

# EasyHerb

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## Group 7

Luna Vazquez-EE

Lindsey Feldman-EE

Chris Hernandez-EE

Kyle Patrick Magboo-CpE



# Motivation



Herbs grown outside face multiple hardships



Design a hydroponic system that can grow herbs in a house or apartment



Other systems are too big or expensive



Easy to use system that an average person can maintain

# Goals and Objectives



System should be automated only requiring minimum observation



Make the system lightweight and portable



User will be alerted when a negative change has occurred



System should be user-friendly and convenient



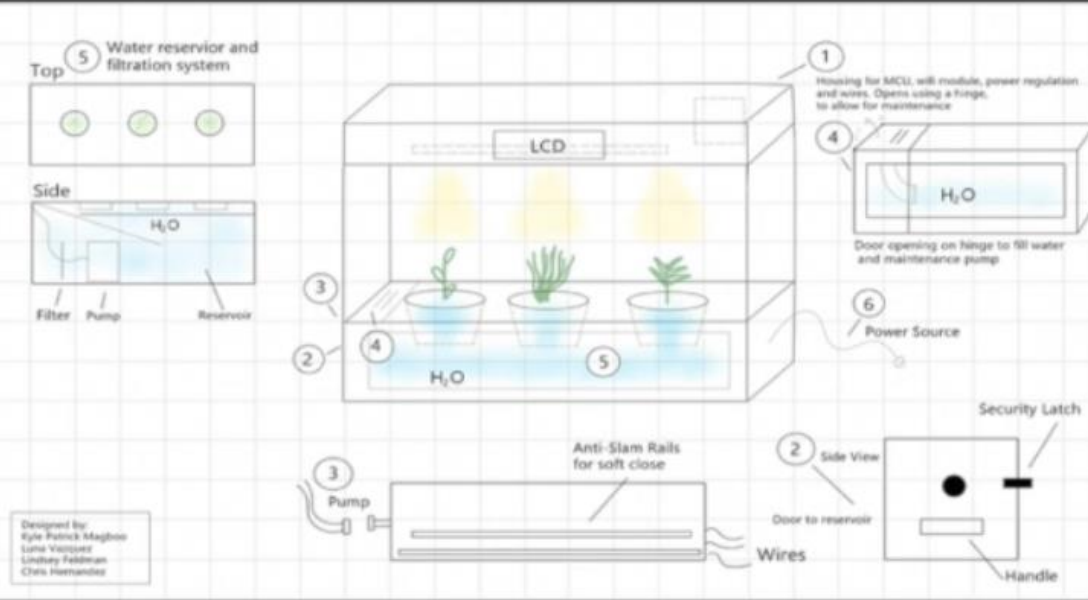
Herbs will be grown in a constant optimal environment

# Specifications

Attribute	Value
Weight (empty)	Less than 15 lbs.
Dimensions	32" x 8" x 28"
Number of Plants	2
Operating Temperature	0 ° to 45 °C
Operating Voltage	12V
Water Volume	8 liters
Sensor Measurements	1 per hour or on demand
pH Sensor Range	0 - 14
Ambient Temperature Range	15.5° to 21 °C
Water Temperature Range	18.3° to 21 °C

Water Pump Flow Rate	63 Liters per hour ( 16 Gallons per hour)
Camera Resolution	2 megapixels
Grow Lights Intensity	Red: 390 – 420 mcd Green: 660 – 720 mcd Blue: 180 – 200 mcd
LCD Resolution	480x320
Data Rate	6Mbps - 54Mbps
Maximum Signal Power	16dBm
Microcontroller Frequency	16 MHz
Microcontroller Flash Memory	32 KB
Microcontroller Architecture	8-bit
Working Environment	Indoor

# Design Overview

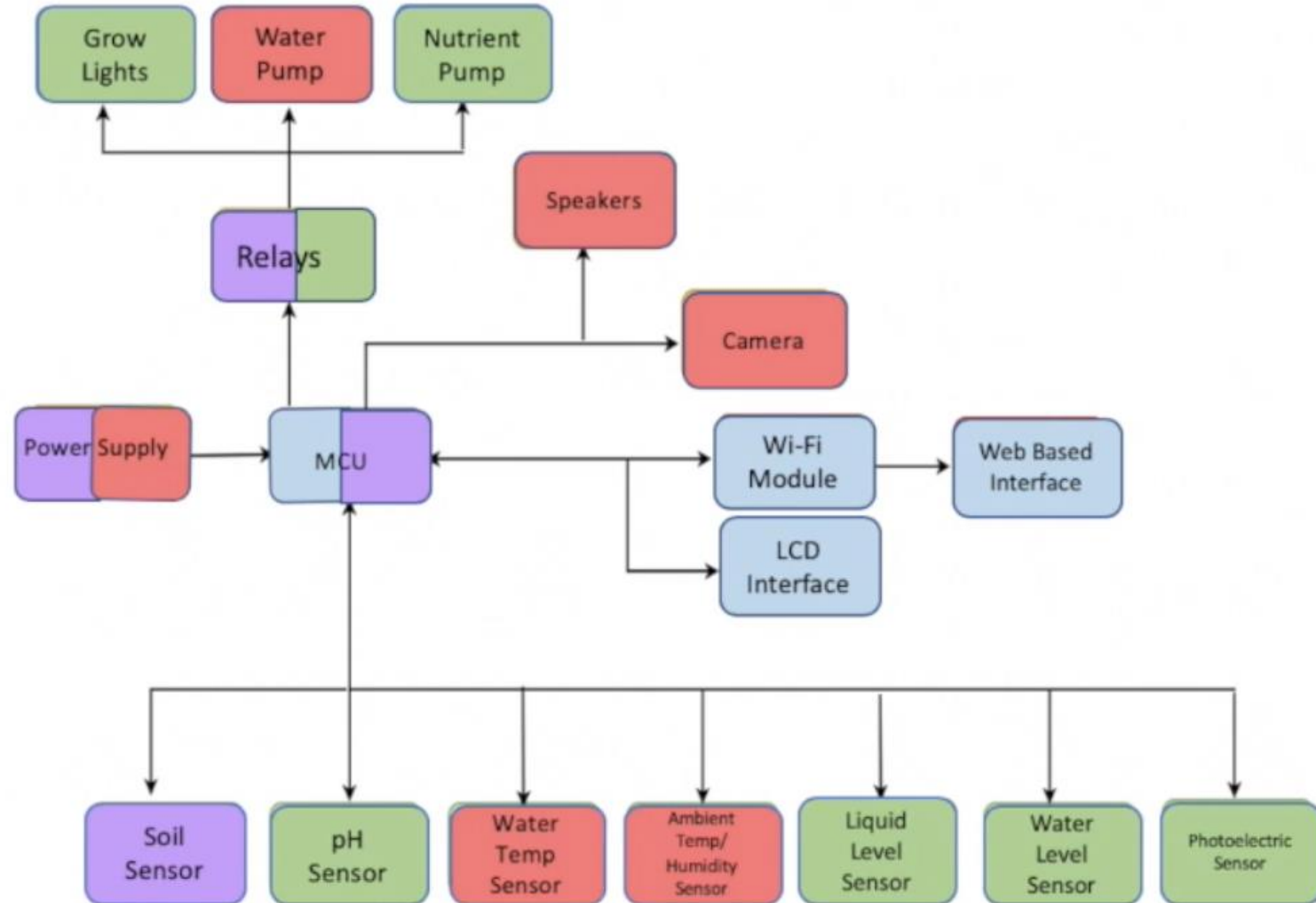


- Multiple subsystems will be used to assist different aspects of plant care
- A variety of sensors will be included to measure water levels, temperature, light, pH, and humidity
- System must be kept compact
- User will interact with the system through the LCD screen and companion website

# Work Distribution

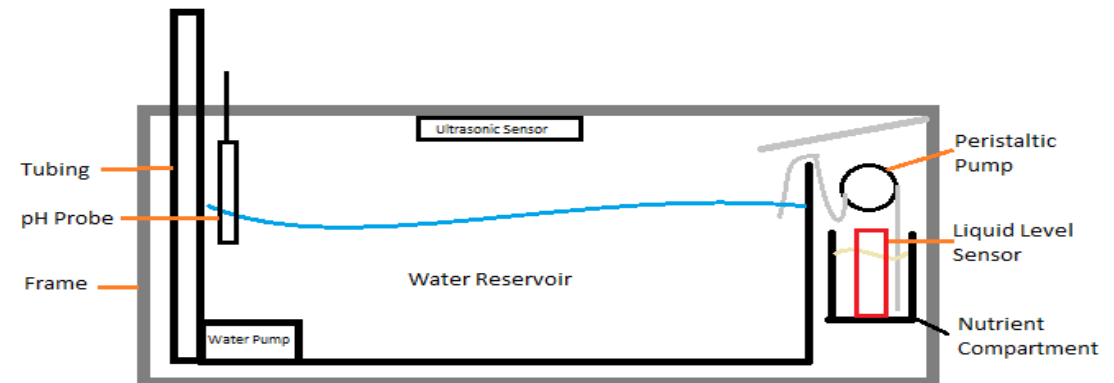
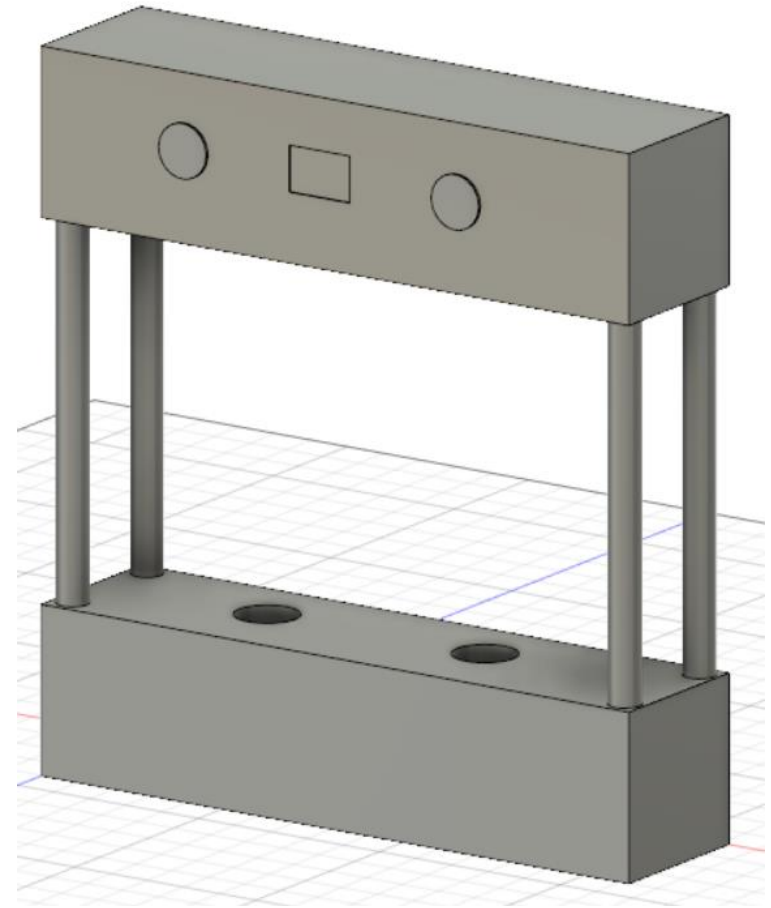
Group Member	Corresponding Color
Luna Vazquez	Light Purple
Lindsey Feldman	Light Green
Chris Hernandez	Light Red
Kyle Patrick Magboo	Light Blue

\*Blocks containing multiple colors indicate the primary member on the left and the secondary member on the right



# Enclosure Design

- **Top Enclosure:**
  - Will contain PCB, LCD screen, speakers
  - Grow lights will hang from the bottom
- **Middle Area:**
  - Will house herbs
  - Will contain temperature/humidity sensor, soil sensor and camera
  - Will contain Irrigation system
- **Bottom Enclosure:**
  - Will contain water and nutrient pumps
  - Will contain water and nutrient reservoirs
  - Will house water level sensor and water temperature sensor





# Nutrient System



Supplemental nutrient solution is essential for hydroponic growing



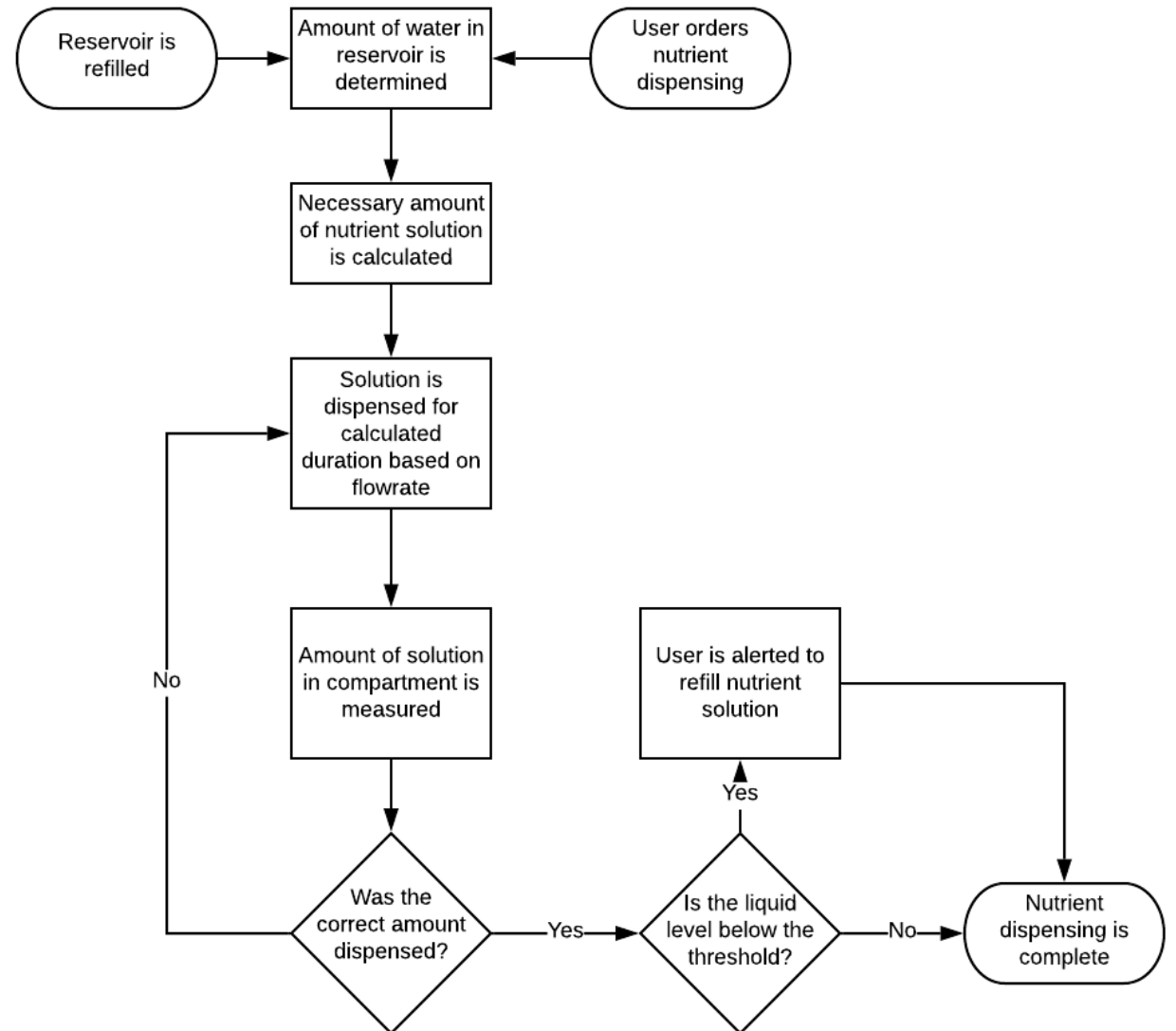
Dispenses necessary nutrients into water reservoir



Measures amount of water in reservoir and dispenses the correct amount of nutrient solution

Peristaltic pump transports solution to reservoir from compartment

Liquid level sensor monitors amount of solution in compartment



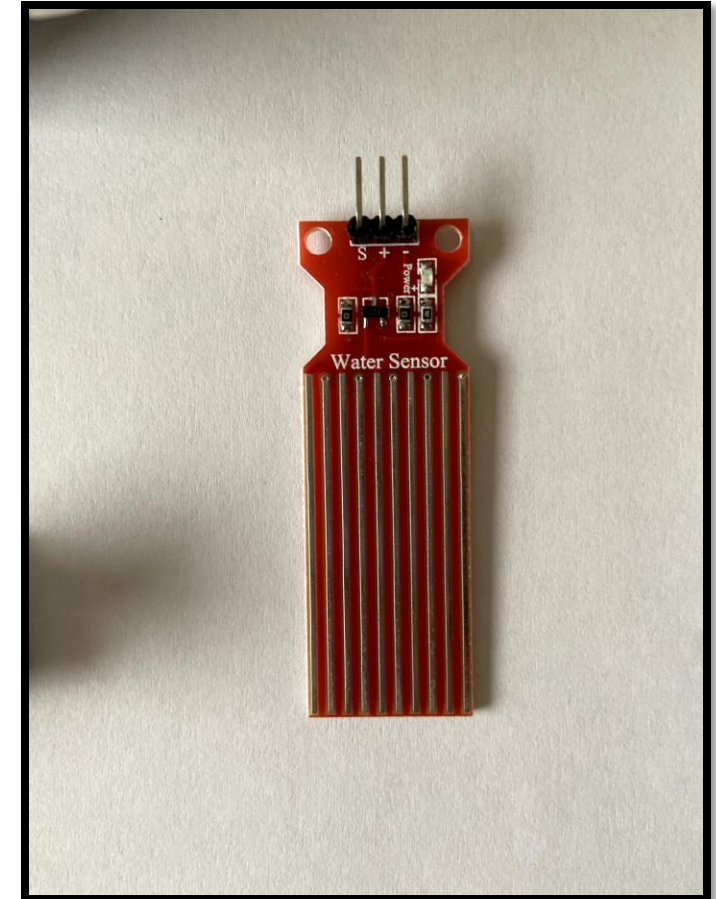


# Nutrient Level Sensor

Part	Water Level Sensor	Mini Liquid Level Sensor
Manufacturer	SUKRAGRAHA	Waveshare
Operating Voltage	3 – 5 V DC	2.0 – 5.0 V DC
Operating Current	< 20 mA	< 20 mA
Operating Temperature	10 – 30 °C	10 – 30 °C
Dimensions	2.5" x 0.75"	2.48" x 0.75"
Cost	\$5.99	\$4.99

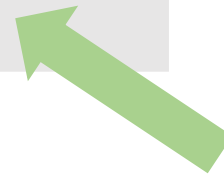


Selected Component



# Nutrient Pump

Part	Peristaltic Pump Liquid	Gravity: Peristaltic (DFR0523) Digital Pump	Peristaltic Pump (1150) Liquid
Manufacturer	INTLLAB	DFRobot	Adafruit
Working Temp.	0 – 40 °C	0 – 40 °C	0 – 40 °C
Voltage	12 V DC	5 – 6 V DC	12 V DC
Current	400 mA	1.8 A	200 - 300 mA
Flowrate	19 – 100 mL/min	>= 45 mL/min	<= 100 mL/min
Dimensions	3 mm ID x 5 mm OD	27.4 x 28.7 mm	27 mm diameter, 72 mm total length
Cost	\$9.80	\$59.50	\$24.95



Selected  
Component

# pH Sensor

<b>Part</b>	SEN0161-V2	E-201-C
<b>Manufacturer</b>	DFRobot	GAOHOU
<b>Supply Voltage</b>	3.3 ~ 5.5 V	5 V
<b>Operating Temperature</b>	5 ~ 60 °C	-10 ~ 50 °C
<b>Detection Range</b>	0 – 14	0 – 14
<b>Zero Point</b>	7 ± 0.5	7 ± 0.25
<b>Response Time</b>	< 2 min	< 5 s
<b>Internal Resistance</b>	< 250 MΩ	≅ 250 MΩ
<b>Output</b>	Analog	Analog
<b>Module Dimensions</b>	42 x 32 mm	42 x 32 x 20 mm
<b>Cost</b>	\$39.50	\$33.99



Selected  
Component

# Watering System



Hydroponic drip irrigation system

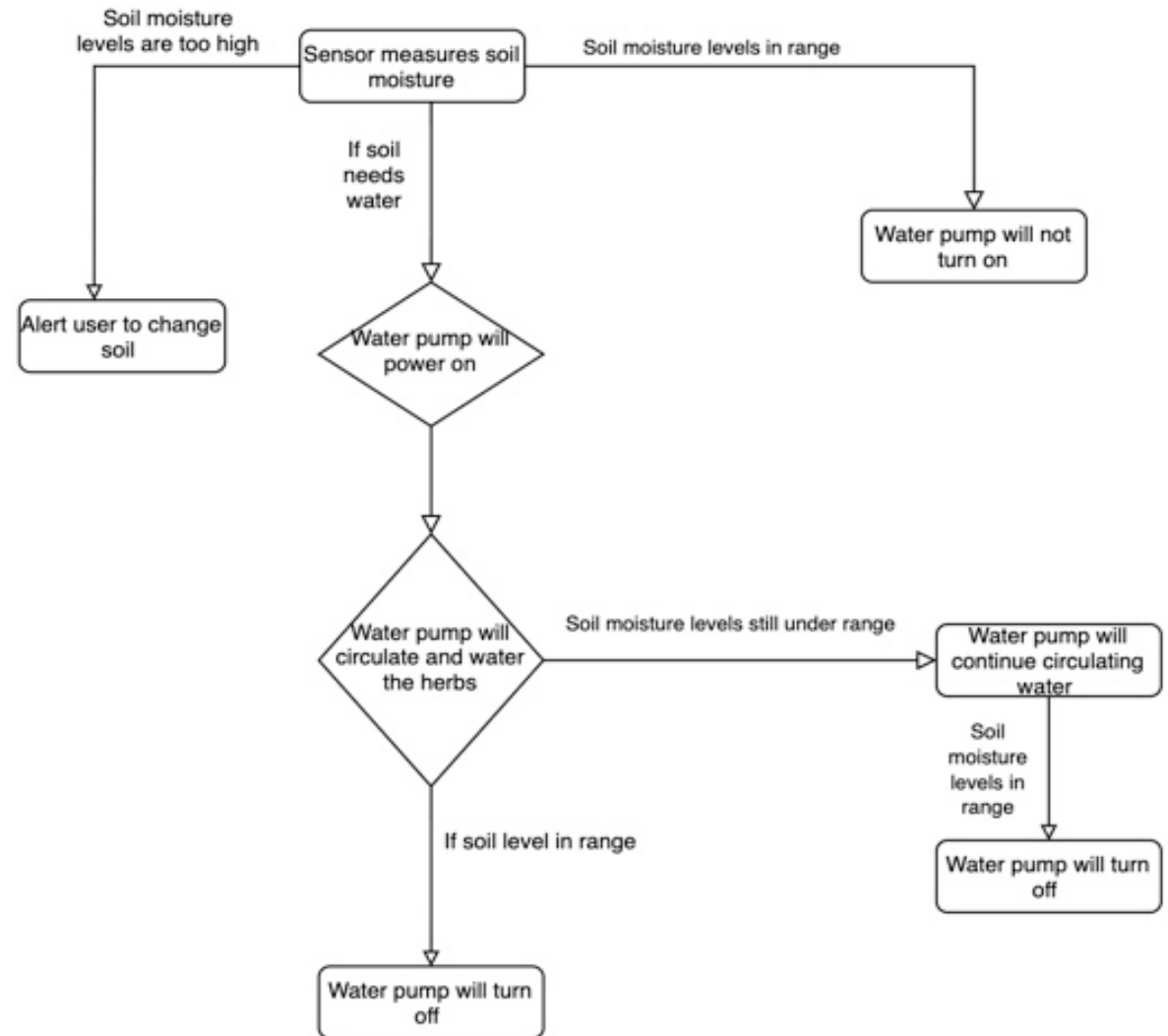


Water containing nutrients is pumped from the reservoir and dripped onto plants

Water will be circulated through the system using drip irrigation

Will distribute the nutrients the herbs need in the solution

Water pump will be controlled by relay



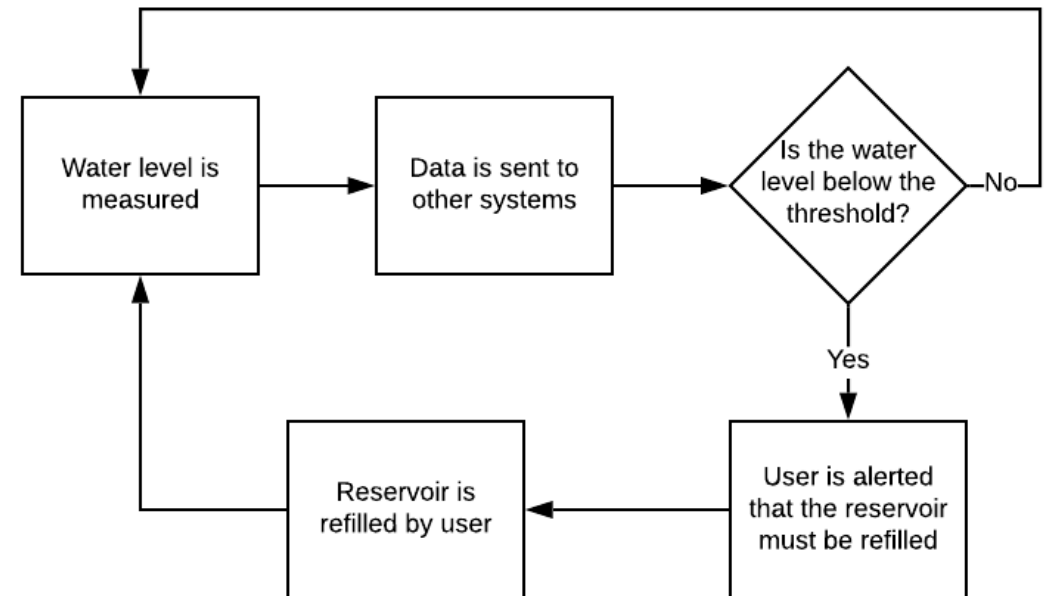
# Water Level Monitoring



Water level in reservoir is monitored, and user is alerted when it is low



Ultrasonic distance sensor measures the distance to the surface of the water, which determine the water level



# Water Temperature Sensor

<b>Manufacturer</b>	Hilitchi
<b>Digital Thermometer</b>	DS18B20
<b>Temperature Testing Range</b>	-55 to 125 degrees Celsius
<b>Cable length</b>	100 cm
<b>Cost</b>	\$12.99 for 5 sensors
<b>Power Supply Range</b>	3 to 5 V
<b>Weight</b>	3.2 ounces



Selected  
Component



# Water Pump

Manufacturer	Active Aqua	Sunshower	Mountain_Ark	Total Pond
GPH Rating	160 GPH	18 GPH	63 GPH	140 GPH
Cost	\$18.33	\$14.99	\$9.99	\$16.84
Power Rating	9.5 W	5.75 W	4.5 W	6.5 W
Head Height	5 feet	4 feet	9.8 feet	4 feet
Fittings	½ inch	¼ inch	¼ inch	½ or 3/8 inch

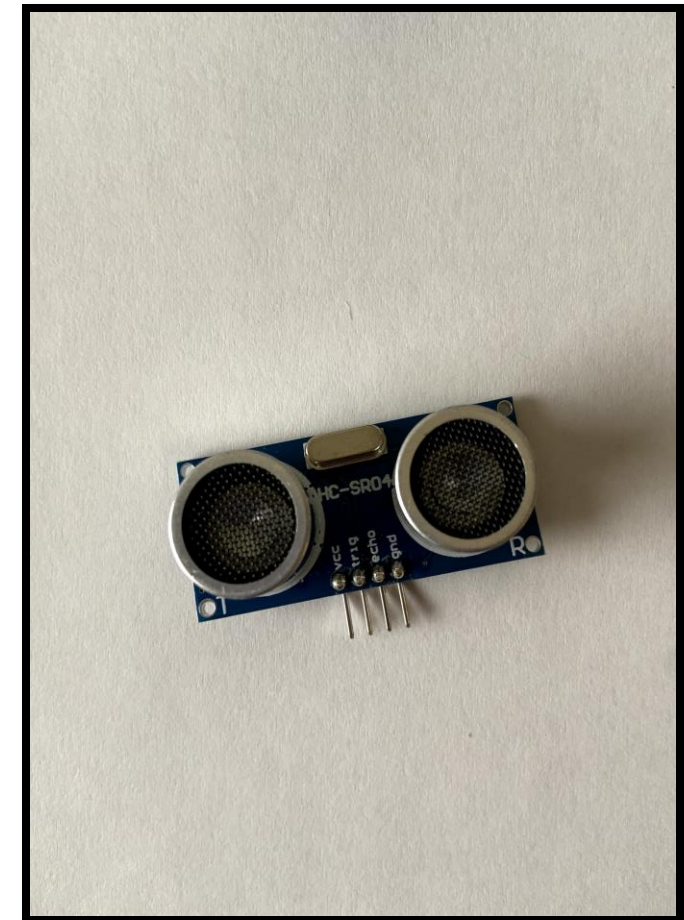
Selected Component





# Water Level Sensor

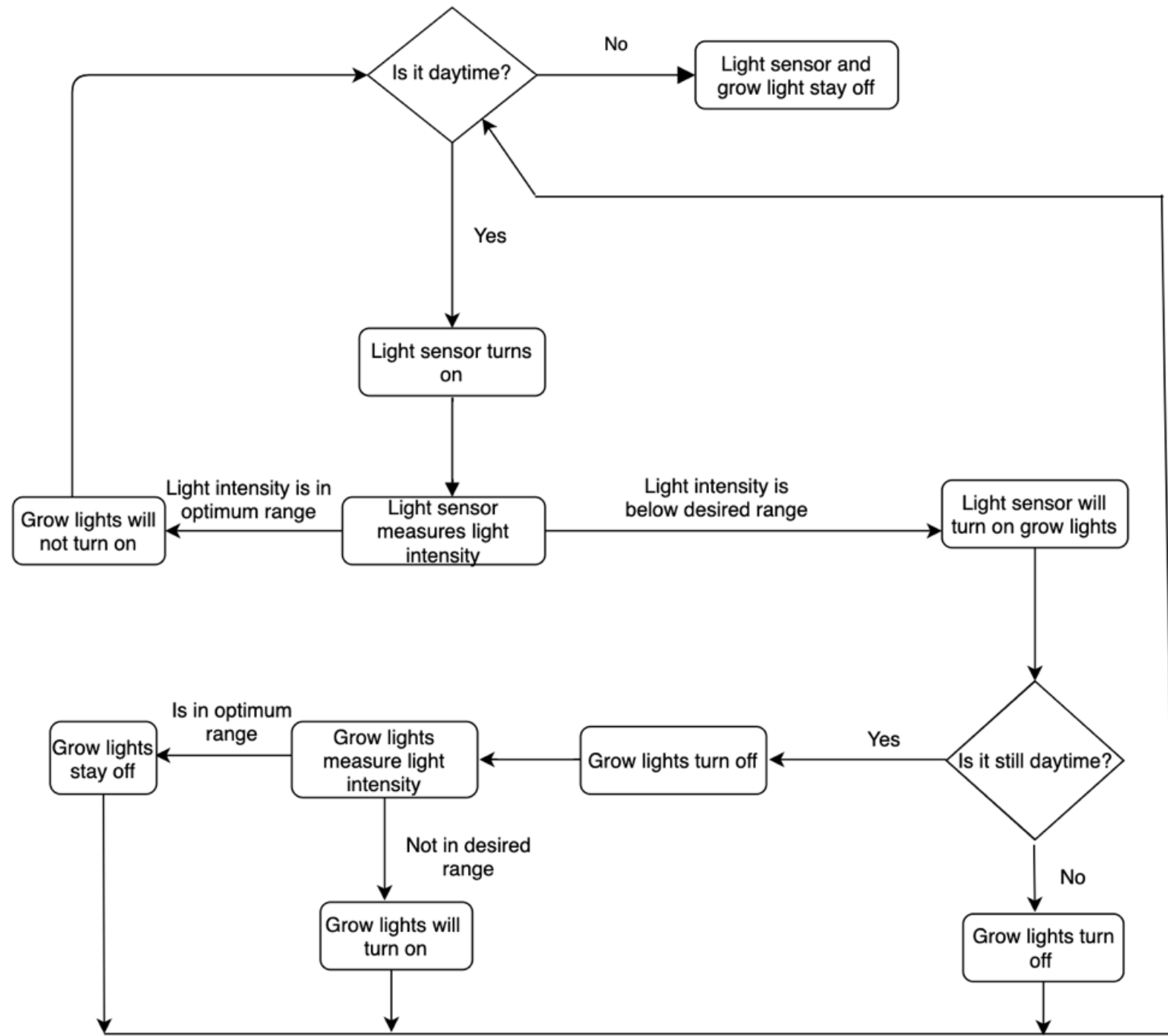
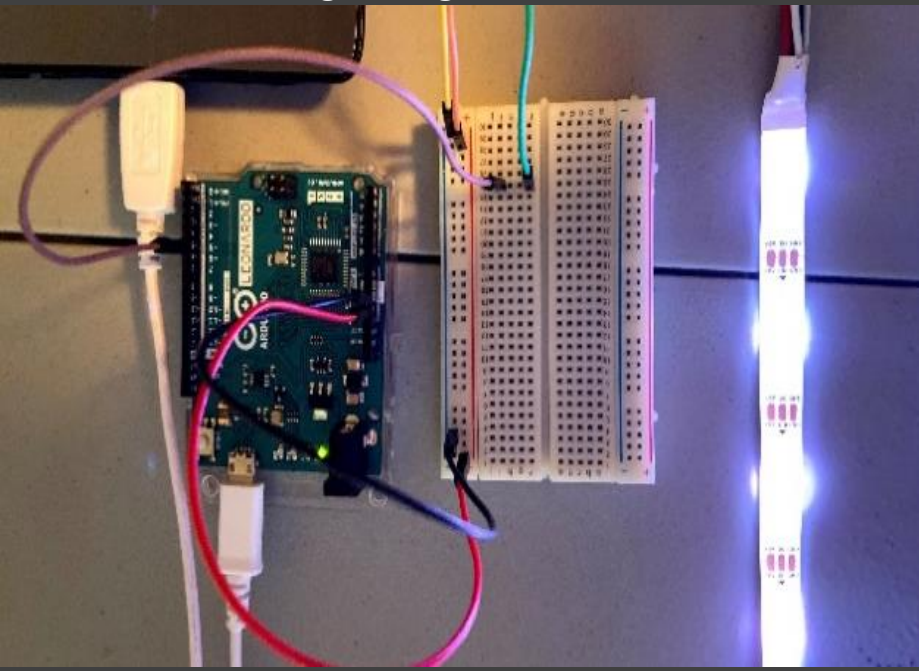
Part	eTape Sensor	Liquid Level	JSN-SR04T	HC-SR04
Manufacturer	eTape		KeeYees	Adafruit
Operating Temperature	-9 ~ 65 °C		-20 ~ 70 °C	-20 ~ 70 °C
Voltage	Vmax = 10 V		3.0 – 5.5 V DC	5 V DC
Distance Range	0 – 31.5 cm		20 – 600 cm	2 – 400 cm
Ultrasonic Frequency	N/A		40 kHz	40 kHz
Working Current	N/A		< 8 mA	15 mA
Resolution	0.25 mm		1 mm	0.3 cm
Dimensions	361 x 25.4 x 0.38 mm		42 x 29 x 12 mm	45.5 x 20 x 15.5 mm
Cost	\$17.47		\$11.99	\$3.95



Selected Component

# Lighting System

- Provides artificial grow lighting to plants
- WS2812b individually addressable LED strip
- Using a relay and LM393 light sensor array to determine when to turn on and off the grow lights

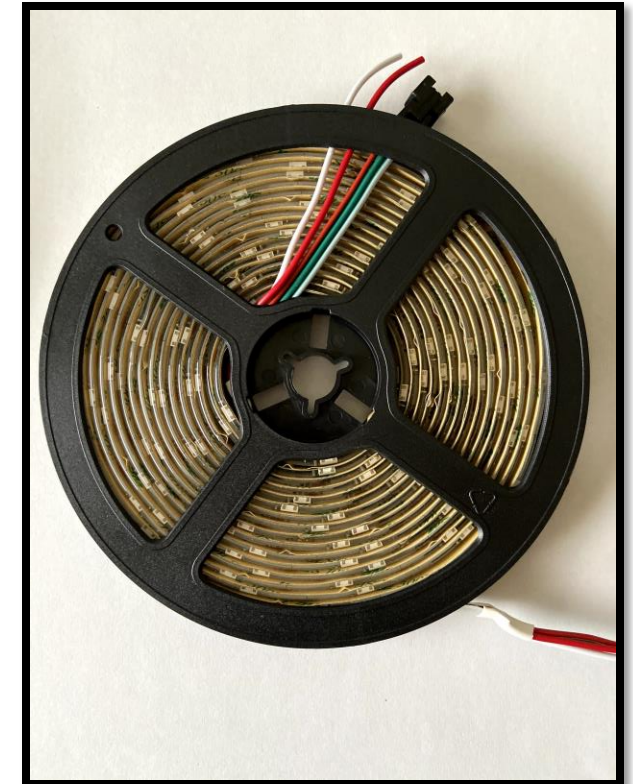


# Grow Lights

Selected Component



<b>Brand</b>	BTF-LIGHTING	BTF-LIGHTING	BTF-LIGHTING
<b>IC Type</b>	WS2812b	WS2811	SK6812 RGBW
<b>Addressable</b>	Individually addressable LEDs	Addressable in groups of 3 LEDs	Individually addressable LEDs
<b>Length</b>	5 m	5 m	5 m
<b>LED Density</b>	30 LEDs/Pixels / m	30 LEDs/Pixels / m	60 LEDs/Pixels / m
<b>Color Order</b>	GRB	RGB	GRBW
<b>Input Voltage</b>	5 V (DC)	12 V (DC)	5 V (DC)
<b>Power</b>	0.3 W/LED; 45 W total	0.3 W/LED; 45 W total	18 W/m; 90 W total
<b>Operating Temperature</b>	-20 °C ~ +40 °C	-20 °C ~ +40 °C	-20 °C ~ +50 °C
<b>Dimensions</b>	5000 mm x 10 mm x 3 mm	5000 mm x 10 mm x 3 mm	5000 mm x 10 mm x 3 mm
<b>Wavelengths</b>	Red: 650 nm Green: 520 nm Blue: 460 nm	Red: 650 nm Green: 520 nm Blue: 460 nm	Red: 650 nm Green: 520 nm Blue: 460 nm
<b>Light Intensity</b>	Red: 390 – 420 mcd Green: 660 – 720 mcd Blue: 180 – 200 mcd	Red: 390 – 420 mcd Green: 660 – 720 mcd Blue: 180 – 200 mcd	Red: 700 – 1000 mcd Green: 1500 – 2200 mcd Blue: 700 – 1000 mcd
<b>Gray Level</b>	256	256	256
<b>Color</b>	Full color 24-bit	Full color 24-bit	Full color 32-bit
<b>View Angle</b>	120 degrees	120 degrees	120 degrees
<b>Waterproof Level</b>	IP65	IP65	IP65
<b>Cost</b>	\$22.88	\$15.99	\$52.88



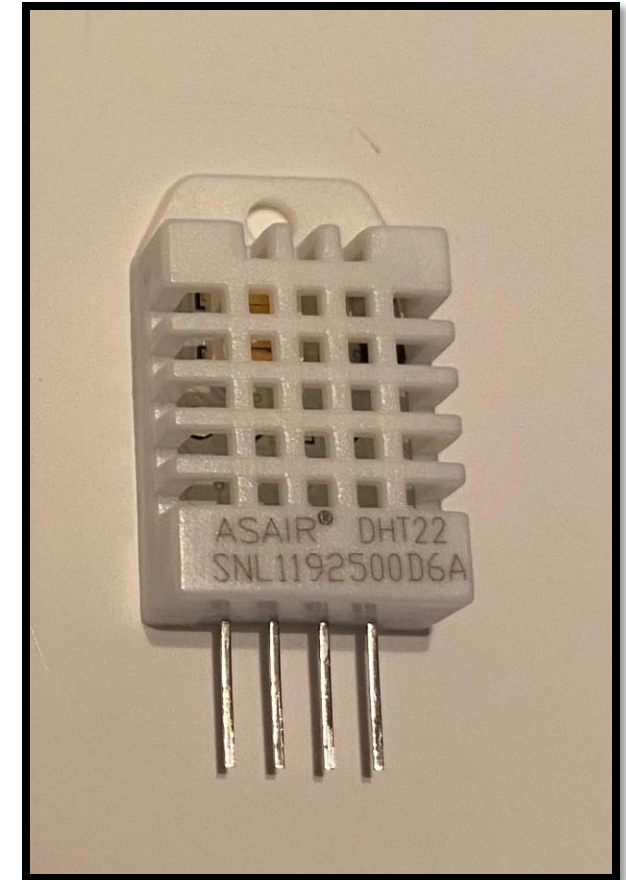
# Microcontroller

	CPU Frequency	Memory	Additional Features	Communication*
<b>Texas Instruments MSP430</b>	25 MHz	512 KB	Low power consumption	Serial
<b>Texas Instruments ARM Cortex-M3</b>	150 MHz	1 MB of flash EEPROM		I2C/SCI/SPI
<b>ATmega2560</b>	16 MHz	256 KB flash memory 8KB RAM	54 Digital I/O pins 16 Analog input pins	USART SPI I2C
<b>Atmel SAM3X8E ARM Cortex-M3</b>	84 MHz	512 K bytes flash memory 2KB RAM	54 digital I/O pins	USART SPI TWI



# Temperature/Humidity Sensor

<b>Manufacturer</b>	Adafruit	Adafruit
<b>Model</b>	DHT11	DHT22
<b>Body size</b>	15.5mm x 12mm x 5.5mm	27mm x 59mm x 13.5mm
<b>Rated voltage</b>	3 to 5V	3 to 5 V
<b>Cost</b>	\$5	\$10
<b>Accuracy</b>	readings $\pm 2^{\circ}\text{C}$ accuracy 20-80% humidity readings with 5% accuracy	readings $\pm 0.5^{\circ}\text{C}$ accuracy 0-100% humidity readings with 2-5% accuracy



Selected  
Component

# Moisture Sensor

Part	Sparkfun	Elecrow crowtail	Adafruit	Parallax
Operating DC Voltage	3.3-5 V	3.3-5 V	3-5 V	2.0V-5.0V
Output Type	Analog	Analog	Analog	Analog
Dimensions	6 cm x 2.5 cm	40 mm x 20 mm x 20 mm	76.2 mm x14 mm x 7mm	20.0mm x 51.0mm
Cost	\$5.95	\$2.50	\$5.90	\$4.99

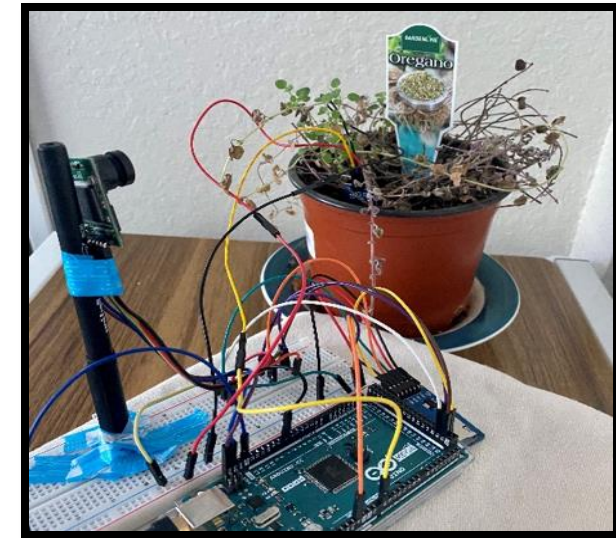
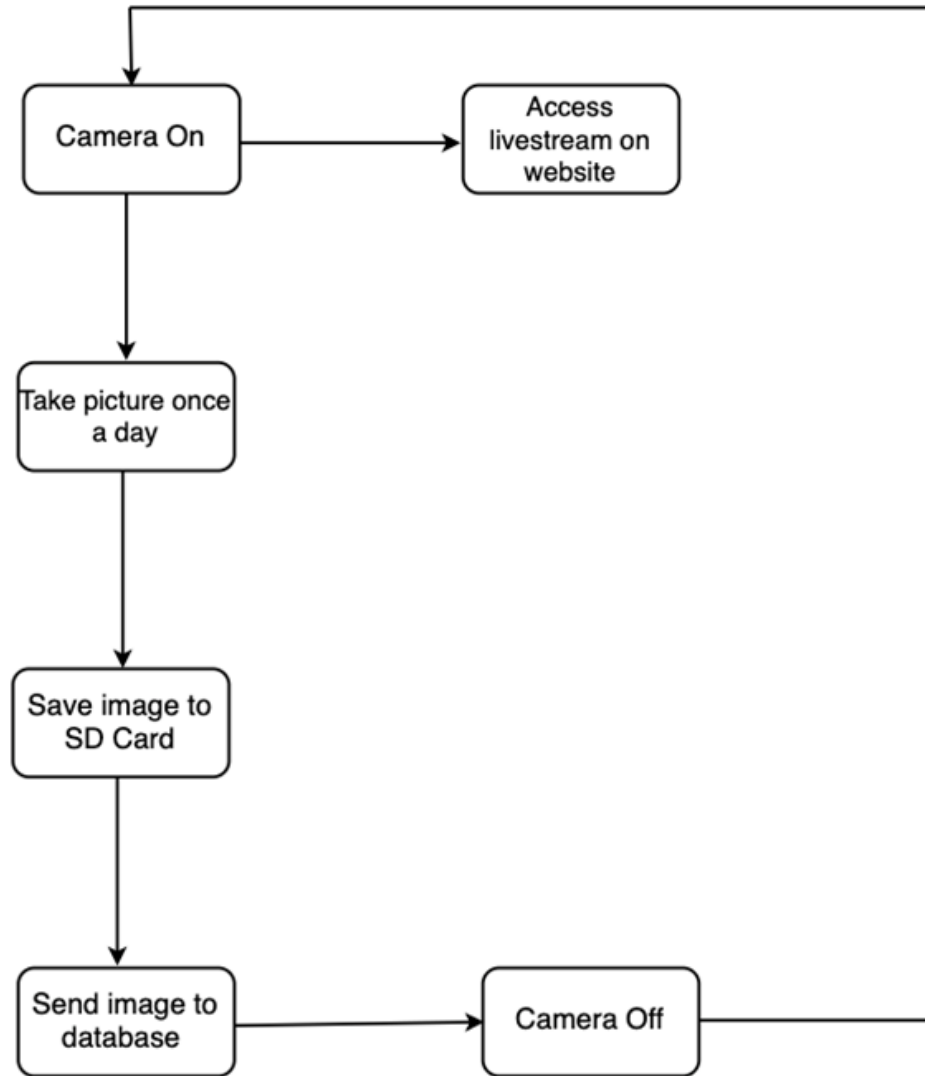


Selected Component



# Camera System

- Using the Arducam 2MP Plus OV2640
- Improved user experience
- Daily image of system to track plant growth
- Live feed available
  - Allows user to ensure that system is functioning properly while away
  - Ensures that plants are maintained and unharmed



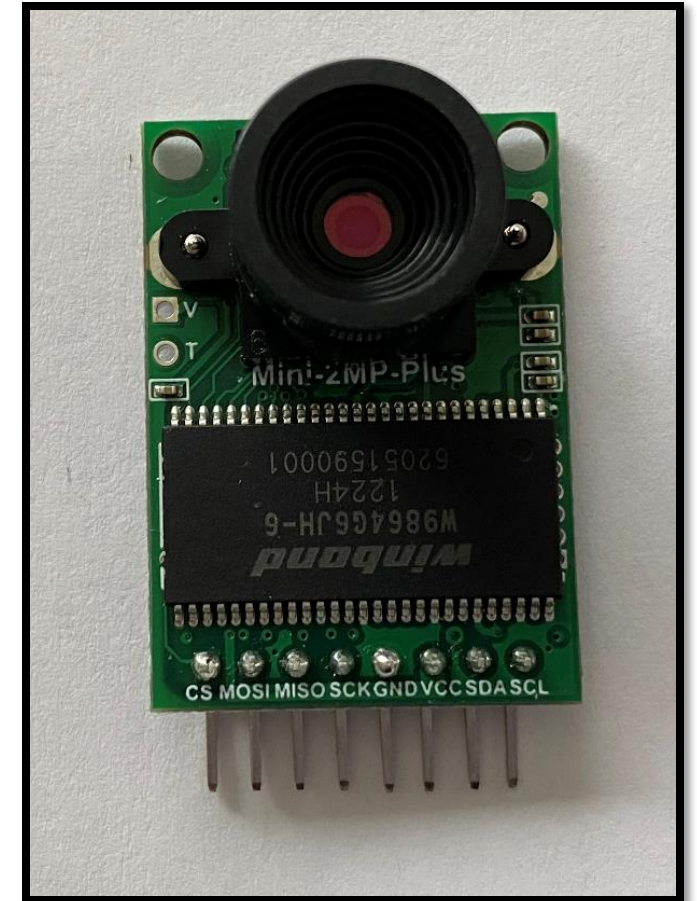


# Camera

<b>Manufacturer</b>	ARDUCAM OV7670	ARDUCAM 2MP OV2640 MINI	ARDUCAM 5MP PLUS OV5642 MINI	RASPBERRY PI CAMERA MODULE
<b>Megapixel</b>	0.3	2	5	8
<b>Video Capability</b>	No	Yes	Yes	Yes
<b>Color Image</b>	Yes	Yes	Yes	Yes
<b>Cost</b>	\$10.99	\$25.99	\$39.99	\$27.91



Selected  
Component



# Speakers

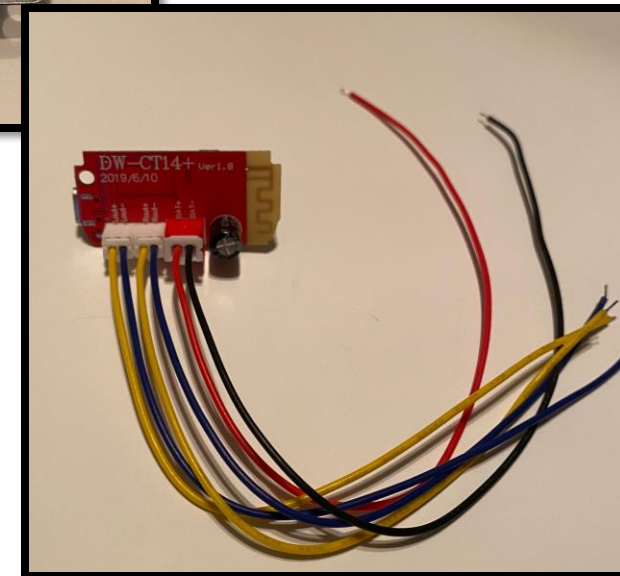
<b>Brand</b>	Visaton
<b>Cost</b>	\$4.68
<b>Nominal Diameter</b>	2.5"
<b>Max Rated Power</b>	5Watts
<b>Impedance</b>	4 Ohms
<b>Frequency Response</b>	130 to 20,000 Hz
<b>Depth</b>	1.14"



<b>Manufacturer</b>	Hyduo	Icstation
<b>Cost</b>	\$8.99	\$10.99
<b>Dimensions</b>	1.6 x 1.3 x 0.5 inches	1.6 x 0.8 x 0.5 inches
<b>Rated Power</b>	5 Watts per speaker	5 Watts per speaker
<b>Supplied Voltage</b>	3.7V-5V	3.7V-5V
<b>Cost</b>	\$8.99	\$10.99



Selected Component

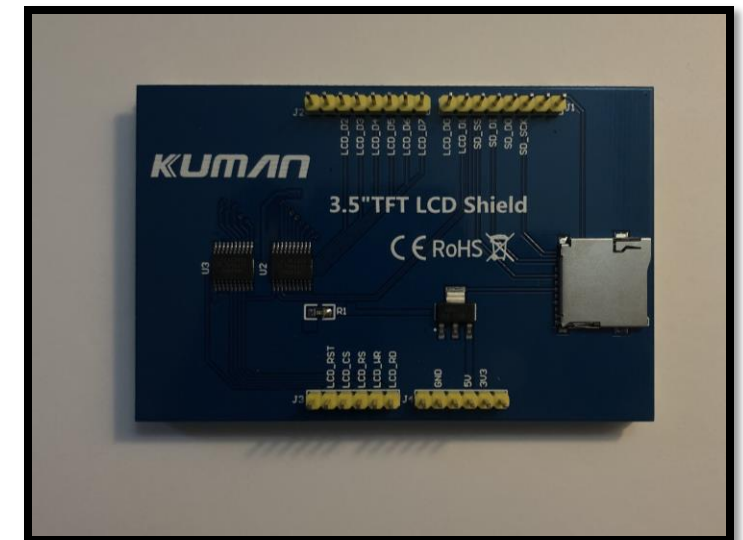


# LCD Screen

Manufacturer	Kuman	HiLetgo	Elegoo
Screen Size	3.5 inches	2.8 inches	2.8 inches
Glass Type	TFT	TFT	TFT
Resolution	480x320	320x240	480x320
Cost	\$17.80	\$13.99	\$15.99
Dimensions	83.5 x 55.6	85 x 48 mm	50 x 69.2
Weight	3.2 ounces	1.6 ounces	1.76 ounces

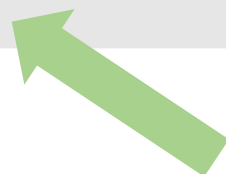


Selected Component

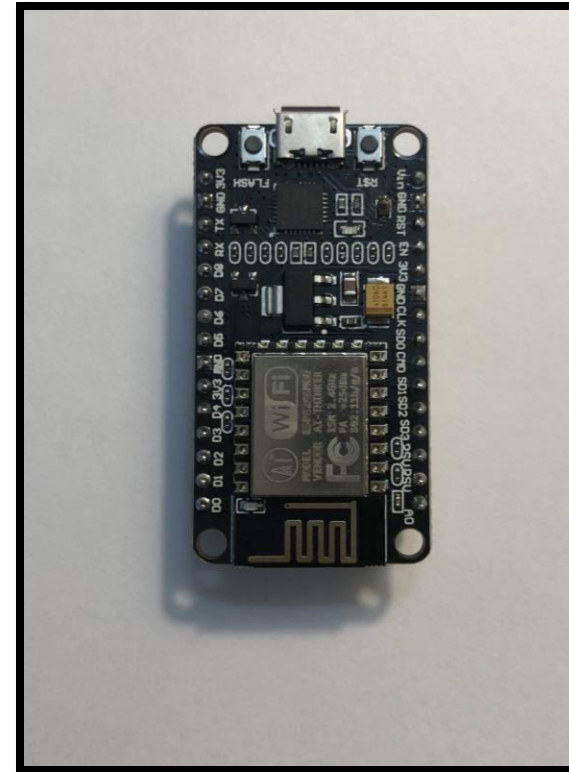


# Wi-Fi Module

<b>Manufacturer</b>	HiLetgo	KeeYees
<b>Model</b>	ESP8266 NodeMCU CP2102 ESP-12E	ESP8266 NodeMCU CP2102 ESP-12E
<b>Data Rate</b>	6Mbps - 54Mbps	6Mbps - 54Mbps
<b>Rated Voltage</b>	3.3V - 5V	3.3V - 5V
<b>Weight</b>	0.986 ounces	1.58 ounces
<b>Cost</b>	\$6.49	\$7.67



Selected  
Component



# System Power Overview

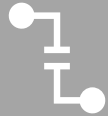


Total System Maximum Power  
consumption:  
≈ 26 Watts

Pumps ≈ 8.4 Watts

LEDs ≈ 4 Watts

Remaining system  
components ≈ 14 Watts



System Max Power Consumption is based off each individual component running simultaneously, unlikely to occur



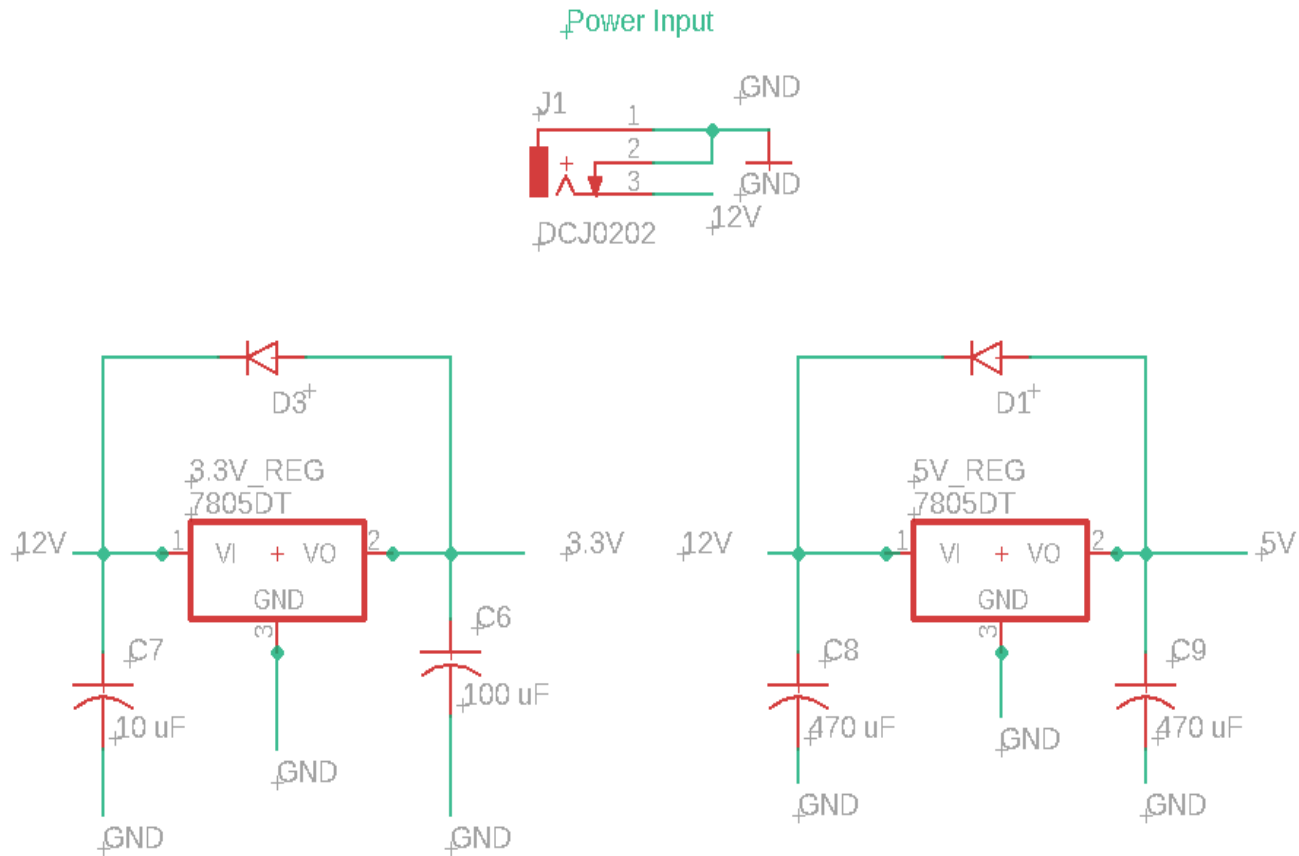
To ensure that the system will not fail the proper AC adapter must be selected

# AC/DC Adapter

- 12 V
- 2.5 Amp
- 30-Watt Power supply will ensure that the system is functioning properly
- Using a wall outlet allows the system to be highly versatile
- Connects to PCB to power entire system
- Jack Size: 5.5 mm x 2.1 mm



# Power Circuit

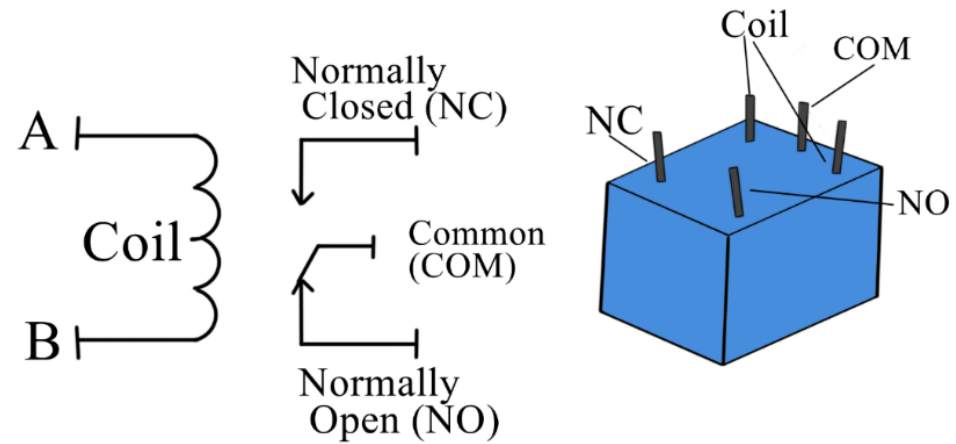


- 12 V input from a wall AC/DC adapter to supply power via a DC barrel connector to entire system
- 12 V will power the water pump and nutrient pump
- Step down to 5 V using a LM7805 voltage regulator and use this to supply voltage to the rest of the system
- Step down to 3.3 V using a LD1117V33 voltage regulator to power ESP8266 WiFi module
- Reverse current protection via diode and bypass capacitors



# Relay Modules

- Relays will be used to control the pumps, grow lights, and speakers
- Trigger Voltage: 5V DC
- Trigger Current: 70 mA
- Max DC Load Current: 10 A @ 30/28 V DC
- Trigger Time: 5-10 msec



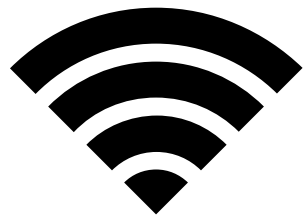
# Software Overview

## Microcontroller

- The software programmed on the microcontroller manages various pumps, lights and sensors within the system.
- Readings collected from the sensors will trigger different actions to ensure that the system is operating under ideal growth conditions.

## Remote Access

- The system can be accessed remotely using the wi-fi module.
- After connecting to any local network, the device is then able to communicate with the non-local EasyHerb web server.
- This will allow the user to access their system data as well as make state changes remotely.

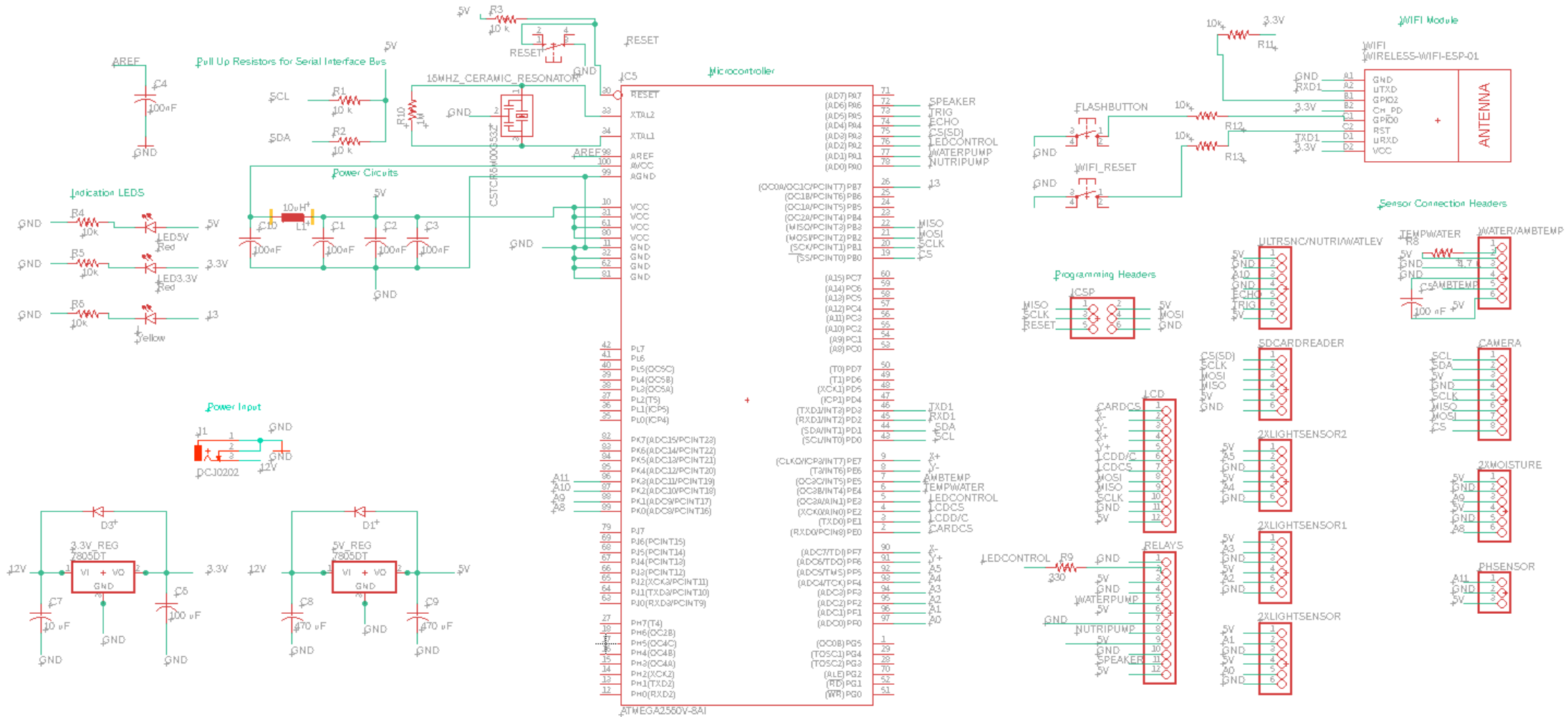


# Difficulties/Challenges for each subsystem

- Determining timing for each measurement
- Ensuring correct water flow rate to the herbs
- Determining best way to implement a certain sensing feature (Water level sensor)
- Determining the thresholds for the sensors



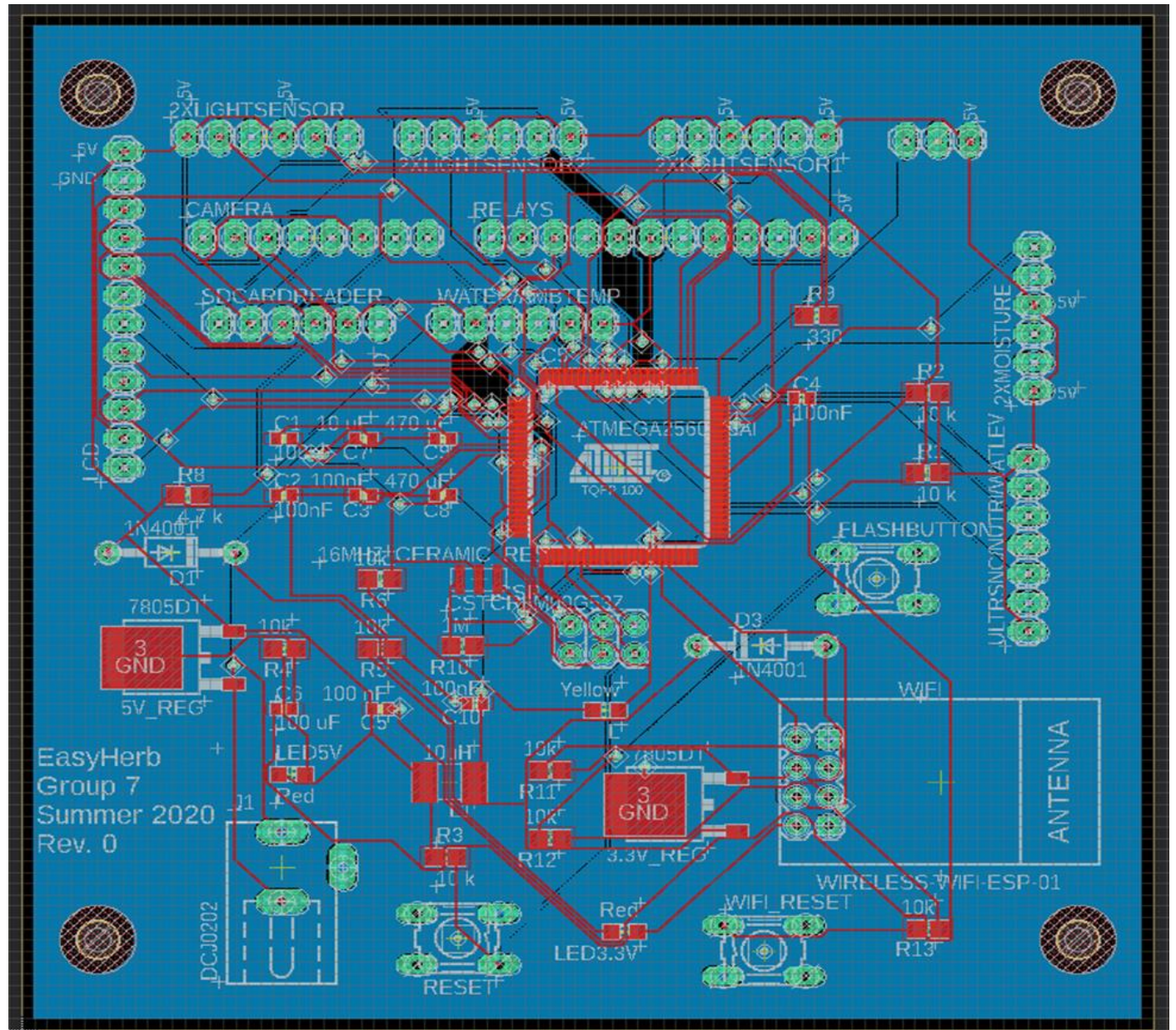
# PCB Schematic





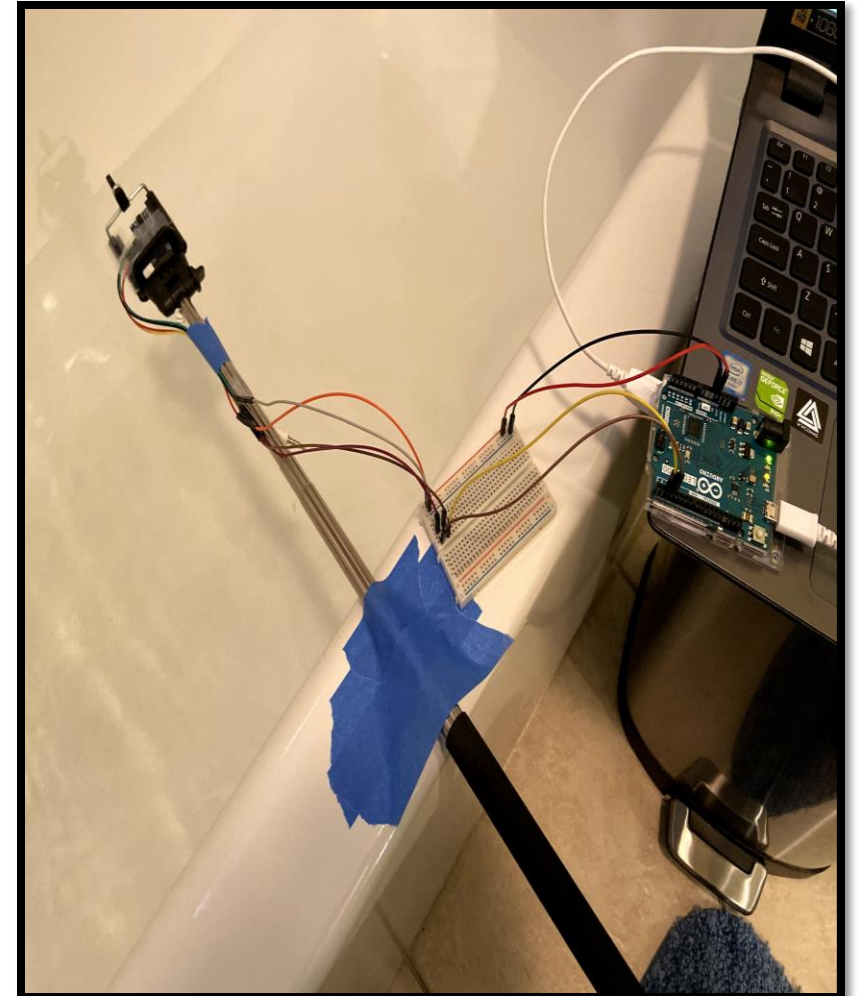
# PCB Layout

- 2 Layers
- 90mm x 90mm
- 12V input stepped down to 5V for majority of the system and 3.3V for the WiFi module
- LEDs for troubleshooting
- Push buttons for reset
- Additional protection circuits
- 4 mounting holes



# Prototyping

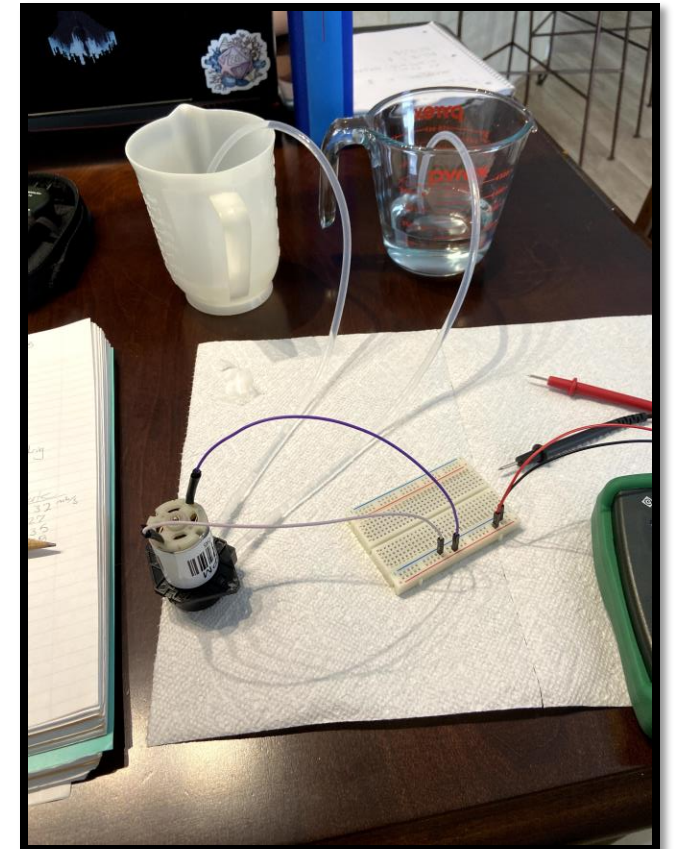
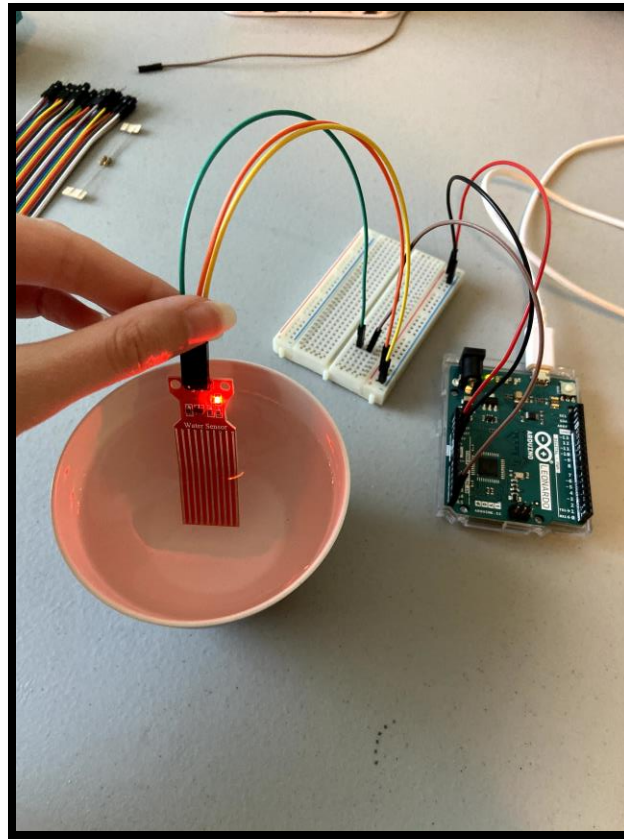
- Each sensor was tested individually for functionality, and data was gathered when necessary
- All sensors, pumps, lights, speakers, and the screen worked as needed
- Relays effectively connect the pumps with 12 V power, allowing them to easily be run when needed
- Ultrasonic distance sensor is able to measure the distance to the surface of water without the need for a bobber





# Prototyping Data Collected

- Liquid level sensor: resistivity value measured at certain percentages was observed, from 0-750, with 0% at 0 and 100% at 750
- Peristaltic Pump: flowrate measured to be 1.34 mL/s

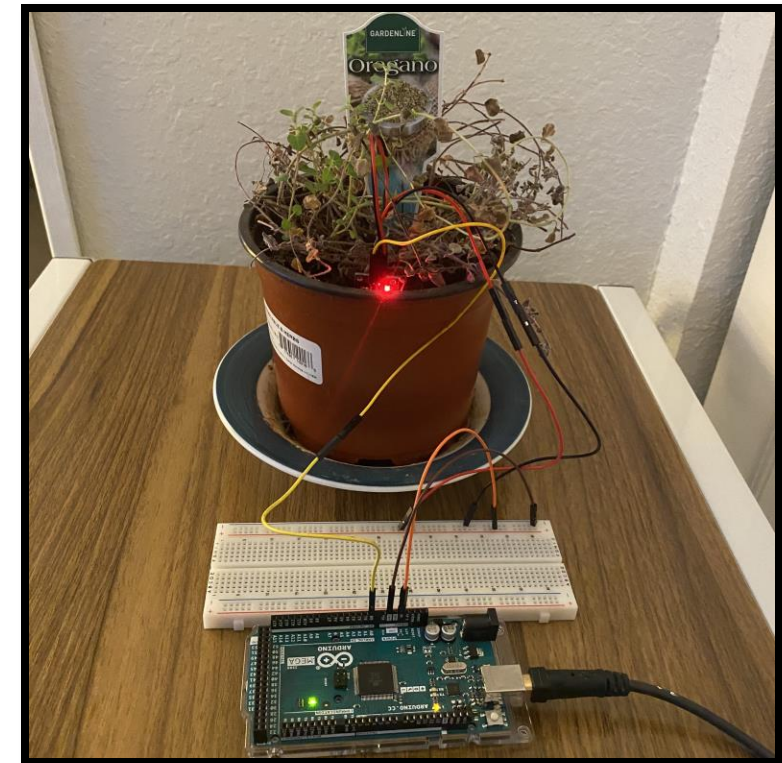




# Prototyping light sensor/moisture sensor

- Light sensors used to determine brightness that will in turn determine if the grow lights should turn on or off
- Determined that a higher integer value read means less light while a smaller number indicates high brightness
- Dark  $\approx 1000$
- Very Bright  $\approx 10-20$
- Using multiple sensors developed a method to find an average brightness
- These sensors can be arranged in different locations to get a better idea of the environment brightness
- Moisture sensors will work using a similar method to determine if the plants should be watered
- Completely Dry  $\approx 0$
- Completely Wet  $\approx 3900$

```
COM3
Sensor 1: 1000 Sensor 2: 1000 Sensor 3: 980
Average = 991
Sensor 1: 1004 Sensor 2: 1006 Sensor 3: 987
Average = 999
Sensor 1: 1005 Sensor 2: 1008 Sensor 3: 997
Average = 1003
```



# Administrative Content

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# Project Budget Projections

- Breakdown of initial estimated costs for the entire system
- This is the guideline of the budget in place for the final product

Item	Cost
Microcontroller	\$40
Wireless Modules	\$55
Water Level Sensor	\$4
pH Sensor	\$30
Nutrient Pump	\$25
Nutrient Level Sensor	\$6
Temperature Sensors	\$3
Camera	\$31
Camera SD Reader and SD	\$8
Water Pump	\$11
Emitters	\$4
Moisture Sensor	\$5
Touchscreen Display Screen	\$35
Grow Lights	\$25
Light Sensors	\$5
Construction Materials	\$60
PCB / Power	\$70
Total	\$418

# Money spent so far

- All sensors and most electrical components have been purchased
- PCB will be ordered soon
- Physical hardware for enclosure must be purchased

Component	Cost
ATmega2560	\$11.85
HC-SR04	\$3.95
Water Level Sensor	\$5.99
Peristaltic Liquid Pump	\$24.95
PH Sensor	\$33.99
WS2812b LED Strip	\$22.88
Water Temperature Sensor	\$2.60
Temperature/Humidity Sensor	\$10
Moisture Sensor	\$4.99
Water Pump	\$10
Camera	\$30.99
LCD Screen	\$17.80
Wi-Fi Module	\$6.49
Speakers	\$20
PCB	\$20
Construction Materials	\$45

# Plans for successful completion

- Enclosure must be constructed
- Systems assembled within containment
- Subsystems must be connected to ensure communication and simultaneous functionality



# Progress Made (% done by category)

