

### College of Engineering

Department of Mechanical Engineering

System Requirements Document

Engineering Design-Senior Design, ME-490A

Project 18, Team M9, Automated Microgreen Growing Machine

Mean Green Growing Machine

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2 October 2020



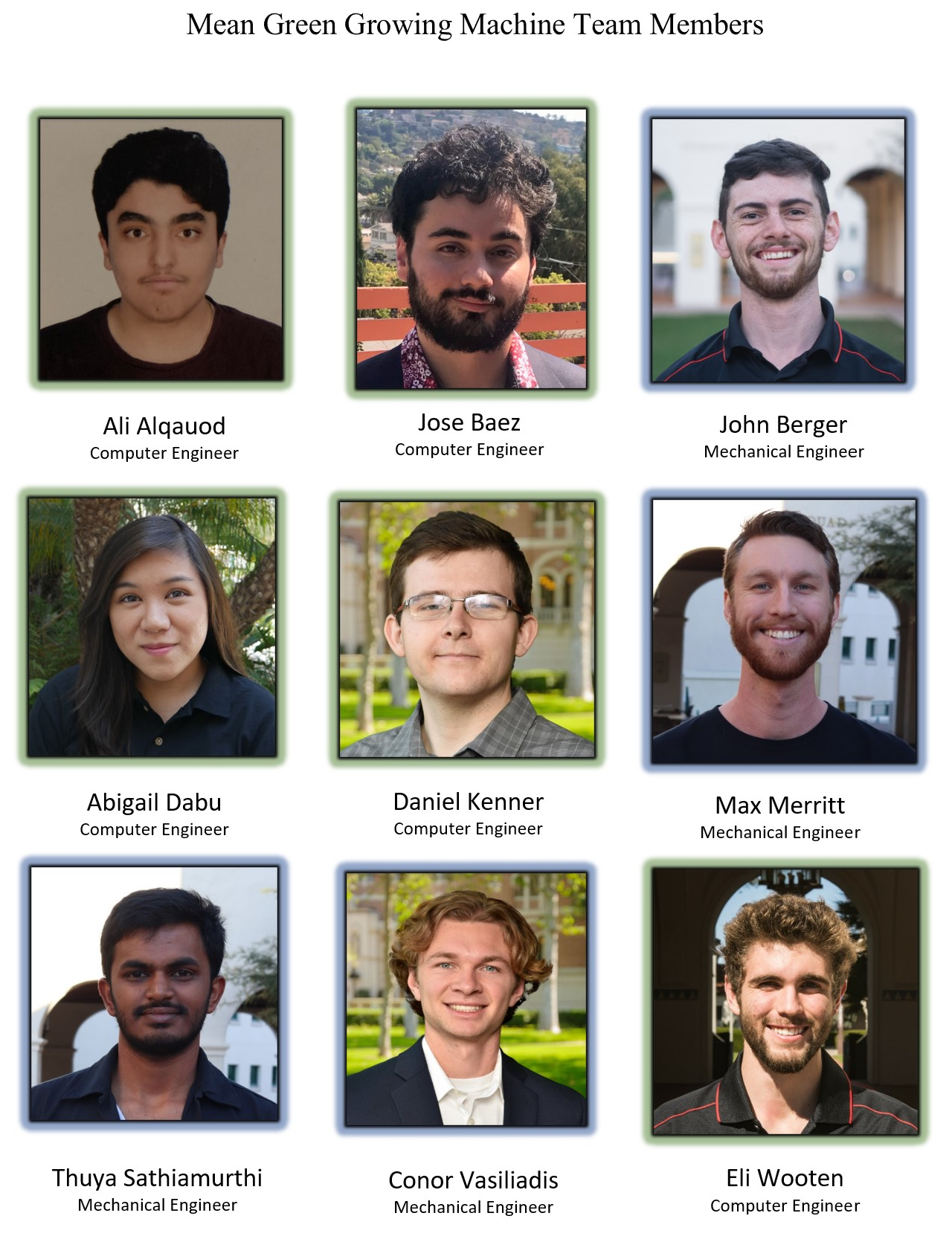


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# 1.0 System Identification, Overview

This document serves to outline the requirements & constraints imposed on the design, manufacturing, and testing of the Automated Microgreens Growing Environment. These specifications will be used throughout the year to clearly. gauge the performance of the team and measure progress towards completion.

The automated microgreens growing environment will include several subsystems integrated into a single package; including artificial lighting, watering, climate control, water quality control and real time growth analysis. These features will be controlled through an integrated control system and user interface.

All project stakeholders (See Below) are intended to review this document and understand its contents/purpose.

**Stakeholders:**  
 Dr. Scott Shaffar

Proff. Barry Dorr

ME490 Team M9

EE496 Team 11

ATOM|greens ZIP Launchpad team

Sponsor: John Berger

# 

# 2.0 System Requirements and Engineering Specifications

# **Functional and Physical Requirements**

Table 1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Requirement Number** | **Priority Level**  **(1 - 5)** | **User Requirement** | **Justification** | **User Requirement Information Sources** |
| 17115100 | 2 | The device will be load bearing. | To ensure other objects can be stacked upon it to conserve space. | Sponsor Requirement |
| 17114000 | 4 | Device must produce microgreens on a daily basis. | 6-7 cups per week will make the device economically viable to the consumer | Sponsor Requirement |
| 17119000 | 4 | Device must be operational over a large amount of cycles. | 5 years minimum product life before service of parts or replacement is needed. Similar to many consumer products | Sponsor Requirement |
| 17116900 | 4 | Device must be portable. | Over 40kg would make the device too cumbersome for the average consumer | Sponsor Requirement |
| 17113000 | 4 | Device must not take up a large amount of space. | The device should be portable/can be installed in any standard home. | Sponsor Requirement |
| 17110200 | 5 | Device will not be used outdoors. | Creating a device that will be able to function outdoors is much more expensive due to factoring in weather conditions | Sponsor Requirement |
| 17111400 | 5 | Maintain growing area at optimal temperature & Humidity | Greens generally need to be kept at an optimal temperature otherwise they will grow more slowly/perish | [Team Requirement](https://www.microgreengarden.com/seeds)  <https://www.microgreengarden.com/seeds> |
|
| 17112800 | 5 | Device will have an autonomous watering system. | Automatic watering will reduce the amount of work from the user | [Team Requirement](https://www.microgreengarden.com/seeds)  <https://www.microgreengarden.com/seeds> |
| 17113700 | 5 | Lighting: Controlled light duration and intensity to maximize plant growth. | Automatic lighting will reduce the amount of work from the user | [Team Requirement](https://www.microgreengarden.com/seeds)  <https://www.microgreengarden.com/seeds> |
|
| 17119100 | 5 | Nutrient/PH: Nutrient and PH balancing to maximize plant growth | Automatic Nutrient/PH control will reduce the amount of work from the user and promote plant growth | [Team Requirements](https://www.microgreengarden.com/seeds)  <https://www.microgreengarden.com/seeds> |
|
| 171158 | 2 | Device will be quiet | Device will operate continuously in a home environment. Excessive noise will not be acceptable to the consumer | Sponsor Requirement |
| 17118600 | 2 | Product will have aesthetic appeal | Device is designed to be sold as a consumer product | Sponsor Requirement |
|

**Functional and Physical Specifications**

Table 2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Specification Number** | **User Requirement** | **Engineering Specification** | **Justification** | **Engineering Specification Information Sources** |
| 17115100 | The device will be load bearing. | Device will withstand minimum load of 90 kg. | To ensure other objects can be stacked upon it to conserve space. | Sponsor Requirement |
| 17114000 | Device must produce microgreens on a daily basis. | Device will produce 2 cups of microgreens per day, with a 3 day harvest window. | 6-7 cups per week will make the device economically viable to the consumer | Sponsor Requirement |
| 17119000 | Device must be operational over a large amount of cycles. | Five year product lifecycle | 5 years minimum product life before service of parts or replacement is needed. Similar to many consumer products | Sponsor Requirement |
| 17116900 | Device must be portable. | Device mass not to exceed 40kg | Over 40kg would make the device too cumbersome for the average consumer | Sponsor Requirement |
| 17113000 | Device must not take up a large amount of space. | Device volume not to exceed .5 m^3 | The device should be portable/can be installed in any standard home. | Sponsor Requirement |
| 17110200 | Device will not be used outdoors. | Device will be rated for indoor use only | Creating a device that will be able to function outdoors is much more expensive due to factoring in weather conditions | Sponsor Requirement |
| 17111400 | Maintain growing area at optimal temperature & Humidity | Growing area temperature will remain between 15°- 25°C | Greens generally need to be kept at an optimal temperature otherwise they will grow more slowly/perish | [Team Requirement](https://www.microgreengarden.com/seeds)  <https://www.microgreengarden.com/seeds> |
| Device will maintain relative humidity >75% |
| 17112800 | Device will have an autonomous watering system. | Scheduled watering frequency and duration to maximize plant growth. | Automatic watering will reduce the amount of work from the user | [Team Requirement](https://www.microgreengarden.com/seeds)  <https://www.microgreengarden.com/seeds> |
| 17113700 | Lighting: Controlled light duration and intensity to maximize plant growth. | Lighting system will provide >15 Daily Light Integral (DLI) | Automatic lighting will reduce the amount of work from the user | [Team Requirement](https://www.microgreengarden.com/seeds)  <https://www.microgreengarden.com/seeds> |
| Lighting quality will maintain the following ratios R87:B10:FR2.5 with 15% adjustability on each wavelength |
| 17119100 | Nutrient/PH: Nutrient and PH balancing to maximize plant growth | pH will remain between 5.5 -6 | Automatic Nutrient/PH control will reduce the amount of work from the user and promote plant growth | [Team Requirements](https://www.microgreengarden.com/seeds)  <https://www.microgreengarden.com/seeds> |
| Nutrient density will remain between 150-200 PPM |
| 171158 | Device will be quiet | Decibel level will remain below 45 dB | Device will operate continuously in a home environment. Excessive noise will not be acceptable to the consumer | Sponsor Requirement |
| 17118600 | Product will have aesthetic appeal | Wiring harnesses will be tightly wrapped, secured, or hidden from sight | Device is designed to be sold as a consumer product | Sponsor Requirement |
| PCB's will be hidden from sight |

**External Interface Requirements**

Table 3

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Requirement Number** | **Priority Level**  **(1 - 5)** | **User Requirement** | **Justification** | **User Requirement Information Sources** |
| 17125400 | 5 | The device will be powered by a standard wall outlet | Households in the United States will be compatible with the 110-120V plug | Sponsor Requirement |
| 17123700 | 4 | The water tank will be filled with filtered or distilled water | To reduce the amount of bacterial and fungus growth as well as to reduce calcium buildup in lines | Sponsor Requirement |
| 17129500 | 5 | Device will be freestanding | A freestanding device gives the customer freedom to place it where they would like | Sponsor Requirement |
| 17121700 | 4 | Growth cycles will be initiated via the user interface | The user will control the growth cycle based on when they wish to harvest the microgreens | Sponsor Requirement |
| 17121800 | 4 | User will be alerted when the greens are ready to harvest | The microgreens should be harvested at their peak to maximize yield and freshness | Sponsor Requirement |
| 17125700 | 3 | User will be alerted of system malfunction | Informing the customer of errors will decrease user frustration and let the user diagnose product malfunctions | Sponsor Requirement |
| 17123900 | 4 | User will perform monthly cleaning and clearing procedure to clear bacteria/debris through all the equipment and growing mats | Harmful bacteria can hurt the plants and debris can make the system more inefficient | Sponsor Requirement |
| 17124300 | 3 | Monthly Service time < 45 mins | Reduce customer strain | Sponsor Requirement |

**External Interface Specifications**

Table 4

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Requirement Number** | **User Requirement** | **Engineering Specifications** | **Justification** | **User Requirement Information Sources** |
| 17125400 | The device will be powered by a standard wall outlet | A NEMA 1-15 or 5-15 will allow users to power the device | Using AC power from an outlet will be the most convenient for the end user | Sponsor Requirement |
| 17123700 | The water tank will be filled with filtered or distilled water | Water shall have less than 250 TDS (mg/L) | To reduce the amount of bacterial and fungus growth as well as to reduce calcium buildup in lines | <https://www.bestrowaterpurifier.in/blog/how-to-check-tds-level-of-water/> |
| 17129500 | Device will be freestanding | The device will be able to support itself as well as a 95th percentile male sitting on top of it | A freestanding device gives the customer freedom to place it where they would like | Sponsor Requirement |
| 17121700 | Growth cycles will be initiated via the user interface | The onboard server will allow users to remotely start growth cycles | The user will control the growth cycle based on when they wish to harvest the microgreens | Sponsor Requirement |
| 17121800 | User will be given a range for when the greens may be ready to harvest | A notification will be sent to the user to monitor the greens every day until they are ready to harvest | The microgreens should be harvested at their peak to maximize yield and freshness | Sponsor Requirement |
| 17125700 | User will be alerted of system malfunction | A notification will be sent to the user within one hour of the error occuring | Informing the customer of errors will decrease user frustration and let the user diagnose product malfunctions | Sponsor Requirement |
| 17123900 | User will clean the machine at predetermined intervals | User will perform monthly cleaning and clearing procedure to clear bacteria/debris through all the equipment and growing mats | Bacteria and debris can hurt the plants and reduce efficiency | Sponsor Requirement |
| 17124300 | Monthly Service time < 45 mins | Total time to clean growing trays, flush the lines, and fill with new water | Reduce customer strain | Sponsor Requirement |

**Electronics and Software Requirements**

Table 5

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Requirement Number** | **Priority Level**  **(1 - 5)** | **User Requirement** | **Justification** | **User Requirement Information Sources** |
| 17132700 | 5 | Electronics will be designed to withstand high humidity environments | PCBs can get corroded and broken under high humidity situations | Sponsor Requirement |
| 17130500 | 3 | Aggregate growth data will be continuously available online | Users will be able to monitor the machine remotely | Sponsor Requirement |
| 17133500 | 5 | PCB designs will meet JLC PCB design standards | JLC PCB is a cheap and easy solution to manufacturing PCBs. In order for them to accept the design it must meet their standards | [Team Requiremnet](https://support.jlcpcb.com/article/68-instructions-for-ordering)  <https://support.jlcpcb.com/article/68-instructions-for-ordering> |
| 17134200 | 4 | Wired connections throughout the device will be minimized | Wired connections create potential failure points throughout the system, and detract severely from aesthetics | Sponsor Requirement |
| 17136200 | 5 | Electronics will be designed to meet safety standards | Customer Safety | Sponsor Requirement |
| 17138400 | 5 | Electronics will perform as designed during 90% of growth cycles | Electronic faults will occur in one out of every ten growth cycles for prototype | Team Requirement |
| 17137600 | 5 | Temporary loss of device power will not alter growth cycle | Power outages occur regularly, the device must reset in a safe manner. | Sponsor Requirement |
| 17138400 | 5 | A bluetooth app will be used for the user interface | Adding a dedicated physical user interface to the machine would add cost & would be less convenient for the user. | Sponsor Requirement |
| 17160400 | 4 | Maintain access to data for 12 months locally | Developers Will want to be able to track data over timeline of project & user will want to be able to show off how many microgreens they have grown | Sponsor Requirement |
| 17123400 | 2 | Data will be recorded every 10 minutes | An entire growth cycle will be able to be housed and analyzed on a single excel sheet | Sponsor Requirement |

**Electronics and software specifications**

Table 6

|  |  |  |  |
| --- | --- | --- | --- |
| **User Requirement** | **Engineering Specifications** | **Justification** | **User Requirement Information Sources** |
| Wired connections throughout the device will be minimized | A communication network (Can Bus/SPI/Serial etc..) will be utilized to transmit signals in place of individual wired connections | PCBs are space efficient, cost effective in comparison with wires, and have less failure points do to not having flexible junctions | FSAE Judge at FSAE lincoln 2019 |
| Use PCB traces instead wires |
| Power consumption will be minimized | Device will consume < 1500 watts | Standard wall outlets in the US are connected to 20 Amp breakers. (2400 Watts @120v peak). This limit will provide a safety buffer such that any outlet can be used, even if other devices are plugged in. | National Electric Code (NEC) |
| Coding languages must be standardized | Coding languages will be limited to C and python | Python is very quick to develop, is good for handling large data sets, and can easily run user interfaces. two members on the team are very familiar with python and 3 others have exposure. C is efficient and well known for its use in embedded systems & all members on the ECE team are taught C in detail. | SDSU Degree evaluation and course list for CE/EE. |
| Electronics will be designed to meet safety standards | Maintain the following spacing through air, or over a surface: 40V per mill or 1.6kv per mm | Electrical Safety | UL796 & UL 60950-1 |

**Safety, Security and Privacy Requirements**

Table 7

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Requirement Number** | **Priority Level**  **(1 - 5)** | **User Requirement** | **Justification** | **User Requirement Information Sources** |
| 17145300 | 5 | High voltage electrical components will not be physically accessible when assembled | Customer Safety | Team Requirement |
| 17147400 | 5 | The device must be able to withstand its own weight as well as the weight of anything placed on top of it. | Consumer products need to be ensure that it will not buckle or break under any repeated stresses | Team Requirement |
| 17148700 | 5 | Thermal stressed parts need to be able to withstand high temperatures. | Thermal stresses on a part that has a life cycle of 5 years will be great and need to be considered | Team Requirement |
| 17149900 | 5 | Electrical components that could become wet need to be water resistant. | Water resistance will ensure that the product does not fail if it gets sprayed with water | Team Requirement<https://en.wikipedia.org/wiki/IP_Code> |
| 17145900 | 5 | The user needs a way to stop the machine in case an error is seen. | This is to ensure that if the system begins to malfunction, the user can press a button to shut down the system. | Team Requirement |

**Safety, Security and Privacy Requirements**

Table 8

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Requirement Number** | **User Requirement** | **Engineering Specification** | **Justification** | **User Requirement Information Sources** |
|  | High voltage electrical components will not be physically accessible when assembled | A 4mm diameter, 6 inch long rod must not be able to touch any high voltage components when the structure is fully assembled. | Customer Safety | Team Requirement |
|  | The device must be able to withstand its own weight as well as the weight of anything placed on top of it. | Factor of safety minimum requirement is to be 1.75 on all load bearing components | Consumer products need to be ensure that it will not buckle or break under any repeated stresses | Team Requirement |
|  | Thermal stressed parts need to be able to withstand high temperatures. | Factor of safety minimum of 1.75 on thermal stressed parts | Thermal stresses on a part that has a life cycle of 5 years will be great and need to be considered | Team Requirement |
|  | Electrical components that could become wet need to be water resistant. | Electrical components standardized at IP56 | Water resistance will ensure that the product does not fail if it gets sprayed with water | Team Requirement<https://en.wikipedia.org/wiki/IP_Code> |
|  | The user needs a way to stop the machine in case an error is seen. | The system shall have a power on/off button. | This is to ensure that if the system begins to malfunction, the user can press a button to shut down the system. | Team Requirement |

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# 3.0 Design and Manufacturing Constraints

**Design Constraints**

* Team will utilize
  + Solidworks for mechanical design
  + Altium for circuit board design
  + Rapid Harness for wiring diagrams
* Total volume not to exceed .5m^3
* Device must operate on 110-120V
* Device will operate without hardware or software fault in 9 out of 10 growth cycles
* Device must weigh under 40kg and be movable by one person
* Device must be able to grow multiple varieties of microgreens
* All subsystems will be designed to be serviceable
  + Lighting
    - LEDs of unique wavelengths will be utilized for growing specific crops
    - Water resistant in order to function in high humidity
  + Watering
    - Water timing and level will be computer controlled
  + Nutrients
    - Nutrient timing and concentration will be computer controlled
  + Climate Control
    - Temperature will be computer controlled
* All PCB design shall follow UL796 & UL 60950-1 for PCB trace spacing:
  + 40V per mill or 1.6kv per mm

**Manufacturing constraints:**

* Manufacturing will be limited to the capabilities of either:
  + Student skill level
  + Capabilities of Rieker Machine shop or other local machine shops
* Circuit boards will be from JLC PCB as per ECE students request.
* Wired connections will either be soldered or crimped with proper tools
* Care will be taken when manufacturing to conserve material
* Majority of the device will be manufactured using screws, nuts and bolts in order to disassemble if necessary.

# 

# 4.0 Requirements Verification Methods

## Demonstration

* Water system will be cycled to ensure proper operation of flow
* Lighting system will be adjusted to show lights change based on input
* Nutrient/PH solution insertion gives proper concentration based on given inputs
* Fan speed changes based on given inputs
* Subsystems will all operate at once to show proper communication/power limit
* Powering on device will activate subsystems
* Emergency stop will pause all subsystems
* User notified when water needs to be replaced
* Show cleaning time is under maximum allotted amount of time
* User interface is able to control plant growth cycle and monitor growing conditions

## Test

* System will adjust conditions based on plant profile chosen
* Chosen plant will grow successfully based on nominal growth cycle
* Measure amount of fresh weight output to see if meet 6-7 cups per week goal
* Verify nutrient pH remains within 5.5-6 during growth cycle
* Verify growing area temperature will remain between 15°- 28°C

## Analysis

* Device will be reset to show how system responds to new parameters
* Verify current nutrient concentration is optimal for plant growth
* Verify lights have correct R:B:FR ratio for optimal plant growth
* Verify watering frequency/amount is optimal for plant growth
* Plant profiles will be adjusted for optimal growth based on several trials

# 

# Appendix A

* + [ME 490 Background Research Assignment](https://sdsu.instructure.com/courses/58401/assignments/70028)

The goal of this assignment is to help you conduct background research on your idea for your senior design project. Remember information literacy is something you don’t ace and you gain these skills from multiple sources: Librarian, Professor, Group Members, Mentor, Friends, Family, Experts on the Internet.

Presentation Slides:

<https://docs.google.com/presentation/d/1I-qDl8M7E1CBk8GPXiQ-dv_FTy8AdFzL5nQRmg5oCoE/edit?usp=sharing>

Example: <https://docs.google.com/document/d/1sikRByGX8qv3rRf3kPjJTJZ4hhyG3gMBbfLSQD3QVGE/edit?usp=sharing>

# Learning Objectives

At the end of this assignment, you will be able to:

1. Investigate research idea options for your senior design project
2. Identify keywords related to your idea that is associated with prior research
3. Understand what research has been done related to your idea
4. Identify and evaluate what other research could be used for your project

# Learning Activities

1. **Share:** Use the Google Doc share feature to share add your Group Members (5 min)
2. **Collaborate:** Use the Comment feature to mention Jenny Wong-Welch, STEM Librarian (2 min)
3. **Brainstorm:** Craft a project idea for your senior design project (10 min)
4. **Draft:** Create a viable search string that produces results related to your idea a search string (15 min)
5. **Search:** Conduct searches in different library databases (10 min)
6. **Review:** Scan through results to evaluate if your search string is good (15 min)
7. **Cite:** Select 3 results from your searches and cite them in the APA-style (15 min)
8. **Summarize:** Describe how your selected results related to your project idea (30 min)

# Q&A

* Resources for this Assignment
  + <https://libguides.sdsu.edu/mechanical-engineering/490>
* If you have questions about this assignment, contact Jenny Wong-Welch
  + Zoom Chat: Search for Jenny Wong-Welch and send me a message
  + Email: [jwongwelch@sdsu.edu](mailto:jwongwelch@sdsu.edu)
  + Book a Zoom: <https://jennywongwelch.youcanbook.me/>

# Instructions

1. **Share with your Group Members** 
   1. When you opened the shared Google Doc link, you made a copy in your own Google Drive. Now, you need to share that Google Doc with your Group Members.
   2. Use the “Share” button in the top right corner to share it with their SDSU email address

|  |
| --- |
| Add their names here too   1. John Berger 2. Conor Vasiliadis 3. Thuya Sathiamurthi 4. Ali Alquod 5. Daniel Kenner 6. Elias Wooten 7. Jose Baez 8. Abigail Dabu 9. Max Merritt |

1. **Collaborate with the STEM Librarian**
   1. To help the librarian provide feedback on your search and results, use the “Comment” located to the left of the “Share” button to use the mention feature
      1. Add a Comment that says [+jwongwelch@sdsu.edu](mailto:+jwongwelch@sdsu.edu)
2. **Brainstorm Ideas**
   1. Your professor will suggest ideas for your senior design project

|  |
| --- |
| Using SDSU library and Google Scholar to research microgreen germination  Using Google Scholar to research Patents for automatic gardens |

1. **Draft:** Create a viable search string that produces results related to your idea a search string (10 min)
   1. Identify keywords from your project idea,
      1. Consider the who, what, where, when, why, how
      2. Include synonyms related to the keywords you have identified

|  |
| --- |
| Add your keywords here   * Hydroponic * Germination * Mold   + Mold mitigation * humidity * control   + Automated garden |

* 1. Create a search string based on your keywords
     1. Combine your keywords together to form a possible search string
     2. Remember you’re searching a computer database
        1. Consider this searching as similar to computer programming
        2. Your search strings should not be complete sentences
        3. Rather your search string should look like different variables in word formats
     3. Search String hints
        1. “ “ quotation marks
           1. means that you’re looking for a phrase and the order of words must appear as typed
        2. \* asterisk
           1. means that you want any prefixes or suffix
           2. Example: print\* would search for print, printing, printed, printer
        3. Boolean Operators
           1. AND - **narrows** a search by telling the database that ALL keywords used must be found
           2. OR - **broadens** a search by telling the database that *any* of the words it connects are acceptable
           3. NOT - **narrows** your search by telling the database to eliminate all terms that follow it from your search results

|  |
| --- |
| Combine your keywords to create a search string to test out   * Automatic AND Garden |

1. **Search:** Conduct searches in different library databases
   1. Now let’s test out your search string in different library databases to see what results come back

|  |  |  |  |
| --- | --- | --- | --- |
| Database Name | URL | Number of Results | How are the Results Sorted |
| Academic Search Premier | <https://libguides.sdsu.edu/Academic-Search-Premier> | 788 | Relevance |
| Scopus | <http://libproxy.sdsu.edu/login?url=http://www.scopus.com> | 179 | newest |
| Google Scholar | <https://scholar.google.com/> | 427,000 | Date (Newest) |
| Compendex | <https://libguides.sdsu.edu/Compendex> | 423 | Relevance |

1. **Review:**
   1. As you look through the results be sure to identify additional (more relevant) keywords

|  |
| --- |
| Any new keywords to use? \*Hint\* look through your results from Compendex   * Computer * Temperature * Indoor * Grow * Microgreen * Automation |

* 1. Based on the results, redraft your search string
     1. To get less, more relevant results
     2. Or to get more, results

|  |
| --- |
| Updated Search strings:  225 results from google scholar with “Automatic AND Garden AND microgreens”  2 results from Compendex with “Indoor AND temperature AND automated AND garden” |

1. **Cite:** Select 3 results from your searches and cite them in the APA-style
   1. Based on your results from the Scopus databases, select 3 that would be useful for your project
   2. Cite these in the APA format
      1. Remember you can use the “Create bibliography” feature under “More” to have the computer create the citation for you
      2. For additional citation help,
         1. check the Purdue OWL - <https://owl.purdue.edu/owl/research_and_citation/apa_style/apa_formatting_and_style_guide/general_format.html>
         2. Try the SDSU Library APA Citation Tutorial - <https://libguides.sdsu.edu/onlineinstruction/APA7>

|  |
| --- |
| 1. Prathyusha, A., Suman, C. Design of embedded system for automation of drip irrigation(2012) International Journal of Application Or Innovation in Engineering & Measurement (IJAIEM), Retrieved from Scopus 2. [Samuolienė](https://www.frontiersin.org/people/u/344075), [G](https://www.frontiersin.org/people/u/344075).,  [Brazaitytė](https://www.frontiersin.org/people/u/622263), [A](https://www.frontiersin.org/people/u/622263)., [Akvile V](https://www.frontiersin.org/people/u/311092)., (2019) Nutrient Levels in Brassicaceae Microgreens Increase Under Tailored Light-Emitting Diode Spectra Plant Sci., 14 November 2019 Retrieved from Google Scholar 3. Roberta Bulgari, Ada Baldi, Antonio Ferrante & Anna Lenzi (2017) Yield and quality of basil, Swiss chard, and rocket microgreens grown in a hydroponic system, New Zealand Journal of Crop and Horticultural Science, 45:2, 119-129, DOI: [10.1080/01140671.2016.1259642](https://doi.org/10.1080/01140671.2016.1259642) Retrieved from Google Scholar |

1. **Summarize:** Describe how your selected results related to your project idea
   1. Now let’s take knowledge from prior research and decide how it might be applied/used in your project
   2. Summarize your 3 chosen results
      1. Remember these results are not meant to be exactly what you plan to do
         1. If someone has already done it, then why should redo it?
         2. If you want to do something similar to what has been done before, then change one aspect of their project and experiment to see what the project outcome becomes
      2. Instead, the results should be about one part or aspect of your proposed project
         1. Example: 1 . bee life cycle affected by humidity; 2. Implement IOT equipment in remote, outdoor environments; 3. Tracking bee life through IOT equipment

Citation 1

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| * Food Borne Illness can be common in leafy greens, frequent cleaning of the machine as well as sourcing of sterilized seeds is essential. * Use of microcontroller to keep from overwatering * Ensure air movement with horizontal airflow fans. * Use clean media and water sources. * Use appropriate seeding density. |

Citation 2

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| * Nutritional value is directly related to light wavelength * An array of LED banks is necessary to maximize nutrition for each species of microgreen * specific wavelengths (eg 447, 638, 655) will enhance different nutrient concentrations in the greens such as β-carotene, iron, and magnesium * 330+ ppfd needed for optimal growth * most all antioxidant/nutrient levels increased with increasing ppfd. Some began to fall off at 545 ppfd. * Insufficient lighting showed increased hypocotyl length and low antioxidant content. * Nitrate content declined in all species with increasing ppfd |

Citation 3

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| * Smaller testing batches will increase testing efficacy and shorten time required to test * Ventilation is key for stopping mold growth * Hydroponic inherently keep the leaves dry which inhibits mold growth * Rocket is not the easiest microgreen to start with |