Hydrophonic system

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1 Executive Summary

Hydroponics is a method of growing plants in which added nutrients and oxygen are delivered directly to the roots of plants without using soil. However there are a number of problems with this system that we may face during the process, and it is very important to know how to avoid or solve those issues because this system is a more technical skill than growing plants in soil. I will discuss below some of the issues that we might encounter during this project and how we can solve these problems.

- The pH level is one of the important parts of the hydroponic system. In this system the soil itself works as a pH buffer and prevents rapid changes in the pH level. That's why we have to monitor the pH of our nutrient solution on a daily basis. For that from our research we have decided to use a ph sensor so that our system can generate that automatically.
- Nutrient solution is another important part for this system because as plants absorb the nutrient and if it's not accurate then plants will not grow healthy. So far from our research we have decided to use a TDS meter to monitor the nutrient solution. So that we can adjust the solution to a certain degree as long as plans don't show any sign of nutrient deficiency.
- There is another issue that we have faced during this research was the budget as this project is a bit expensive but so far we have decided to build some of the parts required.

2 Opportunity

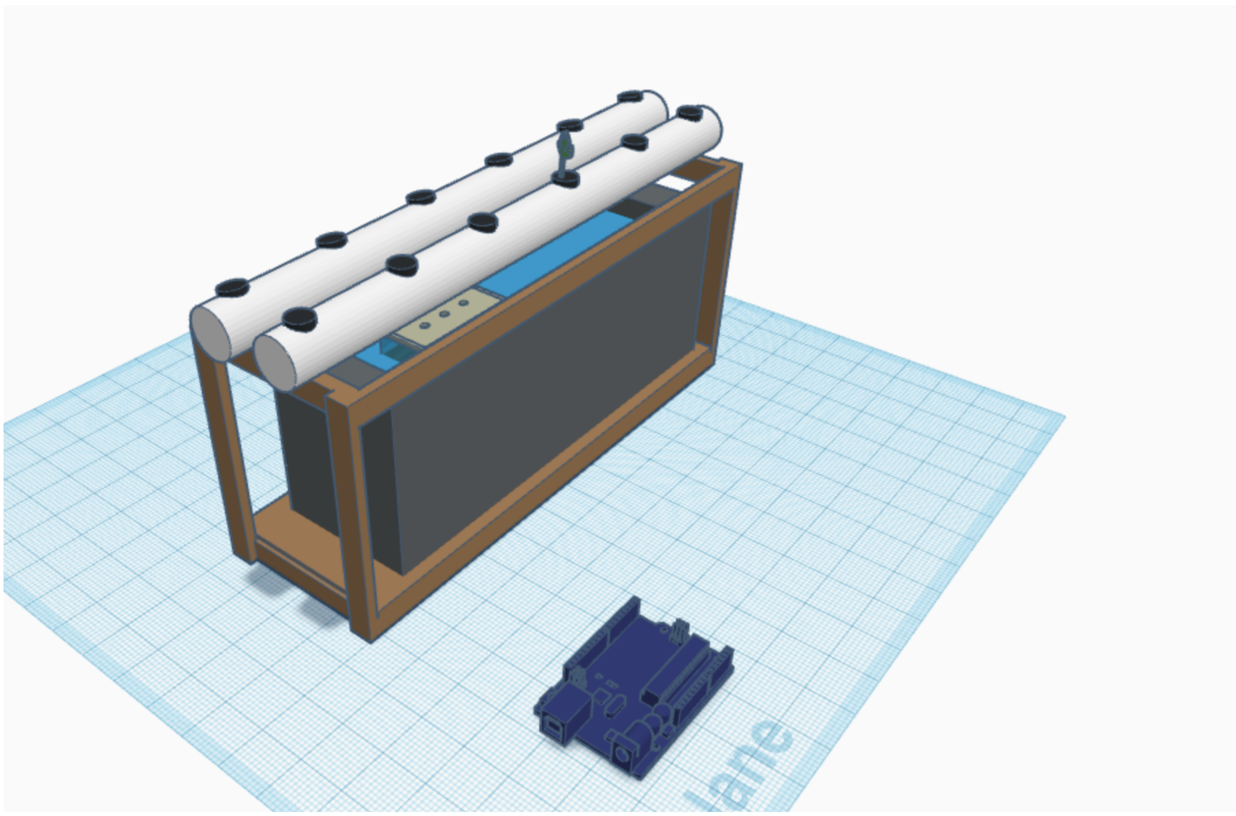
There are several kinds of opportunities a person can have by using a hydroponic farming system. People would be less dependent on the mass farming market and would be able to grow their products. So far, from our research, we have found the market for the hydroponic system currently estimated at 9.5 billion in 2020 and trying to reach 16.6 billion by 2025. In the market, this system is in high demand because it allows the growth of a high density of plants in the same area(cite benziga) and can grow throughout as this is an indoor system. However, from the hydroponics market report, I also have found that this system was affected by Covid-19 in 2020 worldwide. Some of the reasons why hydroponics is being used around the world for food production are:

- No soil is required; save space.
- It can control the nutrient level as needed.
- The water stays in the system and also can reuse it.
- Most importantly, no nutrition pollution is released into the environment because of the control system.
- It's an easy way to grow faster than natural farming.

We are more focused on the automation of our system, which will allow the user to have less control over the system, allowing an automatic adjustment of different metrics for optimal plant growth. We might use LED lights to make the system more efficient, as we have discussed.

3 Proposed Approach

Hydroponic systems give access to a new scope of farming, allowing people to become less dependent on outdoor farming to produce their food. The considered theme is perceived as an emerging technology since this field of agriculture consists of the coupling of sensors performing measurements such as temperature, conductivity, water level, etc.)



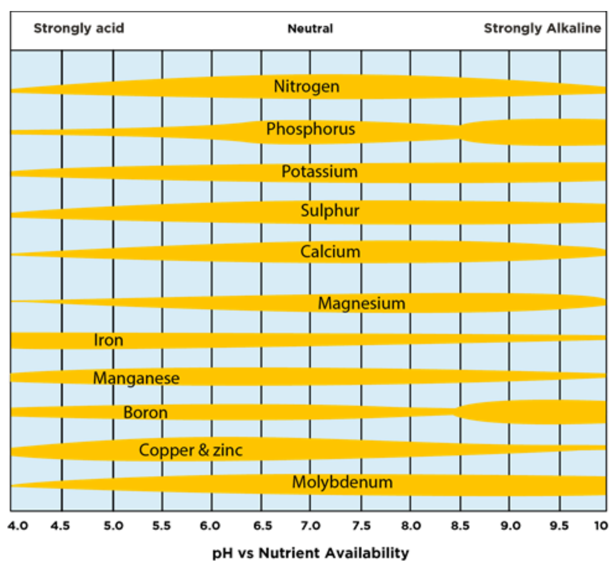
3D design of the hydrophonic system

These same sensors promote an optimal environment for plants to proliferate in a soilless manner. One reason we were attracted to this technology is its rapid development. It has already been confined to academic research, and our designing efforts consist of covering the cost efficiency trade-off gap in the literature. Indeed, intelligent agriculture has several undeniable advantages, mainly tracking plants' growth in an automated fashion, guaranteeing faster growth, and making it easier to control this process. Also, from a sociological perspective, A family of four (the USDA defines this as two adults – one male and one female – and two children) will spend \$568 – \$651 per month. cite With enough research and design, this eco-friendly plant-generating method could compensate for a good fraction of these expenses. However, fully implementing this technology would not happen in a short time-frame. Software simulations would need to be run, satisfactory thermodynamic cycles mastered, excellent atmospheric conditions calculated, and proper sanitary engineering is required to implement this type of technology successfully.

3.1 Basic components of your project

This project's primary goal is to design an indoor hydroponic system used by the average person. Our designing efforts aim to realize an autonomous hydroponic box for the plant growing operations. The plant must be powered and lit on its own but must also remain in good condition. For that matter, different metrics would need to be regulated and adjusted along the process. First, to regulate the system's temperature, a temperature sensor will be placed near the water tank to promote conforming readings from other sensors that can only operate within a specific range; moreover, this allows to send necessary data back and forth to/from the microcontroller. If the specified threshold is exceeded, a flag would be triggered to run fans to cool the system. As for the lightning of the system, we will use (lighting component). This would promote lightning cycles, ensuring periods of the night; to the plant.
The potential of Hydrogen is a crucial factor in maintaining balanced growth. It is defined as a logarithmic measure of the water's acidity, and this value must stay balanced for a given plant type. pH allows the growing of plants without soil, being the most important in hydroponic gardens. A pH meter can measure the concentration of hydrogen ions. The more acidic the solution, the more positively charged hydrogen ions it has, therefore It has tremendous potential to produce an electric current. This is important because a pH meter works like a voltmeter, measuring the solution's electrical potential. Then it compares this value to a known solution then uses the difference in voltage or the potential difference between them to deduce the difference in pH.[3] The goal of having the pH is to determine the plants' ability to take up the nutrients.

The chart shows the nutrient levels and how the absorption of these is affected by the pH level. The ideal range where the plants can take up as many minerals without lacking any is from 5.5 to 6.5 without soil. pH will frequently be affected, so the system needs to alter the reservoir's pH using a chemical pH balancing solution. Implementing a ph sensor on the water tank will track the water's acidity: If the pH is not within the desirable range, specified by the user and that has been decided to be acceptable for optimum plant growth, then a solution is added to affect and adjust the pH level.



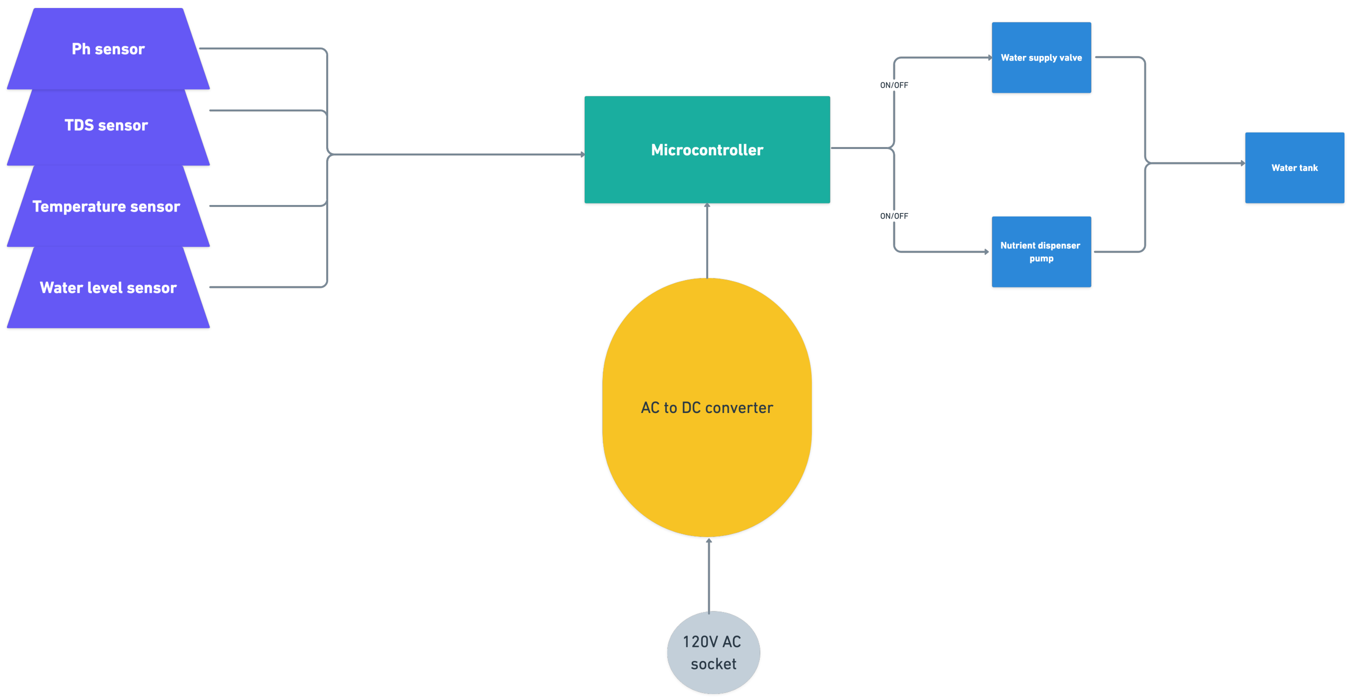
Nutrient levels chart

Our system will also have a conductivity sensor to maintain the nutrient level delivered to the plants at an optimal rate. When the readings are obtained, the microcontroller will interpret the data to operate the pumps and deliver the proper amount of nutrients. For the hydroponic system's proper functioning, the amount of nutrients in the water, which the plants absorb, needs to be continuously measured. Nutrient levels are designed to be balanced to add in various elements, and the plant will respond favorably.

There is a wide range of industrial conductivity sensors compatible with a microcontroller. The price is relatively high, ranging from roughly 70-250$. One potential solution to the constraint is to use a TDS (Total dissolved solids), which calculates the PPM value needed to adjust the nutrient concentration in the water tank. The TDS sensor is a sensitive device that consists of a probe with two small wires at the bottom end. The conductivity reading is obtained by injecting a small current through the spacing between the wires. The TDS sensor's internal capacitor-discharge at a given timeframe; this latter is a metric to obtain the value of nutrients inside water.

3.2 Hardware and software components:

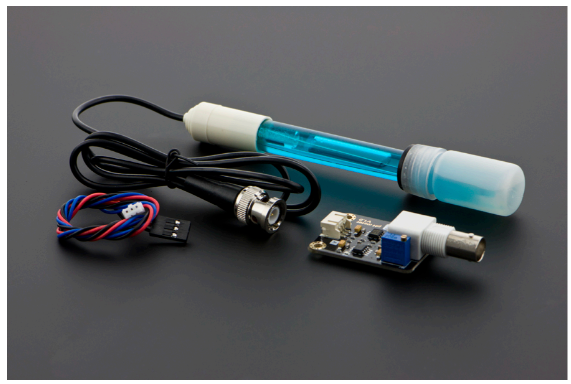
All the major components of the system have been defined, researched and compared to design a low cost hydroponic system. Our efforts are restrained to two key points: Hardware subsystems should be easy to incorporate into the system, within a low price range and while maintaining the necessary specifications. The design below shows a generalised hardware diagram of our system:



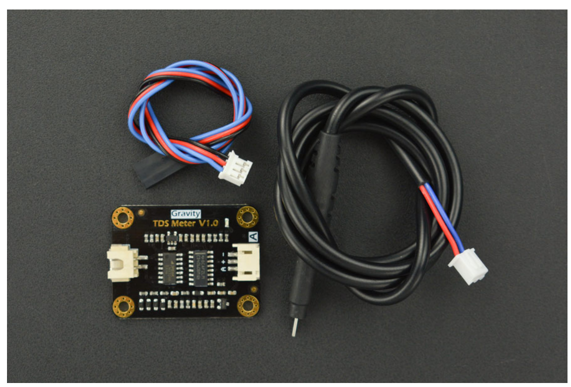
System design diagram

Hardware requirements and Specifications:

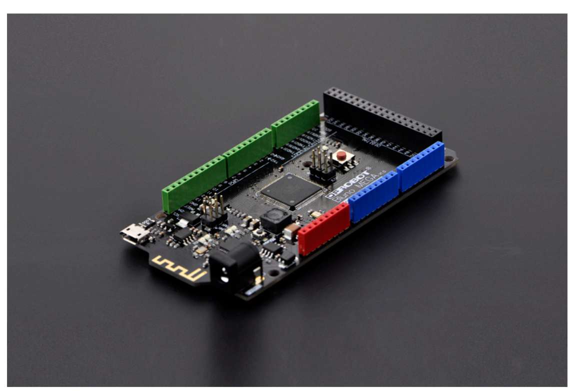
- Housing of the system:
  - Potential 3D printing of the design
- Powering source:
  - AC to DC converter from regular 120 V 60Hz socket



- pH sensor
  - Ph range 0-14
  - Module Power: 5.00V
  - Measuring Temperature: 0 - 60
  - Accuracy : ± 0.1pH (25 C°)



- TDS sensor
  - Input Voltage: 3.3 - 5.5V
  - Output Voltage: 0 - 2.3V
  - Functioning Current: 3 - 6mA
  - Measurement Range: 0 - 1000ppm
  - Measurement Accuracy: ± 10%

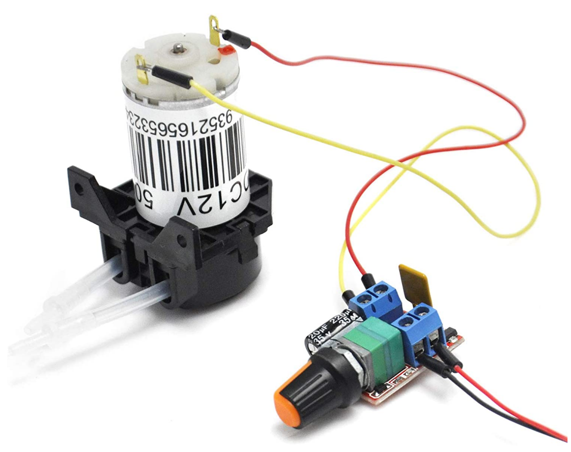


- Microcontroller
  - Arduino Mega 2560
  - Operating Voltage 5V
  - Input Voltage (recommended) 7-12V

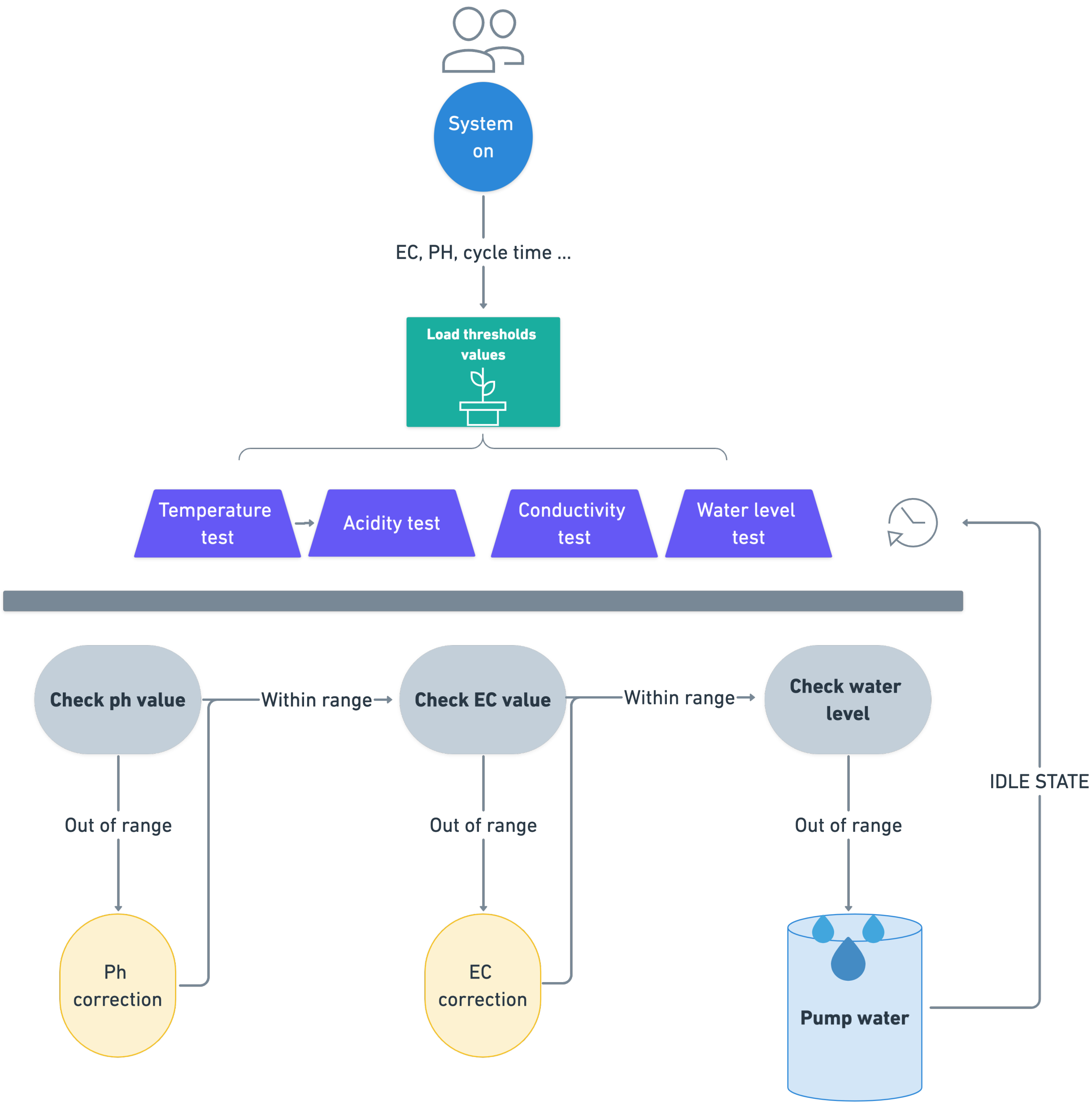
- Water Level Sensor
  - Photoelectric Liquid Level Sensor
  - Operating Voltage: 5V DC
  - Output Current: 12mA
  - Operating Temperature: (-25)-105 ℃
  - Detection Accuracy: ±0.5 mm
  - Life: 50,000 hours

- Temperature sensor:
  - Single-bus communication
  - Compatible with Arduino UNO R3 / Mega2560
  - Working voltage: 3.2   5.25VDC
  - Working current: 2mA (max)
  - Resolution: 9 12 bit programmable
  - Measuring range: -55   110'C
  - Measuring accuracy: ±0.5 C°@ -10 +80 C°; ± 2 C°@ -55 - + 110C°

- Perialistic Pump (for nutrients)
  - Volts:DC 12V
  - Current: 80mA
  - Relative humidity 80%
  - Temperature: 0-40℃
  - Flow rate: 0-100 ml/min
  - Rotate speed:0.1-100 rpm



Software design:



Software closed loop diagram

The first step of our Hydrophonic system is to load initial threshold values. These values consist of the pH range, conductance range, and the temperature supported by the plant. Every plant has specific threshold ranges that allow optimal absorption of the nutrients and significant general growth. If no values are entered by the user, default values would be generated for a young plant: pH = 6.0-6.5 and EC = 0.8-1.2 citeexplainthatstuff.

Plant Name	Lighting conditions	Temperature	pH	PPM/TDS
Basil	High Light	warm	5.5-6.5	700-1120
Mint	High light	warm	5.5-6.5	1400-1680
Oregano	high light	warm	6.0-7.0	1120-1400
Sage	high light	warm	5.5-6.5	700-1120
Scallion	high light	warm	6.0-7.0	980-1260
Thyme	high light	warm	5.5-7.0	560-1120

metric ranges for common plants

Once this initial setup is executed, the system would enter the main loop measuring the sensing activity. Each sensor would retrieve a value from the testing field (water tank). For the TDS sensor, a voltage value is returned and the conversion to a PPM value is calculated using the following Arduni IDE code block:

```
    averageVoltage = getMedianNum(analogBufferTemp,SCOUNT) * (float)VREF / 1024.0; // read the analog value more stable by the median filtering algorithm, and convert to voltage value
    float compensationCoefficient=1.0+0.02*(temperature-25.0);    //temperature compensation formula: fFinalResult(25^C) = fFinalResult(current)/(1.0+0.02*(fTP-25.0));
    float compensationVolatge=averageVoltage/compensationCoefficient;  //temperature compensation
    tdsValue=(133.42*compensationVolatge*compensationVolatge*compensationVolatge - 255.86*compensationVolatge*compensationVolatge + 857.39*compensationVolatge)*0.5; //convert voltage value to tds value
    //Serial.print("voltage:");
    //Serial.print(averageVoltage,2);
    //Serial.print("V   ");
    Serial.print("TDS Value:");
    Serial.print(tdsValue,0);
    Serial.println("ppm");
```

If the value returned is not within the user's range, a correction process is then performed. For the pH level, either an acid or a basic liquid would be added to the tank using peristaltic pumps. To get a correct pH value from the sensor, we start by getting the offset deviation value, using the following steps:

1. Insert pH meter into buffer solution of pH 7, wait for 1 min, it will achieve a stable value.
2. Subtract the value with pH 7, and it will get the offset value. For instance, 7-7.09=-0.09.

Then we use the following formula into our Arduino IDE:

```
voltage = analog value*5/1024  //Determine voltage
pH value = 3.5*voltage+offset //Formula calculation
```

Similarly, specific nutrients are added to the water tank for the EC level, delivered to the plants by a water pump mechanism. If the sensor returns a water level shortage, this latter would be pumped into the tank until an acceptable range (initial user setup) is reached.

When the pH level is too high, more nutrients could be added to the reservoir, bringing down the pH level. The system goes through this examination loop three times. Using a counter, an incrementation of a constant variable accompanies every correction. We anticipate two outcomes:

- If the correction results in an acceptable acidity range, the counter is set to 0, and the system enters an IDLE state for 30 minutes before the nest testing cycle.
- If the correction test results in a Ph value not within the desirable range, the user gets notified within the crystal LCD that the system is out of PH.

After the ph test is complete, the system goes through a similar correction test for conductivity and the water level test.

4 Commercialization

The market for Hydroponics is expected to expand dramatically in the coming years. It is valued at USD 23.94 billion (2018) and is forecast to account for a CAGR of 6.8% from 2019 - 2024

5 Limitations and further development

Throughout any project that goes there are limitations that always happens and can construct the way you do your project differently or even better. However during this Hydroponic project some limitations that came to our attention were:

- Learning Curve
- System Failures
- Cost and Setup
- Labor and Time Consumption

With this being our first time developing and building our own hydroponic, it would take some time to build the setup and strategize what is best. It will be some quality energy with our new hydroponic to work out from arrangements to steady checking. Understanding that all mechanical parts will have its defects and with the majority of parts being in the water for all the time, it will be most likely for system failures and can be destroyed within either a couple of days and even worse a couple of hours. Naturally, plants are usually grown with soil, so this will be another challenge faced with just feeding it off pH solutions and a water pump. The budget that is provided is as most the hardest and most difficult challenge facing because we are limited to a certain amount and performing an hydroponic system takes a lot of considerations and expenses like any other project. Besides the machinery doing the work will have to check on the plants and recycling system to make sure the plants are healthy and well fed. The arduino, sensors, and water pumps at any given time can either give up on us or have hardware failures, therefore we are going to have a manual check in station for the plants to make sure everything is handled properly. These requirements for the check in will be as followed:

- EC and pH meters
- pH solution

The meters will be used to check the plants range of interaction of the nutrients to make sure the plants are being properly grown and the solution is used to buffer the general components of the hydroponic; the solution that will be used more will be the pH down.

In terms of future developments and the expansion of the project we believe that yes you can make this project better by implementing several different cameras and wifi modules to make the project more suitable. This design can be improved with better equipment and yes this design can be improved with further development with trying to expand it with more than 95 percent efficient use of water with the current number being 89 percent. Also having another way of reproducing much faster and majority of plants quickly and efficiently.

5.1 Impact

The projected and expected market for Hyrdphonics are 9.6 billion dollars. This SHOULD be the future of growing and help the economy tremendously because with indoor farming no MATTER what condition of weather it is YOU can grow all year long with a climate controlled environment. Now if proposed that this project is that successful to begin with then that's the case we can make a business and help future nyit students into mixing machinery and plant life together with classes and studies from us. Now if unsuccessful this is why we will have a back up model with a different arrangement and modification and hopefully pray that one does not fail us either. If that ends up being the case for both scenarios not working out then.

The components that are going to be used generally to have this project successful is the:

- Power supply: The power for the system will consist of a plugged wire to an AC power wall outlet. This will be the general source of power and will be running everyday until we get the correct results needed. The arduino and other controllers will toggle on the same wire source or on a power stripe since there is no other form of power supply.

- Control: For data and analysis the controller which will be the arduino and microcontroller will mark and receive any given data due to the sensor implementation and have it all connected together via a Wi-Fi or Bluetooth module which canm be implemented at a later stage of the design.

- Communications: The arduino and microcontroller will be responsive 24/7 meaning that all data will be recorded and dealt with accordingly to link activation and by having it setup for round clock sweeps it will help with collecting the data more efficient and keeping track of graphs each and every day to see any changes or improvements in our design.

- Sensors/Camera: The electronic sensors will help measure the pH, water levels and temperature so that we know the plants are doing quite fine. With adding pH solutions depending if we need to add up or down solution we will manually have to do that everyday to check their nutrients. We will also have a camera being placed to check in live to make sure anything crazy doesn't happen to the plants and to document the growth of the plants as well.

- Hardware: The hardware will consist of water pumps and sensors to make sure the plants are breathing and getting the correct amount of nutrients needed. This will go hand in hand with our sensors and arduino cause it will determine the operation for the containers and plants.

- Software: The system will have the general data from the controllers therefore if anything is going wrong we can check the data and research and configure the changes right then and there. Unfortunately if anything goes wrong during the time frame we will have to wait for the following day to make changes.

5.2 Prior Art

The competing opponents for Hydroponic frameworks will be farmers that do it the original and agricultural way of farming crops with soil. The potential that these farmers don't see is that wildlife won't be a problem for crops since everything will be indoored planting and no chemical like pesticide and chemical weeds will affect the plants any more. Although this operation will be more cost efficient due to electricity and constant worries of if the crops will survive properly; the crops will be more fresh and better produce than it has ever been before and covering that aspect of health and soon more proficient.

6 Project Management plan

6.1 Research Plan

Our group split up the components to research: the I/O, sensors, instruments, equipment, and necessities such as communication, safety and risks. As we research, the key questions we asked are "what is the purpose of this device?", "Is there a market for hydroponics?", and "why is this the ideal design?". When asking the purpose of the design, we are looking for what it is helping in our community, the benefits of having this device. As we gather enough information on how plants best grow and what they need without needing to be outside, we are able to answer this question. This also includes the usefulness to people with disabilities, since regular gardening takes up a lot of components such as needing soil, frequent watering, and a good spot to grow. Some people aren't able to do this regularly because it is tiring, and can take up a lot of time. With an automated hydroponic system, there's no need to go out to get soil, no need to worry as much about watering, the system takes care of the plant.

Our key sources for this project will be from utilizing the database that NYIT has provided and scholarly articles. Experiments can consist of trying out the design of plants at home or workspace. Testing each individual sensor before combining them together to make sure they work correctly. Our top 3 technical risks are

- Sensors not being waterproof, so sensors could potentially break if not well constructed.
- Another potential risk is if not taken preliminary actions for a power outage, the system will stop working immediately, and plants may dry out quickly and will die in several hours.

Hence, a backup power source and plan should be planned for potential failures.

6.2 Team and Collaboration

The team consists of 4 members, each of which have some relevant experience in the project. Kelsey Cordova has experience in research of sensor materials and instruments, which is relevant to the development of sensors to the project, such as cameras and testing equipment, which is taken in as the data, the input for the controller. Hamad has good initiative towards the mathematical portion of the hydroponic system, working on the electrical conductivity which is essential to the hydroponic due to it's determining nutrient levels in the water tank. Imran's experience in working with microcontrollers in previous projects, such as raspberry pi and arduino allows our project to expand and be able to develop new ideas to the working system itself. Nahid's contributions consist of research as well in the temperature aspect of the project.

6.3 Milestones and Timeline

Team member responsibilities:

- Nahid Alin - Responsible for system development
- Kelsey Cordova - Responsible for software design and scheduling
- Hamad El Kahza - Responsible for hardware design of the system and power supply
- Imran Parjohn - Responsible for calibration of components

Senior Design - Hydrophonics

Project Members Nadia Alin, Kelsey Cordova, Hamad El Kahza, Imran Parjohn

Project Start 10/7/20

PHASE ONE			PHASE TWO			PHASE THREE			PHASE FOUR		
WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12
M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F

TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	PCT OF TASK COMPLETE
Research					
Research pH and meter	Kelsey	10/12/20	10/19/20	7	100%
Research EC conductivity	Hamad	10/12/20	10/19/20	7	100%
Research Water Levels	Imran	10/12/20	10/19/20	7	100%
Reseach temperature & thermometer	Nahid	10/12/20	10/19/20	7	100%
Research previous builds (if any)	Group collab	10/19/20	10/26/20	7	100%
Decide on Ideal build and avg cost	Group collab	10/26/20	11/2/20	6	70%
Proposal					
Executive summary & Opportunity	Nahid	10/26/20	11/9/20	13	100%
Proposed Approach	Hamad	10/26/20	11/9/20	13	100%
Commercialization		10/26/20	11/9/20	13	10%
Limitations and further Developme	Imran	10/26/20	11/9/20	13	100%
Project Management Plan	Kelsey	10/26/20	11/9/20	13	100%
Resources and Budget	group collab	10/26/20	11/9/20	13	80%
Design & Simulation					
CAD model	Hamad	11/2/20	11/9/20	7	40%
3D Printing	Hamad	3/29/18	4/2/18	3	0%
Simulation				0	0%
Risk Management	Kelsey			0	0%
Layout system					
Determine outsource options				0	0%
Determine suppliers				0	0%
Determine manufactoring cost				0	0%
Prototype					
				0	0%
				0	0%
				0	0%
				0	0%
Device/board tested					
Project demonstration					
Final Report					

7 Resources and Budget

Equipment name	Price	Company/Website
Gravity: Analog pH Sensor • Meter Kit For Arduino x1 • pH probe (BNC connector) x1 • pH sensor circuit board x1 • Analog cable x1	$30.00	dfrobot
Microcontroller Arduino Mega 2560	$12.00	robotdigg
Analog TDS Meter for Arduino • Waterproof TDS Probe x1 • 3Pin Analog Sensor Cable x1	$11.80	dfrobot
Filament for 3D printing	$24.66	dfrobot
Temperature Sensor	$6.49	dx
LCD display	$9.90	dfrobot
Perialistic pump $\times 2$	$25.00	Amazon
Photoelectric Water sensor	$5.50	Dfrobot
Water pump	$9.20	dfrobot
AC to DC	$9.99	Amazon
Total Cost of Manufacture	$144.54	

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[2] *How do pH meters work?: Measuring acidity*. URL: https://www.explainthatstuff.com/how-ph-meters-work.html (cit. on p. 18).

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