Deliverable F: Prototype 1 and Customer Feedback

GNG 1103 Group 12C

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Date
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This report will showcase components of our LifeLine product and provide a simplified prototype.

Introduction

In this deliverable, we have attached a prototyping test plan outlining each component of our device. The prototyping will be broken down into four aspects: the schematic circuit diagram, phone application set up, visual model for exterior frame, and coding template. Each component contains an objective that it hopes to achieve and will discuss how it aims to do that. This prototype included many preliminary designs in order to provide a good basis of what we want to do before we begin the actual construction and thus did not cost any money. This allowed us to better plan what materials are definitely needed and right for our device. Lastly, we will explain our plan for prototype two, specifically how we plan to improve or build on to our first prototype.

After breaking down each aspect of the device and determining how each is expected to be completed, we decided to make changes to our exterior device frame. Initially, the conceptual design had been a large wristband, however, after researching and receiving some of the device parts we realized that the device will be a lot smaller than expected. As a result, we made adjustments to the exterior frame such that it would be more narrow and short and thus allowing us to appease the request from the client for discreteness better.

The device frame has been altered to accommodate the battery plan. The team has decided to use a rechargeable lithium battery with a charging/USB port in the device frame that allows the device battery to be recharged.

Battery Calculation:

Electrical Components	**Voltage**	**Current**
MAX30100	1.8 V - 3.3 V	150 µA
HC-05	3.3 V	50 mA
Arduino Nano	3.3 V - 5 V	19/20 mA
Total	**-----------------------------**	≈ 70 mA

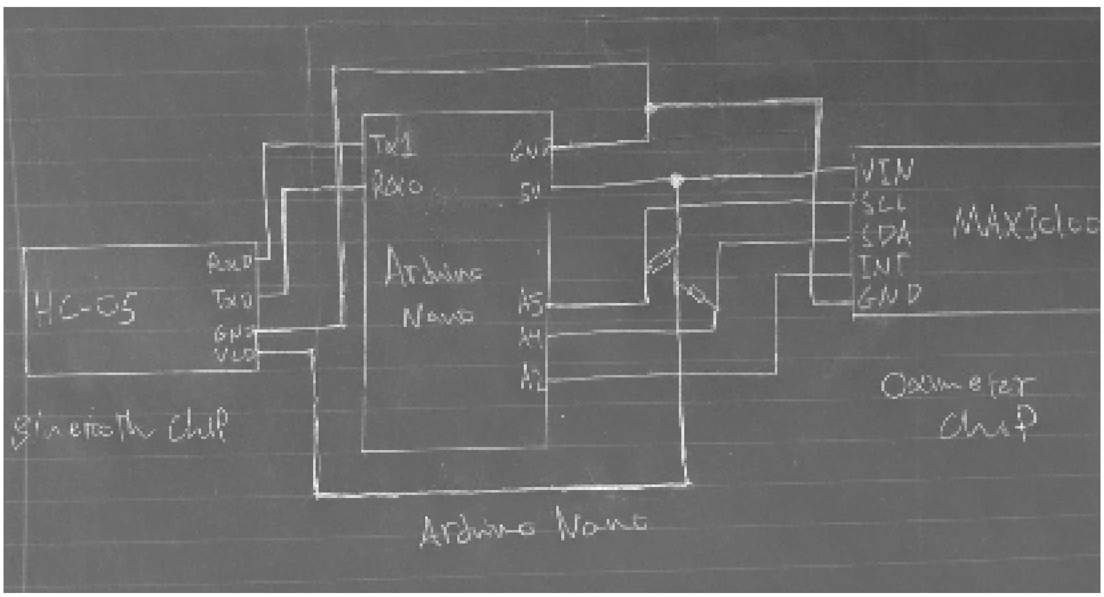
For this device, the battery needs to sustain the device for approximately 24 hours between charging periods, therefore the battery capacity must be (70 mA X 24 hours) 1680 mAh (see attached BOM for battery changes).

Schematic Circuit Diagram

<u>Materials used and cost: 0$</u>

Simple paper representation of the circuit's schematic diagram.

<u>Current progress:</u>



An outlining diagram for the connection of essential device components has been created (the boxy connections are 4.7k ohm resistors). We can begin the construction of the prototyping circuit once the components are here.

<u>Why:</u>

Everything our device does is dependent on the skeletal integrity of the circuit since ultimately the Arduino board is the integrating and coordinating piece in the device. The schematic diagram will provide a basis from which our project can extend to its complete form.

<u>How we tested it:</u>

It will be tested by constructing the circuit and checking the functionality of the oximeter and bluetooth connection after the coding aspect of the project is done. However, the circuit was also tested theoretically by applying knowledge we have on building arduino circuits and it was also tested in comparison to other similarly purposed circuits.

Test results:

We have deemed the circuit to be appropriate for our design. It's compact and it accommodates the essential components that make up our device.

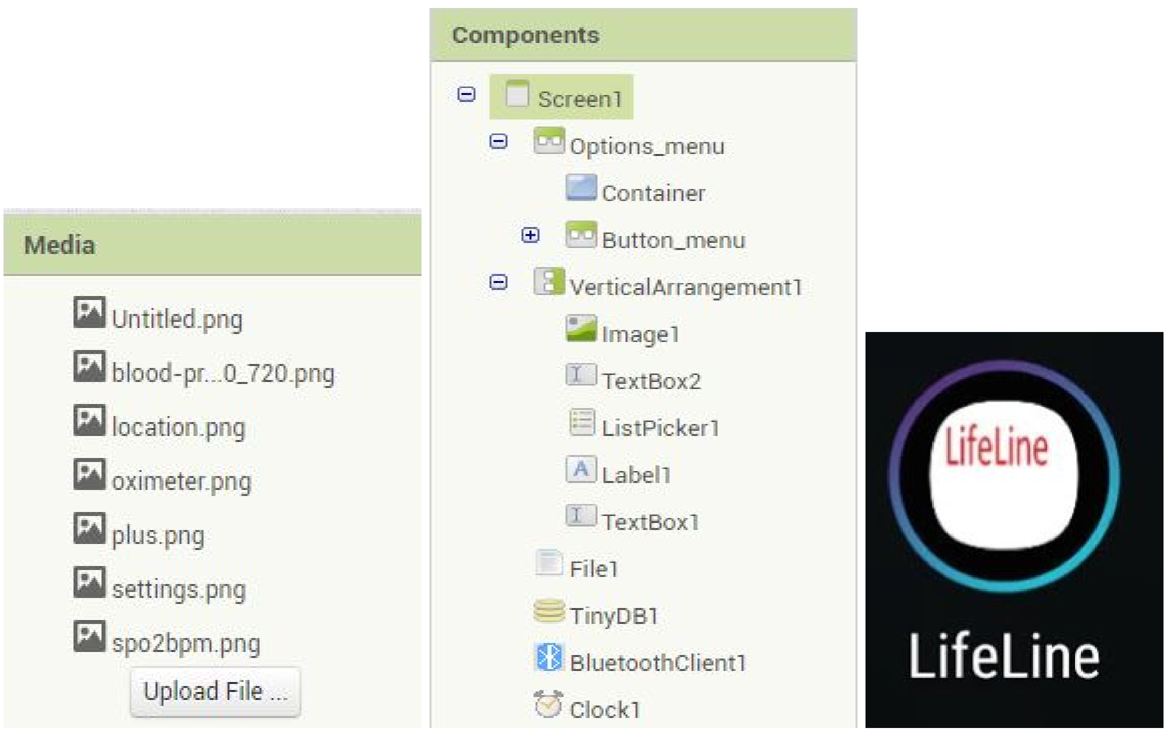
Next step for this:

Next step entails the building of the circuit on top of which the next prototypes (ie oximetry accuracy, bluetooth connection and alarm system) should be tested.

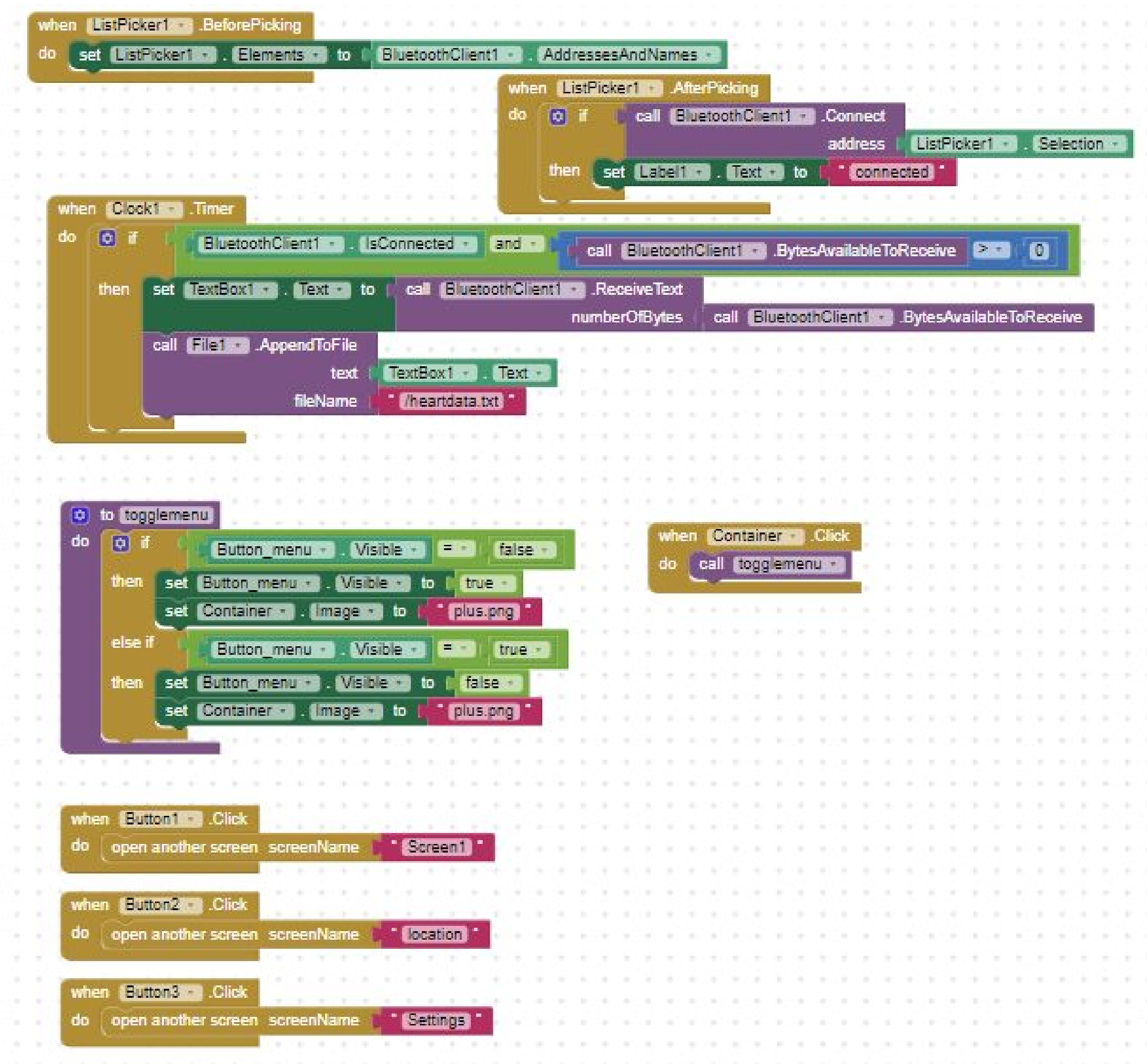
Phone Application Set Up

<u>Materials used and cost:</u> Our group decided on using the website MIT app inventor and the application MIT AI2 companion to make our phone application. Together, this cost us $0.

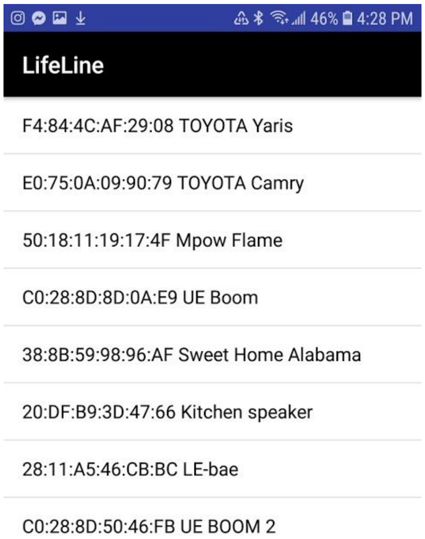
<u>Current progress:</u> We were initially using Android Studio to create our application, but we soon switched over to MIT app inventor because the use of blocks and the drag and drop design was much simpler.s. So far we have found a way to implement a bluetooth connection into our application and have found a way to receive and print readings from the oximeter using our application. We have also created a working toggle menu that can switch between screens so that users could easily navigate our application, and to create a clean and simple looking design.

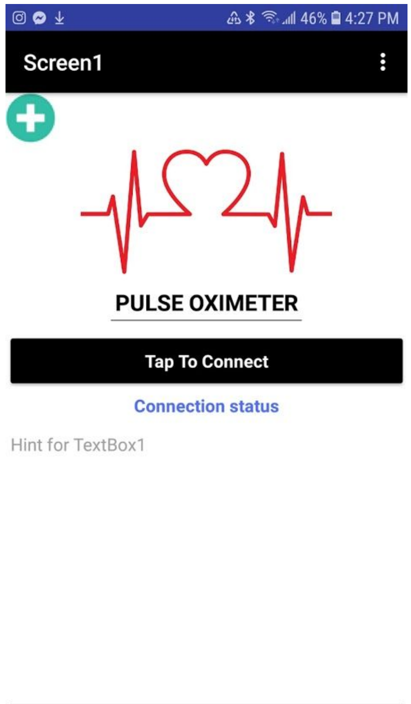


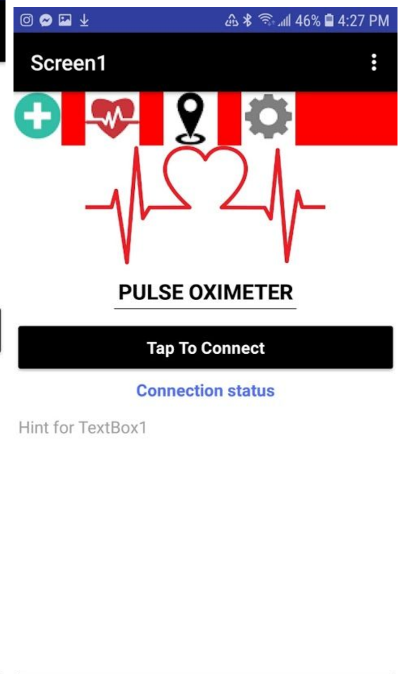
The current pictures and components we have used to create our application, and the current look of our application on an android device.



The current state of our code for the main menu of our application.







Showcasing the current state of our application: The pulse oximeter screen has the option to connect to bluetooth to a chosen bluetooth device, shows if the application is connected, and has a working toggle menu.

Why: For the first prototype, my goal was to not put a lot of focus on the visual aspects of our application. We wanted to mainly focus on getting the main portions (specifically the bluetooth connection to arduino, geolocator and alarm) to work on our app, and then slowly work my way towards making everything look and work better than it did before. Focusing on the main portions of our app will help us get a good perspective on improvements to the design of our application, and will benefit the group by allowing us to coordinate our tasks and be able to ensure that our product will work as it was designed to. We also need to get strong feedback on the main aspects of our application from our client in order to narrow down what needs to be added to our application in terms of additional screens and programs, and to find ways on how to improve the current states of the main aspects of our application.

How we tested it: Using MIT app inventors companion application, we were able to scan QR codes with an .apk version of my application, download and test that version on a phone. The app makes it simple to update the version of our application, and with this, we were able to make changes to my program with ease. Through trial and error of various codes for different designs, we were able to make the current state of our application.

Test results: With the current state of the application, we were able to test out a few things: bluetooth connectivity, multiple styles for our menu (side bar and toggle menu) and ensured that the application we were using was in general, working without errors. By constantly updating my application through QR code scans, we were able to test if the application would force close by itself due to faulty coding, and managed to get everything currently on my application working. The bluetooth connects to different devices such as my headphones. The toggle menu works perfectly, but needs a huge makeover, and overall the app works as it should.

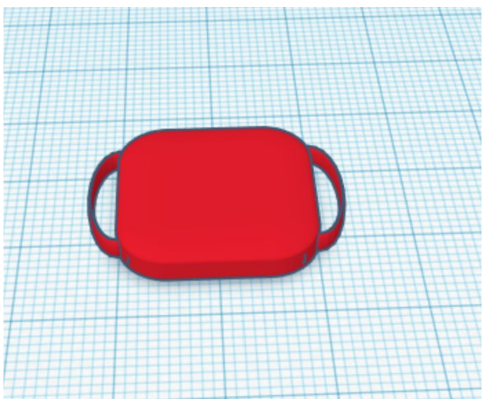
Next step for this: By Friday, we are hoping to have finished up the main components of our application. Once the geolocator is implemented, the alarm and finished making sure the bluetooth connection works, we will move towards allowing our application to send emergency texts with the location to a loved one/relative by allowing users to input numbers and keep them saved in a database, and to create push notifications and prompts for the purpose of our alarm. Afterwards, we are planning on adding additional settings to our application including things such as the option to change languages, instructions on how to use everything (including how to use the device, the administration of naloxone and giving cpr), and massively improving the visual aspects of our application, including the optimization of certain aspects in our application.

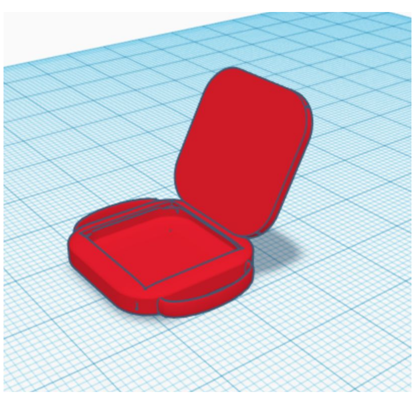
Visual Model of Exterior Device Frame

Materials used and cost: *TinkerCAD* and *Cura* to design and estimate printing time. The cost is $0.

Current progress: We are using the software *TinkerCAD* to build our prototype so that we can have a general idea of how we would like the exterior appearance to be. Once we have the dimensions of the components that make up the device, we will be able to add those dimensions to the design such that we can ensure everything can fit and we can finalize the size of the device. The design options are given from different views and some include visuals with the wrist band and opening/closing mechanism in order to provide more clarity and realism.

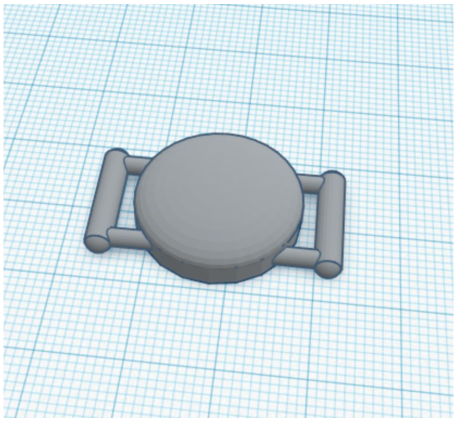
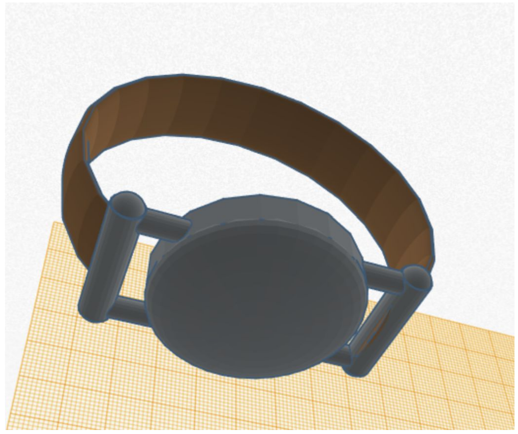
Design 1





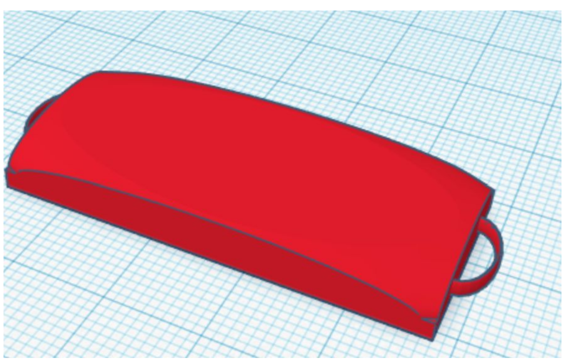
Printing Time: Approx. 27 minutes

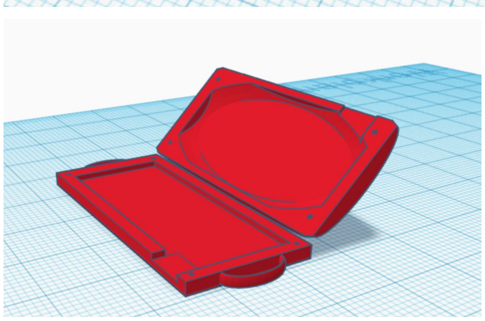
Design 2

Printing Time: Approx. 27 minutes

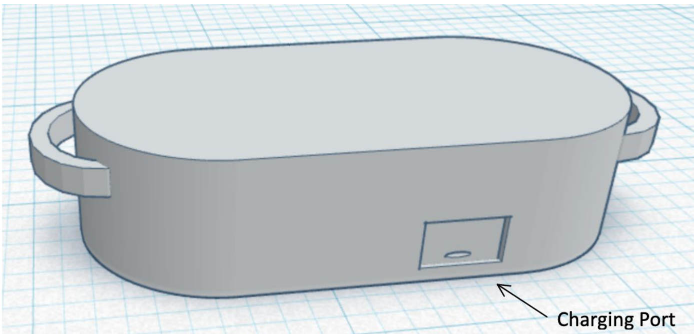
Design 3

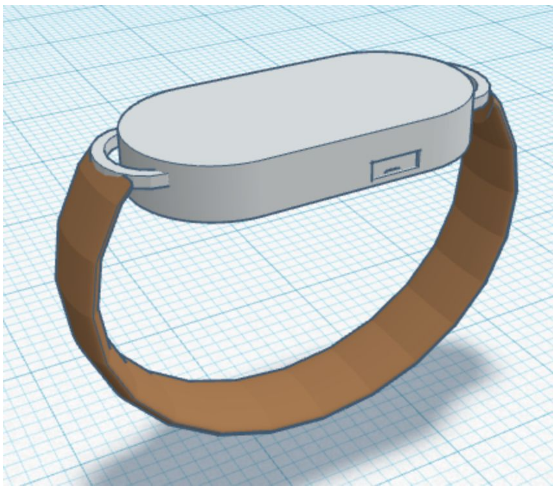




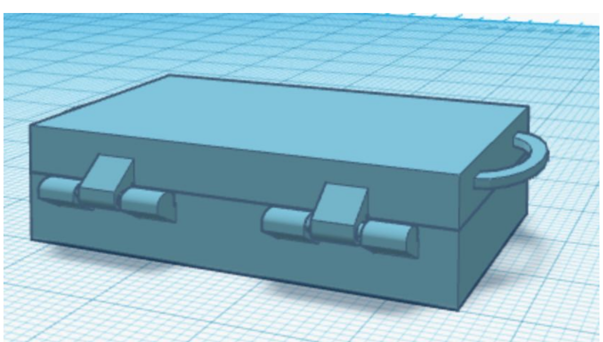
Printing time: Approx. 32 minutes

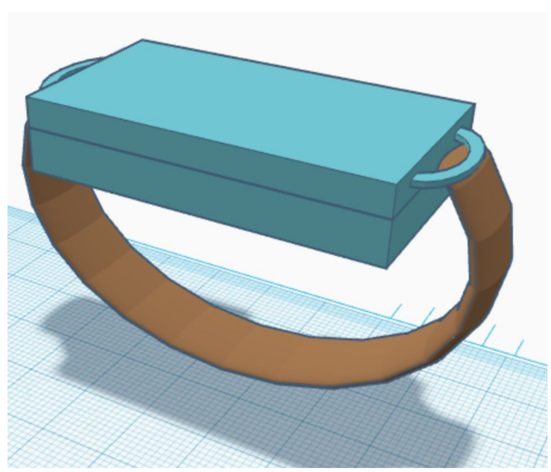
Design 4
Printing time: 10 minutes

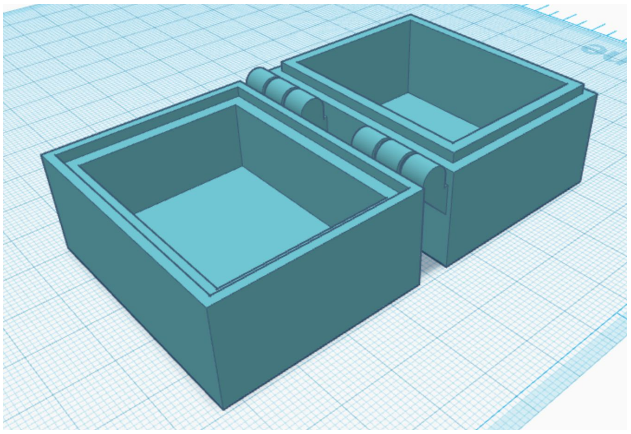




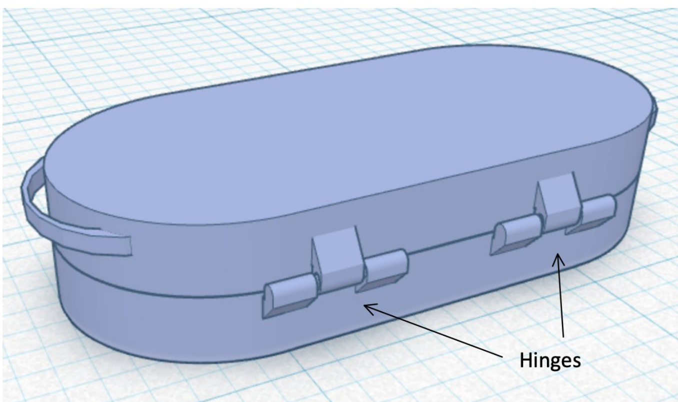
Design 5
Printing Time: 16 minutes

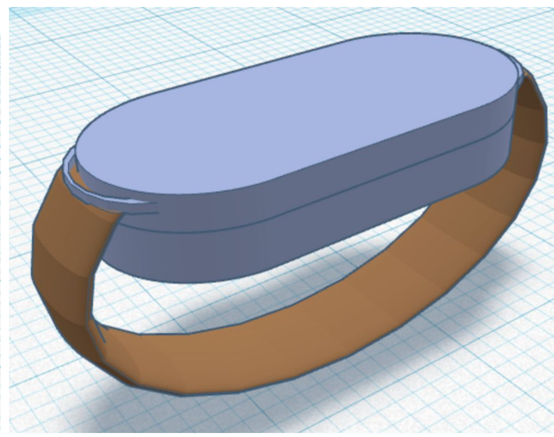






Design 6
Printing time: 12 minutes





__**Why:**__

By designing several exterior frames for our device on *TinkerCAD*, we can gage a better understanding of what would be the best option since we would compare each frame. The goal would be to create a design that is aesthetically pleasing, compactible (for all the components in the device), and convenient for the user. In addition, selecting a few choices as our top designs and showing them to our client will help us gain feedback. This would be beneficial because she can identify preferred designs and suggest ways for improvement before the finalized 3D printing is made and we start adding the components inside.

__**How we tested it:**__

After each design was made, we put it in a program, *Cura*, to determine how long each would take to 3D print such that we can manage the amount of time required for printing while also allocating time for potential mistakes in printings and printing display prototype designs. Also, *Cura* has a feature that allows us to determine the amount of material that is overhanging and thus could be problematic to print. This is beneficial since we were able to make adjustments based off of this feedback and minimize the amount of issues that we might encounter during the printing process.

Test results:

As a team, we had concluded that the top designs were design 3 and 4. This was because their shapes were more discreet while still being realistic to create. However, features from multiple designs will be considered since each design will require a charging port and a opening and closing mechanism. The top designs will be experimented with during the second prototype for their ability to print and will be compared such that we can use each design to determine strengths and weaknesses which can help build on each other's designs.

As of this moment, the results of the survey show that most favoured designs are respectively 1, 2, and 3. The survey conducted was solely based on the devices appearance and as such, these results were reasonable since these designs are the most appealing visually. However, the other options had been more realistic in terms of sizing of interior components and additional features (charging port and opening and closing mechanism).

All of the favoured designs will be taken into consideration as we move forward into prototype three. If the interior components of the device are too large for designs 1 and 2, we will consider the features that made these designs appealing (rounded edges and as thin as possible). We will try to combine the favoured features such that we can create the best design which is feasible.

Furthermore, we would like the watch to include a charging port and a lid to open and close. We would like the inside to be squared to fit the components and the outside to be more rounded to so that it sits more comfortably on our users arm. The printing process will only take approximately half an hour, which is very convenient for our schedule. This will allow us to easily re-print as many prototypes as needed. The overall shape does not attract unwanted attention and can be made in a sleek, compact manner.

Next step for this:

Moving forward we would like to finalize our design by including precise dimensions of our exterior frame. This would be completed by measuring the dimensions of the interior components put together. With these, we can make a shell that is the perfect size to fit everything inside. As well, the next prototype will need to include a more finite opening and closing mechanism such that we can fill it with the interior components. This frame would also be best without using glue to attach the opening and closing parts so that if needed, we are able to change the battery or fix components in the future. Our device will include a battery that is rechargeable, thus the design will require a hole for the charging port in the shell. This means that design will not need to be opened consistently, which helps to narrow our design options such that big and bulky open and closing mechanisms are not necessary, like hinges. However, an optimal design would allow the opening and closing of the device in case a piece needs to be replaced or fixed. In future prototypes, we will print the 3D model as well as begin to include the strap attachment to the device shell.

Code Template

Materials used and cost: $0

Current progress:

The code template acts as a framework for the coding to be done in prototype two. This code template highlights the main functions and aspects that will be required to receive the pulse oximeter reading, send it to the phone applications, send a warning message at overdose detection and trigger an alarm if that message is not responded to.

Why:

The coding portion of the project is broken down into smaller parts so that we are able to complete the coding aspect in prototype one.

CODING TEMPLATE

Definitions and Headers:

To optimize and maintain efficiency in our code, it would be best to define variables here rather than initializing variables with constant values.

Ex. #define READING_INTERVAL 10

We will need to have libraries set up in order to incorporate the pulse oximeter. These libraries can be downloaded online.

Ex. A possible MAX30100 library headers:

```
#include <CircularBuffer.h>
#include <MAX30100.h>
```

```
#include <Wire.h>
#include <MAX30100_BeatDetector.h>
#include <MAX30100_Filters.h>
#include <MAX30100_PulseOximeter.h>
#include <MAX30100_Registers.h>
#include <MAX30100_SpO2Calculator.h>
```

Function Prototypes:

Out of necessity and organizational purposes, functions are going to be required further into the code. If we plan to introduce functions, then we need to have function prototypes here.

Ex. getPulseOx();

Creating Structures:

In the process we might find it easier to collect readings in a structure format instead of individual variables, as we will be collected blood-oxygen levels and heart rate from the MAX30100 chip.

```
Ex. struct INFO
{

};
```

Getting Pulse Oximeter reading:

A function will be used here to retrieve data from the MAX30010 chip. In order to optimize a code, it would be more efficient to get readings every 15 seconds (subject to change) rather than every 2 seconds so that we do not use up the battery. This function would be a looped function.

Sending Pulse Oximeter reading Via Bluetooth

A function will be used here to send the data retrieved to be displayed on the phone application.

Alert System: (Should be done in App)

If statement that detects if the blood-oxygen level is less than (set value), then a series of events are triggered.

1. Sending a warning message to the phone app via bluetooth. Ex. sendWarning();
2. If the response is not sent back in 20 seconds, then an alarm to the app. (done in app)

Customer Feedback Questions

Schematic Circuit Diagram

Would you compromise with a bit of accuracy(of pulse oximetry) to get waterproofing?

Phone Application Set Up

- Aside from the main components of the application, what else would you like to see included in the app? For example, cpr instructions, instructions on how to administer naloxone, etc
- Do you want a start up screen for our application?
- Should we add the option to make the app available in french

Visual Model of Exterior Device Frame

- Our design will most likely be the square shaped one since it is much easier to add in the components and will most likely include the charging hole. Would you like the top to be easily openable even though the customer won't really be needed to open it since they can charge it through the outside?
- Do you think it is unrealistic to have a switch on the device?
- Do you have any comments or concerns on how the design looks so far?

A survey was made containing all designs for the exterior frame and shared on social media like Instagram and Snapchat. As aforementioned in the exterior frame section, the top designs chosen were respectively 1, 2, and 3. The survey also inquired about the preference in watch strap materials and this was found to be the nylon fabric. These designs will be taken under consideration since it provides a large range of opinions preferences that can be used to improve our device. Although this survey does not present the highest fidelity since the reached audience are not opioid users, the results can be used to gain a better understanding of what people might want. This feedback will also be proposed at the pitching presentation so that our client can suggest improvements as she sees fit. The link for the survey is the following:

https://surveyhero.com/c/7d2d2fe6

Specifically, we asked our peers in different engineering disciplines as well as different faculties about what they would be most likely to wear. Most of them said they wanted to wear a small slim device like the first device, but when they got the information that this design may be unreasonable size wise, they said they would prefer that it was larger in width and length rather than height as it seems easier to hide under a sleeve and function with it on.

Moreover, we inquired about the prefered material of the watch strap. The options were faux leather, velcro, and nylon fabric and the top option was the nylon fabric. The velcro was efficient on our behalf since it is cheap and very available, however, is not favourable for the user since it is not the most comfortable and can lose the velcro's stickiness over time. Between the faux leather and nylon fabric, the winner is solely based on personal preference. Due to the nylon fabric's popularity, it will most likely be used within our final device frame.

Also, we asked for any final additional feedback and they said that they would like the top of the device to be rounded as to be less likely to get caught on stuff, and they would want it to be a more neutral colour than those shown. We had already had the idea to make it a neutral colour, but for the next prototypes we will also be displaying colour. Another good suggestion made if we could engrave the device such that it is more visually appealing. All of these suggestions will be taken into consideration to ensure that the device is attractive to the user.

Conclusion

The goal of this deliverable was to create a breakdown of the significant components of the device and ensure that they are planned accurately in order minimize potential problems and create a foundation for our device. The plan was composed of four different aspects: the circuit diagram, phone application design, exterior frame design, and arduino nano code template. Prototype one was designed to assess the skeletal integrity of our device. After creating detailed analysis of each of these aspects, we were able to have conclusive results supporting each aspect's logic and determines their course of action. We were also able to narrow down the options for the frame device that would be the most appropriate for our LifeLine device. The circuitry has proved to be an appropriate baseline to build on and carry out subsequent prototype testing for our second and third stages.

Moving forward, although the foundation of our device seems to be promising and the understanding of our tasks is good, there are many issues that we may encounter in the future if we do not stay on top of our work. For instance, the device frame has many innovative features that would be ideal to include, we must also take into consideration what is possible. 3D printing designs can be difficult because it may need supports or else the overhang will alter the design, or the measurements are too small for the printing to be made with good quality. Also, if the circuitry and code are not correctly planned, then the building of the device will be delayed since most rely on the coordination between all the interior components. Specifically, this could mean not properly calculating the resistance needed or having difficulty with the communication between the phone application and main device.

Considering these risks, it is significant that we are thorough with our work such that we can adapt well to error. The second prototype will provide us with an opportunity to learn from the tests and see what works and what does not. Our strong foundation from this prototype will provide a good starting point for the next prototype to ensure that we are able to effectively build our device.