ECET x30 - Project Definition Template

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High-Level Description

A battery-powered smart plant monitor is designed to be inserted into the soil to measure moisture, temperature, humidity, and light levels. Users can configure optimal ranges for each parameter, and the device provides real-time feedback through an RGB LED indicator. A green light means all conditions are optimal, red signals temperatures that are too high, blue indicates temperatures that are too low, yellow warns that the plant needs water, and orange indicates that the plant needs more sunlight. When multiple conditions are outside the optimal range, the RGB LED flashes the corresponding colors in sequence. The monitor runs on rechargeable batteries that are kept charged by a small solar panel, allowing for extended outdoor operation without frequent maintenance.

Purpose

The Smart Plant Health Monitor helps users track and maintain their plants' well-being by monitoring environmental conditions and providing clear feedback.

Key components of the Smart Plant Health Monitor are:

- Continuous Monitoring: Measures soil moisture, temperature, humidity, and light to ensure conditions remain within user-defined optimal ranges.
- Provides a plant status
  - LED off when optimal
  - Red = too hot
  - Blue = too cold
  - Yellow = needs more water
  - Orange = more sunlight
  - Flashing = multiple conditions are outside the optimal range

- Low Maintenance: Minimizes user intervention with rechargeable batteries supported by solar charging for extended outdoor use.

Client

Target Audience

- Plant owners who want an easy way to monitor the health of their plants
- Gardeners looking for a low-maintenance, portable monitoring system
- Hobbyists or students interested in learning about electronics and plant care

Roles

- Provide a way for users to track key environmental factors (soil moisture, temperature, humidity, light)
- Offer real-time feedback on plant conditions using the RGB LED
- Serve as an educational tool for understanding sensor-based monitoring systems
- Help users maintain healthier plants with minimal effort

Budget Considerations

- Designed to be affordable and accessible for hobbyists and small-scale users
- Estimated cost of components: $30–50 (Arduino, sensors, RGB LED, power supply)
- Optional enhancements (solar panel, wireless connectivity, automatic watering) may increase cost

Communication

For the Smart Plant Monitor, all the documents and diagrams can be found on the GitHub Repository: https://github.com/hgh-29/Smart-Plant-Monitor
The Logbook for this project is the following table:

Project Logbook				
Week	Date	Options/Evaluations/Decisions	More details	Issues
1	9/1-9/6	Came up with project ideas		
2	9/7-9/13	Picked Project Groups and Project Idea: Smart Plant Monitor Created a		

		Block Diagram and Project Definition Template		
3	9/14-9/20	Brainstormed Parts for Project	UC: Arduino Uno Sensors: DHT11, Photoresistor, Soil Sensor Output: RGB LED	Need to figure out which soil sensor to use abd a way for users to input plants data.
4	9/21-9/27	Picked a the Capacitive Soil Moisture Sensor		
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Objectives

The objective of the Smart Plant Health Monitor is to provide plant owners with a simple and reliable way to track the overall well-being of their plants. The device measures key environmental factors such as soil moisture, soil temperature, ambient temperature, humidity, and light levels, giving users a complete picture of the conditions that affect plant health.

To make the data easy to understand, the monitor uses an RGB LED indicator to communicate status at a glance. When all conditions fall within the user-defined optimal ranges, the LED remains off, signaling that the plant is healthy. If the temperature rises too high, the LED turns red; if it becomes too cold, it turns blue. A yellow light alerts the user when soil moisture drops below the ideal threshold, indicating that the plant needs watering. An orange LED indicates the plant needs to be exposed to more sunlight. When multiple conditions are outside the optimal range, the RGB LED flashes the corresponding colors in sequence, for example, if the temperature is too low and the soil moisture is too low, the LED alternates between blue and yellow.

The monitor is powered by a rechargeable battery with integrated solar charging support, which allows it to operate outdoors for extended periods with minimal user intervention. This makes it both practical and low-maintenance, ensuring that users can keep their plants healthy without needing constant monitoring.

Figure 1 below is an example sketch of what the smart plant monitor could look like when placed in a plant pot:

Figure 1

Figure 2 below is the block diagram for the smart plant monitor. Blue blocks represent the input sensors, green are the outputs, purple is the microcontroller, and the yellow is external components such as the battery and user input.

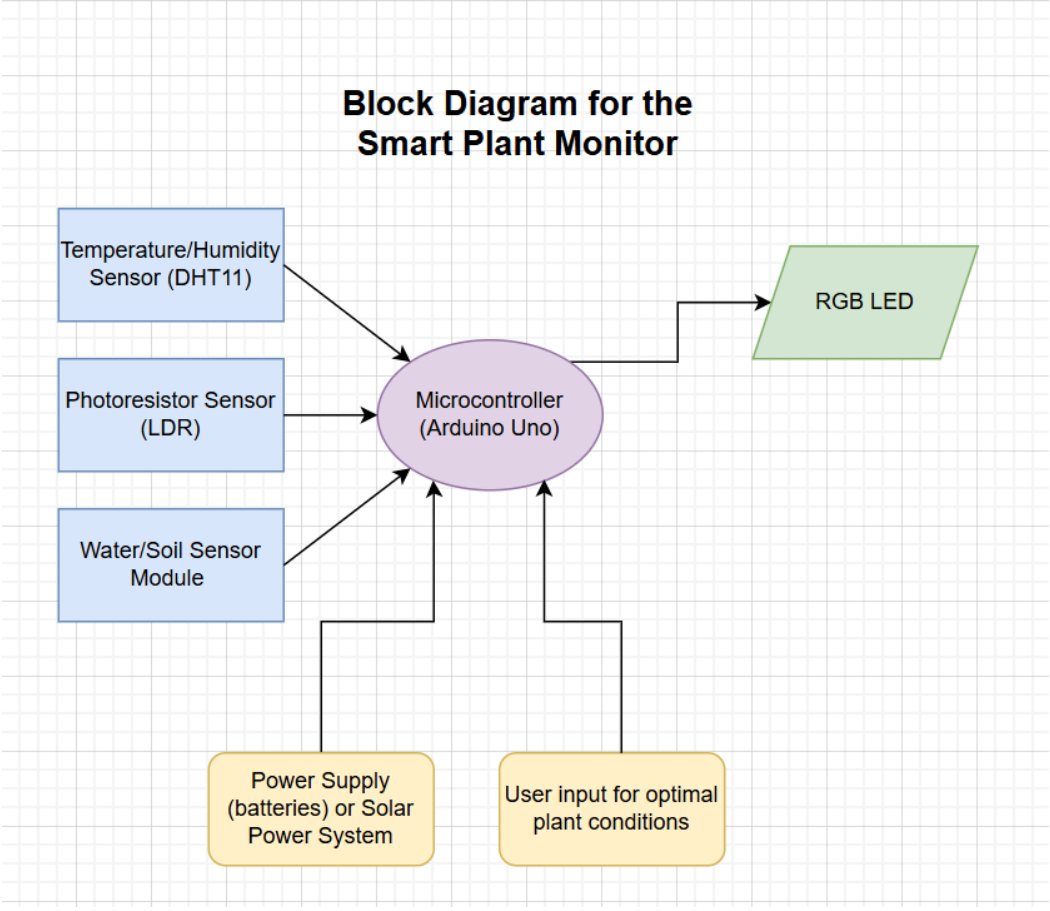


Figure 2

Figure 3 below shows the advanced block diagram of the Smart Plant Monitor, highlighting the function of each sensor and the system's response under different conditions. The monitor is powered by a battery. Once powered, the user can input the optimal temperature range for the specific plant being monitored. The microcontroller stores this data, and the sensors begin monitoring.

Each sensor measures temperature, soil moisture, or sunlight at one-minute

intervals. This intermittent monitoring helps conserve battery life, as continuous monitoring would drain the battery more quickly. After collecting the data, the microcontroller evaluates whether the current conditions fall within the user-defined optimal range.

If the temperature is too high, the RGB LED turns red; if it is too low, the LED turns blue. If sunlight is insufficient, the LED turns orange, and if soil moisture is too low, the LED turns yellow. When multiple conditions are outside the optimal range, the RGB LED flashes the corresponding colors in sequence, for example, if the temperature is too low and the soil moisture is too low, the LED alternates between blue and yellow. When all conditions are within the optimal range, the RGB LED remains off.

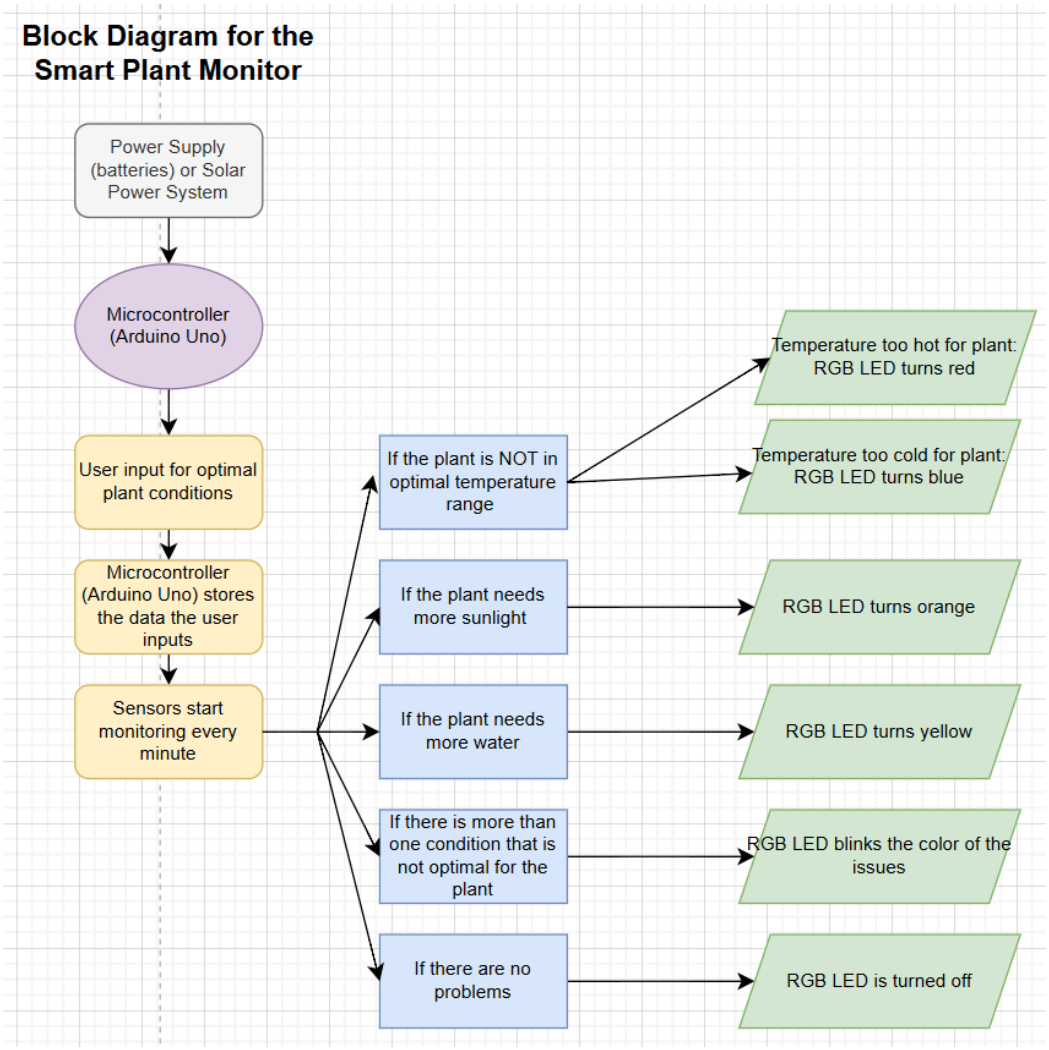


Figure 3

Scenario

User Interaction Stories

When a user first receives the Smart Plant Monitor, they open the package and check that all the components are included, such as the monitor, sensors,

battery, and instructions. The setup is simple and doesn't require any special tools.

To configure the monitor, the user powers it on and uses the rotary encoder to set the optimal temperature range for their plant. Soil moisture and light thresholds can also be adjusted if needed. These settings are saved so the device can monitor the plant automatically.

During normal use, the monitor measures soil moisture, temperature, humidity, and light levels. The RGB LED gives an easy-to-read visual status: green means the plant is healthy, red indicates high temperature, blue shows low temperature, yellow warns that the soil is dry, and orange signals low light. The LED can also flash multiple colors if more than one condition is outside the optimal range.

If the device doesn't seem to work correctly, troubleshooting is straightforward. Users can check the battery, ensure the sensors are properly connected, and adjust thresholds as necessary.

The monitor allows both passive and active interaction. Passively, it continuously tracks plant conditions and displays status via the LED. Actively, the user can change settings, check readings, or use optional features such as data logging or connecting to a display.

Finally, the device is designed for easy servicing. Batteries can be recharged or replaced, and sensors can be cleaned or swapped out if needed. This ensures the monitor remains reliable over time with minimal effort from the user.

User Interface

The Smart Plant Health Monitor provides feedback to the user primarily through an RGB LED indicator, giving a clear, at-a-glance understanding of plant conditions.

LED Indicators:

- Off: Plant is healthy and in its ideal conditions
- Red: Plant is too hot
- Blue: Plant is too cold
- Yellow: Plant needs to be watered
- Orange: Needs more sunlight

Sensors:

- Soil Moisture Sensor (Capacitive Soil Moisture Sensor): Measures soil moisture levels and alerts the user via the LED when the soil is too dry.
- Temperature and Humidity Sensor (DHT11): Monitors ambient temperature and humidity around the plant to ensure conditions remain within the ideal range.
- Light Sensor (Photoresistor): Measures sunlight exposure to determine if the plant is receiving sufficient light.

User Input:

- Rotary Encoder: The user can input their plants' optimal ranges for temperature using the rotary encoder.

The monitors will read all sensor data and updates the LED status in real time, allowing users to quickly assess the health of their plants. By providing clear visual feedback and minimizing user intervention, the system simplifies plant care and helps maintain optimal growing conditions.

User Acceptance

Given–When–Then Criteria:

- Soil Moisture Feedback:
  - Given: the plant is in the soil with the monitor inserted
  - When: the soil moisture drops below the user-defined threshold
  - Then: the yellow LED turns on to alert the user
- Temperature Monitoring
  - Given: the monitor is measuring ambient temperature
  - When: the temperature rises above the optimal range
  - Then: the red LED illuminates; if it falls below the optimal range, the blue LED illuminates
- Light Monitoring
  - Given: the monitor is measuring sunlight exposure
  - When: the light level falls below the user-defined threshold
  - Then: the yellow LED lights up to indicate insufficient light
- Power Operation
  - Given the monitor is powered by the battery and solar panel
  - When the device is deployed outdoors for 24 hours
  - Then it continues operating without requiring manual charging

Quantifiable Goals:

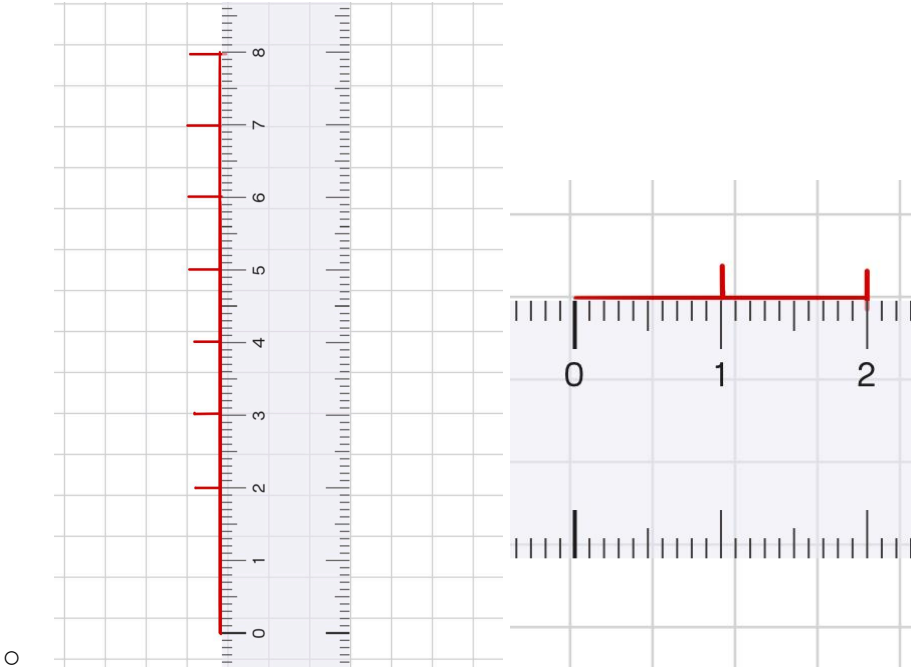
- LED status update response time ≤ 5 seconds after a sensor reading change
- Continuous operation for at least 7 days on a fully charged battery under typical sunlight conditions

Parameters

Technical

This project must be small enough that it can be placed in the pot/soil of a plant. The dimensions can not be larger than 8 inches. The project must be somewhat waterproof or water-resistant since it will be located in the plant pot/soil. This project should be able to read the current temperature, humidity, moisture, and light level.

- Dimensions
  - Height: No larger than 8 inches tall, no smaller than 2 inches tall
  - Width: No larger than 2 inches wide, no smaller than 1 inch wide
  - Weight: 50-300 grams
- Electromagnetic Compatibility (EMC) & Electromagnetic Interference (EMI) Protection

- Add small capacitors near the sensors and microcontroller to keep signals clean
- Add a diode or filter to protect against noise from the servo or pump
- Make sure the solar panel and battery connections are protected against surges or wrong wiring
- 

Functions

The Smart Plant Health Monitor performs several core functions to help users maintain optimal plant conditions.

- Soil Moisture Monitoring: The Capacitive Soil Moisture Sensor measures the moisture level in the soil and alerts the user via the LED when the soil is too dry.
- Temperature and Humidity Monitoring: A DHT11 sensor measures the air temperature and humidity around the plant. If conditions become too hot or too cold, the LED changes color to warn the user.
- Light Monitoring: A light sensor measures sunlight exposure. When the plant is not receiving enough light, an orange LED illuminates to indicate this.
- Power Management: The system is powered by a rechargeable battery and supported by a small solar panel, allowing the monitor to operate outdoors for extended periods with minimal user intervention.
- User Input: The user can input their plants' optimal ranges for temperature using the rotary encoder.

Integration

The Smart Plant Monitor uses standard analog and digital interfaces to

connect its components. Sensors such as the soil moisture sensor and LDR provide analog signals that the Arduino reads through its analog pins. The RGB LED is connected to digital PWM pins for color control. The rotary encoder also uses digital pins to send signals to the microcontroller. Power is supplied via 5V and GND rails, shared across the sensors, LED, and encoder.

The system uses basic Arduino I/O protocols to read sensor data and control outputs. No advanced communication protocols are required for this version. The DHT11 temperature and humidity sensor communicates through a simple digital protocol supported by the Arduino DHT library. The rotary encoder uses standard pulse signals to detect rotation steps and button presses. Overall, the Smart Plant Monitor relies on direct pin-level communication between the microcontroller and each component, keeping the integration simple and reliable.

Operational

The Smart Plant Monitor is designed for indoor and outdoor use, but it has some limitations. It should not be exposed to extreme weather conditions such as heavy rain, flooding, or extremely high temperatures beyond the sensor specifications. The device is intended for use with small to medium-sized potted plants and may not provide accurate readings for very large planters or outdoor garden beds.

The monitor operates on a low-duty cycle to conserve battery life. Sensors take readings at one-minute intervals, rather than continuously, which reduces power consumption and extends the life of the battery. The RGB LED only activates when a condition is outside the optimal range, further conserving energy. This intermittent monitoring ensures reliable operation over long periods with minimal maintenance.

Regulatory

The Smart Plant Monitor is designed to comply with general safety laws regarding small electronic devices. It operates at low voltages (5V from battery or USB), which is below thresholds requiring special electrical certifications.

The device adheres to electrical and electronic component regulations, ensuring that all sensors, LEDs, and microcontrollers are used within their rated voltage and current limits. Any wireless or battery-powered components would comply with local FCC or CE requirements if included in future versions.

The Smart Plant Monitor is intended for educational and personal use, not commercial sale in its current form. Users should follow manufacturer guidelines for battery handling, sensor care, and safe disposal of electronic components to meet environmental and safety policies.

Life Cycle

The Smart Plant Monitor is designed for small-scale assembly using widely available components. The Arduino, sensors, RGB LED, rotary encoder, and battery

are sourced from standard suppliers. Components are mounted on a breadboard for prototyping or a simple PCB for future production. The assembly process is straightforward, allowing easy replication or modification.

The device is programmed using the Arduino IDE with C/C++ code. The program reads sensor data, processes it according to user-defined thresholds, and controls the RGB LED output. The rotary encoder allows users to input settings, which are stored in memory for ongoing operation. Programming is modular, enabling updates or additional features to be integrated easily.

During use, the Smart Plant Monitor tracks environmental conditions such as soil moisture, temperature, humidity, and light levels. Data can be logged or monitored in real-time via the LED indicators. In future versions, tracking could include recording readings for analysis or remote monitoring, providing insight into plant health trends over time.

Environment

The Smart Plant Monitor is designed to operate within typical indoor and outdoor temperature ranges. Extreme heat or cold outside the sensor or Arduino specifications may affect performance or accuracy.

The device should be kept away from water spills, flooding, or corrosive substances. While it monitors soil and environmental conditions, it is not fully waterproof, and exposure to liquids may damage electronic components.

The monitor is intended for potted plants, not direct exposure to rain or heavy outdoor elements. The enclosure should prevent dust and soil from entering sensitive electronics, but full waterproofing is not implemented in this prototype.

The device runs on a 5V regulated battery, with optional solar charging for extended outdoor use. Low-voltage operation reduces safety risks, and the power system is designed to ensure reliable operation of all sensors and the LED.

Starting Point

The Smart Plant Monitor builds on widely available open-source hardware and software. The Arduino platform provides a flexible microcontroller environment, and common sensors like the DHT11, capacitive soil moisture sensors, and LDRs have established libraries and code examples. This existing intellectual property allows the project to focus on integration and user-friendly design rather than developing components from scratch.

During the project, one of the objectives is to create a breadboard prototype to test sensor connections, RGB LED indicators, and rotary encoder input. This prototype will help refine wiring, power management, and software logic. Insights gained during prototyping will guide the development of the final device, ensuring it is reliable, portable, and easy for users to operate.

Key Concerns

The primary concern for the Smart Plant Monitor is accurate and reliable

monitoring of plant health. Ensuring that sensors correctly measure soil moisture, temperature, humidity, and light is critical, as incorrect readings could mislead the user and negatively affect plant care. Battery life and low-power operation are also major concerns, especially for outdoor use.

Certain design parameters are fixed to ensure functionality and usability:

- Sensor types: DHT11 for temperature/humidity, capacitive soil moisture sensor, LDR for light
- Microcontroller: Arduino Uno
- Power supply: 5V regulated battery with optional solar charging
- RGB LED output: Must indicate plant status clearly using color codes (green, red, blue, yellow, orange)
- Size constraints: Maximum height 6.5 inches, maximum width 3 inches for portability and fit in a plant pot

These parameters provide clear boundaries for the design while allowing flexibility in other areas, such as enclosure design or additional features.

Future

After the Smart Plant Monitor project is complete, future work could focus on enhancing functionality and user experience. Potential improvements include adding a small display to show real-time sensor readings, integrating wireless connectivity to log data or send notifications to a smartphone, and developing an automatic watering system that responds directly to soil moisture levels.

Other ideas include expanding compatibility with different plant types, allowing users to customize thresholds for light, temperature, and moisture, and refining the enclosure for better durability and weather resistance. These future enhancements would make the Smart Plant Monitor more versatile, user-friendly, and suitable for a wider range of plant care applications.

Glossary

- Sensor: A device that detects and measures physical properties such as temperature, light, or moisture.
- Microcontroller: A small computer on a single integrated circuit that controls devices and processes data.
- RGB LED: A light-emitting diode that can display red, green, and blue colors to indicate different statuses.
- Battery: A portable power source that supplies electricity to the device.
- Prototype: An early version of a device used to test and refine design and functionality.
- Soil Moisture Sensor: Measures the water content of soil to determine if a plant needs watering.
- Rotary Encoder: A device that converts rotational movement into digital signals for setting or adjusting values.
- DHT11 Sensor: Measures ambient temperature and humidity.
- LDR (Light Dependent Resistor): A sensor that changes its resistance based

on the amount of light, used to measure sunlight intensity.
- Duty Cycle: The frequency or interval at which sensors take readings to conserve power.

Open Questions

- What is the optimal sampling interval for each sensor to balance accuracy and battery life?
- What is the final enclosure design, and how will it protect the device from dust, moisture, or accidental spills?
- Should data logging or wireless communication be implemented now, or reserved for future versions?