ECET 230 - Design Decisions

Rachel Romeo and Hailey Horvath

2025-12-20

Table of Contents

Smart Plant Monitor Overview

The objective of the Smart Plant Health Monitor is to provide plant owners with a simple, customizable, and reliable way to track the overall well-being of their plants. The device measures several key environmental factors, including soil moisture, temperature, and light levels. In addition, the system continuously tracks daily sunlight exposure and calculates how much accumulated sunlight the plant receives over time. Users define all optimal thresholds themselves, including soil moisture, lower and upper temperature limits, minimum light level, daily sunlight goal, and measurement interval, using the built-in keypad and LCD interface.

To make the data easy to understand, the monitor uses an RGB LED to visually communicate plant health at a glance. When all conditions fall within the user-defined optimal ranges, the LED remains off, indicating that the plant is healthy. If the temperature becomes too high, the LED turns red; if it becomes too low, it turns blue. A yellow light warns the user when soil moisture drops below the ideal threshold, signaling that watering is needed. A purple LED indicates insufficient light during the day. When multiple issues occur at once, the system cycles through the corresponding LED colors, blinking each one in sequence so the user can identify all problems clearly.

The monitor also includes a daily light cycle system that detects nighttime conditions. When darkness is sustained for a set duration, the device automatically resets its daily sunlight counter for the next day. The system features a 5-second hold reset button that fully restarts the device and clears alert states. The LCD provides real-time and setup feedback, while the keypad allows easy input and adjustment of all settings. Together, these features make the Smart Plant Health Monitor a practical, low-maintenance solution that helps users maintain optimal growing conditions with minimal effort.

Works-Like Prototype

Electronic Design Section

The Works-Like prototype uses an Arduino Mega 2560 to read the DHT11 temperature/humidity sensor, capacitive soil moisture sensor, and photoresistor. A 4×4 keypad and 16×2 LCD provide user input and feedback, while an RGB LED shows plant health alerts. A 5-second reset button allows a system restart. All components are powered from a 9V battery through a 5V regulator, creating a simple and portable working prototype.

Below outlines the details of each component for the Works-Like prototype:

- Microcontroller: Arduino Mega 2560
  - Serves as the main controller for all sensors, the RGB LED, the LCD, the keypad, and the reset button.
  - Uses the Mega's 5V and GND rails to power the LCD, keypad, DHT11, and other components.
  - Multiple analog and digital pins are used because the design requires many I/O connections.
- Temperature & Humidity Sensor: DHT11
  - Measures ambient temperature and humidity.
  - Connected to Digital Pin 2.
  - Uses VCC (5V), GND, and data pin to the microcontroller.
- Soil Moisture Sensor: Capacitive Soil Moisture Sensor
  - Provides a corrosion-resistant method of measuring soil moisture.
  - Output is read through Analog Pin A0.
  - Uses VCC (3.3–5V) and GND.
  - Soil moisture reading is mapped to a percentage (0–100%).
- Light Sensor: Photoresistor (LDR)
  - Measures ambient light level for detecting daylight, sunlight intensity, and nighttime.
  - Connected via a voltage divider to Analog Pin A1.
  - Used for:
    - Light threshold detection
    - Sunlight accumulation tracking
    - Nighttime reset logic
- RGB LED
  - Indicates plant health and warnings using color-coded alerts.
  - Connected to:

        - Red → Pin 9
        - Green → Pin 10
        - Blue → Pin 11
    - Driven with PWM to blend colors.
    - Uses appropriate resistors to limit current.
    - Provides single-color or multi-color blinking when multiple issues occur.
- LCD Display: 16×2 Character LCD
    - Shows system prompts, configuration menus, and feedback.
    - Connected with 6 digital pins: Pins 30–35.
    - Powered by 5V and GND.
    - LCD Contrast Potentiometer
        - Provides adjustable contrast (VO) for the 16×2 LCD.
        - This component is required so the display is readable across production tolerances and different supply voltages.
- Keypad: 4×4 Matrix Keypad
    - Used for all user input during setup (range settings, thresholds, intervals, etc.).
    - Connected to Digital Pins 22–29.
    - Includes digits 0–9 and function keys: A (enter), B (backspace), C (clear).
- Reset Button (5-Second Hold)
    - Connected to Digital Pin 7 with INPUT_PULLUP.
    - When held for 5 seconds, the system fully resets and restarts setup mode.
- Power Supply
    - The system is powered using a 9V battery, which provides a simple and portable power source for the entire device.
    - The 9V battery is connected to a voltage regulator, which steps the voltage down to a stable 5V required by the Arduino Mega, sensors, LCD, keypad, and RGB LED.

Conclusive Explanation of Design Choices:

The Arduino Mega was chosen as the central controller because it provides a large number of digital and analog pins, making it ideal for connecting multiple sensors, an LCD, a keypad, and the RGB LED simultaneously. Its PWM-capable pins allow smooth control of the RGB LED, and it is fully compatible with widely available libraries for sensors such as the DHT11. Using the Arduino also allows the design to be easy to prototype while supporting future expansion with additional sensors or outputs. Originally, the Arduino Uno was chosen for the controller, however, due to the limited pinouts, the decision was made to upgrade to the Arduino Mega, which offered more pinouts.

User input is handled through the 4×4 keypad, allowing the user to directly enter optimal ranges for temperature, soil moisture, light levels, and monitoring intervals. The keypad works in conjunction with the LCD display, which provides clear prompts and feedback during setup and operation, making configuration simple without requiring a computer or external interface. Before the 4×4 keypad was chosen, the decision was originally between a rotary encoder and an IR sensor + remote. The decision was made to use the IR sensor + remote so that the user can enter the optimal ranges easily with the remote control. However, after extensive code testing, the IR sensor + remote was not able to work properly. The idea of a keypad/buttons to input the optimal ranges was still wanted in the design, so instead of the IR sensor + remote, the decision was made to switch to the keymembrane 4×4 keypad.

The DHT11 temperature and humidity sensor was selected for its simplicity, low power consumption, and direct compatibility with Arduino digital pins. It provides adequate accuracy for monitoring environmental conditions that affect plant health, and the well-supported DHT library allows easy integration into the system.

For soil moisture monitoring, the capacitive soil moisture sensor was chosen since it is more durable and reliable than traditional resistive sensors. Unlike resistive types, it does not have exposed electrodes that corrode over time, making it better for long-term monitoring in soil. It provides more stable and accurate readings of soil moisture and integrates easily with our Arduino-based Smart Plant Monitor, ensuring consistent performance for automatic plant care.

The light sensor is implemented using a simple LDR (photoresistor) providing an analog signal that Arduino can read. This allows the system to measure sunlight exposure and alert the user when light levels are insufficient. This approach integrates seamlessly with the Arduino’s analog inputs.

The RGB LED was chosen as the visual status indicator because it provides a clear, intuitive way for users to understand plant conditions at a glance. Using PWM pins and current-limiting resistors ensures that each LED color can be safely controlled without damaging the Arduino or the LED.

A reset button is included, which allows the user to restart the system by holding it for five seconds, clearing active alerts, and returning the device to its initial setup mode. A separate button for a system reset was not ideal. This decision was made after several issues with attempting to use one of the keys on the 4×4 keypad as a reset button. This was likely due to inexperience with C++ code. To solve this issue, a separate component was added to reset the system if needed.

For power, the system uses a 9V battery connected to a voltage regulator, providing a stable 5V supply to the Arduino Mega and all connected components. This simple power design makes the prototype portable and easy to test without relying on external or rechargeable sources. The 9V battery can be swapped by connecting the Arduino directly to a computer via USB. Either method works perfectly fine with the works-like prototype.

Design Decision Summary Table 1.0

	Component	Explanation	Datasheets
Choice of Microcontroller	Arduino Mega 2560	Widely Used Board that can support all sensors and outputs for this project	https://docs.arduino.cc/resources/datasheets/A000067-datasheet.pdf
Sensors	DTH11	Selected for measuring environmental conditions around the plant. We need to monitor the temperature every few minutes.	https://www.mouser.com/datasheet/2/758/DHT11-Technical-Data-Sheet-Translated-Version-1143054.pdf
	Capacitive Soil Moisture Sensor	More durable and reliable than traditional resistive sensors.	https://rajguruelectronics.com/Product/5538/Capacitive%20Soil%20Moisture%20Sensor%20V2%281%29.0.pdf
	Photoresistor (Photocell)	Measure light intensity	https://www.digikey.com/htmldatasheets/production/5858660/0/0/1/02-ldr2.pdf
User Input	4×4 Keypad	Allows the user to input	https://dosya.motorobit

		threshold values and configuration settings directly into the monitor.	.com/pdf/4x4%20keypad.pdf
	Reset Button	Allows full system reset when held for 5 seconds, clearing alerts and returning to setup mode.	https://www.arduino.cc/documents/datasheets/Button.pdf
	16×2 LCD	Displays system prompts, setup menus, and real-time feedback for user interaction.	https://www.mouser.com/catalog/specsheets/Soldered_100812%20lcd%20display%2016x2%20rgb.pdf?srsltid=AfmBOor7i_N7bGhWCRSRHkyNfYdwT4sh-UrspqS-x_3FtRmy2ncwbR3g
	10k Potentiometer	Used with the LCD to adjust the brightness of the screen.	https://www.piher.net/wp-content/uploads/PIHER_PT-10_PTC-10.pdf
Output	RGB LED	Provides a quick, color-coded indicator of plant status	https://components101.com/sites/default/files/component_datasheet/RGB%20LED.pdf
Resistors	220 ohm	Used to limit the current flowing through the RGB LED	http://assets.rs-online.com/v1699613067/Datasheets/7ec977c91977fd4e95a020bd86d6d6c5.pdf
	10k ohms	Used for a voltage divider with the Photoresistor to limit the current and voltage through the photoresistor	https://www.seielect.com/catalog/SEI-CF_CFM.pdf
Power	9V Battery	Powers the device	https://data.energizer.com/pdfs/522.pdf
Size	No more than	The monitor should be	

	8 inches in height, no more than 7 inches wide.	portable, allowing it to be moved easily between different plants. It must be compact enough not to interfere with plant growth and designed to fit inside the plant pot.	

PCB Prototype

Electronic Design Section

The PCB prototype is slightly different then the Works-Like prototype. This prototype integrates all sensing, user-interface, processing, and power-management hardware required for the Smart Plant Monitor. Unlike the works-like prototype, the PCB uses a bare ATmega2560-16AU microcontroller, onboard oscillator, programming headers, and dedicated connectors for each subsystem.

Below outlines the details of the additional components needed for the PCB prototype:

- Microcontroller System (ATmega2560-16AU)
  - The ATmega2560 is the central controller for all system logic.
  - The PCB includes all support circuitry required for standalone operation:
    - 16 MHz crystal oscillator with 22 pF load capacitors for clock stability.
    - RESET conditioning circuit using a 10 kΩ pull-up resistor and 0.1 µF capacitor.
    - Decoupling capacitors (0.1 µF, 4.7 µF) across VCC and AVCC rails.
    - AREF filtering capacitor for stable analog readings.
- Serial Monitor / USB-TTL Header
  - The 6-pin header is used for connecting a USB-Serial adapter.
  - Used for serial debugging, real-time data logs, and uploading firmware through a bootloader if desired.
  - The pins are the following:
    - GND
    - CTS
    - VCC
    - TXO
    - RXO
    - DTR
- AVR-ISP Programming Header
  - A standard 6-pin AVR-ISP connector is included for direct programming of the ATmega2560.
  - Provides in-system programming of the ATmega2560 firmware using an ISP programmer.

- The lines of this Programmer include:
  - MISO
  - MOSI
  - SCK
  - RESET
  - VCC
  - GND
- Reset Button (Normal Reset)
  - A pushbutton reset switch is included to allow manual restarting of the ATmega2560 without disconnecting power.
  - The reset circuit uses a pull-up resistor and a 0.1 μF capacitor for reliable signal conditioning.
- Temperature & Humidity Sensor: DHT11
  - Measures ambient temperature and humidity.
  - Connected to Digital Pin 2.
  - Uses VCC (5V), GND, and data pin to the microcontroller.
- Soil Moisture Sensor: Capacitive Soil Moisture Sensor
  - Provides a corrosion-resistant method of measuring soil moisture.
  - Output is read through Analog Pin A0.
  - Uses VCC (3.3–5V) and GND.
  - Soil moisture reading is mapped to a percentage (0–100%).
  - Connects to the board via Female 1×3 Header
- Light Sensor: Photoresistor (LDR)
  - Measures ambient light level for detecting daylight, sunlight intensity, and nighttime.
  - Connected via a voltage divider to Analog Pin A1.
  - Used for:
    - Light threshold detection
    - Sunlight accumulation tracking
    - Nighttime reset logic
- RGB LED
  - Indicates plant health and warnings using color-coded alerts.
  - Connected to:
    - Red → Pin 9
    - Green → Pin 10
    - Blue → Pin 11
  - Driven with PWM to blend colors.
  - Uses appropriate resistors to limit current.

    - Provides single-color or multi-color blinking when multiple issues occur.
- LCD Display: 16×2 Character LCD
    - Shows system prompts, configuration menus, and feedback.
    - Connected with 6 digital pins: Pins 30–35.
    - Powered by 5V and GND.
    - LCD Contrast Potentiometer
        - Provides adjustable contrast (VO) for the 16×2 LCD.
        - This component is required so the display is readable across production tolerances and different supply voltages.
- Keypad: 4×4 Matrix Keypad
    - Used for all user input during setup (range settings, thresholds, intervals, etc.).
    - Connected to Digital Pins 22–29.
    - Includes digits 0–9 and function keys: A (enter), B (backspace), C (clear).
    - Connects to the boad via Male 1×8 Header
- Reset Button (5-Second Hold)
    - Connected to Digital Pin 7 with INPUT_PULLUP.
    - When held for 5 seconds, the system fully resets and restarts setup mode.
- Power Supply
    - The system is powered using a 5V battery bank, which provides a simple and portable power source for the entire device.
    - The battery pack is connected via USB-C, which provides the stable 5V required by the Arduino Mega, sensors, LCD, keypad, and RGB LED.
    - A switch is also added to turn the system on and off

Conclusive Explanation of Design Choices:

The Smart Plant Monitor PCB is built around the ATmega2560-16AU microcontroller, selected for its large number of digital and analog I/O pins, extensive peripheral support, and compatibility with Arduino-based firmware. Unlike using an off-the-shelf Arduino board, integrating the ATmega2560 directly into the PCB reduces size, improves reliability, and gives full control over clock circuitry, reset conditioning, and power distribution.

To support stable microcontroller operation, a 16 MHz crystal oscillator with dual 22 pF capacitors is included to provide an accurate system clock. Multiple decoupling capacitors and an RC-filtered reset network were added to ensure clean startup conditions and noise-free power rails. A standard AVR-ISP 6-pin header is included to allow direct firmware programming through an in-system programmer. A serial debug header is also provided to support USB-TTL adapters for testing, calibration, and data logging during development.

User input is handled through the 4×4 keypad, allowing the user to directly enter optimal ranges for temperature, soil moisture, light levels, and monitoring intervals. The keypad works in conjunction with the LCD display, which provides clear prompts and feedback during setup and operation, making configuration simple without requiring a computer or external interface.

The DHT11 temperature and humidity sensor was selected for its simplicity, low power consumption, and direct compatibility with Arduino digital pins. It provides adequate accuracy for monitoring environmental conditions that affect plant health, and the well-supported DHT library allows easy integration into the system.

For soil moisture monitoring, the capacitive soil moisture sensor was chosen since it is more durable and reliable than traditional resistive sensors. Unlike resistive types, it does not have exposed electrodes that corrode over time, making it better for long-term monitoring in soil. It provides more stable and accurate readings of soil moisture and integrates easily with our Arduino-based Smart Plant Monitor, ensuring consistent performance for automatic plant care.

The light sensor is implemented using a simple LDR (photoresistor) providing an analog signal that Arduino can read. This allows the system to measure sunlight exposure and alert the user when light levels are insufficient. This approach integrates seamlessly with the Arduino’s analog inputs.

The RGB LED was chosen as the visual status indicator because it provides a clear, intuitive way for users to understand plant conditions at a glance. Using PWM pins and current-limiting resistors ensures that each LED color can be safely controlled without damaging the Arduino or the LED.

A reset button is included, which allows the user to restart the system by holding it for five seconds, clearing active alerts, and returning the device to its initial setup mode.

A separate reset button was implemented into the design. The standard momentary reset button is tied into the ATmega2560's reset circuit.

The system is powered from a 5V battery bank, connected to the PCB via USB-C. This ensures safe, consistent voltage to the microcontroller, LCD, sensors, RGB LED, and keypad. The decision to use a 5V battery bank makes the device portable and allows the Smart Plant Monitor to operate continuously for up to 100 hours before recharging the battery bank. Depending on the battery bank, the runtime hours can vary. Originally, the PCB prototype was going to be powered by a 9V regulated battery. However, after conducting a Power Budget, it was determined that if the 9V regulated battery were to be used, it would only power the Smart Plant Monitor for 1-2 hours.

Design Decision Summary Table 2.0

	Component	Explaination	Datasheets
Choice of Microcontroller	ATmega2560-16AU	Main microcontroller that reads sensors, drives LCD & keypad, controls RGB LED, handles reset logic, and runs firmware.	https://ww1.microchip.com/downloads/en/DeviceDoc/ATmega640-1280-1281-2560-2561-Datasheet-DS40002211A.pdf
	16 MHz Crystal	Provides an accurate system clock for ATmega2560.	https://abracon.com/Resonators/ABS07.pdf
	Reset Button	Resets the Microcontroller Chip	https://www.ckswitches.com/media/1341/d6.pdf
Programmer	AVR-ISP-6	An AVR-ISP-6 header enables direct in-system programming of the microcontroller.	https://s3.amazonaws.com/catalogspreads-pdf/PAGE123%20.100%20SFH11%20SERIES%20FEMALE%20HDR%20ST%20RA.pdf
2×3 Female Pin Header	2×3 Female Pin Header	Male pin header to connect the 4×4 Keypad to the PCB	https://mm.digikey.com/Volume0/opasdata/d2

			20001/medias/docus/937/Female_Headers.100_DS.pdf?_gl=1*iimhn3*_up*MQ..*_gs*MQ..&gclid=CjwKCAiA3L_JBhAlEiwAlcWO5-j5K4FKzEZoXIIbh33Z9wOY_b6AA1xdjY56bhTluEVsSGGwZLbmHBoCgLAQAvD_BwE&gclsrc=aw.ds&gbraid=0AAAAADrbLljVP_hvsoPNmoiyOzvli6A1H
	2×3 Female Pin Header	2×3 Female Pin Header to connect the Programming Adapter to the PCB	https://s3.amazonaws.com/catalogspreads-pdf/PAGE123%20.100%20SFH11%20SERIES%20FEMALE%20HDR%20ST%20RA.pdf
	1×6 Female Pin Header	Serial Monitor Header Connects to USB-TTL adapter for debugging and serial communication.	https://www.on-shore.com/wp-content/uploads/OSTOQXX3250.pdf
	1×3 Female Pin Header	1×3 Female Pin Header to connect the Soil Moisture Sensor to the PCB	https://mm.digikey.com/Volume0/opasdata/d220001/medias/docus/937/Female_Headers.100_DS.pdf?_gl=1*130qez5*_up*MQ..*_gs*MQ..&gclid=CjwKCAiA3L_JBhAlEiwAlcWO5zIWZln7cfWLXlP-mGdrY4avifrRfDRrSvirMGh95HeIxwVrVNUNEhoCCnoQAvD_BwE&gclsrc=aw.ds&gbraid=0AAAAADrbLliR6uzSVIgWGJhkC321nIKf5
Capacitors	22 pF	Load capacitors for the	https://www.melopero.

	Capacitors	crystal oscillator for stable clocking.	com/datasheets/Disc22pF.pdf
	0.1 µF Decoupling Capacitors	×4 0.1µF Capacitors help filter noise on VCC/AVCC lines for stable MCU power.	https://www.passivecomponent.com/wp-content/uploads/datasheet/WTC_MLCC_General_Purpose.pdf
	4.7 µF Capacitor	Stabilizes regulator output and prevents voltage dips.	https://pim.murata.com/en-us/pim/details/?partNum=GRM035R60J475ME15%23&displayChangeClass=productDetailPrint
Resistors	220 ohms	Used to limit the current flowing through the RGB LED	https://www.seielect.com/catalog/SEI-CF_CFM.pdf
	10k ohms	Used for a voltage divider with the Photoresistor to limit the current and voltage through the photoresistor	https://www.seielect.com/catalog/SEI-CF_CFM.pdf
	22 ohms	Used for the ATmega chip reset button as a pull-up resistor.	https://www.seielect.com/catalog/SEI-CF_CFM.pdf
	5.1k ohms	Used for the USB-C power connection. Resistors connect CC1 and CC2 to ground	https://www.seielect.com/catalog/SEI-CF_CFM.pdf
Sensors	DTH11	Selected for measuring environmental conditions around the plant. Needs to monitor the temperature every few minutes.	https://www.mouser.com/datasheet/2/758/DHT11-Technical-Data-Sheet-Translated-Version-1143054.pdf
	Capacitive Soil Moisture	More durable and reliable than traditional resistive	https://rajguruelectronics.com/Product/5538/C

	Sensor	sensors.	apacitive%20Soil%20Moisture%20Sensor%20V2%281%29.0.pdf
	Photoresistor (Photocell)	Measure light intensity	https://www.advancedphotonix.com/wp-content/uploads/2015/07/DS-PDV-P8103.pdf
User Input	4×4 Keypad	Allows the user to input threshold values and configuration settings directly into the monitor.	https://dosya.motorobit.com/pdf/4x4%20keypad.pdf
	Reset Button	Allows full system reset when held for 5 seconds, clearing alerts and returning to setup mode. Also used to reset the signal for the ATmega	https://www.ckswitches.com/media/1341/d6.pdf
	16×2 LCD	Displays system prompts, setup menus, and real-time feedback for user interaction.	https://soldered.com/productdata/2015/02/Soldered_HD44780_datasheet.pdf
	10k Potentiometer	Used with the LCD to adjust the brightness of the screen.	https://www.bourns.com/docs/Product-Datasheets/pv36.pdf
Output	RGB LED	Provides a quick, color-coded indicator of plant status	https://components101.com/diodes/rgb-led-pinout-configuration-circuit-datasheet
Power	USB-C Connector	Connects the Battery Bank to the PCB	https://www.digikey.com/en/products/detail/gct/USB4125-GF-A/13547388
	Power Switch	Allows the voltage to power the system	https://www.ckswitches.com/media/1422/js.pdf

	Battery Bank	Powers the Smart Plant Monitor PCB with 5V	https://cdn.sparkfun.com/assets/4/f/3/9/1/15593-DS-Lithium_Ion_Battery_Pack_-_10Ah__3A-1A_USB_Ports_.pdf
Size	No more than 8 inches in height, no more than 7 inches wide.	The monitor should be portable, allowing it to be moved easily between different plants. It must be compact enough not to interfere with plant growth and designed to fit inside the plant pot.	

Prototyping on a Breadboard:

Before beginning the prototype, it is important to have all necessary modules ordered and the corresponding datasheets available to understand each component's specifications and requirements. Additionally, appropriate software libraries and a development environment should be set up to program and test the modules efficiently. On the hardware side, breadboards, wires, the Arduino Mega, and any required mechanical elements should be prepared for assembly. Access to a well-equipped workbench with the appropriate tools is essential for safely and effectively building and troubleshooting the prototype. All information regarding datasheets and libraries for the components used will be located in this document.

To prototype the Smart Plant Monitor on a breadboard, we connect each sensor and component to the Arduino using jumper wires. The soil moisture sensor plugs into an analog pin, the photoresistor connects as a simple analog input, and the RGB LED is wired through resistors to its assigned digital PWM pins. The 4×4 keypad and 16×2 LCD are connected to their respective digital pins for user input and display. A reset button is added to a digital pin using the internal pull-up resistor. Power from the 9V battery is regulated to 5V and shared across the breadboard so all components operate together. This setup allows quick testing, adjustments, and verification of functionality before moving to a permanent PCB design.

Libraries Table

Component	Library	Installation
DHT11 Temperature & Humidity Sensor	DHT by Adafruit	Install via Library Manager: Sketch → Include Library → Manage Libraries → search "DHT sensor library by Adafruit"
4×4 Keypad	Keypad	Library name in Arduino IDE: Keypad by Mark Stanley / Alexander Brevig.
LCD Display	LiquidCrystal	Library name in Arduino IDE: LiquidCrystal (usually comes pre-installed).

<u>Checklist for Proof-of-Concept Prototype:</u>

- ☑ Have modules ordered for your prototype
- ☑ Have datasheets for what is on your modules
- ☑ Have software libraries
- ☑ Have development environment for software
- ☑ Have breadboards, wires, mechanical elements
- ☑ Have access to a workbench with appropriate tools
- ☑ Have the sensors working via test codes
- ☑ Started coding for the proof-of-concept prototype