<u>P.U.M.P.E.D:</u> Precision Weighing, User-Friendly Heating, Mobile App Integration, Printed Labels, Expiration Tracking, and Data Management

Group 16 Authors:

Isaiah Robinson - *Computer Engineering*

Jason Devito - *Computer Engineering*

Jamieson Foley - *Electrical Engineering*

Zachary Celentano - *Electrical Engineering*

Reviewer Committee:

Dr. Suboh Suboh	ECE	*Associate Lecturer*
Dr. Wei Sun	ECE	*Associate Professor*
Dr. Hadi Kamali	ECE	*Assistant Professor*
Victoria Rodriguez	***Sponsor***/*Engineering support*	
Matthew Aberman	***Sponsor***/*Engineering support*	

Mentor:

Dr. Chung Yong Chan

Sponsors:

Victoria Rodriguez

Matthew Aberman

Project Background:

Breastfeeding parents often face the challenge of measuring, labeling, heating, and storing breast milk effectively. Traditional methods require manually writing the weight, date, and time on a milk storage bag or container, which can be both time-consuming and prone to human error. In addition, accurate records are crucial not only for understanding how much milk is being stored and consumed but also for ensuring the milk's freshness and safety for the infant.

The purpose of this project is to design and implement a device and application that pair together to accurately measure, heat, catalogue, and provide feedback on the amount of breast milk stored, how long it has been stored for, and show possible allergens to be aware of. With this, parents and healthcare providers can easily manage the supply of breast milk available for infants without risk of human error, all while saving significant time that would have been used to accomplish the same task.

There is a growing need for systems that can store personal healthcare and dietary data. In the context of newborn dietary information, it is clear how this growing need translates; dietary data management for children is of the utmost importance for both the children themselves and also the parents, as being able to easily manage an infants amount of food available saves time and avoids issues that are otherwise unnecessary, like human error when recording pumping amounts and dates.

Previous Work & Existing Products:

This project does not iterate directly from any previous work; the idea itself was formed by sponsors Victoria Rodriguez and Matthew Aberman in response to problems they encountered when managing the food supply with accurate labels for their children. The issue that they want resolved is that there were cumbersome amounts of expired milk that could no longer be used or even donated to hospitals, for the reason that they could not effectively track the data on what has been pumped.

There are few products that perform separate individual functions of the proposed project. Namely, there are many brands that make milk bags that have measurement markings externally to show the amount stored within the bag. The advantage these products have is their convenience. With labels and markings on the bag itself, it takes away the extra effort of needing to manually manage the milk that is pumped. Where our system differs is that it offers a mobile app that will provide reminders and updates on pertinent information, like approaching expiration of milk. Another product that can be used in this context is a label maker. A parent can pump their milk, record the amount, then put the information regarding the milk into a label maker. Our product would remove the intermediate step and directly record the data of the milk and print a label immediately. Furthermore, there are also milk bag organizers sold that allow milk

bags to be separated and stored in freezers; these organizers exclusively help with storage, where ours would not necessarily aid in physical storage, but rather in reminding parents when their supply is low, expiring soon, or some combination of the two scenarios.

When using the breast milk that has been stored, many parents have to heat the milk up to a temperature suitable for the baby's consumption. What is common practice is to place cold or room temperature milk bags in hot water baths to heat the milk, which can take excessive amounts of time. Adding the capability to warm up the milk bags in our design while also monitoring the temperature of the bag could help even further by saving parents time needed to ensure their children's food is at the temperature needed. In our case, it would make sense to model our heater after technology used in mug warmers. Mug warmers are ideal to take inspiration from because they typically do not heat past a temperature of 200 ℉, which is the temperature most polyethylene plastics begins to melt. In our design, using similar topology, we would monitor the temperature to ensure product safety, while keeping it hot enough that someone could place their milk on for a short duration and prepare the milk to consume in a reasonable time frame. The monitoring of the temperature would most effectively be achieved through thermal coupling. Through this, we can send temperature data from the milk bag to our mobile app, where parents will be alerted of the temperature of their children's food.

Parents who use these products previously described must manually take inventory of what is pumped, the time it is pumped, and the amount they have stored, while also keeping track of potential expirations, ideal temperature, and allergens. All of these devices and aids share a common flaw; that being time consumption. The previously mentioned products require an extra step, and thus more time to manage and maintain a parent's supply of breast milk. While parents already have much to keep track of for their children, adding these additional few things can be cumbersome, which is what our device aims to minimize. While all of these systems accomplish their specifically designed task, there is no product that combines all of the strengths of the individual products to provide in-depth data monitoring and ease of use for parents who are not able to manage the many complexities that can arise when pumping breast milk. The system we aim to design would be available on a large commercial scale in a form factor that is cheap for parents, boast similar portability that of kitchen appliances, in both the device itself, as well as the application that allows consumers to track their data at any time.

Project Motivation:

This project was motivated by:

1. **Sponsorship**: Having a sponsored project as college students is a substantial motivating factor because of our lack of funding, while also giving us valuable project experience for our field.
2. **Accuracy**: Providing consistent and precise measurement of breast milk weight.
3. **Traceability**: Using an integrated mobile app to track stored milk bags, expiration dates, and consumption over time.
4. **Peace of Mind**: Helping parents avoid confusion about which bag was pumped when and how long it remains viable, thus improving overall feeding management.
5. **Convenience**: Automating the labeling process to save time and reduce mistakes.

By combining a custom scale with printing functionality and automatically syncing data to a mobile application, this device addresses a real need for modern, tech-savvy parents who want a seamless solution to manage their breast milk supply.

Goals & Objectives:

Our project aims to design an affordable device that accurately measures the amount of milk in a breast milk storage bag. To ensure the user will not waste the milk they produce, we plan to include a label printer to create labels with the measured volume, current date, and time so that the user can keep track of their supply. Additionally, we will develop a mobile app that allows the user to interact with the data, which will be automatically stored in memory after the device prints a label. With milk storage being one of our main goals, we also want to include a milk warmer. The user will have the functionality to either heat or weigh their milk. Below are our general goals and specific objectives for achieving this plan.

Basic Goals

- Build a product that allows parents to easily weigh, label, and store milk bags.
- Build an application that allows an accessible interface with the data of bagged milk.
- Build a system that ensures milk is stored and used at safe temperatures, helping prevent spoilage or degradation of nutrients.

Basic Objectives

- Implement a load cell and ADC for accurate weight measurement. Convert the measured weight to fluid ounces for parents ease of use.

- Integrate a label printer to produce labels containing all relevant information, including fluid ounces, date, time, and temperature.
- Show real-time weight, date, and time on the LCD prior to label printing.
- Measures the temperature of bagged milk using thermal coupling.
- Implement a heating element to allow parents to more freely manage milk temperature.
- Implement a custom power supply to power the device and all peripherals.
- Any surface that makes contact with the milk bags will be able to be taken apart for sanitation purposes.
- Develop an iOS app to interface with a database of information regarding stored milk.
- Provide features for viewing, editing, and managing milk inventory.
- Send alerts for impending expiration dates and low general storage.

Stretch Goals

- Include an option to track allergens in milk bags.
- Track all bagged milk for up to a year.
- Suggest how much milk a Mother needs to pump.

Stretch Objectives

- Build a custom thermal printer and its subsequent PCB to minimize form factor.
- Design the power supply to be able to work with batteries so the product can be portable.

Project Features:

As stated previously, the overall functionality of the project is to provide a quick and easy alternative to manually writing down the current date, time, and weight of breast milk in a storage bag. To accomplish this task, and more, our project consists of five main features.

- **Scale:** The function of the scale is to measure the weight of the breast milk bag and convert that weight into weight. The device would then store that measured weight for use in all the other features.
- **LCD Screen:** The function of the LCD screen is to display the current date, time, and measured weight provided by the scale.
- **Button Functionality**: Buttons will serve a way for the user to choose which action they want the device to run.
- **Label Printer:** The function of the label printer is to, with the press of a button, print out a label with all the required values. This label could then be directly attached to the breast milk bag, allowing for easy access to all the information on each bag when stored.

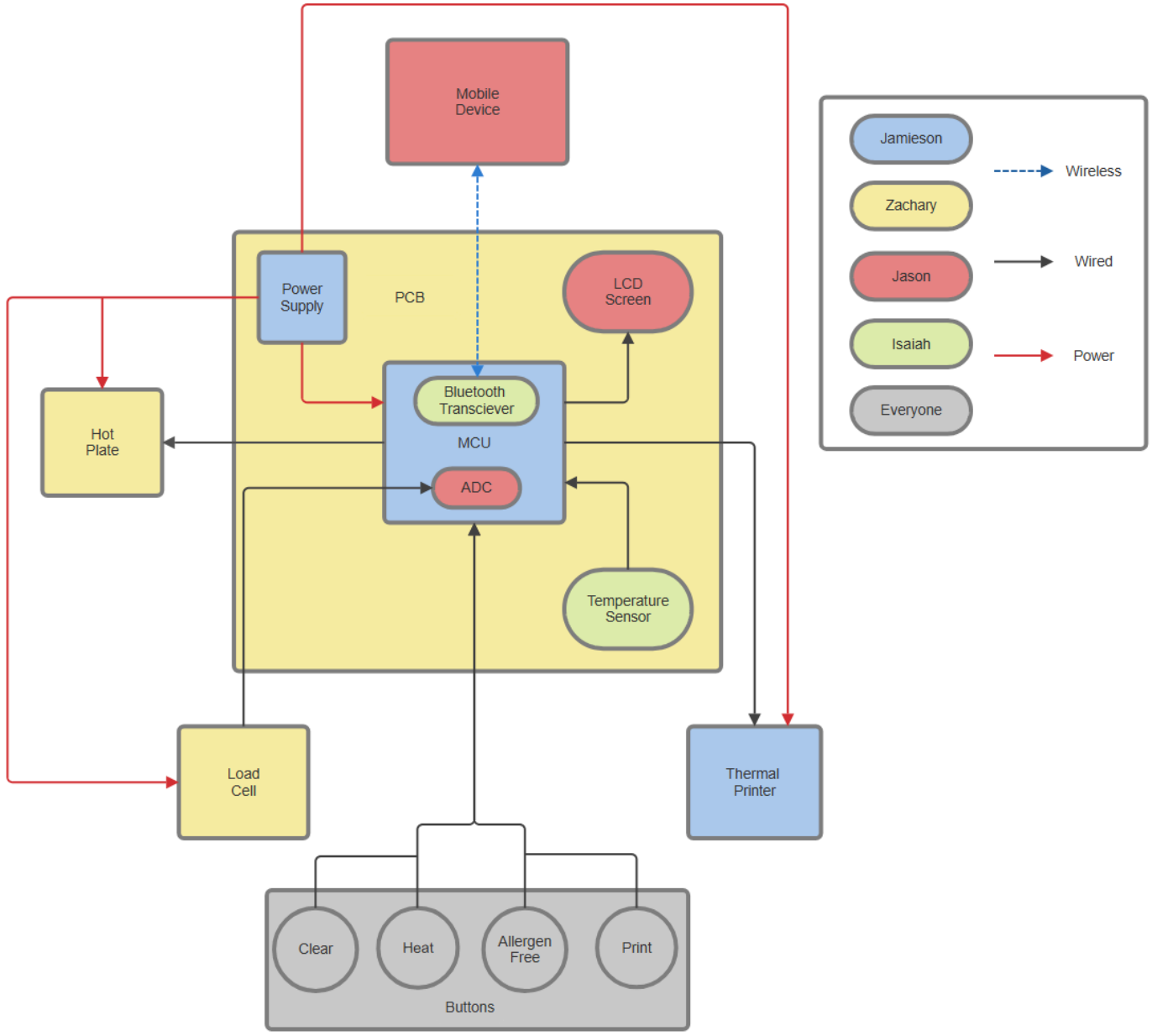
- **Mobile App:** The function of the mobile app is to keep track of each breast milk bag in storage. It should be able to automatically load information from a database. Additionally, the app should be able to track how much milk is left in each bag and send alerts about upcoming expiration dates. In the case of a trip or vacation, the app should be able to portion out the amount of breast milk required over a specified period of time.
- **Bluetooth Connectability:** The function of Bluetooth is to allow the device to directly connect to the users phone, allowing access to the mobile app
- **Temperature Sensor:** The function of the temperature sensor is to measure the temperature of the breast milk bag while it is on the scale.
- **Heating Element**: The function of the heating element is to provide a controlled warming feature for the breast milk bag. This allows users to gently heat milk to an optimal feeding temperature without needing a separate bottle warmer.
- **Custom Power Supply:** To power the heating feature, we will design a DC switching power supply, researching the appropriate topology to efficiently meet the heater's power requirements. The heating process will be closely monitored to prevent overheating and ensure uniform temperature distribution.

Required Engineering Specifications:

Parameter	Value	Description
Weight Accuracy	± 1 Grams	Accurate weight measurements.
Temperature Accuracy	± 1 °F	Accurate temperature measurements.
Label Size	2" x 1"	Large enough to display all data.
LCD Display Time	< 1 Second	Fast response time.
Power Supply	< 60 Watts	Power all peripherals in the device.
Wireless Connectivity	< 5 Seconds	Efficient interface connectivity.
Local Data Storage Capacity	> 20 entries	Enough data storage capabilities to give parents enough information.
Hotplate	90-100 °F	Must heat milk to the proper temperature of consumption.
Cost Estimate	< $800	Needs to be cost effective to manufacture.

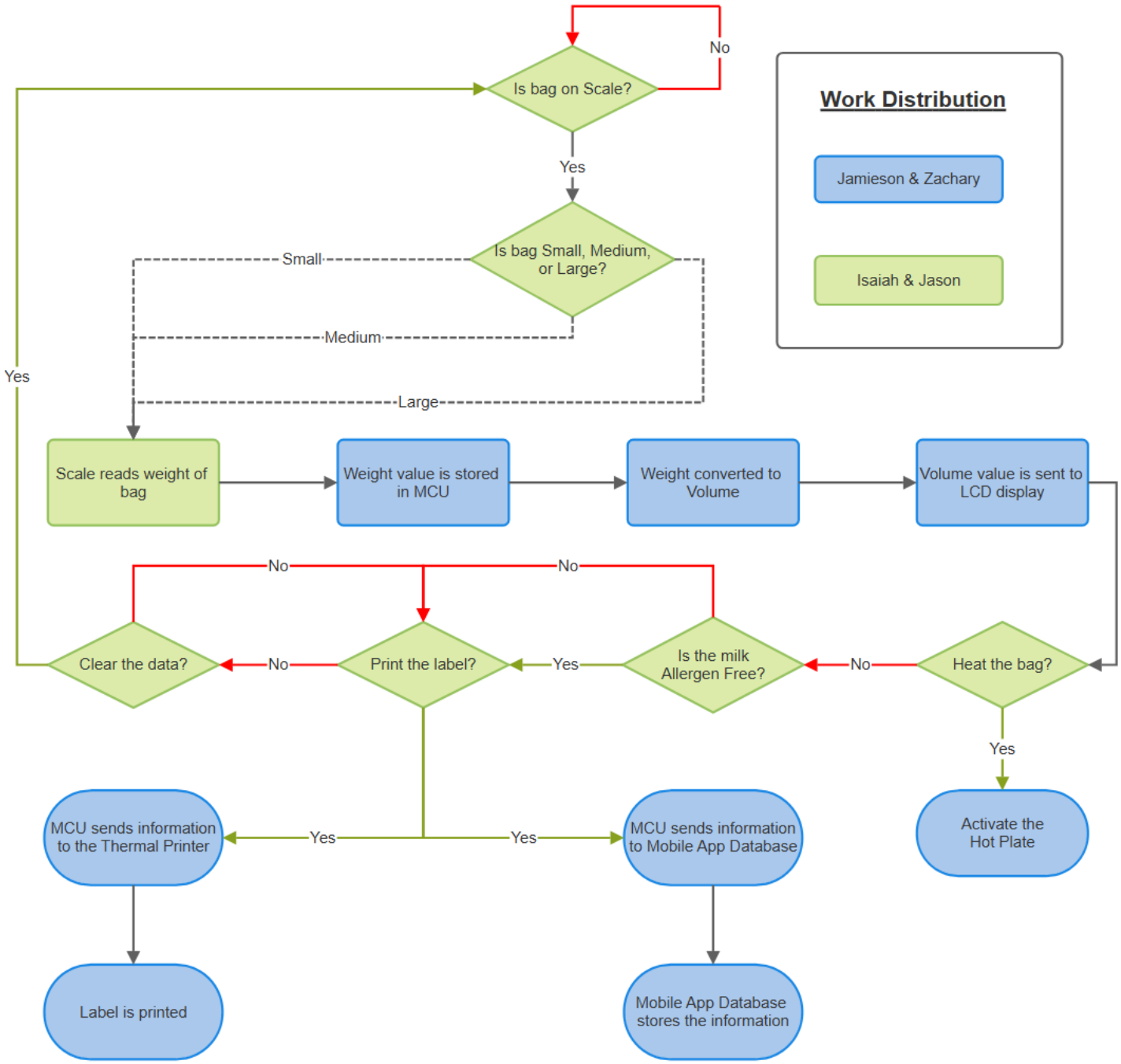
Table 1.1

Hardware Block Diagram:



Hardware Block Diagram
Diagram 1.1

Software Flowchart:



Software Flowchart
Diagram 1.2

Prototype Illustration:

Picture 1.1

Diagram Caption: The illustration above shows a prototype of what we want the device to look like upon its completion. This image was created by AI, and given to us by our sponsors as what they would roughly like the product to look like once it's finished. The Milk bags will sit in a cylindrically encapsulated space, allowing for it not to fall. The bag will sit on top of the scale which will have functionality to both measure and heat its temperature using buttons. Additionally, there will be a button to print a label which will contain the bag's volume in fluid ounces, the current time, and date.

House of Quality:

Interrelationship matrix

Customer Rating
5 High, 1 Low

Major sales point: 1.4
Minor sales point: 1.1

Customer Requirements / Product Requirements	Weight Accuracy	Temperature Accuracy	Label Size	LCD Display Time	Power Supply	Wireless Connectivity	Local Data Storage Capacity	Hotplate			CUSTOMER IMPORTANCE	OUR COMPANY	COMPANY A	COMPANY B	IMPROVEMENT GOAL	IMPROVEMENT FACTOR	SALES POINT	IMPORTANCE RATING
Ease of Use	3	3	3	5	X	5	3	5			4							
App Connectivity	X	X	5	5	1	5	5	X			5							
Responsiveness	5	5	5	5	X	5	3	5			5							
Power Consumption	X	X	X	3	5	3	1	5			3							
Cost	1	1	3	1	3	3	3	5			3							
Data Management	5	5	5	5	X	3	5	X			5							
Organizational Difficulty (5=difficult, 1=easy)	3	2	1	3	4	3	4	5										
Our Company																		
Company A																		
Company B																		
Target Benchmark	<1g	<1F	2"x1"	<1s	<60W	<5s	> 20	90-100										

Relationship weighting factors:

- Strong (5)
- Moderate (3)
- Weak (1)

Budget Estimates:

Component	**Estimated Cost (USD)**
Microcontroller (esp 32, MSP430, RaspberryPi, Arduino)	$10 - $30
ADC Module(If not embedded into MCU)	$10 – $15
Scale Platform / Mechanical Parts	$10 - $20
LCD Display	$10 – $20
Thermal Label Printer	$20 - $50
Bluetooth Transceiver (If not included in MCU)	$10 - $20
Power Supply	$15 - $40
PCB & Prototype Materials	$80 - $200
Misc. (cables, connectors, adhesives, buttons)	$10 - $20
Temperature Sensor	$4 - $30
Heater	$20 - $50
Building parts(MechE)	$40 - $100
Total (Approx.)	**$244 - $595**

Table 1.2

Project Milestones:

Weeks 1–2 (Jan 6 – Jan 19)

- Requirements Gathering & Research
    - Finalize project scope with sponsor/mentor.
    - Conduct feasibility analysis for hardware (scale, printer, LCD, etc.) and mobile app integration.
    - Develop initial problem statements and identify key user needs.

Weeks 3–5 (Jan 20 – Feb 9)

- System-Level Design
    - Create and review the hardware block diagram and software flowchart.
    - Draft House of Quality to correlate customer requirements with engineering specs.
    - Establish measurable specs (weight accuracy, label printing speed, etc.).
    - Research Power Supply.

Weeks 6–7 (Feb 10 – Feb 23)

- Component Selection & Ordering
    - Research and select load cell, ADC module, microcontroller, label printer, heater, and LCD screen.
    - Confirm and design power requirements .
    - Order all long-lead-time components to ensure timely delivery.

Weeks 8–10 (Feb 24 – Mar 16)

- Prototype Assembly (Hardware)
    - Assemble and mount the load cell onto a stable platform.
    - Mount heater to the load cell and insulate accordingly.
    - Begin integrating microcontroller, printer, and LCD.
    - Perform initial tests for power distribution and device safety.

Weeks 11–13 (Mar 17 – Apr 6)

- Firmware & Software Development (Phase I)
    - Write code for reading the load cell (via ADC), converting weight to weight, and displaying values on the LCD.
    - Integrate Real-Time Clock (RTC) or system time to record date/time.
    - Begin label printing code and basic user interface logic.

Weeks 14–16 (Apr 7 – Apr 27)

- Firmware & Software Development (Phase II)
    - Refine user interaction (button press to print, error handling, calibration routines).
    - Optimize label formatting and printing speed.
    - Conduct intermediate testing (accuracy, response time, label clarity).

Weeks 17–19 (Apr 28 – May 18)

- Mobile App Integration (Phase I)
    - Set up basic iOS app structure (user accounts, data model).
    - Implement Bluetooth or Wi-Fi communication to sync weight/weight data.

    - Test data transfer for speed and reliability.

Weeks 20–22 (May 19 – Jun 8)

- Mobile App Integration (Phase II)
    - Implement advanced app features (inventory tracking, expiration date alerts, portioning).
    - Conduct usability testing with mock data.
    - Ensure synchronization logic handles offline mode (caching measurements on device).

Weeks 23–25 (Jun 9 – Jun 29)

- System-Level Testing & Validation
    - Perform end-to-end tests (scale -> label -> app).
    - Perform additional tests on the temperature sensor and heater.
    - Validate accuracy, label content, and data consistency.
    - Gather feedback from peers or target users; iterate as needed.

Weeks 26–27 (Jun 30 – Jul 13)

- Final Adjustments & Optimization
    - Refine mechanical design (enclosure, cable management, ease of cleaning).
    - Optimize firmware/app for performance.
    - Prepare documentation for final demonstration (user manual, technical specs).

Weeks 28–29 (Jul 14 – Jul 31)

- Final Presentation & Demonstration
    - Complete final project report, design website, and any required submission materials.
    - Conduct a polished demonstration of the working device (hardware + mobile app).
    - Receive and integrate final feedback from the sponsor and review committee.