SENIOR CAPSTONE/
SENIOR DESIGN EXPERIENCE
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Modular Hydroponic System

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Executive Summary

The Modular Hydroponics Team strived to create a system that combined the modern control aspect of industrial style hydroponics with the simplicity and affordability of common home growing systems. Modularity was a necessity as home growers need flexibility built into their systems to allow for the healthy growth of a variety of species. A system like this could improve many people's access to healthy food, allowing it to be easily grown in relatively small areas with minimal effort. This could aid the nearly 14% of homes experiencing food insecurity in the United States (USDA, 2023).

Project Characteristics and Limits

This project was approached with a list of constraints and criteria to which the hydroponic system was held.

Criteria	Constraints
System Automation	Material Cost
Water & Nutrient Efficiency	Ease of Assembly
Marketability	System Size
Manufacturability	System Stability
User Friendly	Assembly of Materials
Versatility	Safety

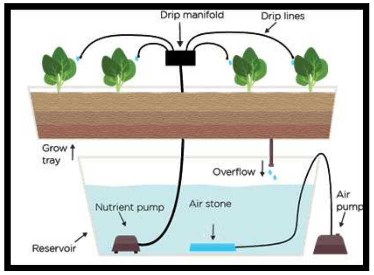

*Figure 1: Example of an Existing Hydroponic System**

Project Research

Hydroponic systems are 80-90% more water efficient than traditional farming methods, giving hydroponics a clear advantage compared to traditional farming methods in terms of water usage. Hydroponics also provides a large reduction in space needed to grow crops, providing new opportunities for the public to grow their own food.

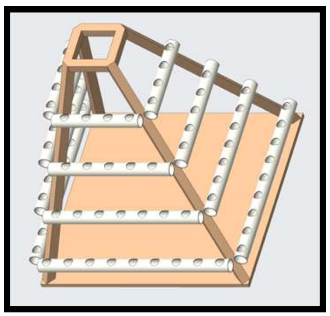

Figure 2: Solution CAD Design

Solution Ideas & Selection

The team considered four different design solutions. Each design accounted for structure, flow, controls, substrate, lighting, nutrients, and power. The final solution was generated through a weighted matrix that specialized in determining the best of each individual variable, leading the team to choose a combination of all four original designs.

Figure 3: Modular Hydroponic System Prototype

Design & Development

The hydroponic system is a three-sided frustrum with a wooden frame supporting chain-hung, adjustable PVC trays for customizable plant growth. It is mobile on caster wheels, and its Arduino microcontroller monitors pH, TDS, temperature, light, and moisture, with data accessible via Bluetooth. A recirculating pump maintains nutrient flow, and calculations for structural load, reservoir capacity, and flow rates were performed to ensure system stability and performance, with the maximum tray load at 10.7 lbs and the total system weight at approximately 135 lbs. Its modular, automated design prioritizes accessibility, efficiency, and scalability for home and community use.

Prototype Progression

Table 1: Prototype Cost Analysis

Costs and Payback Period	
Initial Cost	$697
Electricity	$78
Nutrients	$246
Annual Costs	$327
Profit in Lettuce	$684
Payback Period	2 years

Value Proposition

The main beneficiaries of this hydroponic system are the direct users who build the system and grow the produce. Manufacturers of the individual parts of the system would also benefit. Most importantly, it would benefit any communities that would decide to use the system to grow produce that would be given or sold to those in need.

Testing and Future Work

Several factors were analyzed for overall operation of the system. These include:

- Working water flow system
- Working sensor automation
- Overall structural soundness
- Success of vegetative growth

Potential future work includes:

- Viability and production of larger plant species
- Growth ability in varied temperatures
- Automated nutrient dosing
- Alternative structural materials

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*Life & Agri. (n.d.). *Gardening*. Retrieved April 17, 2025, from Life and Agri