Final Presentation

Automated Home Hydroponics System

Group E
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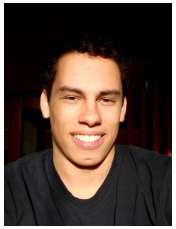
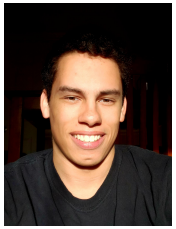
What is Hydroponics?



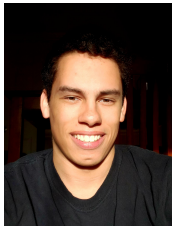
- Dirt-free, space-saving, and water-effective method of growing plants
- Hydroponics is a way to skip soil, use different material to support the roots of the plant, and grow plants directly in nutrient rich water.
- Hydroponics helps conserve water through continuous recirculation system.
- It allows growers to produce food anywhere in the world, at anytime of the year, and to net higher yields with fewer resources.

Project Goals and Objectives



- To build a portable hydroponics system that can be inside a home.
- Have a mobile application for the user to interact with the hydroponic system.
- Real-time values being recorded and displayed to the user.
- Able to support a variety of plant types with preset plant parameters.
- Self sustaining system with little user intervention to operate after initial setup.

Initial Specification and Requirements

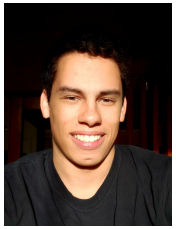


- Fit through a standard door size in width and length (around 34”) and a max height of 7’.
- Max weight of 100 pounds.
- This system will run on 120V wall outlet power.
- Budget to be under $800.
- Have the system use Wi-Fi IEEE 802.11ac.
- Local LCD interface + Android App.

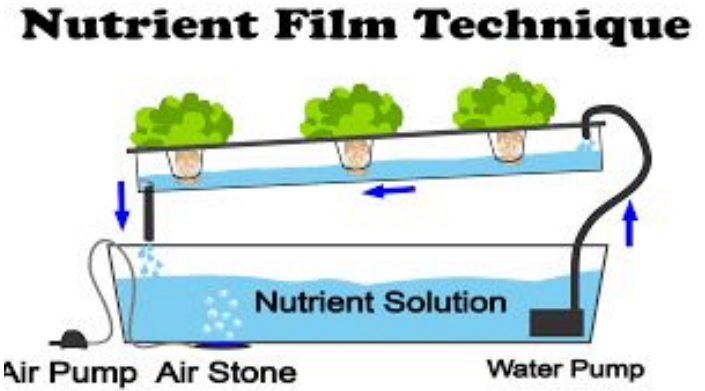
Project Design Approach

- Flexible and practical design
- User friendly features
- Light intensity adjustability
- LCD to display sensor information
- Enclosed design to keep reservoir clean
- S-Shape design to house more plants
- Food grade PVC-U material for no pollution

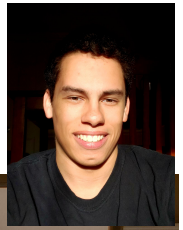
Hydroponics - Nutrient Film Technique (NFT)



- The style of hydronics system we settled on was a Nutrient Film Technique (NFT) design. It is great to grow lightweight plants that don’t need much support.
- NFT System:
  - The water is constantly flowing through the channels 24/7.
  - Growth tray is tilted to utilize gravity.
  - Water is oxidized with air pump.
  - Because the water is recycled, NFT systems consume very little water.



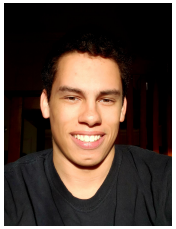
Automated Home Hydroponics System



Structural Design:

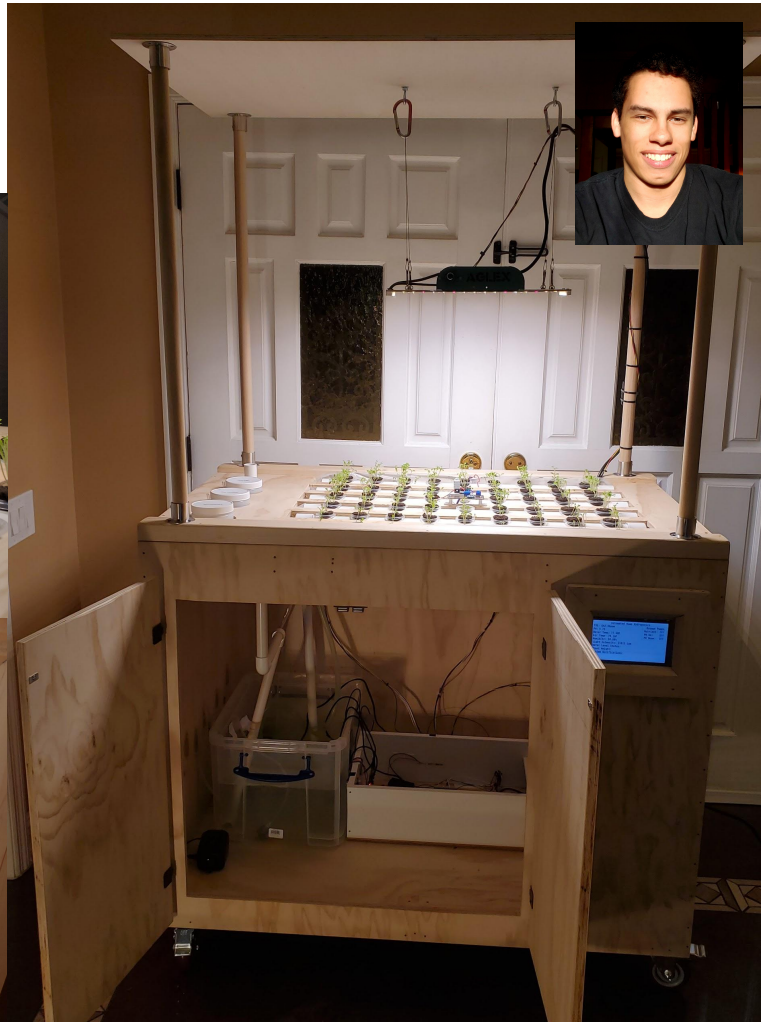
- Wooden Cabinet
  - S-Shaped PVC system to move water through.
  - The PVC system can hold 54 plants across 6 rows.
  - Plastic sheeting below PVC to help prevent possible leaking on the electronics below
  - Electrical Components & various sensors
- Canopy
  - LED light suspended above
  - Distance sensor for measuring plant height.
- Overall Dimensions: (4’ x 29.5” x 6.5’)

Structural Design Features



- Three containers to the left of the plants for easy access and maintenance of the 3 main nutrient and PH control related solutions.
- Refill pipe to the left as well that can be used along with a funnel for easy refill without having to go inside the cabinet. Useful for topping of water when evaporation occurs
- Water drain system out the left side of the cabinet. You can go inside the cabinet and turn a 3 way nob that will direct the pumps water flow such that it could be emptied out of the system.
- Large Cabinet Doors for ease of access
- Cut Out to the right of the cabinet doors for the LCD interface.

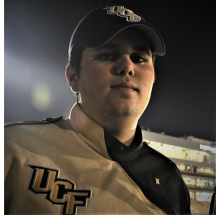
Images of the Structure



Overall Block Diagram

Jarrod Pearman

MCU Comparison



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	ATmega2560	ATmega328	MSP430fr6989
Operating Voltage	1.8V-5.5V	2.7V-5.5V	1.8-3.6V
Volatile Memory	8 KB	2 KB	2 KB
Non-Volatile Memory	256 KB	32 KB	128 KB
GPIO pins	86	23	83
Clock Frequency	16MHz	16 MHz	16 MHz
Cost	11.99/unit	$3.88/unit	$6.48/unit

Pearman

Microcontroller

Atmega2560 MCU

- 16 MHz
- 100 Pins
- 86 GPIO and 32 GPR
- 256KB Flash Memory
- 8KB SRAM
- UART, SPI, I2C
- Operating Voltage: 1.8 to 5.5 Volts
- Temperature Range: -40 to 85 °C
- Compatible with Arduino IDE

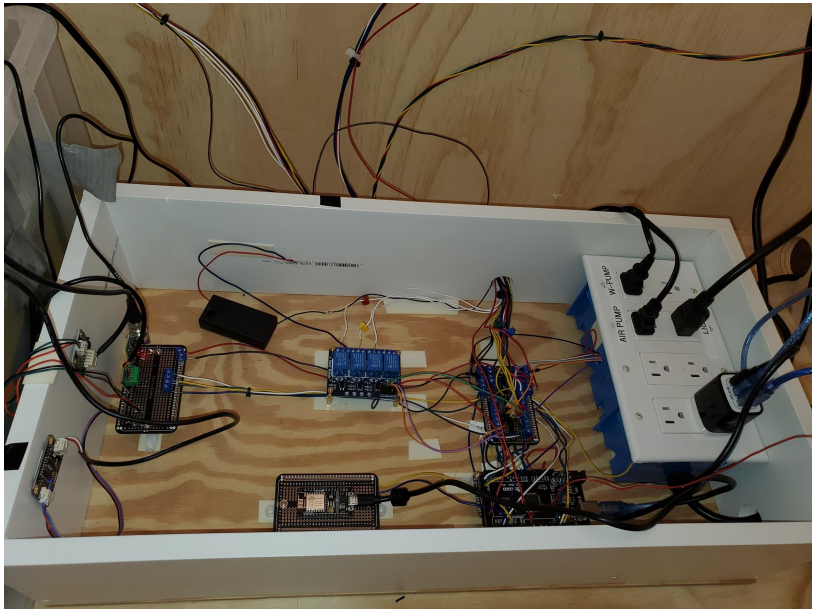
Sensors

Pearman

- For this Hydroponic system we used various sensors in order to automate some of the processes required in hydroponics along with allowing real time monitoring to ensure the user has a good idea of how the system is doing at all times.
- This covers water quality, environment quality, and lighting. Some sensors are directly used in order to provide feedback to the user while others will be used to help improve the automation of specific subsystems.

Sensor Choices

- TDS Sensor
- pH Sensor
- Water Temperature Sensor
- Air Temperature and Humidity
- Light Sensor
- Water Level Sensor
- Distance Sensor
- Solution Level Sensors



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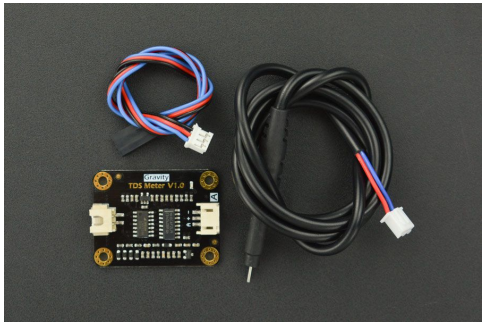
Water Quality



Pearman

DFRobot Gravity Analog TDS Sensor/Meter

- This sensor allowed us to measure the amount of total dissolved solids in the water(TDS).
- This is done by sending an electrical signal into the water column.
- The current of the signal can travel through these dissolved solids, mostly dissolved salts, and we can get an indication of the signal strength and determine the level of nutrients within the system.
- We provide the user with updates on TDS along with any automated or manual changes needed to handle any TDS issues.

Water Quality

Pearman

Liquid PH Value Detection Regulator Sensor

- This sensor consist of a module and a probe.
- The probe is placed in the water and returns pH readings ranging from 0-14.
- This pH is an indication of the amount of hydrogen ions in the water.
- Different minerals in the water can react differently based on the amount of hydrogen ions in the water, as a result, we want to ensure that the waters pH is an acceptable range for proper growth.
- This provides us with an idea of the amount of available nutrients in the system.

Pearman

Water Quality

DS18B20 Temperature Sensor Module Kit Waterproof

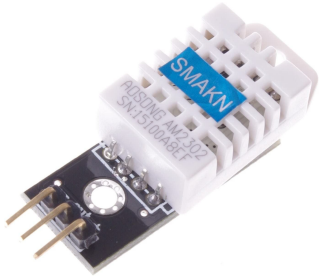
- This sensor allows us to measure the temperature of the water in the system.
- The temperature of the water can indicate the level of dissolved oxygen, a plants ability to absorb nutrients, and the potential for various bacteria and fungi to form.
- The temperature of the water will be provided to the user and if the water temperature falls out of range the user will be notified.

Temperature and Humidity

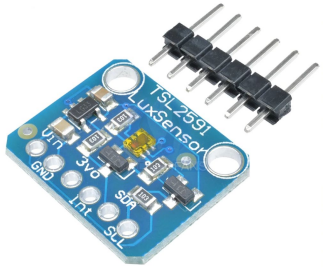
Pearman

SMAKN DHT22 / AM2302 Digital Temperature and Humidity Measure Sensor

- This sensor module allows us to measure both the temperature and humidity of the environment surrounding the plants.
- This is to ensure that we can provide monitoring on the local climate of the system such that the ambient temperature and the level of humidity are within acceptable ranges for plant growth.
- We will provide real time updates in order to ensure the user can appropriately handle any issues that arise.



Light Sensor and Distance sensor



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TSL2591 IIC I2C Light Sensor Breakout Module

- This sensor allowed us to monitor the light intensity of the grow light and help us keep track of a simulated day night cycle. The user will be able to specify hours of daylight in which the system will modify a day/night cycle accordingly.

HC-SR04 To World Ultrasonic Wave Detector

- We used a distance sensor to monitor the distance between the lighting and the plants themselves. This will be used to monitor the plants height as it grows. Although not a key feature in keeping the plants alive it can be useful for the user to keep track of the plants current state in its growth cycle.

Pearman

Water Volume Monitoring

CQRobot Contact Water/Liquid Level Sensor

- We used this sensor in order to monitor the water levels within the main reservoir to ensure that there is enough water in the system such that the plants can grow properly.
- Ensure equipment has enough water volume to work.
- We provide updates to the user in an event that the water level is too low so they can add or drain water accordingly.

Pearman

Nutrient and PH Solution Level Sensors

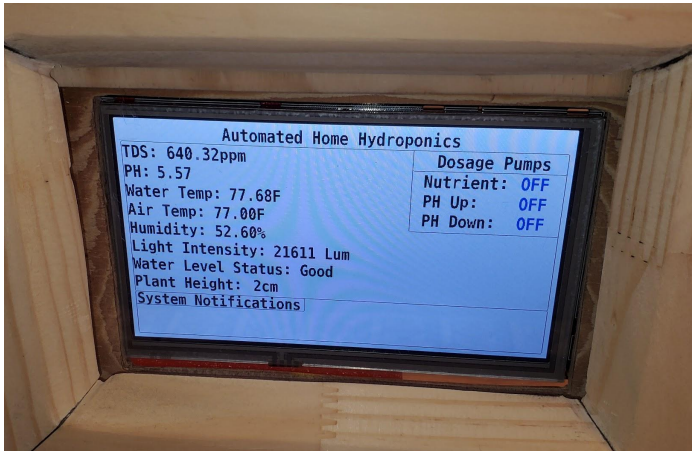
Gikfun M8 Liquid Level Sensor , Water Float Switch

- We will be using this sensor in order to monitor the levels of the three liquid solutions involving the nutrients and the PH UP and DOWN solutions which are used as part of the TDS and PH automated adjustment systems.
- These sensors allows to to check when the solutions are filled up and have enough liquid to keep running or if the containers are empty and require a refill.
- We will provide updates to the user in an event that any of the solutions need refill through the LCD along with being displayed in the android app.

Local Interface/LCD

Pearman

- We want to provide the user with information that is directly a part of the physical system at all times.
- Decided on a 7 Inch TFT LCD Resistive Touch display that uses a Shield to connect into an ELEGOO MEGA 2560.
- This display will provide us with enough screen real estate such that we can properly display the most important information at all times such that the user can glance at the hydroponic system and get an idea of its current status just by looking at the display.



MCU Sensor Flowchart

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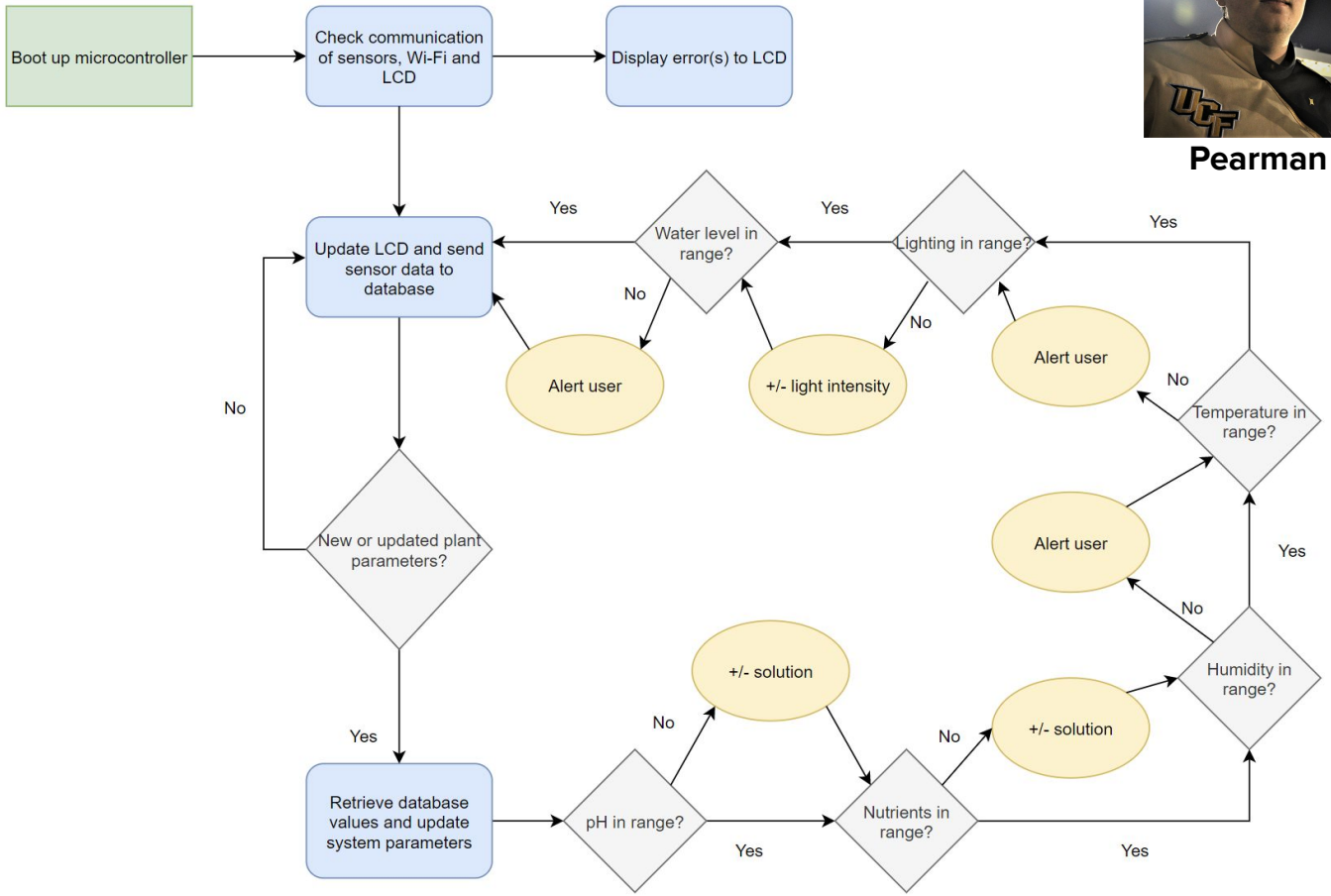

Development Environment

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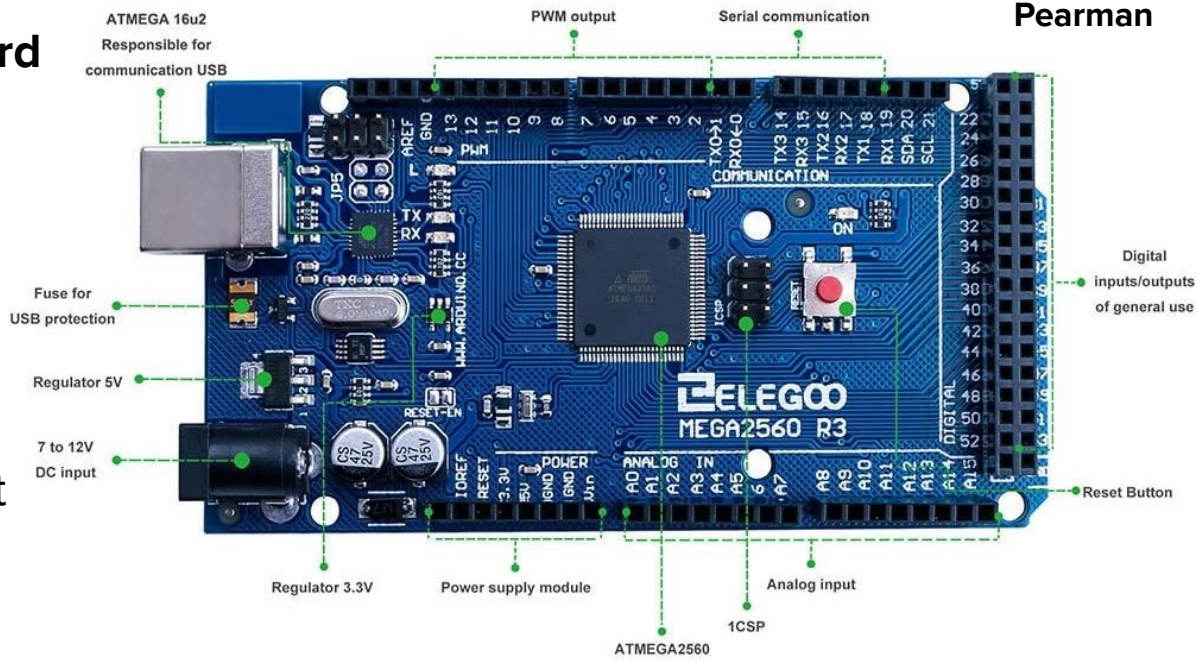
ELEGOO MEGA 2560 R3 Board

- Arduino IDE
- Program in C
- Large list of libraries
- MCU is an Atmega 2560
- Flexible design layout
- Large Community Support



Wireless System

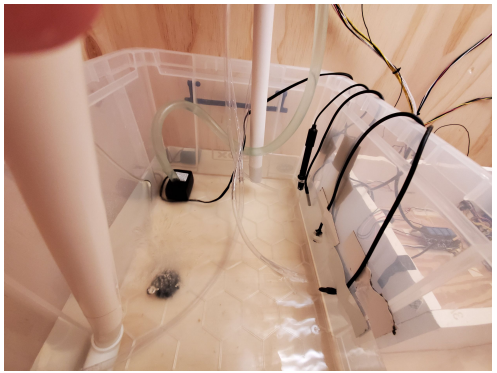
- In order to connect our hydroponics system to our android app, we need a form of communication to deliver plant data and system information.
- Considered Wi-Fi and Bluetooth to transfer data.
- Decided on Wi-Fi for the increased range and increased data transfer rate.
- We used the NodeMCU ESP8266 Wi-Fi module to connect our system to the internet.

ESP8266 WiFi Module

- It operates at 3.3V and will be powered through USB connection.
- The ESP8266 will communicate with the MCU through UART using serial pins.
- We used a Wi-Fi library that connects our home Wi-Fi with standard user authentication.
- Then, we created an asynchronous web server with 192.168.1.150 as the IP address that utilizes TCP connections for communication. This web server processes incoming commands from the android app and updates with plant data. This will also allow us to send system settings to the Wi-Fi module.

Water Reservoir

- A core part of hydroponics is the reservoir.
- The reservoir houses the majority of the water volume in the system that will be circulated through the plants and back. The larger water volume helps aid water quality and slow down the effects of evaporation.
- The reservoir also allows us the perfect location in order to place many of our sensors and where the water pump and air stone will be located.
- We used a roughly 10 gallon plastic container for the system which unlike glass will hold up better to accidental bumps.



Liquid Dosage System - pH

- The pH plays an important role in plant's ability to absorb a number of nutrients which affects its growth.
- In hydroponics there are pH UP and DOWN solutions that are used to help control the pH within the system.
- There will be local containers near the main water reservoir that will contain each of the pH solutions.
- When the pH sensor finds that the pH falls out of acceptable range the system can adjust this automatically with some smaller liquid pumps that provide an appropriate amount of pH solution until appropriate levels are met.

Liquid Dosage System - Nutrient Solution

- When the system TDS is low, nutrients needs to be added to the water. We used FloraGro for our nutrient solution for this project. There are many different types out there, even for specific plants.
- There will be a container with such nutrient solution that has a small pumps that will automatically add the solution when needed.
- If the TDS sensor finds that the nutrient levels are low the pump will add the appropriate amount. If there is too much nutrients in the system the user will be notified that a water change is recommended.

Liquid Dosage Systems - The Pumps

- Small submersible liquid pumps.
- Can run on 3V-5V
- 100L / H
- Pumps turn on briefly for less then a second in order to dose a small amount of solution for their respective chemical/nutrient. Over time this will be done until system requirements are met.

Lighting System

- The lighting we chose for our project is AGLEX K Series LED.
- This light is equipped with 160 LEDs with full spectrum lighting.
- AGLEX is also IP65 Waterproof, which is great when dealing with hydroponics as water can damage electronics during operation
- There is also a dimmable knob on the side to adjust light intensity for different plants and a knob for changing plant heights.
- This light is also fanless, which the consumers will appreciate a lot.
- This light also only consume 90 Watts to provide the most light intensity without greatly increasing the power consumption.

Submersible Water Pump

- The water pump is responsible for circulating nutrient water solution throughout the system in a “S” shape fashion.
- The water pump we have has a maximum flow rate of 150 ml/min.
- The max flow rate is enough to make sure the water can flow upwards a few feet and provide adequate amount through the PVC piping.
- It plugs into the custom relay power strip.

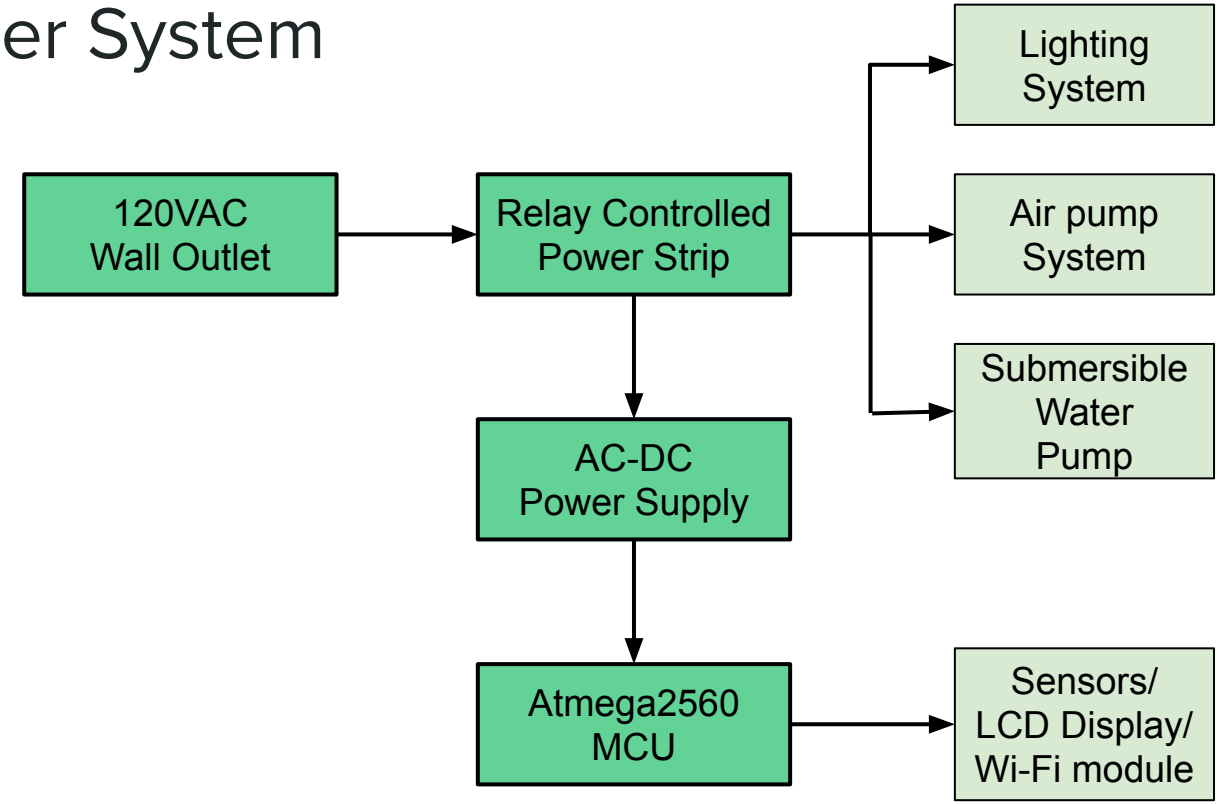
Air Pump System

- Air pump helps create dissolved oxygen in the water for the plants to absorb.
- The air pump also helps prevent algae and disease growth in the reservoir.
- Air pump will sit outside and connect to the air stone inside the water reservoir. The air pump takes oxygen from the air and channels it into the air stone, which emits hundreds to thousands of tiny bubbles into the reservoir.
- The max flow rate of the air pump is 15 L/min, which is plenty for our system.
- The air pump is controlled and powered by the relay power strip.

Power Considerations

- No Solar
  - Solar Cells are expensive and hard to implement.
- Battery Supply vs 120V AC Outlet
  - Batteries eventually die and need to be replaced.
  - Using a battery is more expensive than power from wall outlet.
  - Rechargeable batteries take a lot of time to charge thus are not user friendly.
- Since our hydroponics system is an inexpensive system, using the wall outlet power is the best and cheapest option for us.

Power System



Power Supply

- The ATMega2560 board will be powered through a USB power connection into our custom relay power strip, in an always on outlet.
- The ATMega2560 board will help power most of the essential sensors. The dosage solution pumps are powered by AA batteries. The main water pump,air pump, and lighting will be powered separately by the relay power strip that has been created. This power strip allows the ATMega2560 board to power on and off the pumps and lighting when desired.

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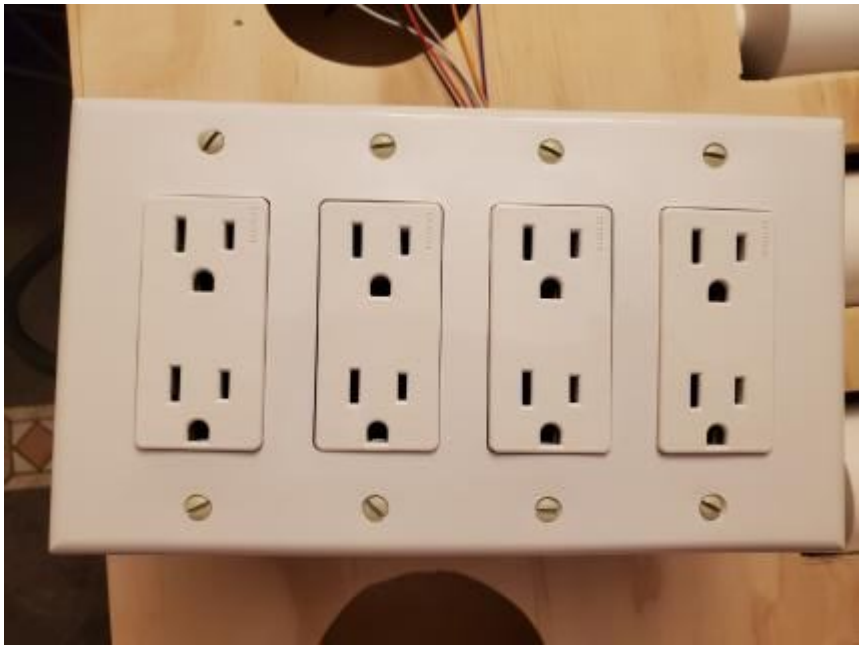
Relay Controlled Power Strip

- A Relay module is a programmable electrical switch, which is controlled by Arduino. It is used to programmatically control ON/OFF the devices, which use high voltage/current.
- It will connect to the ATMega2560 with control lines which will trigger the relays independently.

Relay Implementation Design

- As shown in the image the 4 right outlets are always on with the 4 left each being individually controlled by the MCU.
- This relay power strip is used to power the lights, main water pump, and air pump.



System Design Overview

The system is a relatively large structure that acts as an iconic piece in a home for growing plants using hydroponics.

The system gives the user the ability to grow a large range and amount of plants while also have many convenient and automated features included in order to save time and to improve plant growth.

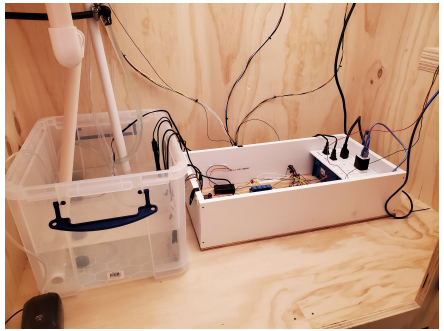
Pearman

System Design Overview

System provides user with key sensor readings such as TDS,PH,Temperature and Humidity. This is displayed via the local LCD and the android application.

The user can select predefined plant types along with adding their own allowing the user to customize the system to their specific scenario. This is done using the android app.

Pearman



Pearman

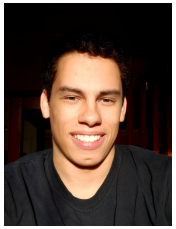
System Design Overview

The user can control the lighting along with both the air and water pumps using the android app.

Automated dosing system for nutrients and PH in order to keep the plants healthy.

Easy access to refilling the nutrient and PH solutions along with easy filling and draining of water for easy maintenance.

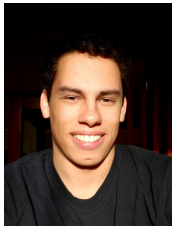
Android App



- Decided with Android Studio for extensive documentation, cloud integration and advanced emulation.
- Will be coded mainly in Java for ease of use within the team.
- Web technologies will be used to connect to the cloud and other files within the app.

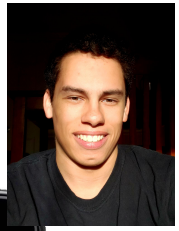
android

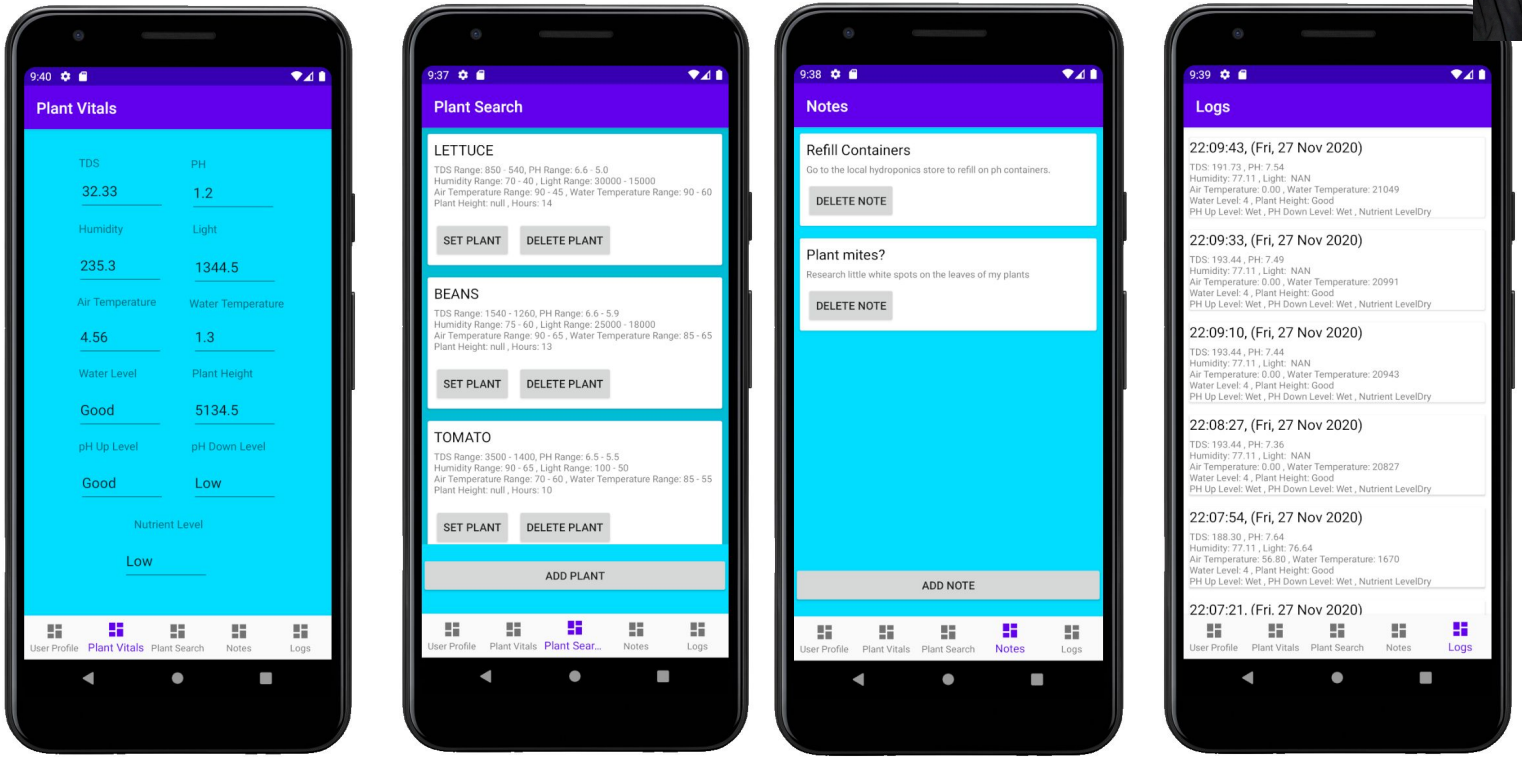
App Goals



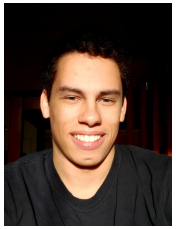
- User accounts to keep data separate for each hydroponic system.
- Dedicated plant vitals page to display current reading from the hydroponic system in real time.
- A plant search page to set parameters for a specific plant that can be modified to the users' liking.
- A notes page to jot down observations or anything related to the system.
- A log page to see vitals progress through time.

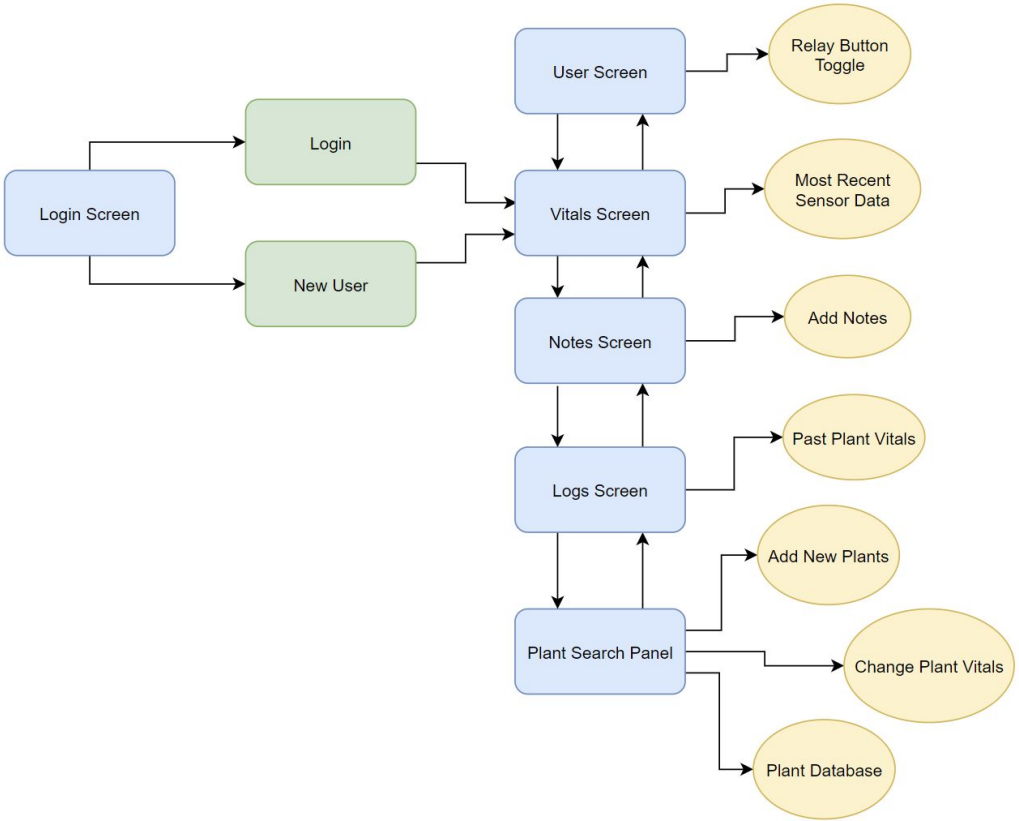
Main App Layout



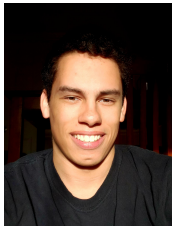


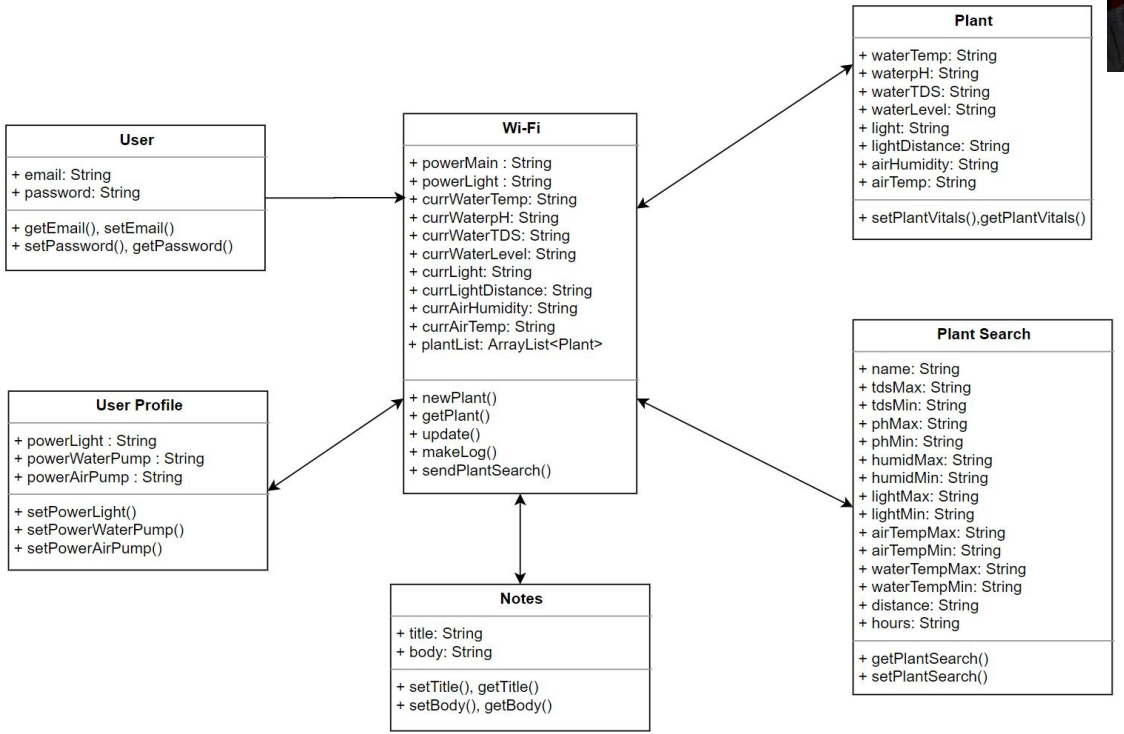
Use Case




Login Screen
Login
New User
User Screen
Vitals Screen
Notes Screen
Logs Screen
Plant Search Panel
Relay Button Toggle
Most Recent Sensor Data
Add Notes
Past Plant Vitals
Add New Plants
Change Plant Vitals
Plant Database

Class Diagram

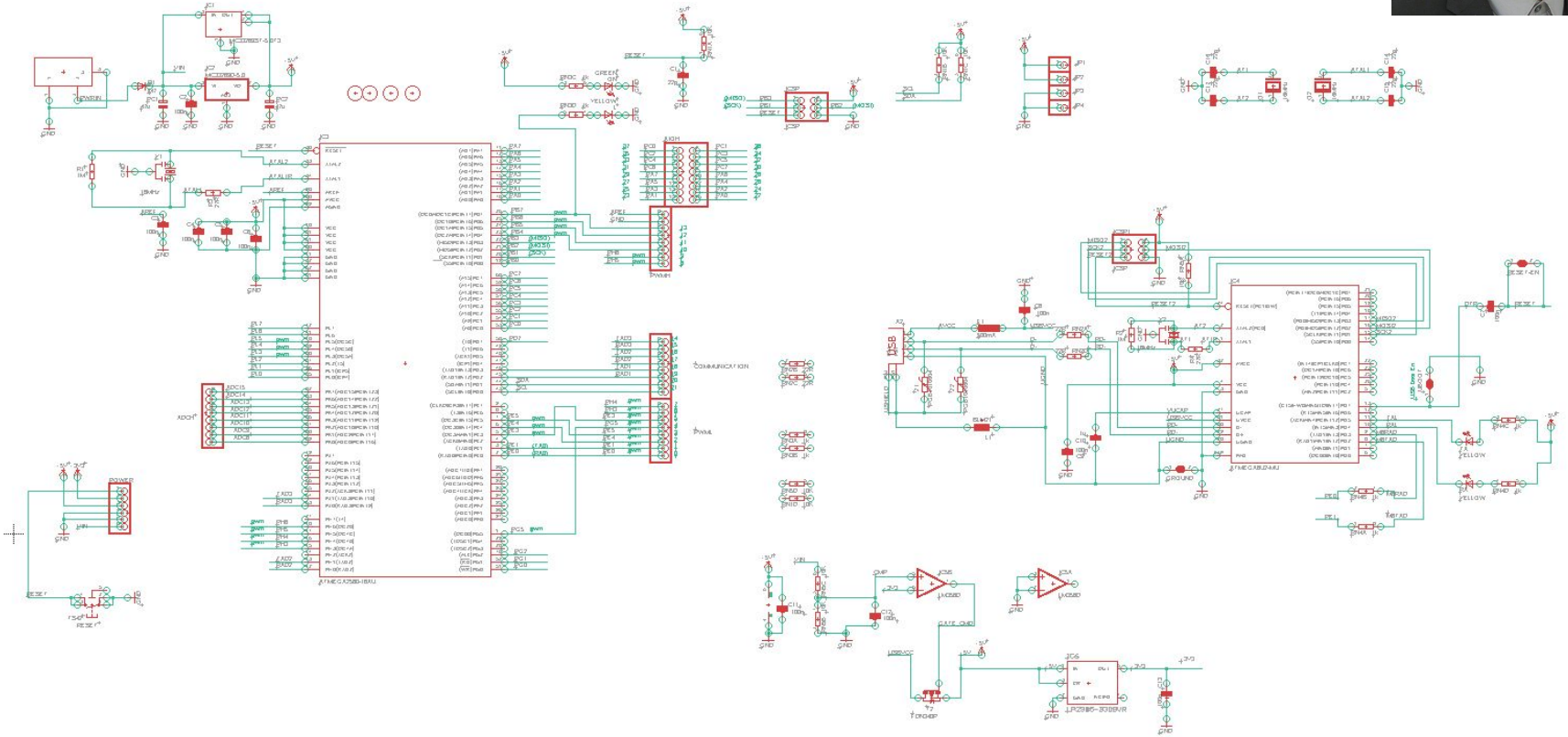




Printed Circuit Board Design

Lopez

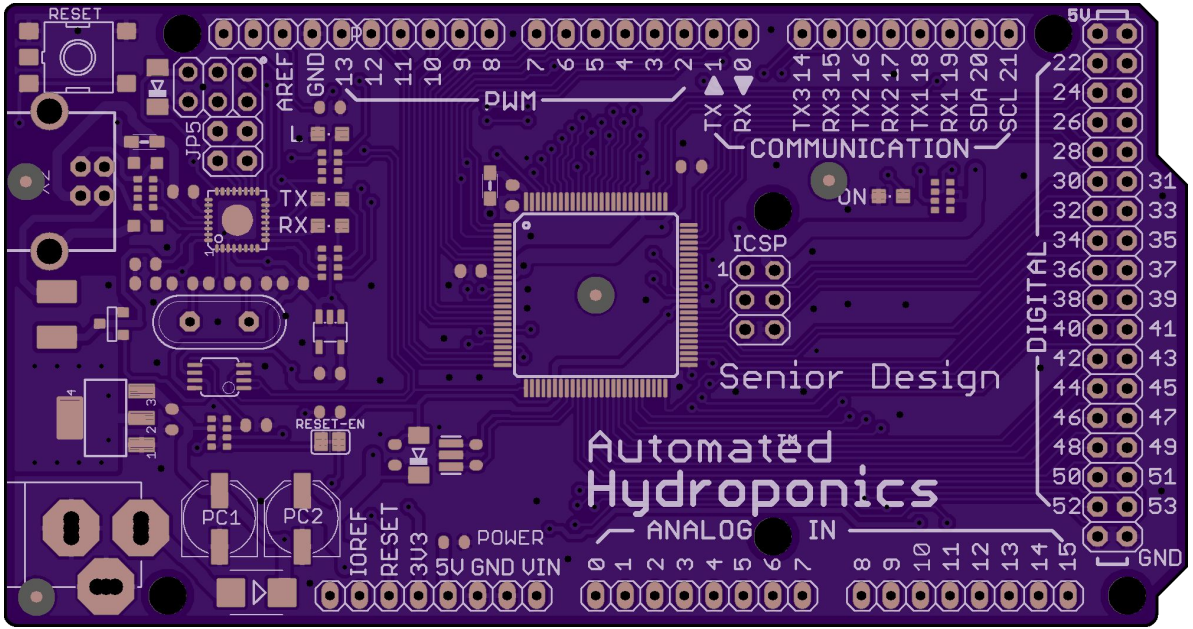
Our board was created using the open source Arduino 2560 design



Lopez

PCB Procurement and fabrication

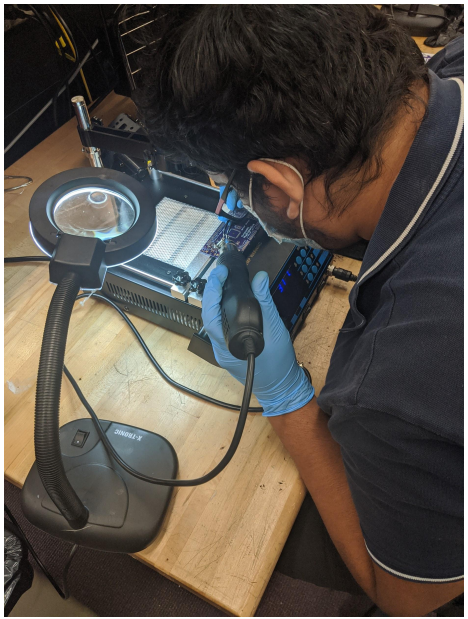
The Printed Circuit Board for the Automated Home Hydroponics System was fabricated through OSH Park and the components were ordered through Mouser Electronics.

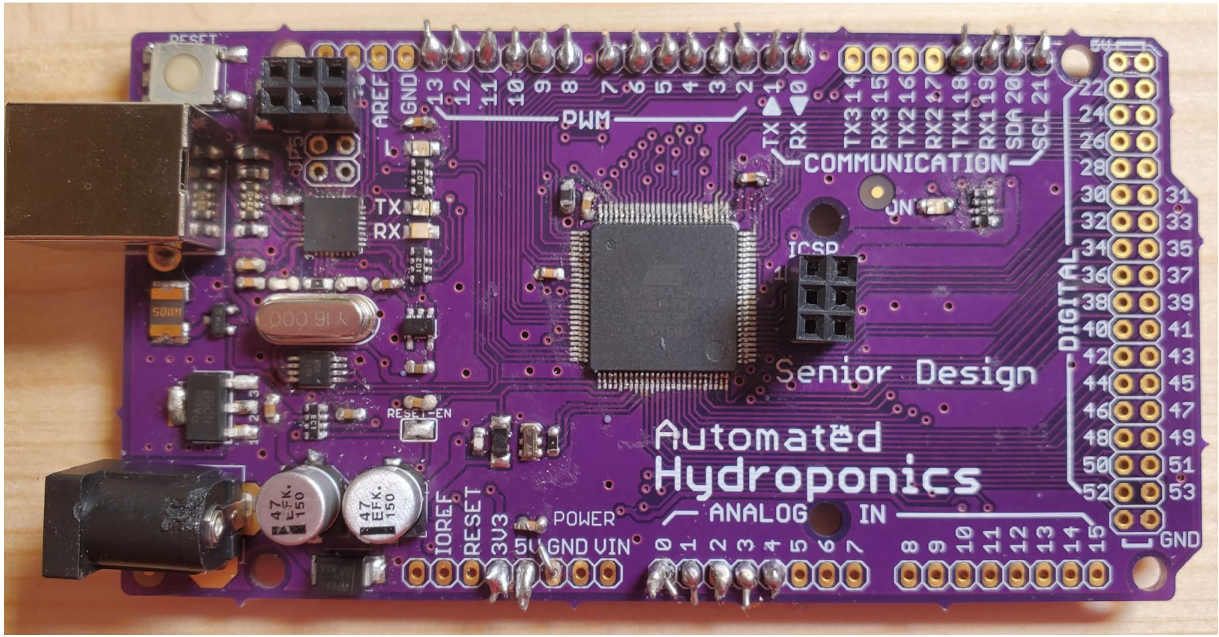


Lopez

PCB Procurement and fabrication

Components were mounted and preliminary testing was done utilizing the senior design laboratory at UCF.





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Testing Section

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Hardware Testing

- Sensors Functionality- Sensor Functionality was tested by running sample code for the sensors to ensure it worked properly.
- PCB Design - PCB was tested by uploading our main MCU arduino code to the board through ICSP header to test the full functionality.
- Wi-Fi module Wiring- The Wi-Fi module serial communication was tested with the main MCU to ensure the messages were sent/received properly.
- Breadboard Testing - The sensors/LCD were initially wired on a breadboard to test the main arduino code before using perf boards for final wiring.
- Physical Structure- We ran water through the entire system for 24 hours to ensure there weren’t any leaks that can destroy our structure.

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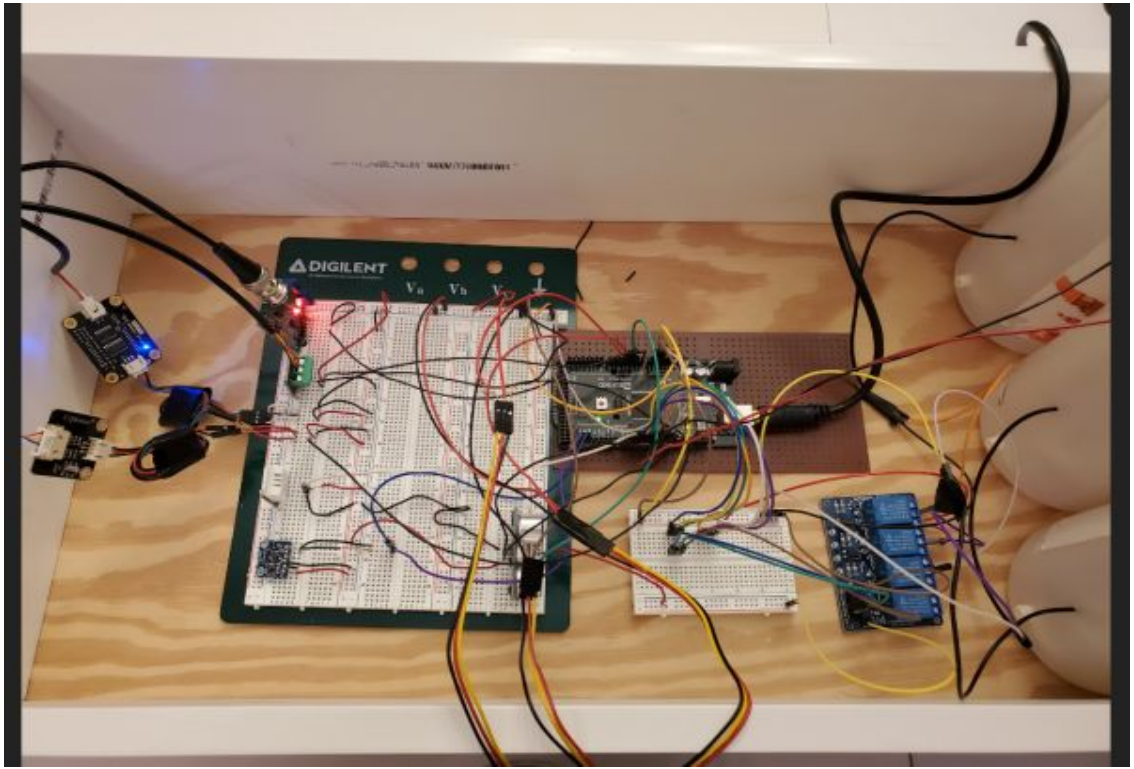
Hardware Testing



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Software Testing

- App Design
- LCD Screen Coding
- Wi-Fi module Coding
- Database

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Administrative Content

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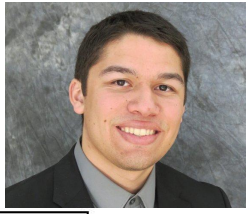

Initial Budget Overview

Our project budget is $500 with a breakdown of price estimation as shown in the accompanying table.

Atmega 2560 Microcontroller	$15
Arduino Mega	$30 (including power supply)
Peristaltic pump	$25
pH sensor	$15
Temperature Sensor	$10
Distance sensor	$5
Water level Sensor	$20
Light sensor	$7
TDS sensor	$20
WiFi chips	$20
LCD	$20-$30
LED Lights	$100
PCB construction	$50
Assorted electronic parts	$50
Construction Materials	$100

Final Budget Comparison

Our final project budget far exceeded our initial expectation. A breakdown of the project is shown in the accompanying table.

Project Portion	Associated Costs
Battery Casing	8
PCB Perf Boards	12
Solution level sensors	10
Associated sensors and MCU	160
LCD	40
Wiring	30
three way valve	10
Caster wheels	25
Plant nutrients	15
PH Up and Down	25
Assorciated screws	10
LED grow light	80
4 channel relay	8
Dossage pumps with tubing and relay module	30
PVC structure	100
Organic plant plugs and seed starter	20
Lettuce seeds	7
Misc construction costs for cabinet	248
canopy construction misc	60
PCB Fabrication	42
PCB components	100
Total Cost	1040

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Design Constraints

- COVID-19 has limited the amount of face-to-face time available as a group.
- As this is not a sponsored project, we were limited in budget to what members could reasonably afford.
- Due to being a two semester long project, design decisions were made that can be implemented within a reasonable timeframe and with good alternatives if they failed.