Pumped

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1.0 Project Background and Motivation

In the realm of innovative engineering, our senior design project seeks to address a challenge experienced by mothers everywhere. New mothers generally resort to breastfeeding as opposed to formula, as natural breast milk contains more nutrients and correlates to better immune system responses as the baby matures. Mothers aim to build a milk stash so that when they start work or travel, the baby can still receive the same amount of nutrients without reverting to formula. For pumped milk, it is important to label the date, time, and amount collected to ensure that it is consumed in a timely manner and does not expire or waste. While pumping milk for later use can save time and money, the process can be taxing. Currently the only way to label milk bags is with a sharpie and manually checking the number of ounces when pouring into the storage bag as well as checking for the latest date and time. Although it may just seem tedious this process usually occurs late at night or early in the morning when the mother is tired. This can lead to errors when labeling, cause added stress and be an inconvenience for the mother. Our project consists of creating an efficient system for tracking and properly labeling breastmilk storage bags. This system aims to combine practicality with ingenuity, empowering mothers with a solution that saves time, reduces stress and waste, as well as enhances their caregiving experience.

Our sponsors, Victoria Rodriguez and Matthew Aberman, approached our section and presented the idea of creating a device that would help with efficiently tracking breastmilk bags. After learning more about this idea, our group recognized the potential of this project to make a meaningful difference in the lives of mothers everywhere. Being able to save even a few minutes each day allows the mothers to feel some relief knowing that the milk has been accurately labeled, reducing guilt or anxiety when feeding their child. Victoria expressed that being able to keep track of how much milk their baby consumes is key when trying to avoid over and under feeding. She had shared that when many mothers are ready to go back to work after giving birth the process can be more complicated due to their breastmilk schedules overlapping with professional responsibilities. Having a portable device to take on the go and an application that keeps track of her milk supply provides a comforting feeling when a caretaker is with her child. Beyond alleviating a small portion of the stress for mothers, the product aims to call to mothers that are able to produce an excess amount of milk, to consider donating to milk banks or hospitals. With the ability to easily label dietary restrictions and allergens on the milk it can easily be distributed for NICU babies, fosters, and families where the mother cannot produce sufficient amounts of milk.

This present difficulty not only requires technical skills but creativity and empathy to ensure the final product meets the needs of its users seamlessly. We strongly believe in this idea, knowing its immense value to future mothers, and are taking on this project to create something beneficial for women everywhere. Victoria and Matthew are both engineers which interested us as well knowing they can provide helpful feedback and new insights on the direction of our project.

Our project integrates software and hardware elements which will challenge us to work cohesively together as a team. Guided by the feedback and expertise of our sponsors we aim to not only create a solution that meets expectations but exceeds them. Through this venture we hope to contribute to a brighter, more supportive future for mothers, families, and caretakers.

1.1 Existing Products

1.11 Arduino Weighing Scale

For our hardware design our main goal is to create a scale that can be easily integrated with our software needs. After much research we have found a DIY Arduino weighing scale project by a user on the website “Instructables.” It gave us valuable insight into the components we need for our own project as well as their specific usages. In this project they use both an Arduino and an HX711 module. For their Arduino they are using a nano, which they recommend because of its low weight and its built-in USB interface. Our aim is to keep our project portable, so we will likely be using the same Arduino as them. They integrate the HX711 by connecting to the Arduino to share the weight’s data. This processed data shows up on the LCD display of the scale. Since this is similar to our scale concept, we will be using their build as a reference for that portion of our design.

1.12 Zebra Printers

Zebra printers are highly versatile in their usage. They have incredible utility and are an immensely popular choice for businesses. In our design, we are aiming to print the date, time, weight, and possible dietary restrictions on our labels. Zebra printers are able to combine pre-printed labels with the aforementioned dynamic data. They also provide their own software development kits (SDKs), which are immensely useful for our own software integration. They provide things such as APIs, libraries, and documentation that we can use for our design. This would make it easier to program our microcontroller of choice to transmit commands to the printer.

Zebra Technologies also offers breast milk tracking barcode labels. The details include date, time, volume, and expiration. This form of labeling accommodates other caregivers by letting them access this information with a simple scan. It also ensures that the milk is handled properly based on its specifications. Barcode labeling is an element we are considering, especially because of its accessibility to caregivers.

1.13 Cubtale Smart Milk Inventory Tracking

Cubtale is a company that offers innovative solutions to inconveniences mothers face on a regular basis. One of such solutions is a product called “Smart Milk Inventory Tracking – Labels". These labels include a barcode along with manually recorded details such as the date, time, volume, name, and milk bag number. Users are able to enter these details into the accompanying app using the corresponding label number. The app offers features such as feed reminders, which tell the user which milk bag to use, as well as expiration date notifications. Within the application, there is information on breastmilk storage guidelines which tells users how to properly store their breastmilk to prevent premature expiration. The user can also track how much milk is available in their inventory. There are also instructions that provide guidance to caregivers by informing of how to feed the baby, including warming instructions for the milk.

Beyond milk tracking, Cubtale also offers 'Cubtale Cubs,' smart devices that are designed to track daily activities. They can track sleep, diaper changes, personal care, medicine, and pump use. When you press a specific button on the Cub, it then logs the activity. If there is no WiFi, the Cubs can store the latest five records in its memory. This is a possible function we can implement in our scale in case our Bluetooth connection fails. Another positive feature of this

device is that they only connect to WiFi for a few seconds, which lessens radiation exposure significantly for the child. We would also like to limit this exposure by implementing this aspect. After the button is pressed, the information is sent to the application, and the user is notified of the activity being completed. This is an excellent feature for users who have other caregivers looking after their child, and it gives them peace of mind knowing their routine is being followed.

Our project will incorporate several of these key functionalities. We intend to develop software that provides expiration date reminders and suggests which milk bag to use based on past data. Labeling is also a critical aspect of our design, and incorporating a barcode system for seamless data logging is a strong consideration. Its capabilities will serve as a strong reference for our own design.

1.2 Goals and Objectives

Our goals are organized into three tiers: basic, advanced, and stretch. The basic goals focus on fundamental functions to assist mothers in breastmilk management. The advanced goals expand on this foundation by adding more interactive features to the device. Stretch goals further enhance the system by integrating data-driven insights and multi-user accessibility.

Goals:

Basic Goals:

- To help mothers manage pumped breastmilk
- Design a device that measures pumped breastmilk
- Have the device print a label for breastmilk
- Creating a user-friendly interface for mothers to access information

Advanced Goals:

- Optimize design for portability
- Offer customizable labeling
- Help monitor milk inventory
- Design a physical guide system to minimize milk spillage.
- Provide visual feedback on system status

Stretch Goals:

- Provides insights to help mothers make informed dietary decisions.
- Implement multi-user access with varying levels of permission.
- Enhance software for integration with milk banks.

Objectives:

To enable accurate tracking and management of breast milk storage, the device will be used to measure and log milk volume after each pumping session. A built-in sensor will determine the exact volume of milk with consideration for the weight that may come from the packaging used for the milk. Labels will include date, time, & weight received from the scale, with optional input for allergens or dietary restrictions. Using a pre-built printer, a label will be printed with the data collected from the scale. Advanced labeling options will allow users to enter additional details such as donation specific fields for more personalization. The system will utilize labels that

adhere to milk bank and hospital requirements. Then the user-interface will allow users to manually edit details in the mobile application, if needed.

To prioritize portability, the device will be designed with compact and lightweight hardware components, which will enable mothers to carry it while traveling or pumping on the go. In addition, the shape of the scale will be ergonomic, allowing it to support the bag of breastmilk to minimize spillage. A battery-operated structure ensures this convenience without sacrificing its functionality, and the implementation of LEDs will provide visual feedback in the case of low battery.

The software that will be accompanying this device will manage inventory, track expiration dates, and notify users of inventory issues; this ensures the efficient and safe use of breastmilk. These features will be provided through a user-friendly app, allowing mothers and caregivers to make informed decisions regarding the child's intake. Additionally, the app will analyze patterns from the data entered such as feeding frequency, baby's age, and amount stored in inventory to help mothers anticipate future milk needs. By integrating accurate hardware measurements with software capabilities, this system aims to provide a solution that meets the needs of breastfeeding mothers and their support networks.

1.3 Description of Features

Our sponsor has provided us with a list of primary user jobs and requirements for this project. In our design, we are aiming to solve the problems presented to us for breastfeeding moms as well as caregivers and healthcare professionals.

Breastfeeding moms must not only mentally track but label all of the milk they produce for their child. This can become tricky, as sometimes mothers lose track of when they have produced the milk and how much of it has been produced as well. With the scale feature, we aim to fix this problem. In our design we would like to create a scale that can weigh the volume of the milk, and then print the date, time, and weight on a label. Sometimes mothers must make sure they label the bags based on allergy specifications, such as writing if it is dairy-free. In our design, we want to add a feature that prints these specifications on the same label.

In collaboration with the device, we are looking to develop an app that will make keeping track of milk inventory seamless. Utilizing the device after entering the proper information and printing the label, the device will then log the new quantity of milk into the inventory stored in the app. Through this app users can edit the details of the milk inventory as well as delete from it as the milk is being used. Other features of this app would include the ability to receive notifications when milk is about to expire and check-ins for if any milk was properly logged out of inventory. This application will be accessible at the mother's discretion where she can create secondary accounts for caregivers that will allow them access to her data but provide restrictions for that user's access too. Since this app is not only being designed for mothers as users it will have a feature that will calculate the necessary amount of milk needed for feeding based on user input. Utilizing this information, it will also be able to determine when more milk is necessary to meet feeding needs. The user would be able to set a threshold of when they want to be notified of when inventory is getting low. Every baby's feeding schedule is different so this feature will help to account for that.

1.4 Engineering Specifications

At this time, we are currently making informed estimates on our values based on research of previous projects/products. For our testable specifications, we are planning on testing weighing accuracy, LEDs, and display.

Table 1: Prioritized Specifications

Parameter	Description	Value
Weight	Weight of product	1-3 lbs.
Dimension	Total volume of product must adhere to portability requirements	10 x 5 x 3 inches
Storage Capacity	Total logs of milk bags that can be stored in data inventory	1200 Entries
Battery Life	Rechargeable battery must charge scale and printer	6-8 Hours
Weighing Accuracy	Feedback from scale must be accurate	±0.005–0.02 oz
Maximum Weight Capacity	Max amount of weight the scale can hold, must account for breastmilk bags of larger volumes	1-3 lbs.
Dimension of Labels	FDA compliant, has date/time/dietary restrictions	2 x 3 inch labels
Wireless Connection Range	Range of Bluetooth connection between product and mobile device	30 feet
Software Response Time	Response time to see data from hardware device to mobile application	< 5 seconds
Printing Time	Time it takes to print one label	< 5 seconds

1.5 Hardware Block Diagram

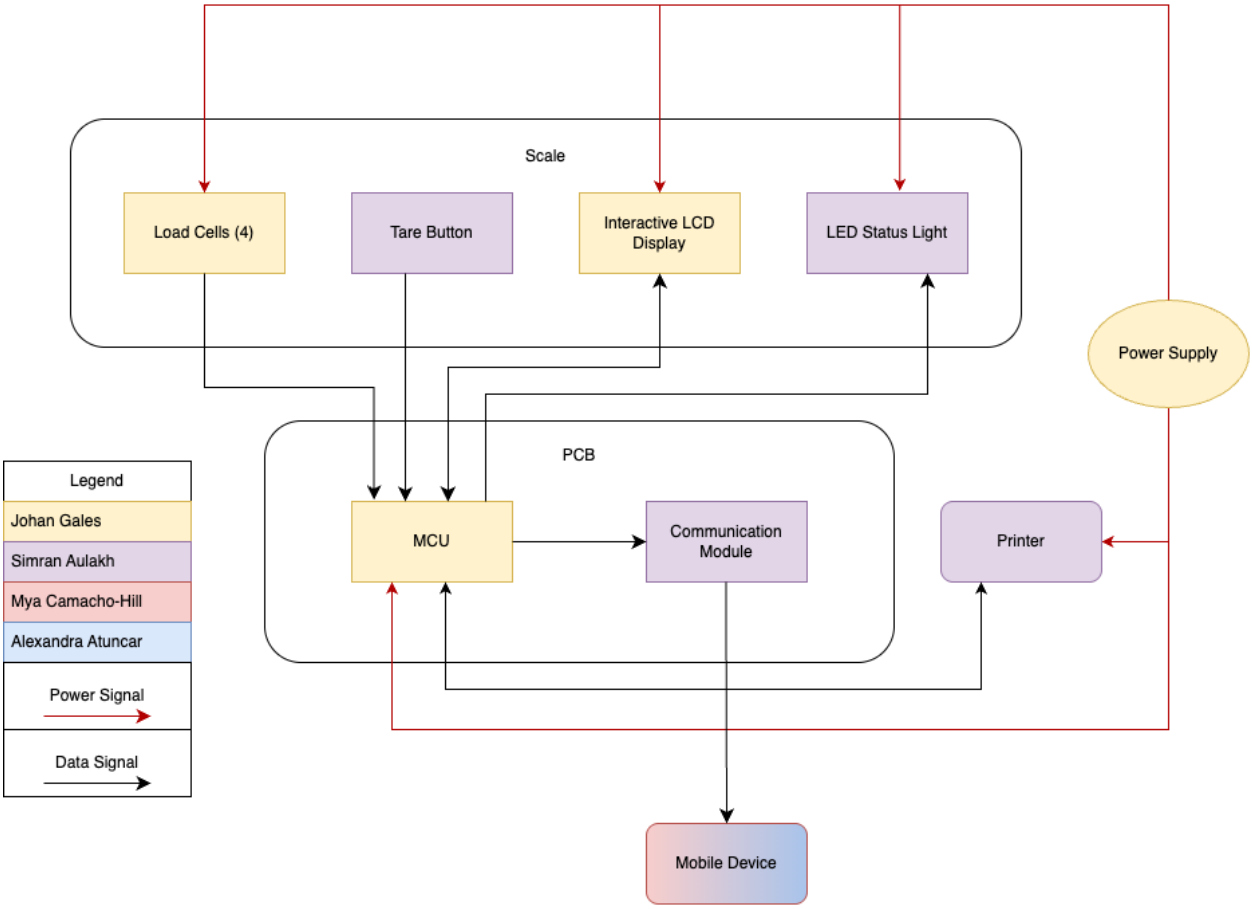

Figure 1: Hardware Block Diagram

For our prototype we are planning to implement all our circuitry on a PCB. The PCB holds components such as the weight sensor (load cell), microcontroller, and the interface that connects to the label printer. This layout allows us to troubleshoot separate components without having to change unrelated components minimizing the risk of errors.

1.6 Software Flowchart

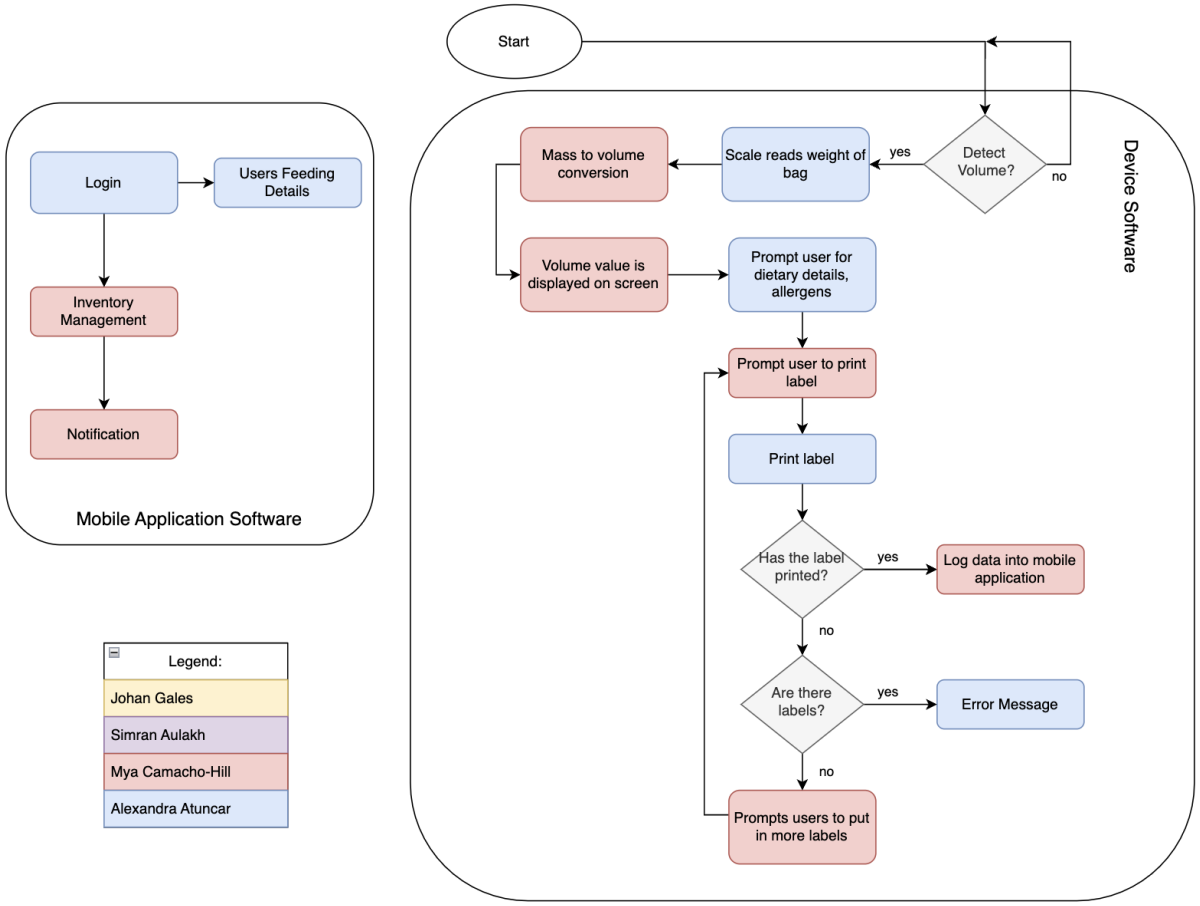

Figure 2: Software Flowchart

In our software diagram we have outlined how our device will label and log breastmilk. The device's software will determine the milk's volume, prompt user for additional dietary concerns, and send the data into our mobile application. The application allows the user to manage inventory and provide more details about their child's milk needs, as well as notifications for specified reminders.

1.7 House of Quality

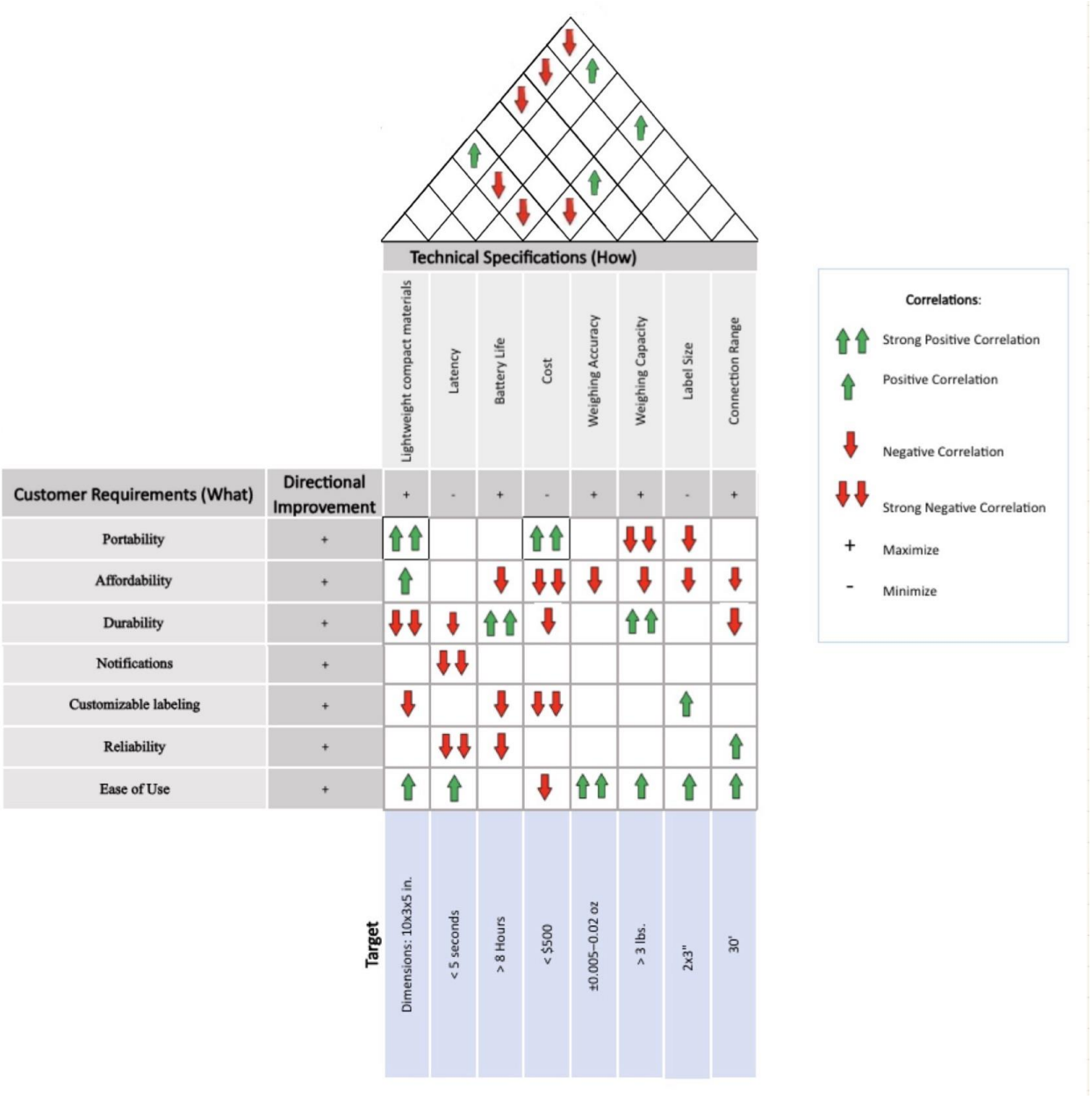

Figure 3: House of Quality

1.8 Prototype Illustration

Figure 4: Prototype Illustration

1.9 Budget and Project Milestones

The budget provided to us for this project is $500. This money is funded by us through our sponsor, and our goal is to be as cost-efficient as possible while meeting all our goals in our prototype. We are still updating our project cost table, but the list below has all the known current supplies needed.

Table 2: Estimated Pumped Project Budget

Product Name	Cost
Arduino Microcontroller	$10-$35
4 Load-Cells	$6-$10
LCD Display	$20-$60
Thermal Label Printer	$30-$120
Thermal Label Paper	$10-$30
Power Supply	$20
PCB Designs	$30-$50

In Senior Design I, we have a timeline of 16 weeks to research and finish our documentation for our prototype. Every week we are planning to update our documentation based on developments with our software and hardware development. We will also be meeting with our sponsor regularly to ensure our direction aligns with their requirements.

Table 3: Pumped Project Timeline

Weeks	Important Tasks + Due Dates
1 (Jan. 5th – Jan. 11th)	Form Group and Discuss Ideas
2 (Jan. 12th – Jan. 18th)	Finalize Idea and begin Divide & Conquer Document

3 (Jan. 19th – Jan. 25th)	Meet with Sponsor, Divide & Conquer Document Due
4 (Jan. 26th – Feb. 1st)	Divide & Conquer Meeting and Revisions Research the software needed to create the app.
6-7 (Feb. 9th – Feb. 22nd)	Research scale and label printer designs
8 (Feb. 23rd – Mar. 1st)	Start PCB design
9-10 (Mar. 2nd – Mar. 15th)	Continue software and PCB development
11 (Mar. 16th – Mar. 22nd)	Continue software and PCB development
12 (Mar. 23rd – Mar. 29th)	Midterm Report and Meeting
13 (Mar. 30th – Apr. 5th)	Midterm Report Revisions and Upload
14-15 (Apr. 6th – Apr. 19th)	Continue Report Revisions
16 (Apr. 20th – Apr. 26th)	Final Documentation

Citations:

1. **Instructables.** "How to Build Arduino Weighing Scales." Instructables, www.instructables.com/How-to-Build-Arduino-Weighing-Scales/. Accessed 19 Jan. 2025.

2. **Zebra Technologies.** "Mobile Printer Battery FAQ." Zebra Technologies, www.zebra.com/content/dam/zebra_dam/en/faq/mobile-printer-battery-faq-a4-en-us.pdf. Accessed 19 Jan. 2025.

3. **Cubtale.** Smart Milk Inventory Tracking Stickers. Cubtale, https://www.cubtale.com/products/smart-milk-inventory-tracking-stickers. Accessed 4 Feb. 2025.

4. **Barcodes Inc.** Zebra Breastmilk Tracking Solutions. Barcodes Inc., https://www.barcodesinc.com/zebra/breastmilk-tracking.htm. Accessed 2 Feb. 2025.

Declaration: We hereby declare that we have not copied more than 7 pages from the Large Language Model (LLM). We have utilized LLM for drafting, outlining, comparing, summarizing, and proofreading purposes.