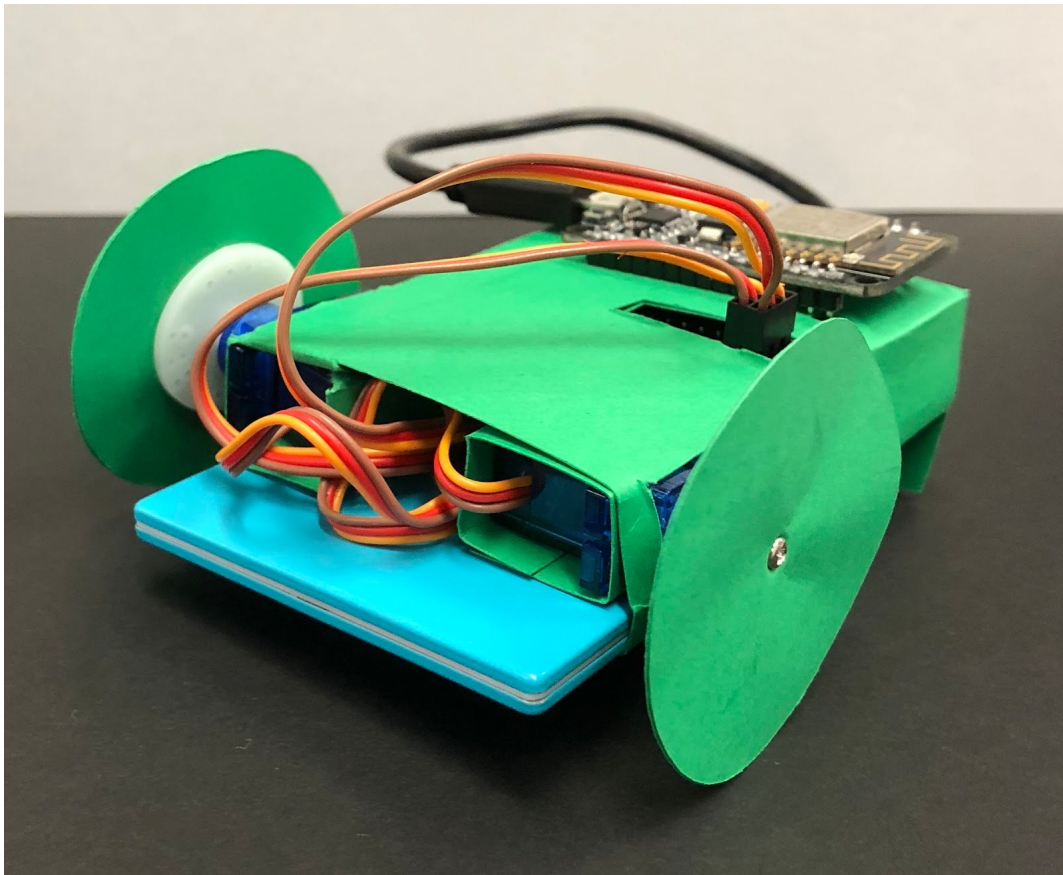# PAPER ROBOTS FOR EDUCATION

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Tanvi Pati

Content

Introduction

As more robots get integrated into our daily lives, they have started getting used in classrooms as tools for education. However, most robots being used to teach lessons are quite expensive and not that simple to make. We decided to use the robot compiler made by our lab, LEMUR, at UCLA, to make simple paper robots for education. You can simply fold the 2D cutouts into 3D structures and mount on the electrical components to make use of these robots.

In this document, we have prepared a few lesson plans and activities that teach various math and science lessons with the use of a paper robot car. The instructions on how to fold the 2D outline along with its electrical parts along with the use of them are included. There are a few basic activities that teachers and students can use (with alterations if necessary) to learn a couple of topics from the Common Core State Standards curriculum.

We hope to use this means of learning as a fun introduction to robotics for young students. We also believe that making lessons more engaging will help students grasp concepts more efficiently. Enjoy!

Required Materials

These are all the parts included in this kit to build your robot:

1. 2D paper cutout of robot

2. 4 paper wheels

3. 2 continuous micro servos

4. NodeMCU Amica DevKit board (ESP8266 chip)

5. Motor Shield for NodeMCU

6. Battery

7. Micro USB to Micro USB cable

8. USB to Micro USB cable
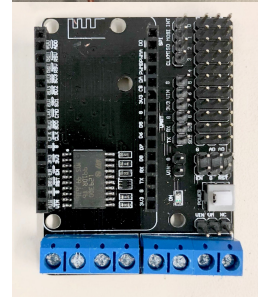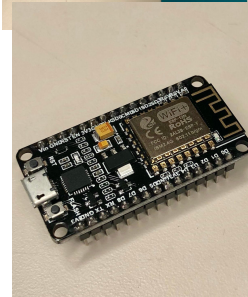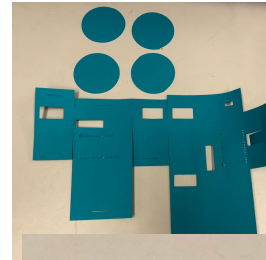
These are the tools you will need to build this robot:

1. Glue stick

2. Screw driver

3. Tape (optional but helps with sturdiness)

Instructions for building the paper robot car

Guide for Folding

If the arrows on a dotted line point towards each other, fold the paper upwards, bringing both sides of the paper toward you. In origami, this is called a "valley fold" because from your view, the paper should be making a valley. Likewise, If the arrows are pointing away from each other, fold downwards pulling the two pieces of paper further away from you. In origami, this is called a mountain fold because from your view, the paper should look like the peak of a mountain. Below is are step by step instructions on how to build this paper car, but if at any point you get confused about which way to make a fold, refer back to this image to know the right fold.
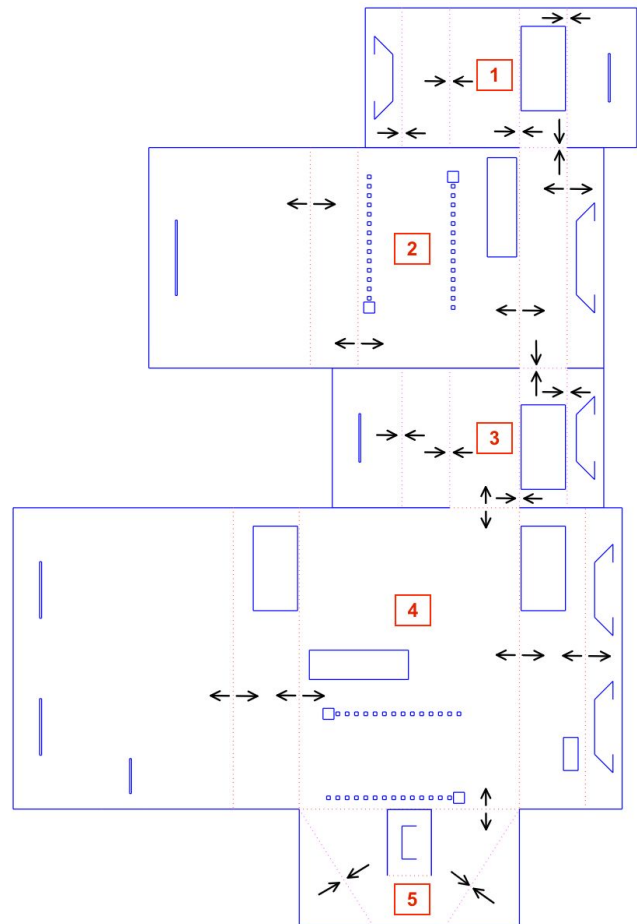
Wheel Motors

1. Orient the blueprint as shown

2. Remove the plastic wheel from the micro servo so you are less likely to rip the paper cut out throughout building this robot.

3. Place a micro servo through the rectangular hole cut out of box 1. Make sure the micro servo is placed so the wires go up, away from the paper cutout.

4. Fold box 1 around the micro servo inserting the tab into the slit to hold it all together. At any point during this process, use tape to hold the folds together even better.
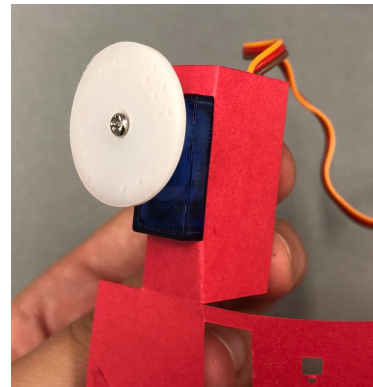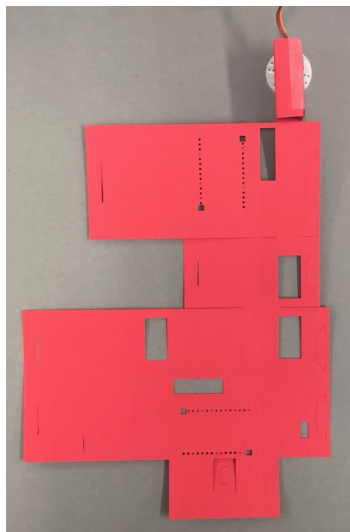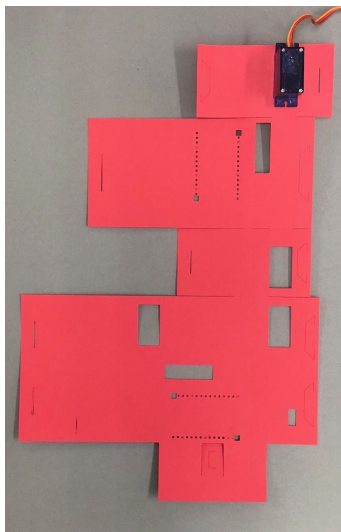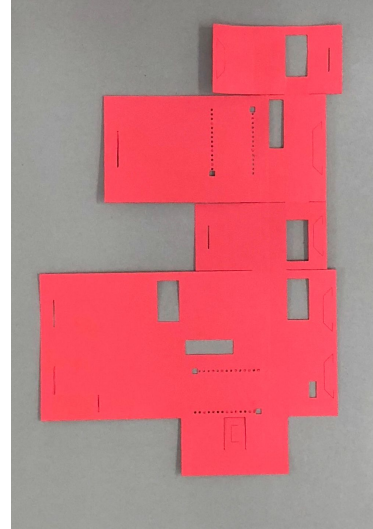
5. Repeat this process for the second micro servo that goes in box 3. Make sure the wires go down, opposite from the first micro servo, like in the picture.
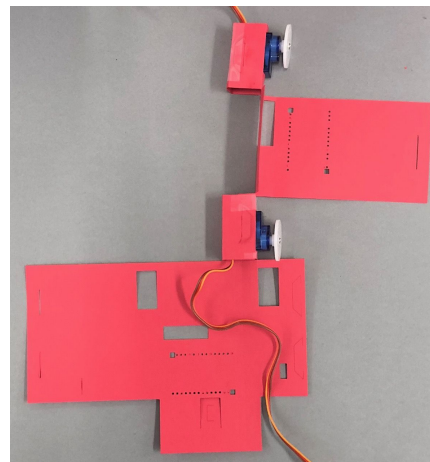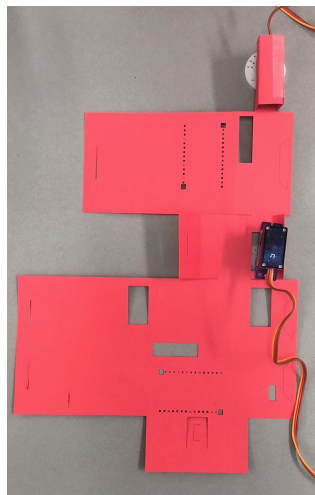
Motor Shield

1. Bring box 2 around to the right hand side if you haven't already.

2. Place the motor shield so that the part with row of pins 3 pins wide and 11 pins long lines up with the hole cut out.

3. Fold box 2 around the motor shield, folding the tab into the slit.
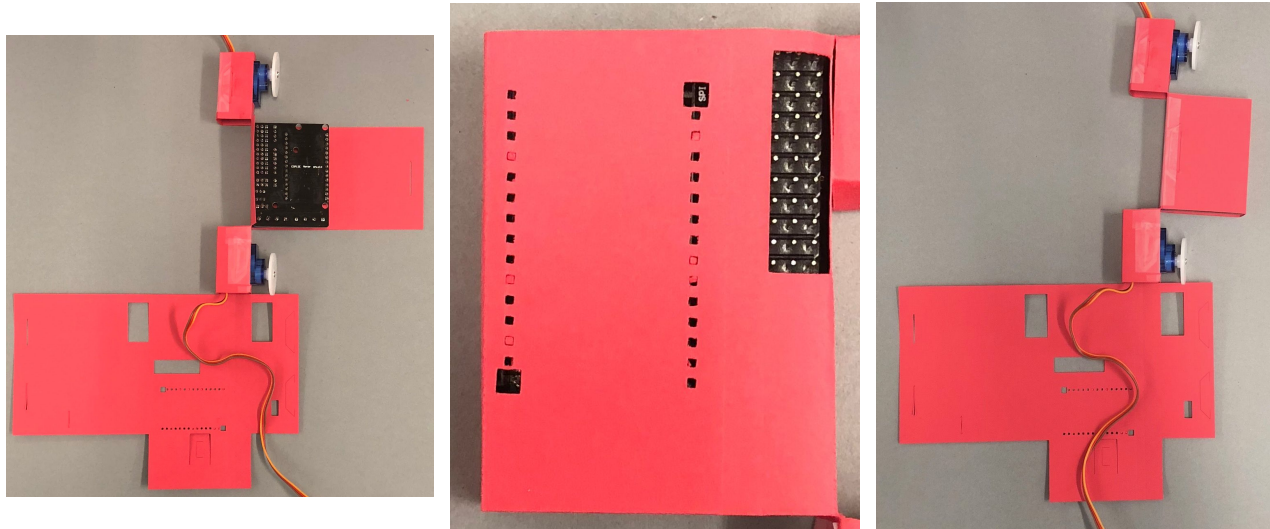
Putting it All Together

1. Curl the micro servos and motor shield to the left so the micro servos are both touching the edge of box 5 and the wires are going downwards in the same direction.

2. Bring the micro servos and motor shield under box 5 and put the micro servos through the rectangular holes on box 5. (The image show in the bottom side of the robot)
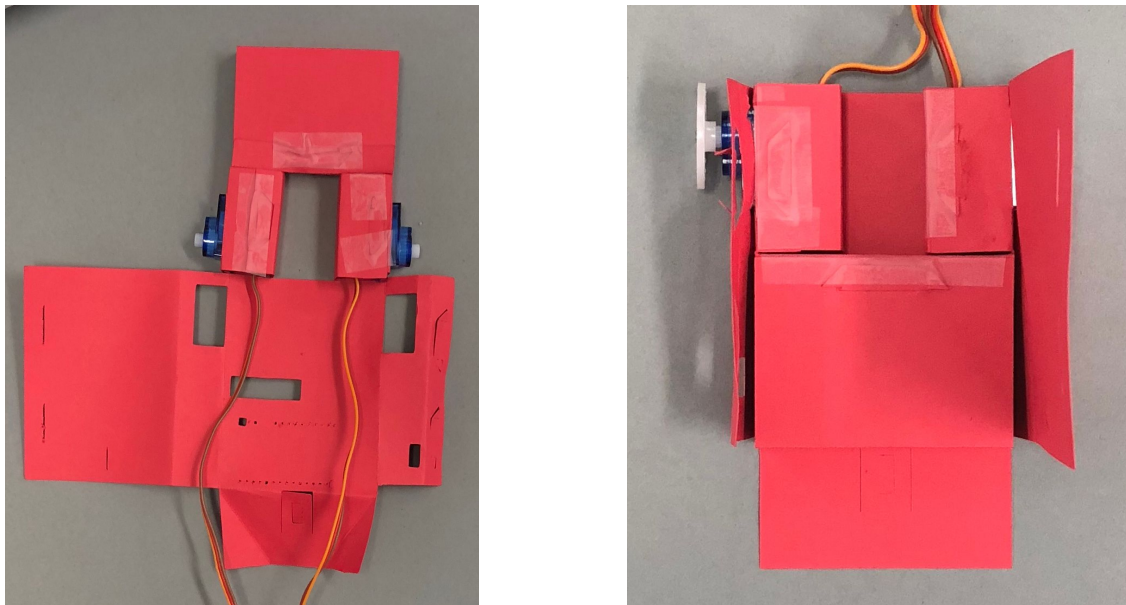
3. The microcontroller can be put in the motor shield at any point now, but it is easiest to put it in at this point because you can see where the pins need to go in on the motor shield. Put the micro controller in so the power input is further from the edge.
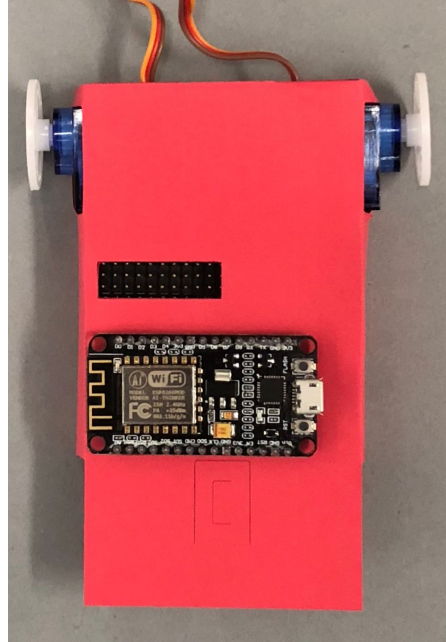
4. Flip the car over fold, put the battery in, and fold the flap down, inserting the tabs into the slits. This is easiest done without the battery inserted, but also use caution when sliding in the battery later. Make sure the power port is on the side of the robot opposite the micro servos, on the same end as the microcontroller.
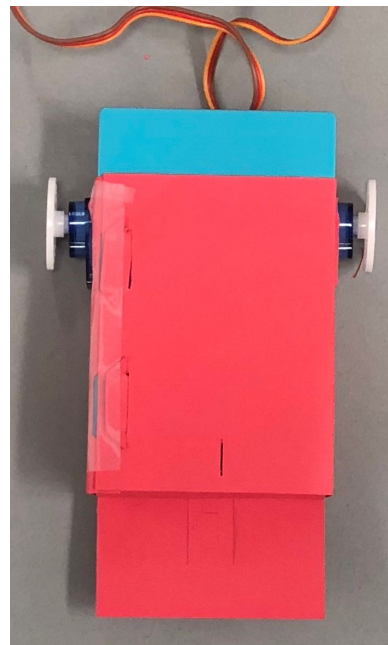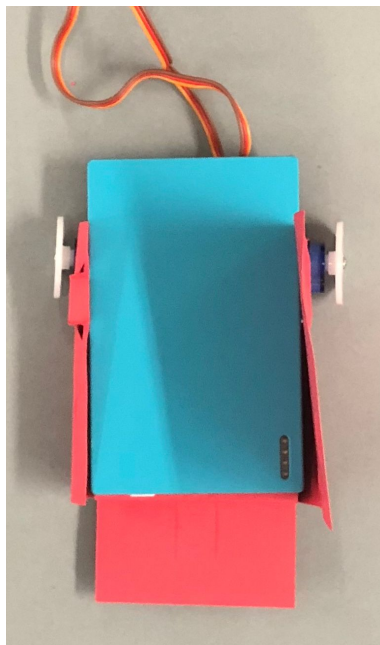
5. Fold the flap last flap on the end and tape the tab down.
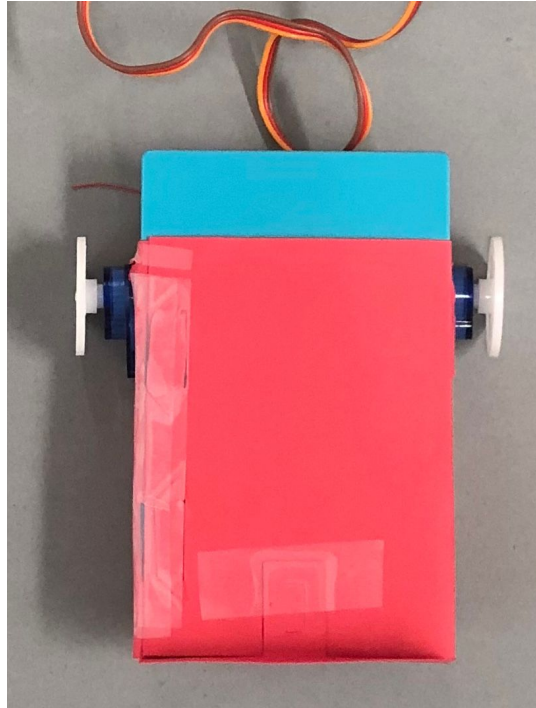
The Wheels

1. Make two wheels by gluing two of the paper circles together.

2. Make the hole at the center larger so the screw from the micro servo can fit in it.

3. Put the screw through the hole of the paper wheel and using a phillips head screwdriver, screw the paper wheel onto the micro servo.
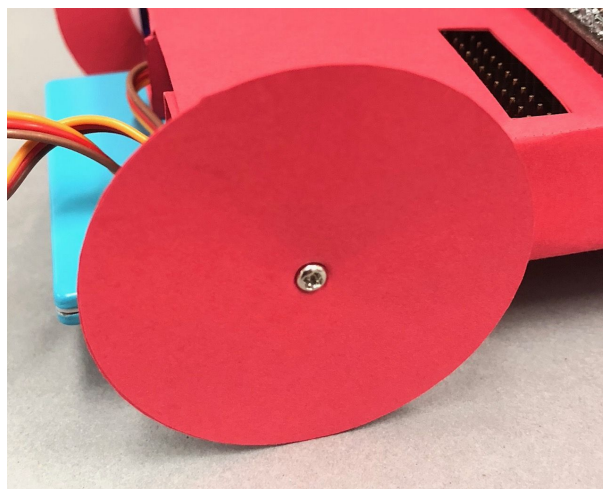
The Electronics

1. Attach the cable coming from the left micro servo to the pins corresponding with D1
    (The pins are numbered starting with D0, so this is the second row of pins from the right).
    Attach the cable from the right micro servo to the row of pins corresponding with D2.
    The yellow wire should be closest to the microcontroller. The cables should be crossed so
    that the left motor connects to the right of the right motor's cable on the motor shield.
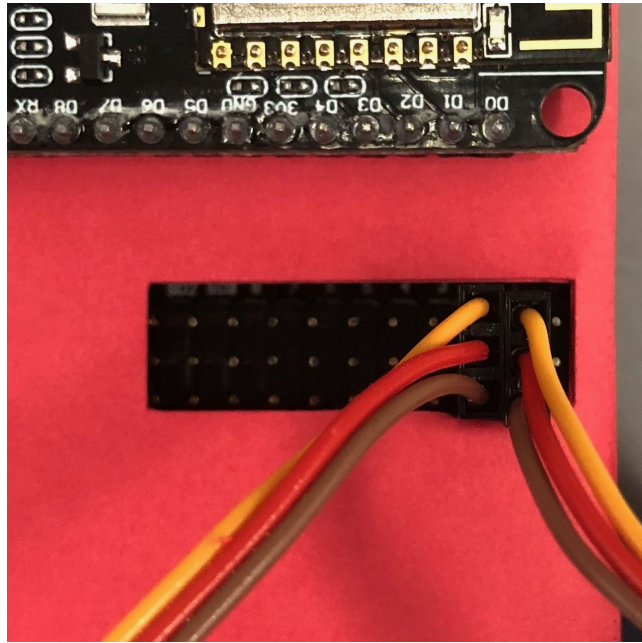
2. Use a micro USB to micro USB to power up the two wheeled car by connecting the
    battery to the microcontroller.
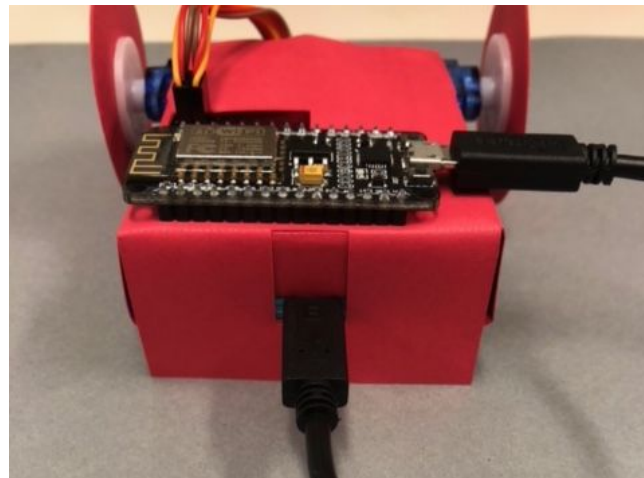
The Software

(These instructions are for Mac users, but you can follow a similar procedure for other operating systems as well.)

1. Install the latest version of Arduino on your computer. You can do so at:
   https://www.arduino.cc/en/Main/Software
2. Connect the NodeMCU to the computer using the USB to Micro USB cable.
3. Plug in the USB given to you. You will find a folder named "paperbot". When you open the folder, click on the file named "paperbot.ino".
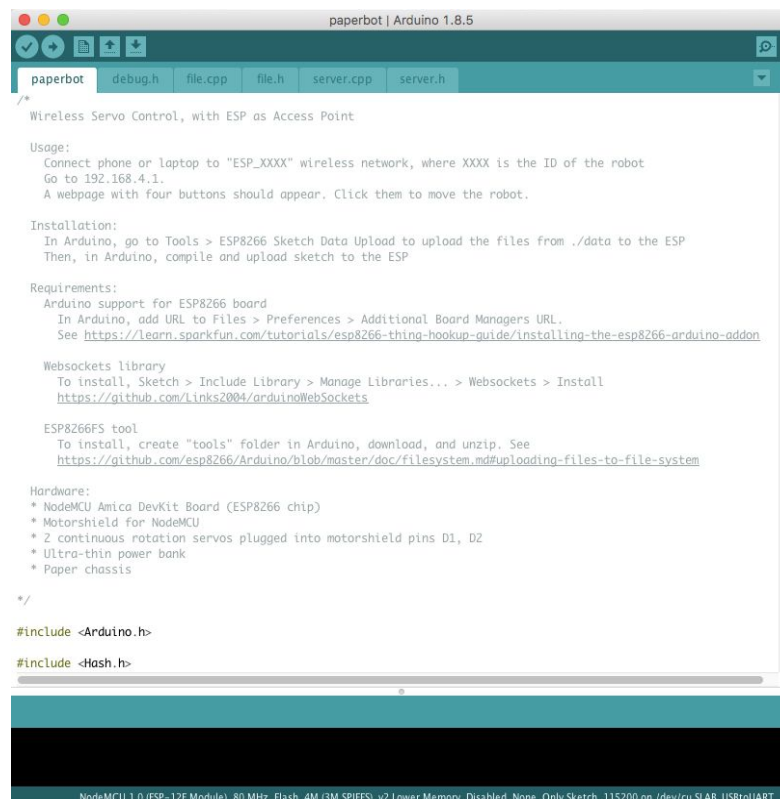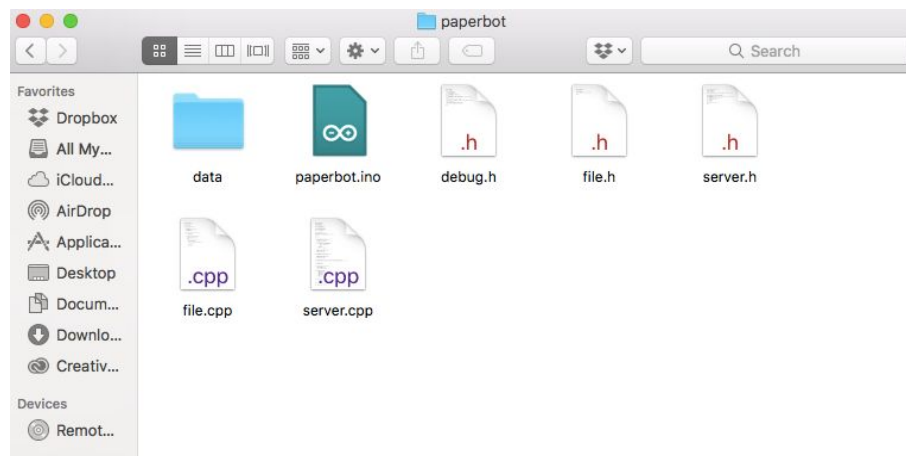
4. You need to set up the Arduino to support the ESP8266 board. To do so, open up Arduino and go to "Files" in the menu bar. In the drop-down menu, select "Preferences" and then "Additional Board Managers URL".

5. Copy this URL http://arduino.esp8266.com/stable/package_esp8266com_index.json into the "Additional Board Managers URLs" text box at the bottom of the pop-up window. If you have another URL already in the textbox, add a comma after it and copy the given URL after the comma. Hit "OK".
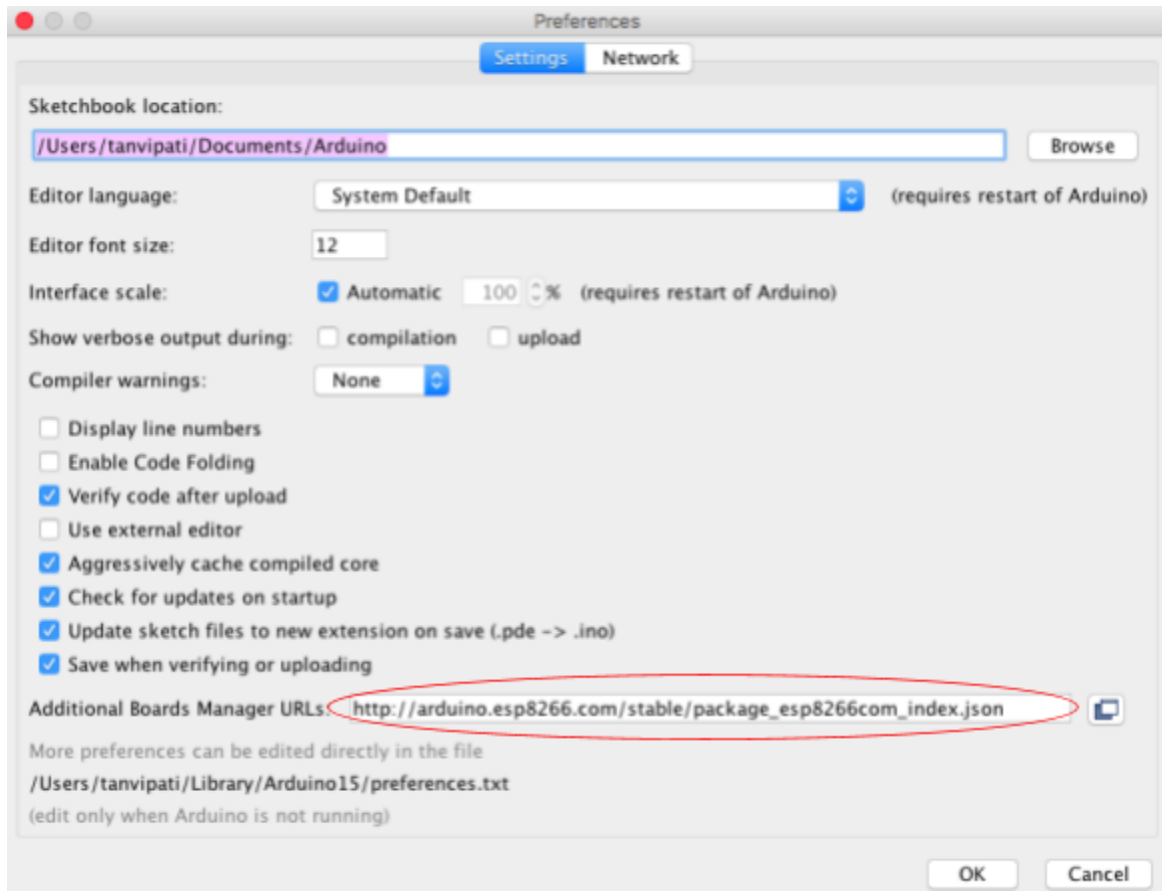
6. Go to "Tools" and select "Boards". From the drop-down menu, select "Boards Manager...". In the pop-up window, filter your search by typing "esp8266" and click "Install" on the option that shows up.
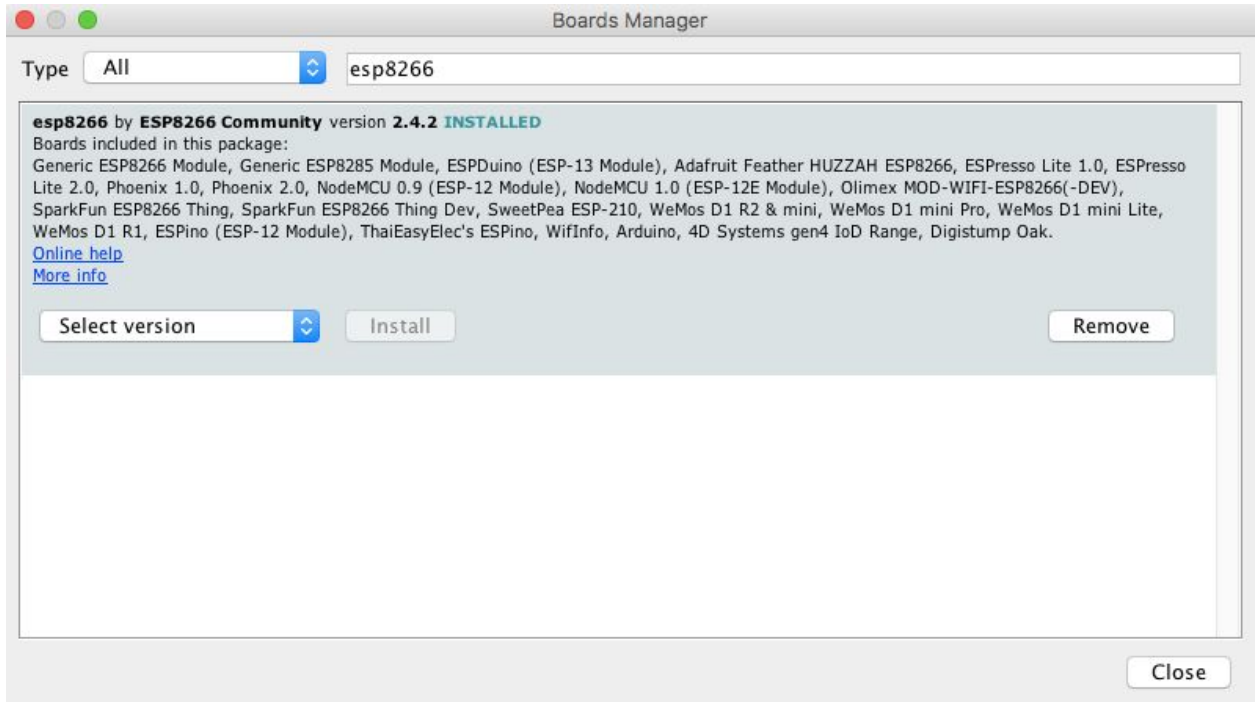
7. Next, your microcontroller needs to able to communicate with the device you will be using to control it over WiFi. To do this, you have to set up the WebSockets library in Arduino. Go to "Sketch" in the menu bar and select "Include Library". In the drop-down menu, select "Manage Libraries…". Filter your search by typing "WebSockets". A few options may appear - find the one titled "WebSockets" and "Install".
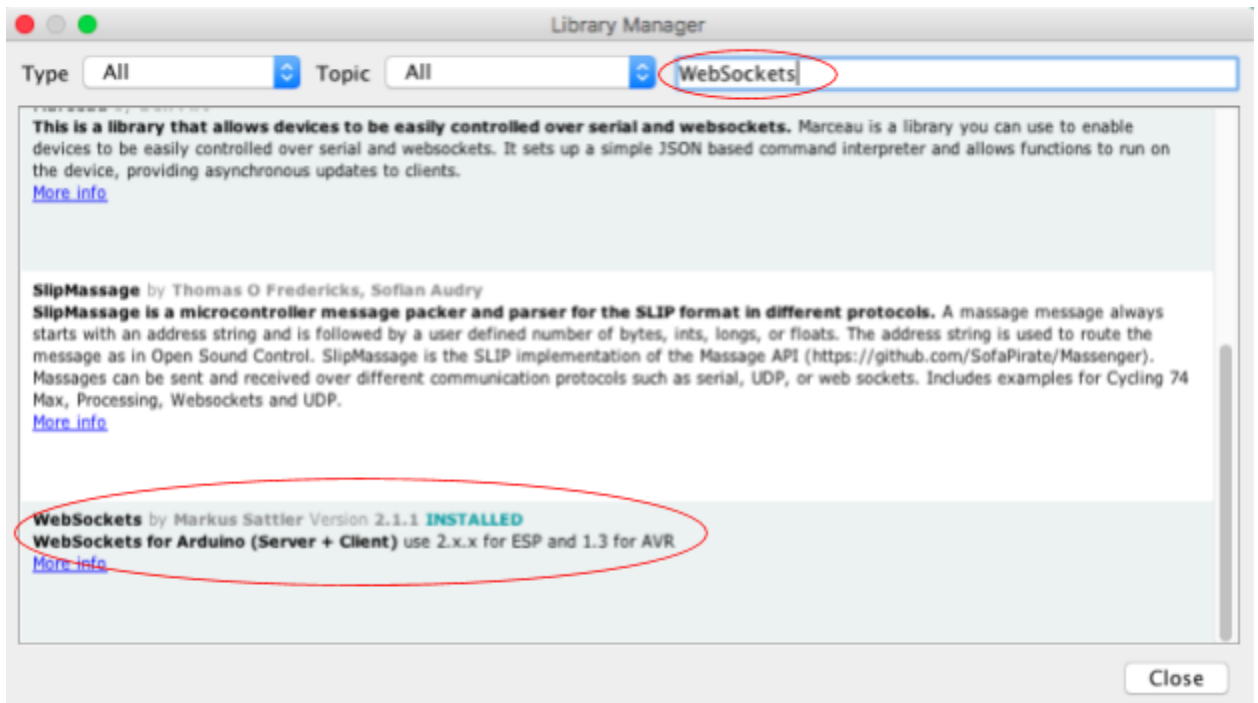
8. Next, you need to download the ESP8266FS tool. To do so, go to your computer's "Arduino" folder. Create a new folder named "tools".

9. Download the first .zip file on this page:
   https://github.com/esp8266/arduino-esp8266fs-plugin/releases

10. Move this from your "Downloads" folder to the "tools" folder you created. Double click on the file. A new folder named "ESP8266FS" will appear.
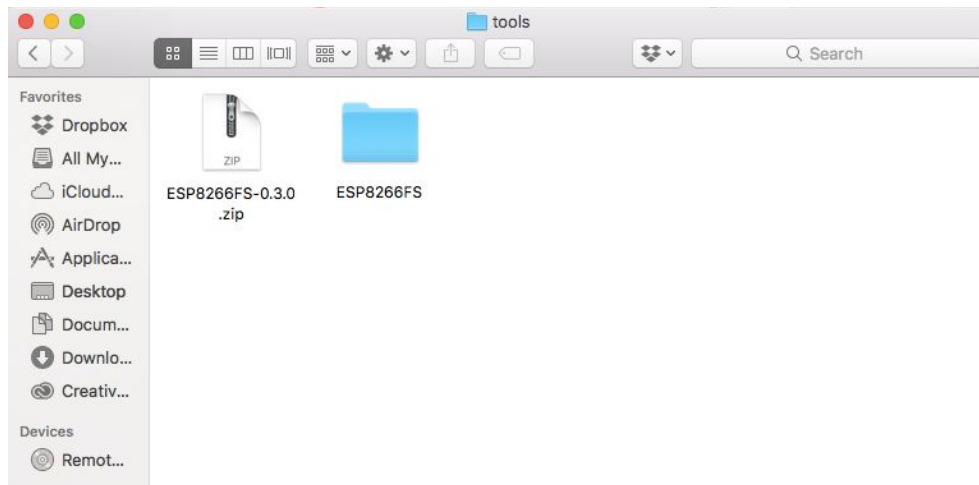
11. If you click on the "ESP8266FS" folder, you will find a folder named "tool". In the "tool" folder, you should find a file named "esp8266fs.jar". You do not need to click on it, but check this to make sure you've downloaded the correct files.
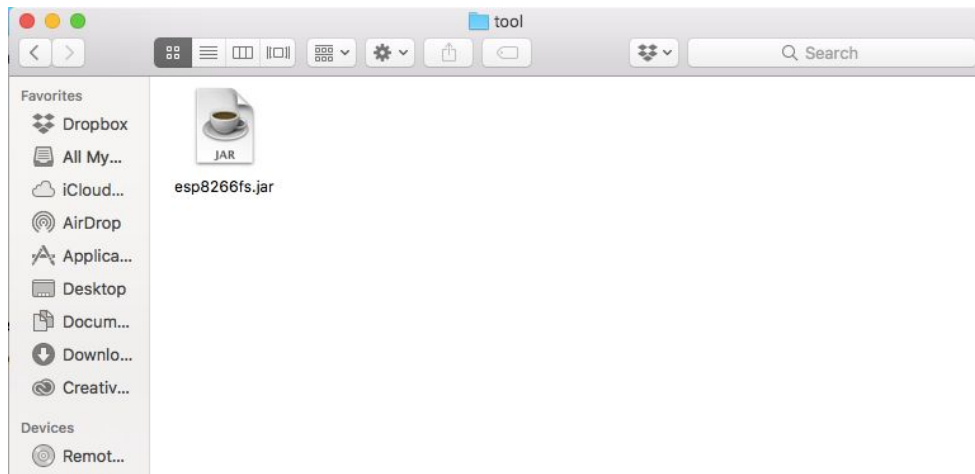
12. Go to "Tools" in the menu bar and select "Board". In the drop-down menu, select "NodeMCU 1.0 (ESP-12E Module)".
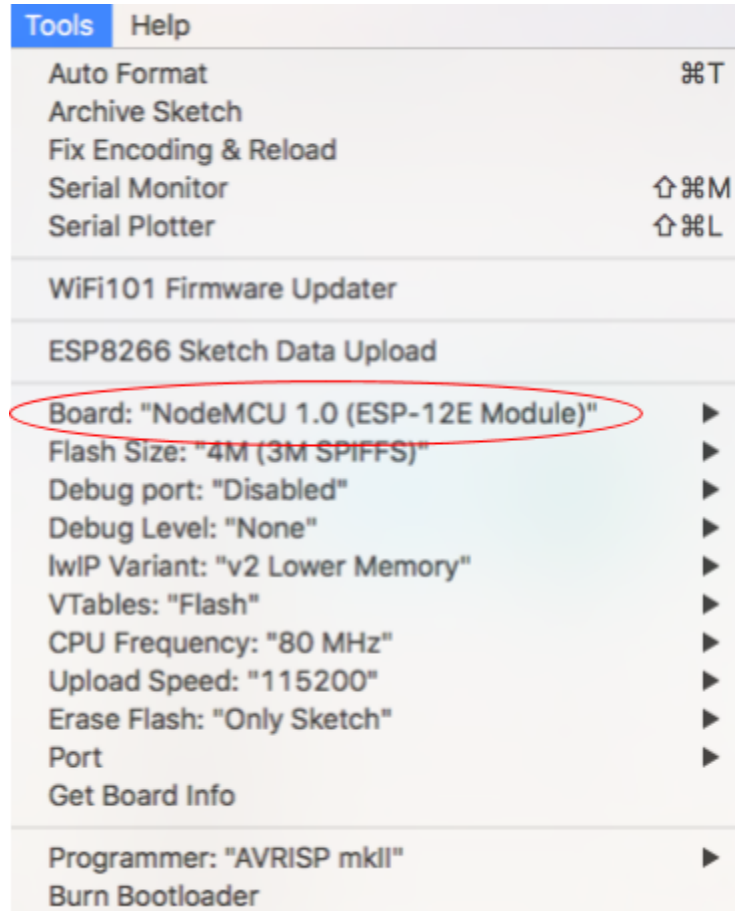
13. Now, you need to make sure your computer can communicate with the NodeMCU through the USB to Micro USB cable. Click on the link and download the suitable driver: https://www.silabs.com/products/development-tools/software/usb-to-uart-bridge-vcp-drivers

14. Open the .zip file from your "Downloads" folder and follow the instructions to install the driver.

15. Restart your computer. Reopen "paperbot.ino" and go to "Tools" in the menu bar. In the drop-down menu, go to "Port" and select "/dev/cu.SLAB_USBtoUART".
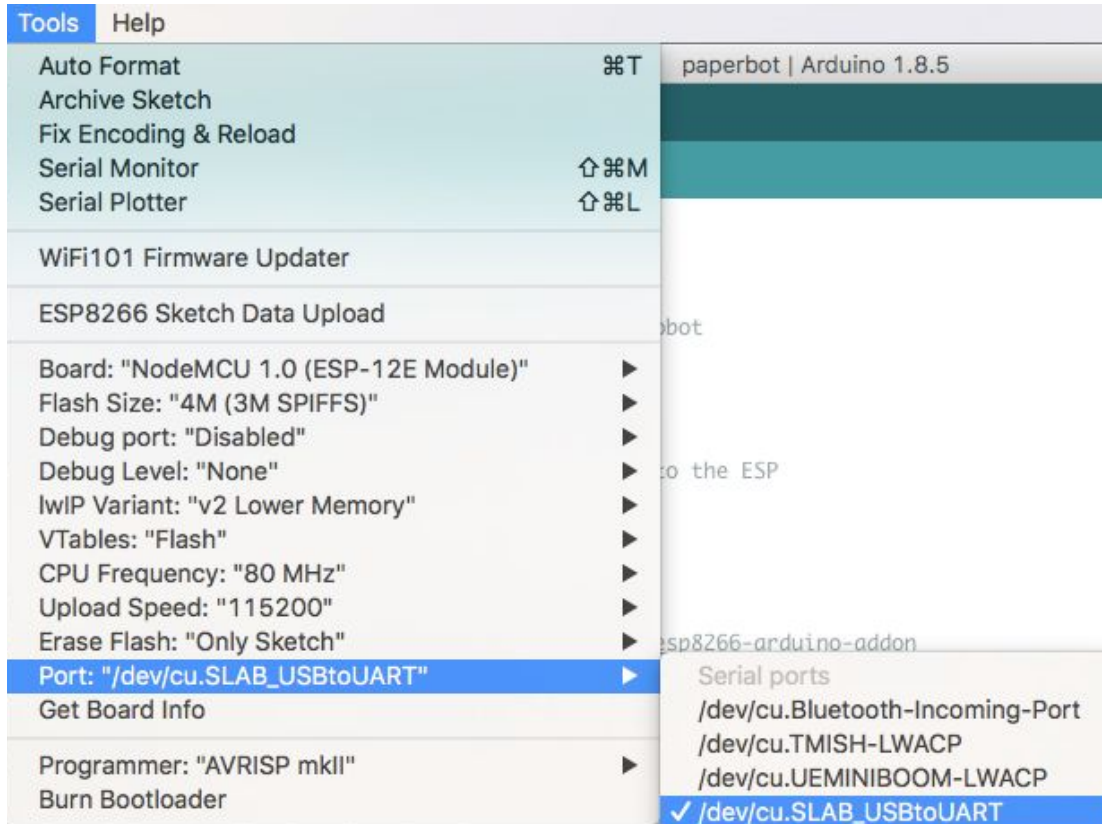
16. Go to "Tools" in the menu bar. In the drop-down menu, go to "Flash Size" and select "4M (3M SPIFFS)". Go to "CPU Frequency" and select "80 MHz". GO to "Upload Speed" and select "115200". You can refer to the picture given above for more clarity.

17. In the menu bar, go to "Sketch" and choose "Show Sketch Folder". Make sure that there is a folder named "data" with the files "controls.html" and "style.css". You don't have to click on them, but make sure that they are there.
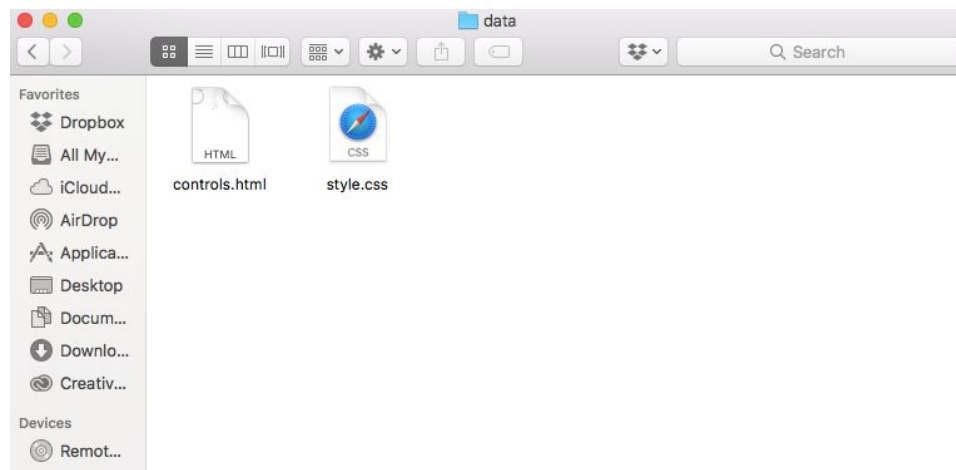
18. Select "Tools" and click on "ESP8266 Sketch Data Upload". Once you are done, the message "SPIFFS Image Uploaded" will appear in the status bar at the bottom of the window.

19. Finally, you can click on the arrow at the top left corner of the window and upload the code onto the NodeMCU.

20. Once you have finished this, you can disconnect the NodeMCU from the computer. The microcontroller outputs a WiFi signal starting with ESP you can connect to using your phone, tablet or laptop device. Then go input the IP address 192.168.4.1 into your device's web browser to control the car.

(2:27:23 PM) : RX = ESP_000B45BF   (2:27:23 PM) : CONNECTED
(2:27:23 PM) : RX = Connected to
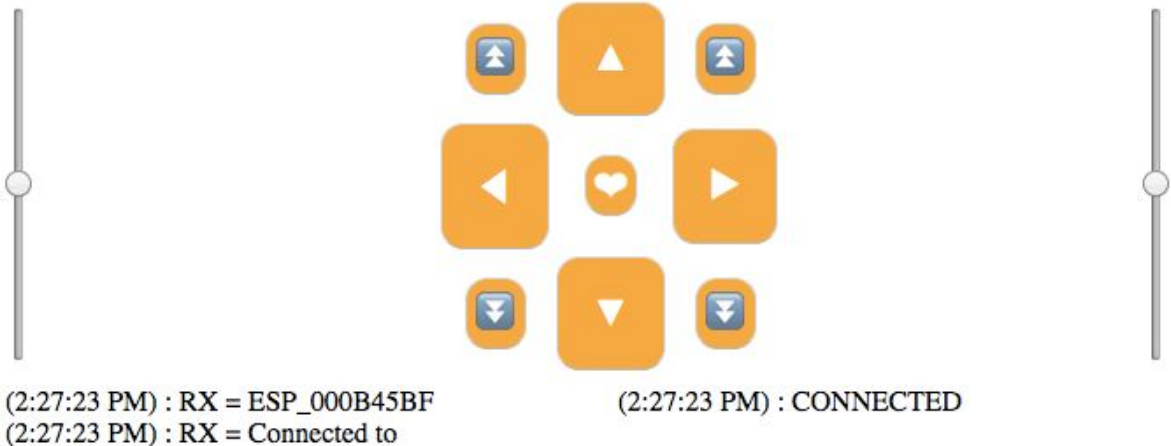
21. Drive it around and have some fun!

Lesson - Pi

Introduction: What is Pi?

If you've done almost any math involving circles, odds are you've used the number pi. Also written as π, pi is a very special number when it comes to circles. To find the area of a circle you use the equation $A = \pi r^2$ and to find the circumference of a circle, you use the equation $C = 2\pi r$ where r is the radius of the circle. With just the measurement of the radius, you are able to find these important values all because of pi, but what is pi? Pi is simply the ratio between the circumference of a circle and its diameter, which is exactly what this demonstration will show.

Pi is an extremely significant number that has been known for nearly 4000 years. We normally just use the value 3.14, but pi is actually an irrational number, meaning the decimal never ends and never repeats. Mathematicians, with the help of computers have been able to find 10 trillion digits of pi. Long before computers, over 4000 years ago, ancient Egyptians and Babylonians were able to get rough guesses of pi, calculating it to be 3.16 and 3.12. If people could do it 4000 years ago, you can do it know, so lets get started on understanding and calculating pi! If you look at the equation $C = 2\pi r$ and use a little bit of algebra to move some variables around, the relationship between diameter and circumference becomes clear.

$C = 2\pi r$ This equation tells us the circumference of a circle is equal to the circle's radius times 2 multiplied by pi. Let's simplify that.

$C = \pi d$ Because a circle's radius is one half the length of its diameter, $2r$ can become d for diameter because it takes 2 radii to make 1 diameter.

$\frac{C}{d} = \pi$ By dividing both sides by d, now we have the relationship between circumference

and diameter

Let's Take Some Measurements!

If you have already built your two wheeled race car robot, then great! If not, you can still find pi just as easily. Here is what you need to do to find pi.

1. Cut out (if it isn't already) and measure the diameter of the circle you are using. Make sure you measure from one side of the circle to the opposite side, going through the center of the circle as shown.The cool thing about pi is that it doesn't matter what size circle you use. It also doesn't matter if you measure in inches, centimeters, or any other unit as long as you use the same one for all your measurements. Write down your value for the diameter on the calculations page.
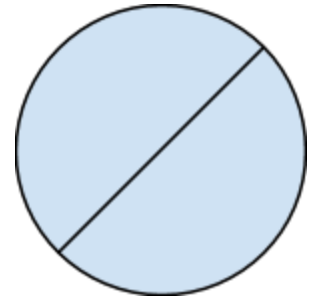
2. Make a small mark on the circle at any point along the edge

3. If you have not made the two wheeled race car, put the wheel on a paper clip. Lay a piece of paper on the table and rotate the wheel so the mark you just made is touching the paper. Mark this point on the paper. If you have the two wheeled race car, drive it forward until the mark on the wheel touches the paper again, the wheel has now gone one full revolution. Mark this point on the paper. If you are using a paperclip, do exactly the same, but by roll the wheel forward using the paperclip (Roll the wheel in as straight of a line as possible). Measure the distance between the two points on the paper. This distance is the circumference of the circle, write down the value on the calculations page
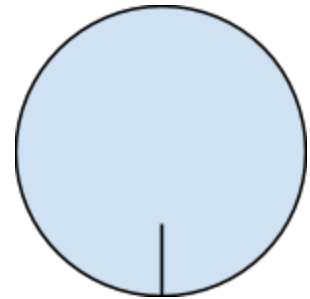
Let's Calculate Pi!

Write down your found values for diameter and circumference here (Don't forget your units!)

Diameter: _____

Circumference: _____

Divide your found circumference by the diameter. What did you get as your value for pi?

Pi: _____

How close were you to the actual value? Did you do better than the ancient Egyptians and

Babylonians? If not, Why? What could be done to make your value more accurate?

_____

_____

_____

_____

_____

Try this again with a different sizes of circles. If you used your two wheeled race car robot

before, use a paperclip instead so you don't have to change the wheels.

What this trial more accurate of less accurate than the one before? Why do you think that is?

What could be done in future trials to improve your result?

_____

_____

_____

_____

_____

Lesson - Measurements and Units, Speed and Average

Summary:
The following activities are being used to learn concepts in physics and math using a single robot: the two wheeler paper car.
Students will learn about units and conversions by measuring distances and time.
This information will be used to introduce the concept of speed to students.
Finally, by taking several calculations, students can learn about averages (mean, median, mode).

Subjects Topics Covered:
- Math - Measurements and Conversions
- Physics - Speed
- Math - Statistics

Learning Objectives:
- Take measurements and convert between different units.
- Learn the difference between base units and derived units through calculation of speed.
- Learn and know how to use the formula of speed.
- Know the different ways of calculating average.

Materials needed:
- Printable robot car -
  https://docs.google.com/document/d/1QOZm5OIf2MDEg2lgWulSbQRUB9CkfvRab6pC4CVkHVY/edit?usp=sharing
- Rulers marked with different units of measurement -
  https://www.amazon.com/dp/B073GN6XPH/ref=psdc_1069364_t1_B073GM75MG
- Stopwatch/Timer -
  https://www.amazon.com/dp/B07D15FNPL/ref=sspa_dk_detail_0?pd_rd_i=B07D16MQ4Y&pf_rd_m=ATVPDKIKX0DER&pf_rd_p=a54d13fc-b8a1-4ce8-b285-d77489a09cf6&pf_rd_r=XRZYG62VTPG3PC115Q2N&pd_rd_wg=fb7VD&pf_rd_s=desktop-dp-sims&pf_rd_t=40701&pd_rd_w=c0u1R&pf_rd_i=desktop-dp-sims&pd_rd_r=d0f45425-9685-11e8-b87d-57bbe9c8dcbd&th=1

Activity Instructions for the Teacher

<u>Measurement and Units Activity</u>

1. Before the activity starts, create a track using marker or tape on the floor with different measurements in increasing order (given in the worksheet) up till 1 meter.
2. Split the students into groups of three students.
3. Pass out the activity worksheets to all the students.
4. Divide the roles for the activity for each student:
    a. One student will be the driver.
    b. One student will be the timer.
    c. One student will measure the distance.
5. Give them rulers with different measurement units.
6. Give each group a stopwatch.
7. Explain the basic outline of the activity:
    a. Tell the student who is measuring the distances to place the car at the starting position and have the student measuring time ready to start.
    b. Using the controls of the car from an electronic device, make the car travel in a straight line until the first checkpoint. The driver and timer should start the car and stopwatch at the same time. When the driver stops the car, the timer should pause the stopwatch.
    c. The student measuring distances should measure and record the length from the start to this checkpoint using the rulers having different measurements to fill up the worksheet.
    d. After they are done with the activity, explain to the students how to convert from one unit to another (like finding out how many centimeters is 1 inch?) and have them follow the same procedure for several different units (that will be mentioned in the worksheet).
    e. Have them fill out the worksheets and then move onto the next activity.

<u>Speed Activity</u>

1. Explain the concept of speed.
2. Ask them to find the distance of some of the distances (mentioned in the worksheet).
3. Ask them to share some of their answers.

<u>Average Activity</u>

1. Explain what average is and the different ways of finding average (mean, median and mode)
2. Ask them to write down their speed for one of the units calculated (probably m/s as that is a commonly used unit for speed) on the board. If there aren't any repeated values, add one or two repeating values for the sake of calculating the mode.
3. Discuss and calculate the mean, median and mode for all the speeds written on the board.

LET'S LEARN MEASUREMENT & UNITS WITH PAPER ROBOT CARS!

Some words to know:
- **Measurement** - The amount or size of something is known as a measurement.
- **Unit** - A unit is just one of something. It is used as a standard for measurement.
- **Conversion** - Changing from one unit to another.

For example, what is your age? If you are 10 years old:

10 is the **measurement** of your age.
Years is the **unit** that is used to count how many years you are.

Let's say you want to know how many months old you are.
On your birthday, you are 120 months old.

120 is the **measurement** of you age.
Months is the **unit** that is used to calculate your age.

How did we get from 10 years to 120 months?

Since **1 year** is equal to **12 months**:

$$10 \text{ years} \times 12 = 120 \text{ months}$$

To **convert** someone's age from **years** to **months**, we **multiply** by **12**.

What if we have someone's age in **months** and want to **convert** to **years**?

$$120 \text{ months} \div 12 = 10 \text{ years}$$

We should **divide** by **12**.

Similarly, we can measure other quantities as well. In the following activity, we will be measuring the distance traveled by your paper robot car. Before that, let's see what all you know so far.

LEMUR, UCLA
Emily Evans, Tanvi Pati

Pre-Activity Questionnaire - Measurements and Units

Choose an answer for the questions below:

1. Which is the biggest length?
   - ☐ 1 centimeter
   - ☐ 1 inch
   - ☐ 1 foot
   - ☐ 1 meter
   - ☐ I don't know

2. How many centimeters is 1 meter?
   - ☐ 3
   - ☐ 10
   - ☐ 100
   - ☐ 1000
   - ☐ I don't know

3. How many inches is 1 foot?
   - ☐ 3
   - ☐ 10
   - ☐ 12
   - ☐ 100
   - ☐ I don't know

4. How many inches is 1 yard?
   - ☐ 3
   - ☐ 12
   - ☐ 36
   - ☐ 100
   - ☐ I don't know

5. How easy do you think conversions are?
   - ☐ Super easy
   - ☐ A little confusing
   - ☐ I hate conversions!

MEASUREMENTS AND UNITS WITH PAPER ROBOT CARS

Activity Instructions:
- For this activity, you will need:
    - The paper robot car
    - Rulers with different units of measurement
    - Stopwatch
    - A marker or some tape
- There are three roles for the students:
    - The driver
    - The timer
    - The evaluator
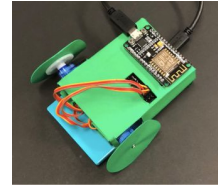
    Divide the roles among yourselves.
- Evaluator: Keep the car's two front wheels at the start position.
- Driver: You need to have an electronic device with WiFi connection. Connect to the car's "ESP_XXXX" wireless network. (XXXX will actually be a number that is the car's ID).
- Driver: Search 192.168.4.1 on the device's internet browser (like Google Chrome or Safari). A web page should appear with four buttons for controlling the car.
- Timer: Set up the stopwatch so that it starts at 0.
- Driver and Timer: Driver should press the forward button and start moving the car in a straight line. Timer should start the stopwatch at the same time that the car starts moving.
- Driver and Timer: Stop the car at the first checkpoint. Timer should pause (do not press stop) the stopwatch at the same time that the car stops moving.
- Evaluator: Using the ruler marked with centimeters (cm), measure the distance from the start position to the first checkpoint. Record the measurement in the given worksheet. If you need help with this task, ask the driver and timer for assistance.
- Evaluator: Measure the same distance, but use the ruler marked with inches instead. Record the measurement in the given worksheet.
- Timer: How much time did the car take to travel from the start to checkpoint? Record it in the worksheet.
- Repeat the same for all checkpoints until you reach the last checkpoint.

Activity Worksheet

Some abbreviations:
- Centimeter - cm
- Inch - in
- Feet - ft
- Meter - m
- Seconds - s

Record the values you found in the table given below:

Distance (cm)	Distance (in)	Distance (ft)	Distance (yard)	Distance (m)	Time (s)
1					
2					
	1				
	6				
		1			
		2			
			1		
				1	

How can we use this information to **convert** from one unit to another?

Let's say, we want to find how many centimeters are 3 inches.
- **Step 1:** Identify which unit you have and which you are converting to.
  - Based on the question, what units does the distance currently have?

    _____

  - What is the unit you want to convert to?

    _____

- **Step 2:**
  - Look at the table again, and find how many centimeters is 1 inch. Write it in the box:
  - Another way to find this out is by dividing the number of centimeters (unit you want to convert to) by the number of inches (unit your number currently has). Do this by using the 4th row of the table and write that number in the box:

- **Step 3:** Multiply the number in the box with the number of inches you wanted to convert to centimeters. So, in this example, you will multiply that number with 3.

$$\underline{\quad 3 \quad} \textbf{ in } \quad \text{X} \quad \underline{\qquad\qquad} \quad = \quad \underline{\qquad\qquad\qquad} \textbf{ cm}$$
<div align="center">number in box</div>

- If we want to convert from centimeters back to the inches:
  - Divide the number you calculated in step 3 by the number in the box from step 2.

$$\underline{\qquad\qquad} \textbf{ cm } \quad \div \quad \underline{\qquad\qquad} \quad = \quad \underline{\qquad\qquad\qquad} \textbf{ in}$$
<div align="center">number in box</div>

  - Another way of doing that is finding the number of inches in 1 centimeter. Look at the 1st row of the table and find this number:

  _____

  - You could also divide the number of inches by number of centimeters to get this value. Use the second row of the table to do so:

  _____

  - Follow step 2 and step 3, but use the number you just calculated instead of the number in the box.

Post-Activity Questionnaire - Measurements and Units

Choose an answer for the questions below:

1. Which is the biggest length?
   ☐ 1 centimeter
   ☐ 1 inch
   ☐ 1 foot
   ☐ 1 meter
   ☐ I don't know

2. Convert 2 meters to centimeters.
   ☐ 200 centimeters
   ☐ 100 centimeters
   ☐ 50 centimeters

3. Convert 72 inches to feet.
   ☐ 3 feet
   ☐ 6 feet
   ☐ 21 feet

4. How many inches is 1 yard?
   ☐ 12 inches
   ☐ 24 inches
   ☐ 36 inches

5. How easy do you think conversions are?
   ☐ Super easy
   ☐ A little confusing
   ☐ I hate conversions!

Pre-Activity Questionnaire - Speed

Choose an answer for the questions below:

1. Which is your definition of speed?

   _____

   _____

   _____

2. Choose the correct formula of speed.
   ☐ Speed = Distance + Time
   ☐ Speed = Distance ÷ Time
   ☐ I don't know

3. Are the units of speed base units or derived units?
   ☐ Base
   ☐ Derived
   ☐ I don't know

4. Calculate the speed of a girl who walked 500 meters in 10 minutes.
   ☐ 5 meters/second
   ☐ 50 meters/minute
   ☐ I don't know

5. How well do you understand speed?
   ☐ Very well
   ☐ A little confusing
   ☐ I hate speed!

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HOW FAST CAN YOUR CAR GO?

Remember how you measured the amount of time it took to travel to each checkpoint?
Now, we are going to use all that information to learn about **speed**!

The basic definition for speed is how much **time** an object takes to move a certain
distance.

We have already calculated these two values in our previous activity. Now, let's calculate
the car's speed!

$$\text{Speed} = \text{Distance} \div \text{Time}$$

So, for each measurement you took, you will divide the distance by time taken to travel
that distance to obtain the speed.
How will you know which measurement to use? Use any!
The **unit** of speed changes based on the unit of distance and time. This means that speed
has a **derived unit**, whereas distance and time have **base units.**
So, what is the unit of speed? It is the unit of distance divided by the unit of time.
For example, if the car moved **3 cm** in **3 s**, the speed is **1 cm/s**.

Now, let's use some of the measurements from the table from the previous activity to
calculate speed! Fill up the blank cells in the table given below:

Distance	Distance Unit	Time	Time Unit	Speed	Speed Unit
2	cm				
6	in				
2	ft				
1	yard				
1	m				

Post-Activity Questionnaire - Speed

Choose an answer for the questions below:

1. Which is the definition of speed?

   _____

   _____

   _____

2. Choose the correct formula of speed.
   ☐ Speed = Distance - Time
   ☐ Speed = Distance ÷ Time
   ☐ I don't know

3. Are the units of speed base units or derived units?
   ☐ Base
   ☐ Derived
   ☐ I don't know

4. What was the fastest speed your car travelled?

   _____

5. How well do you understand speed?
   ☐ Very well
   ☐ A little confusing
   ☐ I hate speed!

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Pre-Activity Questionnaire - Averages

Choose an answer for the questions below:

1. What does the word "average" mean to you?

   _____

   _____

   _____

2. Match the following:

   Mean   Number situated in the middle of all the values

   Median   Number calculated by dividing the sum of
                                          values by the number of values

   Mode   Number that appears most frequently in the set
                                          of values

3. How easy do you think calculating averages are?
   ☐ Super easy
   ☐ A little confusing
   ☐ I hate averages!

LET'S AVERAGE IT OUT

Now, let's learn about average!

In Math, **average** means a 'central' number for a set of many numbers that measure the same thing. So, which number best represents the set of numbers?

Let's say you want to calculate the average of ages of 5 people. Their ages are 9, 10, 10, 10 and 11 years. How would you do this?

There are three ways to calculate the average:
- **Mean** - Add up all the values and divide by the number of values.

$$\frac{9 + 10 + 10 + 10 + 11}{5} = \frac{50}{5} = \textbf{10 years}$$

- **Median** - Write all the values in ascending order. Cross out the numbers at the ends and keep going until only one number in the center is not crossed out.
    - Step 1:

9, 10, 10, 10, 11

    - Step 2:

9, 10, 10, 10, 11

    - Step 3:

9, 10, (10), 10, 11

Therefore, the median is **10 years.**
- **Mode** - The number that is repeated the most in the set.

9, 10, 10, 10, 11

9 appears **1** time, 10 appears **3** times, and 11 appears **1** time. Therefore, the mode is **10 years.**

Now, let's do an activity with the entire class. Write down what value of speed you got for the unit **m/s** on the board.

- First, let's calculate the **mean** of all the speeds in the class.
  - What is the sum of all the speeds?

    _____

  - What is the number of values written on the board?

    _____

  - Calculate the mean:

    _____

- Second, let's calculate the **median** of all the speeds in the class.
  - Write all the speeds in increasing order:

    _____

  - Cut out the values from both ends untils you get one value in the center.
  - What is the median?

    _____

- Finally, let's calculate the **mode** of all the speeds in the class.
  - Write down how many times each speed appears on the board:

    _____

    _____

    _____

    _____

    _____

  - Which is the mode (number that appears the most)?

    _____

Post-Activity Questionnaire - Averages

Choose an answer for the questions below:

1. What does the word "average" mean?

    _____

    _____

    _____

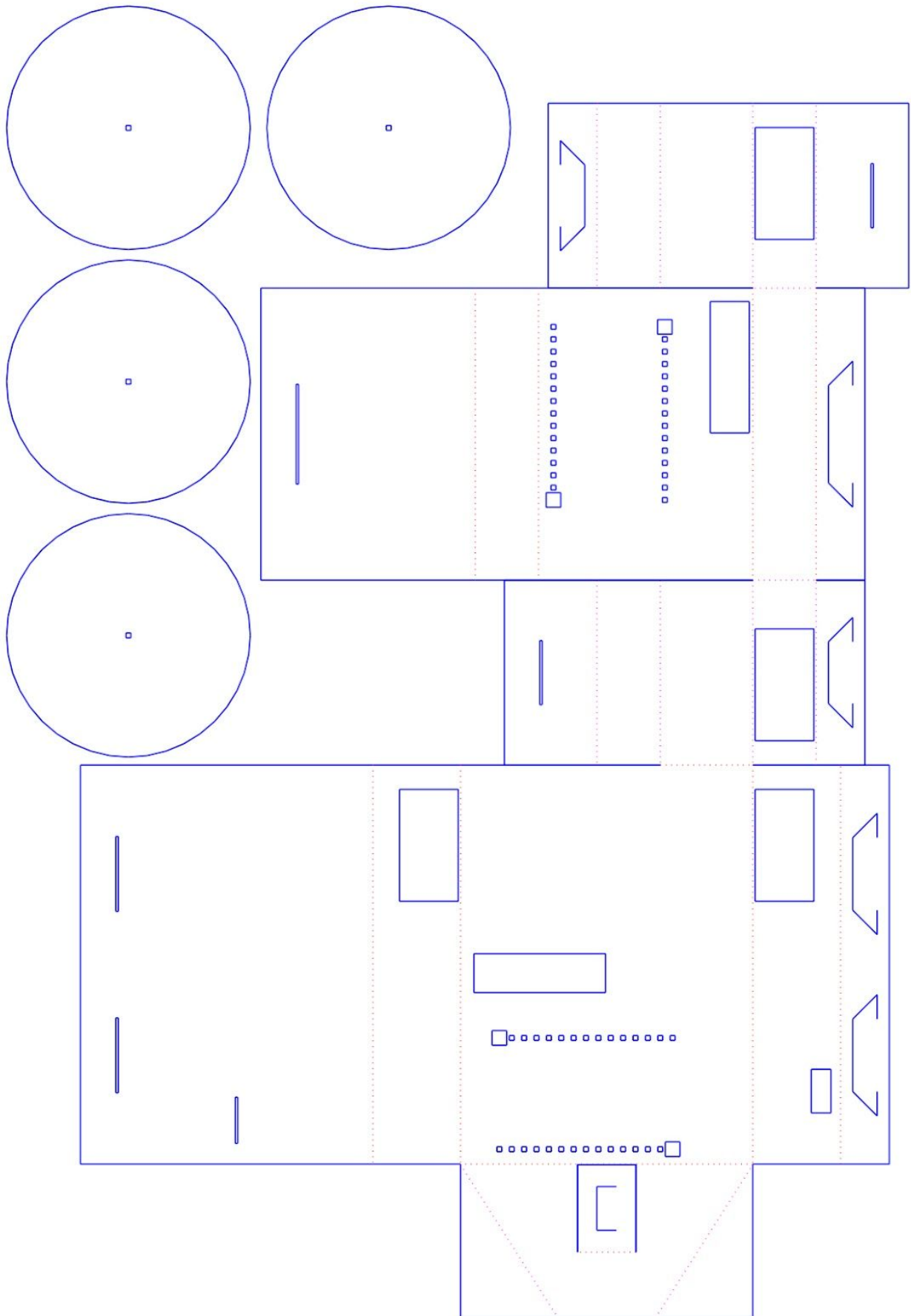2. What are the three ways of calculating the average of a set of values?

    _____

    _____

    _____

3. How easy do you think calculating averages are?
    ☐ Super easy
    ☐ A little confusing
    ☐ I hate averages!

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References

- https://git.uclalemur.com/mehtank/paperbot
- https://www.arduino.cc/en/Main/Software
- https://learn.sparkfun.com/tutorials/esp8266-thing-hookup-guide/installing-the-esp8266-arduino-addon
- https://github.com/esp8266/arduino-esp8266fs-plugin/releases
- https://www.silabs.com/products/development-tools/software/usb-to-uart-bridge-vcp-drivers
- https://www.pcworld.com/article/191389/a-brief-history-of-pi.html
- https://www.ck12.org/measurement/tools-for-measurement-of-customary-and-metric-lengths/lesson/Appropriate-Tools-for-Measurement-of-Squares-and-Rectangles-MSM7/
- https://www.teachengineering.org/activities/view/nyu_unitconv_activity1
- https://www.vectorstock.com/royalty-free-vector/stopwatch-line-icon-fitness-and-sport-vector-19221886
- https://www.pickleballdepot.ca/products/vinyl-court-tape
- https://www.pinterest.co.kr/pin/15833036167185200/
- https://www.mathsisfun.com/definitions/average.html