Concen-training System

Group D

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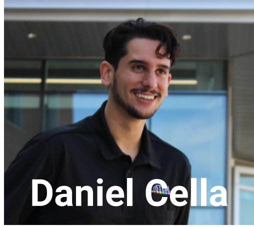
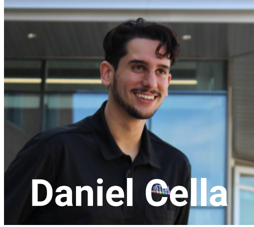


Agenda

- Project Overview
- Hardware
- Software
- Testing
- Administrative/ Next Steps

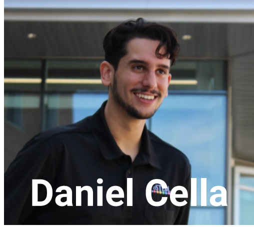
Project Overview

Problem Statement



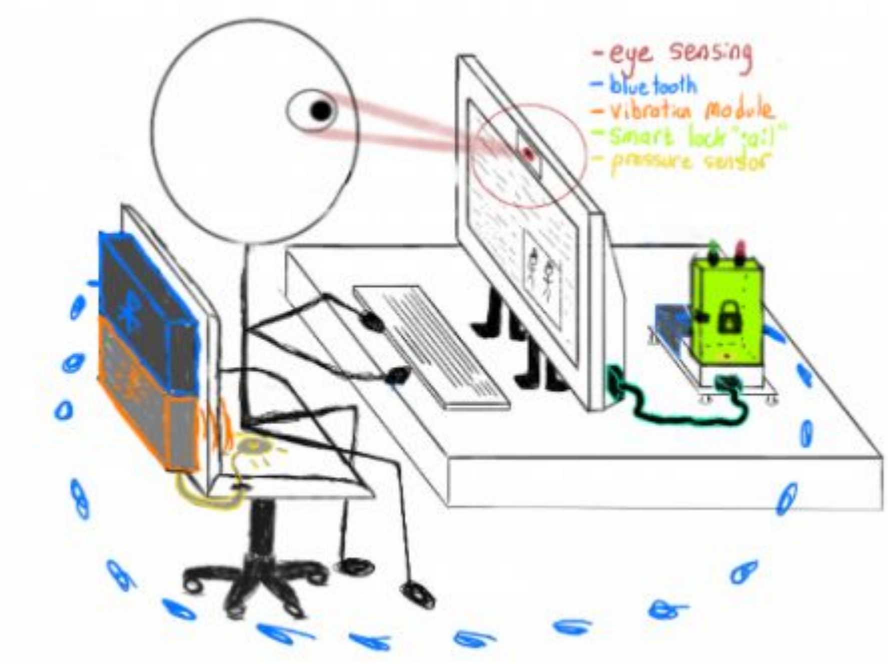
- In the current age, instant gratification and technology rule the lives of the masses. Although smartphones offer quick access to limitless informative resources, much of the time people are distracted by other things such as social media, mobile games and other trivial diversions.
- Personal Note: I have found it difficult to study effectively with my phone in my vicinity

Goals & Objectives (Project and Personal)



- **Project:**
  - Create an electromechanical reinforcement system to improve study habits.
  - Help train users to maintain focus during online classes, studies, or work.
  - Utilize positive reinforcement to promote good study behaviors.
  - Utilize negative reinforcement to deter poor habits.
- **Personal:**
  - Improve skill sets across engineering disciplines.
  - Circuitry & physical layout design experience through multiple PCB designs.
  - Electromechanical design experience through sensor development and housings.
  - Coding integration experience with multiple microcontrollers.

Design Approach/Proposed Implementation



Two MCUs will communicate via bluetooth between the lockbox module and the chair module to track the user’s focus and alert them once focus is lost.

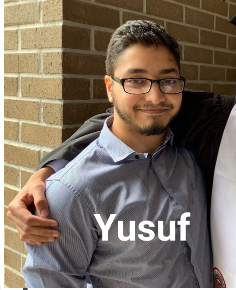
Module Description

Lock Box

- Holds User's Phone to Minimize Distractions
- Store PCB used to Control Lock Box Hardware and Communicate with Chair Module
- Weight Sensor to tell when Phone is Placed Inside

Chair

- Senses When User is Seated
- After Set Time Without Focus, Alert User via Vibration
- Contains All Components Needed for Chair Operation
    - Vibration, PCB, Weight Sensor, Power



Specifications

- The eye-tracking system should be greater than 90% accurate and be able to register a user within 1 meter
- The chair should register a weight of at least 50 lbs or greater, up to 200 lbs
- The lockbox should register a weight of at least 0.3 lbs
- The total set-up time for the system should not exceed 10 minutes
- The eye-tracking system must note inattention within 30 seconds
- The vibration system must alert the user of inactivity within 30 seconds of inattention

Constraints

- Lockbox must:
  - fit majority of cellular devices
  - Utilize weight sensor able to register devices
- Chair module must:
  - Use motors strong enough to alert user
  - Use motors compact enough to fit comfortably in chair module
  - Be comfortably compact and portable
- Software language must:
  - Be compatible with computational devices
  - Be compatible with operating system

Constraints (continued)

Economic: Our project has no sponsors, fully funded ourselves

Environmental: Florida is humid, could affect electronic parts

Social/Cultural: User interface only in English for the time being

Ethical: Privacy concerns, eye shape for eye tracking

Health & Safety: Lockbox must have emergency release within 60 seconds

Manufacturability: Limitations on parts due to microelectronics shortage

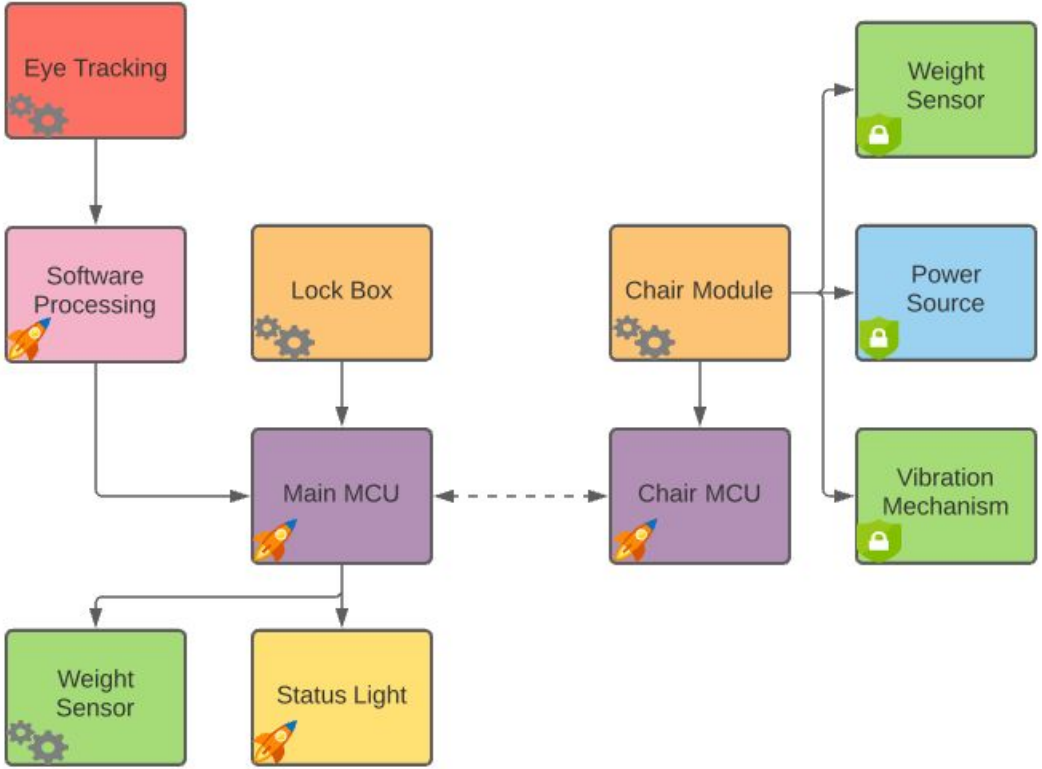
Sustainability: Possible need to get new batteries after current ones go bad

Related Standards

- IEEE 1625-2004: Standard for Rechargeable Batteries for Portable Computing
- IEEE P7004.1: Recommended Practices for Virtual Classroom Security, Privacy and Data Governance
- IEEE 802.15.1: Standard for Telecommunications and Information Exchange Between Systems - LAN/MAN - Specific Requirements - Part 15: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Wireless Personal Area Networks (WPANs)
- IEEE C95.1-2019: Standard for Safety Levels with respect to Human Exposure to Electric, Magnetic and Electromagnetic Fields, 0 Hz to 300 GHz

Hardware

Hardware Block Diagram



Blue - Danny
Green - Mitch
Red - Yusuf
Yellow - Zoe
Pink - Yusuf & Zoe
Purple - Danny & Zoe
Orange - Danny & Mitch

Hardware Overview

- Cross-Module Selections
- Eye Tracker
- Lockbox Module
- Chair Module

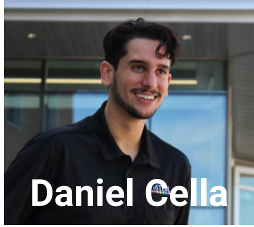
Cross-Module Selections

Microcontroller Selection

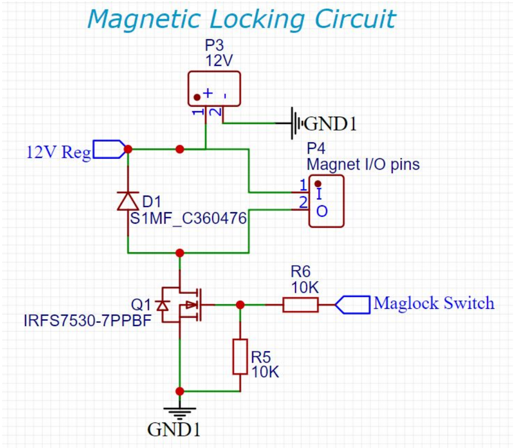
		Computational Device					
		MSP430G2553	MSP430FR6989	nRF52840	RP Zero [W]	RP 4B	RP Pico
Features	Price	$13.29 (free)	$24.00 (free)	$12.95	$10.00	$35.00	$4.00
	Memory Size	512B	128KB	256KB	512MB	2/4/8GB	264KB
	GPIO	24	83	48	54	58	23
	Operating Voltage	1.8 V - 3.6 V	1.8 V - 3.3 V	1.7 V - 5.5 V	3.3 V - 5 V	3 V - 5 V	1.8 V - 5.5 V
	Clock Speed	16 MHz	16 MHz	64 MHz	1 GHz	1.5 GHz	133 MHz
	Bit Depth	16 bit	16 bit	32 bit	32 bit	64 bit	32 bit
	Supported Languages	C/C++	C/C++	C	Python/C++	Python	C/C++/ MicroPython
	Communication	UART, IrDA, SPI (2), I2C	UART (2), I2C (2) SPI (4)	UARTE (2), SPI (3), I2C, BLE 5.0	mini HDMI, mini UART, SPI (2), I2C, [BLE 4.1, WLAN]	mini UART, SPI (2), I2C, BLE 5.0, 2.4/5.0 GHz WLAN,	UART (2), SPI (2), I2C (2)

- Experience with MSP430s
- Experience with C
- UART needed for wireless communication
- Have MSP430s for testing purposes

Switching Mechanism: MOSFET circuits



- Used as switch for motors & magnetic lock
  - Each core circuit item powered by 12V source.
  - 3.3V Low-voltage microcontroller signal sent to open/close circuit for desired result, but not enough to activate the circuit.
  - Mosfet selected over relays for minimal mechanical parts: longevity, less fatigue



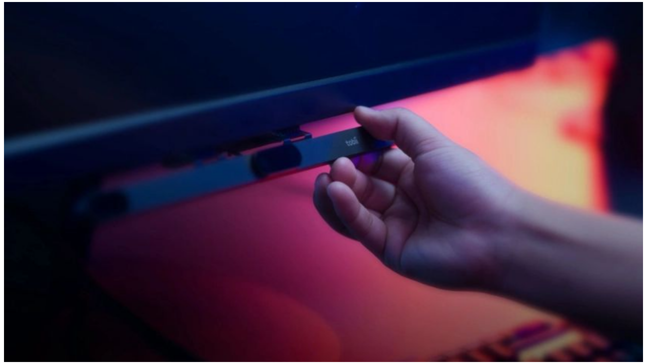
Eye Tracker

Eye Tracking Overview

- Infrared eye trackers vs Webcam eye trackers
- Pros and Cons of Webcam eye tracking
- Pros and Cons of IR eye tracking

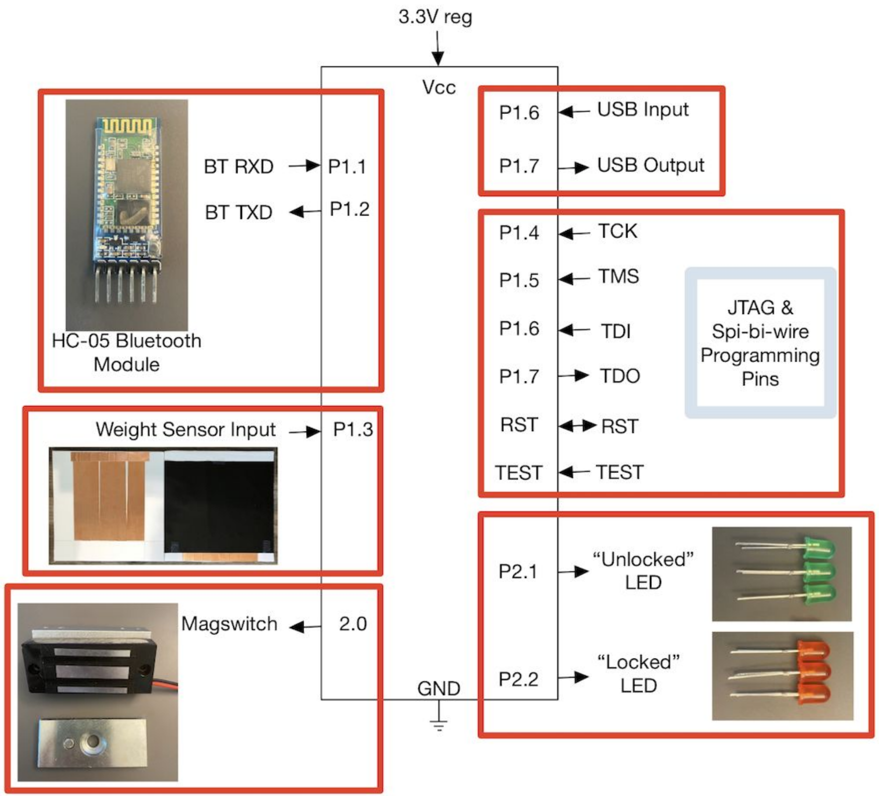
Eye Tracking Devices

- Mounted camera vs wearable device
- Tobii Eye Tracker 5
- Tobii Pro
- Why not design an eye tracker?



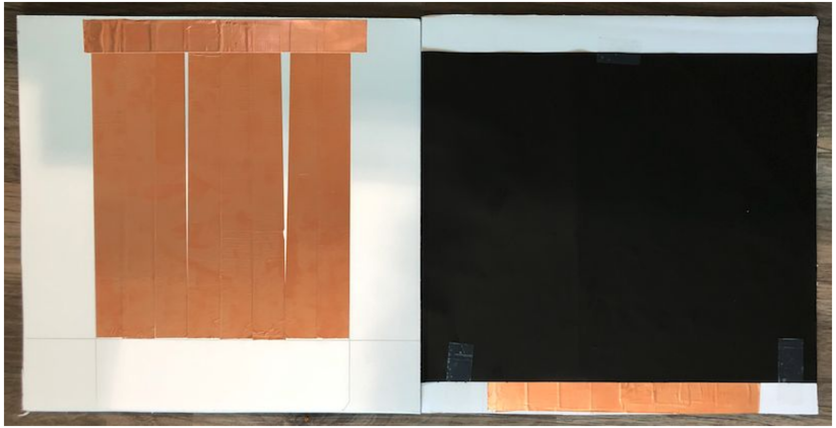
Main Desk Module

Main MCU Connections (MSP430G2553)

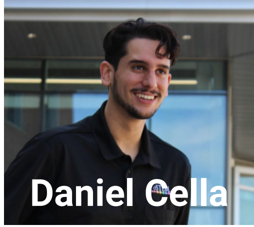


Lockbox Weight Sensor

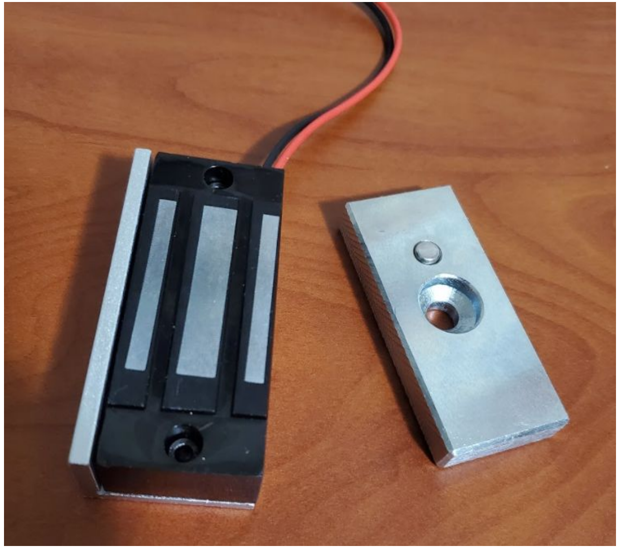
- Velostat
  - Piezoresistive Material - Resistance changes as pressure is applied
  - Placed between two conductive surfaces
  - Apply voltage to one side
  - Change in reading on other side
- Only Reading Phone Weight
  - Sensor does not need to read high weight
- Uses Minimal Space
  - Allows more space in box for phone



Magnetic Locking Switch

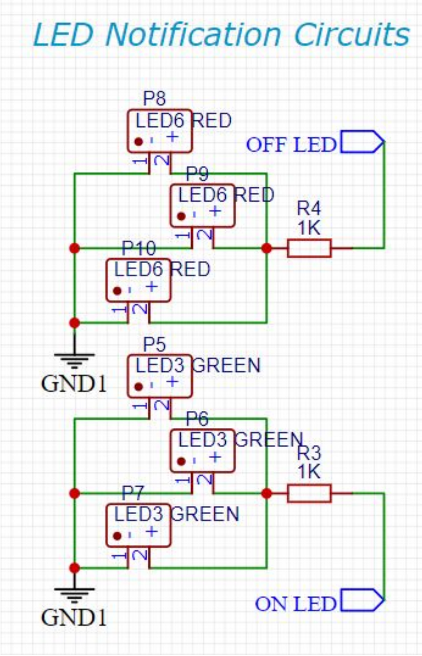


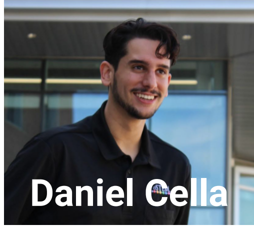
- Magnetic locking mechanism used to ensure that the user's phone is unreachable during study sessions.
- Takes 12V of power to operate
- Is something typically used for extra home security along doors.
- Chosen to limit amount of mechanical parts in the design. Can be turned off/on simply by power connection.



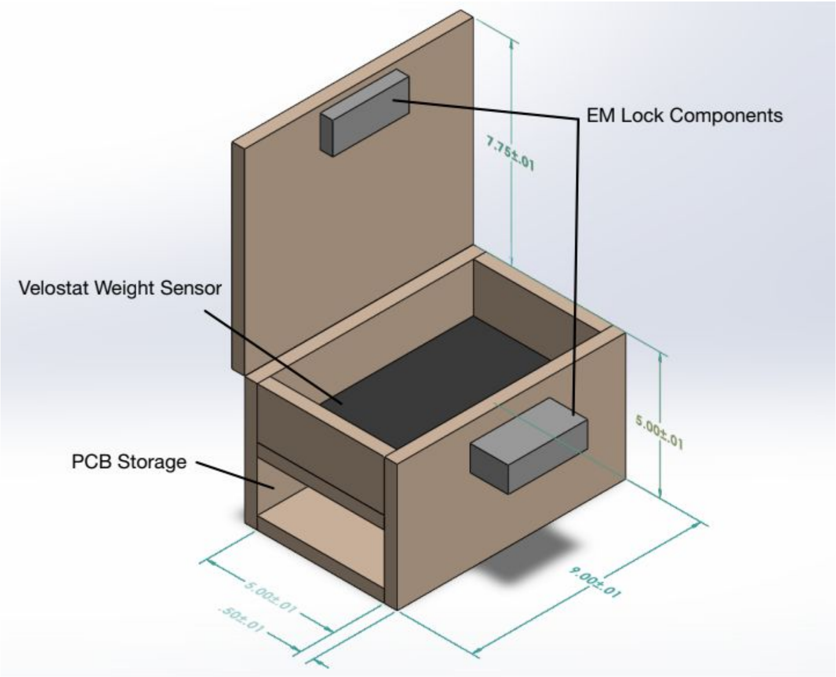
LED Notification Circuit

- Used to help user identify when it is time for a study break, as well as when they need to return their phone back to the magnetic locking box.
- Consists of input from microcontroller pin, series resistor and LEDs in parallel.





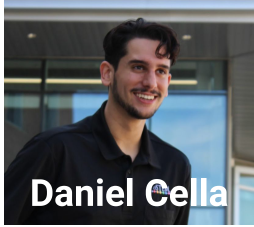
Phone Lockbox Model



- Wood Housing
  - Cheap, easy to work with
- Compartment For PCB
  - Easily accessible while giving PCB a dedicated storage space

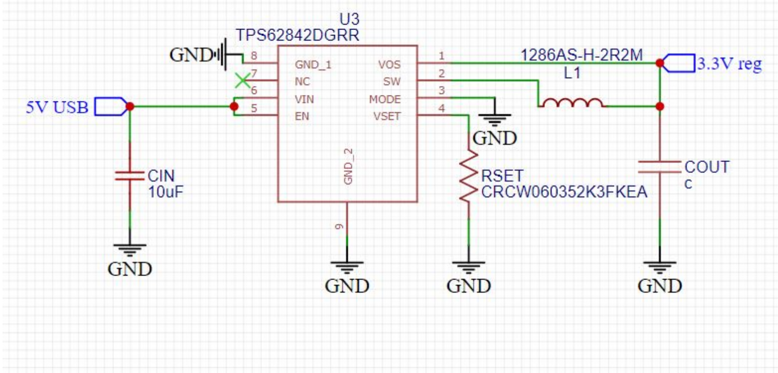
Phone Lockbox Prototype

Main Desk Power Design



1) Microcontroller

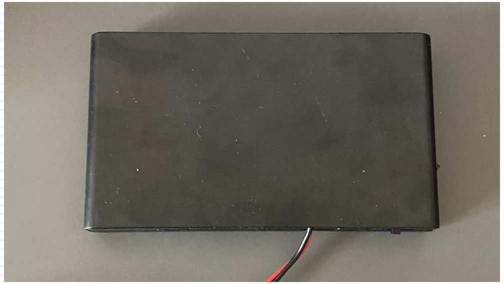
- Since it needs to take in data from the computer in real time, connected via USB.
- 5V USB to 3.3V Power converter implemented using WEBENCH Designer tool



2) Mag Lock

- Maglock requires 12V to operate, and we believe that the USB will not be able to provide adequate power.
- 12V battery to be implemented, hidden within the lockbox.

Allows better portability of the apparatus

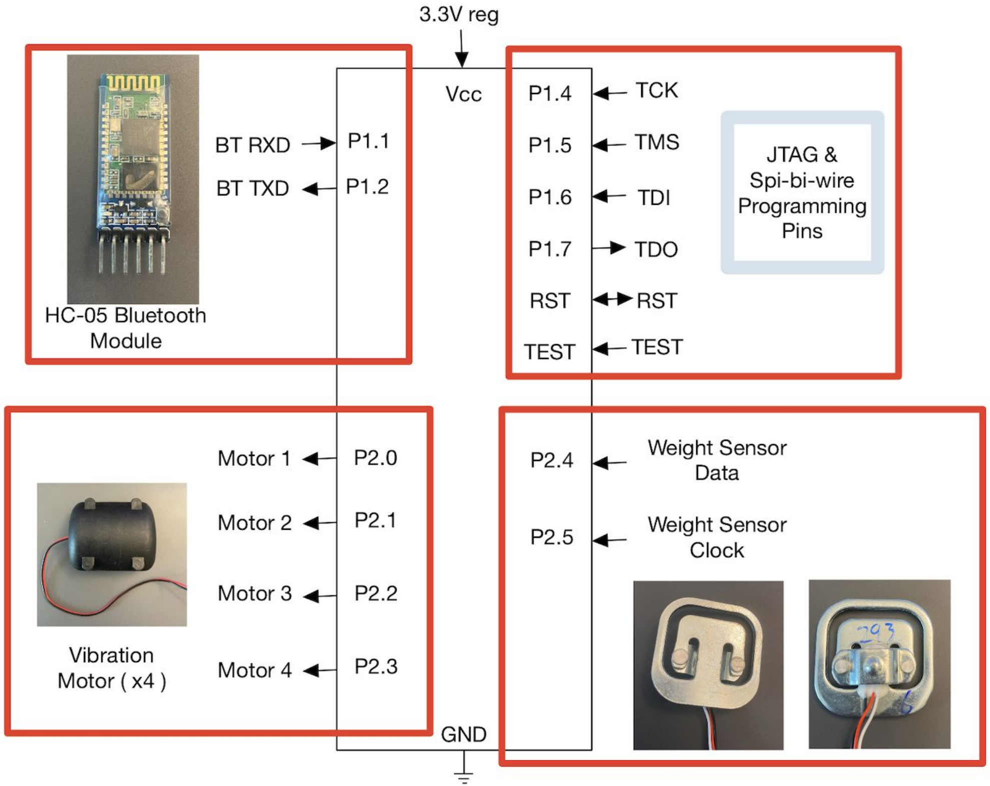


3) Bluetooth Power

- Bluetooth powered by 5V DC.
- To be supplied straight from the USB source, since it is 5V.

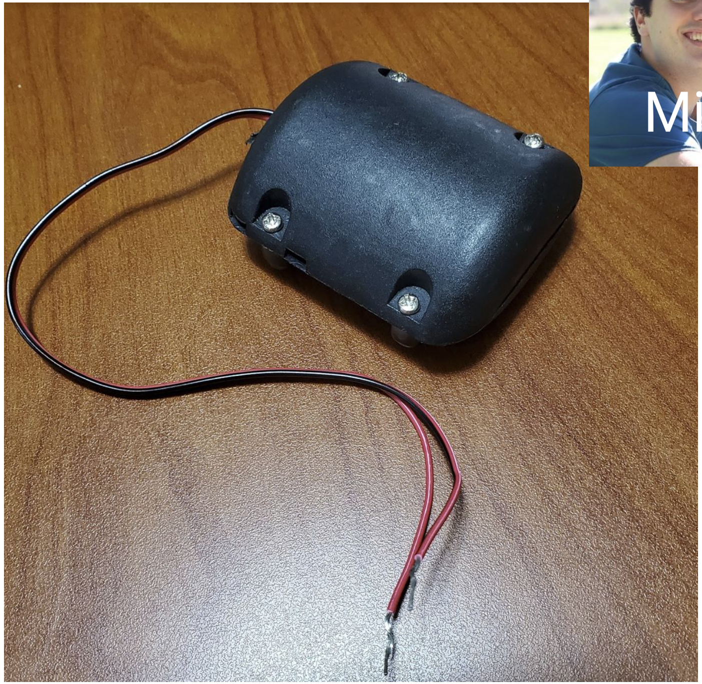
Chair Module

Chair MCU Connections (MSP430G2553)



Vibration Motors

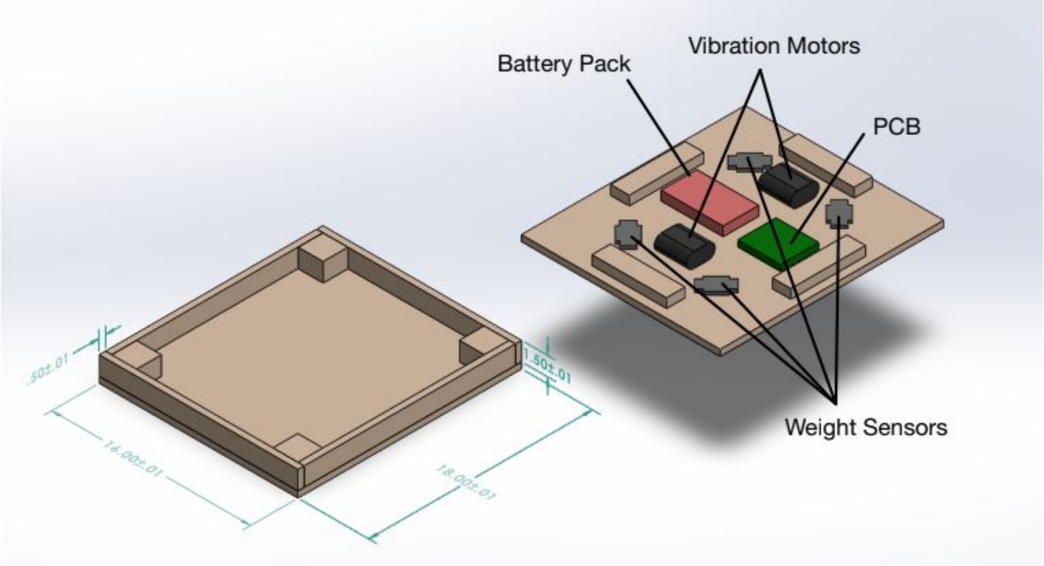
- 12V Encased Motor
  - Eccentric Rotating Mass (ERM) motor
    - 5000 rpm
  - Designed for use in massage chairs
- Hard case for motor
  - Easily incorporated into seat



Chair Weight Sensor

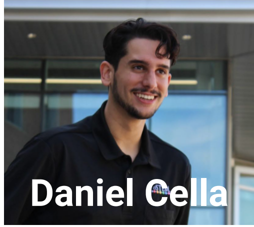
- Strain Gauge Load Cells
  - 50 kg (~110 lbs) each
  - Total of 200 kg (~441 lbs)
- Used in Household Scales
  - Designed for reading human weight
- HX711 Amplifier Circuit
  - Used to connect sensor readings to microcontroller
  - We will incorporate into our pcb design

Chair Module Model



- Wood Housing
  - Cheap, easy to work with
- Components Mounted to Bottom Side of Seat Top
  - Space inside allows all components to be contained within the module

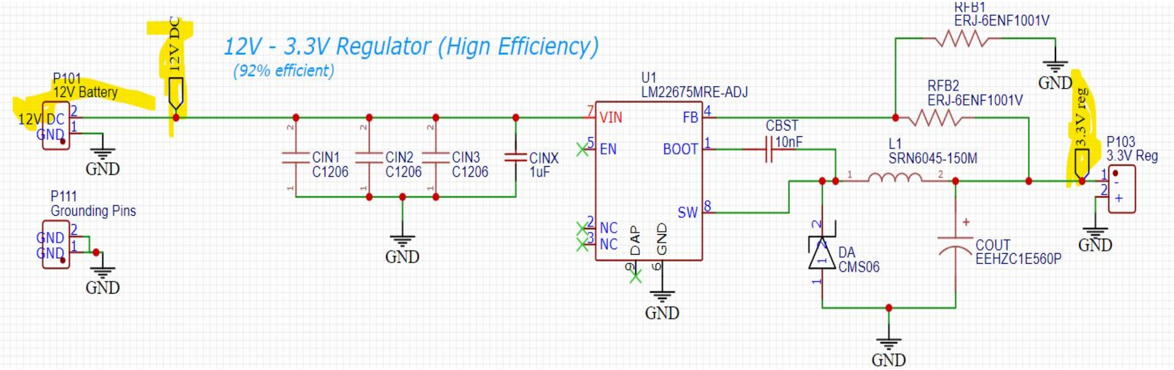
Chair Module Prototype

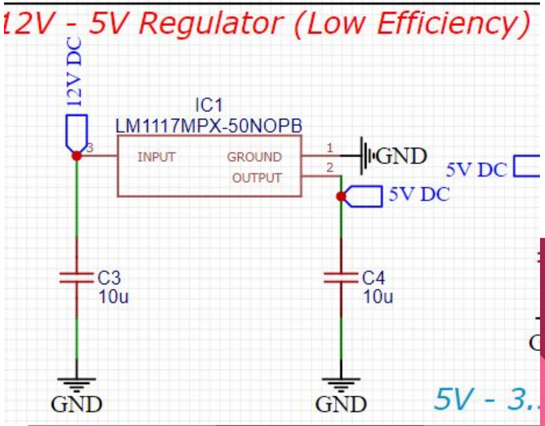


Chair Power Circuit

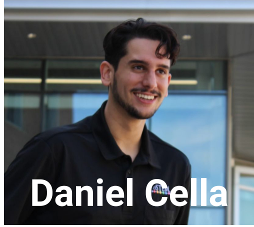
Microcontroller, Bluetooth & Motor Power

- 12V battery pack being used to power all elements of this remote system.
- 12V - 3.3V DC-DC converter used to power the microcontroller and sensor amplifier circuit.
- 12V-5V DC-DC converter used to power the bluetooth module.
- Motors powered straight from the battery pack.



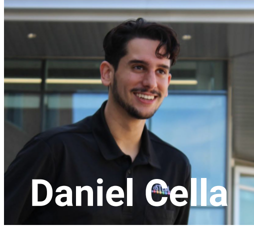


Difficulties for Subsystems: PCB Design



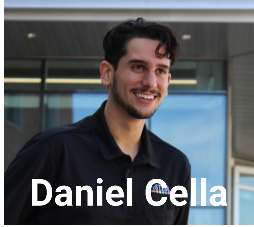
- Still unsure if initial 2 motors would be good enough to for the user to sense vibration
- Power circuits redesigned 3 different times due to parts going out of stock.
- Varied package microcontroller backups needed to be ordered as a result of only 2 SMT versions being available online.
- Difficulty finding parts large enough to be hand soldered in order to save money creating final board.
- Personal deadlines for PCB design submission not met due to redesigns needed for above problems.

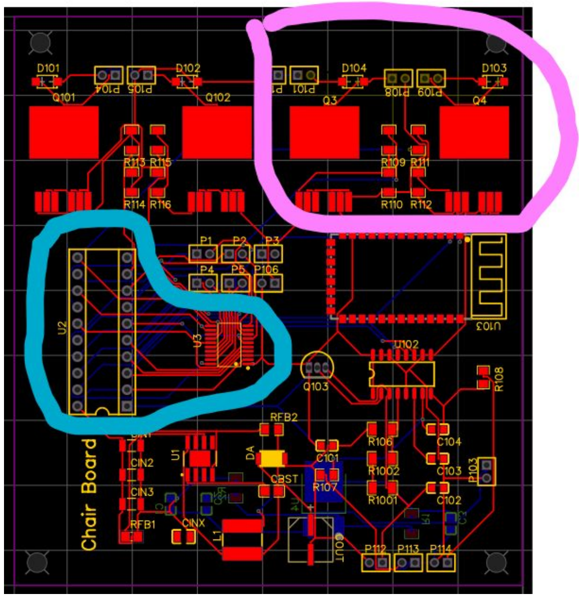
PCB Solution: Backups, Backups, Backups!

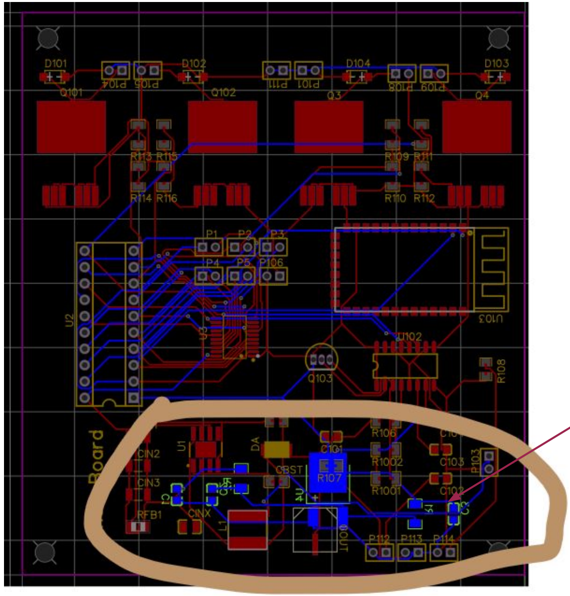


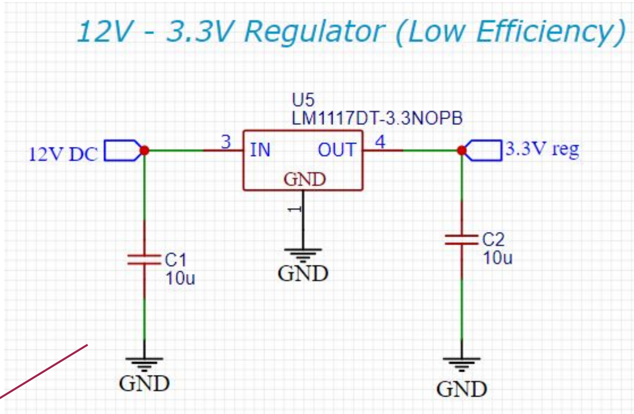
- 2 extra locations are designated for vibration motor circuits in case 2 vibration motors are not enough.
- An extra, less efficient 12V-3.3V DC-DC converter was wired into the PCB in case the complicated WEBENCH design does not work properly (can try and be de-soldered if not working)
- In case the SMT microcontroller chip is unable to function properly, the less ideal 20 pin dip chip has a spot on both boards (have those chips on hand)
- Better to do redesigns now, include unpopulated PCB space and correctly sized components and increase chances of functionality than order the boards that could fail or are unable to properly fabricate.

PCB Solution: Backups, Backups, Backups!





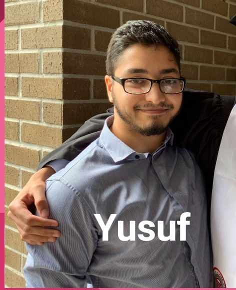




Difficulties for Subsystems: Physical Housings

- Thin Wood kept Splitting
  - On the thin edges of the wood, trying to screw wood together made it split.
  - Worse the closer we were to the corner of the wood.
  - Solved by using smaller screws and staying as far away from edges as possible.
- No 3D Printing Experience
  - To mount load cells on chair, found a resource for a mounting bracket.
  - After two attempts at printing, brackets came out not as designed.
  - ASME 3D Printing Lab on campus has offered us a lot of help and are assisting us in trying to fix the issue

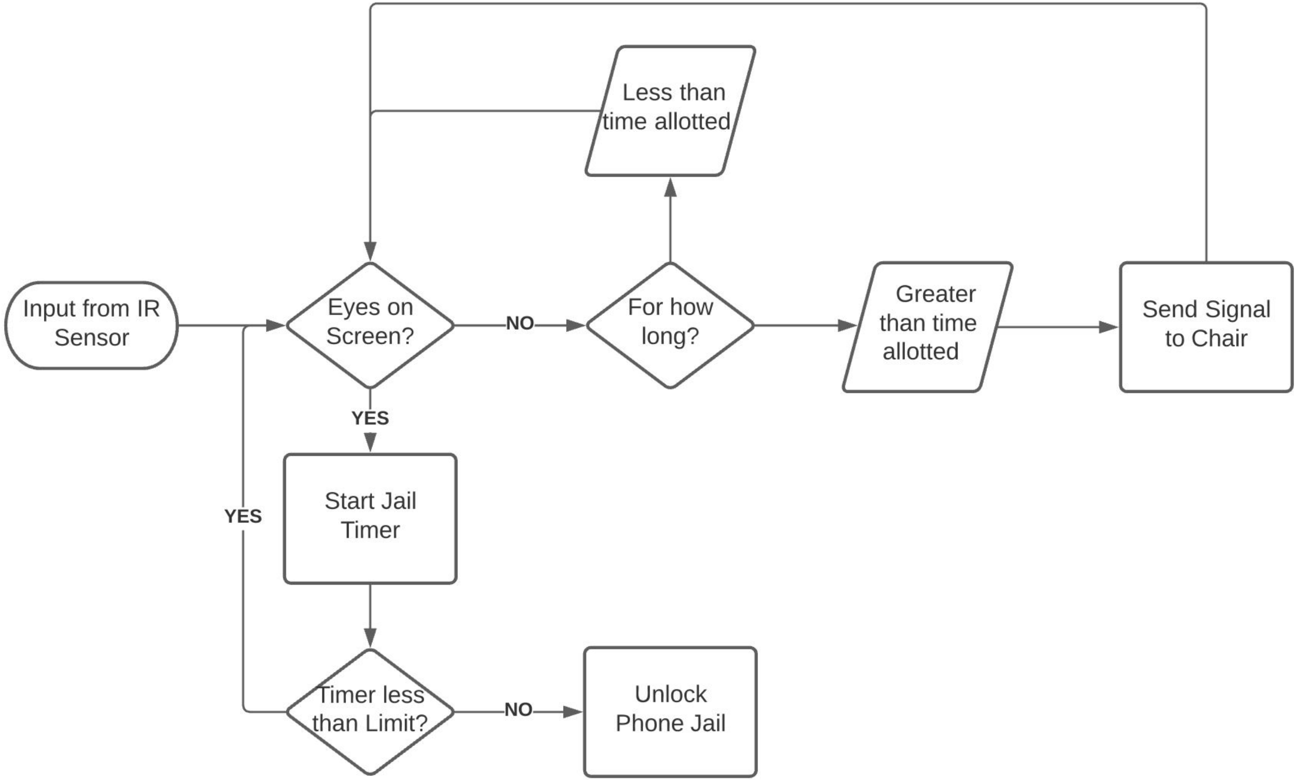
Software



Software Overview

- Eye tracking software
- Bluetooth/microcontroller communication
- User Interface

Software Block Diagram



Eye-Tracking Software

- The eye tracking software will be written in C code
- The Tobii device has support for C and C++ code integrated
- C code is also a good bridge between the eye tracker and microcontrollers

PROGRAMMING

User Interface Software

- The user interface will be written using either C++ or Java
- C++ integrates well with the C code being used for the eye tracking software
- Java offers a robust set of UI design options that the team is more familiar with
- The purpose of the user interface will be to allow users to start, end and configure the eye tracking software at will without having to look at or touch code

Wireless Communication Selection

- WiFi was considered but we ultimately went with bluetooth because we will be sending small chunks of data and internet access is not necessary
- MCUs selected do not have wireless communication built in
- Supported baud rate: 9600, 19200, 38400, 57600, 115200, 230400, 460800

		Wireless Communication Modules			
		HC-05	Bluefruit LE SPI Friend	Bluefruit LE UART Friend	HM-10
Features	Price	$7.99 (1) or $12.59 (2)	$17.50	$17.50	$9.99
	Operating Voltage	4V - 6V	3.6V - 6V	3.6V - 6V	2V - 3.6V
	Range	100 m	10 m	10 m	100 m
	Communication	USART	SPI	UART	UART

Microcontroller Language

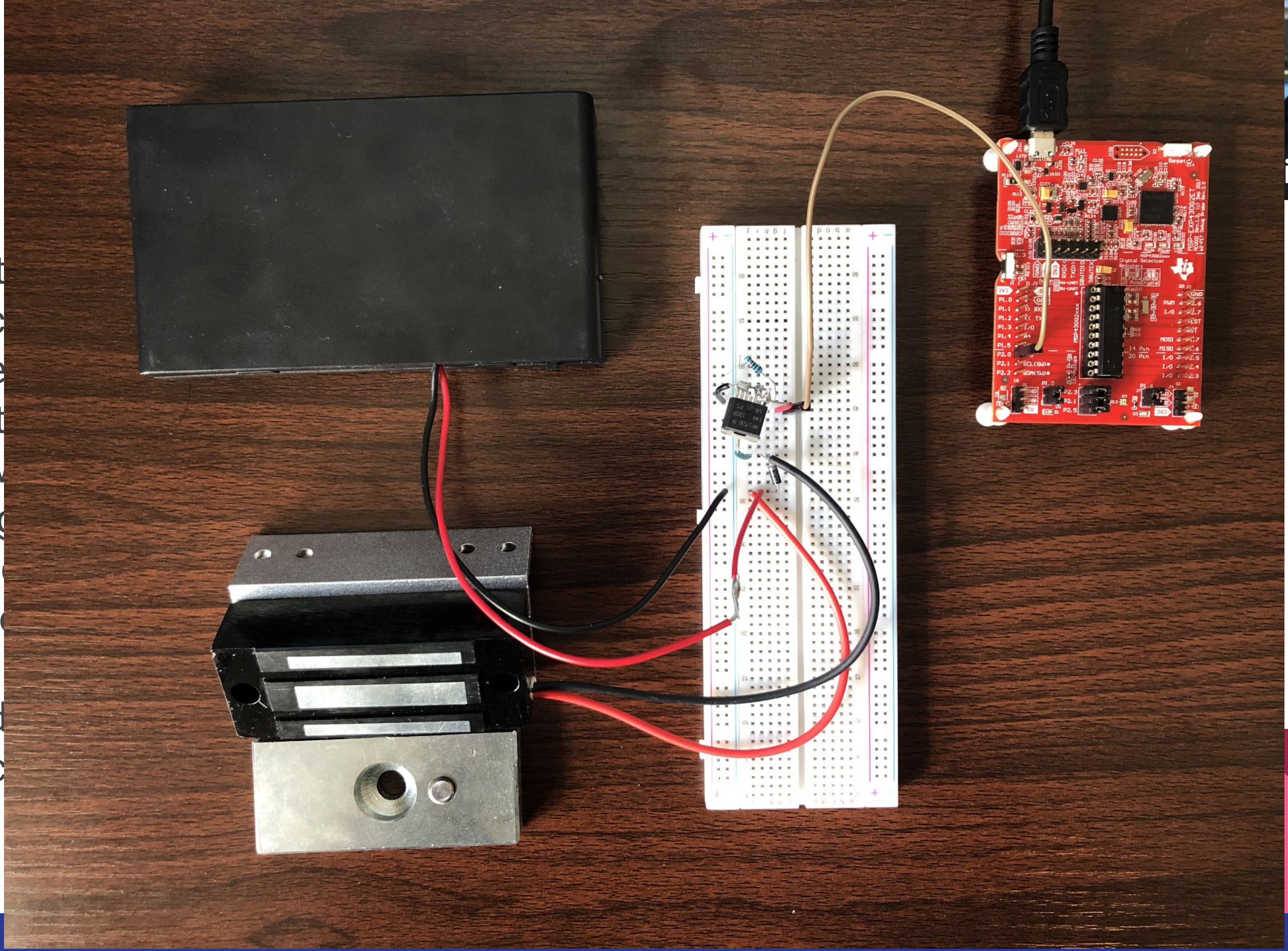
- Code Composer Studio is the IDE designed for Texas Instruments embedded processors (MSP430s)
- C/C++ can be used in CCS
- TI offers many helpful resources for programming MSP430s

- HC-05 Bluetooth Module - UART
- USB from main module to computer - UART (software)

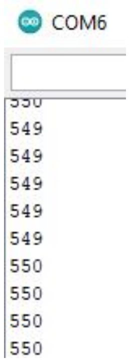
Testing

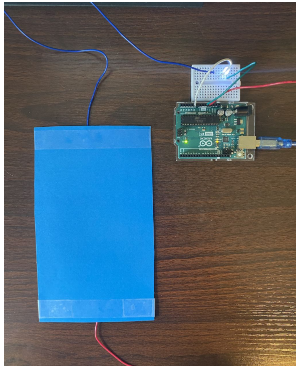
MOSFE

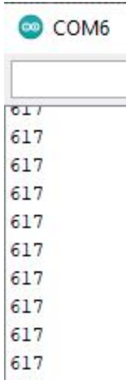
- Since it
  sacrific
  sample
- Since it
  wires w
  phalang
- Circuit
  microc
  battery
  learned
  per eac



Lockbox Weight Sensor Testing

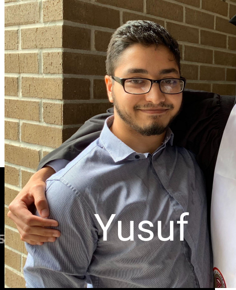






- Test Performed on Arduino
  - Used velostat with Arduino for previous project
- Analog Values Shown
  - Will give thresholds for when user’s phone is placed on sensor or not
- Will need to be retested for values on our PCB

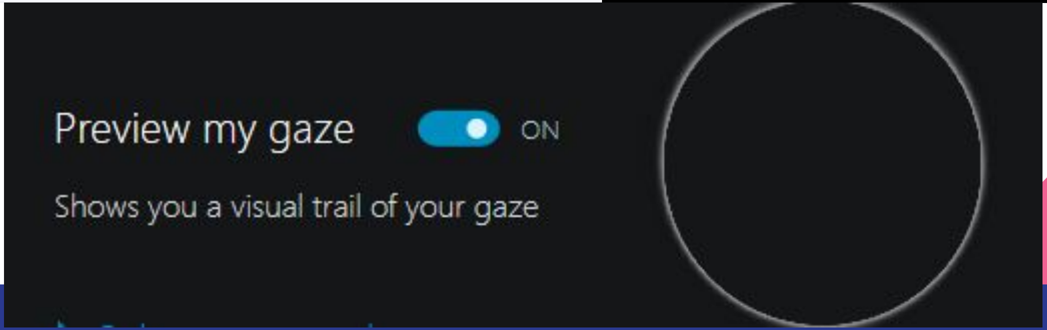
Eye-tracking Testing



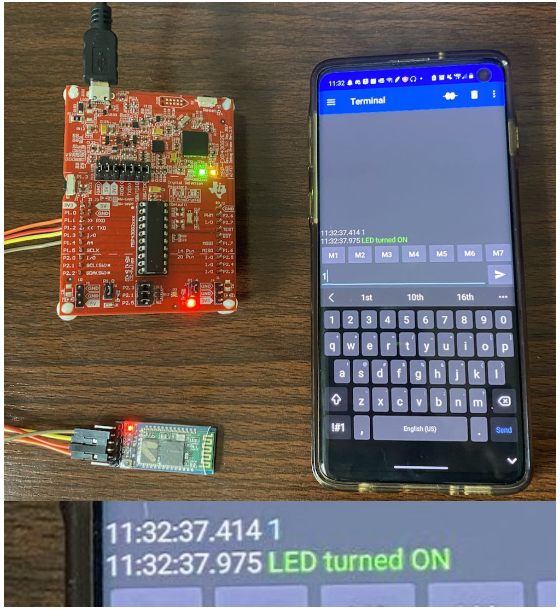
Such a screen region is called an *interactor* in the Interaction Library API.

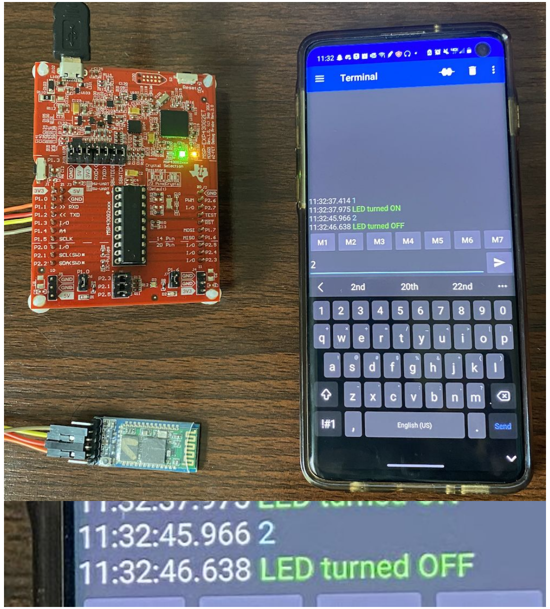
```
A screen with 4 "corner" interactors A, B, C and D:

                 2560
 +-------+-------------------+-------+
 |   A   | 500           500 |   B   |
 +-------+                   +-------+
   500                          500        1440
   500                          500
 +-------+                   +-------+
 |   C   | 500           500 |   D   |
 +-------+-------------------+-------+
```

```
left side Interactor: 5, focused: true, timestamp: 153546841361 us
left side Interactor: 5, focused: false, timestamp: 153546901486 us
bottom left corner Interactor: 2, focused: true, timestamp: 153546901486 us
bottom left corner Interactor: 2, focused: false, timestamp: 153547354509 us
left side Interactor: 5, focused: true, timestamp: 153547354509 us
left side Interactor: 5, focused: false, timestamp: 153547384861 us
top left corner Interactor: 0, focused: true, timestamp: 153547384861 us
top left corner Interactor: 0, focused: false, timestamp: 153547686288 us
top middle Interactor: 4, focused: true, timestamp: 153547686288 us
top middle Interactor: 4, focused: false, timestamp: 153547747063 us
top right corner Interactor: 1, focused: true, timestamp: 153547747063 us
top right corner Interactor: 1, focused: false, timestamp: 153548018657 us
right side Interactor: 6, focused: true, timestamp: 153548018657 us
right side Interactor: 6, focused: false, timestamp: 153548049190 us
top right corner Interactor: 3, focused: true, timestamp: 153548049190 us
top right corner Interactor: 3, focused: false, timestamp: 153548469966 us
bottom middle Interactor: 7, focused: true, timestamp: 153548469966 us
bottom middle Interactor: 7, focused: false, timestamp: 153548498252 us
middle area Interactor: 8, focused: true, timestamp: 153548498252 us
middle area Interactor: 8, focused: false, timestamp: 153548531610 us
top middle Interactor: 4, focused: true, timestamp: 153548531610 us
top middle Interactor: 4, focused: false, timestamp: 153548622177 us
top left corner Interactor: 0, focused: true, timestamp: 153548622177 us
top left corner Interactor: 0, focused: false, timestamp: 153548804358 us
left side Interactor: 5, focused: true, timestamp: 153548804358 us
left side Interactor: 5, focused: false, timestamp: 153550072594 us
bottom left corner Interactor: 2, focused: true, timestamp: 153550072594 us
bottom left corner Interactor: 2, focused: false, timestamp: 153550102156 us
left side Interactor: 5, focused: true, timestamp: 153550857337 us
```



Bluetooth Testing



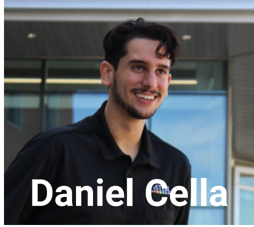


- When a 1 is sent from the phone the LED turns ON
- When a 2 is sent from the phone the LED turns OFF

- HC-05 with MSP430G2553 to Android phone
- Energia IDE used for simplicity

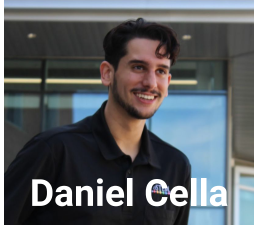
Administrative/ Next Steps

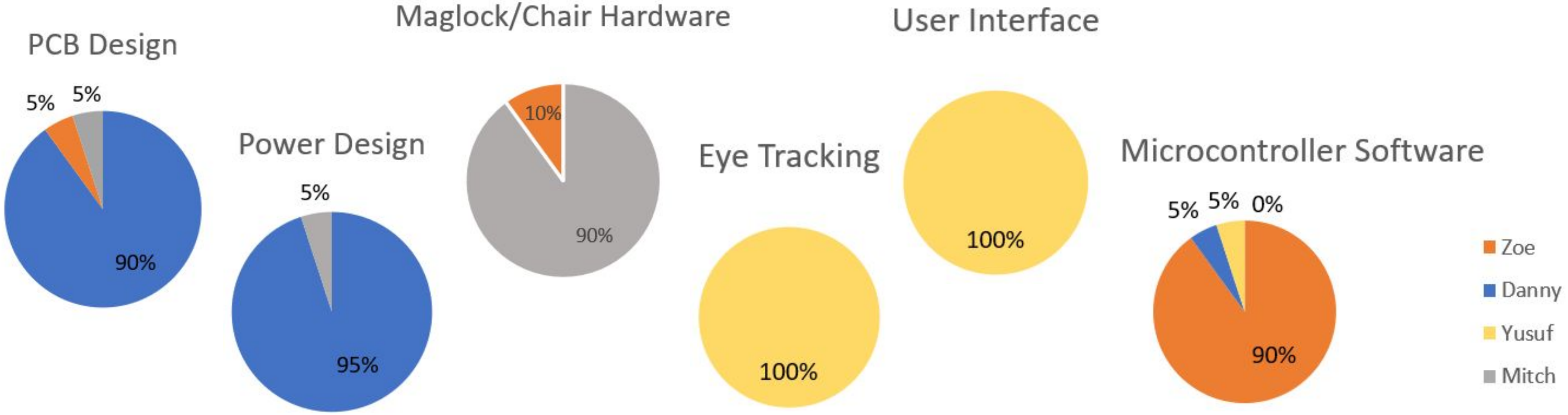
Budget for Concen-training System



Item Name	Price
Lockbox	$63.98
Chair Module	$51.10
Eye Tracking	$229
PCB Components	$200
PCB/Soldering	$100
Total	$644.08

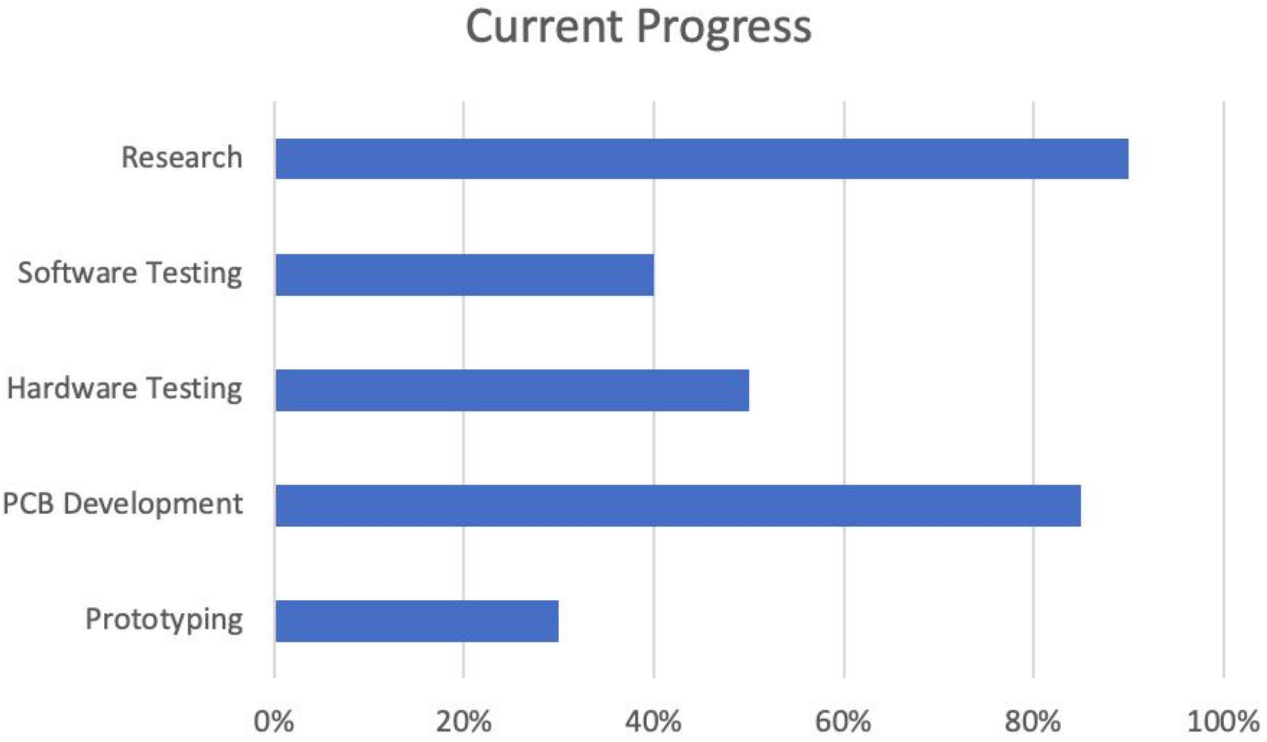
Work Distribution





- **Danny**:
  - Primary: PCB Design (90%), Power Design (95%)
  - Secondary: Microcontroller Software (5%)
- **Mitch**:
  - Primary: Chair and Lockbox Hardware (90%)
  - Secondary: PCB Design (5%), Power Design (5%)
- **Yusuf**:
  - Primary: Eye Tracking (100%), User Interface (100%)
  - Secondary: Microcontroller Software (5%)
- **Zoe**:
  - Primary: Microcontroller Software (90%)
  - Secondary: Chair and Lockbox Hardware (10%), PCB Design (5%)

Current Progress



Plans for Successfully Completing Project

	Wk1 (8/23-29)	Wk2 (8/30-9/5)	Wk3 (9/6-9/12)	Wk4 (9/13-9/19)	Wk5 (9/20-9/26)	Wk6 (9/27-10/3)	Wk7 (10/4-10/10)	Wk8 (10/11-10/17)	Wk9 (10/18-10/24)	Wk10 (10/25-10/31)	Wk11 (11/1-11/7)	Wk12 (11/8-11/14)	Wk13 (11/15-11/21)	Wk14 (11/22-11/28)	Wk14 (11/29-12/5)	Wk16 (12/6-12/13)
Build Chair Module			■	■												
Build Lockbox				■	■											
Order PCB						■										
Test Hardware					■	■	■	■								
Test Software			■	■	■	■	■	■	■							
CDR Presentation (10/7)							■									
Project Summary (10/15)								■								
Prototype							■	■	■	■	■					
Mid Term Demo (11/1)											■					
Conference Paper (11/12)												■				
Presentation Practice									■	■	■	■	■			
Project Showcase Video (11/26)														■		
Final Presentation Submission (11/28)														■		
Final Documentation (12/7)																■

Questions?