THE OHIO STATE UNIVERSITY

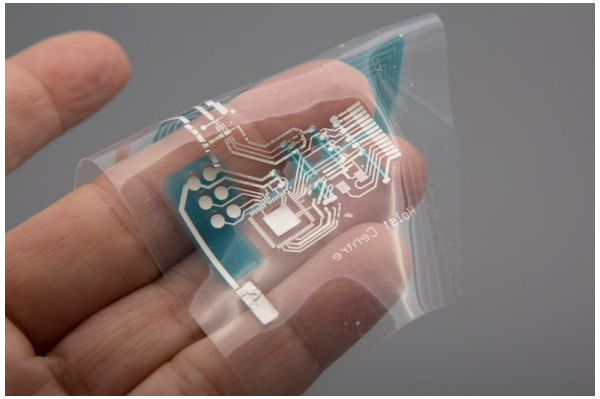
Wearable Device Presentation

Presentation Outline

1. Problem Statement, Project Needs, and Project Restraints
2. Requirements Table
3. Similar Product Market Research + Inspiration for Project
4. Visual Representation of Final Device and User Interface
5. Block Diagram of System Architecture and Process/Flow
6. Value Added
7. Project Milestones and Management
8. Project Management
9. Cost Analysis, Approach to prototype, and Component Selection
10. Hardware and Software Design Methodology
11. Hardware and Software Results
12. DEMO

Problem Statement

Design, build, and test a device that tracks health vitals to ensure a person is in a stable conidition or alert them if they are not. The device needs constant contact with the person's skin, high accuracy, long battery life for everyday use, and enough area to integrate the system on. The final device will be composed of discrete components and chips that are integrated in a hybrid fashion to form a whole system that is powered by a FlexEnergy battery and or energy harvester.



Project Needs

Target User 1: Fitness Enthusiast:

1.Heart rate
2.Electrolytes
3.V02 max
4.Curve of heart rate
5.Calories burned (estimation)

Target User 2: Patient/Healthcare Professionals:

1.Heart rate
2.Oxygen levels
3.Body temp
4.Respiration rate
5.Blood pressure

Project Restraints

-$200 Spring Semester Budget and $500 Fall Semester Budget

-Lingering Supply Chain Constraints leading to lots of components being out of stock with long lead times

-P Card availability related issues

-Project Milestones set by Team and Structured assignments

Requirements Table

	Requirements	Requirement Status	Units	Range	Ideal
Dimensions	Width	Mandatory	mm	100 - 200	130
	Length	Mandatory	mm	200 - 300	250
	Thickness	Mandatory	mm	7.0 - 15.0	12
Performance	Accuracy Measuring Vitals	Mandatory	%	95 - 100	99
	Battery Life	Mandatory	Hours	9.0 - 15.0	12
	Power Output (Transmitting)	Mandatory	mW	10 - 100	20
	Comfortability	Mandatory	Likert Scale	0 - 10	9
Transmitting	Update Display Speed	Mandatory	Seconds	30 - 300	30
	Data Recording Speed	Mandatory	Seconds	0 - 300	200
	Data Transmission Speed	Mandatory	GHz	2.0 - 5.0	2.4
	Transmitting Range (Indoors)	Mandatory	Feet	100 - 200	150
	Transmitting Range (Outdoors)	Mandatory	Feet	200 - 400	300
	Transmitting Frequency	Mandatory/Tradeoff	GHz	2.3-2.5	2.4
Data/Vitals	Heart Rate	Mandatory	BPM	50 - 200	80
	Oxygen Levels	Mandatory	%	80 - 100	95
	Blood Pressure	Mandatory	mmHg	100/60 - 200/140	120/80
	Motion Detection (1D)	Mandatory	Status	no motion - motion	
	Advanced Motion Detection (3D)	Tradeoff	TBD	TBD	TBD
	Sweat Concentration Levels	Tradeoff	mg/L	700-1500	1100
	Blood Sugar	Tradeoff	mg/dl	70-200	120

Market Research: Similar Products and Ideas – Apple watch

-Also has LEDs and photosensors to detect oxygen levels
-Also measures heart rate
-Also displays motion and location data

-Capable of interacting with other apple products and capable of messaging

-More geared to a Fitness Enthusiast/Recreational use
-Comes in at a very high price for the consumer ($250-$800)

Market Research: Similar Products and Ideas - fitbit

-It's also a wearable device marketed towards fitness enthusiasts for tracking progression and vitals

-Tracks heart rate, step count, sleep, water and food intake, stress, weight, etc

-Comes at a lower/intermediate cost to the consumer ($100-$350)

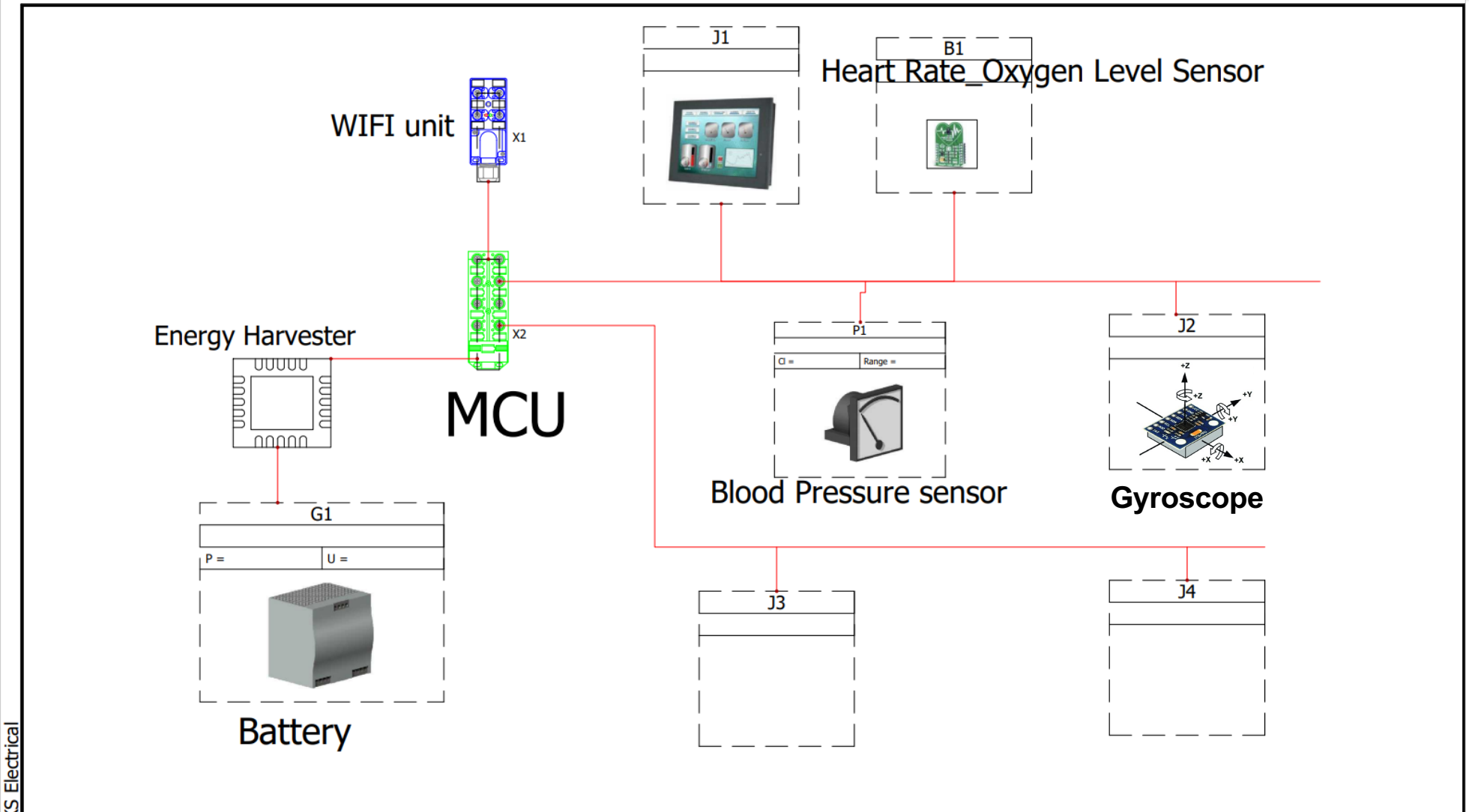
Inspiration for Current Design Idea

+

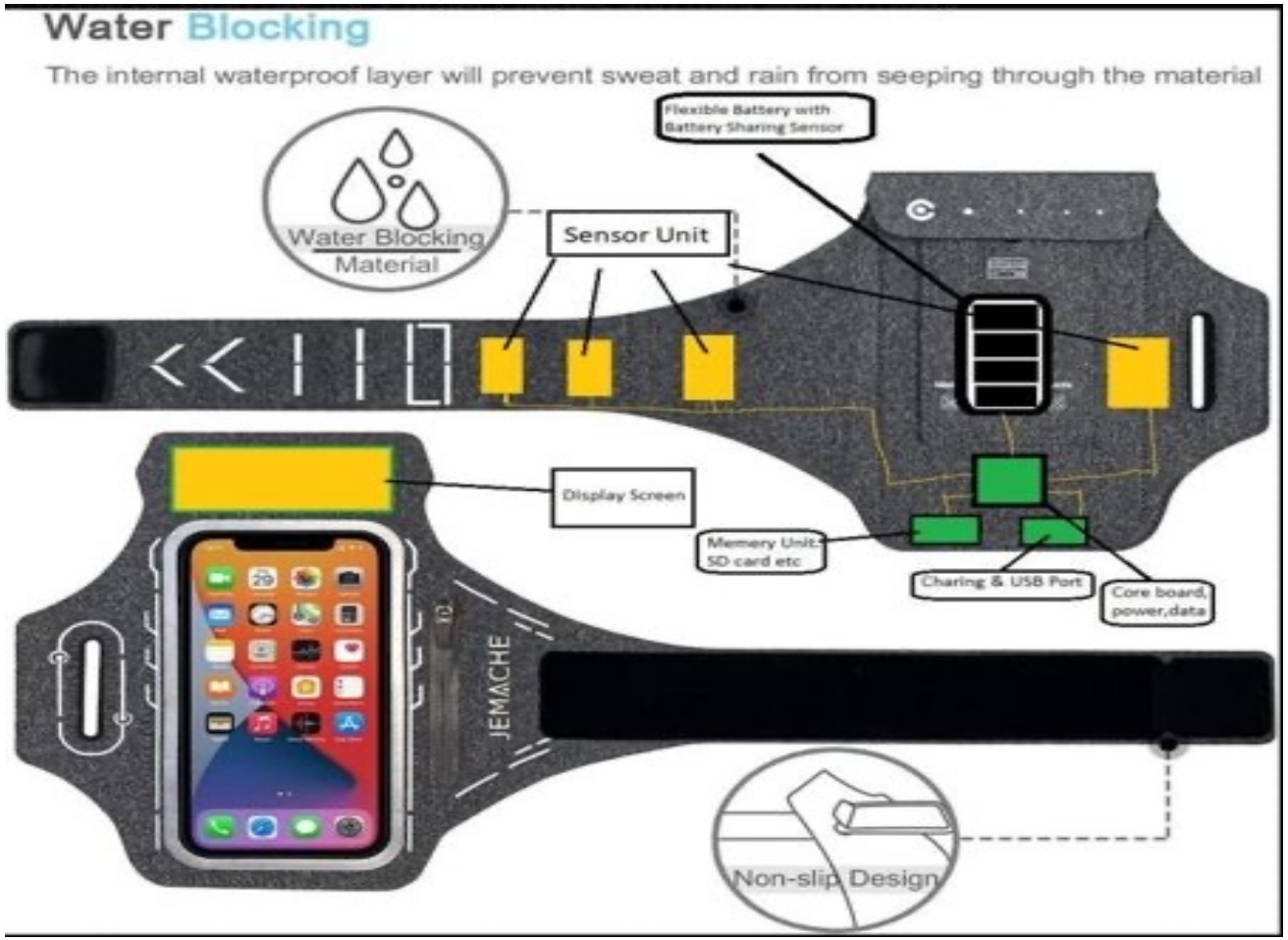
+

+

=


J1
B1
Heart Rate_Oxygen Level Sensor
WIFI unit
X1
X2
Energy Harvester
MCU
P1
Cl =
Range =
Blood Pressure sensor
J2
+Z
+Y
+X
Gyroscope
G1
P =
U =
Battery
J3
J4
SOLIDWORKS Electrical
Line diagram
REVISION
0
0
2/27/2023
67380
REV.
DATE
NAME
CHANGES
SCHEME
03
CONTRACT:
LOCATION:
L1
Main electrical closet
User data 1
User data 2
Document realized with version : 2022.0.0.529

Visual Representation of Final Device



Final Device Schematic

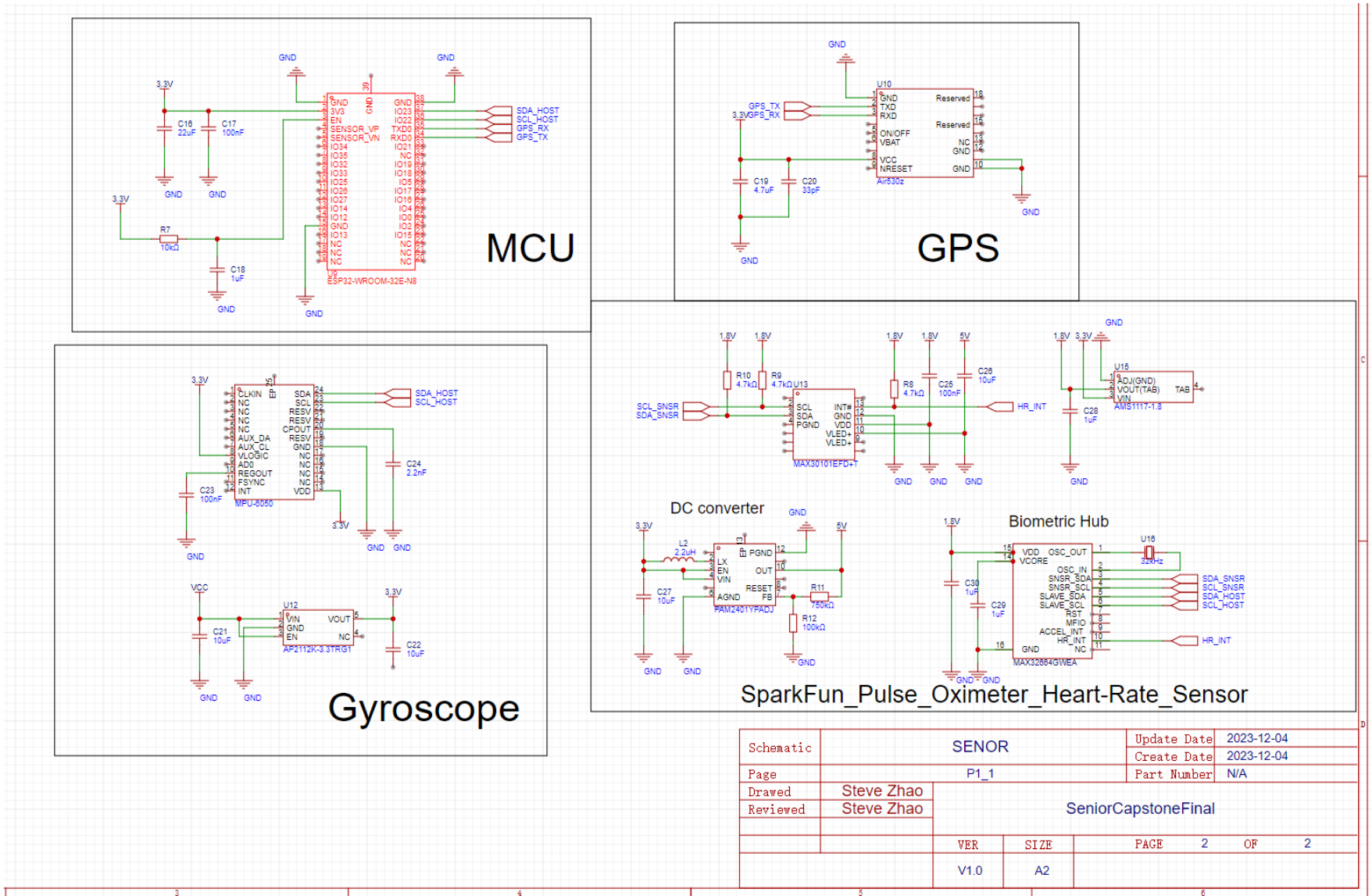
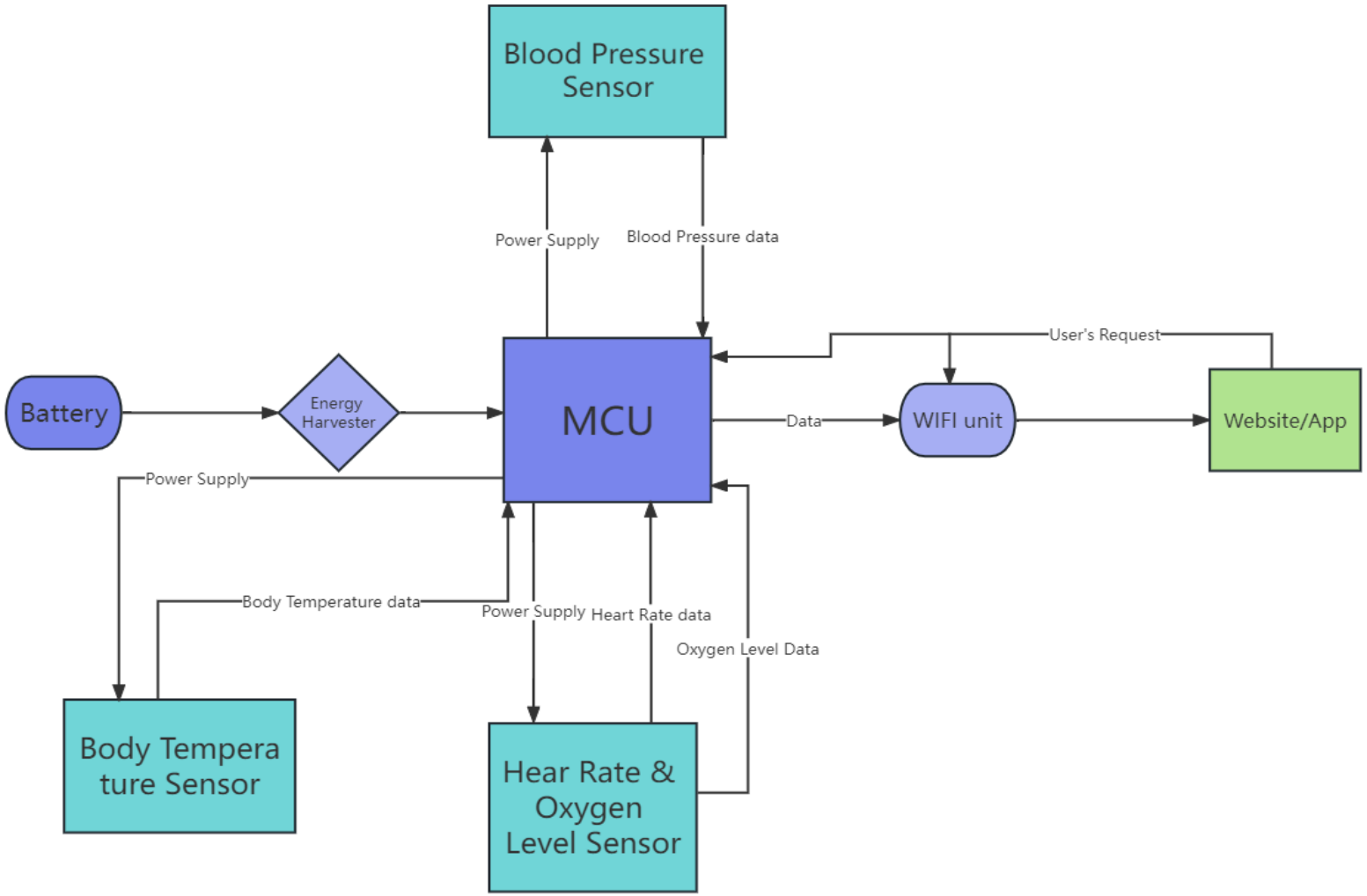


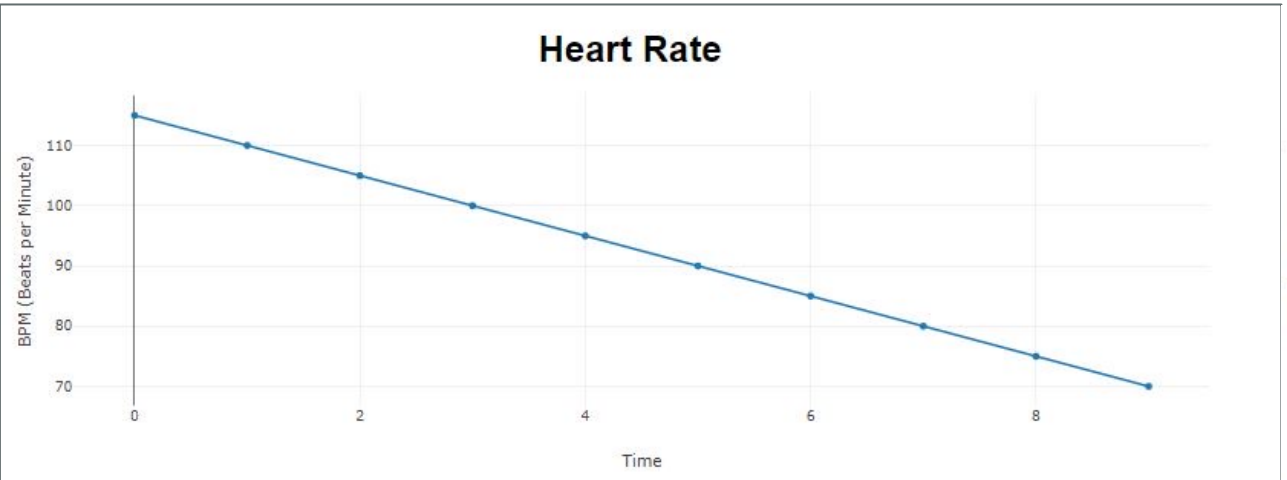
Diagram Of Process



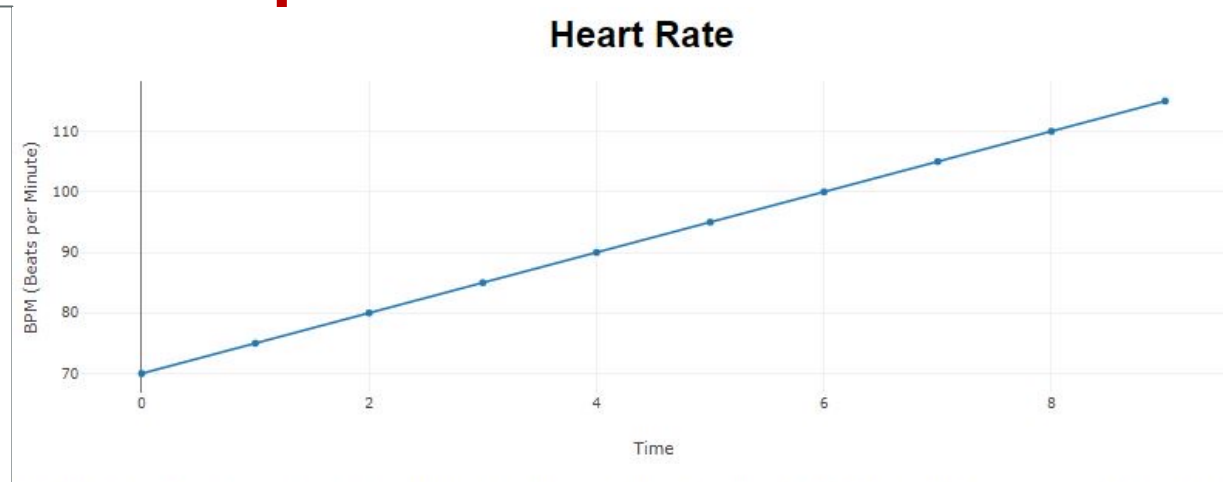
REST API Features – "Sessions"

```python
# Login route
@app.route('/login', methods=['GET', 'POST'])
def login():
    token = ACCESS_TOKEN
    if request.method == 'POST':
        username = request.form['username']
        password = request.form['password']
        user = UserData.query.filter_by(username=username).first()
        if user and user.password == password:
            session['logged_in'] = True
            session['user_id'] = user.user_id
            return redirect(url_for('home'))
        else:
            session['show_popup'] = True
            return redirect('signup')
    else:
        if session.get('logged_in', False):
            return render_template('login.html')
```

Session Examples



Heart rate refers to the number of times the heart beats per minute, and it indicates the strength and efficiency of the heart's pumping function. The normal range for heart rate in adults is 60 to 100 beats per minute, with variations depending on age, physical activity, and health conditions.



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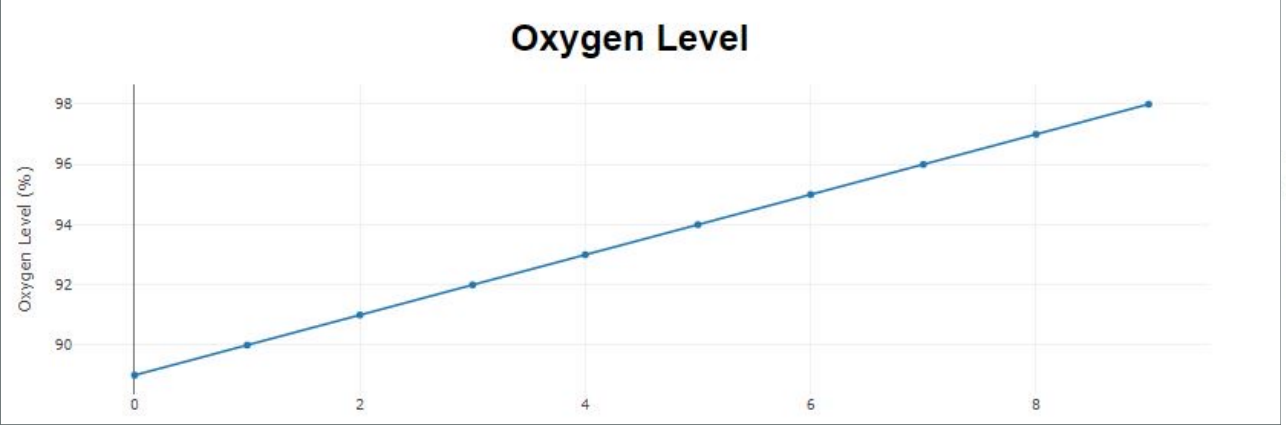
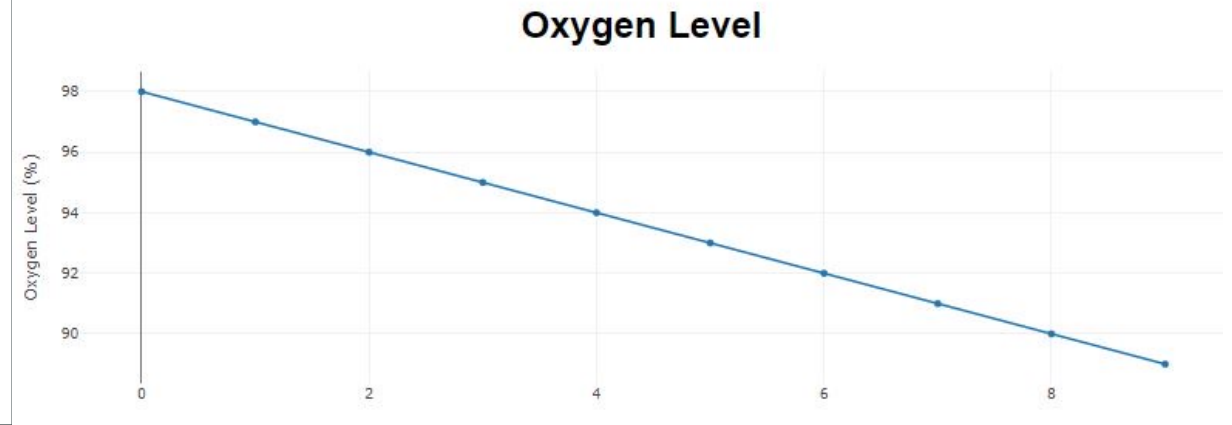
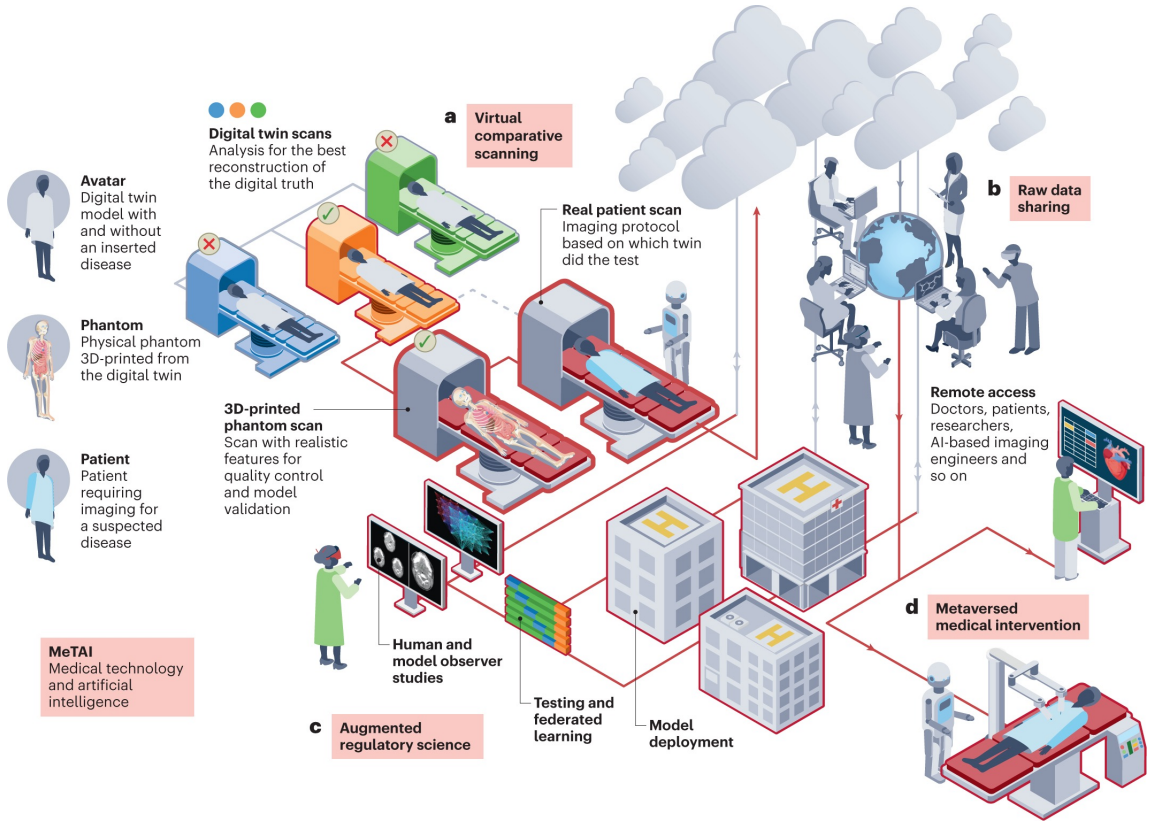




Market Research: The Value our Product Provides; The So what?



-Remote healthcare opens the door to limitless opportunities, especially when paired with IoT.

-It is projected to be one of the most innovative and rapidly expanding fields.

-The team's idea applies some critical technological possibilities, while still being accessible to patients, geared towards health enthusiasts as well.

-Additionally, the use of flexible components will make the device size, weight, portability, comfort, and power more efficient for the user

Project Milestones

1. Finalize language(s) used for sensors, post request, database/data dashboard, and email/SMS by 9/14/23
2. Order and received components by 9/28/23
3. Learn basics of Arduino and read data from assigned sensor, and have functional data dashboard by 10/17/23
4. Give Midsemester Progress Presentation on 10/26/23
5. Have made post request(s) with at least one real measured vital displayed on dashboard by 11/2/23
6. Integrated all real data to be reported via post request by 11/16/23
7. All presentation materials prepared for Capstone Design showcase by 11/26/23
8. Give Demonstration at Capstone Design Showcase on TBD
9. Final Report turned in by 12/6/23

TESTPLAN – Check Equipment

Checking Equipment

Requirement / Verification Cross-Reference Matrix

	Method of Verification N/A – NOT APPLICABLE A – ANALYSIS D – DEMONSTRATION I – INSPECTION T – TEST	Classes of Verification I – FIRST CLASS ARTICLE TEST II – ENVIRONMENTAL QUALIFICATION III – ACCEPTANCE TEST IV – NONE	

Project Requirement	Tests	Verification Class				Completion	Verification
		I	II	III	IV		
Valid Components – Verify Devices Work/Receive Power	ESP32 MCU	T				Y	Appendix C
	Raspberry Pi Pico MCU	T				Y	Appendix C
	Arduino MCU that Dr. Sengupta Suggested						
	LEDs	T					
	Buzzers	T				Y	Appendix C
	Antenna/GPS	T				Y	Appendix C
	Battery Voltage Check	T				Y	Appendix C
	Pusle/Oximeter	T				Y	
	Flexible Breadboard						

TESTPLAN – Hardware Testing

Hardware Testing

Requirement / Verification Cross-Reference Matrix

Method of Verification	Classes of Verification
N/A – NOT APPLICABLE A – ANALYSIS D – DEMONSTRATION I – INSPECTION T – TEST	I – FIRST CLASS ARTICLE TEST II – ENVIRONMENTAL QUALIFICATION III – ACCEPTANCE TEST IV – NONE

Project Requirement	Tests	Verification Class				Completion	Verification
		I	II	III	IV		
Vitals	Heart Rate Detection Range	T				Y	Appendix D
	Oxygen Level Detection Range	T				Y	Appendix D
	Blood Pressure Direction Range	T					
	Compare Team O2 Vital Accuracy vs Other Health Monitoring Equipment	T/D		I		Y	Appendix D
	Skin Temperature Range	T					
Motion	Speed Detection Range	T				Y	Appendix D
	Angular Speed Detection Range	T				Y	Appendix D
	Orientation Check	T					
GPS	Obtain Coordinates and Time	T/D				Y	Appendix D
	Compare Sensor Coordinates to Other GPS Equipment	T/D					
Alarm	Buzzer Warning for Critical Vitals	T					
	Verify LED status for Vital Ranges	T					
Battery Usage (3.7V Lithium, Flex Energy)	Voltage Check	T				N, Y	Appendix D
	Max Current Draw	T				N, Y	Appendix D
	Recharge Voltage & Time Check	T					
	Battery Life (Nominally)	T					
	Battery Life (Various Conditions)	T	T				
	Power Usage Dissipated	T					
	Max Heat Dissipated	T				N, Y	Appendix D

TESTPLAN – Software Testing

Software Testing

Requirement / Verification Cross-Reference Matrix

	Method of Verification N/A – NOT APPLICABLE A – ANALYSIS D – DEMONSTRATION I – INSPECTION T – TEST	Classes of Verification I – FIRST CLASS ARTICLE TEST II – ENVIRONMENTAL QUALIFICATION III – ACCEPTANCE TEST IV – NONE	

Project Requirement	Tests	Verification Class				Completion	Verification
		I	II	III	IV		
User Interface/Website	New User	T				Y	Appendix E
	Login/Recurrent Use	T				Y	Appendix E
	Data Retention	T				Y	Appendix E
	Heart Rate, Oxygen Level, and Step Count Post Request Data Displays					Y	Appendix E
	Data on Data Dashboard Corresponds to Color Status of Vitals	T/D				Y	Appendix E
	Website Displays Updates Visuals at Post Request Speed	T/D				Y	Appendix E

TESTPLAN – Physical Testing

Physical Testing

Requirement / Verification Cross-Reference Matrix

	Method of Verification N/A – NOT APPLICABLE A – ANALYSIS D – DEMONSTRATION I – INSPECTION T – TEST	Classes of Verification I – FIRST CLASS ARTICLE TEST II – ENVIRONMENTAL QUALIFICATION III – ACCEPTANCE TEST IV – NONE	

Project Requirement	Tests	Verification Class				Completion	Verification
		I	II	III	IV		
Dimension	Width Check	T					Appendix F
	Height Check	T					
	Length Check	T					
Physical Comfort	Weight of Device			I			
	Form Fitting			I			
	Flexible/Nonrestrictive			I			
Environmental Testing	Temperature Resistance	T	T/D				
	Drop Resistance	T	T/D				
	Water Resistance	T	T/D				

TESTPLAN – Integration Testing

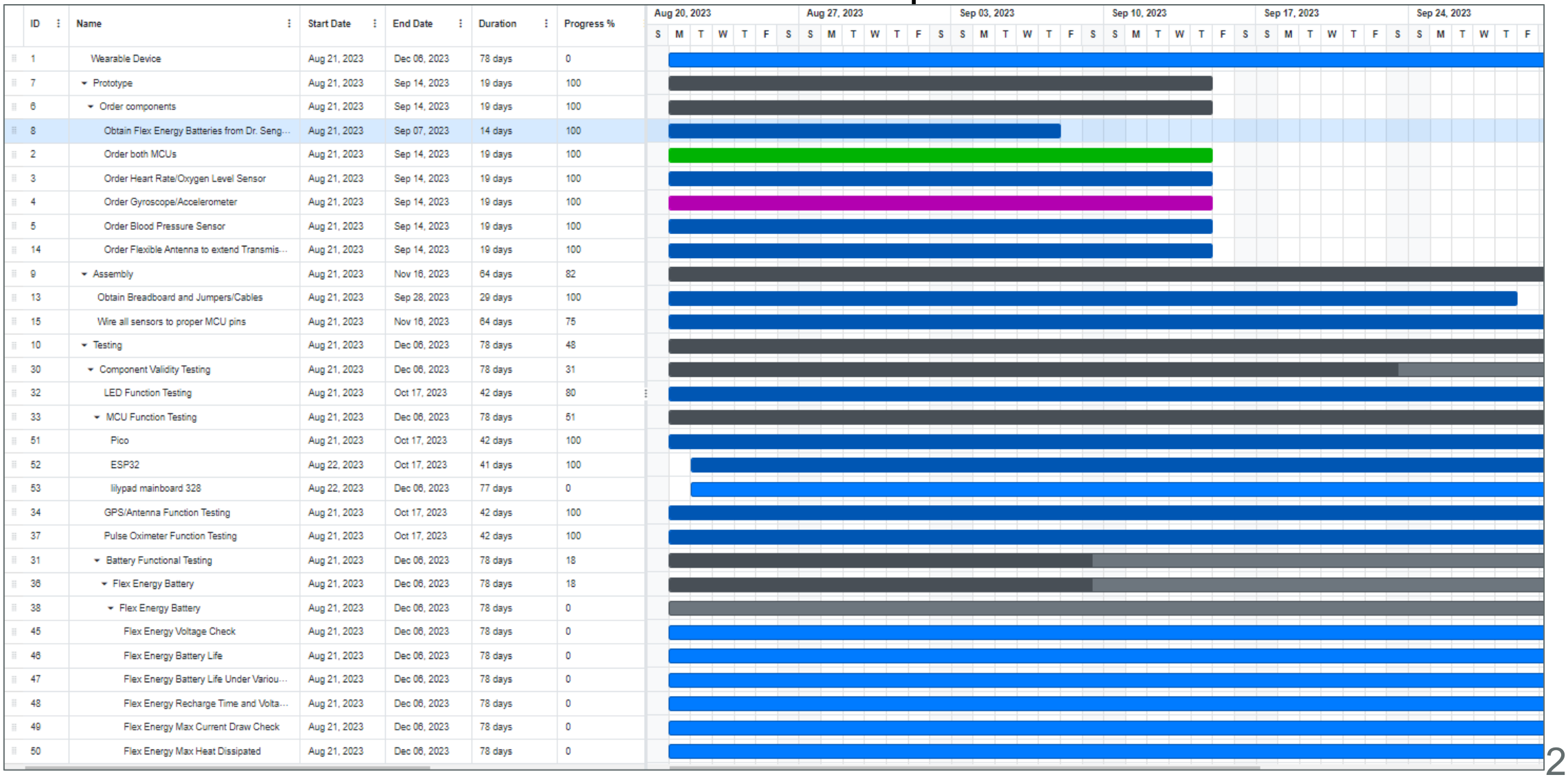
Integration Testing

Requirement / Verification Cross-Reference Matrix

	Method of Verification N/A – NOT APPLICABLE A – ANALYSIS D – DEMONSTRATION I – INSPECTION T – TEST	Classes of Verification I – FIRST CLASS ARTICLE TEST II – ENVIRONMENTAL QUALIFICATION III – ACCEPTANCE TEST IV – NONE	

Project Requirement	Tests	Verification Class				Completion	Verification
		I	II	III	IV		
Data Update Speed	Sensor Data Measuring Speed	T/A					
	Website Display Speed	T/A				Y	Appendix G
	Data Storage	T				Y	Appendix G
Transmission	Indoor Transmission Range	T					
	Outdoor Transmission Range	T					
	Able to Communicate Via WiFi	D				Y	Appendix G
	Power Transmitted	T					

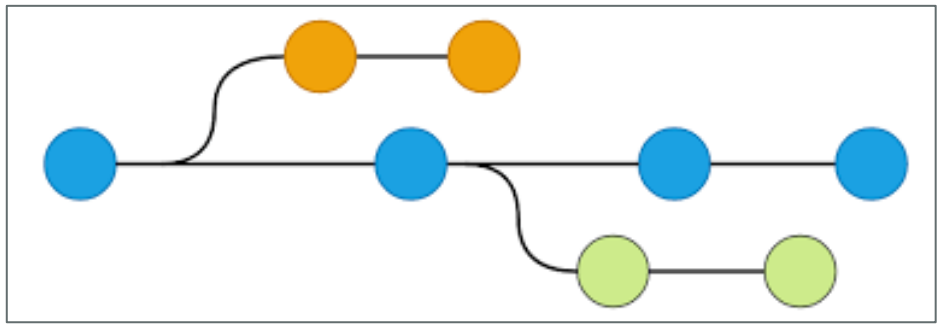
Gantt Chart Sample



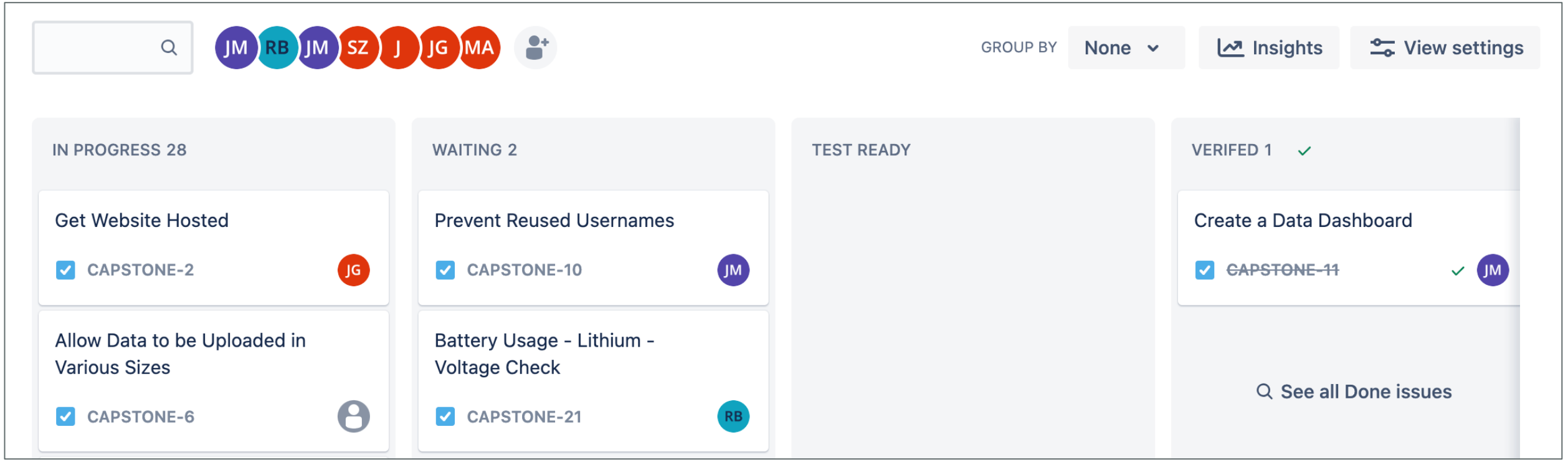
ID	Name	Start Date	End Date	Duration	Progress %
1	Wearable Device	Aug 21, 2023	Dec 06, 2023	78 days	0
7	Prototype	Aug 21, 2023	Sep 14, 2023	19 days	100
6	Order components	Aug 21, 2023	Sep 14, 2023	19 days	100
8	Obtain Flex Energy Batteries from Dr. Seng…	Aug 21, 2023	Sep 07, 2023	14 days	100
2	Order both MCUs	Aug 21, 2023	Sep 14, 2023	19 days	100
3	Order Heart Rate/Oxygen Level Sensor	Aug 21, 2023	Sep 14, 2023	19 days	100
4	Order Gyroscope/Accelerometer	Aug 21, 2023	Sep 14, 2023	19 days	100
5	Order Blood Pressure Sensor	Aug 21, 2023	Sep 14, 2023	19 days	100
14	Order Flexible Antenna to extend Transmis…	Aug 21, 2023	Sep 14, 2023	19 days	100
9	Assembly	Aug 21, 2023	Nov 16, 2023	64 days	82
13	Obtain Breadboard and Jumpers/Cables	Aug 21, 2023	Sep 28, 2023	29 days	100
15	Wire all sensors to proper MCU pins	Aug 21, 2023	Nov 16, 2023	64 days	75
10	Testing	Aug 21, 2023	Dec 06, 2023	78 days	48
30	Component Validity Testing	Aug 21, 2023	Dec 06, 2023	78 days	31
32	LED Function Testing	Aug 21, 2023	Oct 17, 2023	42 days	80
33	MCU Function Testing	Aug 21, 2023	Dec 06, 2023	78 days	51
51	Pico	Aug 21, 2023	Oct 17, 2023	42 days	100
52	ESP32	Aug 22, 2023	Oct 17, 2023	41 days	100
53	lilypad mainboard 328	Aug 22, 2023	Dec 06, 2023	77 days	0
34	GPS/Antenna Function Testing	Aug 21, 2023	Oct 17, 2023	42 days	100
37	Pulse Oximeter Function Testing	Aug 21, 2023	Oct 17, 2023	42 days	100
31	Battery Functional Testing	Aug 21, 2023	Dec 06, 2023	78 days	18
36	Flex Energy Battery	Aug 21, 2023	Dec 06, 2023	78 days	18
38	Flex Energy Battery	Aug 21, 2023	Dec 06, 2023	78 days	0
45	Flex Energy Voltage Check	Aug 21, 2023	Dec 06, 2023	78 days	0
46	Flex Energy Battery Life	Aug 21, 2023	Dec 06, 2023	78 days	0
47	Flex Energy Battery Life Under Variou…	Aug 21, 2023	Dec 06, 2023	78 days	0
48	Flex Energy Recharge Time and Volta…	Aug 21, 2023	Dec 06, 2023	78 days	0
49	Flex Energy Max Current Draw Check	Aug 21, 2023	Dec 06, 2023	78 days	0
50	Flex Energy Max Heat Dissipated	Aug 21, 2023	Dec 06, 2023	78 days	0

Tracking Progress of Work

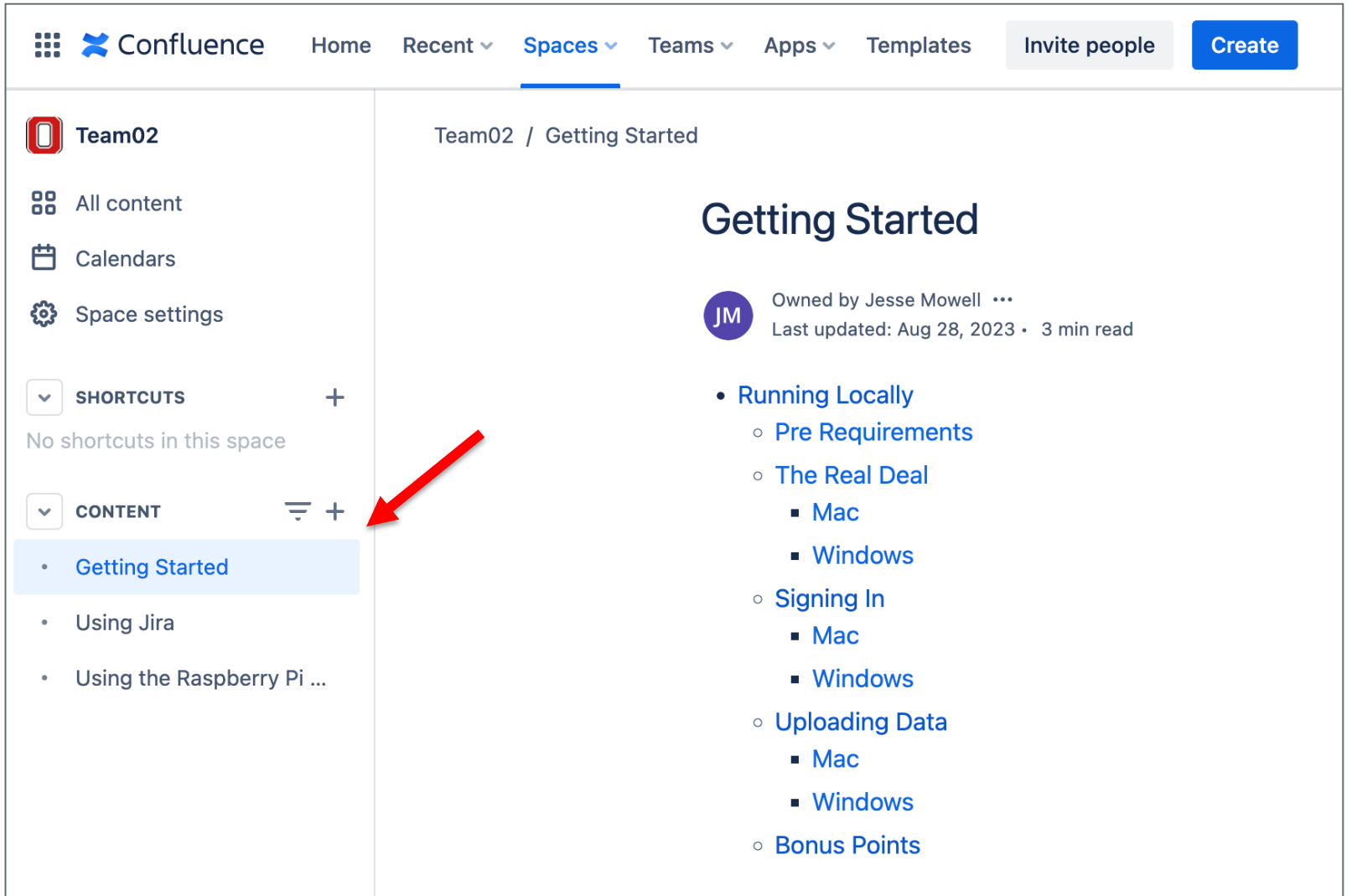
- Jira
- Confluence
- GitHub



Tracking Progress of Work - Jira



Tracking Progress of Work - Confluence



Tracking Progress of Work - Confluence

The Real Deal

These commands will get you up and running with the source code as well as all the dependencies required by the actual website

Mac

```
git clone https://github.com/JMowell99/capstone.git
cd capstone
python -m venv .venv
source ./.venv/bin/activate
pip install -r requirements.txt
python main.py

```

Windows

```
git clone https://github.com/JMowell99/capstone.git
cd capstone
python -m venv .venv
.venv\Scripts\activate
pip install -r requirements.txt
python main.py

```

BOM/Component Purchase Order

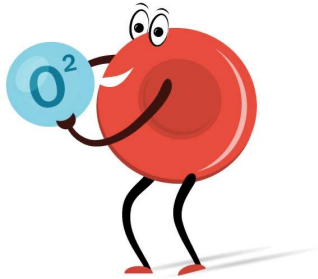
Item Description	Manufacturer Part No.	Unit of measure	Price (individual)	Quantity	Price (total)	URL	Special INSTRUCTIONS	Student Contact
MPU 6050 - Gyroscope/Accelerometer	3886	Each	$12.95	1.00	$12.95	https://www.adafruit.com/product/3886		brennan.355@osu.edu
Headers for Raspberry Pi Pico to make more solid connections to pins	5584	Each	$0.95	1.00	$0.95	https://www.adafruit.com/product/5584?gclid=CjwKCAiA3pugBhAwEiwAWFzwdbnOwVD8D0CO90fHI5uqNvUp7-3BERKeLJGXxdrYh71Vm0amQqqgWhoCSW4QAvD_BwE		brennan.355@osu.edu
Molex antenna - 2.4GHz (Series 212498) and 2.4/5GHz (series 214061) Cabled On-metal Antenna - RF Flexible Patch Antenna to Extend WiFi Coverage	WM17823-ND	Each	$3.35	1.00	$3.35	https://www.digikey.com/en/products/detail/molex/1461531200/8543421?utm_adgroup=General&utm_source=google&utm_medium=cpc&utm_campaign=PMax%20Shopping_Product_Zombie%20SKUs&utm_term=&utm_content=General&gclid=Cj0KCQiA6fafBhC1ARIsAIJjL8kJJRdWIoWXBtLVLsAARgc89y7pRlAKTdiri-I28t_5qMNrxvKbilgaAnlyEALw_wcB		brennan.355@osu.edu
SparkFun Pulse Oximeter and Heart Rate Sensor - MAX30101 & MAX32664 (Qwiic)	SEN-15219	Each	$42.95	1.00	$42.95	https://www.sparkfun.com/products/15219		brennan.355@osu.edu
			Total (Without Shipping):		$60.20			
			Total Shipping:		$24.81			
				Total:	$85.01			

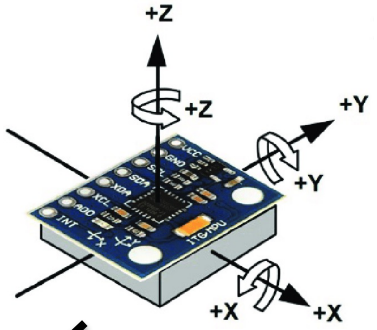
-ESP32s, Breadboards, Jumper Wires, MicroUSB chords, Passive Components, Lithium Battery and GPS sensor all found within Capstone Lab

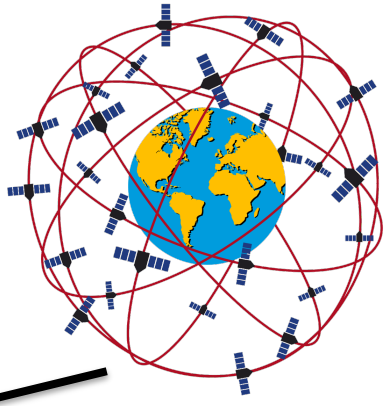
-Dr. Sengutpa provided a lilypad and Flex Energy LLC Batteries

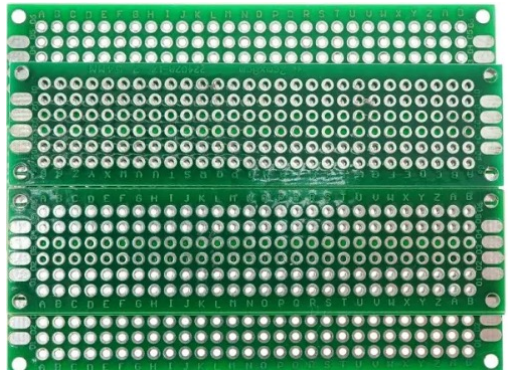
Approach to Prototype Hardware

- Prototype was on a generic PCB and connected with jumpers
- It consists of a MCU development board and sensor boards





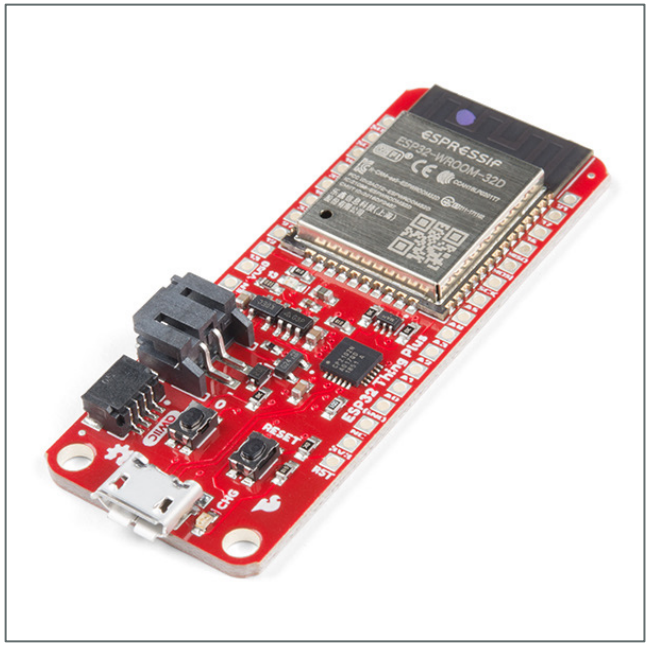




- Note: Power was sourced from a flat lithium battery, not a Flex Energy Flexible Battery due to power requirements and time

Market Research: MCU Development Board

ESP32WROOM32



- Famous for IoT starter projects
- Integrated WiFi, Bluetooth, and BLE modules -> highly flexible
- Can be programmed using Arduino, a language derived from C++.
- Multiple Other IDEs support the MCU programming in Micropython

Serial Communications – Top Level

-Data from sensors is sent serially – one bit at a time between master and slave(s) devices

-Three main utilized protocols – UART, I2C, and SPI

-Varying skill level, performance tradeoffs, connections, and data integrity

	UART	I²C	SPI
Complexity	Simple	Easy to chain many devices.	Complex as device increases
Speed	Slowest	Faster than UART	Fastest
	1.5 Mbps	**3.4 Mbit/s**	**48-100 Mbps**

Preferred

Hardware Development and Design Methodology – Arduino Sketch Basics

-Arduino chosen due to availability of sensor libraries

-Similar to C++

-Compatible with esp32

-Uses wire.h library for I2C communication with Pulse Ox and MPU

```
1  void setup() {
2    // put your setup code here, to run once:
3
4  }
5
6  void loop() {
7    // put your main code here, to run repeatedly:
8
9  }
```

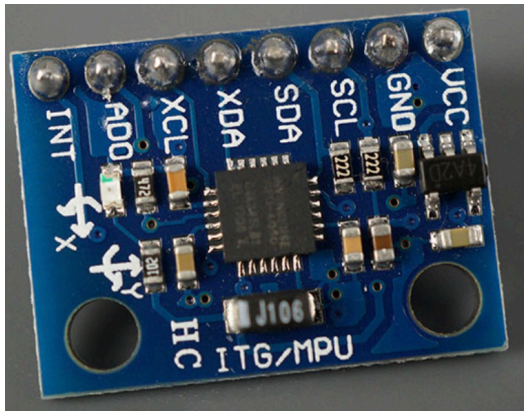
Market Research: MPU-6050 3D Gyroscope and Accelerometer Module

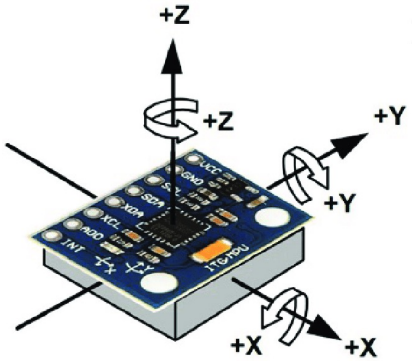
-The MPU-6050 IMU (Inertial Measurement Unit) is a 3-axis accelerometer and 3-axis gyroscope sensor

-The accelerometer measures the gravitational acceleration, and the gyroscope measures the rotational velocity.

-Additionally, this module also measures temperature.

-Compatible with Arduino, uses I2C for serial communication





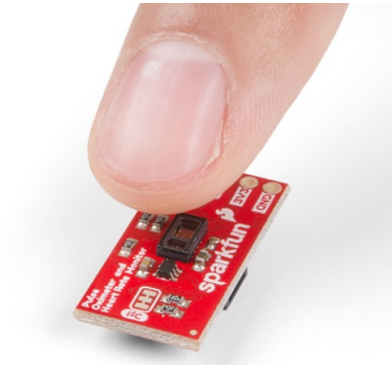
Market Research: SparkFun Pulse Oximeter and Heart Rate Sensor - MAX30101 & MAX32664 (Qwiic)

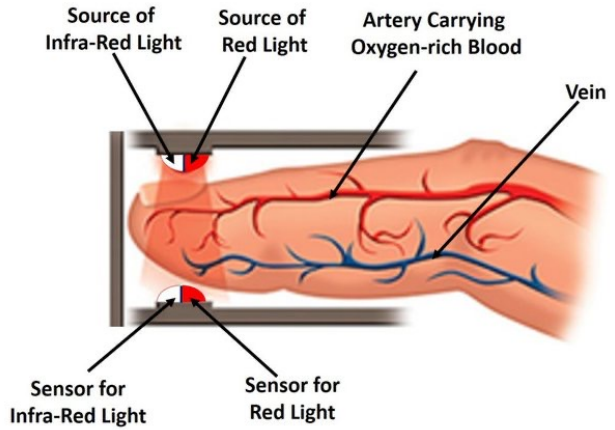
-The MAX30101 Pulse Oximetry and Heart Rate Module sensor, relies on I2C

- MAX32664 onboard MCU for filtering, configuration, detection, signal processing, etc.

-The two LEDS implement the process of “photoplethysmography” that returns readings based off amount of light absorbed by the blood

- It is enough to place an index finger on a top of the sensor to get both of the heart rate and blood oxygen saturation.





Market Research: Grove-GPS (Air530)GPS location, Long-distance communication

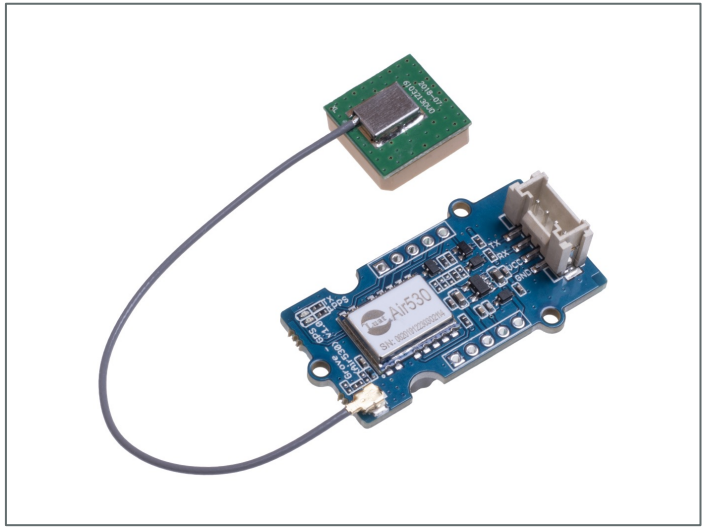
-Highly Integrated Multi-mode Satellite Positioning

-High precision Positioning: Positioning error within 10 meters

- Low Power Consumption: Low power consumption at only 31uA

- Supported Arduino and general GPS library such as TinyGPS

- Detected and reported longitude, latitude and altitude by controllable delay

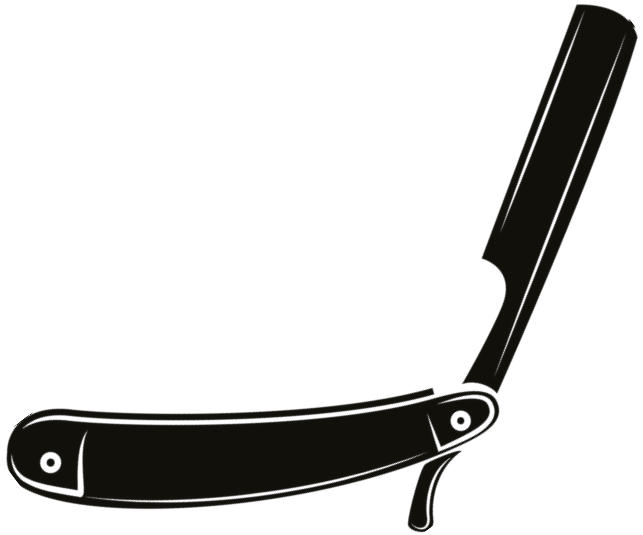


Technology and Strategies Utilized

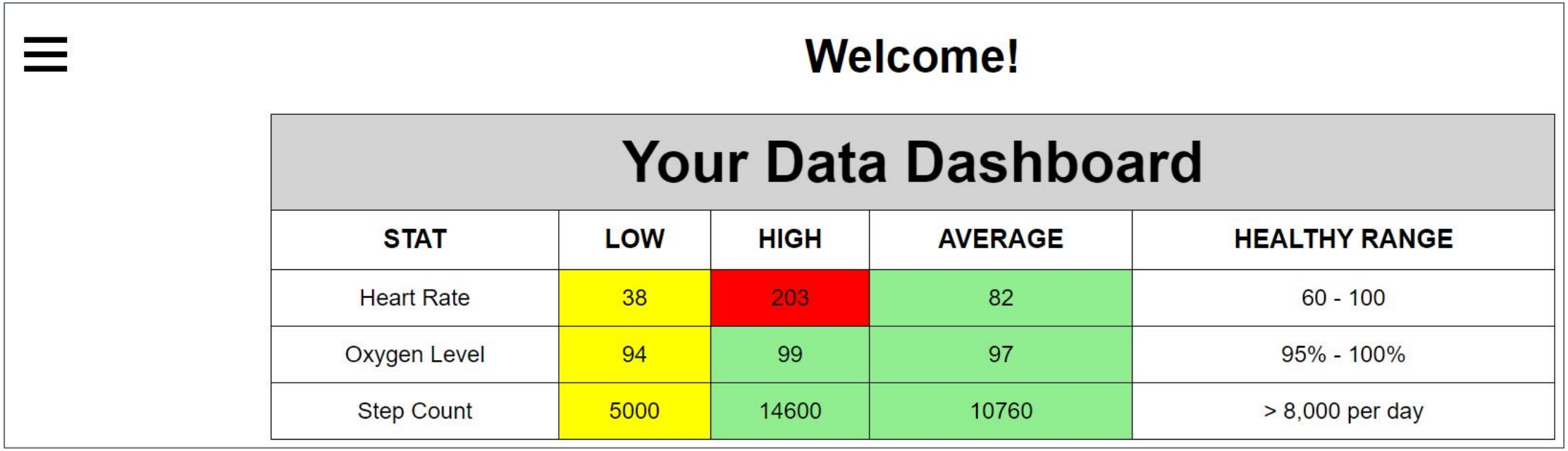
- Arduino
- Arduino IDE
- Wi-Fi
- Flask Web Framework
- REST API

Software Development & Design Methodology - Website

- Functionality **>>>** Features
- Occam's Razor
- Less is more



Visualization of Data Dashboard



Welcome!

Your Data Dashboard

STAT	LOW	HIGH	AVERAGE	HEALTHY RANGE
Heart Rate	38	203	82	60 - 100
Oxygen Level	94	99	97	95% - 100%
Step Count	5000	14600	10760	> 8,000 per day

Visualization of Data Displayed

New Features Added to Website

- Database "sterilized"
- Variable upload data length
- Sign-Up via GUI
- Displayed data broader

Software Development & Design Methodology – Warning Messages

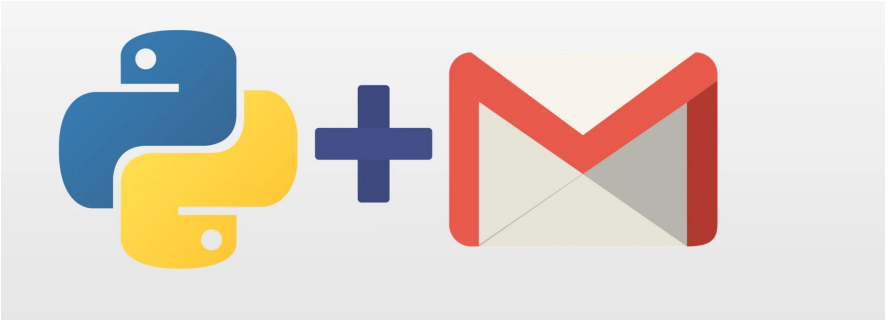
-Utilizes Python as the programming language to achieve the task.

-Free interaction through email-to-SMS gateways

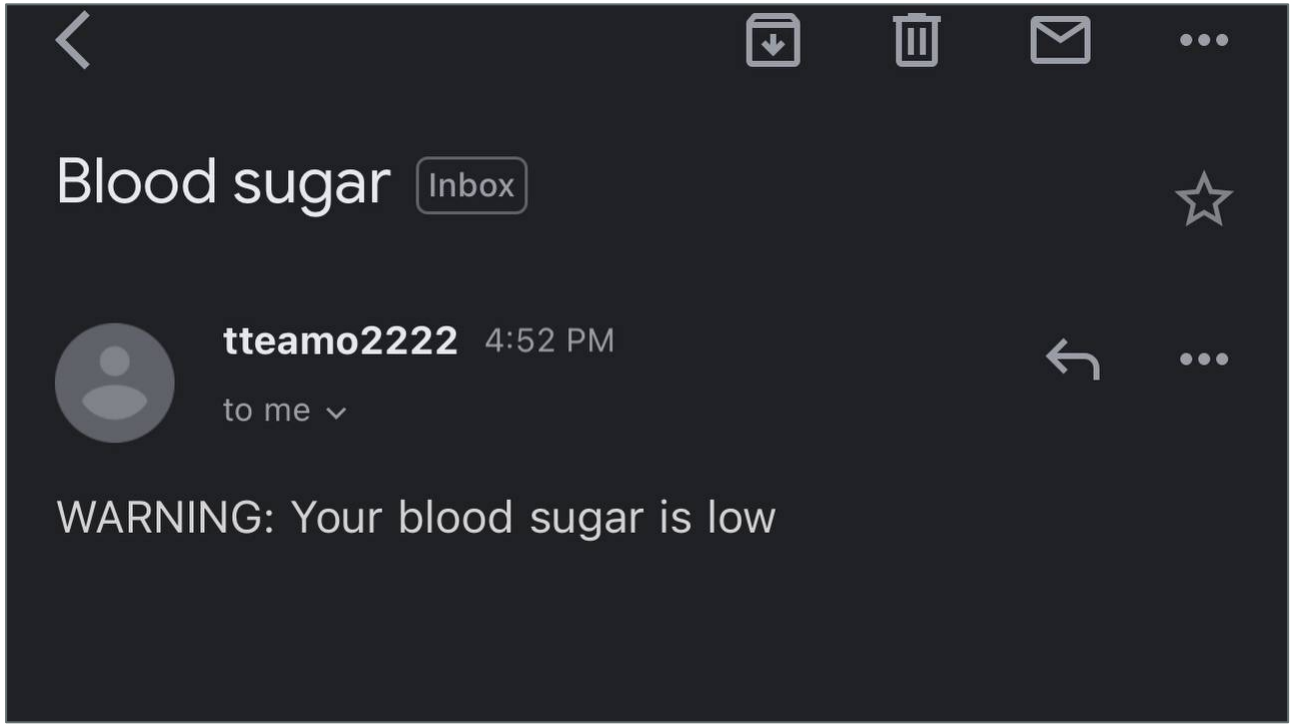
-Mobile providers' gateways convert emails to text messages

-Enables messaging to phones without additional cost

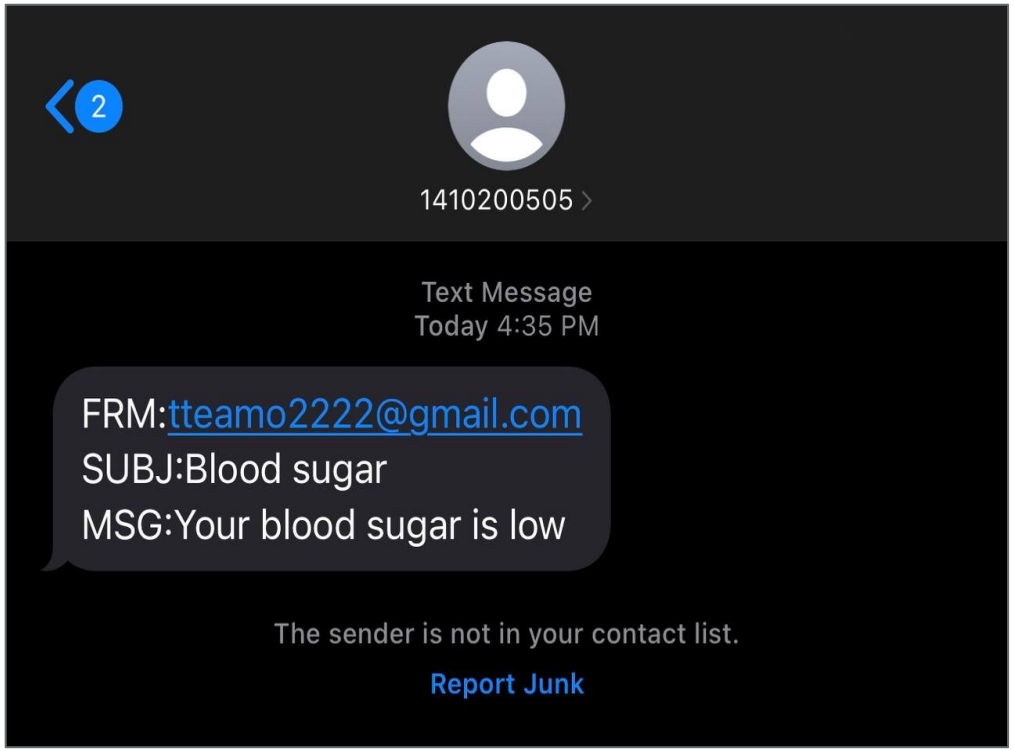
-Flask-Mail is an extension for the Flask web framework that provides support for sending emails from your Flask application Gmail SMTP server



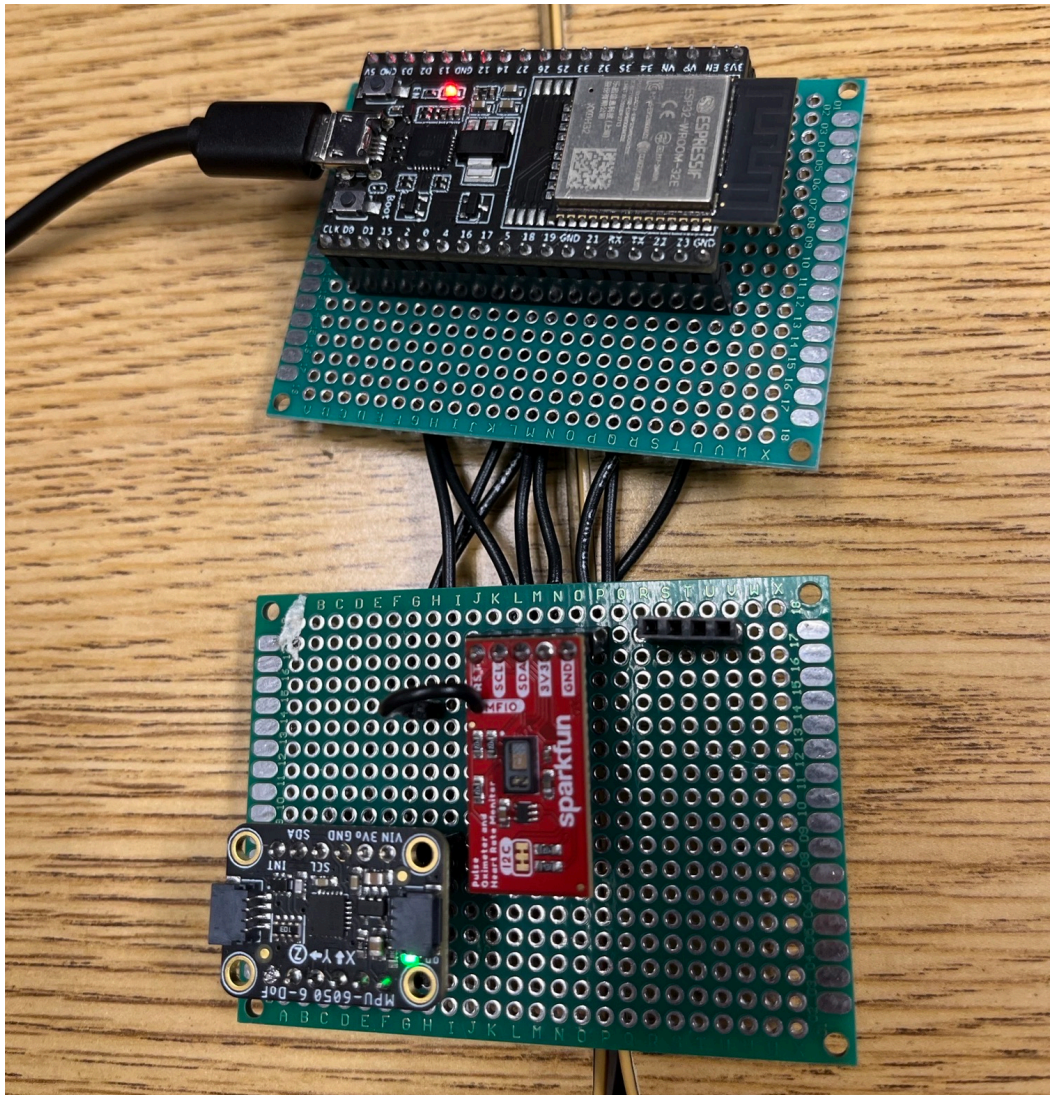
Demonstration of Critical Health Status Email Warning

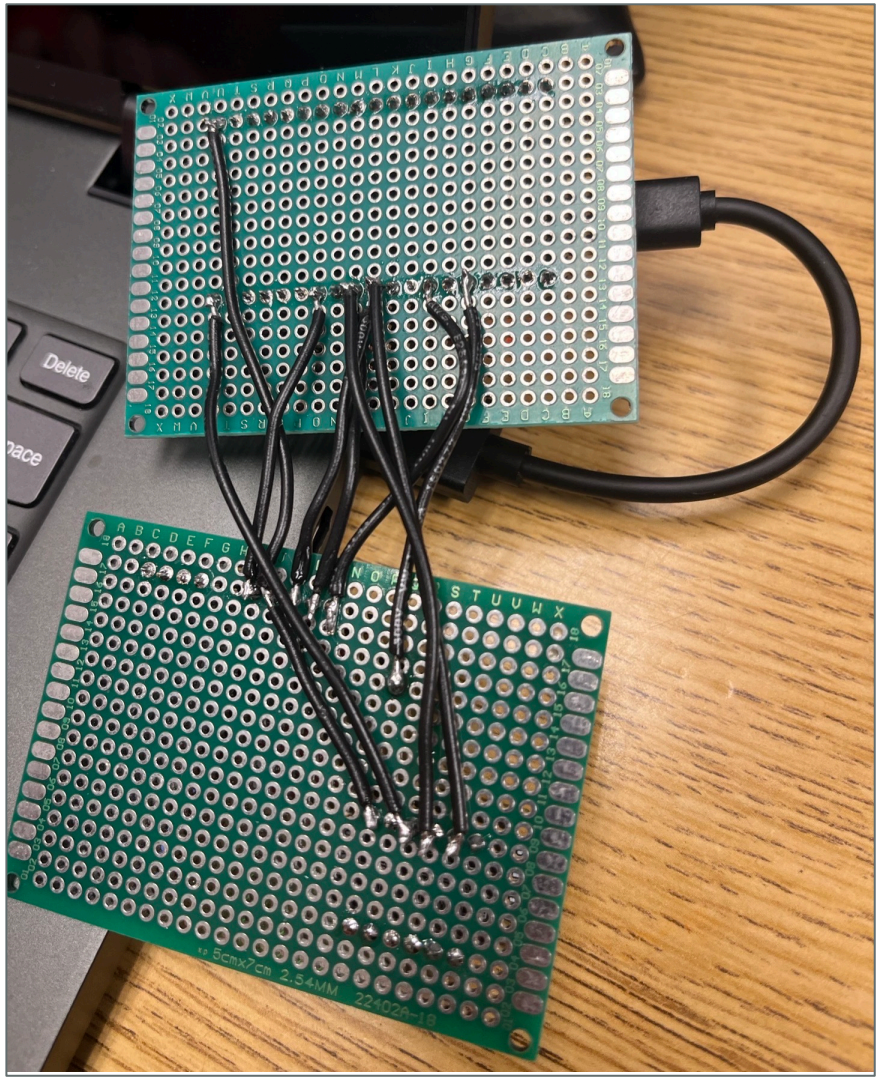


Demonstration of Critical Health Status SMS Warning



Hardware Prototype PCB Setup





DEMO

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Detail Design Presentation

Conclusion

Any Questions?