**Hot Car Emergency: Prototype III and Customer Feedback**

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November 25, 2021**Abstract**

This document begins with an introduction to our third and final prototype before the final product. This entails the components included as well as the testing purposes. Following this are the objectives to be met by this edition of our design. Sub-prototypes are then listed. Then, performance status is analyzed and given feedback. Finally, we developed the final product plans for design day which takes place on the 2­­­nd of December and included the overall task plan.

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# Introduction

Our third and final prototype focuses on four main components: the outer casing, the Arduino code, the mobile application, and the mounting method. While the last prototype focused on the Arduino code and wiring, this prototype aims to finalise both of these components and create a general framework for the remaining components. This prototype is thus focused on ensuring that the product is fully functional so that we may redesign the user interface and finalise the product’s aesthetics by the Design Day on December 2, 2021.

# Prototyping Objectives

“Why” Objectives:

1. Confirm that the product is able to send message to mobile device
2. Determine whether dimensions of casing is suitable for contents and ease of use
3. Ensure that code is functional and connections are soldered properly
4. Institute a suitable car mounting method that is both effective and versatile

“What” Objectives:

1. Demonstrate a scenario in which the arduino initiates action on app
2. Place contents in product casing and analyze convenience of weight and dimensions
3. Run finalized code and solder connection to proto board
4. Test for mounting feasibility by simulating in a similar environment

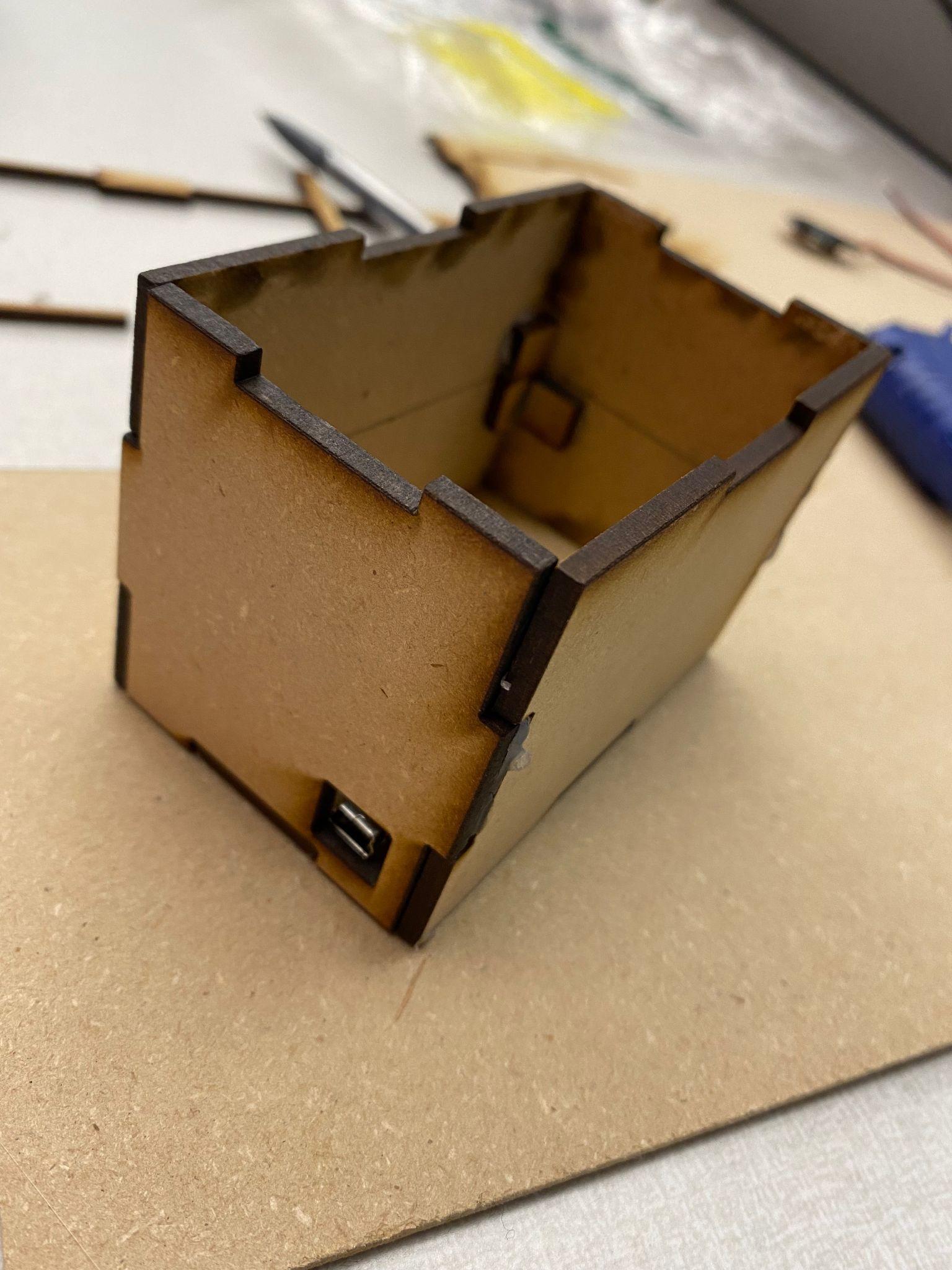
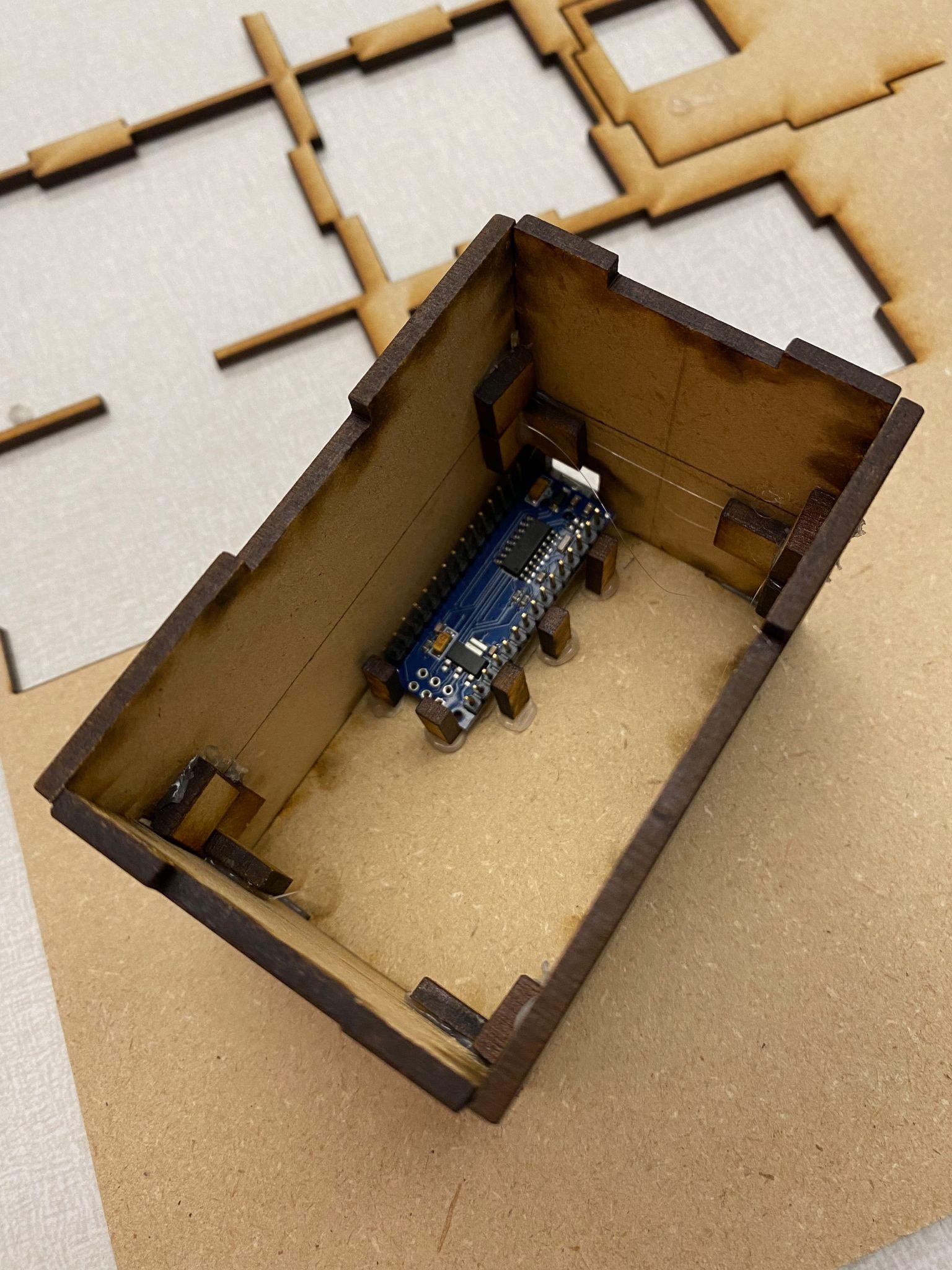
“When” Objectives:

1. Signal test between arduino and mobile app - November 23
2. Checking compatibility of components to the casing - November 21
3. Simulation of completed code - November 22
4. Checking security of device when hooked up via mounting attachment - November 25

# Prototype III

## Laser Cut Product Casing

The product casing was constructed using 3mm MDF, inkscape software and an epilog laser cutter. Its dimensions were set at 80x55x50mm based on the preliminary measurements of the inside components. On the bottom level, 5x13mm standoffs were glued in place to hold the Arduino Nano in position. A 10x10mm hole was cut to provide access to the USB connector on the nano so that it is easily accessible for any code updates.

  
Figure 1. Photographs of the casing interior, showcasing the standoffs used to hold the Arduino Nano in place and the side opening used for easy access to the micro-USB connection.

A second level was added to provide support for the sensors, including several 5x5mm holes to allow for the connection of the wiring to the Arduino nano. In the top panel, a hole for the PIR sensor was put in place to allow for the detection of motion throughout the rear of the vehicle.

  
Figure 2. Top-down view of the casing to demonstrate the platform and opening used to position the PIR motion sensor.

Hot glue was used to construct the preliminary version of the product casing, however epoxy will be used to construct the finalized version with updated dimensions. Refer to the testing and feedback section for the changes to be made to the product casing prototype.

## Finalised Arduino Code

The previous prototype tested all of the components individually to ensure that all of the sensors and modules are in working condition. However, because the purpose of the last code was to test for functionality, the objective for this prototype was to alter the code to allow for proper communication between the modules and the mobile application. The main alterations were to remove the Serial print statements that were used to calibrate the sensors and to introduce communication between the HC-05 Bluetooth module. Comments were also added in the heading to credit our references and to add useful footnotes for others who may attempt to replicate our project.

1 /\* Backseat Buddy by The Backseat Drivers (Group B06)

2 \*

3 \* Pins (in order):

4 \* RX (0): HC-05 Bluetooth TXD

5 \* TX (1): HC-05 Bluetooth RXD

6 \* 4: PIR Motion Sensor (OUT)

7 \* 7: DHT22 Temperature Sensor (OUT)

8 \* A05 (Analog 5): MQ-7 CO Sensor

9 \*

10 \* NOTE: Unplug the RXD and TXD pins from the Arduino before

11 \* uploading the Arduino code. Re-plug pins after uploading.

12 \*

13 \* Default password to connect to HC-05 is 1234.

14 \*

15 \* References:

16 \* DHT22 library by Michaelis Vasilakis (2015)

17 \* DHT22 temperature monitoring code by Muhammad Afzal (2016)

18 \* MQ-2 gas sensor code by Aritro Mukherjee (2016)

19 \* PIR motion sensor code by DIY Electronics Projects (2020)

20 \* Bluetooth code by Dejan Nedelkovski (2016) \*/

21

22 #include <DHT.h>

23 DHT dht(7, DHT22);

24 int gasSensor = A5;

25 int motionSensor = 4;

26 int motionStatus = 0;

27 int gasThreshold = 250;

28 int bluetoothState = 0;

29

30 void setup() {

31 pinMode(gasSensor, INPUT);

32 pinMode(motionSensor, INPUT);

33 Serial.begin(9600);

34 dht.begin();

35 }

36

37 void loop () {

38 float hum = dht.readHumidity();

39 float temp = dht.readTemperature();

40 int gasLevel = analogRead(gasSensor);

41 motionStatus = digitalRead(motionSensor);

42

43 if ((gasLevel > gasThreshold || temp > 30) &&

motionStatus == HIGH) {

44 Serial.write(“DANGER”);

45 }

46

47 delay(5000);

48 }

Figure 3. Code to be used in the final product.

## Bluetooth Connected Mobile Application

Although the completion of an aesthetically pleasing mobile application was not a priority for this comprehensive prototype, it was nonetheless necessary to verify the functionality of the HC-05 bluetooth module and all associated code. Consequently, a ‘barebones’ app was created using the MIT App Inventor. This application was designed to do the following:

* Establish (and re-establish) a bluetooth connection to the device, independent of user interaction (allows the user to leave the immediate vicinity of the device)
* Continually read data broadcasted from the HC-05 bluetooth module
* Interpret that data and notify the user in the case of an emergency

MIT App Inventor uses a block based system for the construction of code. The code of the basic application that was used to test the bluetooth module can be observed in Figure 4 (below). When activated, the application attempts to connect to the HC-05 every 5 seconds, until such a connection is established. Once the app has paired with the device, it requests a signed 1 byte number each second. If the bluetooth connection is severed, the app will resume the aforementioned connection procedure until the connection is re-established. The app continues these functions when minimized.

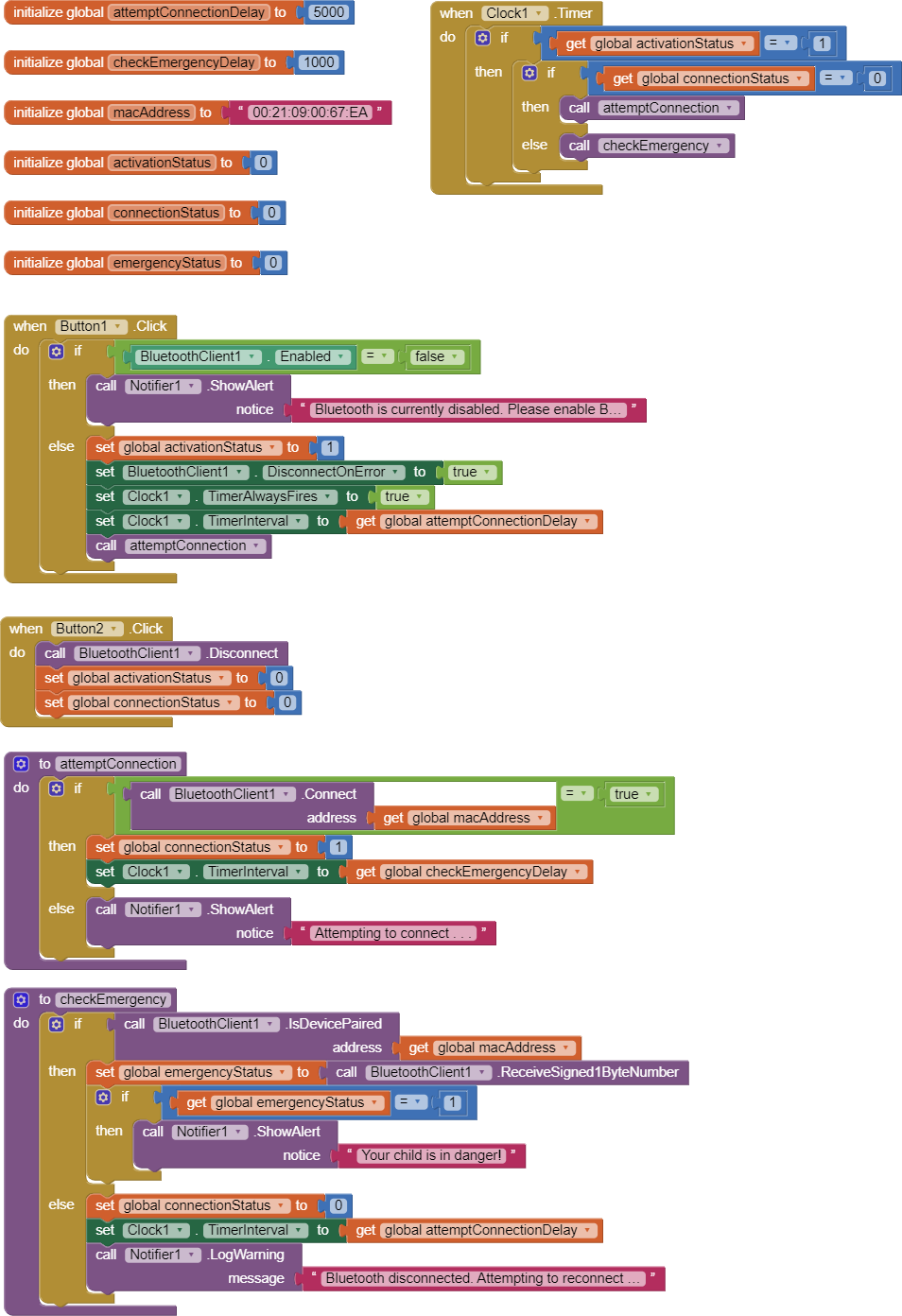
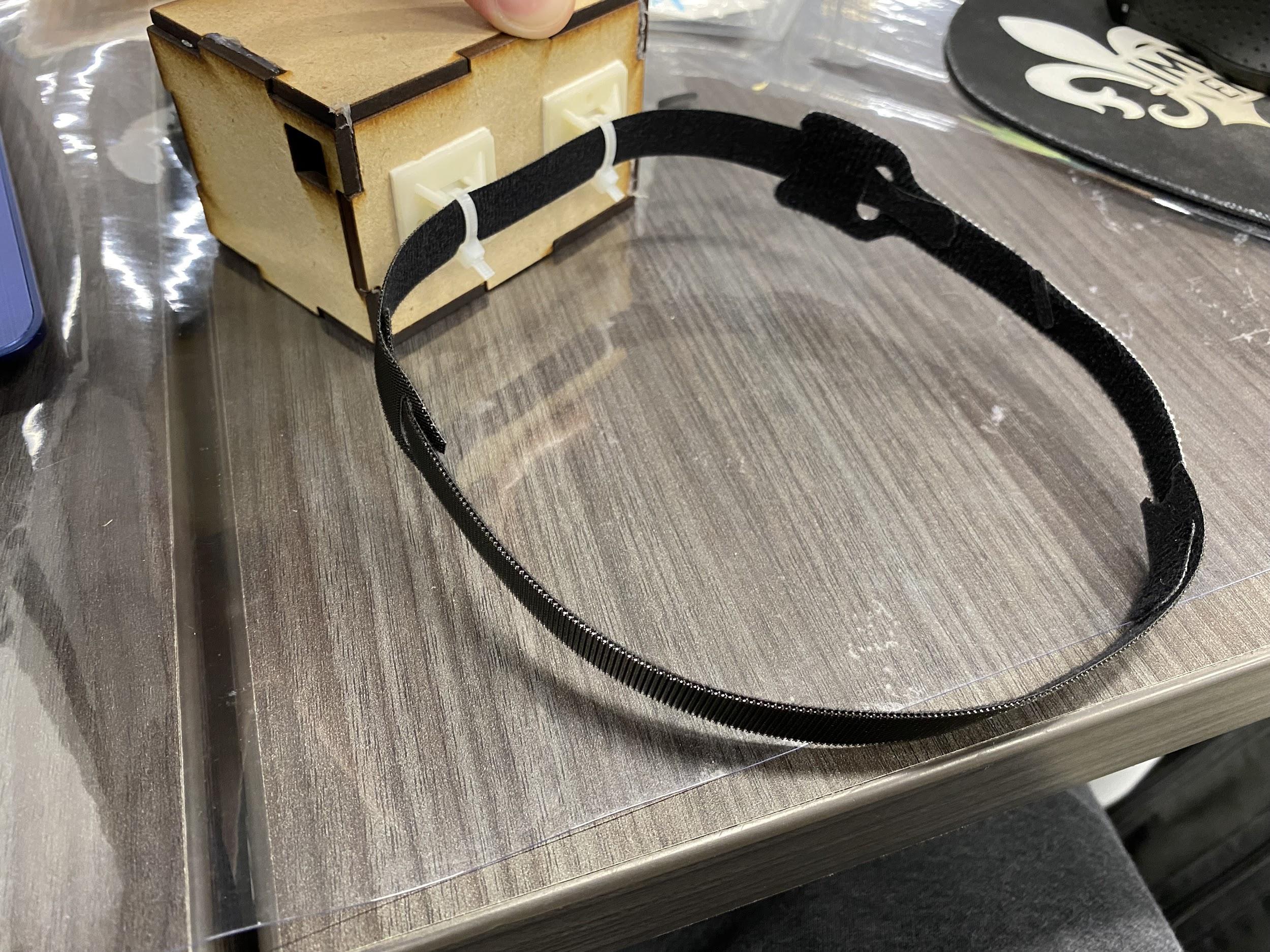


Figure 4. Block diagram depicting the code of the mobile app.

## Car Mounting Method

With the product casing we were able to start thinking about how to mount it to the specified location. Two main locations were considered, one being the coat hanger in the back of the car in which you have a vertical view of the back seats and the second being the abc of the front seats headrest. In terms of the actual mounting method however, a couple different things were considered. Initially, our ideas revolved around making holes/slots in the case to have either rope/string or straps pass through. However, for the strap concepts, we were dancing around the idea of purchasing a 2’’ velcro or clip strap or even use cinch straps found on your everyday backpack that would function similarly to the rope concept (in terms of fastening). In the end we found our final concept once we moved away from creating further openings in the product case. Using a combination of adhesive hybrid command hooks and plastic ties, we were able to pass a velcro strap through.



# Testing, Analysis, and Feedback

## Laser Cut Product Casing

The product casing was tested to determine changes required to the design and dimensions of the product. It was determined that several changes were required based on an improved understanding of the placement of the final circuitry. Firstly, the standoffs used to encase the Arduino Nano will be removed as it was determined that the Nano will sit on the protoboard. Secondly, the dimensions of the casing will need to be adjusted to fit the protoboard dimensions and dimensions of the final circuit. The platform height will need to be adjusted to ensure adequate space is available for the temperature and CO sensor in the casing. In addition, the platform will be replaced by the protoboard and this will serve as a support for the sensors and the soldering base. The supports for the platform will also need to be modified to allow for the protoboard to be screwed in upon finalization of the design. Finally, the casing will need to be epoxied to ensure greater strength of the product, and upon consultation with the course coordinators, a logo will be added to provide greater visual appeal.

## Finalised Code

The code was altered and finalised to suit the intended function: to notify the client through an app when the Arduino senses an emergency. Because there was no app during Prototyping Phase II, we could not properly test the bluetooth connection. So, following the creation of the barebones application, we were able to test the bluetooth connectivity. This meant that we could remove the unnecessary lines of code and print statements that served only to test sensors. Although much of the code has been finalised, it is still open to changes to better suit the mobile phone application.

## Bluetooth Connected Mobile App

When the code for the mobile app was first tested, we noticed several issues immediately. Most importantly, the ‘.show alert’ function does not send a push notification (i.e. a notification that triggers sound and/or vibration in a locked phone). Without this functionality, the device cannot change the awareness of a user whose focus is elsewhere, and therefore does not address the needs of the client. Furthermore, status updates pertaining to the bluetooth connection appear in the centre of the screen regardless of minimization or emergency status. This makes the application completely impractical for the average user. The final version of the app will display connection information only when the app is maximized (through the use of a dedicated status bar), reserving invasive notifications for true emergencies. It may also use the signed 1-byte integer provided by the bluetooth module to encode more complex status information.

## Mounting mechanism

For the mounting method we considered and tested the options considered. In terms of the desired location, we agreed that the back of the head rest would both be easier to mount to, provide more security, and every car is guaranteed to have one. The scope was a little larder for the actual mounting mechanism. The rope proved to be less than satisfactory for security and for convenience. Once we settled on a strap we realized that purchasing a large velcro or clip strap would make us exceed our spending limit. In the end we were left with the backpack cinch idea which could have worked. However, it was far easier to use an adhesive attachment and combined velcro straps rather than create slots as it would have interfered with our current wiring setup. After testing the external mounting attachment we came to the conclusion that it provided enough support for the device even in a setting with potential commotion.



Figures 5 and 6. A water bottle is used as a proxy for the headrest.

# Design Day Project Task Plan

| Test  ID | Test Objective  (Why) | Description of Prototype used and of  Basic Test Method  (What) | Description of  Results to be  Recorded and  how these results  will be used  (How) | Estimated Test  duration and  planned start  date  (When) |
| --- | --- | --- | --- | --- |
| 1 | Establish connection from bluetooth module to mobile app | Create a mobile phone application that interfaces with Arduino circuit | Effectiveness and range capabilities of bluetooth connection to mobile phone | Test duration: 1 minute, planned start Friday Nov 25 |
| 2 | Communicate design and functionality of mobile app | Ensure mobile app and Arduino circuit are able to function in a live demonstration | Mobile app that is able to issue a push notification upon the detection of an emergency variable provided by the Arduino | Test duration: 1 minute, planned start Friday Nov 25 |
| 3 | Reduce uncertainty surrounding final circuit connections and design. | Physical circuit using Arduino Nano and soldered connections. | Functional Arduino Nano circuit that is able to detect motion, temperature, and CO concentration. | Test duration: 1 minute, planned start Friday Nov 25 |
| 4 | Reduce uncertainty surrounding product dimensions | Physical product casing using laser cutting techniques that fits updated circuit and protoboard | Product casing will be used to create the final product | Test duration: 5 minutes, planned start Friday Nov 25 |
| 5 | Verify feasibility of car mounting method | Physical comprehensive prototype able to attach to the back seat of a car | Product straps support weight of product, are stable and are able to attach to all vehicle types. | Test duration: 1 minute, planned start Friday Nov 25 |

# Conclusion

To summarize the contents seen in this document, the predetermined objectives of the prototype included the final dimensions and material used for the product casing, the establishment of a finalized code, the implementation of bluetooth communication between the product and mobile app and the production of a mounting mechanism for the product. The components listed were all evaluated for effectiveness to establish a base to go off of for the design day product. This led to the project plan for our final design to be accompanied by a recorded presentation.