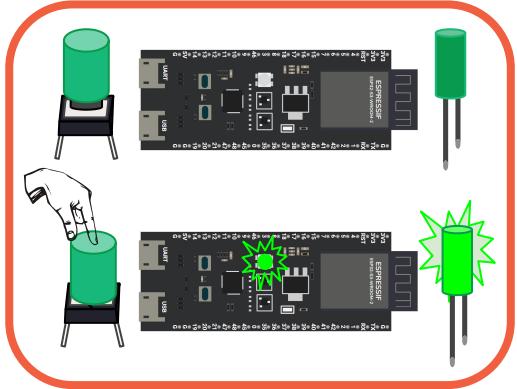
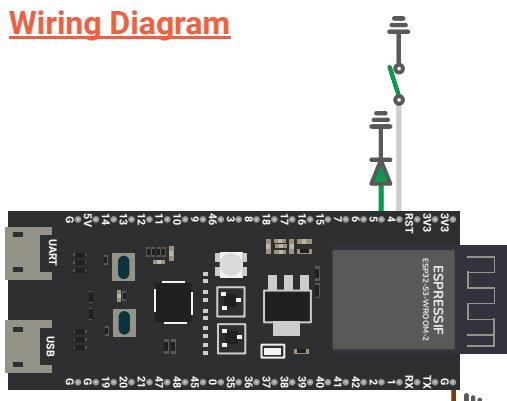


Let's use a **Green** wire to link **pin 5** of the ESP32 to the **Green** LED.



LED
short leg
connects to GND

Wiring Diagram



Common Ground

The three ground symbols are the same connection

LED Software Control

Pulse Width Modulation - PWM

- PWM turns the light on and off so quickly that our eyes can't see the flickering.
- By adjusting the on/off time, PWM can make the light appear dimmer or brighter.
- Because the light is off part of the time, PWM reduces power consumption and saves energy while maintaining the desired brightness.



Drone Workshop | Stage One Education

Connected

Upload

```
359 void setLed(int pin_num, bool on_off) {  
360     int duty = 0;  
361     if (on_off) {  
362         duty = 400;  
363     }
```

Change the LEDs duty cycle
Set the LED to your preferred brightness
Try values: 400 or 4000

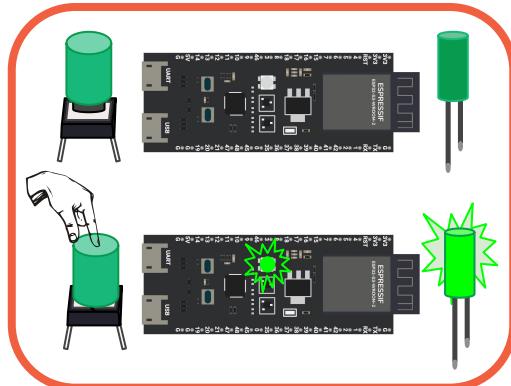
Upload

Upload the code
After every software change
you will need to reupload

Serial Monitor:

Autoscroll

```
Green button pressed  
Green button released  
Green button pressed  
Green button released  
Green button pressed  
Green button released  
Green button pressed  
Green button released
```



STAGE ONE EDUCATION

Hands-on Engineering Workshops

Cleared For Takeoff

Parts we need



Drone



Battery



Safety Glasses



SAFETY GLASSES REQUIRED



Installing the Battery

1. Power OFF the drone
2. Open the battery compartment door
3. Insert the battery, silver side first
4. Connect the slotted battery plug
5. Close the battery compartment door



Power OFF
the Drone



Airspace

Stay in your airspace

Your designated airspace extends from your table to the light pole.

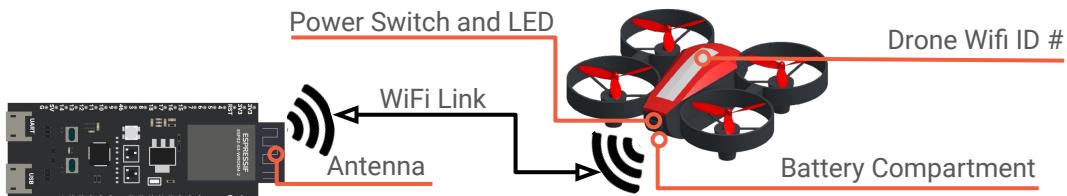


Airspace

Drone Sync

Wireless Fidelity (WiFi) Drone

- The drone has a WiFi transmitter that creates a local network for the ESP32 to connect to.
- The ESP32 will send signals via WiFi to adjust propeller speeds controlling the drone.
- Powered by a LiPo battery, which offers high energy density for long flight times.



Drone Workshop | Stage One Education

Connected Upload

2 `const char* quadcopter_id = "";`

Type your **Drone ID #**
exactly as it appears inside the ""

Upload

SAFETY GLASSES REQUIRED

Power ON
the Drone

WiFi Not Connected
Power cycle the drone by
turning it OFF and ON

Serial Monitor:

Autoscroll

WiFi not connected (turn drone off and back on)

WiFi not connected (turn drone off and back on)

WiFi Link
`Serial.println`
(line 904)

WiFi connected! IP address: 192.168.0.2

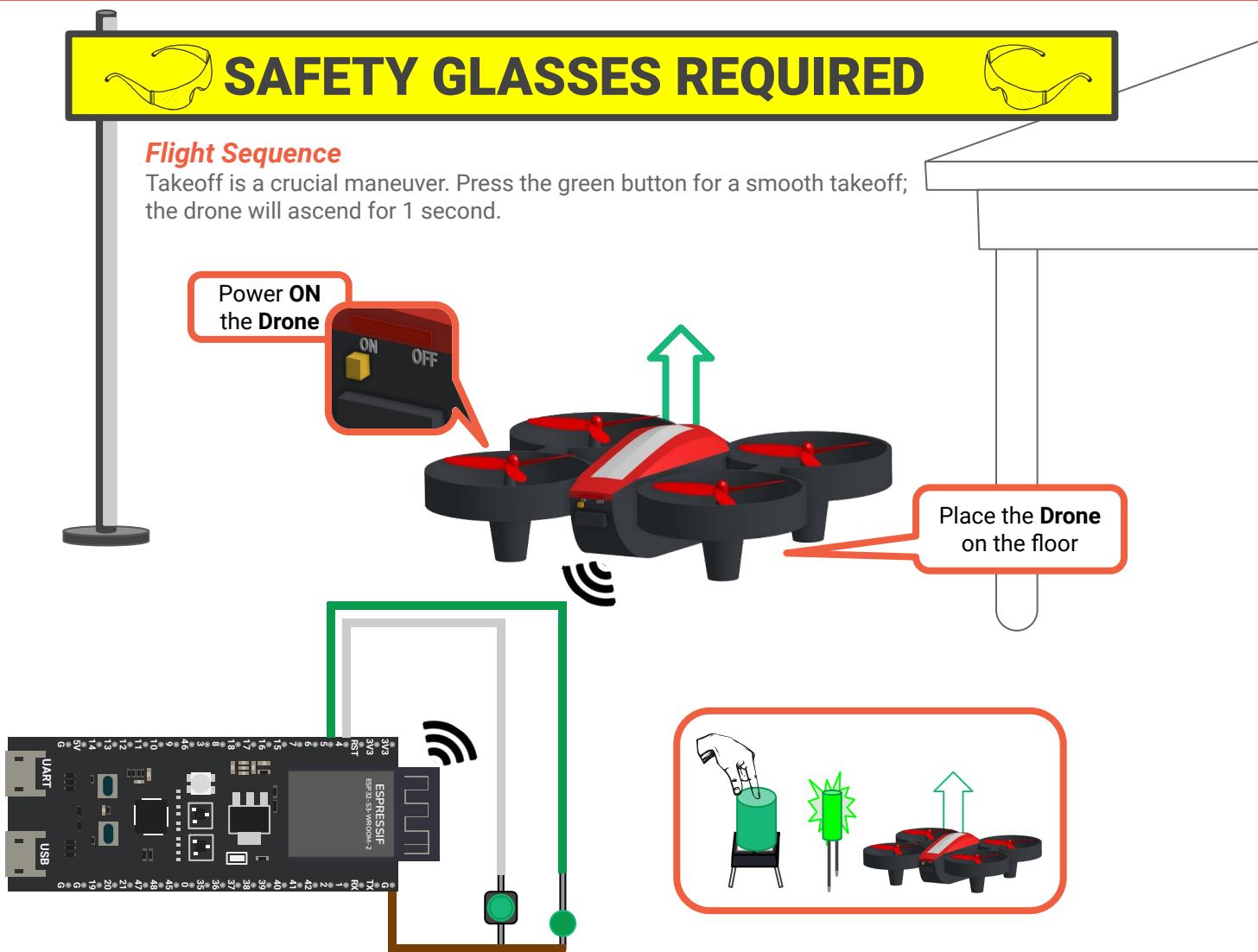
No throttle. 20: Pitch: 127 Roll: 127, Yaw:127, Altitude: 128

No throttle. 40: Pitch: 127 Roll: 127, Yaw:127, Altitude: 128

No throttle. 60: Pitch: 127 Roll: 127, Yaw:127, Altitude: 128

Flight Commands
`Serial.println`
(line 466)

Takeoff Button Test Flight

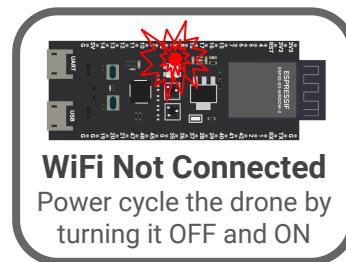


Serial Monitor:

Autoscroll

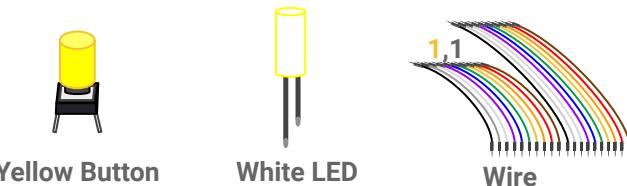
WiFi not connected (turn drone off and back on)

```
WiFi connected! IP address: 192.168.0.2
No throttle. 20: Pitch: 127 Roll: 127, Yaw:127, Altitude: 128
No throttle. 40: Pitch: 127 Roll: 127, Yaw:127, Altitude: 128
No throttle. 60: Pitch: 127 Roll: 127, Yaw:127, Altitude: 128
Green button pressed
Green/Take-Off Button Pressed [Serial.println (line 193)]
No throttle. 0: Pitch: 127 Roll: 127, Yaw:127, Altitude: 128
No throttle. 20: Pitch: 127 Roll: 127, Yaw:127, Altitude: 128
```



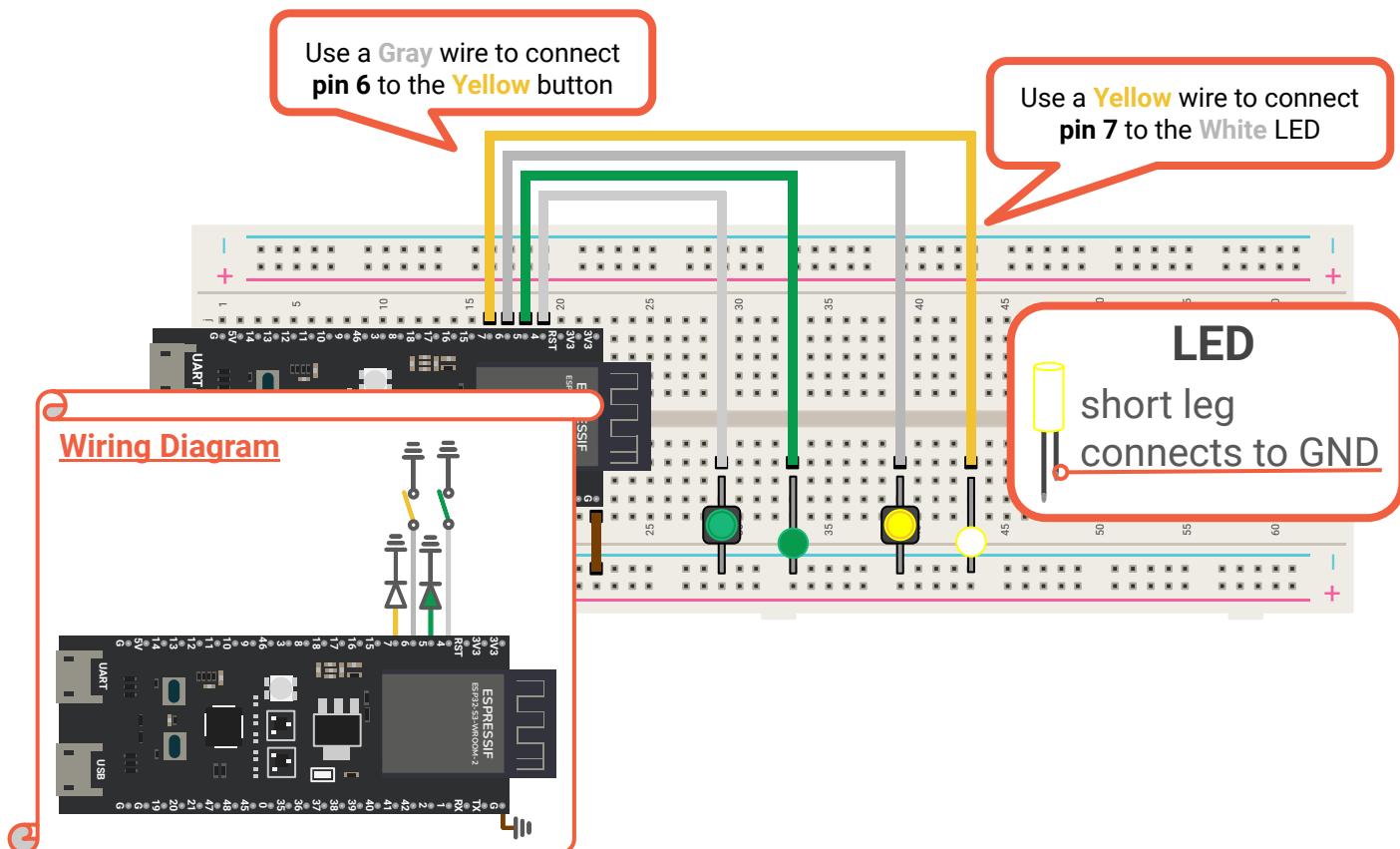
Stop Button Assembly

Parts we need



Stop vs. Landing

To control our soon-to-be autonomous drone, we'll install a stop button that immediately ends the flight.
This is different from landing, which is a controlled maneuver we'll program later.



Flight Mode

We will utilize LEDs to provide visual indicators of our flight controller's state



Activate STOP

Drone Workshop | Stage One Education

Connected Upload

```
1  
2 const char* quadcopter_id = "Drone";  
3 const char* light_pole_id = " ";  
4 const bool yellow_button_connected = true;
```

Change line 4 to true
This will activate the stop button pins on the ESP32

Serial.print("Hello, world!");

- Sends data from a microcontroller (e.g., ESP32) to a computer via a serial connection (USB)
- The text between the quotation marks (" ") will be sent and displayed on the serial monitor

```
840 void sendPacket(String packetString) {  
841     // Always check for stopped here since this function  
842     if ((digitalRead(YELLOW_BUTTON_PIN_BASE) == LOW) |  
843         Serial.println("Stop/Yellow button pressed");  
844         stopPressed();  
845     }
```

Change line 843 Serial.println(
"STOP/YELLOW BUTTON PRESSED"
or
"STOP STOP OMG my drone is crashing! :("
or
"Yellow button pressed! Drone's nap time activated. See you later, aviator!"
);

if();

- checks whether a condition is true or false. If the condition is true, the code inside the if block runs.
- If the condition is false, this code is skipped.

Upload

Upload the code



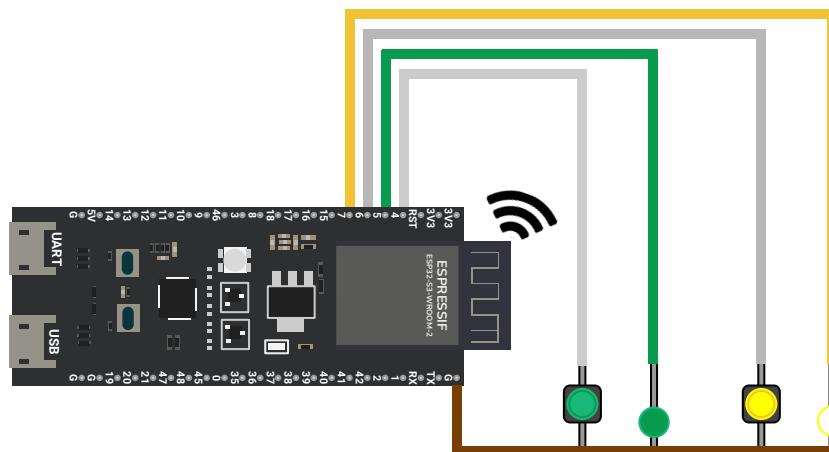
//

In Arduino, // is used to write a comment, which is like a note for humans to read that the computer ignores when running the code.

STAGE ONE EDUCATION

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STOP Button Test Flight



Not connecting...
Power cycle the drone by
turning it OFF and ON

STAGE ONE EDUCATION

Hands-on Engineering Workshops

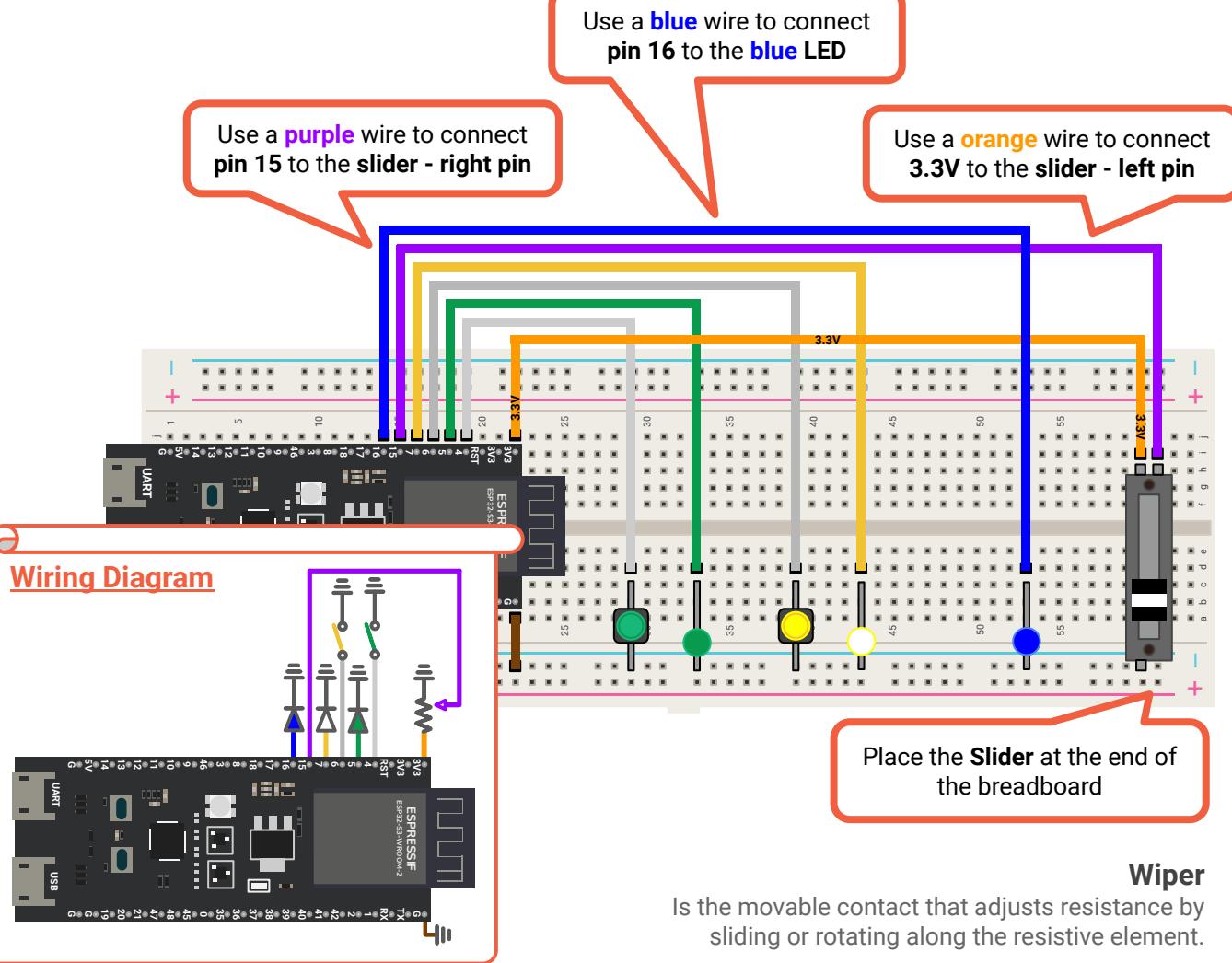
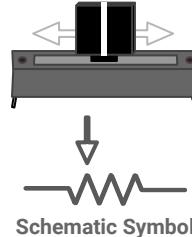
Altitude Control Slider

Parts we need



Variable Resistor - Slider

- Change circuit resistance by moving the slider, controlling electrical flow
- Sliding closer to one end decreases resistance there and increases it at the other end
- Common in volume controls, light dimmers, and sensor inputs, variable resistors are available in linear (straight slider) and rotary (knob) styles



Is the movable contact that adjusts resistance by sliding or rotating along the resistive element.

Activate Altitude Control

Drone Workshop | Stage One Education

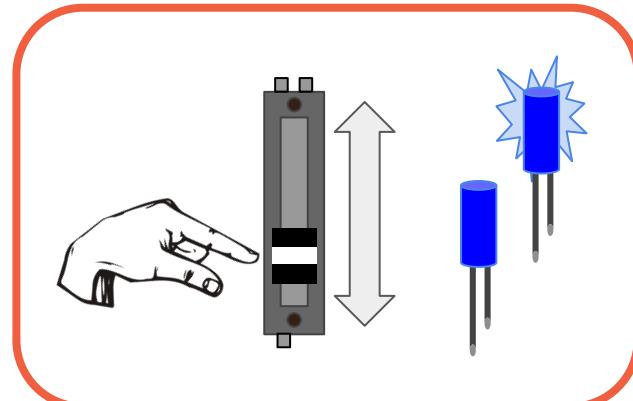
Connected Upload

```
1  
2 const char* quadcopter_id = "Drone";  
3 const char* light_pole_id = " ";  
4 const bool yellow_button_connected = true;  
5 const bool slide_connected = true;
```

Upload

Upload the code

Change line 5 to true
This will activate the slider pins on the ESP32



Altitude Control Test Flight



Flight Sequence

Press the green button for smooth takeoff; the drone will ascend.

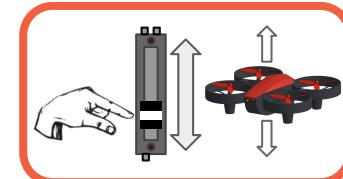
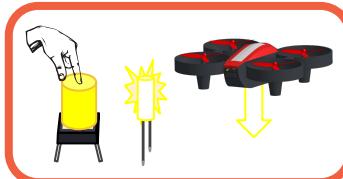
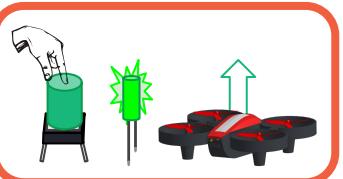
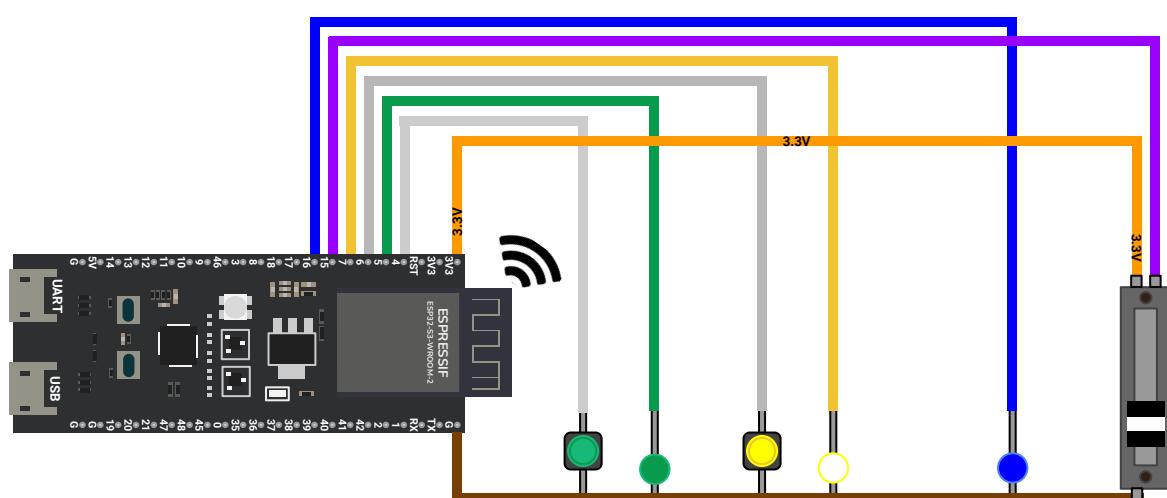
Use the slider to adjust the throttle to change the drone's altitude.

Press the yellow button to stop the flight.



Power ON
the Drone

Place the Drone
on the floor

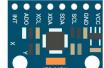


Not connecting...

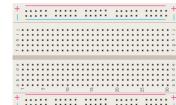
Power cycle the drone by
turning it OFF and ON

Pilot Controller Assembly

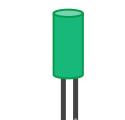
Parts we need



GY-521



Small Breadboard



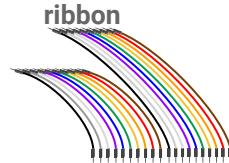
Green LED



White LED



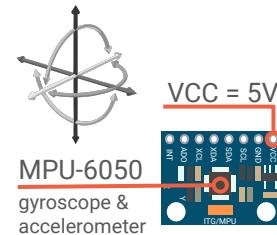
Yellow Button



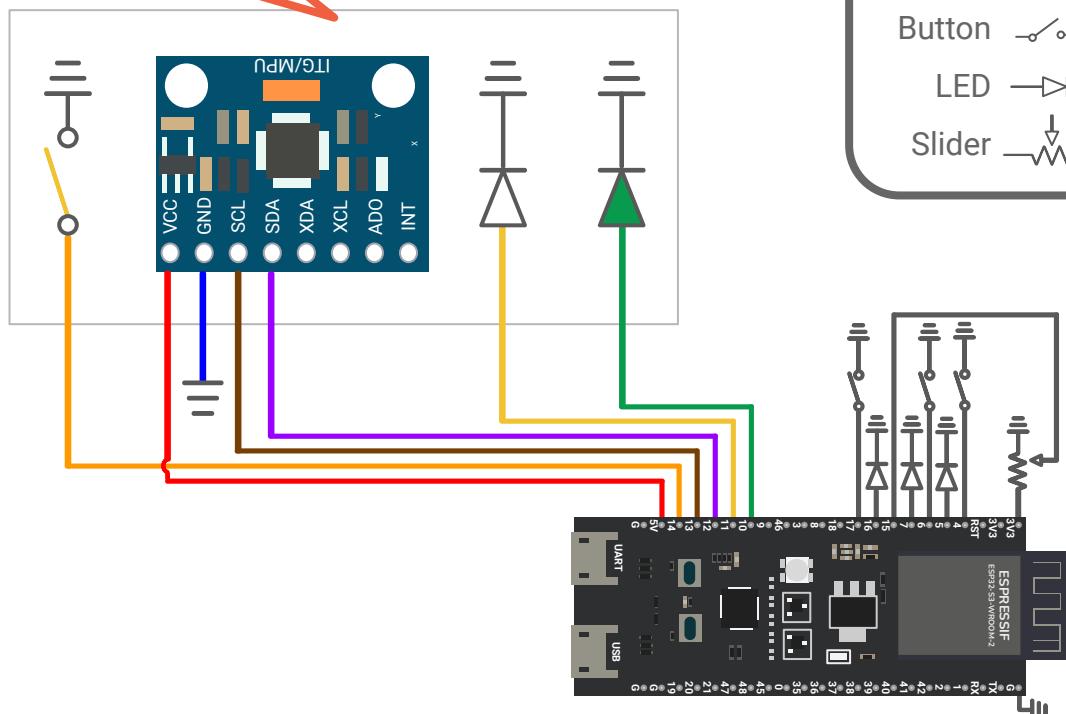
Wire

GY-521 Module

- PCB with an MPU-6050 sensor
- Combines 3-axis gyroscope and accelerometer, measuring angular rates and linear accelerations
- Digital Motion Processor - DMP reduces main processor load
- Used in gaming, virtual reality, and robotics for motion tracking.

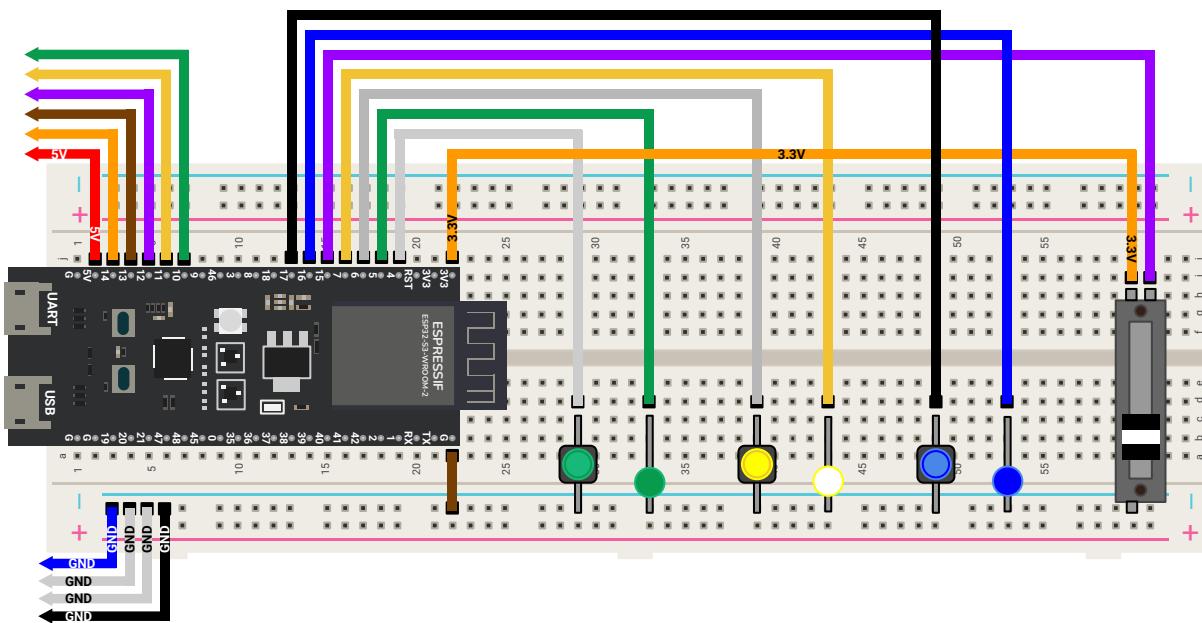
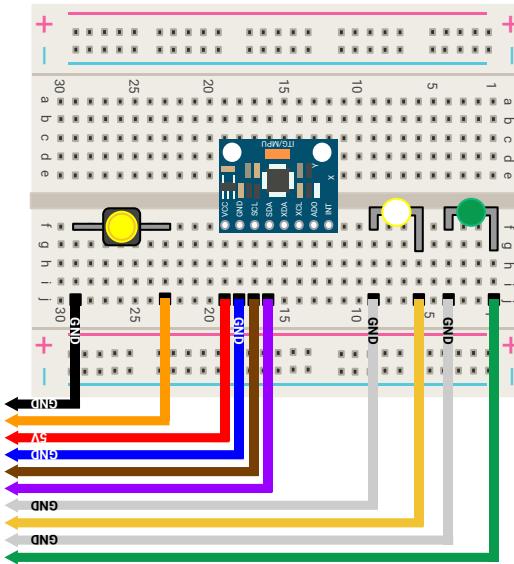


Use the **Wiring Diagram** to assemble the Pilot Controller on the small breadboard



Need a hint, go to the next page

Pilot Controller Assembly

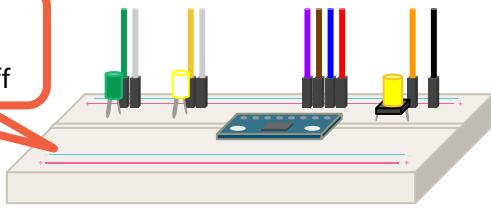


Pilot Controller

 SAFETY GLASSES REQUIRED 

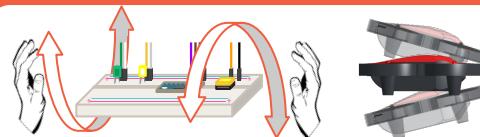
Calibration

Drone & Pilot controller must be level before takeoff



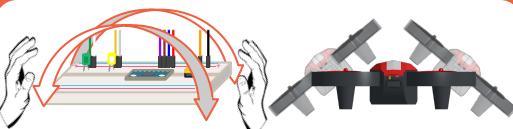
Pitch

Tilting up/down moves the drone forward/backward



Roll

Tilting left/right moves the drone left/right



Yaw

Turning left/right changes the drone's direction



STOP

Immediately ends the flight



Ground Controller

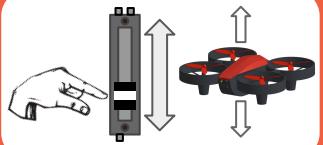
Takeoff



STOP



Altitude - Throttle



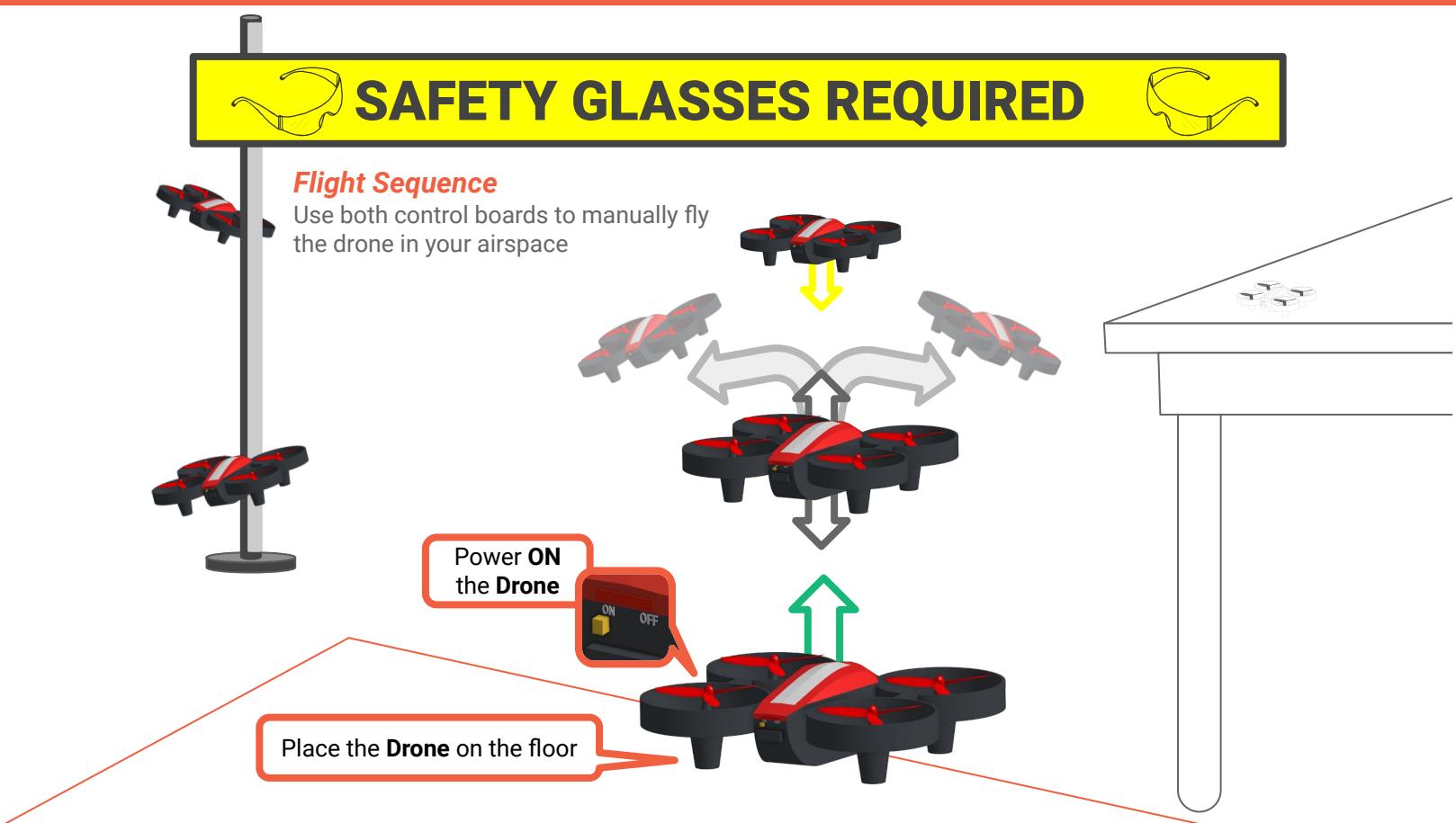
Teamwork

Both partners must collaborate for a controlled flight. One person operates the ground controller while the other operates the pilot controller.

STAGE ONE EDUCATION

Hands-on Engineering Workshops

Manual Control Flight



Challenge

Put your flying skills to the test by controlling your teams drone to fly from your table, circle around the light pole, and return to the table.

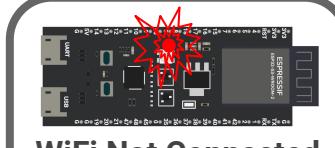
Serial Monitor:

Autoscroll

Green/Take-Off Button Pressed

```
0: Pitch: 127 Roll: 127, Yaw:127, Altitude: 122  
20: Pitch: 107 Roll: 127, Yaw:127, Altitude: 122  
40: Pitch: 196 Roll: 87, Yaw:127, Altitude: 122  
60: Pitch: 127 Roll: 90, Yaw:127, Altitude: 122  
80: Pitch: 127 Roll: 127, Yaw:127, Altitude: 209  
100: Pitch: 199 Roll: 0, Yaw:127, Altitude: 176  
120: Pitch: 227 Roll: 0, Yaw:127, Altitude: 123  
140: Pitch: 44 Roll: 84, Yaw:127, Altitude: 122
```

Observe the values change as you control the drone

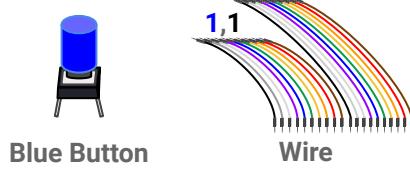


WiFi Not Connected

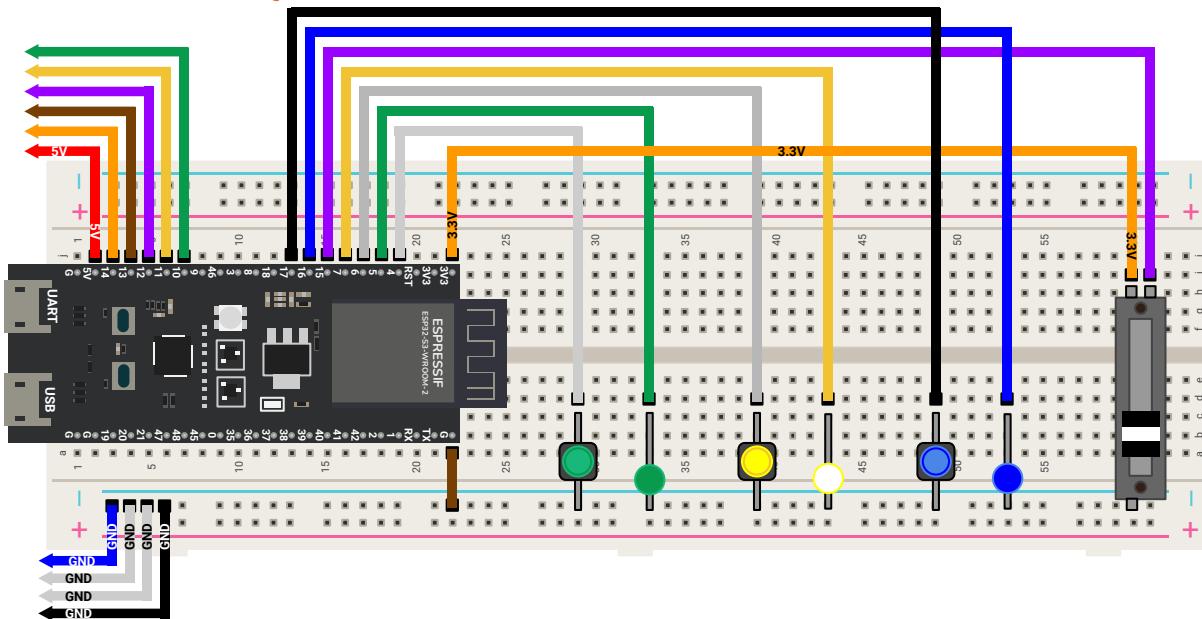
Power cycle the drone by turning it OFF and ON

Autonomous Button Assembly

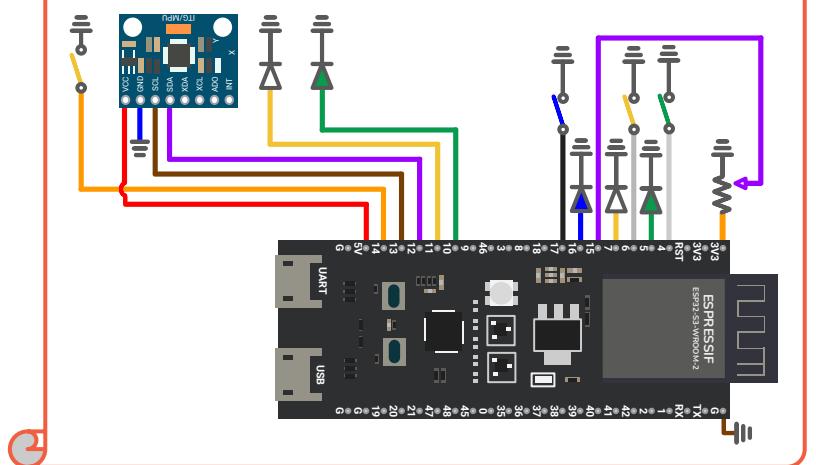
Parts we need



Use a **black** wire to connect pin17 to the **blue** button



Wiring Diagram



Activate Autonomous Control

Drone Workshop | Stage One Education

Connected Upload

```
1
2 const char* quadcopter_id = "Drone";
3 const char* light_pole_id = " ";
4 const bool yellow_button_connected = true;
5 const bool slide_connected = true;
6 const bool blue_button_connected = true;
```

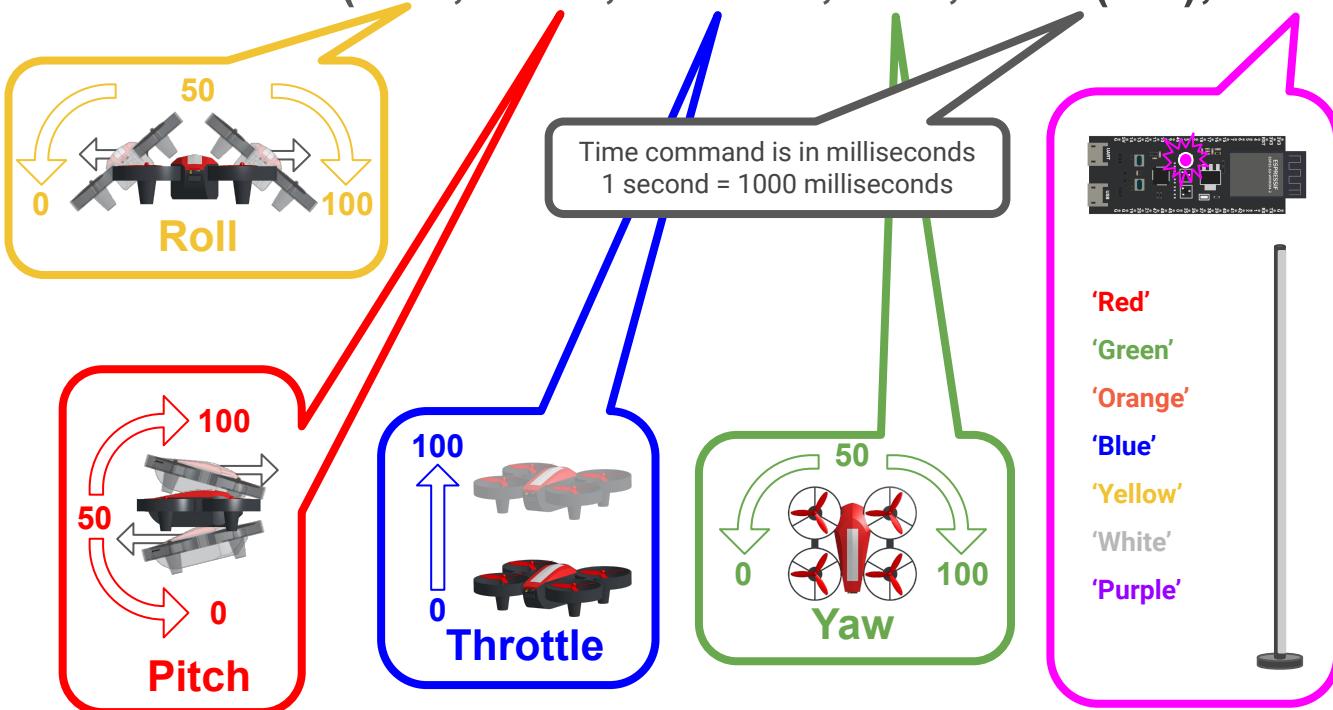
Change line 6 to **true**
This will activate the autonomous button pins

Upload 

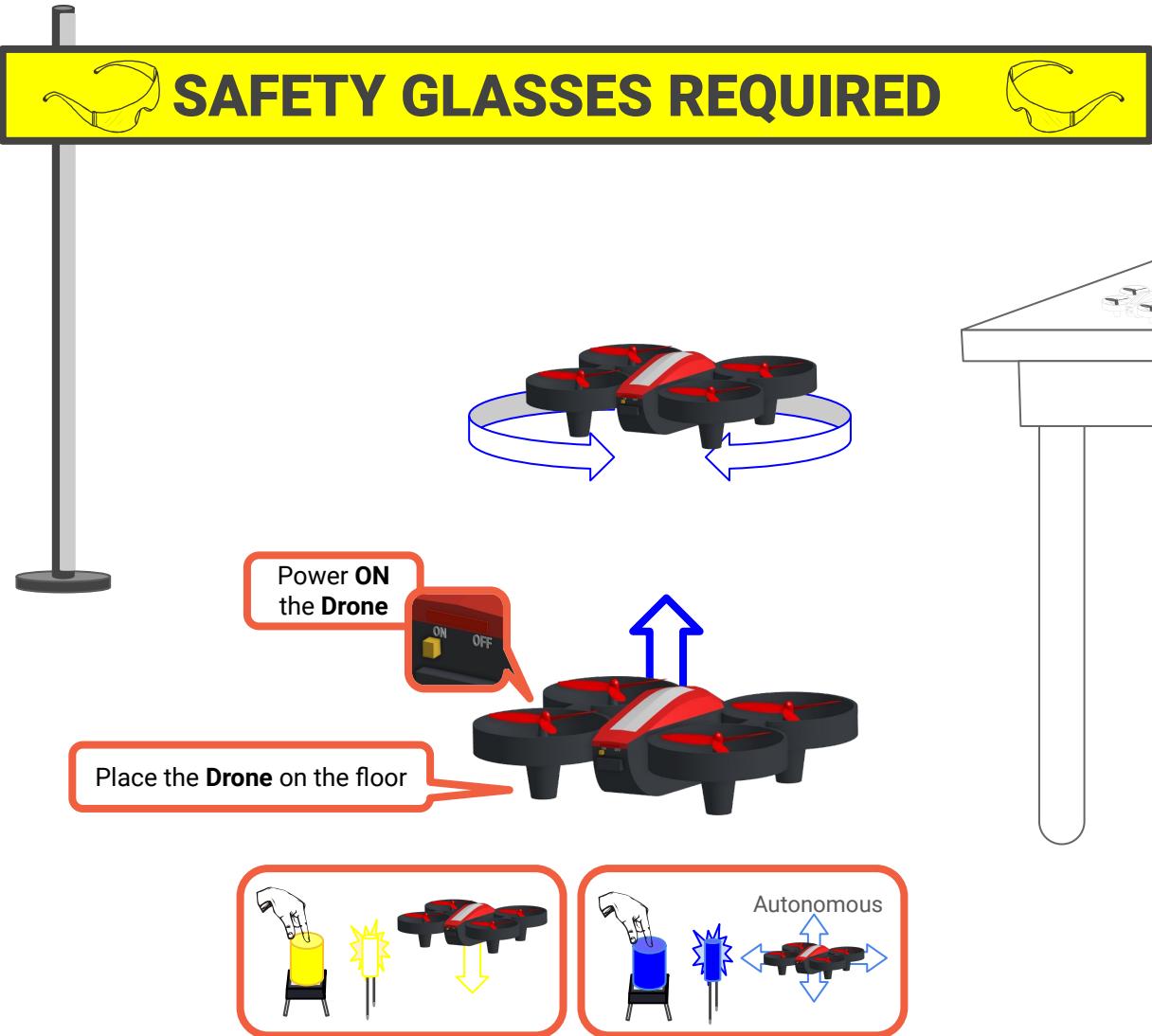
Autonomous Flight

A hold command keeps the drone steady in one position for a set time. This can be a simple hover or a cool descending spiral. We'll use hold commands to create an autonomous flight, combining them to develop a complex flight pattern.

holdCommand(Roll, Pitch, Throttle, Yaw, Time(ms), Color);



Autonomous Control Flight



Autonomous Flight Commands:

```
// holdCommand(Roll, Pitch, Throttle, Yaw, Time(ms), Color);
```

```
9| holdCommand(50, 50, 55, 50, 500, 'blue');  
10| holdCommand(50, 50, 55, 100, 750, 'purple');  
11| holdCommand(50, 50, 55, 0, 750, 'orange');
```

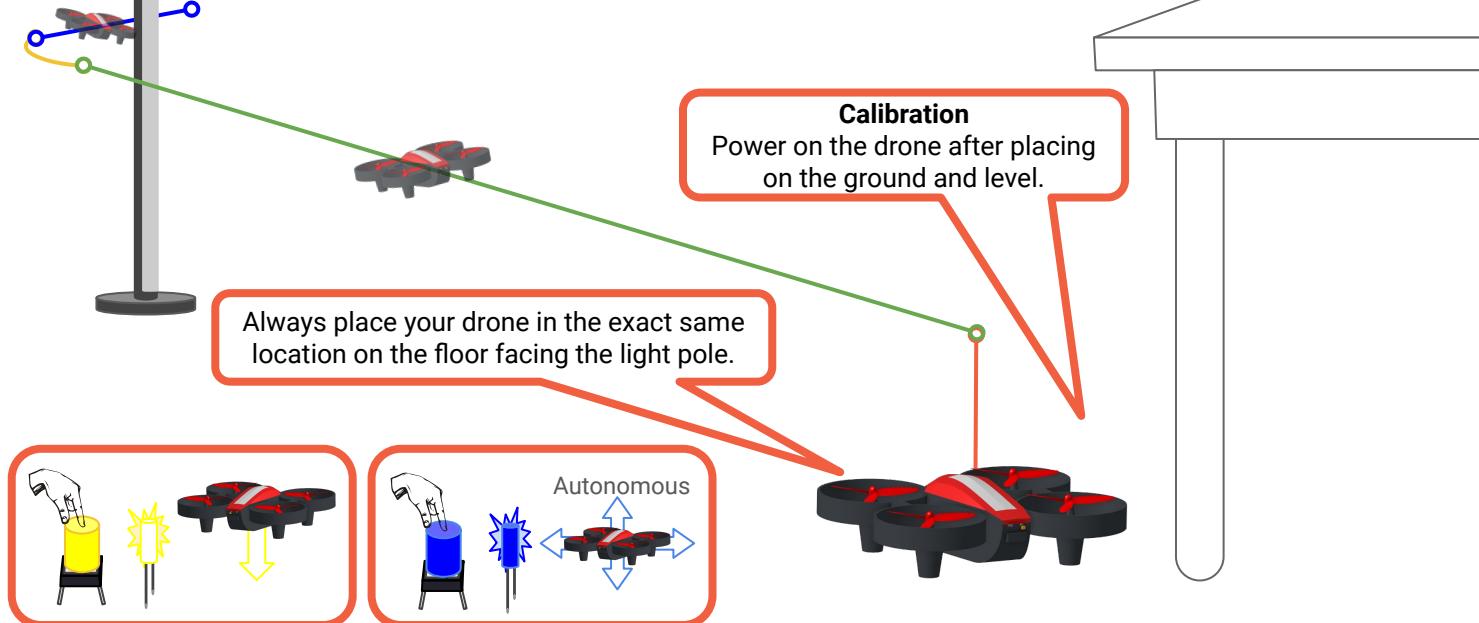
The left and right yaw is due
to the change in the 4th
value of each holdCommand

Autonomous Flight 1



Autonomous Flight 1

Write holdCommands to have your drone takeoff and make a right turn around the light pole



Tuning

- Begin with small adjustments, focusing on the first one or two hold command lines.
- Upload and test each change, expecting to crash many times before achieving a successful flight.
- Embrace the engineering process, which involves learning from each attempt, including inevitable crashes.
- Each test brings you closer to a successful autonomous flight.

Autonomous Flight Commands:

Modify as required for your airspace.

```
// holdCommand(Roll, Pitch, Throttle, Yaw, Time(ms), Color);
```

Write your own commands to successfully complete the autonomous flight in your airspace

Upload
After every code change

Upload

Battery Level

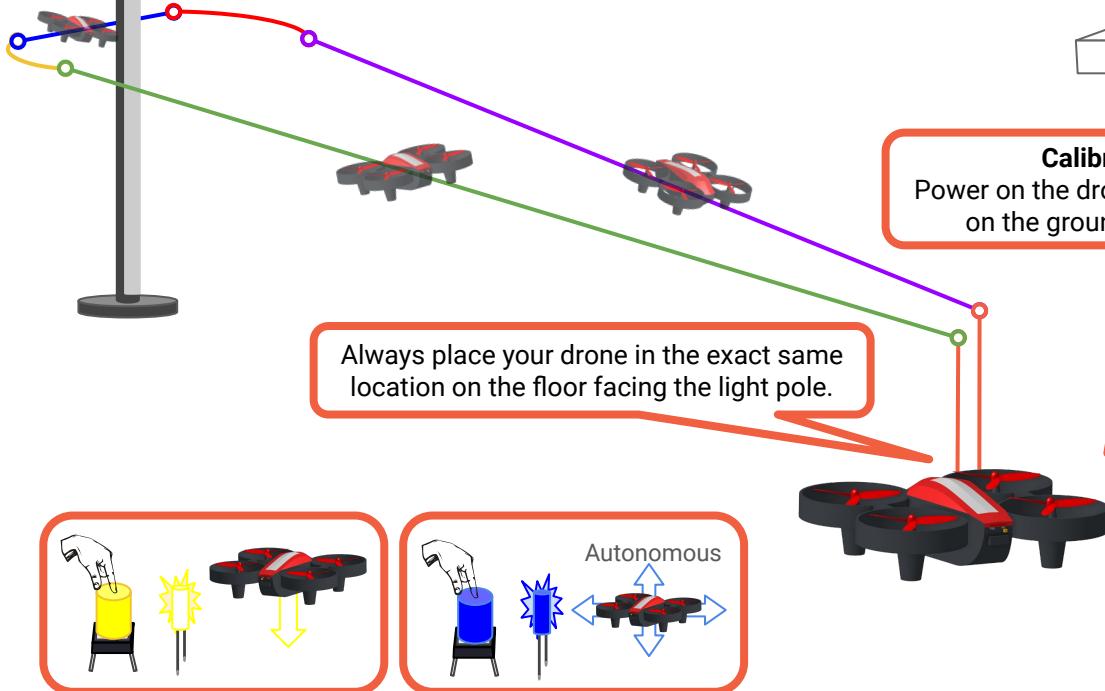
Recharge your battery to ensure consistent autonomous flights

Autonomous Flight 2



Autonomous Flight 2

Write holdCommands to have your drone return to the takeoff position



Autonomous Flight Commands:

```
// holdCommand(Roll, Pitch, Throttle, Yaw, Time(ms), Color);
```

Modify the values to successfully complete the autonomous flight in your airspace

Upload
After every code change

Upload

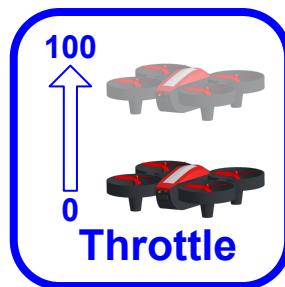
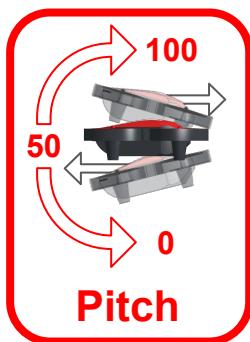
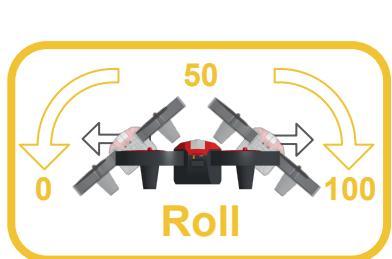
Custom Mission



Autonomous Flight Commands:

Build your own flight
You can add and modify your existing hold commands.

`holdCommand(Roll, Pitch, Throttle, Yaw, Time(ms), Color);`



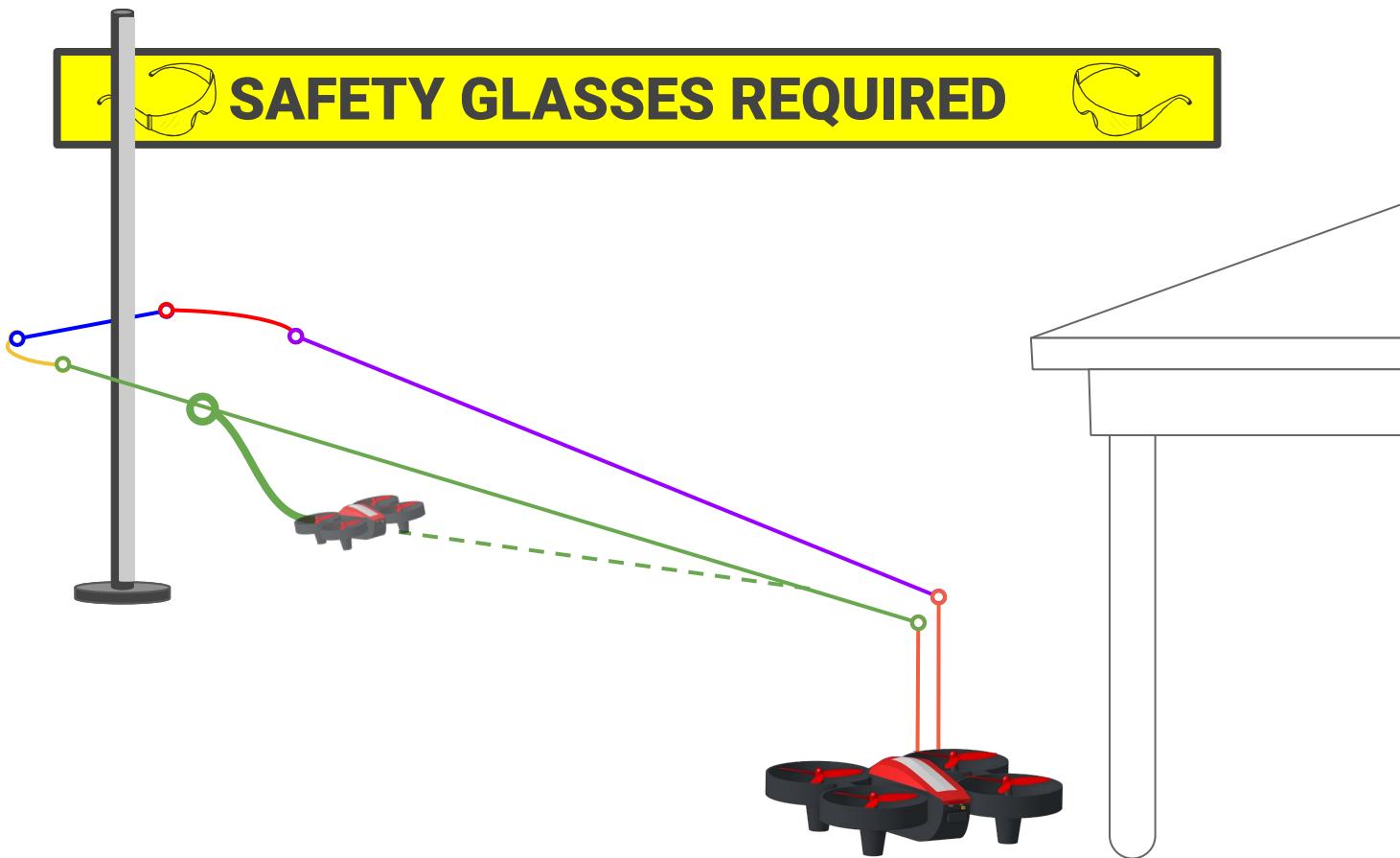
Color

'Red' 'Green' 'Orange' 'Blue' 'Yellow' 'White' 'Purple'

STAGE ONE EDUCATION

Hands-on Engineering Workshops

Pilot Override

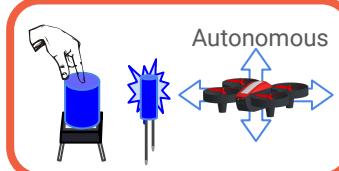


Pause and Override Autonomous Flight

Hold down the green button to pause and override the autonomous flight.

Release the green button to resume the autonomous flight.

Be prepared to operate both the pilot and ground controller.



Checklist

1

SHUTDOWN



Autonomous Flight ControlCOMPLETE
SAFETY GLASSES.....OFF

2

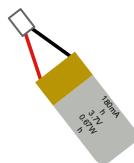
COMPUTER



Applications.....CLOSE ALL
Laptop Power.....OFF

3

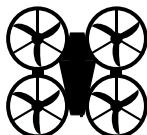
DRONE



Battery from Drone.....REMOVE
Return Batteries to Instructor....YES

4

PARTS



Return All Parts.....NEXT PAGE

Parts Cleanup

On your desk



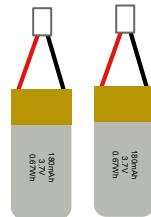
Laptop



Instructions



Safety Glasses



Drone Batteries

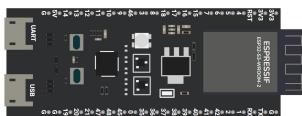


Electronics Box

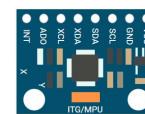
Check that all your parts are returned to the Electronic Box



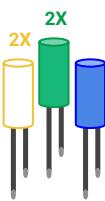
Drone



ESP32
Development Board



GY-521
Accelerometer



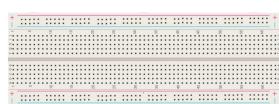
LED's



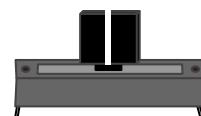
Wires



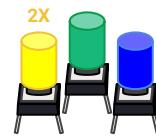
Small Breadboard



Large Breadboard



Slider
Variable Resistors



Buttons



Drone Battery
Charging Cable



USB to
Micro USB

Feedback Survey

YOU JUST COMPLETED THE
Robotics Workshop

Workshop Feedback Survey
feedback.stageoneeducation.com



Thank you for your participation