

Introduction/Background

• Project Objectives:

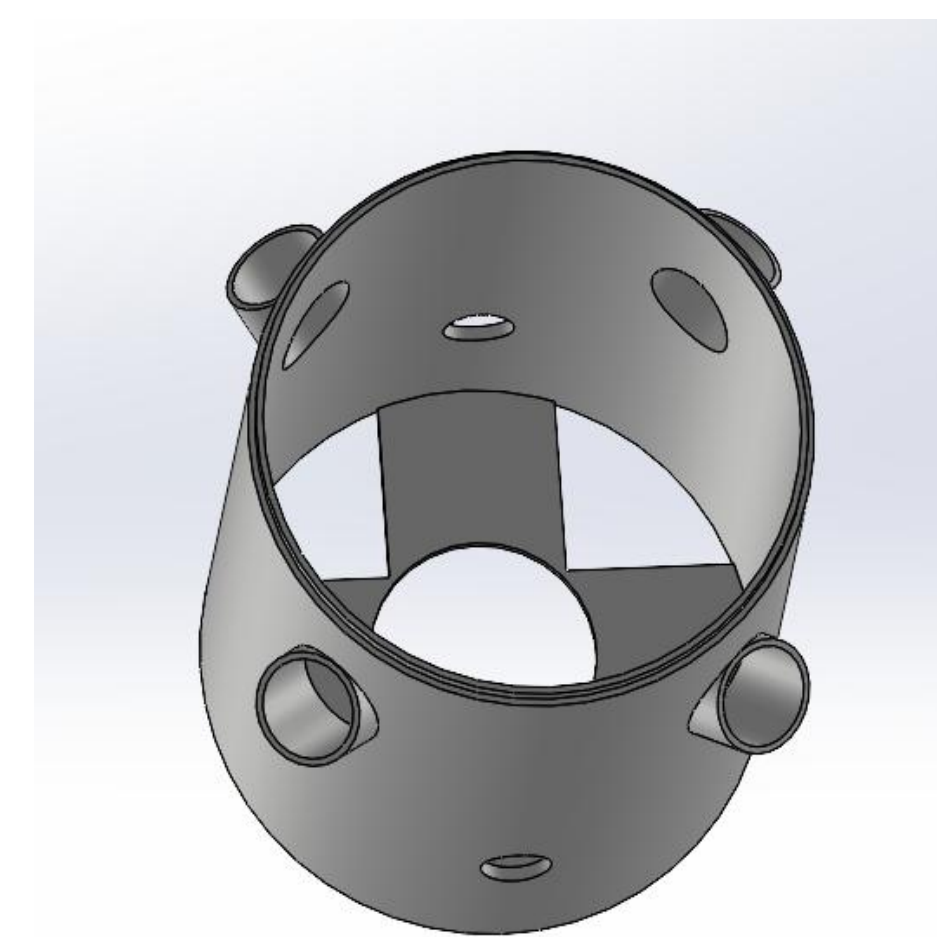
The objective of this project is to design and develop a **compact, automated, closed-loop vertical hydroponic farm** that enables households and small businesses to grow fresh produce year-round with minimal farming expertise. **The system aims to integrate smart monitoring, automation, and space-saving design** to provide a reliable and sustainable alternative to traditional farming methods.

• Constraints / Specifications:

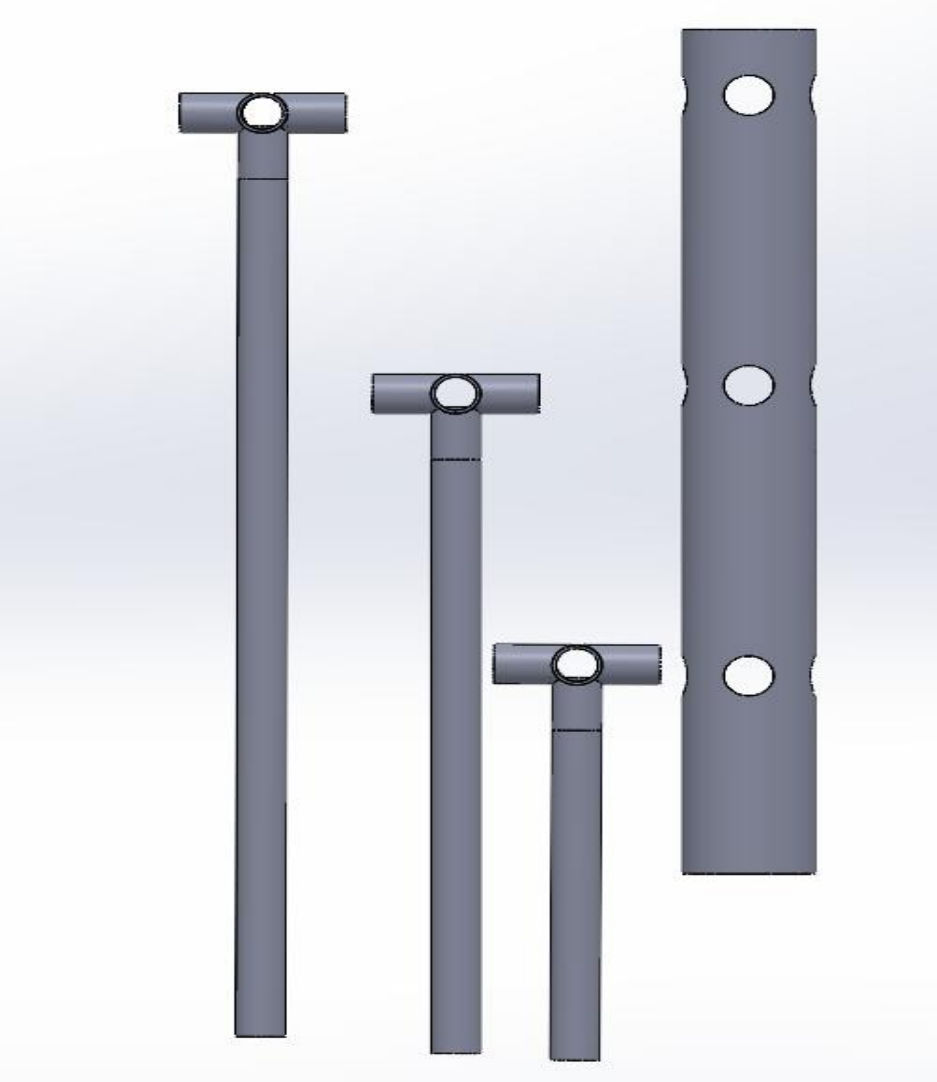
Constraint / Specification
Constraint 1 – Operates on 110–220 V AC and complies with indoor electrical safety regulations.
Constraint 2 – Food-safe, non-toxic, corrosion-resistant materials for all parts contacting nutrient solution or produce.
Constraint 3 – Footprint $\leq 60 \times 60$ cm for residential/small-business spaces.
Constraint 4 – Real-time dashboard from installed sensors.
Constraint 5 – Encrypted user data (e.g., AES-256) for credentials and logs.
Constraint 6 – Limited to herbs and small plants.
Specification 1 – $\geq 80\%$ water recirculation; ≤ 0.5 L/plant/day consumption.
Specification 2 – Mechanical stability under 25 kg; ≤ 1 cm vertical deflection.
Specification 3 – Store operational data (T/RH/pH/EC...) for ≥ 6 months.
Specification 4 – UI responds ≤ 45 s for 95% of interactions (24 h, normal load).
Specification 5 – Maintain EC within 1.2–2.0 mS/cm with hourly verification/adjustment.
Specification 6 – Water-quality sensors (pH, EC) $\pm 10\%$ accuracy with alerts.
Specification 7 – Regulate pH within ± 0.1 of setpoint; auto-adjust every 10 min; log all adjustments.
Integrated Specification 1 – Maintain RH 55–65% ($\pm 5\%$) via coordinated CHE/ME/ICS control.
Integrated Specification 2 – Achieve $\geq 20\%$ faster harvest versus traditional farming.
Integrated Specification 3 – Fully automatic operation for ≥ 14 days without intervention.

Prototype Development

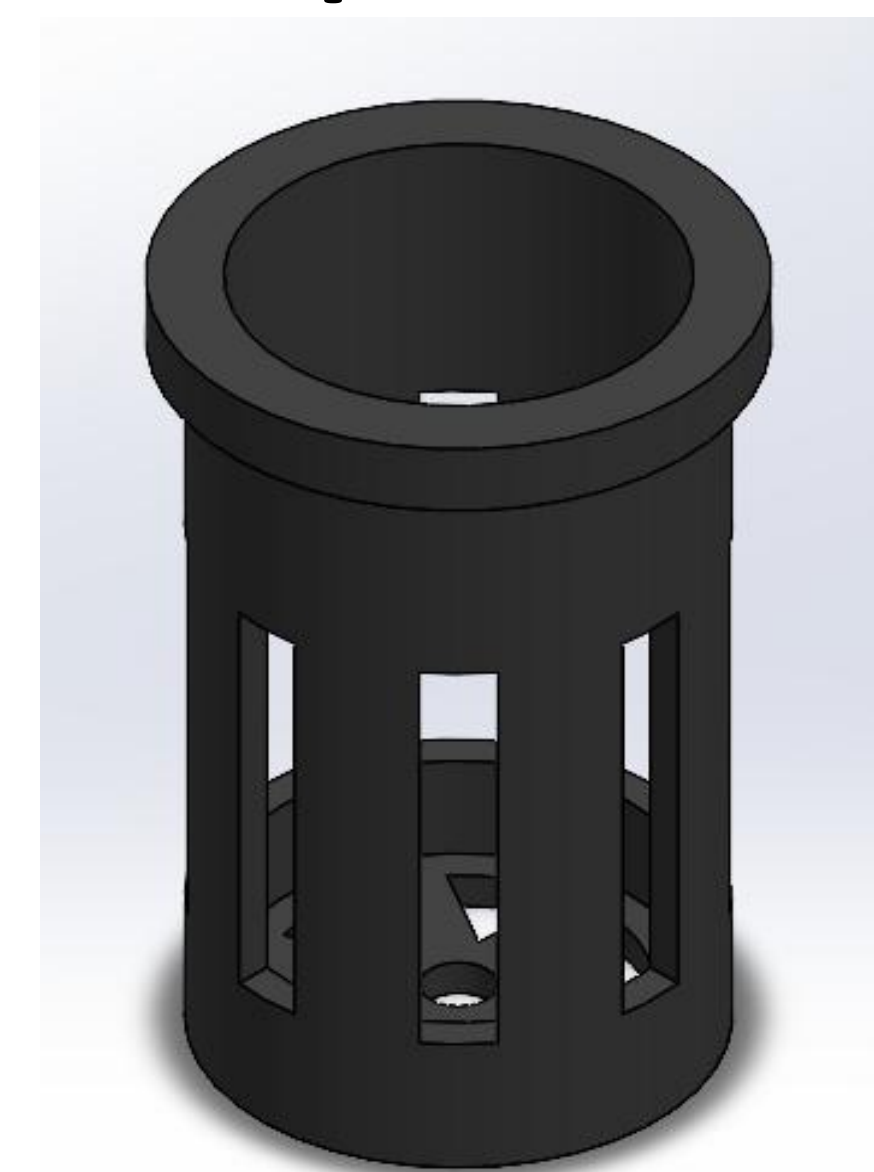
• Layers Design



• Piping

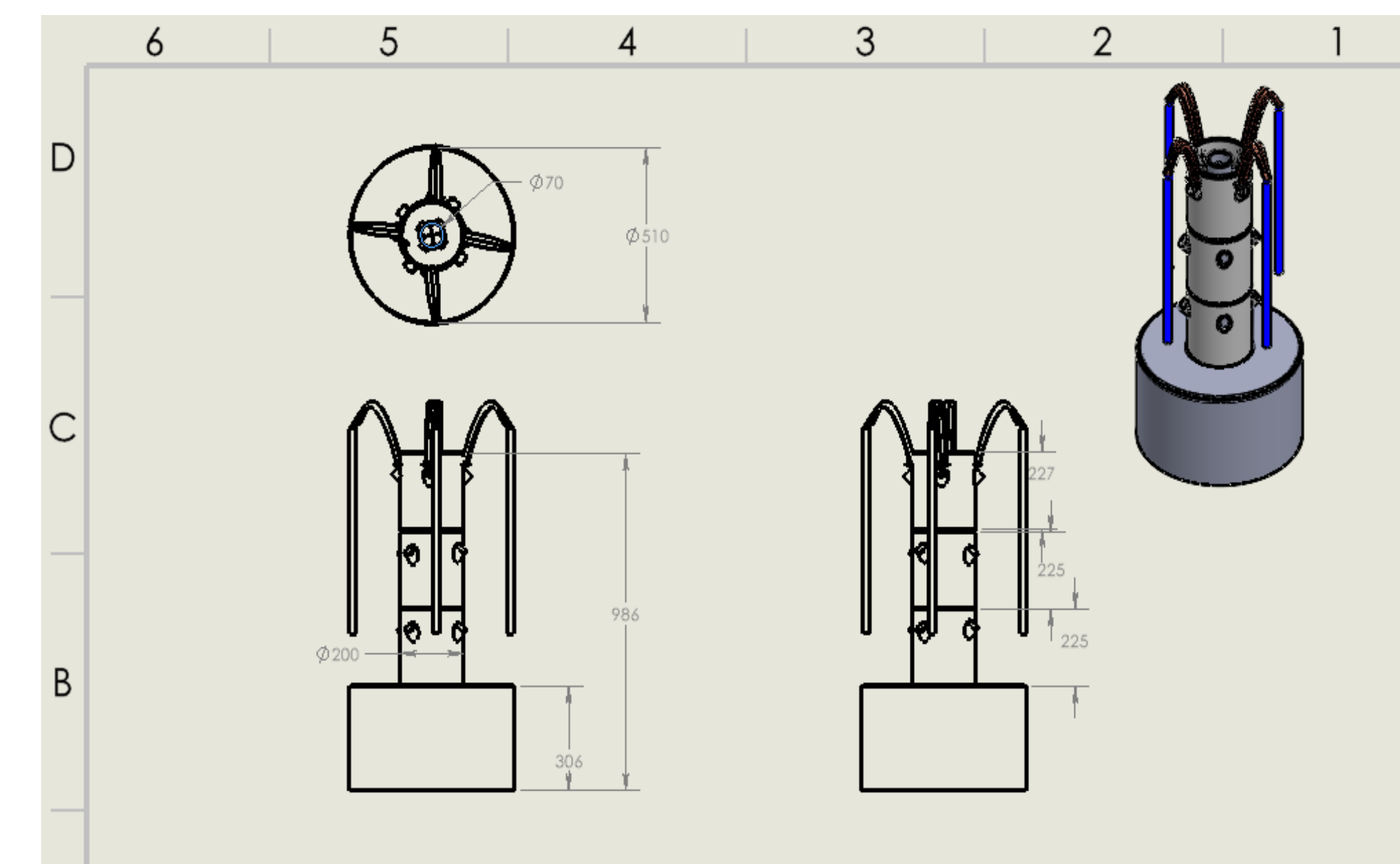


• Crop Holders

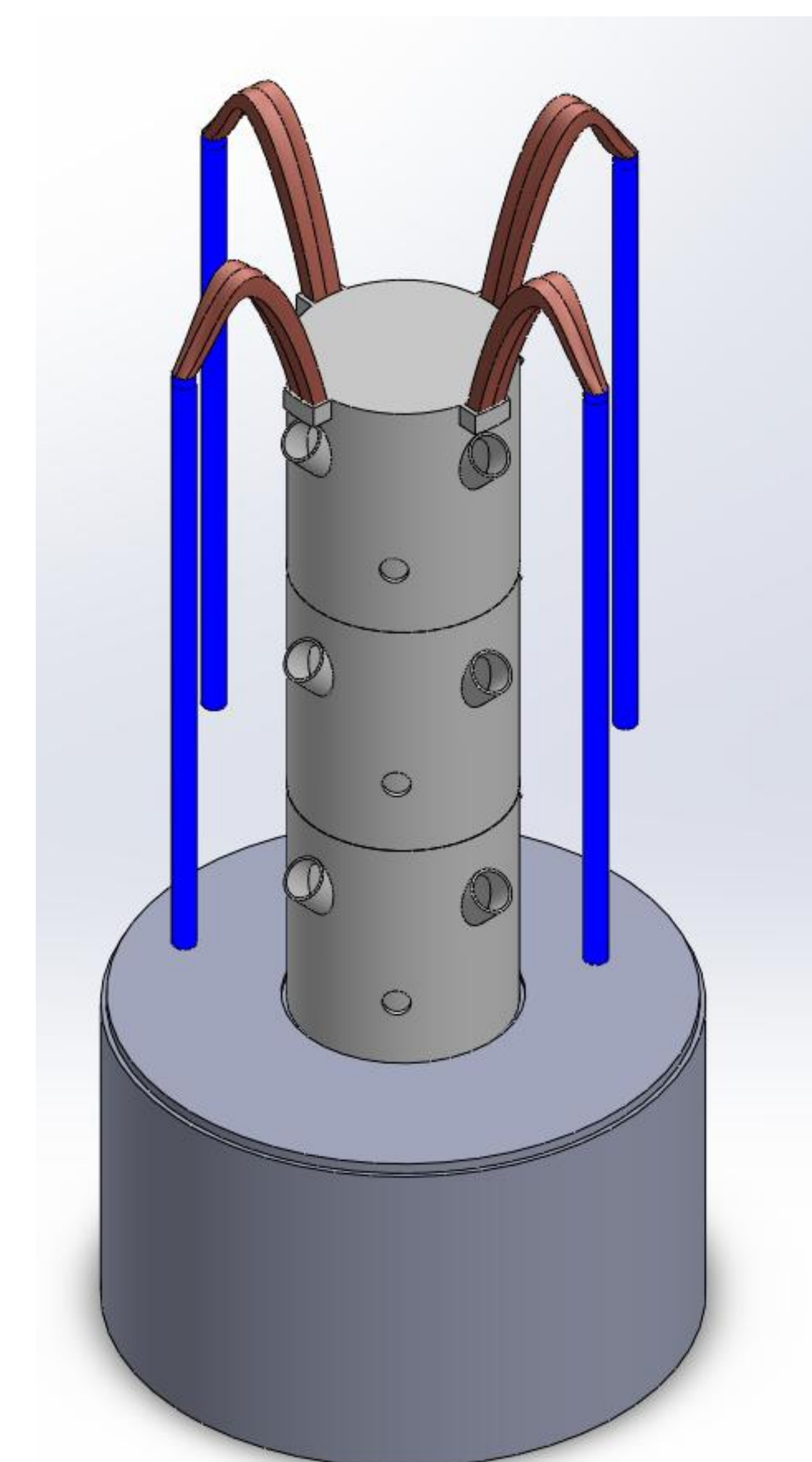


Final Prototype

• Final Drawing



• Final Design



Testing/Validation

- Constraint 1:** Power operation verified ✓
- Constraint 2:** Food-safe materials confirmed ✓
- Constraint 3:** Footprint within 60×60 cm (physical measurement) ✓
- Constraint 4:** Real-time dashboard validated (live sensor display test) ✓
- Constraint 5:** User data encryption implemented (AES-256 code check) ✓
- Constraint 6:** Optimized for herbs & small plants (growth trial) ✓
- Specification 1:** $0.08\text{--}0.26$ L/(plant*day) $\rightarrow \geq 80\%$ (spec ≤ 0.5 L/plant/day). ✓
- Specification 2:** Stability under 25 kg confirmed (measured using KG scale) ✓
- Specification 3:** 6-month data storage verified (memory capacity test) ✓
- Specification 4:** UI response within limit (timed response test) ✓
- Specification 5:** kept within 1.2–2.0 mS/cm
 - Mint: 1.5–1.7 mS/cm ✓
 - Thyme: 1.7–1.9 mS/cm ✓
 - Portulacaria: 1.3–1.5 mS/cm ✓
- Specification 6:** Sensor accuracy validated (calibration vs reference) ✓
- Specification 7:** pH (all tanks): 5.8–6.1 (target 5.9) ✓
- Integrated Spec 1:** RH sensor 55–60% ✓
- Integrated Spec 2:** Faster harvest validated (growth comparison trial)
- Integrated Spec 3:** 14-day unattended operation confirmed (the total consumption of water is less than the total volume of tanks) ✓