TEAM SENTINEL

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Acknowledgments

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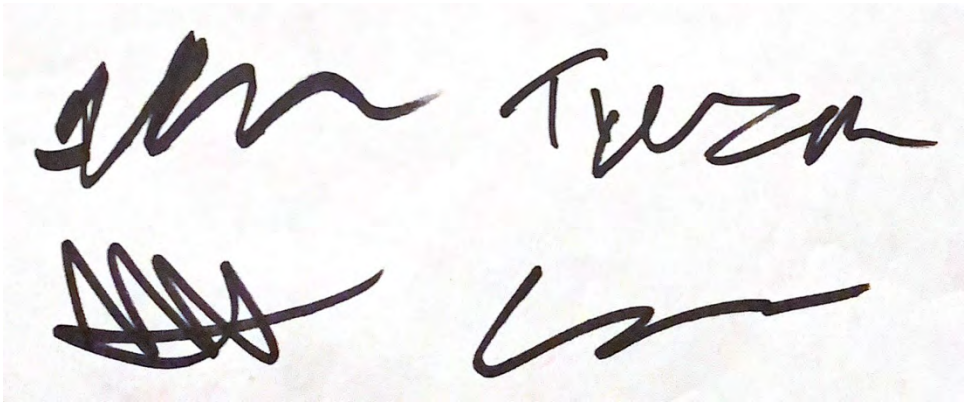
- John Bruce
- Will Madison
- Marina True
- Brian Cobb
- Orlando Gonzalez

Team Values

Team sentinel prides itself on working as a cohesive unit that effectively moves towards providing an efficient and useful device to help ensure the safety of people returning to in person facilities in the wake of COVID-19. In pursuit of this solution team sentinel adheres to a set of strict moral guidelines, this is a necessity as the sentinel is based in the medical industry and protecting people requires lots of diligence and care.



Executive summary

COVID-19 has impacted the lives of millions of people, from the work environment to each person’s personal life. Now that the pandemic is around us, we have to evolve and learn how to live with it. One way to ensure that everyone’s lives return to something resembling normalcy is by ensuring that they can go to work, study, or practice their favorite sport safely. Since the pandemic started, the issue that all businesses and teams face is how can I ensure a safe environment for my workers, students, customers, or athletes? The solution that this screening process provides is a screening process that utilizes multiple common symptoms of COVID-19 that have been confirmed as indicators by the CDC. The Sentinel uses blood oxygen levels, body temperature, and a smell test as indicators toward a subject's possible contraction of COVID-19. These tests are done using a standalone station that the subject interacts with using a touchpad. This rapid screening allows for administrators to have confidence that their venue is a safe space with minimal risk of creating a COVID-19 spreading scenario. In the development of the

Sentinel many different parts are utilized including 5v relays, buck converters, pumps, Arduino mega, infrared thermometer, pulse oximeter, and a lcd screen as well as a multitude of custom 3D printed parts. The process of building the Sentinel consists of multiple parts, coding, design, and manufacturing. In order to get a good idea for the design, there must be an initial phase of coding, in order to determine what hardware is required, once the initial coding is completed, the design can begin, and this will consist of mounting points for hardware both internally and externally. The design process will run in conjunction with the manufacturing process in order to reduce the lengthy expected print time. Once the major components are printed, the gross assembly can commence in conjunction with the wiring of hardware. When the final prints are completed and mounted on the Sentinel the final assembly can be completed and the testing and troubleshooting phase will begin. When completed the Sentinel will be able to give users a COVID-19 risk rating of either low risk, mid risk, or high risk. With this ability users will be able to effectively screen individuals for COVID-19 symptoms.

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Scope of work

Project Phase Tasks	Assigned	Start Date	End Date	Due Date	Notes
Mechanical Design	David/Chris	1/25/2021	N/A	3/26/2021	
Parts Available on Campus	David/Chris	N/A	N/A	2/26/2021	
Materials Research	David/Chris	1/25/2021	N/A	3/5/2021	
Parts Design	David/Chris	2/9/2021	3/1/2021	2/26/2021	
First Design for cparts	Chris	2/9/2021	2/25/2021	2/25/2021	
Draw all parts with their measurements	Chris	2/9/2021	2/17/2021	2/22/2021	
3D Print Sides of the Case	David	3/1/2021	3/22/2021	3/8/2021	
Research Manufacturability	David/Chris	2/9/2021	3/1/2021	3/8/2021	
How to intergrate sensors	Chris	2/16/2021	2/18/2021	2/20/2021	
Looked into different types of manufacturing(ex. 3d print)	David/Chris	N/A	N/A	3/5/2021	
Research a Potential Mold	David/Chris	N/A	3/1/2021	3/1/2021	
Research G-Code for CNC Machine	David/Chris	2/9/2021	2/18/2021	2/22/2021	
Part Requirements	David/Chris	2/7/2021	2/18/2021	2/20/2021	
3D Print Doors	David	4/5/2021	4/12/2021		
3D Print storage system for Hand sanitizer dispenser	David	4/5/2021	4/12/2021		
Mold/Shell Manufacturing	David/Chris	2/9/2021	3/3/2021	3/5/2021	
CAD Model	Chris	2/9/2021	3/3/2021	2/20/2021	
Create G-Code for Mold	Chris	2/22/2021	N/A	3/5/2021	
Order Material for Mold	David/Chris	2/22/2021	N/A	3/19/2021	
Research materials to be used for Mold (ex. Wood)	David/Chris	2/22/2021	2/29/2021	3/8/2021	
Create 3D Print Pattern for the Mold for a reference	David/Chris	3/1/2021	N/A	3/8/2021	JU Issue
Made wood frames for Mold	Tyler/David	3/19/2021	3/19/2021	3/22/2021	
Smoothing Wood Frames	David	3/22/2021	N/A	3/26/2021	
Acrylic made from Mold	David	3/22/2021	5-Apr	4/25/2021	
Acrylic Shell	David	4/5/2021		4/25/2021	
Cuting of the Shell	David	4/12/2021	4/14/2021	4/25/2021	
Side pieces mounted with shell	David	4/12/2021	4/14/2021	4/25/2021	
Electrical Design	Tyler/Ian	1/25/2021	N/A	3/25/2021	
Research/ Get up to speed with coding					
Create Logic Sheet	Ian	2/9/2021	2/13/2021	2/16/2021	
Bring Tyler up to speed	Ian	1/30/2021	N/A	2/16/2021	
Research coding for Arduino	Tyler/Ian	2/16/2021	-	2/16/2021	
Work on Control Diagrams	Tyler/Ian	2/16/2021	-	3/4/2021	
Research how to get all parts to connect with one another	Tyler/Ian	2/16/2021	-	3/4/2021	
Research into QR Codes for Smell test	Tyler/Ian	2/16/2021	-	2/22/2021	
Work through Python tutorial for Arduino	Tyler/Ian	2/16/2021	-	2/22/2021	
Arduino/Sensor Work	N/A	1/28/2021	-	3/25/2021	
Began coding touch screen	Ian				
Worked through Arduino Box	Tyler	2/8/2021	2/11/2021	2/11/2021	
Temperature Sensor	Ian	3/8/2021	4/14/2021	4/25/2021	
Temp reading on to LCD Screen	Ian	3/13/2021	3/30/2021		
Pulse Oximeter	Tyler	3/11/2021	-	4/15/2021	
Sensor working for Heart Beat	Tyler	3/11/2021	3/29/2021		

Pulse Oximeter	Tyler	3/11/2021	-	4/15/2021	
Sensor working for Heart Beat	Tyler	3/11/2021	3/29/2021		
Sensor working for Spo2	Tyler	3/21/2021	4/1/2021	4/25/2021	
Pulse OX LCD Readout	Tyler	4/1/2021		4/25/2021	
Connecting Temperature and Pulse OX Sensors to each other	Tyler	3/8/2021	-		Scratched Idea
Smell Test	Ian	N/A	-	3/25/2021	
Random Number/Servos	Ian	3/29/2021		4/5/2021	
Create a mechanism for the smell test	Tyler/Ian	4/5/2021		4/12/2021	
Soldering	Tyler/Ian	4/5/2021	-	4/25/2021	
Connecting 2 Arduinos to each other	Tyler	4/19/2021		4/25/2021	
Writing out Master Code for all Test/Sensors	Ian	4/19/2021		4/25/2021	
Testing and Troubleshooting					
Testing topics	ALL	5/3/2021	N/A	5/5/2021	
Master Code	ALL	5/3/2021	N/A	5/5/2021	
Frame function	ALL	5/3/2021	N/A	5/5/2021	
Power Supply	ALL	5/3/2021	N/A	5/5/2021	
Time to run	ALL	5/3/2021	N/A	5/5/2021	
Each Sensor working in tantum	ALL	5/3/2021		5/5/2021	
Troubleshoot issues	ALL	5/3/2021	N/A	5/5/2021	
Testing Complete	ALL	5/3/2021	N/A	5/5/2021	
Final Report					
Drafting Sections	ALL	N/A	N/A	5/7/2021	
Build Process	ALL	N/A	N/A	5/7/2021	
Testing Performed	ALL	N/A	N/A	5/7/2021	
Results	ALL	N/A	N/A	5/7/2021	
Discussion	ALL	N/A	N/A	5/7/2021	
Conclusion	ALL	N/A	N/A	5/7/2021	
Report Complete	ALL	N/A	N/A	5/7/2021	
Report Submitted	ALL	N/A	N/A	5/7/2021	
Poster Defined	ALL	N/A	N/A	5/7/2021	
Poster Complete	ALL	N/A	N/A	5/7/2021	

Table 1 (Scope of work)

Voice of the customer

Introduction & Initial Problem Statement

In late 2019, COVID-19 was the cause of an outbreak in Wuhan, China. In February 2020, the first case reached the United States and by the middle of March, all fifty states had a positive case in their location. The World Health Organization declared COVID-19 a National Emergency. As the nation reopens from its shutdown in mid-March, many different states are going into Phase 3 of reopening (which eliminates all current COVID-19 restrictions on businesses). This means that universities and businesses across the country are slowly integrating from a virtual environment to returning to in-person classes and meetings. The current COVID-19 screening process at the school and some businesses is a Wellness Survey asking the user questions such as if they have any symptoms or if they have come into contact with anyone who tested positive for COVID-19. Problems with this screening process include:

- Someone is allowed on campus or work even if they have not filled out the Wellness Survey. There is no accountability as to who fills it out and who is allowed in buildings and classrooms.
- Someone can lie about their symptoms to come to an in-person meeting. This can spread the virus quickly across campus, especially one as small as Jacksonville University or other businesses.
- Someone could be feeling sick but not have the resources to check. Not everyone owns a thermometer and having a fever is a common symptom of COVID-19.
- During the weekends or off periods throughout the school year, you cannot control where people go. Someone can be healthy on a Saturday, go out to a restaurant Sunday and contract the virus, but not show symptoms 2-14 days after contraction. Using the survey process, they can potentially infect others without even knowing they contracted the virus.
- Some institutions only take temperature as a requirement before entering a building. Although fever is a common symptom of COVID-19 there are a lot of cases where those who contracted COVID-19 had other symptoms that did not include a fever. A person can have other common symptoms including loss of smell and taste and shortness of breath without having a fever. A simple temperature check cannot detect other symptoms of COVID-19.

A proper screening process is important and crucial to slow the spread of COVID-19 during these transitions. Without a proper screening process, anyone can enter a building with no prior screening and can infect everyone in the room with them, causing them to infect the people they come into contact with and so forth. Having accountability on who enters what buildings and making sure they are properly screened for symptoms will slow the spread. With the number of people that enter and leave a building a day, proper screening methods are crucial to the health of everyone.

Goal of VoC

Our VoC goal for this project is to determine and come up with a list of prioritized needs based on our customers' feedback from a questionnaire. Through interviewing and asking questions from a broad audience that has been affected by COVID-19, we can establish needs based on their answers and determine what specifications and vital sign sensors our device must-have. This will help us come up with the best solution to screening a variety of people for COVID-19 before they enter a building.

Voice of Customer Plan

The first step in our voice of customer plan is to establish who our customers are. Some questions we asked ourselves before we even began included:

1. What is the current screen process for schools and businesses?
2. Is there a way to make it better?
3. What are some ways we can screen people to slow the spread of COVID-19?
4. If a health monitoring device were developed, what symptoms would it screen for?
5. Who is most impacted by COVID-19?
6. How has COVID-19 affected people, and is there a way to alleviate that?

Once we establish who our market and customers will be, we will then need to establish interview questions to ask. Each set of questions will need to adhere to each person we are asking in order to get accurate information. For example, asking an engineering company questions about students in a classroom will not help us, but asking them if there are new guidelines they need to follow before they come to work will be beneficial to us. Our questions will include topics on:

1. Current screening process
2. What improvements could be made to the current screening process
3. Current guidelines that have to be followed
4. Effect on school/work due to COVID-19

The raw data we collect will help us determine what needs and requirements we will have for our device and use those to move on to the design process.

Market Segment

The market segment for this project consists of large institutions that are encountering the reality that people have to go back either to work or class. This includes school, sports teams and businesses. They all require a more accurate and reliable system that can control the spread of the virus within their institution.

List of Customers

For our customer list, we have collected information from different people that are related to the school like management, students and staff. These people are the ones who show up to their campus every day. Since there is no lockdown, anyone is able to have people over to their residence or head off campus and come back. This makes the campus a perfect place for a virus spread to occur. Getting responses from them is crucial to see what is the best way to screen them and make entering buildings on campus more safe.

We are also going to gather information from a team outside the school and an engineering company that resides in Miami. This gives us a perspective on how businesses outside a school environment have been handling COVID-19. Each business and university has their own guidelines they follow, and having such a broad audience will help us get more precise information in order to create a list of needs and solutions that can be a solution for any business or university. Here is the list from each field:

Sports teams

- JU sailing team

Faculty and staff

- JU professor
- JU Department workers

Schools and Companies

- Engineering company, Architectural company

Students and athletes

- ROTC, Sailing athletes

Interview Questions

Faculty and Staff at JU

1. Are you happy with JU's current method of screening students for COVID-19 before they come to campus?
2. Do you currently feel comfortable with the number of students coming into your classroom?
3. Would a real-time testing device make you more comfortable with students coming into the classroom?
4. What do you think would improve on JU's current method for screening students?
5. Given the fact that most young adults are asymptomatic or show mild symptoms, how would you screen the students to come on campus?
6. Would you consider yourself as a part of the group of people at the most risk of contracting COVID-19?
7. Do you have any preexisting conditions?
8. Briefly explain how COVID-19 has affected your daily life? This includes school, work, going shopping, etc.
9. Where and how often do you get your temperature taken per day?
10. In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?
11. How often do you meet in person?
12. If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?
13. How often do you go out during the week on the weekends? Can you list some example places where you go? Examples include work off-campus, the gym, physical therapy, restaurants, etc.
14. Are there more preventative measures that your school/work should make to help mitigate the spread of COVID-19?

Business Outside JU

15. Are you happy with your company's current method of screening workers for COVID-19 before they come to the workplace?
16. Do you currently feel comfortable with the number of workers coming into work?
17. Would a real-time testing device make you more comfortable with workers coming into work?
18. What do you think would improve the company's current method for screening workers?
19. Given the fact that most young adults are asymptomatic or show mild symptoms, how would you screen the workers to come to work?

20. Briefly explain how COVID-19 has affected your daily life. This includes school, work, going shopping, etc.
21. Where and how often do you get your temperature taken per day?
22. In areas with high demand such as the lunchroom, the lobby, etc. What preventative measures are taken to maintain capacity guidelines and sanitization?
23. How often do workers meet, is there a hybrid system where some workers are at home and others in the building?
24. If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?
25. How often do you go out during the week on the weekends? Can you list some example places where you go? Examples include the gym, physical therapy, restaurants, etc.
26. Are there more preventative measures that your school/work should make to help mitigate the spread of COVID-19?

Customer Process & Gemba

From the outside perspective, people who are exposed the most to COVID-19 can be seen teaching a sport or subject and working in a company where practicing social distance becomes hard. These people have a higher chance of exposure compared with other people that do not have the need of meeting with others for their daily routine.

A teacher's routine deals with a large number of kids and young adults. These groups of people tend to have a softer response to the virus; therefore, making it easier for professors and coaches to contract the virus. Something similar happens to people that have to go to work, wherein some circumstances they have to go to their workplace and interact with other workers. In this case, adults tend to be more careful and show more symptoms. It also means that they have a higher chance to expose someone that has pre-existing conditions and makes the infection worse.

Having a system that makes people with higher exposure to the virus safer will improve their chances of not getting infected in the first place. At the same time, lowering the rate of infection in all these fields will help the country and the world overcome the COVID-19 crisis.

Raw Data

Our raw data consist of the questionnaire answers from our different customers. They are divided by either JU personnel as students, professors and administration, or the engineering company outside of JU.

ROTC Student 1	
Questions	**Answers**
Briefly explain how COVID-19 has affected your daily life? This includes school, work,	I've spent 14 days in quarantine, wear a mask when I leave my residence, Clorox bleach my

going shopping, etc.	apartment before moving in as a Safety precaution.
What preventative measures is your campus/work doing to help mitigate the spread of COVID-19?	Hybrid or in-person and online classes, requires masks but doesn't enforce it, limits social gatherings
Where and how often do you get your temperature taken per day?	Only when checking into the unit, once per day.
In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	Limit on the number of students sitting and eating, tables are sanitized after use
How often do you meet in person or virtually?	In person on T & W for 2 classes, virtual for all other days (6 classes)
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	The university publishes a questionnaire everyday regarding symptoms though there is no accountability for it. The ROTC unit does temperature checks and keeps a log of everyone who enters the building.
How often do you go out during the week on the weekends? Can you list some example places of where you go? Examples include work off campus, the gym, physical therapy, restaurants etc.	Internship of campus, 2x per week. Gym 3-4x per week. Grocery store and farmers market 1-2x per week.
Are there more preventative measures that your school/work should make to help mitigate the spread of COVID-19?	Temperature checks in classroom settings
Are you happy with JU's current method of screening students for COVID-19 before they come to campus?	No
Would a real time testing device make you more comfortable with students coming into the classroom?	Yes
What do you think would improve on JU's current method for screening students?	Instant results cost effective and cheap

ROTC Student 2	
Questions	**Answers**
Briefly explain how COVID-19 has affected your daily life? This includes school, work, going shopping, etc.	A lot more conscious about how close I am to people, how frequently I sanitize/wash my hands, making sure I never forget my mask, making sure I color coordinate my mask with my outfit
What preventative measures is your campus/work doing to help mitigate the spread of COVID-19?	Social distancing, incorporating sanitation stations, non-contact food service, sanitizing frequently
Where and how often do you get your temperature taken per day?	In my room and done by myself daily
In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	Split class to be hybrid learning, using disinfectant wipes to clean desks
How often do you meet in person or virtually?	Half and Half
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	Yes and no there is no accountability to make sure
How often do you go out during the week on the weekends? Can you list some example places where you go? Examples include work off-campus, the gym, physical therapy, restaurants, etc.	Work on campus every day, gym on campus every day, restaurants on the weekend twice a month, grocery store every other week, casual shopping every weekend
Are there more preventative measures that your school/work should make to help mitigate the spread of COVID-19?	Take accountability for the people that are on campus to ensure they don't have any symptoms. Make people who go into isolation/quarantine get tested prior to their release.
Are you happy with JU's current method of screening students for COVID-19 before they come to campus?	No
Would a real-time testing device make you	I guess so

more comfortable with students coming into the classroom?	
What do you think would improve on JU's current method for screening students?	Not much room for improvement

ROTC Student 3	
Questions	**Answers**
Briefly explain how COVID-19 has affected your daily life? This includes school, work, going shopping, etc.	Completely virtual events for everything
What preventative measures is your campus/work doing to help mitigate the spread of COVID-19?	Going more virtual than in class
Where and how often do you get your temperature taken per day?	My room about once a day if feeling headache or symptoms
In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	Very high sanitation procedures, take out containers
How often do you meet in person or virtually?	Virtually about three times a week and in-class about five
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	No, except restaurants and military establishments. They have requirements.
How often do you go out during the week on the weekends? Can you list some example places where you go? Examples include work off-campus, the gym, physical therapy, restaurants, etc.	4-5 for the gym and stores
Are there more preventative measures that your school/work should make to help mitigate the spread of COVID-19?	Going virtual as much as possible, wearing my mask and social distancing

Are you happy with JU's current method of screening students for COVID-19 before they come to campus?	No, because it relies only on students to be truthful
Would a real-time testing device make you more comfortable with students coming into the classroom?	Yes. Or temp checks on the way into class at least
What do you think would improve on JU's current method for screening students?	Temp checks before classes or another screening tool. Like one of the new COVID-19 dogs (like drug dogs but for COVID-19)

JU Employee 1	
Questions	**Answers**
Briefly explain how COVID-19 has affected your daily life? This includes school, work, going shopping, etc.	COVID-19-19 has impacted my daily life by me having to readjust how, when, and why i do things. I have to conscientiously decide what is most important when choosing to go places.
What preventative measures is your campus/work doing to help mitigate the spread of COVID-19?	wearing a mask, social distancing, washing hands more
Where and how often do you get your temperature taken per day?	Once
In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	i adhere to social distancing and maintain distance
How often do you meet in person or virtually?	Twice a week
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	I self check my temperature
How often do you go out during the week on the weekends? Can you list some example places where you go? Examples include work	Grocery stores

off-campus, the gym, physical therapy, restaurants, etc.	
Are there more preventative measures that your school/work should make to help mitigate the spread of COVID-19?	Yes
Are you happy with JU's current method of screening students for COVID-19 before they come to campus?	No
Would a real-time testing device make you more comfortable with students coming into the classroom?	Yes
What do you think would improve on JU's current method for screening students?	Consistency

JU Employee 2	
Questions	**Answers**
Briefly explain how COVID-19 has affected your daily life? This includes school, work, going shopping, etc.	No able to do as much or trust people.
What preventative measures is your campus/work doing to help mitigate the spread of COVID-19?	Updates on Our Safety Policies
Where and how often do you get your temperature taken per day?	Self check
In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	Face coverings are still required inside all campus buildings and whenever social distancing is not possible. In-person gatherings of more than 10 people are not permitted. We will continue limiting capacity within our classrooms, labs, dining facilities and other indoor spaces.
How often do you meet in person or virtually?	University employees who are working remotely continue to do so, and meetings should are virtual.

If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	In-person meetings of only 1 person permitted at a time
How often do you go out during the week on the weekends? Can you list some example places where you go? Examples include work off-campus, the gym, physical therapy, restaurants, etc.	In-person meetings of only 1 person permitted at a time
Are there more preventative measures that your school/work should make to help mitigate the spread of COVID-19?	limiting capacity within our classrooms, labs, dining facilities and other indoor spaces.
Are you happy with JU's current method of screening students for COVID-19 before they come to campus?	No not at all
Would a real-time testing device make you more comfortable with students coming into the classroom?	Yes very
What do you think would improve on JU's current method for screening students?	It can be better and safer for faculty if students who have came in contact with someone having COVID-19 10 are tested

JU Student 1	
Questions	**Answers**
are you happy with JU's current method of screening students for COVID-19 before they come to campus?	Yes
Do you currently feel comfortable with the number of students coming into your classroom?	Yes
Would a real-time testing device make you more comfortable with students coming into the classroom?	Yes

What do you think would improve on JU's current method for screening students?	Not make possible COVID-19 exposure students come to school.
Given the fact that most young adults are asymptomatic or show mild symptoms, how would you screen the students to come on campus?	Temperature checks
Would you consider yourself as a part of the group of people at the most risk of contracting COVID-19?	Yes
Do you have any preexisting conditions?	No
Briefly explain how COVID-19 has affected your daily life? This includes school, work, going shopping, etc.	I can't go to the bar and I am very stressed about it.
Where and how often do you get your temperature taken per day?	At my house and once a day
In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	I don't know I don't visit these places.
How often do you meet in person?	Never
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	NA
How often do you go out during the week on the weekends? Can you list some example places where you go? Examples include work off-campus, the gym, physical therapy, restaurants, etc.	I go to a club once a day
Are there more preventative measures that your school/work should make to help mitigate the spread of COVID-19?	Yes we need a device that constantly monitors our temperature and other COVID-19 symptoms

JU Student 2	
Questions	**Answers**
are you happy with JU's current method of screening students for COVID-19 before they come to campus?	No- it is not thorough enough and there is no way that JU can 100% say that students aren't just lying about their symptoms so they won't have to quarantine.
Do you currently feel comfortable with the number of students coming into your classroom?	Yes - none of my classes are larger than 10 or 12 and if they are my professors have divided them into split sections
Would a real-time testing device make you more comfortable with students coming into the classroom?	Yes
What do you think would improve on JU's current method for screening students?	Real time testing and temperature checks for all students
Given the fact that most young adults are asymptomatic or show mild symptoms, how would you screen the students to come on campus?	Through contact tracing, have students report if they had been around anyone with symptoms or a positive test.
Would you consider yourself as a part of the group of people at the most risk of contracting COVID-19?	No
Do you have any preexisting conditions?	No
Briefly explain how COVID-19 has affected your daily life? This includes school, work, going shopping, etc.	It has affected every aspect. Since I am a college student, living on campus has become very different since COVID-19. My roommates and I are very conscious of who we hang out with in our immediate circles as well as where we go on a day to day basis.
Where and how often do you get your temperature taken per day?	Every morning and once a day
In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	There are markers on the floors of where to stand, masks are mandatory, and sanitization happens periodically on high-touch surfaces.
How often do you meet in person?	With my professors and in my classes – once-

	twice a week; with my teammates on the JU sailing team – 3-4 times a week depending on the teammate.
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	There is a loosely required, much more 'recommended' JU health screening that students fill out via email online, however I have seen students fill it out while sitting already in their classrooms. Therefore, I believe there is not accountability or requirement involved and that the health screenings are simply a legal loophole that JU has put into place to prevent being sued
How often do you go out during the week on the weekends? Can you list some example places where you go? Examples include work off-campus, the gym, physical therapy, restaurants, etc.	I probably go out once-twice on the weekends to either the beach or a restaurant/ coffee shop. I try to go places outside where I know I will be able to maintain social distancing.
Are there more preventative measures that your school/work should make to help mitigate the spread of COVID-19?	Yes

Engineering Firm	
Questions	**Answers**
Are you happy with your company's current method of screening workers for COVID-19 before they come to the office?	Yes
Do you currently feel comfortable with the number of workers coming into work?	Yes
Would a real-time testing device make you more comfortable with students coming into work?	Yes
What do you think would improve on the current method for screening workers?	Something that would give us standards on what to check. This virus is so new, most of the time we don't know if everything we are checking is correct, and if there are more things we should be checking or looking for.

Given the fact that most young adults are asymptomatic or show mild symptoms, how would you screen the workers to come to work?	We have no way of testing asymptomatic unless they get tested.
Would you consider yourself as a part of the group of people at the most risk of contracting COVID-19?	Yes
Do you have any preexisting conditions	No, but some of our employees do.
Briefly explain how COVID-19 has affected your daily life? This includes school, work, going shopping, etc.	Constantly wearing a mask, washing our hands several times a day, being scared of touching anything, being scared of getting too close to someone, I do not come into an elevator that already has two people in it, going to the gas station is the scariest part of my routine.
Where and how often do you get your temperature taken per day?	Once
In areas with high demand such as the lunch room or the lobby what preventative measures are taken to maintain capacity guidelines and sanitization?	Lunch room is not open, employees must have lunch at their desks. When they get up from their seats they have to wear a mask anywhere they go.
How often do you meet with other workers, is there a hybrid system where some workers are at home and others in the building?	We have established a protocol where all meetings have to be done by Microsoft Teams or Zoom, even if both employees are at the office.
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	No, there is no check. Employees are told not to come to the office if they are not feeling okay.
How often do you go out during the week on the weekends? Can you list some example places where you go?	Examples include the gym, physical therapy, restaurants etc. I go to the gym every day, I have to wear a mask and clean all the equipment I use. The gym has been separated into sections where people can work out by themselves with social distancing standards. Restaurants on the weekends.
Are there more preventative measures that	If there are, we are not aware of them.

your school/work should make to help mitigate the spread of COVID-19?	

Architecture Firm	
Questions	**Answers**
Are you happy with your company's current method of screening workers for COVID-19 before they come to the office?	I am okay, we don't really have one
Do you currently feel comfortable with the number of workers coming into work?	Yes, we work outside in the constructions so there is no worry about not being able to respect social distance
Would a real-time testing device make you more comfortable with students coming into work?	Yes, it would be really helpful to have something on site
What do you think would improve on the current method for screening workers?	A device that we can take to different houses depending on where we are working
Given the fact that most young adults are asymptomatic or show mild symptoms, how would you screen the workers to come to work?	I don't know how, but just the temperature outside is not pretty accurate
Briefly explain how COVID-19 has affected your daily life? This includes school, work, going shopping, etc.	I have to wear a mask to most places and it slowed the business for a little because we did not have a way to make sure the workers were not infected
Where and how often do you get your temperature taken per day?	I usually check my temperature when I have to go to the workplace or do any paperwork
In areas with high demand such as the lunch room or the lobby what preventative measures are taken to maintain capacity guidelines and sanitization?	We do not have any measures besides washing our hands

How often do you meet with other workers, is there a hybrid system where some workers are at home and others in the building?	Workers meet 5 days a week. There is no possibility for a hybrid schedule
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	We don't have a method, we depend on the workers to say something if they are feeling sick
How often do you go out during the week on the weekends? Can you list some example places where you go?	I usually go for groceries and work-related activities
Are there more preventative measures that your school/work should make to help mitigate the spread of COVID-19?	Something that can tell us more than a thermometer.

JU Dance Professor	
Questions	**Answers**
Are you happy with your company's current method of screening workers for COVID-19 before they come to the office?	Yes
Do you currently feel comfortable with the number of workers coming into work?	Yes
Would a real-time testing device make you more comfortable with students coming into work?	Do you mean a Covid test or a thermometer? No
What do you think would improve on the current method for screening workers?	Not sure
Given the fact that most young adults are asymptomatic or show mild symptoms, how would you screen the workers to come to work?	I would not screen a student I would leave the screening up to the security and University.

Briefly explain how COVID-19 has affected your daily life? This includes school, work, going shopping, etc.	I have to wear a mask daily, I take less trips to the store or to see friends. I order to go instead of eating in a restaurant. I don't go to crowded places.
Where and how often do you get your temperature taken per day?	1 time a day at my kids school.
In areas with high demand such as the lunch room or the lobby what preventative measures are taken to maintain capacity guidelines and sanitization?	Air ventilation is key for high traffic areas.
How often do you meet with other workers, is there a hybrid system where some workers are at home and others in the building?	N/A
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	Depends on where I am going. To a school yes, to a restaurant no
How often do you go out during the week on the weekends? Can you list some example places where you go?	Examples include work off campus, the gym, physical therapy, restaurants etc. 1- 2 time a week to order take out
Are there more preventative measures that your school/work should make to help mitigate the spread of COVID-19?	A vaccine

Table 2-11 (Questionnaire)

Unmet Needs

The unmet needs as the word represent the necessities that people feel they would love to have implemented in their workplace or classroom, but they do not have anything similar. Here we have highlighted them in order to make it easier to find the possible solution for the problem.

- Real-time testing device in classroom/workplace
- Temperature checks in a classroom/workplace
- A more accountable way of screening students/employees

Grouped & Organized Needs

All the needs have been extracted from the outcome statements that can be seen in the appendix. We analyzed each answer from the questionnaire and determined what outcome they represent. Below you can see a pie chart with each need represented by a letter from A-K.

A. Temperature checks in a classroom/workplace setting (8) (17%)
    a. Engineering firm
    b. Student 1
    c. Student 2
    d. ROTC 1
    e. ROTC 3
    f. ROTC 4
    g. JU employee 1
    h. JU employee 2

B. Going virtual as much as possible (4) (8%)
    a. Student 1
    b. Student 2
    c. ROTC 3
    d. JU Dance Professor

C. A real time testing device (10) (19%)
    a. Engineering firm
    b. Student 1
    c. Student 2
    d. ROTC 1
    e. ROTC 3
    f. ROTC 5
    g. JU employee 1
    h. JU employee 2
    i. Architectural firm
    j. JU Dance Professor

D. A more accountable way of screening students/coworkers (11) (21%)
    a. Engineering firm
    b. Student 1
    c. Student 2
    d. ROTC 1
    e. ROTC 2
    f. ROTC 3
    g. ROTC 4
    h. ROTC 5
    i. JU employee 1
    j. JU employee 2
    k. JU Dance Professor

E. Standards on what to check (6) (11%)
    a. Engineering firm
    b. Student 1
    c. ROTC 4
    d. JU employee 1
    e. JU Dance Professor
    f. Architectural firm

F. Need to be sanitized (6) (13%)
    a. ROTC 1
    b. ROTC 2
    c. ROTC 3
    d. ROTC 4
    e. JU employee 1
    f. Architectural firm

G. Cheap Real time testing Device (1) (2%)
    a. ROTC 1

H. Device must be transportable (2) (4%)
    a. ROTC 4
    b. Architectural firm

I. Social distancing (2) (2%)
    a. JU employee 1
    b. JU Dance Professor

J. Screening several people consecutively (1) (2%)
    a. JU employee 2

K. Rapid screening (1) (2%)
    a. JU employee 2

-Total = 52

We are using the interview data method.

We will take a tally of how often a need is brought up and then divide this number by the total number of needs and multiply by 100 to get a percentage. We will then compare the percentage of times a need is brought up to the other needs and use this method to rank them.

$$P = N/T * 100$$

P = Percentage
N = Number of times a need is brought up
T = Total needs

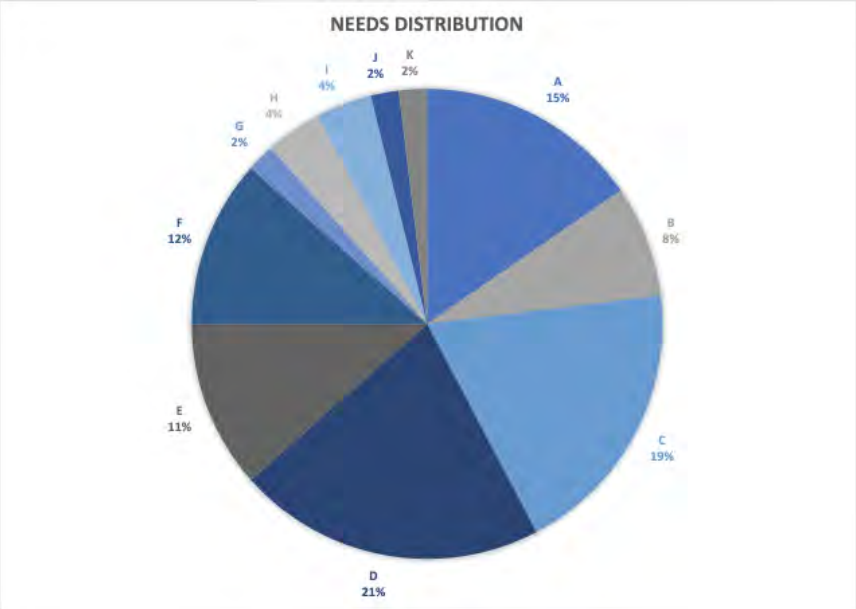


Fig. 1 (Needs distribution pie chart)

Needs ranked

1. A more accountable way of screening students (21%)
2. Real-time testing device in classrooms or work environment (19%)
3. Temperature checks in a classroom or work environment (17%)
4. Needs to be sanitized (13%)
5. Standards on what to check (11%)
6. Going virtual as much as possible (6%)
7. Device must be transportable (4%)
8. Cheap real-time device (2%)
9. Rapid screening (2%)
10. Social distancing (2%)
11. Screening several people consecutively (2%)

Requirements

In order for the Sentinel to function as desired, it must have certain characteristics that either meet the criteria set by the VOC or certain industry standards. These needs are derived from the customer needs, and their value is determined by the ranked needs. As for industry standards, those are derived from research, and an example of this is the IP rating or “ingress protection rating”. The requirements are also broken up into 4 categories in the Sentinels case, functional, performance, interface, and non-functional.

Functional

- Monitor temperature within a range of 80 degrees Fahrenheit to 110 degrees Fahrenheit with an accuracy of .36 degrees. (R2). This is a consistent noninvasive measurement of a common symptom of COVID-19. Not tied to a user need but derived from CDC guidelines.
- Monitor oxygen levels in blood with a .1 percent accuracy(R3). A quick measurement with the ability to be tracked over a long period of time to track health. It has been stated by the CDC that a downward trend of oxygen levels is an indication of COVID-19. Users need 5 (Standards on what to check).
- Monitor and test sense of smell (R4). Qualitative analysis of smell which loss of is a symptom of COVID-19 as stated by the CDC. Users need 5 (Standards on what to check). According to the CDC an individual's loss of smell is a very common symptom of COVID-19.

Performance

- Real-time response and notification. The user must have a result from the Sentinel in less than 3 minutes of interaction(R1). Testing with a slow response is already out, this device must focus on rapid identification and notification of symptoms. Users need 2 (Real-time testing devices in classrooms or work environments).
- Be self-sufficient and have stand-alone testing and data gathering capabilities and be able to store at least 512 gigabytes of data in the device(R5). There must be no one administering the tests as this would cause unwanted contact between individuals. Not tied to a user's needs.

Interface

- A streamlined device that is intuitive to use in less than a minute of approaching the device (R11). There is a need to make it easy for the user to use the device. Not tied to a user's needs.

Non-Functional

- Set up and ready to use in less than 3 hours (R6). There is a need for this to be able to be portable and the key to portability is set up time. Users need 7 (Device must be transportable).
- Able to be sanitized in less than 5 minutes with basic sanitization tools (R7). Rapid sanitization helps guarantee user safety. Users need 2 (Real-time testing devices in classrooms or work environments) and 4 (Needs to be sanitized).
- IP-51 water and dust resistance (R8). The device must not break and a common threat to electronic devices is water intrusion. Not tied to a user's needs.

- Physically stable platform (R9). The device must be continuously usable and to help guarantee this the device needs to be resistant to falling over and being pushed over. Not tied to a user's needs.
- Cost of development must be within budget ($750) (R10). Not tied to a user's needs.

Background

From the end of the year in 2019 to now, the world has become a very different place due to the coronavirus spread across the globe. COVID-19 started in Wuhan, China quickly spreading across the globe. The virus has caused economies to shut down, travel bans to be enacted, lockdown procedures within cities, and hospitals being overworked. Across the globe, there have been over 38 million positive cases of COVID-19. There have also been over one million global deaths. In late January, the US received its first COVID-19 case in Washington. The CDC also announced in late January that COVID-19 is spread through human transmission. The virus quickly spread across the country with a shutdown of the United States occurring in March of 2020. [1]

Some symptoms of COVID-19 include:

- Fever
- Cough
- Loss of taste/smell
- Difficulty breathing
- Congestion

In early 2020, the CDC developed its first laboratory test kits. The test consists of an anterior nasal swab to collect a sample. This viral test determines if you are currently infected with the virus. Those who are displaying symptoms of COVID-19 or who have been in close contact with someone who tested positive should get tested. As lockdowns and travel bans get lifted, it is important to slow the spread of COVID-19. In order to do this, everyone must take the following precautions:

- Wearing a mask
- Social Distancing (6 feet from each other)
- Staying home if displaying symptoms
- Limit the amount of time one leaves their residence
- Wash hands/sanitize often
- Capacity limits in buildings

In order for the spread to slow down, everyone must adhere to these guidelines. In order to adhere to these guidelines and transition to going back to work and school in person, there must be a screening process for those who return to work or school. This screening process needs to test people for COVID-19 symptoms and occur before anyone enters a building. As COVID-19 has been proven to spread the most through human contact, it is urgent to not allow anyone

into a building that is displaying symptoms of COVID-19. The current screening process for businesses and universities include a Wellness Surveyor form that needs to be filled out before entering a building/campus. In order to slow the spread of COVID-19 and get an accurate reading of everyone, a health monitoring device needs to be stationed outside every building or facility that people get screened before they enter.

Different health monitoring devices measure different vital signs. The most basic vital signs monitors record pulse rate, blood pressure, and temperature. More advanced vital sign monitors can detect blood-oxygen levels or a respiration rate. Some devices use different methods for taking vital signs and some have different features in them. The purpose of this project is to create a health monitoring device that detects symptoms of COVID-19 and can be used as a pre-screening process for businesses before anyone enters a building.

Temperature Checking Methods

A simple accessible and accurate health monitoring technique is temperature monitoring. Fever has been shown to be a consistent symptom of COVID-19. This has been widely implemented throughout the world as a basic screening process for many institutions already. A fever is generally defined as a temperature above 100.4 degrees Fahrenheit. An increase in temperature is generally caused by an infection in the body due to either bacteria or virus.

Digital

When temperatures are taken orally, rectally, or through the ear often a digital thermometer is used. “A digital thermometer uses a microprocessor computer containing stored information relating to the response characteristics of a transducer to supply a measurement of temperature” [2]. This transducer is generally a thermistor, which has a resistance that varies in a known and nonlinear way. The microprocessor approximates the relationship between the change in resistance of the thermistor and the temperature of the thermistor. This change in resistance is calculated by the voltage across the thermistor which is created by a current source. This voltage is converted to a digital signal, which is then used by the microprocessor to find the temperature. This is done by relating the digital signal to a piecewise function that is stored inside of the microprocessor.

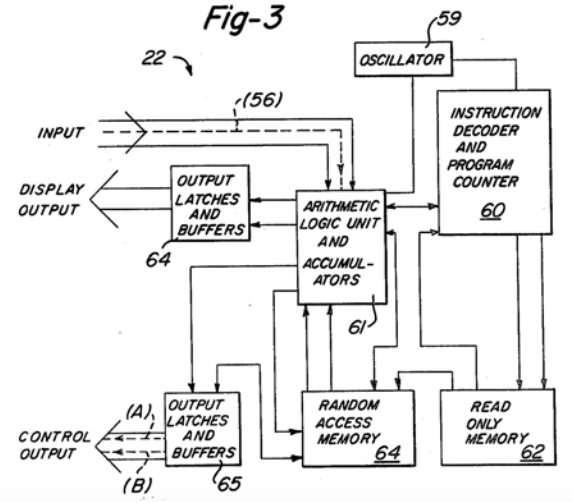


Fig. 2 (control diagram for a microprocessor within a digital thermometer) [2].

A requirement for this method is the direct heating of the thermistor. Because air is a good insulator this means direct contact of the device to the subject's body is fundamental for a successful reading.

Liquid crystal strip

Liquid crystal strip thermometers are the strips that you hold up to your forehead, after a little while you take it off and look at the color it has become. Depending on the color of the strip you can see what your temperature is. This process can seem mind-blowingly complex but in reality, it is quite simple. The strip consists of cholesteric liquid crystals, the molecules of these crystals are rods, as these rods heat up they begin to rotate. As these rods rotate they reflect different colors. This rotation is a constant relationship with the temperature of the crystal so this effect is consistent and recreatable. This rotation is not just individual rods the rods are actually stacked on top of each other almost forming a spiral staircase [3]. As the rods heat not only does their angle to each other change, but also the spacing between each one gets larger as the crystals warm. This method of temperature monitoring is effective and noninvasive however it takes a relatively long time and has a large opportunity for user error. This is due to the fact that these strips rely on conduction to work. The strip must be securely pressed against the user's skin for at least a minute to get an accurate reading and can sometimes be difficult to decipher if the user has minimal experience with the device. Another factor to be considered is that these strips must be disposable as they become contaminated by each individual that uses them. This means they would cause an ongoing cost and the monitoring station would have to be resupplied constantly with more strips.

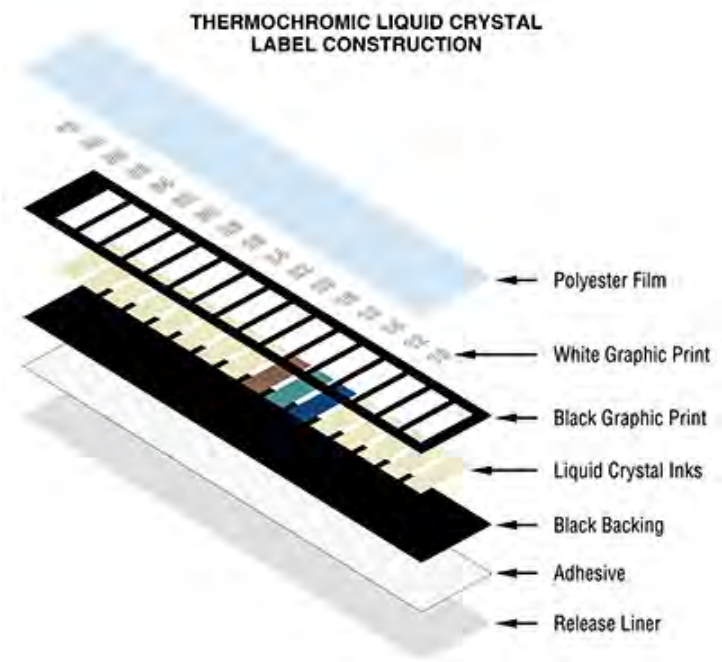


Fig. 3 (Composition of a Liquid crystal thermometer) [4]

Infrared

Infrared thermometers rely on what is called black body radiation. This is the idea that anything with a temperature above absolute zero has molecules moving inside of it [5]. The higher the temperature the faster the molecules move. As the molecules move they emit infrared radiation, this radiation increases the faster the molecules move. Infrared thermometers use a lens to focus this radiation onto a thermopile. A thermopile is a detector that converts the radiation into heat, the more radiation the hotter it gets. This heat is then converted into electricity. The more electricity the hotter the object that is being measured. This is a known relationship using this relationship the temperature of the object can be calculated. Infrared thermometers are more accurate the closer they are to the subject. Infrared ear thermometers are very accurate but require being very close to the eardrum (less than an inch away) general infrared thermometers are deemed accurate from less than 6 inches away from the subject. This allows for a contact-free method of gathering the subject's temperature accurately.

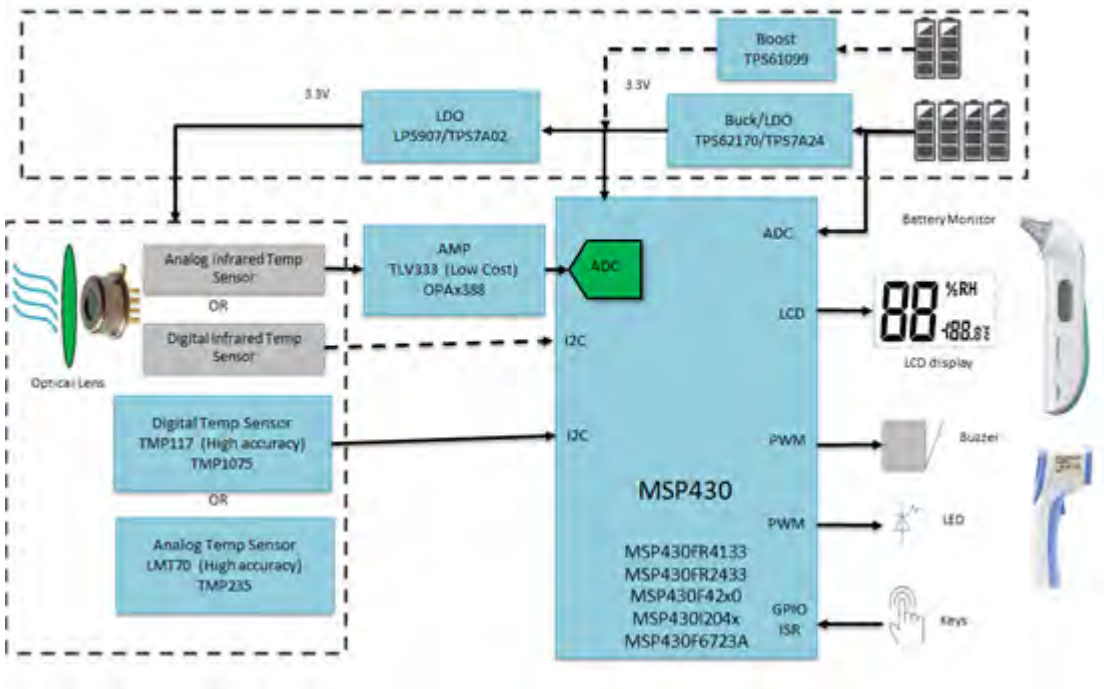


Fig. 4 (control diagram for IR Thermometer) [5]

Blood Oxygen Monitoring

To understand the relationship between COVID-19 and oxygen saturation in blood, we need to know how these levels can be related to each other. Our body extracts oxygen from the air by breathing, the air goes through your lungs where it is transferred to the bloodstream. Once in the bloodstream, “oxygen helps replace cells that wear out, provides energy for our bodies, supports the way our immune system functions and more”[6]. Low blood oxygen levels could indicate that there may be an issue with how your lungs are extracting oxygen or your circulation.

A sign that is usually related to low oxygen blood levels is shortness of breath, which is also one of the symptoms of COVID-19. The problem is that you do not necessarily have to develop shortness of breath when your oxygen saturation levels are low. There have been a lot of cases where individuals develop "silent hypoxia".

When you develop silent hypoxia, the virus attacks your lungs differently. "The air sacs in COVID-19 patients' lungs do not fill with fluid or pus as in normal pneumonia infections but rather the virus only causes the air sacs to collapse, thereby reducing the oxygen levels that lead to hypoxia in these patients but still maintains the lungs' normal ability to expel carbon dioxide. Consequently, the still-efficient removal of carbon dioxide is the reason why COVID-19 patients do not feel shortness of breath in the initial stages of COVID-19 pneumonia"[7].

Therefore, the early detection of low oxygen blood saturation is really helpful in the fight against COVID-19. It could not just save other people's lives by detecting it early, but mainly it could help save that individual from developing dangerous levels of COVID-19 related pneumonia that could kill him. Also, "early detection of COVID-19 pneumonia can prevent patients from having to be treated with highly invasive procedures such as intubation and mechanical ventilation, a procedure which currently results in an 80% mortality rate for COVID-19 patients"[7].

There are several ways we can check for the oxygen level in your blood that can help diagnose or monitor lung diseases:

Pulse Oximetry Test

This device works in a very simple way. You can use your finger, earlobe, toe, or nose to place the device and get an accurate measurement. The main principle behind this technology and why it is so reliable is that it measures how much light is absorbed by your blood. The device shines one red light and one infrared light through a specific part of the body. It relies on the concept that "blood containing higher amounts of oxygen absorbs more infrared light and lets the red light pass through it"[8]. If blood cells do not have enough oxygen they will appear bluer.

The oximeter expresses the results obtained through the process shown in Fig.4 in the form of a percentage and the heart rate. To be more precise, your oxygen blood levels should be between 95% and 100%. A change in your oxygen blood level below 92% should be concerning and it could be a sign of a lung problem. People that fall under this percentage may need further testing.

This test requires physical contact with the subject that has been tested. Therefore, it would need to be sanitized from one use to the next. It takes less than ten seconds to get the results, so it suits for rapid testing.

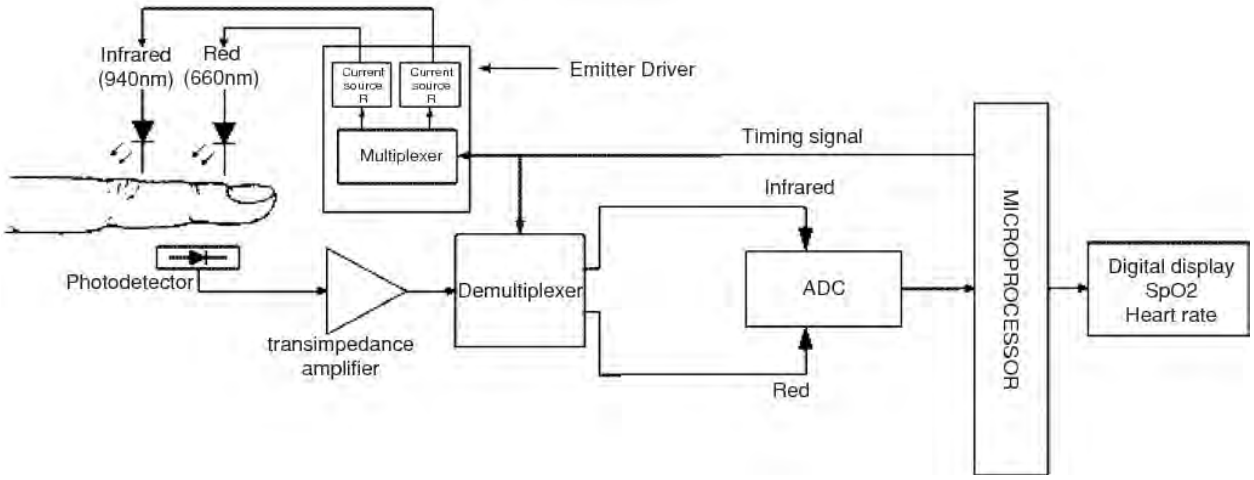


Fig. 5 (Block diagram of a pulse oximetry device) [8]

Blood Gas Test

This kind of test is more accurate, and it is usually applied after the oximetry test. It looks for how much oxygen and carbon dioxide there is in your blood. The sample of blood can be taken from your wrist called an "arterial blood gas test" as shown in Fig. 6. But it can also be taken from your earlobe and it is called a "capillary blood gas test"[9].

It requires a person to use a needle and a syringe to extract the sample of blood from the desired part of your body. The blood sample will then be analyzed by a portable machine or in an on-site laboratory and the results show the amount of oxygen, carbon dioxide, and pH in the blood.

This method takes longer than the oximetry test and it requires a person to implement it.

Fig. 6 (Arterial blood gas test) [10]

Respiratory Rate

The respiratory rate is the number of breaths someone takes every minute. A normal respiratory rate keeps in balance how much oxygen is breathed in and how much carbon dioxide is breathed out. Breathing rates below 12 or above 20 in adults are out of range for a healthy adult. To measure the breathing rate, you can count the number of breaths for an entire minute or 30 seconds and multiply that by 2. Common health concerning causes of high respiration rate include:

- Anxiety
- Fever
- Respiratory Diseases
- Heart Problems

COVID-19 attacks your lungs which can cause shortness of breath. Shortness of breath occurs when you consciously have to think about breathing because you are having trouble doing so. If you can't hold your breath, feel like you're suffocating, or every inhale makes you cough you are experiencing shortness of breath. [11]

Smell and Taste Testing

One of the symptoms of COVID-19 is a loss of smell and taste, this is due to the fact that the virus tends to infect the olfactory receptor cells in the upper nasal canal. "Now, an international team of researchers led by neuroscientists at Harvard Medical School has identified the olfactory cell types in the upper nasal cavity most vulnerable to infection by SARS-CoV-2, the virus that causes COVID-19" . The loss of taste is another symptom common among COVID-19 patients, but like the loss of smell this is linked to the virus blocking the taste receptors, this is known as "ageusia"[12].

When it comes to monitoring for COVID-19, testing for smell and taste can lead to very reliable results when paired with screening for other symptoms such as blood oxygen levels and temperature. There are already methods for testing a patient's sense of smell due to there being various smell disorders such as Anosmia, Hyposmia, and Parosmia. There are two methods that are used to test for these disorders, one where a patient is asked to detect a faint odor, and the other includes sheets with beads that contain odor and the patient is asked to scratch the beads to release the odor.[13] For each of these tests if the patient cannot detect the odor, or identifies it incorrectly there is a good chance that they have an impaired sense of smell. Odor detection is generally done by measuring a patient's threshold for odor detection, this can be done by either testing the patient's minimum odor detection threshold or their ability to differentiate different odors from odorless air.[14] The method of testing for a patient's minimum odor detection is a very sensitive but time-consuming method of comparing a patient's minimum odor detection rate to the normative data of other individuals. The less time-consuming method involves odor detection rather than the minimum detection threshold, this method involves presenting a patient with various odors and having them identify the odor from a bank of various names describing odors (such as chocolate, roses, lemons, etc). Their performance in this test can then be compared to other individuals within their age range in order to determine the proficiency of their sense of smell, if their score lands below the average score then it shows that they have a current lack of sense of smell.[15]

When it comes to our project and our requirements, we require a method of screening smell that is quick but also effective. Listed above are two versions of the test, the odor test, and the scratch and sniff test, then there are the two forms of achieving those results, one where the patient is screened for minimum detection rate, and the other where the patient is asked to detect odors and then the data is compared to other individuals. One method that might be worth looking into more, is using an odor dispenser, having the patient identify the scent, and comparing the individual's ability to identify the scent correctly to other individuals.

Waterproofing Standard (IP rating)

The standard for measuring a product's resistance to water and other contaminants is known as an IP rating or *Ingress protection rating*. This rating consists of the letter *IP* followed by two numbers, the first digit refers to the products resistance to intrusion from solids and is on a scale of 0-6, a 0 being "not protected" and a 6 being "dust tight".[16] The second rating refers to the product protection from the ingress of water and is on a scale of 0-8, a 0 being "not protected" and an 8 being waterproof in "immersion beyond 1m".[16] These two numbers are then combined represent how well a product can keep foreign objects and water out, an example of this would be "IP68"

IP Ratings Chart			
Protection Against Solids		Protection Against Liquids	
First Number	Defintion	Second Number	Defintion
0	No Protection	0	No Protection
1	Protection against solid objects over 50mm (e.g. hand)	1	Protected against falling drops of water (10 minutes, 1mm rainfall per minute)
2	Protection against solid objects over 12mm (e.g. finger)	2	Dripping water, tilted 15° (10 minutes, 3mm rainfall per minute at 15° from vertical)
3	Protection against solid objects over 2.5mm (e.g. tools or wire)	3	Spraying Water (5 minutes, 0.7Lpm at 60° from vertical, P=80-100 kPa)
4	Protection against solid objects over 1.0mm (e.g. small tools or wires)	4	Splashing Water (5 minutes, 10Lpm at any angle, P=80-100 kPa)
5	Protected against dust - limited ingress (no harmful deposits)	5	Water Jets (3 minutes, any angle, 12.5Lpm, 30kPa at a distance of 3m, nozzle 6.3mm)
6	Protected against dust - fully protected/sealed	6	Powerful Water Jets (3 minutes, any angle, 100Lpm, 100kPa at a distance of 3m, nozzle 12.5mm)
		7	Immersion (30 minutes, between 15cm and 1m)
		8	Immersion (long periods of immersion under pressure)

Figure. 7 (IP Ratings) [17]

Based on our requirements, we need a design that is rainproof and should not let any foreign objects, such as dust into the components. According to our customers' needs, the device must be able to rapidly screen multiple individuals consecutively, with this in mind, the device must be resistant to routine cleaning, because of this the device must have very minimal protection to ingress from a liquid. One of the factors that go into the IP rating of our device that isn't in our customer's needs, is protection from rain due to the fact that the device may be stationed outdoors. According to the IP rating chart, our device needs an IP rating of IP41, this means that it prevents ingress from objects greater than 1.0mm, and can protect from raindrops (10 minutes, 1mm rainfall per minute).

How do we achieve this rating, first of all in order to protect from ingress of objects greater than 1.0mm, all that is required here is a casing that can protect from anything that might damage the internal components. When it comes to protecting from rain, this is not something that needs to be over-engineered, as long as the seams between different panels are tight then minimal water can get into the device. As a safety cushion, it might be worth looking into rubber seals that can be slotted in between panels to prevent the ingress of water.

Other Health Monitoring Devices

There are many health monitoring devices already present in the world around us. Understanding these and what they do helps show what people want to know and how it can be used to improve the health and safety of society.

Oura Ring

One of the best health monitoring devices on the market is the Oura ring. This company has partnered with the NBA and has been used to keep players safe while in the bubble. It has many functions from monitoring sleep to body function and nutrition usage. The Oura ring monitors when the user goes to sleep, how long they were in different types of sleep (deep sleep, REM). As well as how long the user was asleep and when they woke up. The Oura also measures health in a multitude of ways. This includes Body temperature, heart rate both resting and active and heart rate variability alongside respiratory rate. Another set of features that the Orua possesses is its activity monitor, this monitors calories burned through active activity and passive calories burned [18]. It also measures active time and rest time along with steps taken throughout the day. The feature that means the most for monitoring possible COVID-19 contact is temperature. All of the other features of the Oura ring are not really applicable to COVID-19. The biggest benefit that a technologie such as the Oura ring serves in respect to COVID-19 has nothing to do with what it monitors, it's helpful because it is constantly monitoring and can give up to date information about the users health whenever required.

Fig. 8 (picture of the Oura ring) [18]

Hospital Check-in Testing

Electronic vital sign monitors have been in hospitals for years. The most basic monitors show your heart rate, blood pressure and body temperature through sensors that wrap around your arm, clip to your fingers, or go under your tongue (depending on the model). More advanced monitors can also show your O2 levels and your breathing rate.
Normal readings are as follows:

Heart rate: 60-100 BPM
Blood pressure: Systolic (Force on arteries at heartbeat): 100-130
Diastolic (Force on arteries at heart rest): 60-80
Temperature: Just under 98 to just over 99 F
Respiration: 12-16 breaths per minute
Pulse Oximetry: Anything below 90

If one or more vital signs start rising or falling outside normal levels, the monitor will sound a warning with a beeping noise. If there is a sudden spike or drop in vital signs, the warning will shift to an alarm and may be louder or faster. [19]

Basic combined health monitors include these specifications:

1. Digital LED display
2. Measures and displays BPM
3. Non-invasive blood pressure monitoring
4. EMR (Electronic Medical Record) connectivity
5. Records respiration rate
6. Oxygen saturation
7. Dual temperature [20]

An example of a general vital sign monitor is the Mindray Accutorr 3 produced by the company Mindray. It is a lightweight, portable monitor that can be transferred around a hospital easily that

measures temperature, pulse rate, blood pressure and SpO2 levels. The monitor also signs data into an EMR. Key features include:

1. Carrying handle
2. Li-ion battery for 22 hours of use
3. Standard RS-232 communication to EMR solutions
4. Mounting options for wall mounting or a rolling stand
5. LCD screen
6. Weight: 1.9 kg [21]

Questions asked when checking into a hospital:

1. Why are you here today?
2. Are you in any pain?
3. What medications do you currently take?
4. Are you allergic to any medications?
5. Any pre-existing conditions?

Apple Watch Series 6

The new Apple Watch is one of the leading devices in fitness monitoring. It focuses on monitoring your health while exercising and also resting. The purpose of this device is to calculate throughout it several sensors how well you are performing while exercising. It calculates the active calories and passive calories that you burn while you have the watch on. Its exercise app has several settings that vary depending on the specific workout that you are doing. Through its intelligent software it is capable of adjusting depending on the settings and obtaining the most accurate evaluation of the workout that the customer does.

Fig. 9 (picture of Apple Watch Series 6) [22]

This is a really powerful watch that records your oxygen saturation levels, your heart rate, and altitude within other sensors. The combination of all the sensors combined helps the watch understand how much physical effort you have put throughout the day and while doing a workout. Besides all these health features, the watch has a lot more to offer. It has internet connectivity and Bluetooth that allows it to connect with other devices and get more precise measurements of how much you move. Also, it offers an infinite amount of features like phone calling or listening to music.

However, this watch is not meant to detect or indicate any possible COVID-19 infection. It can monitor crucial symptoms for COVID-19 according to the CDC standards, but it does not use the data to deliver any diagnosis. Besides not being designed for COVID-19 screening, this watch would not be feasible for screening a large group of people. The watch cost would make it impossible to control a large group under a specific budget given that it will require one per customer. Finally, the watch also does not follow our requirements given that it does not measure the body temperature and the cost is too high.

Self-Monitoring Spreadsheets/ Daily Surveys (JU Survey)

The daily survey sent out by some institutions is based on the honesty of the recipient in order to be filled out. The purpose of this survey is to acquire crucial information that will be used to determine if you are eligible to come to campus or the workplace. The baseline of these questions varies from if you are going to be on-site that day, to if you feel any symptoms as shown in Fig.4-6. There are several ways this survey is performed.

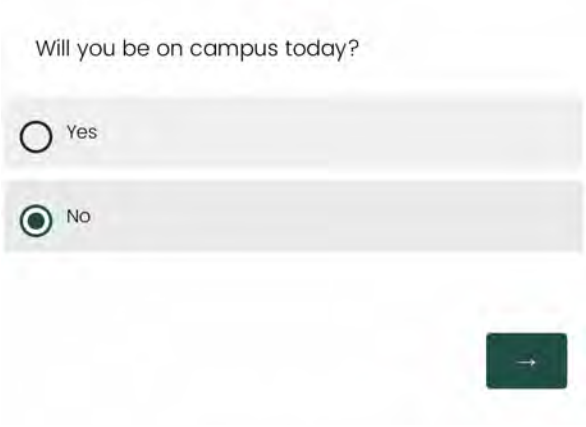


Fig. 10 (Survey example)[23]

Fig. 11 (Survey example)[23]

Fig. 12 (Survey example)[23]

Some sports teams have a spreadsheet that is shared with the people of your team. In order to fill out the spreadsheet, you have to use a thermometer to measure and share your body temperature in the mornings. You also have to specify if you have been in contact with any person or show any symptoms as shown in Fig.12.

10/5/2020			
Temperature Check	Symptoms Y/N	List Symptoms	Covid Contact?
98.4	N		N
97.9	N		N
98.5	N		N
97.7	N		N
98.2	N		N
98.2	N		N
97.2	N		N
97.7	N		N
97.8	N		N
98,7	N		N
98.6	N		N
98.1	N		N
98.4	N		N
97.6	N		N
97.6	N		N
96.1	N		N
98.1	N		N
97.6	N		N
97.3	Y	Sore throat	N

Fig. 13 (Spreadsheet example)[24]

Other institutions tend to send out an email or a text with a link asking people to answer critical questions that are used to determine if you are eligible to go to the workplace or campus. This method helps you protect your personal information so it is not shared with other people. The questions format looks like Fig.11-12 where the answers are multiple-choice and it does not require inserting your temperature.

These two different methods work on a large scale, but they rely a lot on people's honesty. Also, it relies on people's ability to access the survey and take their temperature. We do not know what financial situation each person requested to answer the survey or spreadsheet has.

Take Away

As research on COVID-19 continues the demands and mitigations caused by the virus will change as well. It is crucial we design a health monitoring device that must be better than the current screening procedures, detect the most common symptoms of COVID-19, and be able to be posted outside of buildings to be used by those entering. The most effective sensors our health monitoring device will need to have in order to adhere to the limitations of COVID-19 are an infrared thermometer, a pulse oximetry sensor, and an odor test. These sensors correlate with the most common symptoms of COVID-19 and can help mitigate the spread of COVID-19 in close contact areas.

As the temperature is a key symptom of COVID-19 is a fever. There are many ways to measure temperature including digital, liquid crystal, and infrared thermometers. However, one method stands out for its sanitary methodology. Infrared thermometers are accurate at a distance of six inches away from the subject. This provides a sanitary and accurate way to measure temperature.

Oxygen blood level monitoring is a necessary measurement in order to have a reliable monitoring device. It helps prevent invasive procedures such as intubation and mechanical ventilation that is directly related to COVID-19. Measuring oxygen blood saturation allows us to predict upcoming pneumonia that reduces your survival opportunity.

We analyzed different methods where you can get your oxygen in blood levels plus your heartbeat. The method that met our requirements was the pulse oximetry test. This test requires sanitizing between uses but provides a response in under ten seconds. Speed is crucial for our product and it fits our final design goals.

A health monitoring device is not required to test respiration rate considering it can be measured simply by counting how many times you breathe in a minute. A spirometer can assess how well your lungs work, but it is typically used for patients who have asthma, COPD, or other lung diseases. This test also requires you to place a tube in your mouth and is completed in under 15 minutes. Due to this, this test would not be suitable for our health monitoring device.

When it comes to testing an individual's sense of smell there are two methods that can be utilized, using an odor, or a scratch and sniff tab, both have their pros and cons in our application. The overall method that will be utilized, is presenting the user with either the odor or scratch and sniff and then prompting them to identify the scents on the device's UI. The pros of using the odor method is that the device will dispense the odors towards the user thus making it very hands-off, conversely, the odor being presented to the user may cause them to sneeze onto the device which would not be very sanitary especially with COVID-19 concerns. For the scratch

and sniff method, the disadvantage is that the user will have to touch the device in order to extract the scratch and sniff tab, but the fact that the user does not get the odor sprayed into their face will reduce the risk of them sneezing onto the device.

When a product is being designed it needs to meet a certain standard of permeability to ingress particles and liquids, this is known as an IP rating "*Ingress protection rating.*" This rating consists of two digits, the first digit refers to the product's permeability to ingress of particles, the second digit refers to the products ability to prevent ingress from liquids, these are both on a scale of 0-8 and an example of an IP rating would be IP35. Based on the relevant work, the device will need to prevent ingress from objects greater than 1.0mm, and protect from raindrops (10 minutes, 1mm rainfall per minute), which gives it an IP rating of IP4.

There's a lot to be learned from the consistent monitoring performed by wearable health products. A powerful wearable product is the Oura ring. This device has been utilized by the NBA as well as many individual users. It monitors multiple factors however most do not apply to COVID-19 screening, the most important for this purpose is temperature monitoring.

The Apple Watch is a very powerful tool that also measures your oxygen blood levels and heart rate. Its main purpose is not to check whether you are infected or not, it focuses on monitoring your health through your fitness activities. For this reason and the price that it is on sale, we have decided that it is not an option for our device.

Hospitals use a variety of health monitoring devices, but the ones that check the most common vital signs can serve as a good foundation for our design of a health monitoring device. The Mindray Accutorr 3 for example is a simple vital sign monitor that can help us figure out what engineering specifications we would need for our design. Also knowing the ranges of the vital signs of a healthy adult can help us determine when the alert system for our device will need to go off.

The self-monitoring survey or spreadsheet is another method that we evaluated for our final design. It would be perfect for getting a fast response from a large size group. One of our strongest requirements was accountability on the results. Through these methods, people can lie about their symptoms or not have the opportunity to measure them properly. Therefore, we have decided to leave this monitoring method outside of our final design.

The overall research has made us explore all our options for the final design of the product. We have used our requirements to match the most suitable test that we can run on a person to find an accurate and reliable response. The selected tests will help us detect possible COVID-19 infections and slow the spread of the virus.

Concept Generation

Introduction

The concept of this project is to design a health monitoring device that can detect popular symptoms of COVID-19. The three most common symptoms of COVID-19 are fever, loss of smell, and shortness of breath, which relates to blood oxygen levels. Our health monitoring device must have sensors that can detect these three symptoms. The most effective sensors our device will need must limit the number of times someone will touch the device while still taking accurate readings.

We used a Morphological Analysis to generate several concepts that we could use to get the most accurate test. First, we had to define the standards on what to check. Based on the customer needs and requirements combined with the symptoms that the CDC recommends we determined that the device needed to check the temperature, blood oxygen levels, pulse rate, and smell. We recognized that current health monitoring devices lack complexity. In order to find the standards on what to check we did research on the types of tests, or symptoms that can help us predict a possible COVID-19 patient. Once we found several ways to monitor symptoms, we had to down select which ideas were the best and most suitable for a task like ours that were being in use. Finally, we concluded that the most suitable measurements that would satisfy our needs would be a combination of several testing options. This helped us determine the sensors that can help us achieve our goal.

Functions/Potential solutions	Potential solution 1	Potential solution 2	Potential solution 3	Potential solution 4	Potential solution 5
Measure temperature	Digital thermometer ■	Infrared thermometer ●	Liquid crystal strip	Oura ring	Mindray Accurtorr 3 ▲
Measure blood oxygen levels with pulse rate	Apple Watch ■	Gas blood test	Pulse oximetry test ●	N/A	Mindray Accurtorr 3 ▲
Measures odor	Scratch and sniff test ●	N/A		Odor dispenser ■ ▲	N/A
Power source	Connect to the wall ●	N/A		Portable battery ■ ▲	N/A

Concept 1 = ■ Concept 2 = ▲ Concept 3 = ●

Fig. 14 (Morphological Analysis Chart)

Overall Concept 1

According to the morphological analysis chart (Fig.14) concept 1 will include a digital thermometer, an Apple watch, and odor dispensing method for testing the sense of smell. This concept will require the implementation of an app into the Apple watch, this is the most streamlined way to include the digital thermometer and the odor dispensing device into the system. The best way to incorporate this is with the use of Bluetooth. This concept will require

each individual in the organization using this device to own or be provided an apple watch, the reason an apple watch is being used is that it has a function that can detect a user's blood oxygen levels. The two main components of this concept are the Apple watch and module that includes both the digital thermometer and the odor testing device. The beauty of using an Apple watch is that it serves a dual purpose, a sensor for blood oxygen levels and a GUI. In order for the Apple watch to serve as a GUI, there will need to be an application developed that will allow the user to interface with the other sensors, as well as showing results to the user. This application will interface with the other two sensors via Bluetooth, this is the most practical method as the Apple Watch has a built-in Bluetooth transmitter/receiver. The other two sensors will be contained in a module that incorporates the digital thermometer, the odor tester, and a Bluetooth transmitter for communication with the Apple watch/GUI.
In terms of power, this concept is going to use a portable battery, this is due to the fact that one of the requirements is for a portable device. A battery will allow the device to be transported and placed nearly anywhere, with the only drawback being battery life.

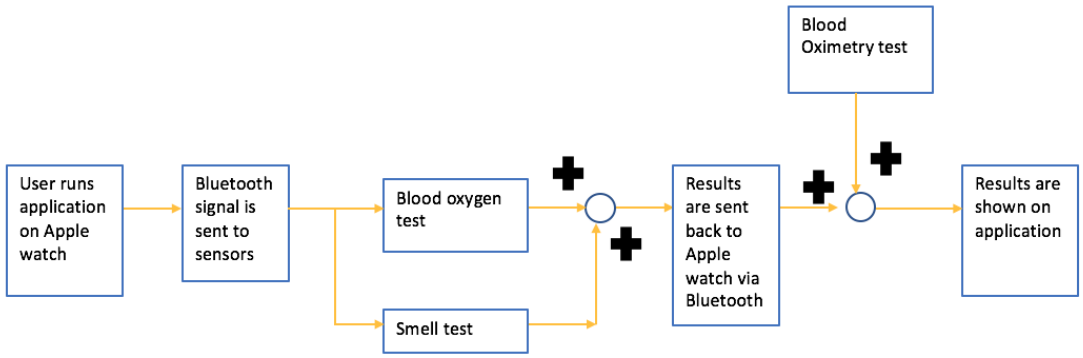


Fig. 15 (Block diagram- Concept 1)

Overall Concept 2

The Sentinel's goal is to create a safer environment for everyone that has to interact with other people in work, school, or practice environment. In order to facilitate it, we came up with a series of tests that combined will create a set of standards that anyone who buys the product can check. It does so by obtaining the patient's temperature, blood oxygen saturation, heart rate, and sense of smell. This device uses the combination of a device that already exists called Mindray

Accutorr 3 to collect the temperature, oxygen saturation, and heart rate combined with our own odor dispenser test. It collects the data for each individual and compares it to the CDC's standards for COVID-19 symptoms. Each sensor would be weighted equally to come to a final outcome of "Pass or Fail". Each sensor is going to have the same weighting; therefore, if one or more of the sensors does not comply with CDC's standards you fail. If you fail you should get tested for COVID-19.

For the overall concept two, there is an input voltage that will power the whole system coming from a portable battery. Then, Mindray Accutorr 3 is going to analyze the temperature, heart rate and oxygen saturation of the customer. At the same time, our odor sensor will start working. An actuator will spray a fragrance several times into a piece of paper. The customer has to collect the paper strip and sniff the fragrance. A display will ask you what odor can you smell, and you have to select which fragrance is the correct one. All the data will be sent to the microprocessor that will analyze the data. Once the data is analyzed and follows the CDC's standards, it will send a fail or pass the signal as an output.

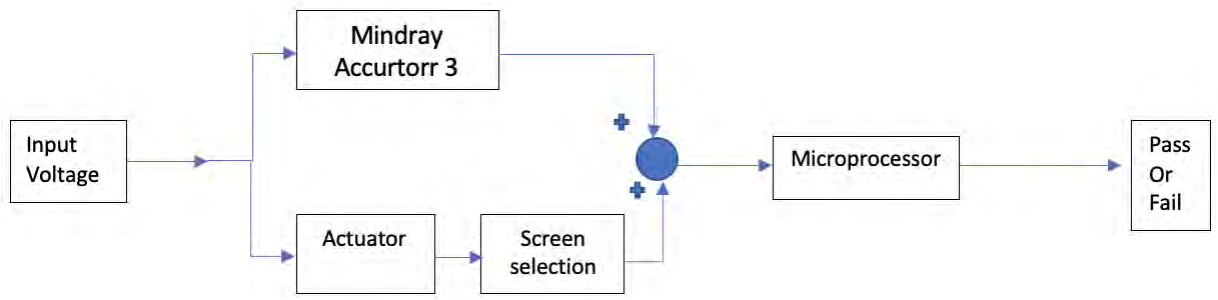


Fig. 16 (Overall concept 2 block diagram)

Overall Concept 3

The goal of the Sentinel is to evaluate whether or not the subject has a high possibility of being COVID-19 positive. This is done by evaluating three common symptoms, temperature, smell, blood oxygen levels. For more accuracy blood oxygen is compared against a subject's previous screenings performed by the Sentinel using the microprocessor 1. If a drastic decrease from their average is sensed then this is deemed to fail. The blood oxygen test is the most reliable and accurate so this is weighted more heavily (by a factor of 3). The next best is

temperature and is moderately weighted (by a factor of 2). The least accurate is smell test so this is weighted the least (by a factor of 1). If a subject fails the smell test they are given a score of -1, -3 if they fail blood oxygen and -2 if they fail the temperature check. If they pass, they are given the same score but a positive value. In order to achieve an overall pass the subject must get a score of at least 1. If a score of 0 is achieved this is seen as a reason to be cautious. All the scoring is made by the second microprocessor that also generates the different lights. If the subject passes a green light is displayed if they fail a red light and if they get a score of 0 a yellow light. The reaction to each result will be deemed by the organization that implements the Sentinel.

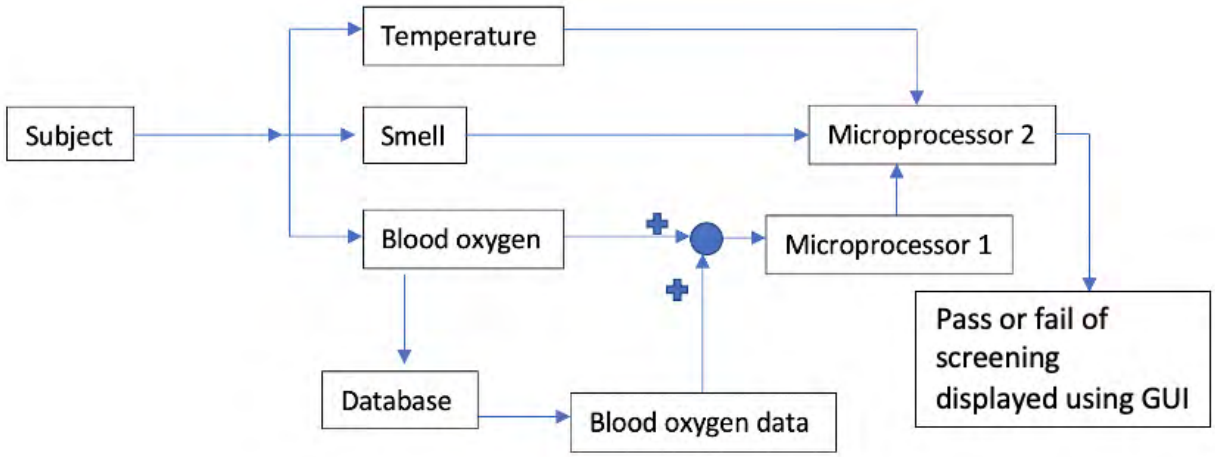


Fig. 17 (Concept 3 block diagram)

Concept Evaluation (Pugh Chart)

The following are the types of sensors our design will have:

- Temperature
- Blood oxygen levels & heart rate
- Odor test for sense of smell testing

Our health monitoring device will need these capabilities to work together to create one overall reading on someone entering a building. There will also need to be a screen or a way of recording the readings and an alert system to notify the user if their symptoms are out of range.

Once we have generated the concepts we are going to use for our project, we had to evaluate which concept would work better. In order to achieve the best results, we used the Pugh chart. This methodology compares the concepts using a system of better, same, worse than the scoring system. This chart is comparing the attributes of each individual system to a self-reporting COVID-19 survey. A score of 0 means that the concept is below the baseline of the survey. A score of 1 means that the system is equal to a self-reporting survey, and a 2 means that the system is superior to the self-reporting survey.

Criteria/Concept	1	2	3
Sanitation	0	0	2
Human Contact	1	0	1
Instant Results	1	1	1
Resistance to water/dust	1	1	1
Accuracy of results	1	1	1
Weight	2	0	2
Complexity of device	0	1	2
Price	0	0	1
Total points	6	4	11

Fig. 18 (Pugh Concept Generation Chart)

The final concept includes the weighting and lighting criteria from concept three. Microprocessor 1 utilizes the old data of the subject's blood oxygen levels with the reading from this evaluation to garner an accurate interpretation of the subject's health. Microprocessor 2 performs the weighting action and computes the output which is a light. Red if the user gets a negative score, yellow if a 0 is achieved, and green if a positive value is determined. The cost, sanitation, and simplicity of design 3 made it stand out from the other two concepts.

Sensor functionality

In the sensor functionality, we analyzed each sensor from the concept selected. Here we explain how the sensor properly works to get a better understanding of the Sentinel.

Temperature

While there are many ways to measure a subject's temperature one stands above the rest for the purposes of the Sentinel. This is an Infrared thermometer. Infrared thermometers rely on what is called black body radiation. This is the idea that anything with a temperature above absolute zero has molecules moving inside of it [25]. The higher the temperature the faster the molecules move. As the molecules move they emit infrared radiation, this radiation increases the faster the molecules move. Infrared thermometers use a lens to focus this radiation onto a thermopile. A thermopile is a detector that converts the radiation into heat, the more radiation the hotter it gets. This heat is then converted into electricity. The more electricity the hotter the object that is being measured. This is a known relationship using this relationship the temperature of the object can be calculated.

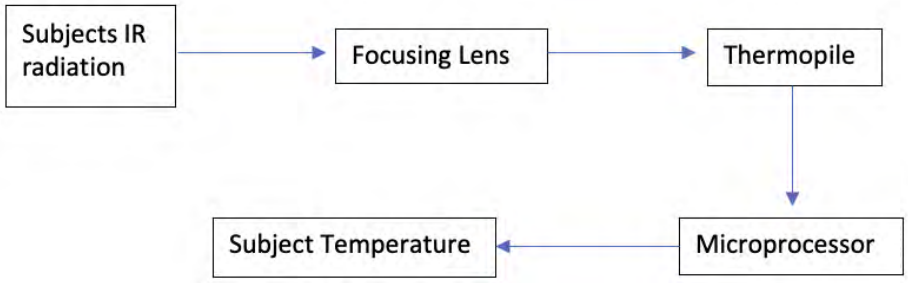


Fig. 19 (Infrared thermometer block diagram)

Pulse Oximetry

There are several ways we can monitor your blood oxygen levels, but we have chosen the pulse oximetry test. This test is performed by a “clip-like device called a probe that is placed on a body part, such as a finger or ear lobe. The probe uses light to measure how much oxygen is in the blood” [26]. This technique widely spread for the study of blood saturation is called Photoplethysmography.

It works in a very simple way. The probe has two light bulbs; one shines infrared light, and the other shines red light. Both lights go through your skin; they get reflected, absorbed and scattered in the tissue or blood. On the order side of the probe, there is a photodetector that measures the emerging modulated light. You can measure the light by “calculating the difference

in the ratio of the wavelength received to the one emitted" [27]. From this data, we can determine the blood saturation levels and the patient's heart rate. This data is then displayed on a digital display within seconds of running the device.

The oximetry test block diagram will have an input voltage for the device to work. Once the device is powered and the subject places the finger in the probe, the test will start. The microprocessor sends a timing signal to the emitter driver. The emitter driver following that timing signal will produce two frequencies of light. The red and infrared light will have a set frequency that will vary with the disturbances encountered in the bloodstream and will be received by the photodetector. Then the signals from the photodetector go through the transimpedance amplifier which converts the current output into a signal voltage. Once the signals are separated by a demultiplexer into red and infrared, they are converted by an analog-to-digital converter (ADC). This digital signal is then analyzed by the microprocessor that expresses the result in the percentage of oxygen in the blood and the heart rate.

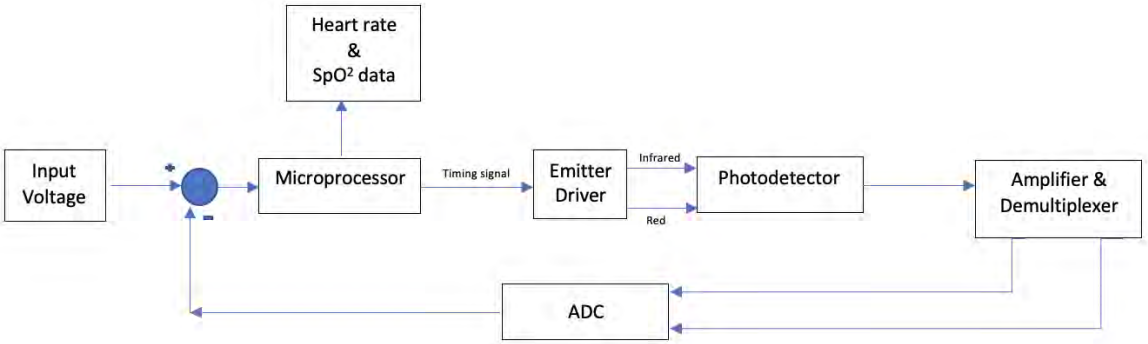


Fig. 20 (Pulse oximetry test block diagram)

Smell Test

Testing an individual's sense of smell is a complex task with various procedures available for use. In our research, we came across two methods of screening someone's sense of smell, the first being a lowest threshold test where the patient is asked to detect a faint odor. The other one asks the patient to identify various odors from a bank of odors, their aptitude for smell is based on how well they identify the odors, and this result is compared to the mean of individuals in the same age range, in order to determine how good their sense of smell is.

According to the Pugh chart, the Scratch and Sniff method is a better application for the device compared to the odor test. The advantage of using this method is a reduced risk of the individual sneezing onto the device and a more efficient use of resources. The layout of the

concept is very similar to the odor system, with the exception odor release method, instead of using cans that dispense odor, there are scratch and sniff tabs that are dispensed to the individual.

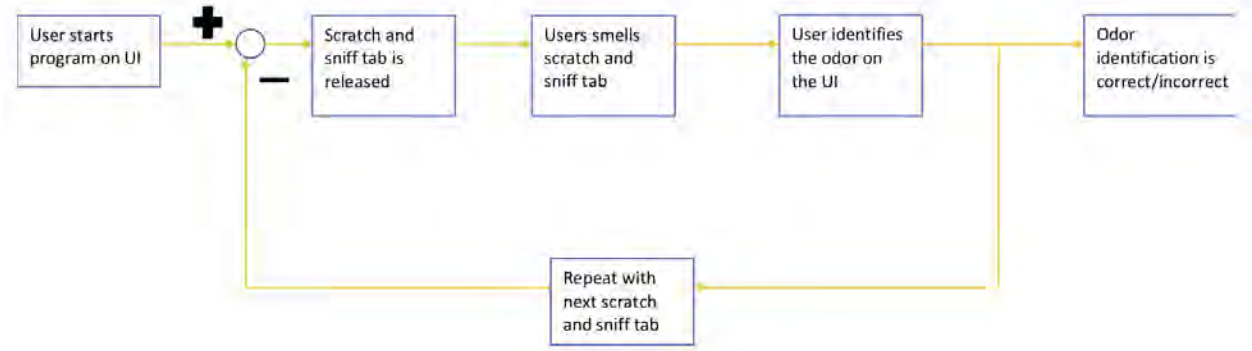


Fig. 21 (Block diagram- Scratch and Sniff)

Detailed design

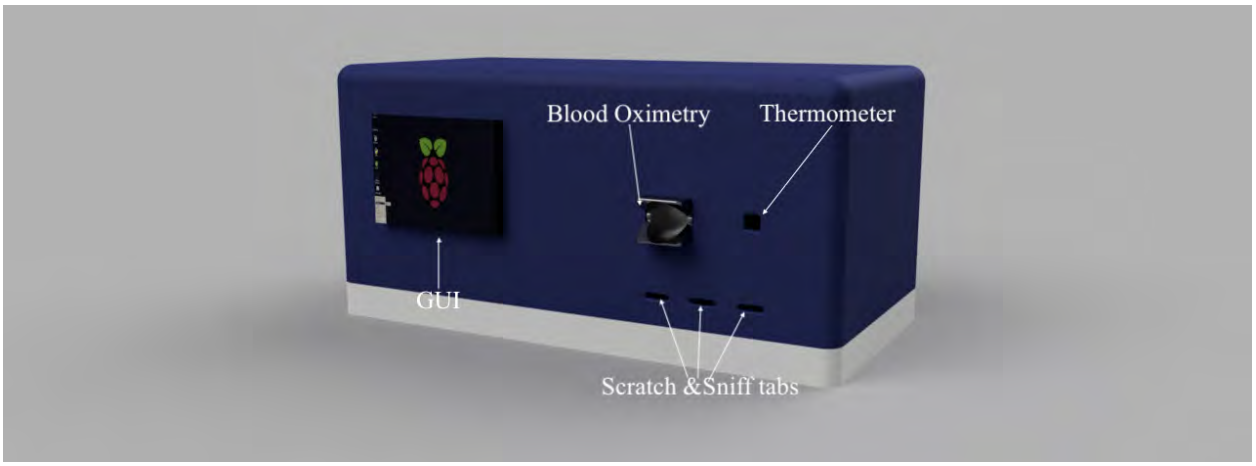


Fig. 22 (Sentinel Prototype)

Introduction

The goal of the Sentinel is to be able to screen individuals for COVID-19 symptoms in order to determine the likelihood that they may have COVID-19. This is achieved by running three different tests on an individual that screen for three common COVID-19 symptoms, temperature,

blood oxygen levels, and smell. This device will need to be sealed off, must be easy to maintain, sanitary, as well as be capable of cooling the hardware.

Functionality of the design

For the sentinel to work we need a simple and secure design for all the components that are going to be placed inside. Starting with the casing, our preliminary design has a box shaped case. This allows us to have a compact design that can withstand any weather hazards or any falls due to mishandling the Sentinel. This case has to be made from a light material that is waterproof. All the sensors are mounted on the case in a way that prevents damage from outside elements. The side of the Sentinel will be a lid that will have rubber sealing to provide protection against water or dust splashes. In order to provide a comfortable device that is easy to transport it will have a handle on top or any kind of nodge to facilitate transporting it.

Inside the Sentinel, there are several components that are crucial for the proper functioning of the monitoring device.

- Current source: for the Sentinel we will have to be connected to the wall. By doing this we will ensure that the weight of the device is within the requirements. Regarding water and dust resistance we will mount the cable that comes out of the shell of the Sentinel. It will reinforce the junctions between the device and the power source. Having a cable connect to the device will create an extra and unnecessary access point out the inter components that could get corroded or water in the electrical system.
- Sensors: each sensor will be placed and interconnected inside the shell of the Sentinel. Ensuring that they do not get damaged by any external conditions. For the infrared thermometer, the mlx90614 gathers the temperature of the customer and shares it with the microprocessor. The oximetry test will be performed by the SEN 15219 and will send all the data to the microprocessor. Finally, the smell test will be done by our design where the scratch and sniff tabs will be released by a servo mechanism.
- Memory: the memory size will vary depending on the size of the company, school, or team. The greater the amount of people that has to be screened, the more data that will have to be collected. All the information collected will stay in the system and could only be accessed by the institution that acquires the Sentinel. The sentinel will need to have an ample amount of memory, as it will have to store data of many individuals over a period of time. It will have a minimum of 512 gigabytes.
- Cooling: in order to keep all of these electrical devices from overheating we will need a cooling system. The most energy efficient way to cool the system is through a ventilation fan. This fan will be placed on one of the sides of the shell. To prevent water intrusion we

are considering building a tunnel that will connect the fan at a higher altitude from the hole on the shell. By doing this we are using gravity to avoid any water coming into the device. Also, we want to include a simple filter to prevent dust from coming in.

- Interface: The goal of the Sentinel is to provide an intuitive experience for the users, The best way to do this is by implementing a touch screen into the design. This will allow the user to efficiently interface with the program, and will also be able to display the vitals that are being tested. It will be able to show the user their temperature and their blood oxygen levels as well as how well they score on the smell test. (Fig. 23) shows a potential GUI on the Sentinel. On the Sentinel the user interface will display a start button to run the program, once this has been set in motion, it will run through each of the tests and display the results to the user. Once all the tests have been run, the GUI will display the overall results to the user.

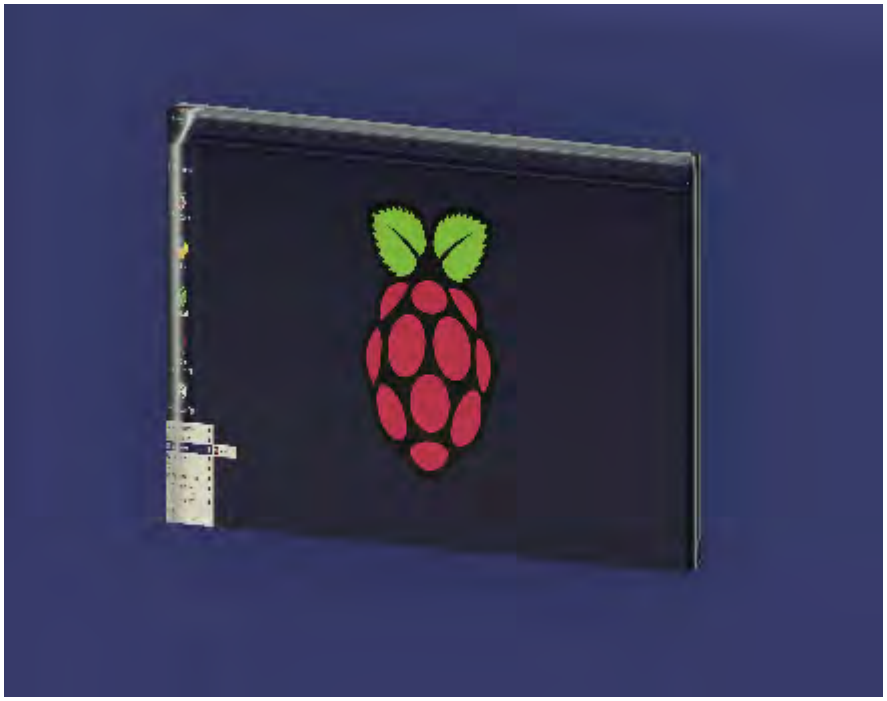


Fig. 23 (GUI)

- Servos- In order for the scratch and sniff tab system to work there must be servos involved. These servos will be in an array of three and will be tasked with rotating the reels that the scratch and sniff tabs are attached to. (Fig. 24) below shows a potential servo configuration in the Sentinel.

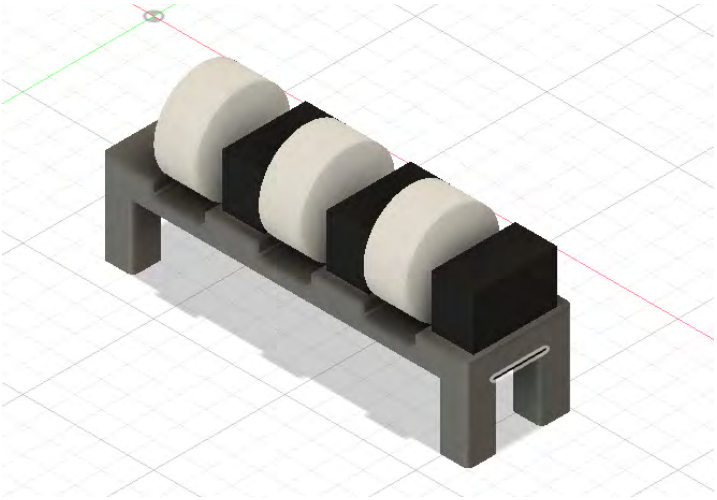


Fig. 24 (Scratch and Sniff Servo mechanism array)

Control loop

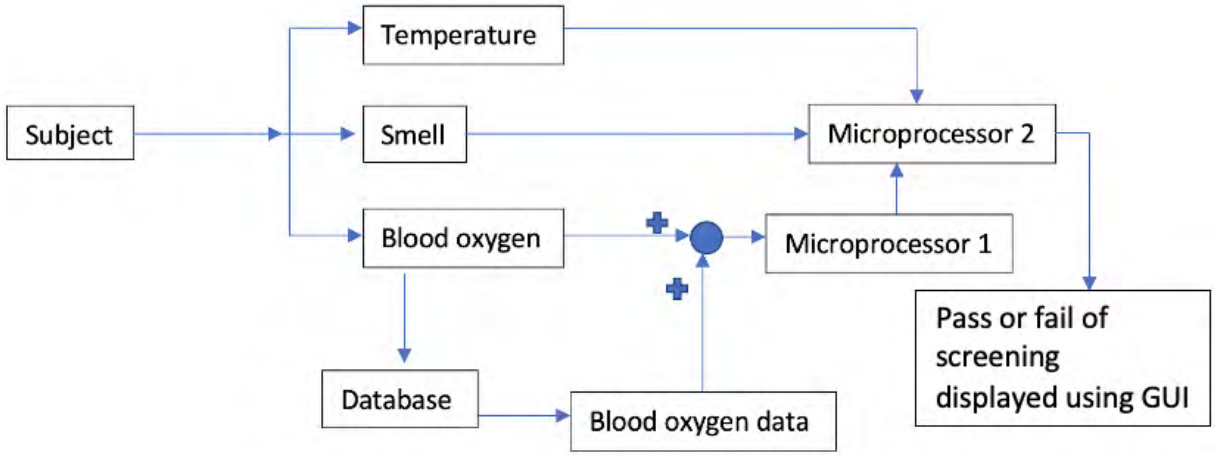


Fig. 25 (overall control loop)

The testing loop is started by the subject, this is followed by a prompt for them to utilize the infrared thermometer. The infrared thermometer is turned on when the user is prompted the process of the infrared thermometer can be seen in (Fig. 25). Once the thermometer gets a reading the user is alerted using an auditory alert. Next the Sentinel prompts the user to utilize the pulse oximeter, when this prompt is performed the pulse oximeter is turned on. The process that the pulse oximeter uses can be seen in (Fig. 4). When the pulse oximeter garners an accurate

reading the user is again notified via an auditory alert. Following this the user is given instructions for how to perform the smell test, utilizing scratch and sniff tabs. After the user inputs their answers to the smell test the Sentinel utilizes the data found at this screening and previous screenings to compute a score which is then displayed on the graphical user interface (GUI).

Inputs and outputs

Temperature

The inputs into the infrared thermometer are voltage and infrared radiation, this radiation is then focused using a focusing lens. This infrared radiation is directed onto the thermopile which converts the radiation into an output voltage. This output voltage is converted to a temperature using a microprocessor, by utilizing the known relationship between the output voltage of the thermopile and the temperature of the subject.

Smell

In the process of testing an individual's sense of smell is relatively complex when compared to the other functions of the Sentinel. This function will work by presenting the individual with scratch and sniff tabs of various scents, and having the individual identify the scent on the Sentinels GUI. This system will be composed of three main components, the scratch and sniff tabs, the servos, and the GUI. Once the program is started the first scratch and sniff tab will be presented to the individual. This will occur when a signal is sent via the operating system to the servo, the servo will rotate a reel that holds all of the scratch and sniff tabs of a certain scent, by rotating the reel a single tab will be presented to the user like a cashier receipt. The user will smell the tab and then will be presented with four different scents on the GUI like a multiple-choice exam question. They will then repeat this with two additional scents.

Blood oxygen & heart rate

The pulse oximeter is a relatively simple element in our design. It consists of several parts: microprocessor, multiplier, current source, photodetector, transimpedance amplifier, demultiplexer, and an analog-to-digital converter.

It all starts with the microprocessor getting a voltage input and sending a timing signal to the multiplexer. The multiplexer is in charge of making sure that the light emitter diodes send the light wavelength at different times. The reason behind the use of the multiplexer is that there is only one photodetector, and it can only measure one signal at the time. Therefore, the signals must be multiplexed [28]. Once the emitters are timed, they send different wavelengths. One of them emits a 660 nm wavelength which is equivalent to the red LED. The other LED sends a 940

nm wavelength that is equivalent to the infrared light. The different multiplexed photoplethysmography (PPG) signals are received by the photodetector and sent to the transimpedance amplifier. It converts the current output into a signal voltage. The signal voltage is then separated by the demultiplexer into the red and infrared signal. Then these signals are converted from analog to digital signals by the analog-to-digital converter (ADC). These digital signals are now interpreted by the microprocessor that determines your pulse rate and your oxygen saturation levels that are shown as an output.

Database

The input into the database is the data currently being collected by the blood oxygen sensor. The output is all of the user's old blood oxygen readings.

Microprocessor 1

The first microprocessors inputs are the data gained from the blood oxygen sensor and the data of previous screenings. The microprocessor then utilizes the following formula of $O1 = PD - CD$. O1 represents the output of this equation and PD represents the average of the users previous screenings, CD represents the data from the current screening. If O1 is then found to have a value that is more than 3% different than the users previous screenings, this is seen as a positive indicator for the users possible contraction of COVID-19. The output of this microprocessor is a pass or a fail. Outputting a 1 for a pass and a -1 for a fail.

Microprocessor 2

The second microprocessors inputs are the pass fail data from microprocessor 1 and the data from the thermometer as well as the data from the smell test. The pass fail data is multiplied by a factor of 3 as the blood oxygen test is seen to be the most effective and accurate. The data from the thermometer is compared against the known average safe temperature for humans that being 98.6 degrees Fahrenheit. If the data from the thermometer registers a temperature of more than 2.4 degrees Fahrenheit greater than the average (98.6), that being 101 degrees Fahrenheit, then this is seen as a positive indicator for the users possible contraction of COVID-19. A pass is represented by a value of 1 and a fail is represented by a value of -1. As temperature is seen as being the second most accurate indicator the pass fails, data from this test is multiplied by a factor of 2. The last input into this microprocessor is the data from the smell test. If the user fails to identify two of the three scents accurately then this is seen as a fail which is represented by a -1. If the user successfully identifies two or three of the scents accurately this is seen as a pass and is represented by a 1. As smell testing is based on qualitative analysis it is weighted with a factor of 1. The results of all the values of the tests after they are multiplied by their respective weighting factors are added together if this comes out as a positive value the participant is told they passed. If this value comes out as a negative, then the participant is told they have failed. If the value comes to zero, then this is seen as a reason to be cautious about possible COVID-19

contraction and the implementing institution will decide what actions to undertake in this scenario. So, the outputs of this microprocessor are the pass, fail or cautious statements to the GUI.

Final Design

Overall system block diagram

The overall system block diagram gives the overall structure for what happens when the user approaches and uses the Sentinel. The first block of the diagram is the Sentinel waits for the user to interact with the system. This allows the product to be turned on and never needs a worker to prompt each test for the Sentinel. The next step is the user to input their student/work ID, so that each Sentinel is unique for each environment that it is placed in. Unfortunately, HIPAA (Health Insurance Portability and Accountability Act) does not allow us to record and store the user's medical data without their disclosure. The following 2 blocks are initializing the Sentinel and prompting the pulse oximeter. The Sentinel initializing allows the user time before they run all of the test simultaneously. The pulse oximeter needs prompting because of the infrared light that requires it to work. The pulse oximeter uses this infrared light as a measuring tool. The next step is the user performs the pulse oximeter test. All this test consists of is the user placing their finger on the infrared light and waits for the LCD screen to display if they pass. If they do not pass then the LCD will display a “0” and move on to the next test which is the temperature check. The temperature check also needs a prompt for the thermometer. This prompt is not as long because it only needs a few seconds to measure the temperature for what it is right in front of it. The user will simply place their forehead in front of the thermometer, and like the pulse oximeter, will display either a pass or a “0” to determine whether or not they pass the test. Following the temperature check the smell test will begin to prompt. This prompt consists of the LCD displaying which scent will be dispensed. Once the scent is dispensed the user will determine which scent they believe it is, and they are alerted whether they are correct or incorrect. Once this is complete based on each test the user will be given a low, mid, high, or GO TO DOCTOR display on the LCD. Once this is complete the Sentinel will reset back to the stage of waiting for interaction. See Appendix for full block diagram.

Pulse Oximeter

The pulse oximeter works by first turning on and initializing the infrared light. In the initialization of the pulse oximeter the infrared light will get to be its brightest allowing for more accurate readings when calculating SpO2. Once the pulse oximeter has finally initialized the user will place their finger on the light. The pulse oximeter will then use the light along with the users finger to calculate their SpO2 levels. The way this is done is by a constant pressure that is being applied by the user. This constant pressure on the light blocks how much light is being emitted from the pulse oximeter. Depending on the user and how much blood flows to the end of the users finger the light will be emitted at different values.

This value is then used to calculate the SpO2 value. This value is then compared to the recommended CDC values for a healthy individual's SpO2 levels. The Sentinel uses this value to determine if the user passes or fails this test.

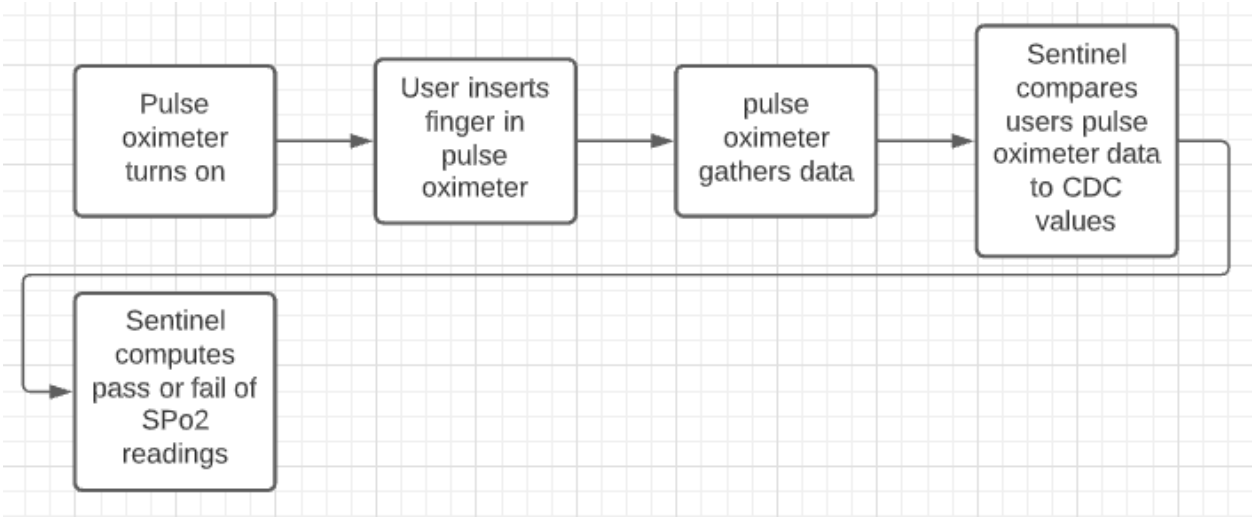


Fig. 26 (Pulse oximeter block diagram)

Thermometer

The temperature test is the next test that follows the pulse oximeter. This test works by first the thermometer turning on. Once the thermometer is on the user will present their forehead in front of the thermometer. The thermometer then takes the users temperature and compares it to the recommended CDC value for a healthy individual. If the user's temperature is within the range for a healthy individual, then the user will pass. Pass or fail the test will continue.

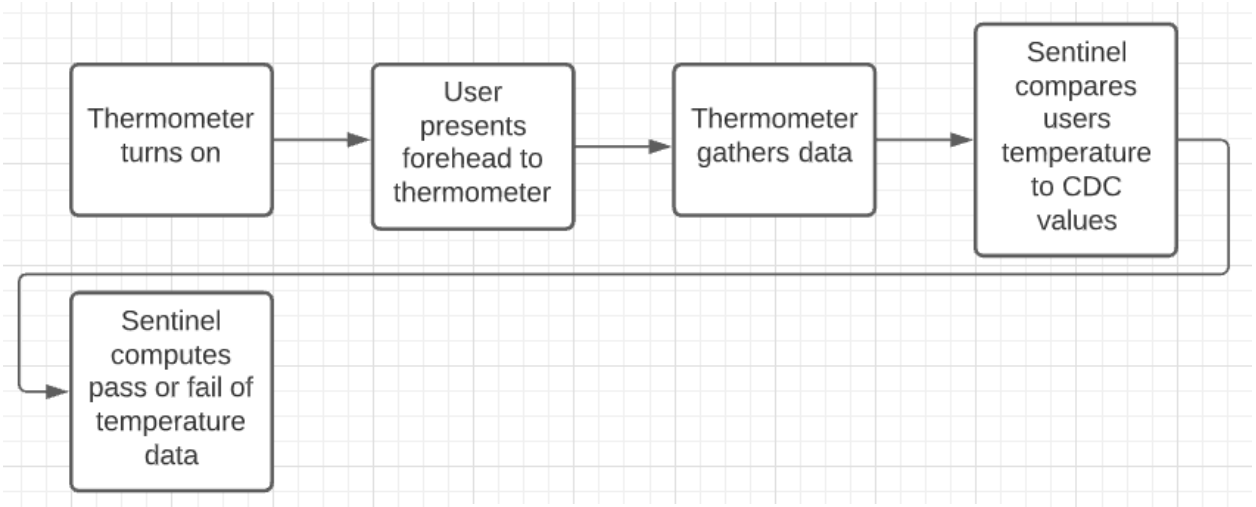


Fig. 27 (Thermometer block diagram)

Smell Test

The last test that follows the temperature check is the smell test. The smell test begins by first randomly selecting a scent between the values of 1,2, and 3. The user is then alerted which scent is being dispensed, and that scent is dispensed. The user will then have a multiple-choice test to determine if they are able to smell the scent correctly. Pass or fail the data is then recorded to determine the final test.

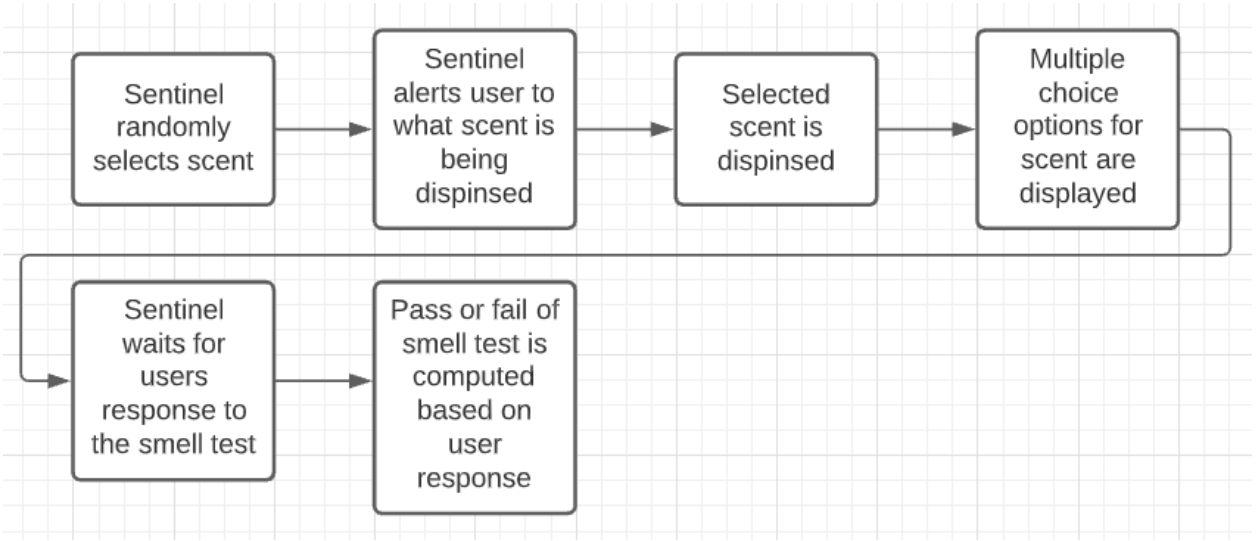


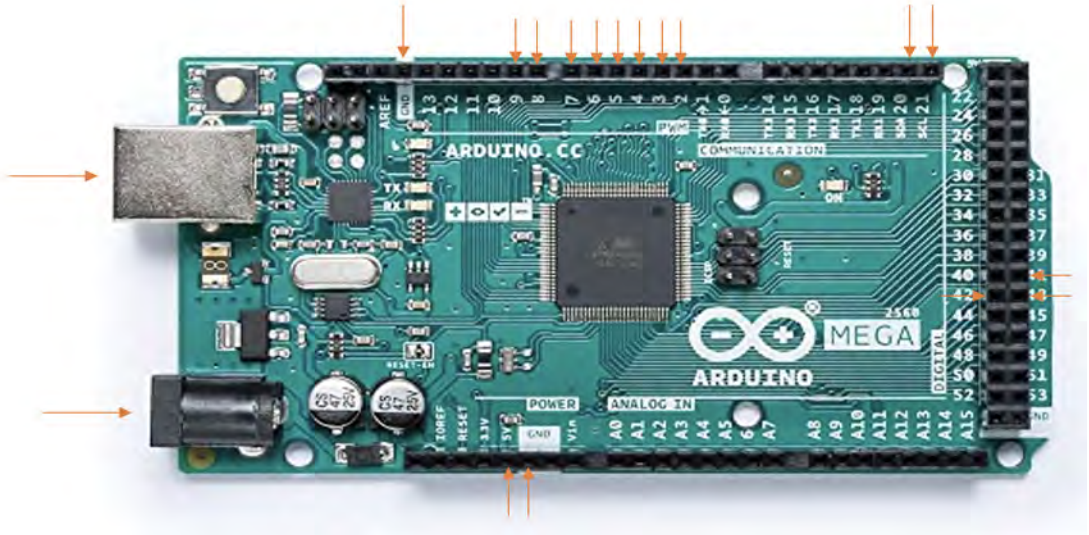
Fig. 28 (Smell test block diagram)

Detailed Schematics

Electrical Engineering

1. Arduino - The first step to assembling the electronics of the Sentinel is to attach the correct pins to the Arduino mega, the wiring diagram can be referred to below (appendix 8). For the first connection two black male-male jumper cables are required for the two grounding points, these are attached to the ground ports indicated below (Fig. 29). The following connection will require one red male-male jumper cable attached to the 5v power port indicated below (Fig. 29). The next set of connections will be the SDA and SCL connections, one blue male-male jumper cable for the SCL connection and one green male-male jumper cable for the SDA connection. These get plugged into ports 21 for SCL(blue) and port 20 for SDA(green) (Fig. 29). The next set of connections that will be made are for the control of the relays, for these three yellow male-male jumper cables are needed, these will get plugged into pins 41, 42, and 43 (Fig. 29). The final set of connections that need to be made to the Arduino are for the keypad. For this 8 white male-male jumper cables are needed, plug these cables into pins 2 through 9 (Fig. 29). The Arduino mega power cable also needs to be connected as well as the usb cable for programming and troubleshooting purposes (Fig. 29).

2. Printed circuit board - The next step to assembling the electronics is soldering wires into the printed circuit board. For these 5 spools of 18-gauge wire is needed, red, black, blue, green, blue, and yellow as well as a 70x30 mm printed circuit board. A soldering iron and solder will also be needed as well as assorted sizes and colors of heat shrink tubing to help with organization and a pair of wire cutters/strippers. First cut 4 lengths of blue wire 3 feet in length do the same for 4 lengths of green wire. Next cut 11 lengths of black wire to 3 feet in length. Then cut 10 lengths of red wire to 3 feet in length. Next cut 3 lengths of yellow wire to 3 feet in length. Next strip the last 20 millimeters of both ends of all of the lengths of wire that have been cut. Prepare all of the ends of the wires by twisting the exposed strands together insert 7 of the black wires into the row of holes on the far-right side of the printed circuit board (Fig. 30). Next insert two red wires in the 4th row from the right edge of the printed circuit board (Fig. 30). Next insert another pair of two red wires in the 7th row from the right edge of the circuit board (Fig. 30). Next insert another pair of two red wires in the 10th row from the right edge of the circuit board (Fig. 30). Next insert the 4 green wires into the 13th row from the right edge of the circuit board (Fig. 30). Next insert the 4 blue wires into the 16th row from the right edge of the circuit board (Fig. 30). Next insert 4 red wires into the 19th row from the right edge of the circuit board (Fig. 30). Next insert 4 black wires into the 22nd row from the right edge of the circuit (Fig. 30). Finally solder all of the connections together in each row, do not make connections across any of the rows of wires. Group one red wire of the right most pair of red wires with one blue and one green wire as well as one black wire from the far right using a large tube of heat shrink, heat this up using a heat gun or hair drier to make permanent. Group one red wire from the middle pair of red wires with one blue and one green wire as well as one black wire from the far right using a large tube of heat shrink. Group one red wire from the left most pair of
red wires located on the 10th row from the right edge of the circuit board, with one blue wire as well as one green wire and one black wire from the far right grouping. Group the



one remaining blue wire with the one remaining green wire and one black wire from the

Fig. 29 (Arduino Mega)

far right grouping of black wires. Group the three of the four red wires on the left together. Group three of the 4 black wires on the left together.

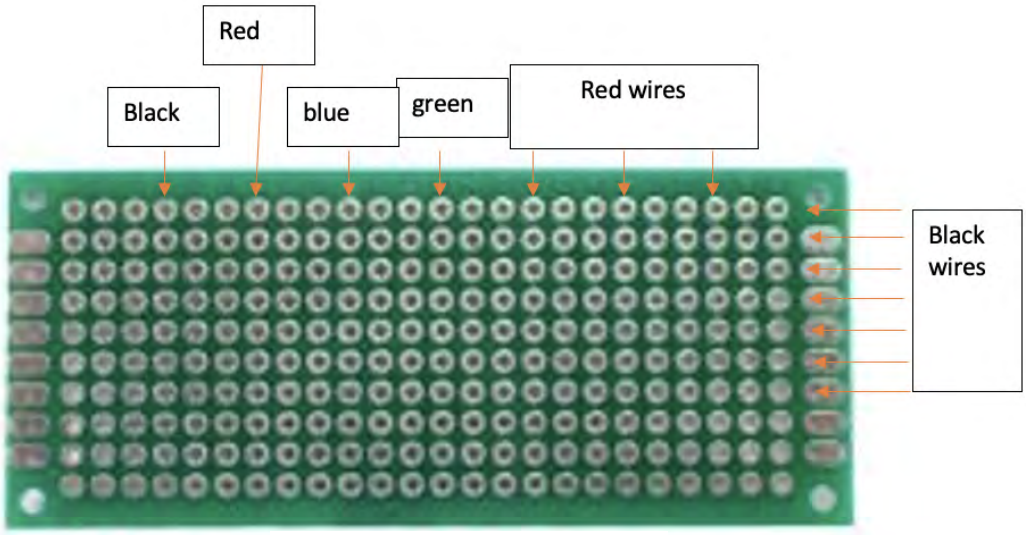


Fig. 30 (Circuit board)

3. Buck converters - to wire in the power into the buck converters the first step is to expose the wires from the 3 9v power supplies. After this prepare the wires by twisting the exposed strands of the positive side together and then twisting the exposed strands of the negative side together. Next insert them into the positive and negative spots on the buck converter (Fig. 31) and solder these connections to make them permanent. Repeat this process for the other two buck converters. Cut 3 lengths of black wire 2 feet in length then cut 3 lengths of red wire 2 feet in length. Next strip the ends of all lengths of wire and prepare them by twisting the exposed strands together. Insert the black wires into the out negative spots on each of the buck converters (Fig. 31) and solder them in place. Insert the red wires into the out positive spot on the buck converters (Fig. 31) and solder them in place.

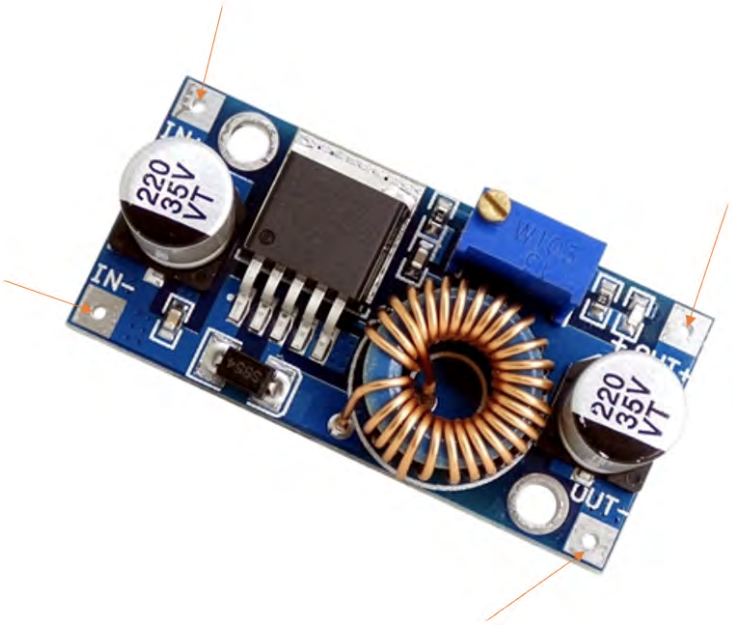


Fig. 31 (Buck converter)

4. Relays and pumps- for wiring the relays the first step is to expose an inch of the positive and negative ends of the 12v power supply then prepare these by twisting the exposed wires of the positive end together and twisting the exposed wires of the negative end together. Then cut 3 lengths of black wire 2 feet in length. Then cut 3 lengths of red wire 2 feet in length. splice these black wires onto the negative end of the power supply and splice the red wires onto the positive end of the power supply. Take each of these red wires and attach them to the “on" port of the three separate relays. Splice each of the black wires to their respective pumps. Cut another 3 lengths of red wire about 2 feet in length. Prepare the ends of these wires as previously described. Take each of these and attach one end to the “COM” port of the respective relays. Take the other end of the red wires and attach them to their respective pumps. On the control side of relays 3 lengths of yellow wire about 2 feet in length. 3 lengths of red wire about 2 feet in length and 3 lengths of black wire about 2 feet in length. Prepare the ends of these wires as previously described. Attach one end of each of the yellow wires to the “IN” port on each of the relays. Attach one end of the red wires to the “VCC” port on each of the relays. Attach one end of the black wires to the “GND” port on each of the relays (Fig. 32). Attach the yellow wires to the “IN” port on the relays and attach the corresponding relays to the yellow wires attached to pins 41 42 and 43

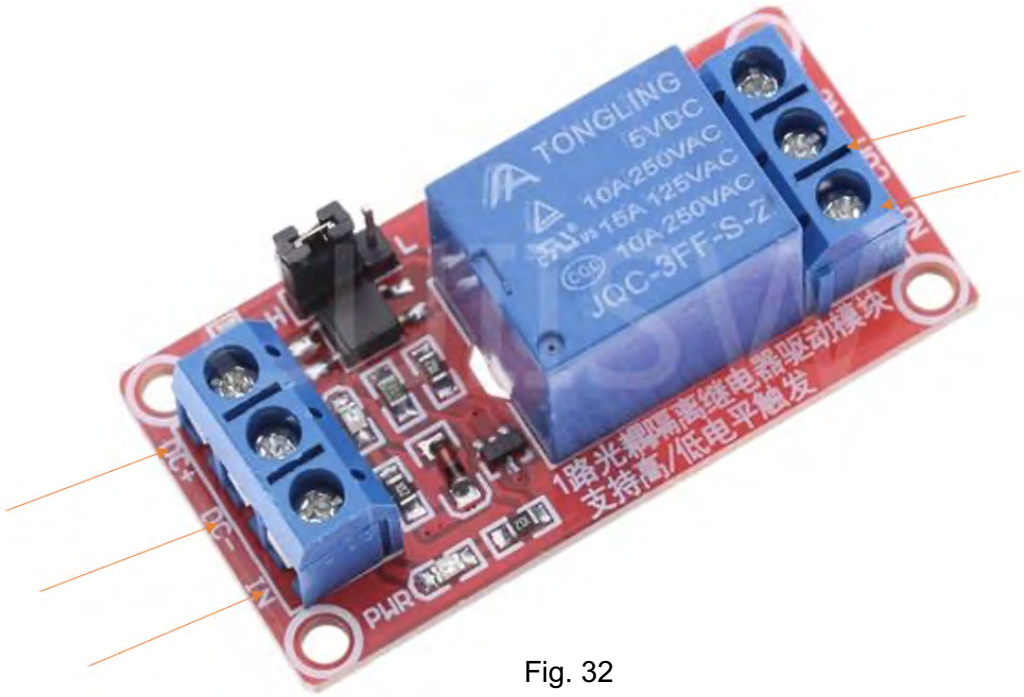


Fig. 32

5. Making connections - the last thing to do for the electronics is to make all of the connections. To start this process, make connections between the Arduino and the circuit board, the grouping of one black one blue and one green wire get spliced and soldered with the blue and green as well as the black wire on the right side of the Arduino. Next attach each of the three remaining red wires from the three pairs on the circuit board to each of the positive outputs of the buck converters. Attach the negative ends of the buck converters to the remaining black wires on the right-hand side of the circuit board. Then take the groupings of red blue black and green and attach it to the lcd screen. Take another grouping and attach it to the pulse oximeter. Take the remaining grouping of black blue green and red and attach it to the thermometer. Attach one of the red wires on the left side and connect it to the remaining red wire on the Arduino. Attach the other three red wires on the left to the red wires attached to the “VCC” port of each of the relays. Next is to wire the pumps, attach the negative end of each pump to one of the black wires attached to the 12v power supply, attach the positive end of each pump to the red wire plugged into the “COM” port on the corresponding relay. The next step is to attach the red wires plugged into the “VCC” ports of the relays and attach them to the three remaining red wires on the left side of the circuit board. Next attach the black wires plugged into the “GND” to the three remaining black wires on the left-hand side of the circuit board.

Mechanical Engineering

1. Mold - To begin building the mold it is needed a MDF panel with dimensions (0.5” x 4’ x 4’) approximately. It is important to make sure that there is enough MDF to make the two

sides of the mold. Besides the MDF material, the sentinel also needs PVC sheets of (2’ x 3’ x ½’) that will match the curve of the side pieces. Plywood (2” x 2”’ x 6’) will be cut in pieces with the width of the Sentinel (14”). Cut the MDF accordingly using the side profile from blueprints of the side pieces offsetting the outer shape by 0.5” outwards based on the width of the PVC. Once all the pieces are cut to scale, the assembly comes next. For this assembly it will be necessary the use of a heat gun, electrical screwdriver, wood screws, router, and wood glue. Then the sides of MDF already cut to the shape of the side pieces will be put vertically and joined together by the plywood rectangles (total with 14” counting the width of the MDF). The plywood pieces need to be flush with the curve of the MDF because it will be used as reference for the PVC. To get a steady mold, the joints between the plywood and the MDF will be done with wood screws and applying wood glue to the surfaces that bind together. Then the PVC will be curved to match the skeleton of the mold. To match the bottom angle, there needs to be several horizontal incisions made with a router on the PVC where the sharpest angle is. These incisions will eat ¼” of the bottom of the PVC (Fig. 33). This ensures that the material can be bent without breaking. With the cuts in the PVC made, the heat gun will be used to bend the PVC to match the skeleton. Insert screws in along the plywood to secure the bended PVC to the skeleton (Fig. 34). If everything is mounted correctly the mold should look like (Fig. 35).

Fig. 33 (Incisions in PVC)

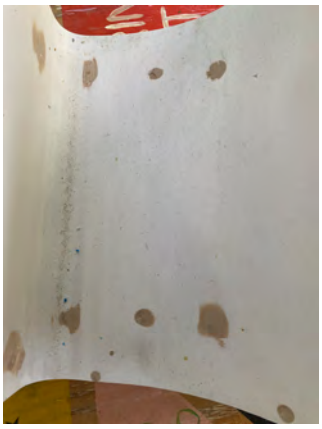


Fig. 34 (Screws along the plywood)

Fig. 35 (Mounted mold)

2. Acrylic - Buy one acrylic sheet with dimensions (24” x 48” x 0.093”). Use an end mill to cut the holes for the sensors, touchpad, and nozzles based on the dimensions of the blueprints (Appendix 8). The acrylic needs to be cut with a vertical saw to match the dimensions of the mold Once the holes are made properly, place the acrylic in an industrial oven and heat it up 260 degrees Celsius. Place the mold close to the oven and once it reaches the set temperature put the acrylic piece on top of the mold and shape it with a cylindrical tube. Make sure to do the process quickly because if the acrylic cools down too much and it is forced to bend, it will break. If necessary, repeat the process several times until the desired shape is accomplished (Fig. 36)

Fig. 36 (Acrylic after bending)

3. Print and assemble Sides- Print off files named (LeftSideBottomL, LeftSideBottomR, LeftSideTopL, LeftSideTopR, RightSideBottomL, RightSideBottomR, RightSideTopL, RightSideTopR, 2*SideSecuringBlock) using either PLA or ABS filament. The male peg will slide into the female slot in each piece. The pieces will be assembled in the order of 1. The Top Right piece will slide into the Top Left piece. 2. The Bottom Left piece will slide onto the assembly listed in the previous step. 3. Slide the Bottom Right piece onto the right side of the assembly. 4. Slide the Securing Block into the cavity in between the Bottom Left and Bottom Right piece. Some sanding will be required depending on the type of filament used to print. In order to secure each piece, use any super glue, (Fig. 37) shows the appropriate assembly steps. Repeat for the opposite side. When done there will be a left piece and a right piece. Finally glue the 6mm magnets into the holes on the inside rim of each side piece, 8 magnets will be required. Make sure that magnet polarity lines up appropriately.

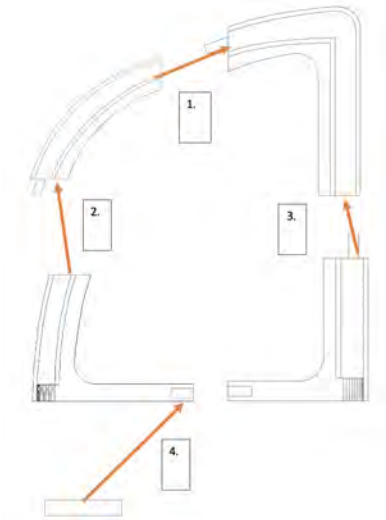


Fig. 37 (Side Piece assembly)

4. Mount Sides with Acrylic - Draw a line with a dry erase marker along the profile of the edge with an offset of 0.5” towards the inside. It will be done on the inside of the curve to outline the part that will be sanded out. Once it is marked, use making tape to make sure the sanding does not ruin the finish of the acrylic. Sand the part where the Sides will bind to the acrylic. Clean the sanded part with water (not alcohol or acetone). Get gorilla glue epoxy and mix the two liquids together on a mixing surface. Apply the epoxy blend to the sanded parts of the acrylic and the Sides. Put them together and place them on the mold. Clamp everything together to ensure the epoxy binds the two surfaces together and let it rest for a day (Fig. 38).

Fig. 38 (Clamp method)

5. Assemble doors- Print of files named (DoorTopLeft, DoorCenterLeft, DoorBottomLeft, DoorTopRight, DoorCenterRight, DoorBottomRight) using either PLA or ABS filament. Each part is labeled either Left or Right. Start by sliding the Door Top piece over the Door Center piece and glue with super glue. Repeat this step for the Door Bottom piece. Repeat this step for the opposite side. When completed there will be a Left door and a right Door, (Fig. 39) shows the appropriate assembly steps. Glue in the 6mm magnets into the holes seen on the back side of each door, 8 magnets will be required. Make sure that magnet polarity lines up appropriately.

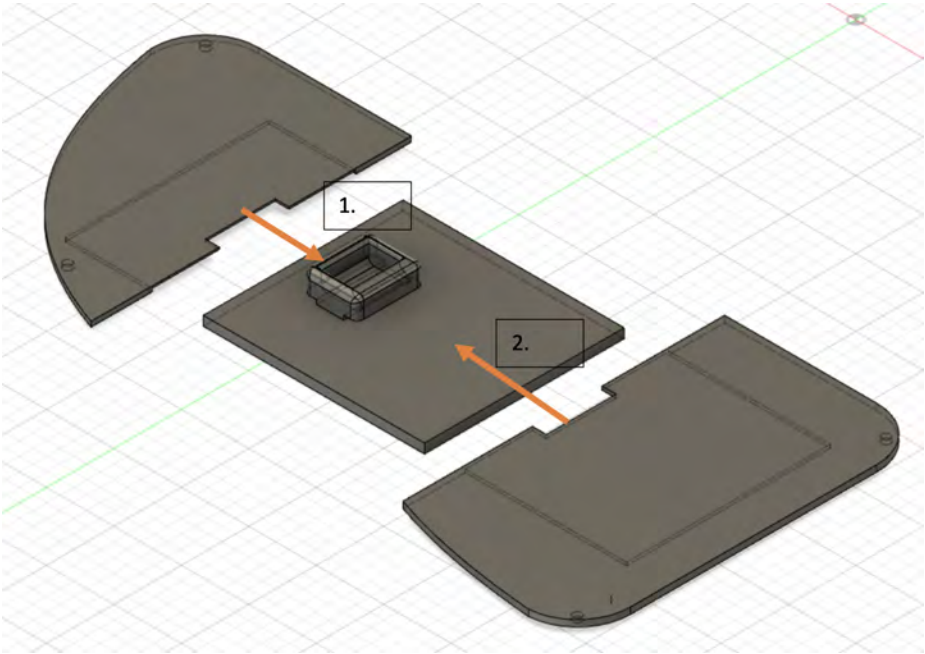


Fig. 39 (Door assembly)

6. Assemble Base- Print of files named (BasePlate BL, BasePlate BR, BasePlate FL, BasePlate FR) using either PLA or ABS filament. The Front Right side will glue to the Back Right Side. The Front Left side will glue to the Back Left side, (Fig. 40) shows the appropriate assembly steps. Apply glue in the seam in between the Right and Left assemblies. Make sure to prep the surface with tinfoil in order to not glue the assembly to the gluing surface.

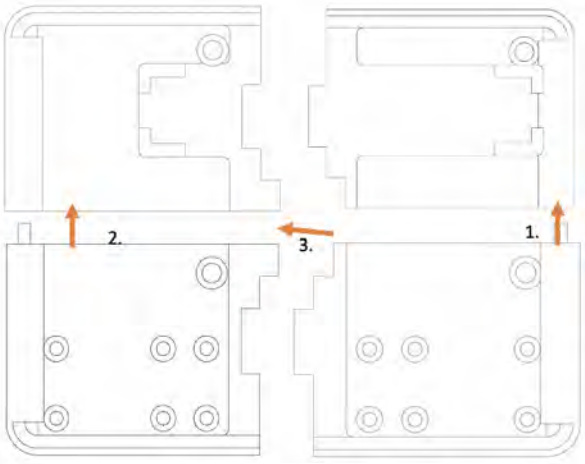


Fig. 40 (Base assembly)

7. Assemble Hand sanitizer mounts- Print of files named (Print 3 of each, HandSanitizerMount, 4mmSpacer, TopCylinder, BottomCylinder, Head) using either PLA or ABS filament, acquire 5’ of 7/16” of plastic tubing, and 3 pumps referenced in the parts list seen in Appendix. x. Start by drilling a 7/16” hole in the top left corner of the hand sanitizer bottle glue in a 3” strip of plastic tubing with super glue, this will make the breather/ fill tube. Next Silicon the hand sanitizer bottle onto the Hand Sanitizer Mount, make sure that the long side of the bottle lines up with the long side of the amount (Fig. 41) shows the appropriate orientation. Cut a 2” length of the tubing and use this to attach the pump to the flange on the bottom of the Hand Sanitizer Mount, pump inputs and outputs are seen in (Fig. 42), make sure all wiring for the pumps is done before securing the pumps. Next glue the 4mm Spacer and the Hand Sanitizer mount onto the part named Base. Assemble the rest of the Hand sanitizer assembly by following the steps seen in (Fig. 43), use super glue to ensure security. Finally run a 9” length of tubing from the output of the pump out the octagonal opening in the Base up to the back and through the circular opening in the Top Cylinder. Repeat these steps two more times.

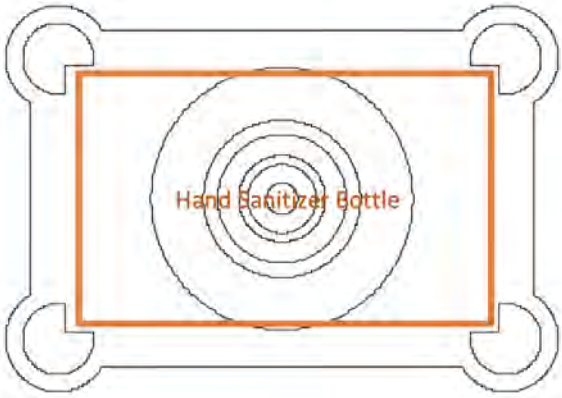


Fig. 41 (Hand sanitizer orientation)

Fig. 42 (Pump Input/Output)

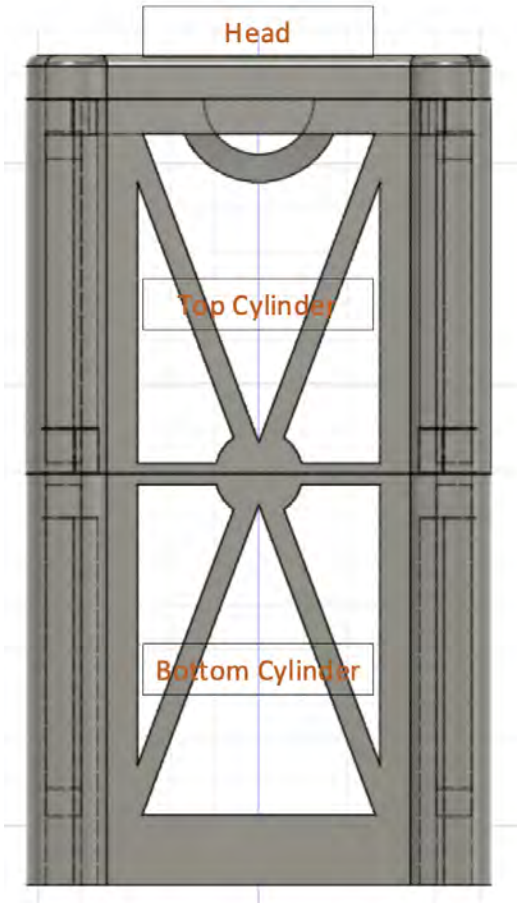


Fig. 43 (Cylinder assembly)

8. Assemble Hardware mount- Print of files named (6*BottomColumn, 2*TopBackColumn, 2*TopFrontColumn) using either PLA or ABS filament, and acquire the two hardware mounts seen in the parts list, Appendix x. First cut down the plates as seen in (Fig. 44), this will result in a (6”x8”) plate and a (4”x8”) plate. Using super glue secure the Bottom Columns to the corner holes of the (6”x8”) plate, the smaller diameter peg will fit into the plate holes, glue into place with super glue. The bottoms of the Top Front Columns have a small pentangular peg that will slot into the pentagonal hole in the tops of the bottom columns. These two parts will sandwich the (6”x8”) plate as seen in (Fig. 45). The Top Back Columns will slot into the holes on the (6”x8”) that are 4” from the front of the plate. Finally glue the (4”x8”) onto the tops of the Top Columns.

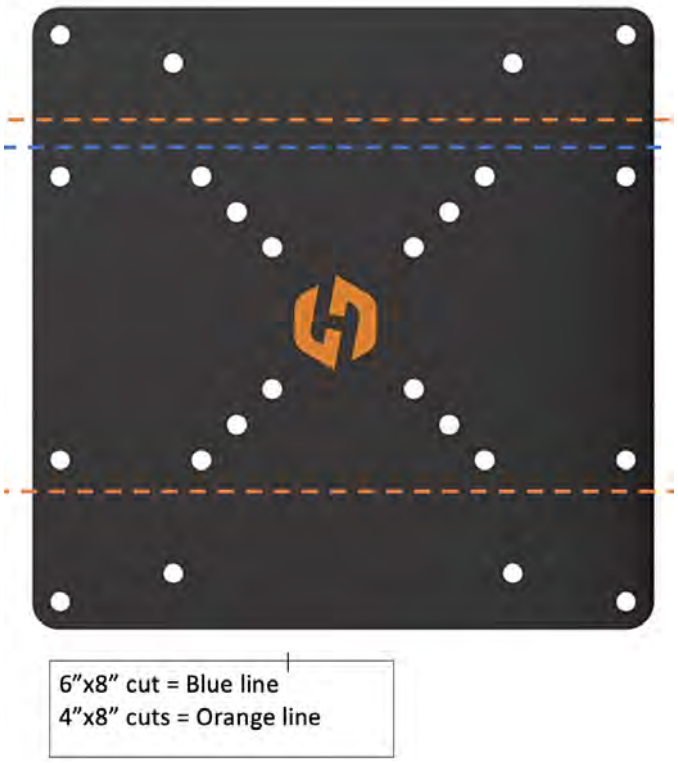


Fig. 44 (Hardware cutting lines)

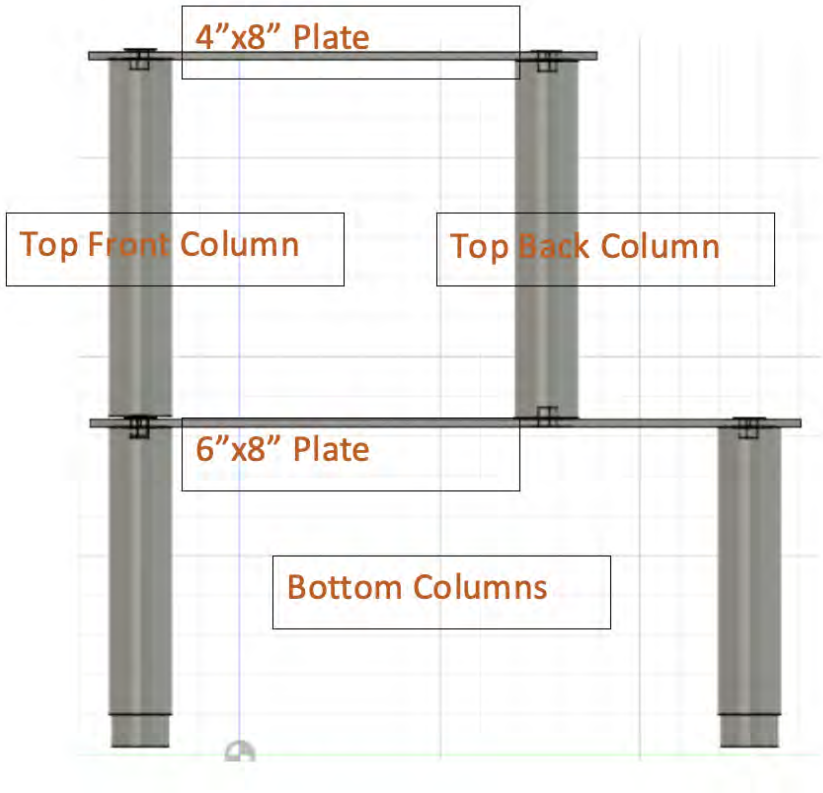


Fig. 45 (Hardware plate assembly)

9. Mount hardware- Print of files named (Arduino/RelayMount, BuckConverterMount, CircuitBoardMount) using either PLA or ABS filament, acquire 3 Relays, 1 Arduino MEGA, 3 Buck converters, and a PCB. Make sure all wiring is completed before mounting hardware. Mount Buck Converters onto Buck Converter Mount as seen in (Fig. 46). The arrow on the bottom of the Buck converter should face towards the front of the Sentinel. Mount PCB onto the Circuit Board Mount as seen in (Fig. 47). Secure the Arduino Mega and 3 relays onto the Arduino/Relay Mount as seen in (Fig. 48). Mount Arduino/Relay Mount onto the (4”x8”) as seen in (Fig. 49) using super glue. Mount Arduino/Relay Mount onto the (6”x8”) as seen in (Fig. 50) using super glue

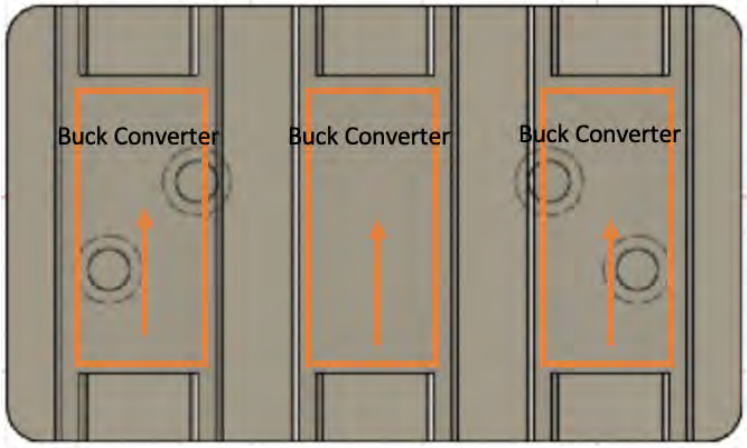


Fig. 46 (Buck Converter plate)

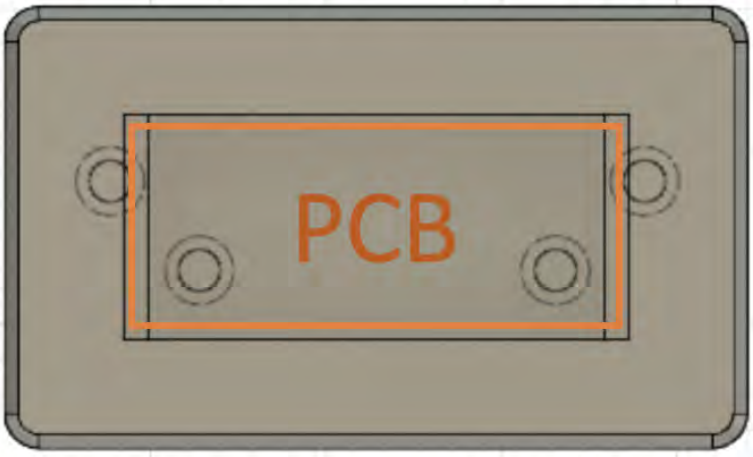


Fig. 47 (PCB Orientation)

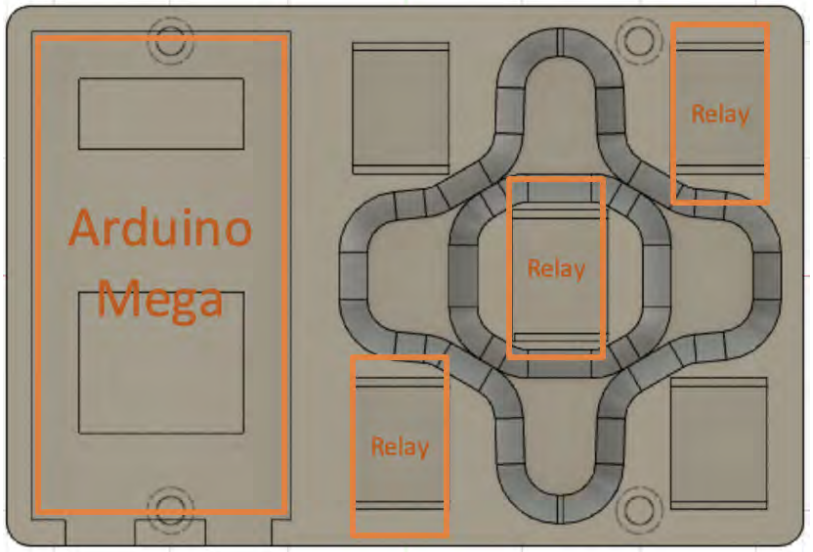


Fig. 48 (Arduino/Relay plate)

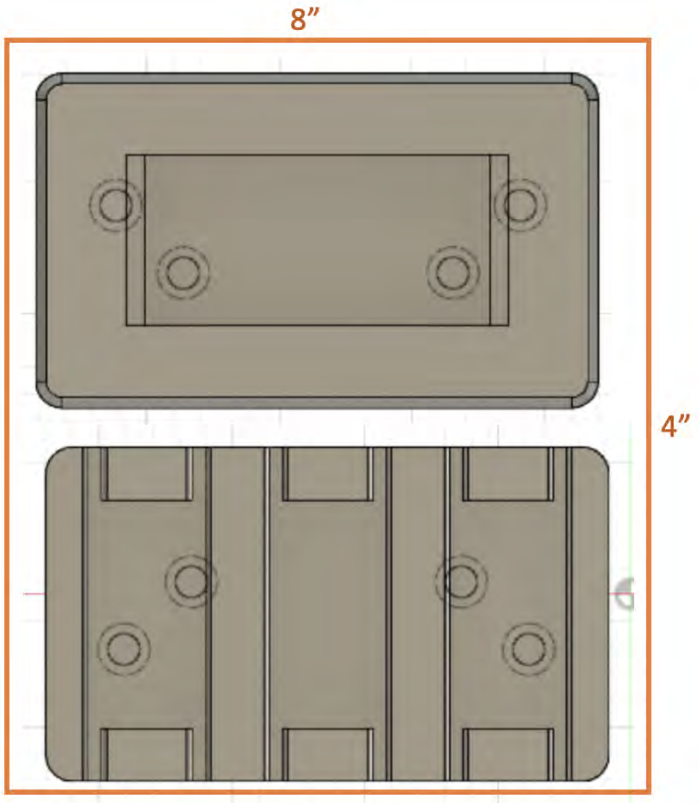


Fig. 49 (Mount orientations)

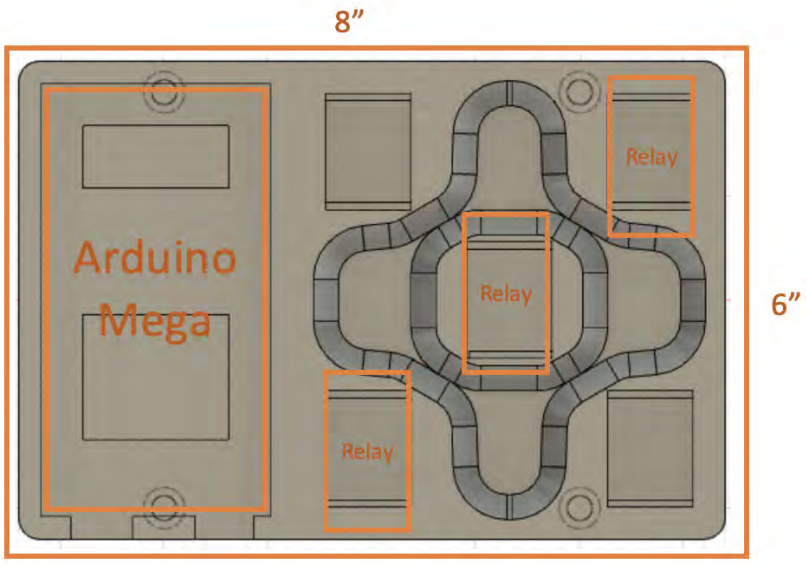


Fig. 50 (Arduino/Relay mount orientation)

10. Mount Hardware mount, Power strip, and Hand sanitizer mounts- Arrange power sources on the power strip as seen in (Fig. 51). Mount the 3 Hand sanitizer mounts, hardware mount, and power strip onto the Base plate mounts as seen in (Fig. 52). Secure with super glue.

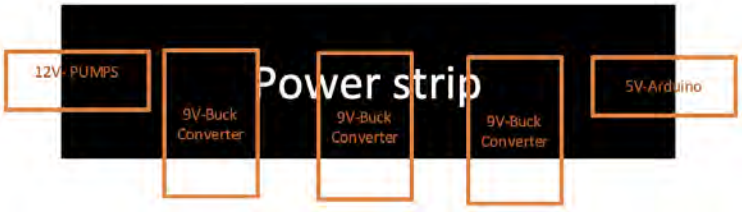


Fig. 51 (Power strip layout)

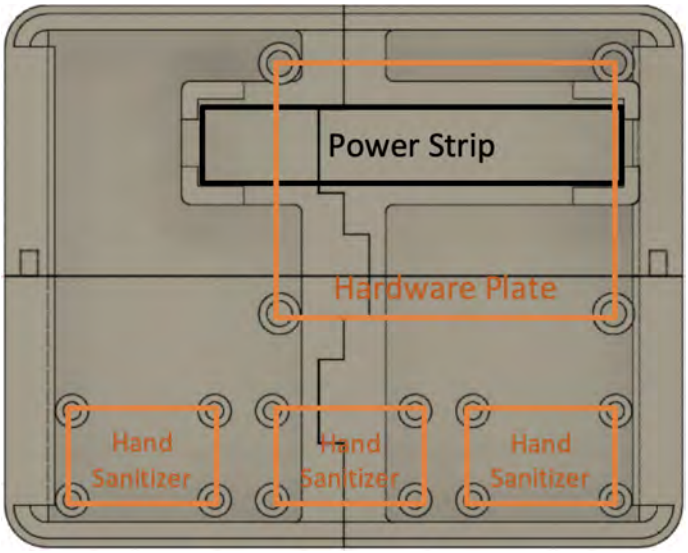


Fig. 52 (Base Plate layout)

11. Mount case- Fit case over onto the Base plate. The Front of the case with the holes from Step.2 will line be adjacent to the Hand sanitizer assemblies
12. Print external hardware mounts- Print of files named (PulseOXMount, PulseOXMountBack, ThermometerMount,ThermometerCover, KeypadMount,KeyPadCover, LCDScreenMount, 3*Nozzle) using either PLA or ABS filament.
13. Mount external hardware- This step will require all the parts printed in Step.11 as well as the Pulse Oximeter, Thermometer, Keypad, and LCD screen. Start by assembling the Pulse Oximeter mount, take the Pulse Oximeter and glue it onto the 1mm deep cavity in the mount, run the wiring through the notch in the back of the piece. Next glue the back cover of the Pulse Oximeter mount onto the mount, reference (Fig. 53). Next Assemble the Thermometer mount, glue the thermometer into the thermometer mount. Finally place the top cover for the thermometer mount over the whole assembly, the hole in the cover should line up with the sensor, reference (Fig. 54) for placement. Assemble the Keypad mount, first glue the Keypad onto the Keypad mount and run the wiring through the rectangular cavity in the keypad mount. Next place the Keypad Cover over the mount and glue in place. Finally assemble the LCD mount, using double sided tape in order to avoid fogging secure the LCD screen onto the mount, lining up the rectangular posts on the screen with the rectangular notch in the screen mount. Place each Hand Sanitizer Nozzle, run the 7/16” tubing through the nozzles. For placement of each component reference (Fig. 55). The Pulse Oximeter mount, Thermometer mount, Keypad, Hand Sanitizer Nozzles, are placed externally using super glue, and the LCD screen mount is placed internally using double sided tape. Reference (appendix. 8) for wiring

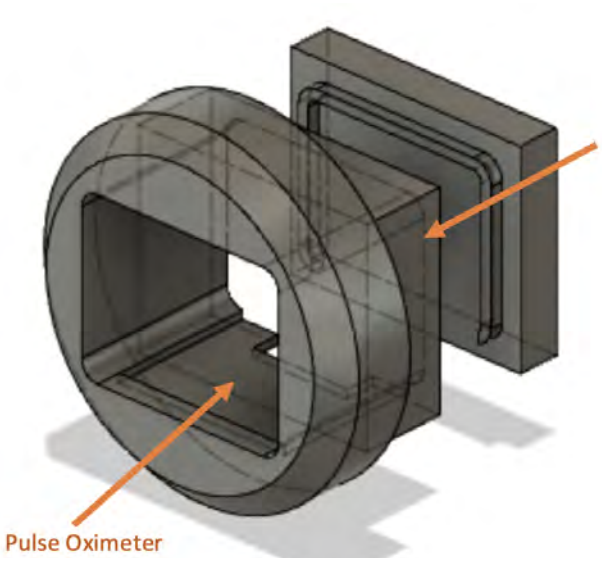


Fig. 53 (Pulse Oximeter mount assembly)

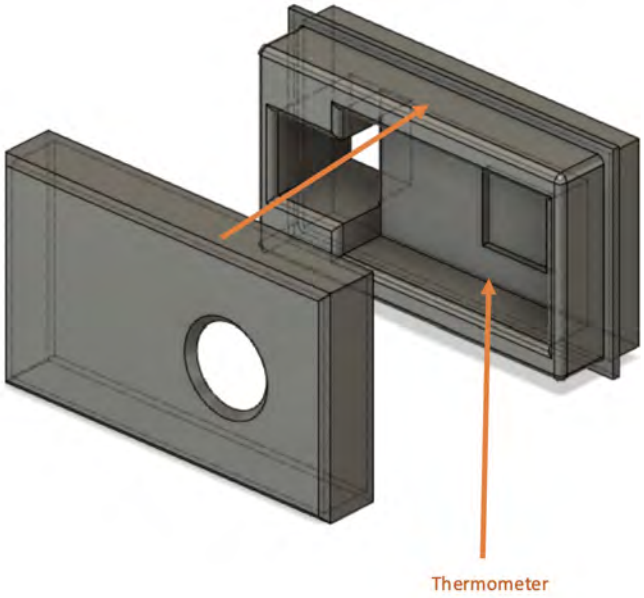


Fig. 54 (Thermometer mount assembly)

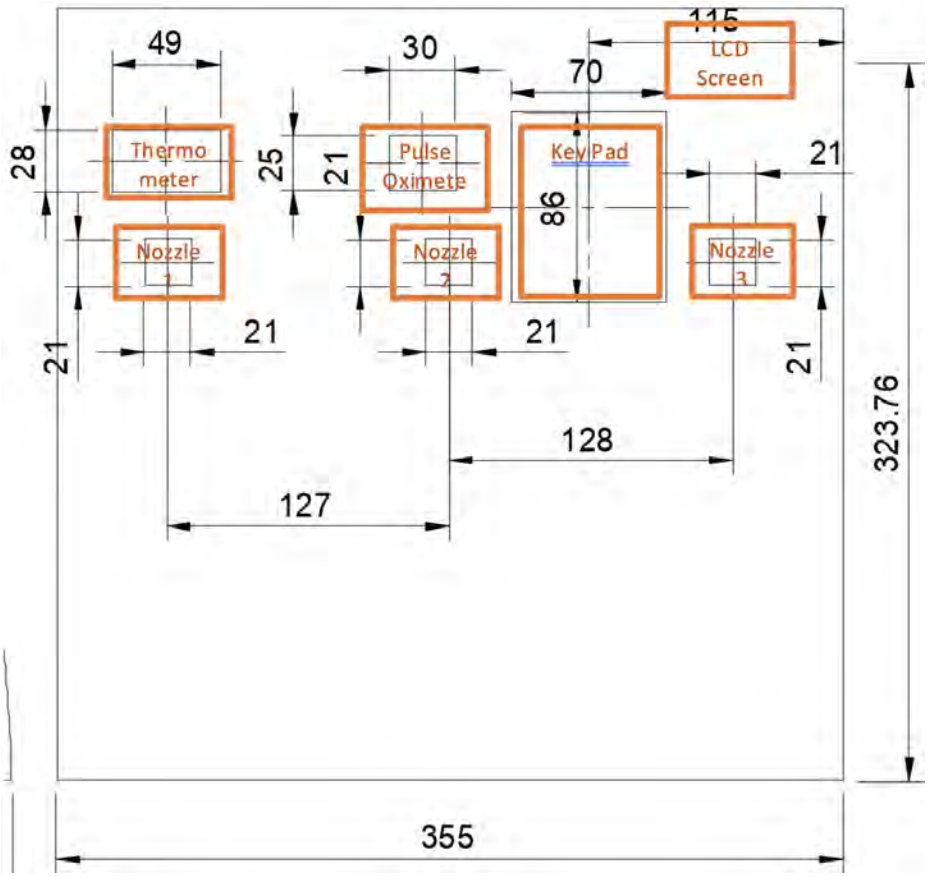


Fig. 55 (Sentinel front face layout)

Explanation on how it works

The Sentinel has been designed to be used in a very simple way. The device needs to be placed on a stable surface like a table. It needs to be plugged to a power source like an outlet. Once everything is in place, the user will approach the Sentinel and input their identification number (Fig. 56). Then the sentinel will start the test and will prompt the user to approach their index finger to the pulse oximeter sensor (Fig. 58). When the pulse oximeter is done taking the reading, it will display “Pass” and prompt the user to start the temperature test. The user will approach their head to the sensor that is located on the top left corner of the device (Fig. 59). Make sure that there is no hair in between the sensor and your forehead. The LCD will then say “Pass” and the smell test will begin. For the smell test the screen will give directions on which nozzle will dispense hand sanitizer (Fig. 60). After it prompts the nozzle number, that nozzle will dispense hand sanitizer on the hand of the user. Make sure to rub your hands well with the hand sanitizer. Smell your hands to identify the sense and the screen then will prompt four different senses with a number. Identify the smell and press the number that matches the sense. Once the answer is imputed, the Sentinel will determine if the user has high, medium, or low risk of having COVID-19. Then the institution will have a guideline to follow depending on the result of the test.

In order to Fill the hand sanitizer, connect a 2’ length of the 7/16” tubing to the hand pump on a 1-gallon unscented hand sanitizer bottle, and the other end into the breather tube of one of the hand sanitizer storage tanks on the Sentinel, pump until the hand sanitizer container is half full. Next connect the 2’ hose to one of the scented hand sanitizer pumps and pump until the Sentinel hand sanitized container is full, the unscented and scented hand sanitizers will mix with time. Repeat this step with the remaining two hand sanitizer containers on the Sentinel.

Fig. 56 (Input ID)

Fig. 57 (Starting test)

Fig.58 (Pulse oximeter test)

Fig. 59 (Temperature test)

Fig. 60 (Smell test)

Software

X = pulse pass
Y = temp pass
Z = smell pass
‘=Opposite

The logic of our software is broken down into four main parts. First, we have the pulse oximeter which measures the users blood oxygen levels, this is computed using a moving average. If the users

SPo2 levels are seen to be above 90% saturation this is seen as a pass otherwise it is seen as a failure. In the case of a pass pulse pass (x) is set equal to one, in the case of a failure it is set equal to zero. The next portion of the logic is using the infrared thermometer. The thermometer uses the output voltage of a thermopile in order to calculate the user's temperature. If the user's temperature is seen to be within CDC acceptable values then temp pass(y) is set equal to one, if not then it is set equal to zero. The third piece of our logic utilizes the smell test. If the user correctly identifies the scent, then smell pass(z) is set equal to one. If the user fails to properly identify the scent, then smell pass is set equal to zero. The final piece of our logic is the overall risk assessment logic. If one of the values is seen to be equal to one, then the situation is deemed high risk. If two of the values are equal to one, then the situation is deemed to be of middling risk. If all three of the values are equal to one, then the user is seen to be of low risk of having COVID-19. Lastly if all three of the values are found to be equal to zero then the Sentinel recommends that the user goes to find a doctor and seek professional help.

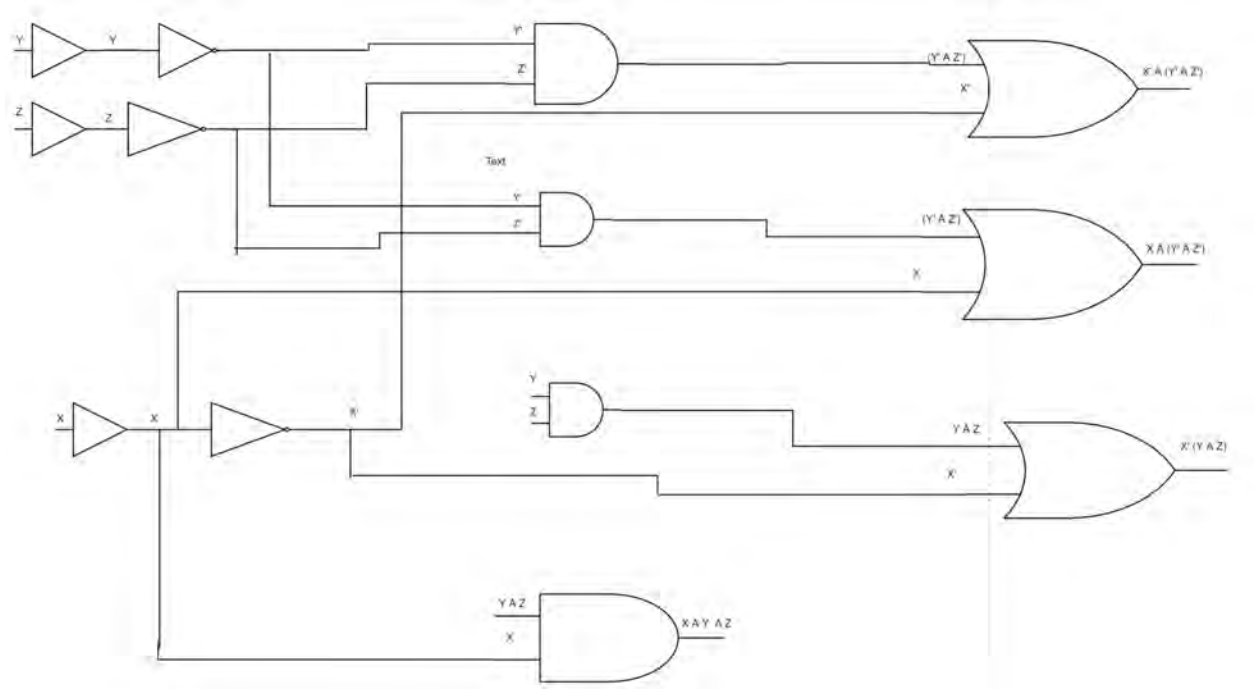


Fig. 61 (Software Logic)

Performance of your design

The Sentinel can be evaluated based on the requirements that are stated in earlier sections. In order to analyze the performance of the prototype, there are several functions that have to be checked. A full functioning device will perform the test in less than three minutes, has to be self-sufficient, and has to be able to be sanitized with no leakage inside the case. After running several tests, it has been determined that the Sentinel can run the complete test in less than one minute and a half. This means that the user gets to the device and inputs their ID number, gets his/her blood oxygen levels checked along with the temperature, and then it takes the smell test. Once the three tests are performed, it is evaluated and given a result that will vary from low, medium, and high risk. The performance of the Sentinel can be affected by different factors that can change the result of the diagnostic.

With the first test, pulse oximeter, it was found that the result depends on the position of your finger and how clean the surface of your finger is. The ideal position to get the most consistent and accurate results requires the user to place the tip of their index finger on top of the red light that shines on top of the sensor. The best spot on your finger has been determined to be the section that touches your thumb when the two fingers are joined together (Fig. 62). Also, if the index finger is not properly clean meaning that it is covered in a layer of grease or sweat, it can affect the results of the pulse oximeter for you and the following users negatively.

Fig. 62 (Ideal spot on the index finger)

The temperature test will follow up, it has been performing very consistent with accurate readings. The only alterations that have demonstrated some fluctuations in the result of this test were the placement of the head too far away from the sensor or having hair in between the sensor and the skin. These can negatively affect the reading of the sensor and result in a medium or high-risk final score depending on how you performed in the other test. Finally, the smell test will start by prompting the nozzle that will be dispensing. The programming section of the smelling test was changed throughout the trials. At first the time each pump was working was too long pushing a large amount of hand sanitizer through the nozzle. Once the time for each pump was determined, just the right amount of hand sanitizer was dispensed. This test proved to have the most reliable functioning.

The overall performance of the Sentinel was changing throughout the testing process. At the beginning there were a lot of details that needed to be addressed. Later in the testing portion, it was easier to analyze how each part of the process was working with proper settings. At the end, the prototype proved to work properly about 86% of the time. Each sensor demonstrated different performances with ideal conditions that were explained earlier. The pulse oximeter would work properly 65% of the time due to the extreme sensitivity of the sensor and how the finger was placed. The temperature sensor had an overall effectiveness of 95% of the time and the sense smell test worked 99% of the time. It was concluded that the process needs more refining work and maybe research deeper in some areas to increase the overall performance of the Sentinel.

Parts List

Part	Cost per Unit ($)	Quantity	Link
Pump	11.99	3	Amazon
Hose (7/16”)	19.95	50’	Amazon
5V Relay (12 pack)	11.99	1	Amazon
12V Power Supply	7.99	1	Amazon
Arduino MEGA	15.99	1	Amazon
Buck Converter (6 pack)	9.99	1	Amazon
PCB	.89	1	Console 5
Power Strip	12.38	1	Amazon
Pulse Oximeter	11.99	1	Amazon
Thermometer	18.50	1	DfRobot
LCD screen	11.99	1	Amazon
KeyPad	7.59	1	Jameco
Wiring set	12.99	1	Amazon
Acrylic	39.99	2	Home Depot
Hand sanitizer	4.99	3 (different scents)	Target
Heat Shrink tubing	9.49	1	Amazon
MDF	7.99	1	Home Depot
Hardware Plate	13.95	2	Amazon
Epoxy	6.49	3	Gorilla Glue epoxy
Paint	5.98	3	Paint+Primer
Super Glue	5.97	4	Home Depot
Silicon	4.27	1	Home Depot
Plywood	74.99	1	Home Depot

3D Printing Filament	30.72	6	Amazon

Table 12 (Parts list)

Tool list

For the construction of the Sentinel, it required several tools:

- Dremel
- 3D printer
- Table saw
- Vertical saw
- Router
- Angle grinder
- Solder
- Industrial oven
- Heat gun
- Screwdriver

Testing of Requirements

Functional

- Monitor temperature within a range of 80 degrees Fahrenheit to 110 degrees Fahrenheit with an accuracy of .66 degrees. (R2). This is a consistent noninvasive measurement of a common symptom of COVID-19. Not tied to a user need but derived from CDC guidelines.
  - ***Sentinel meets the requirement with testing of MLX90614. It meets the requirement based on the MLX90614 datasheet (see Appendix). The MLX90614 datasheet test for accuracy within .5 degrees.***
- Monitor oxygen levels in blood with a .1 percent accuracy(R3). A quick measurement with the ability to be tracked over a long period of time to track health. It has been stated by the CDC that a downward trend of oxygen levels is an indication of COVID-19. Users need 5 (Standards on what to check).
  - ***Sentinel meets the requirement with testing of the FL400 pulse oximeter. The FL400 tests for accuracy to the .01 percent.***
- Monitor and test sense of smell (R4). Qualitative analysis of smell which loss of is a symptom of COVID-19 as stated by the CDC. Users need 5 (Standards on what to check). According to the CDC an individual's loss of smell is a very common symptom of COVID-19.

- ***The Sentinel smell test requirement was met with the use of 10 different people both male and female and they were able to successfully select each scent.***

Performance

- Real-time response and notification. The user must have a result from the Sentinel in less than 3 minutes of interaction(R1). Testing with a slow response is already out, this device must focus on rapid identification and notification of symptoms. Users need 2 (Real-time testing devices in classrooms or work environments).
  - ***The Sentinel meets this requirement by running the test against multiple timers, and the test roughly takes 1 minute and 5-10 seconds.***
- Be self-sufficient and have stand-alone testing and data gathering capabilities and be able to store at least 512 gigabytes of data in the device(R5). There must be no one administering the tests as this would cause unwanted contact between individuals. Not tied to a user's needs.
  - ***The Sentinel does not meet this requirement as a whole because of HIPPA Laws. With these laws the Sentinel was not able to have a storage device attached to the Arduino, so all data is reset with each test that the user does. However, it does meet the portion of the requirement that involves being self-sufficient and stand alone testing with the use of the keypad.***

Interface

- A streamlined device that is intuitive to use in less than a minute of approaching the device (R11). There is a need to make it easy for the user to use the device. Not tied to a user's needs.
  - ***The Sentinel meets this requirement by the use of keypad and LCD screen. The LCD screen displays each step from the beginning and walks through each step with the user.***

Non-Functional

- Set up and ready to use in less than 3 hours (R6). There is a need for this to be able to be portable and the key to portability is set up time. Users need 7 (Device must be transportable).
  - ***The Sentinel meets this requirement with the use of the single power cord into the wall and priming the pumps with a code in under 10 minutes.***
- Able to be sanitized in less than 5 minutes with basic sanitization tools (R7). Rapid sanitization helps guarantee user safety. Users need 2 (Real-time testing devices in classrooms or work environments) and 4 (Needs to be sanitized).
  - ***The Sentinel meets this requirement by being tested with a bleach spray that can wipe the entire product.***
- IP-51 water and dust resistance (R8). The device must not break and a common threat to electronic devices is water intrusion. Not tied to a user's needs.
  - ***The Sentinel meets this requirement by testing with a Clorox spray, and none of the sensors or frame of the product was harmed or stopped fulfilling its needs.***

- Physically stable platform (R9). The device must be continuously usable and to help guarantee this the device needs to be resistant to falling over and being pushed over. Not tied to a user's needs.
    - ***The Sentinel meets this requirement by physical contact with the product or table that the product is on. By bumping, pushing, or shaking the Sentinel was able to maintain its frame and manufacturing abilities.***
- Cost of development must be within budget ($750) (R10). Not tied to a user's needs.
    - ***The Sentinel meets this requirement by the parts list and the cost which is within budget.***

Self-Evaluation

Overall Evaluation- As a group we found this process as an amazing learning experience in how to function cohesively as a team. Some of the key points of the project were coordinating multiple parts in order to have a finished product by the deadline. This required a great amount of communication and admittedly some head butting from time to time when one part or another was lagging behind, but we were able to solve our issues efficiently and internally. We put this success down to the fact that three of us live together and we have worked with Tyler on multiple projects over the years. We believe that if we were to redo this project, we would have made a more thorough schedule, but with that being said we all had a collective desire to get the job done so there was never a real concern that the project would not be completed. One of the major setbacks were the 3D printers, one way this issue could have been circumvented is by starting the design process a month sooner and printing within that time frame. We solved this issue by outsourcing printing, finding an alternative printer from a fellow JU student, and spending hours upon hours in Nelms 6 lab troubleshooting the 3D printers. We also spent months troubleshooting the troublesome sensors such as the thermometer, pulse oximeter, and pioneered a smell test, which we were told was impossible. We believe this is a testament to our overall group resilience to get the project completed.

Chris Kiener- Overall this project was a huge learning experience in time management. I was put in charge of all of the design work and for the first month I didn't have a good idea of how the Sentinel was going to come together. I believe that If I had started the process of designing the internal components in mid-February then there would not have been a huge time crunch in the last month before the deadline. In terms of communication, I believe that our group was very successful with this, while we did butt heads from time to time, we always solved the issue and moved the project in a positive direction, every argument ended with a positive outcome. When it came to individual communication with other teammates, it was very crucial for me to be as flexible as possible with the teammates. For example, David and I had many long conversations over how the best way to design a piece in order to ease manufacturing and assembly. Another point of communication was speaking with Ian and Tyler to decide how to design the mounting points for all of the hardware and trying to figure out how the internal layout of the hardware will be set up. These conversations were always very productive and pushed the project forward.

David Perez - This project has been a great experience of teamwork for me. It highlighted the importance of working together as a whole. At the beginning of the spring semester, we had a lot of ideas on how to build the prototype for the Sentinel. It took us a little while before we had a precise idea on how we wanted to build the mold. I feel like I started a little late on the manufacturing of the mold. Trying to get the proper materials with the tools necessary to build the mold was the most challenging part about this. Once I had the opportunity of using my friend's machine shop, I was able to speed up the process of the mold. Then I started using his shop to quickly catch up with the molding and making the shape of the acrylic. In order to catch up on the work, at this point Kiener was designing the piston assembly so I got in charge of the printing all the parts necessary. The 3D printing was not as reliable as we thought and heated up the environment in the team. We were able to manage the stress and continue with the process to the point where each one of us was working on their part to finish the Sentinel. Towards the last two weeks collaboration between the mechanical and electrical team started to happen more to improve the performance of the team. At the end we were all working together and building the final prototype. The biggest experience I got from the project was how to lead when it is your time and how to let others lead when you are behind. Thinking as a team and not several individuals is what has made us finish in time what was designed. I think my favorite part of the whole process was sitting down for hours and designing all of the 3D printed parts.

Tyler Morris- I believe that this project taught me how to do a few different skills that will be beneficial in my life. The first would be coding specifically in Arduino. I believe that this skill will be very beneficial after speaking with my cousin who works in C++. I was told that coding in Arduino is very similar to working in C++, and I had to learn all of which through Youtube and research about the code. Another important skill that I believe I learned even more was adapting to the situation. I say this because I was put into a group in the beginning of the semester, and had to learn everything about their potential ideas, add my ideas, and link them all together to somehow come up with a great product idea. With this came working where the group needed me most. Even though I was not able to work in the area where I was the most comfortable; I was able to work in an area that would challenge me to produce a great product. Another skill that I would say was learned in a different way was communication. Working with 3 other people who all live together, play on the same team, and spend a lot of time together I knew that they would want to get the project done while they were together. With that I knew I had to be willing to call or text people in the group to see where they needed help.

Ian Hunter - This project was easily my favorite part of my college education. Nothing else has challenged me like this project has in both a technical aspect in having to learn how to code in a language i have never used before, but as well as the personal side, this project forced us to work together more than we have ever before. Even though Chris David and I have lived with each other and been on the same team for the past four years nothing has challenged our teamwork and communication like this project has, this was expanded upon when Tyler joined our group he was an invaluable asset that made this project possible but adding a component of the team that was not part of our lives on a day to day basis forced me to work hard on communication with him to ensure that he was kept in the loop. My favorite part of this project was building the circuitry because as intellectual as the coding was for this project it did not satisfy my innate desire to build something. Putting the project together in the last

couple of weeks honestly brought joy to me as it was very satisfying to work for hours on making a nice and effective circuit. I would not trade any member of this team for anyone else and even though at first i was disappointed that we were not working on the MIS project in the end i would not trade this project for another as this gave us the freedom to make the Sentinel our own and something i will be forever proud of.

Impact of your Solution

The Sentinels mission is to actively screen individuals for COVID-19 symptoms in order to determine if it is safe for them to enter an institution. With its Thermometer, Pulse Oximeter, and smell test, it is able to screen for sense of smell, user temperature, and user blood oxygen levels. While COVID-19 at this stage is slowly getting under control the Sentinel will be effective at easing COVID-19 stress in the population where some individuals are vaccinated, and a growing portion of the population are removing masks from their faces. As COVID-19 moves from the pandemic stage to the endemic stage there will still be isolated individuals testing positive for the virus, but the Sentinel will prevent symptomatic individuals from mingling with healthy individuals and further reducing the spread and preventing new outbreaks of COVID-19.

Ethical and Professional Responsibilities

It is the responsibility of an engineer to hold paramount the safety, health and welfare of the public. In the requirements, the Sentinel must be self-sufficient in order to not further spread COVID-19. The Sentinel also has a requirement to store data, but this requirement could not be met due to the HIPAA regulations put in place by the United States Government in order to protect patient confidentiality. Additionally, Sentinel must by waterproof with an IP rating of IP41, this is in place to prevent the ingress of water which could potentially cause the Sentinel to catch fire and potentially cause bodily harm to the user. Finally, all of the hardware is electrically filtered to protect the user from electrical malfunctions which could potentially cause harm to the user. Team Sentinel holds itself to high ethical standards not only for the safety of the possible users of the Sentinel but also for the product itself. This team prides itself on the quality and novelty of the Sentinel, especially the smell test which is an entirely custom and unique system. In the creation of this test high ethical standards were adhered to, this is a necessity as this test is used in not only gauging someone's health but also calculating whether or not an individual is safe to bring into an environment and come into contact with a multitude of other people.

Conclusion and Recommendations

The Sentinel project has gone a long way. Since the first day this project was assigned to us, we have had steady progress. There were a lot of step backs that required all team members to work together seamlessly in order to get the project done. Staying together and helping each other was the main reason the team has a working prototype. Nevertheless, team dynamics was not an easy task. There were a lot of times where we would bump our heads against each other but always we would come to a reasonable compromise. Outside of the team dynamics, there are a few parts of the design that would help the future

development of the Sentinel. Further testing for the pulse oximeter is needed, there are a few hypotheses on why there are some discrepancies with the results. The main hypothesis besides cleaning your hands properly to avoid grease on the sensor is to paint the mount for the sensor black. By doing this, the pulse oximeter will not reflect light from the mount therefore lowering the number of false positives. From the interface perspective, introducing an OLED display with instructions for the user would facilitate the screening process in a more effective manner. Also, to reduce the manufacturing time we have proposed to start from the beginning with 3D printing instead of going through the process of making the mold and shaping acrylic. This could save time and will ensure that there are no missed measurements or human error that divert the attention of the team from working on the prototype to working on fixing mistakes. Overall, the two semesters are the culmination of all the work the four of us have put into the classes since day one. We have learned to work as a team and be resilient with our set goals. Lastly, a good take away from this project was “always plan for something to go wrong”. This sentence covers preparing a detailed schedule and starting to work on everything early which are the two aspects that could have helped the team finish earlier.

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Appendix

JU Student 1		
Question asked	**Answer**	**Outcome statement**
Are you happy with JU's current method of screening students for COVID-19 before they come to campus?	Yes	Is happy with JU's current method
Do you currently feel comfortable with the number of students coming into your classroom?	Yes	Feels comfortable in class
Would a real time testing device make you more comfortable with students coming into the classroom?	Yes	Needs a real time testing device
What do you think would improve on JU's current method for screening students?	Not make possible covid exposure students come to school.	Needs to avoid possible Covid exposure
Given the fact that most young adults are asymptomatic or show mild symptoms, how would you screen the students to come on campus?	Temperature Checks	Needs temperature checks for asymptomatic people
Would you consider yourself as a part of the group of people at the most risk of contracting COVID-19?	Yes	Doesnt have a need here
Do you have any preexisting conditions?	No	Doesnt have a need here
Briefly explain how COVID-19 has affected your daily life? This includes school, work, going shopping, etc.	I cant go to the bar and I am very stressed about it.	Accurate system with rapid implementation

Where and how often do you get your temperature taken per day?	At my house and once a day	Doesnt have a need here
In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	I don't know I don't visit these places.	Doesnt have a need here
How often do you meet in person?	Never	Doesnt have a need here
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	N/A	Doesnt have a need here
How often do you go out during the week on the weekends? Can you list some example places of where you go? Examples include work off campus, the gym, physical therapy, restaurants etc.	I Go to a club once a day	Needs an accurate system with rapid implementation to go to Club once a day
Are there more preventative measures that your school/work should make to help mitigate the spread of COVID?	Yes we need a device that constantly monitors our temperature and other COVID symptoms	Needs a device to constantly monitor for COVID

(appendix 1)

JU Student 2		
Question asked	**Answer**	**Outcome statement**
Are you happy with JU's current method of screening students for COVID-19 before they come to campus?	No- it is not thorough enough and there is no way that JU can 100% say that students aren't just lying about their symptoms so they won't have to quarantine.	Needs more accountability

Do you currently feel comfortable with the number of students coming into your classroom?	Yes - none of my classes are larger than 10 or 12 and if they are my professors have divided them into split sections	No needs here
Would a real time testing device make you more comfortable with students coming into the classroom?	Yes	Needs a real time testing device
What do you think would improve on JU's current method for screening students?	Real time testing and temperature checks for all students	Real time testing on all students
Given the fact that most young adults are asymptomatic or show mild symptoms, how would you screen the students to come on campus?	Through contact tracing, have students report if they had been around anyone with symptoms or a positive test.	Needs contact tracing and student accountability
Would you consider yourself as a part of the group of people at the most risk of contracting COVID-19?	No	No needs here
Do you have any preexisting conditions?	No	No needs here
Briefly explain how COVID-19 has affected your daily life? This includes school, work, going shopping, etc.	it has affected every aspect. Since I am a college student, living on campus has become very different since Covid. My roommates and I are very conscious of who we hang out with in our immediate circles as well as where we go on a day to day basis.	Needs a more accurate way to measure if he/she is possibly infected with Covid
Where and how often do you get your temperature taken per day?	every morning and once a day	No needs here
In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	There are markers on the floors of where to stand, masks are mandatory, and sanitization happens periodically on high-touch surfaces.	No needs here

How often do you meet in person?	With my professors and in my classes – once-twice a week; with my teammates on the JU sailing team – 3-4 times a week depending on the teammate.	Meets with professors, classmates, and teammates a few times a week
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	There is a loosely required, much more 'recommended' JU health screening that students fill out via email online, however I have seen students fill it out while sitting already in their classrooms. Therefore, I believe there is not accountability or requirement involved and that the health screenings are simply a legal loophole that JU has put into place to prevent being sued	Needs more accountability
How often do you go out during the week on the weekends? Can you list some example places of where you go? Examples include work off campus, the gym, physical therapy, restaurants etc.	I probably go out once-twice on the weekends to either the beach or a restaurant/ coffee shop. I try to go places outside where I know I will be able to maintain social distancing.	Needs met here
Are there more preventative measures that your school/work should make to help mitigate the spread of COVID?	Yes	Needs met here

(appendix 2)

Engineering Company		
Question asked	**Answer**	**Outcome statement**
Are you happy with your company's current method of screening workers for COVID-19 before they come to the office?	Yes	Happy with current method

Do you currently feel comfortable with the amount of workers coming into work?	Yes	Happy in the work place
Would a real time testing device make you more comfortable with students coming into work?	Yes	Real time testing device
What do you think would improve on current method for screening workers?	Something that would give us standards on what to check. This virus is so new, most of the time we don't know if everything we are checking is correct, and if there are more things we should be checking or looking for.	Standards for testing
Given the fact that most young adults are asymptomatic or show mild symptoms, how would you screen the workers to come to work?	We have no way of testing asymptomatic unless they get tested.	A way to test aympotomatic students and employees.
Would you consider yourself as a part of the group of people at the most risk of contracting covid?	Yes	Needs more precautions in public setting
Do you have any preexisting conditions	No but some of our employees do.	Needs more precautions in public setting
Briefly explain how COVID-19 has affected your daily life? This includes school, work, going shopping, etc.	Constantly wearing a mask, washing our hands several times a day, being scared of touching anything, being scared of getting too close to someone, I do not come into an elevator that already has two people in it, going to the gas station is the scariest part of my routine.	Has had to change their routines and habits
Where and how often do you get your temperature taken per day?	Once	
In areas with high demand such as the lunch room or the lobby what preventative measures are taken to maintain capacity guidelines and sanitization?	Lunch room is not open, employees must have lunch at their desks. When they get up from their seats they have to wear a mask anywhere they go.	Already have protocols set to prevent spread of Covid

How often do you meet with other workers, is there a hybrid system where some workers are at home and others in the building?	We have stablished a protocol where all meetings have to be done by Microsoft Teams or Zoom, even if both employees are at the office.	Already have needs met for meetings
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	No, there is no check. Employees are told not to come to the office if they are not feeling okay.	No need for more precautions here
How often do you go out during the week on the weekends? Can you list some example places of where you go?	Examples include the gym, physical therapy, restaurants etc. I go to the gym every day, I have to wear a mask and clean all equipment I use. The gym has been separated into sections where people can work out by themselves with social distancing standards. Restaurants on the weekends.	Needs to be more cautious in public settings cmpared to pre-COVID
Are there more preventative measures that your school/work should make to help mitigate the spread of COVID?	If there are, we are not aware of them.	Needs more preventative measures

(appendix 3)

Architectural Company		
Question asked	**Answer**	**Outcome statement**
Are you happy with your company's current method of screening workers for Covid-19 before they come to the work place?	I am okay, we don't really have one.	Need a screening method

Do you currently feel comfortable with the number of workers coming into work?	Yes, we work outside in the constructions so there is no worry about not been able to respect social distance	No need
Would a real time testing device make you more comfortable with students coming into work?	Yes, it would be really helpful to have something on site	Need a real time screening device
What do you think would improve on the company's current method for screening workers?	A device that we can take to different houses depending on where we are working	Need to be transportable
Given the fact that most young adults are asymptomatic or show mild symptoms, how would you screen the workers to come to work?	I don't know how, but just temperature outside is not pretty accurate	Needs to check more symptoms
Briefly explain how Covid-19 has affected your daily life? This includes school, work, going shopping, etc.	I have to wear a mask to most places and it slowed the busines for a little because we did not have a way to make sure the workers were not infected	Need a real time screening device
Where and how often do you get your temperature taken per day?	I usually check my temperature when I have to go to the work place or do any paperwork	No need
In areas with high demand such as the lunchroom, the lobby, etc. What preventative measures are taken to maintain capacity guidelines and sanitization?	We do not have any measures besides washing our hands	Need more sanitazing measures
How often do workers meet, is there a hybrid system where some workers are at home and others in the building?	Workers meet 5 days a week. There is no possibility for hybrid schedule	No need
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	We don't have a method, we depend on the workers to say something if they are feeling sick	Need method to screen workers

How often do you go out during the week on the weekends? Can you list some example places of where you go? Examples include the gym, physical therapy, restaurants etc.	I usually go for groceries and work related activities	No need
Are there more preventative measures that your school/work should make to help mitigate the spread of COVID?	Something that can tell us more than a thermometer.	Need to check more that just temperature

(appendix 4)

ROTC Student 1		
Question asked	**Answer**	**Outcome statement**
Briefly explain how Covid has affected your daily life? This includes school, work, going shopping, etc.	Ive spent 14 days in quarantine, wear a mask when I leave my residence, clorox bleach my apartment before moving in as a Safety precaution.	No need
What preventative measures is your campus/work doing to help mitigate the spread of Covid?	Hybrid or in person and online classes, requires masks but doesn't enforce it, limits social gatherings	Need to have more accountability with the preventibe measures that are in place
Where and how often do you get your temperature taken per day?	Only when checking into the unit, once per day.	No need
In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	Limit on number of students sitting and eating, tables are sanitized after use	Need to be sanitized

How often do you meet in person or virtually?	In person on T & W for 2 classes, virtual for all other days (6 classes)	Need a reliable health screening device to attend in person class
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	The university publishes a questionnaire everyday regarding symptoms tho there is no accountability for it. The ROTC unit does temperature checks and keeps a log of everyone who enters the building.	Need more accountability for recording syntoms
How often do you go out during the week on the weekends? Can you list some example places of where you go? Examples include work off campus, the gym, physical therapy, restaurants etc.	Internship of campus, 2x per week. Gym 3-4x per week. Grocery store and farmers market 1-2x per week.	No need
Are there more preventative measures that your school/work should make to help mitigate the spread of Covid?	Temperature checks in classroom settings	Need to take more temperature checks
Are you happy with JU's current method of screening students for Covid before they come to campus?	No	Need better health screening method
Would a real time testing device make you more comfortable with students coming into the classroom?	Yes	Need real time testing device
What do you think would improve on JU's current method for screening students?	Instant results, cost effective and cheap	Need real time testing device that is cheap

(appendix 5)

ROTC Student 2		
Question asked	**Answer**	**Outcome statement**
Briefly explain how Covid has affected your daily life? This includes school, work, going shopping, etc.	A lot more conscious about how close I am to people, how frequently I sanitize/wash my hands, making sure I never forget my mask, making sure I color coordinate my mask with my outfit	Need to be able to sanitize hands
What preventative measures is your campus/work doing to help mitigate the spread of Covid?	Social distancing, incorporating sanitation stations, non contact food service, sanitizing frequently	Need sanitation station/other preventative measures
Where and how often do you get your temperature taken per day?	In my room and done by myself daily	No need
In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	Split class to be hybrid learning, using disinfectant wipes to clean desks	Need less crowded class and sanitrazing method
How often do you meet in person or virtually?	Half and half	No need
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	Yes and no there is no accountability to make sure	Need more accountability for the screening method
How often do you go out during the week on the weekends? Can you list some example places of where you go? Examples include work off campus, the gym, physical therapy, restaurants etc.	Work on campus everyday, gym on campus everyday, restaurants on the weekend twice a month, grocery store every other week, casual shopping every weekend	Need a screening method on campus buildings

Are there more preventative measures that your school/work should make to help mitigate the spread of Covid?	Take accountability of the people that are on campus to ensure they don't have any symptoms. MAKE PEOPLE WHO GO INTO ISOLATION/QUARANTINE GET TESTED PRIOR TO THEIR RELEASE	Need acountability for testing
Are you happy with JU's current method of screening students for Covid before they come to campus?	I Guess	No need
Would a real time testing device make you more comfortable with students coming into the classroom?	I guess so	No need
What do you think would improve on JU's current method for screening students?	Not much room for improvement	No need

(appendix 6)

ROTC Student 3		
Question asked	**Answer**	**Outcome statement**
Briefly explain how Covid has affected your daily life? This includes school, work, going shopping, etc.	Completely virtual events for everything	Need to go virtual for class
What preventative measures is your campus/work doing to help mitigate the spread of Covid?	Going more virtual than in class	Need to go virtual for class
Where and how often do you get your temperature taken per day?	My room about once a day if feeling headache or symptoms	Need to keep measuring temperature when necessary

In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	Very high sanitation procedures, take out containers	Need sanitation proceadure
How often do you meet in person or virtually?	Virtually about three times a week and in class about five	No need
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	No, except restaurants and military establishments. They have requirements .	Need a symtoms checking device in places on campus
How often do you go out during the week on the weekends? Can you list some example places of where you go? Examples include work off campus, the gym, physical therapy, restaurants etc.	4-5 for the gym and stores	No need
Are there more preventative measures that your school/work should make to help mitigate the spread of Covid?	Going virtual as much as possible, wearing my mask and social distancing	Need to go virtual for class
Are you happy with JU's current method of screening students for Covid before they come to campus?	No, because it relies only on students to be truthful	Need more accountability
Would a real time testing device make you more comfortable with students coming into the classroom?	Yes. Or temp checks on the way into class at least	Need real time testing
What do you think would improve on JU's current method for screening students?	Temp checks before classes or another screening tool. Like one of the new covid dogs (like drug dogs but for covid)	Need real time temperature check

(appendix 7)

ROTC Student 4

Question asked	Answer	Outcome statement
Briefly explain how Covid has affected your daily life? This includes school, work, going shopping, etc.	I have to wear a mask everywhere and I carry hand sanitizer everywhere. I don't go out as much so I have more free time.	Need more sanitation stations
What preventative measures is your campus/work doing to help mitigate the spread of Covid?	JU has a covid team that reaches out to students who are feeling symptoms or test positive.	Need to rely on a symtoms testing device
Where and how often do you get your temperature taken per day?	Once	Need to get tempearute taken in different buildings
In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	Students are spaced out in the classroom	No need
How often do you meet in person or virtually?	I go to in person class everyday as well as online class	No need
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	No	Need a symptoms testing device that takes more than just temperature
How often do you go out during the week on the weekends? Can you list some example places of where you go? Examples include work off campus, the gym, physical therapy, restaurants etc.	I go to the gym and go shopping usually.	Need to have a device that could be placed on the gym and other places
Are there more preventative measures that your school/work should make to help mitigate the spread of Covid?	No	No need
Are you happy with JU's current method of screening students for Covid before they come to campus?	I think it's about effective as it's going to get.	Needs it to be effective

Would a real time testing device make you more comfortable with students coming into the classroom?	No covid is only dangerous to older people or people with other illness or underlying conditions.	No need
What do you think would improve on JU's current method for screening students?	The only way to improve it would be by having an abundance of covid testing materials that give instant results.	Need instant result with several ways to test for symptoms

ROTC Student 5		
Question asked	**Answer**	**Outcome statement**
Briefly explain how Covid has affected your daily life? This includes school, work, going shopping, etc.	Just the fact that gyms were closed for a while. Therefore I couldn't workout as effectively.	Needs to be able to continue workout routine
What preventative measures is your campus/work doing to help mitigate the spread of Covid?	Mandatory mask wearing, limited occupancy, predetermined walkways	Needs preventative measures to be taken
Where and how often do you get your temperature taken per day?	Depends but sometimes twice a week	
In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	I'm assuming the ladies at the front desk of the caf are managing the occupancy.	Needs accountability
How often do you meet in person or virtually?	I meet in person for 5 of my 6 classes	No need

If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	Generally, no	No need
How often do you go out during the week on the weekends? Can you list some example places of where you go? Examples include work off campus, the gym, physical therapy, restaurants etc.	I don't necessarily go out on the weekends. I go to the gym 6 times a week off campus. And I frequently go to restaurants.	Needs to be able to continue workout routine
Are there more preventative measures that your school/work should make to help mitigate the spread of Covid?	No	No need
Are you happy with JU's current method of screening students for Covid before they come to campus?	No	No need
Would a real time testing device make you more comfortable with students coming into the classroom?	Yes	Needs real time testing device
What do you think would improve on JU's current method for screening students?	Instant results, cost effective and cheap	Needs real time testing device

JU Employee 1		
Question asked	**Answer**	**Outcome statement**
Briefly explain how Covid has affected your daily life? This includes school, work, going shopping, etc.	COVID-19 has impacted my daily life by me having to readjust how, when, and why i do things. I have to conscientiously decide what is most important when choosing to go places.	Needs to take preventive measures

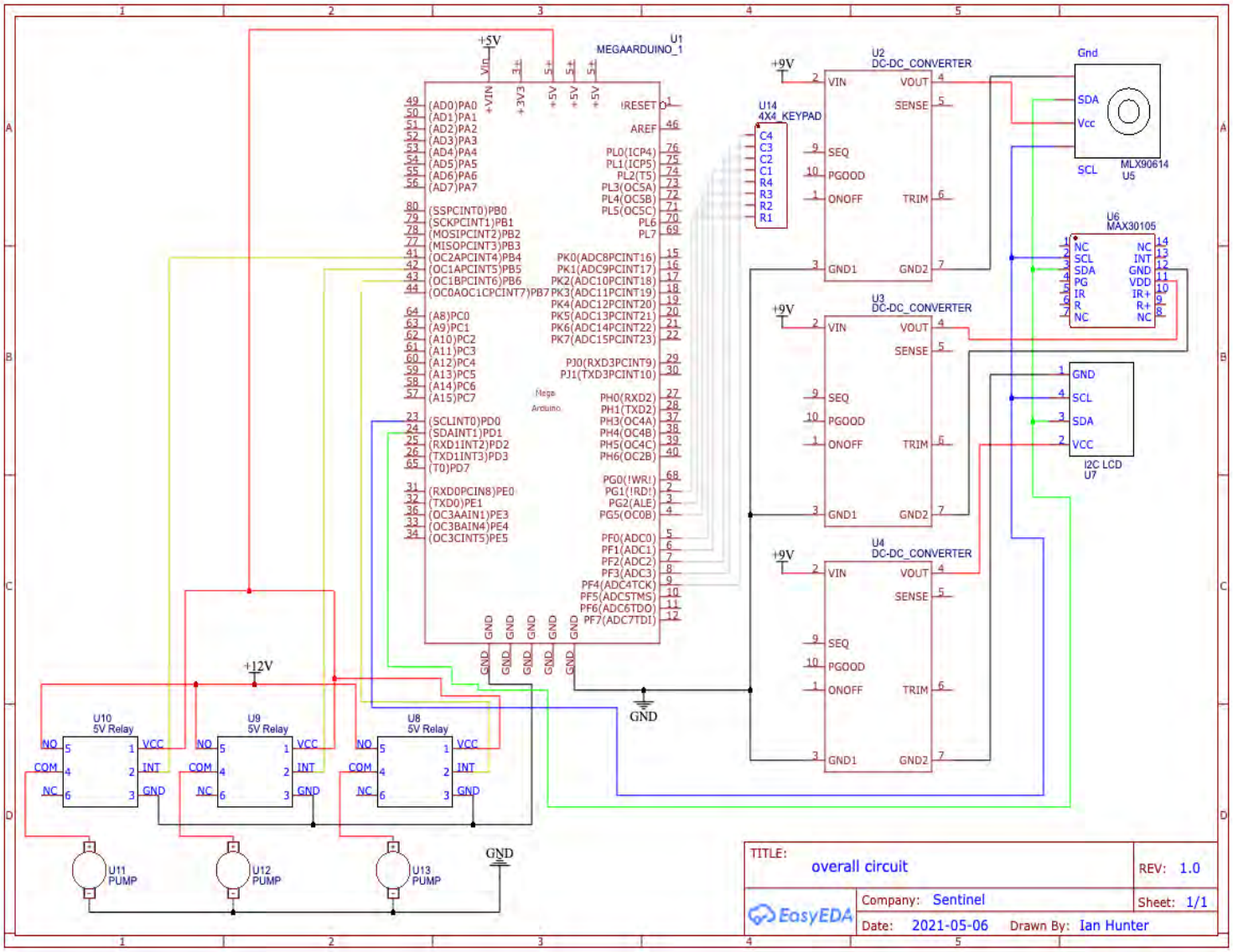
What preventative measures is your campus/work doing to help mitigate the spread of Covid?	Wearing a mask, social distancing, washing hands more	Needs sanitation
Where and how often do you get your temperature taken per day?	2-3	No need
In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	I adhere to social distancing and maintain distance	Needs social distancing
How often do you meet in person or virtually?	Twice a week	No need
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	I self check my temparature	No need
How often do you go out during the week on the weekends? Can you list some example places of where you go? Examples include work off campus, the gym, physical therapy, restaurants etc.	Grocery stores	No need
Are there more preventative measures that your school/work should make to help mitigate the spread of Covid?	Yes	Need a screening device that is not just temperature
Are you happy with JU's current method of screening students for Covid before they come to campus?	No	Need more accoutability
Would a real time testing device make you more comfortable with students coming into the classroom?	Yes	Needs real time testing device
What do you think would improve on JU's current method for screening students?	Consistency	Needs real time testing device

JU Employee 2		
Question asked	**Answer**	**Outcome statement**
Briefly explain how Covid has affected your daily life? This includes school, work, going shopping, etc.	No able to do as much or trust people.	Need a device that holds people accountable
What preventative measures is your campus/work doing to help mitigate the spread of Covid?	Updates on Our Safety Policies	Need safety polices updated
Where and how often do you get your temperature taken per day?	n/a	No need
In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	Face coverings are still required inside all campus buildings and whenever social distancing is not possible. In-person gatherings of more than 10 people are not permitted. We will continue limiting capacity within our classrooms, labs, dining facilities and other indoor spaces.	Need to be a ble to screen several people
How often do you meet in person or virtually?	University employees who are working remotely continue to do so, and meetings should are virtual.	No need
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	In-person meetings of only 1 person permitted at a time	Need to screen fast
How often do you go out during the week on the weekends? Can you list some example places of where you go? Examples include work off campus, the gym, physical therapy, restaurants etc.	Maybe once or twice a week	Need more temperature checks

Are there more preventative measures that your school/work should make to help mitigate the spread of Covid?	limiting capacity within our classrooms, labs, dining facilities and other indoor spaces.	No need
Are you happy with JU's current method of screening students for Covid before they come to campus?	No not at all	No need
Would a real time testing device make you more comfortable with students coming into the classroom?	Yes, very	Need real time screening device
What do you think would improve on JU's current method for screening students?	It can be better and safer for faculty if students who have came in contact with someone having COVID-10 are tested	Need get tested for Covid

JU Dance Professor		
Question asked	**Answer**	**Outcome statement**
Are you happy with JU's current method of screening students for COVID-19 before they come to campus?	Yes	No need
Do you currently feel comfortable with the amount of students coming into your classroom?	Yes	No need
Would a real time testing device make you more comfortable with students coming into the classroom?	Do you mean a Covid test or a thermometer? No	No need
What do you think would improve on JU's current method for screening students?	Not sure	Need some standards on what to check
Given the fact that most young adults are asymptomatic or show mild symptoms, how would you screen the students to come on campus?	I would not screen a student I would leave the screening up to the security and University.	Needs university to screen students

Briefly explain how COVID-19 has affected your daily life? This includes school, work, going shopping, etc.	I have to wear a mask daily, I take less trips to the store or to see friends. I order to go instead of eating in a restaurant. I don't go to crowded places.	Needs to avoid contact with COVID-19
Where and how often do you get your temperature taken per day?	1 time a day at my kids school.	No need
In areas with high demand such as the cafeteria or the classrooms what preventative measures are taken to maintain capacity guidelines and sanitization?	Air ventilation is key for high traffic areas.	Air ventilation
How often do you meet in person.	Meet who in person and where (outside or inside)?	No need
If you meet in person, is there a pre-symptom check you must do prior to entering a building? If so, is it a requirement and is there accountability on making sure everyone has been approved prior to entering a building?	Depends on where I am going. To a school yes, to a restaurant no.	Needs real time testing
How often do you go out during the week on the weekends? Can you list some example places of where you go?	1- 2 time a week to order take out	No need
Are there more preventative measures that your school/work should make to help mitigate the spread of COVID?	A vaccine	A Vaccine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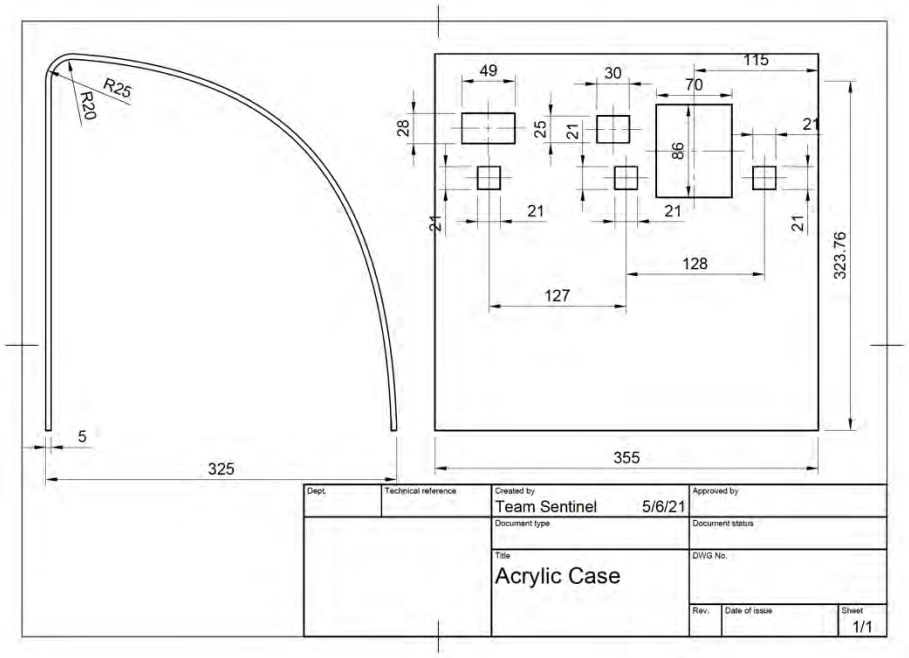
Sheet: 1/1
Date: 2021-05-06
Drawn By: Ian Hunter
EasyEDA

(Appendix 8)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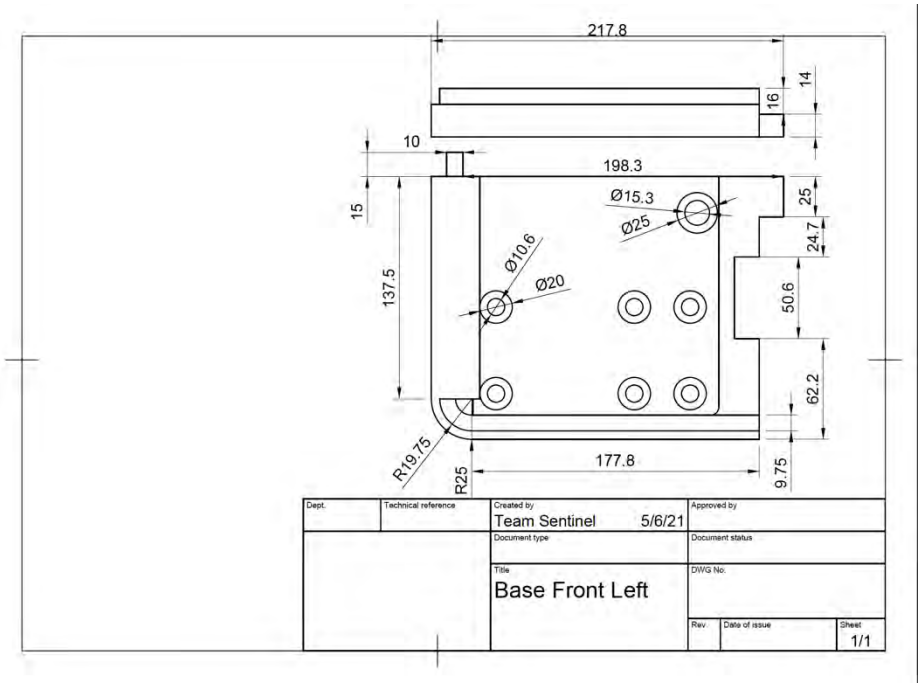
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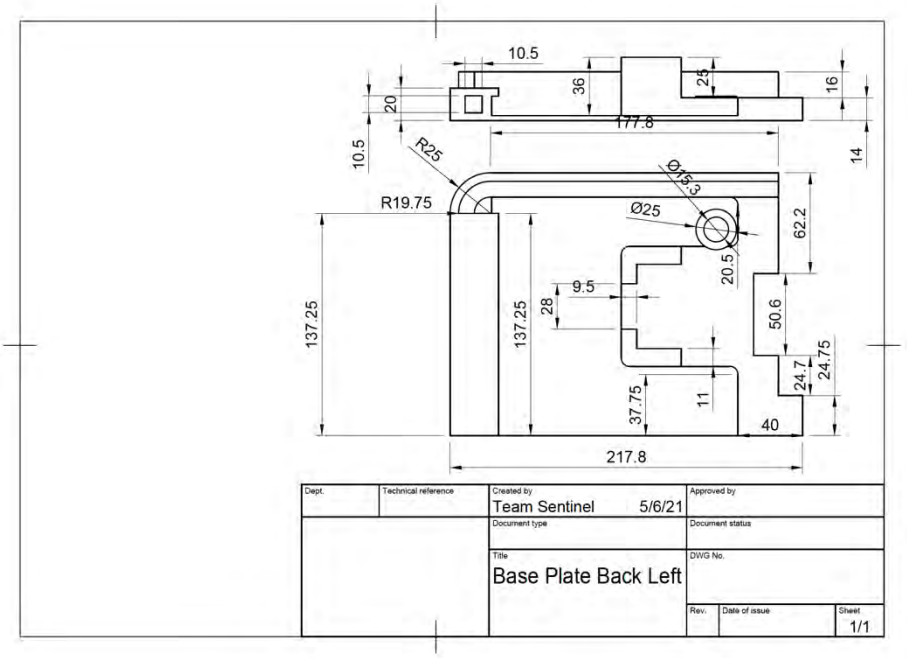
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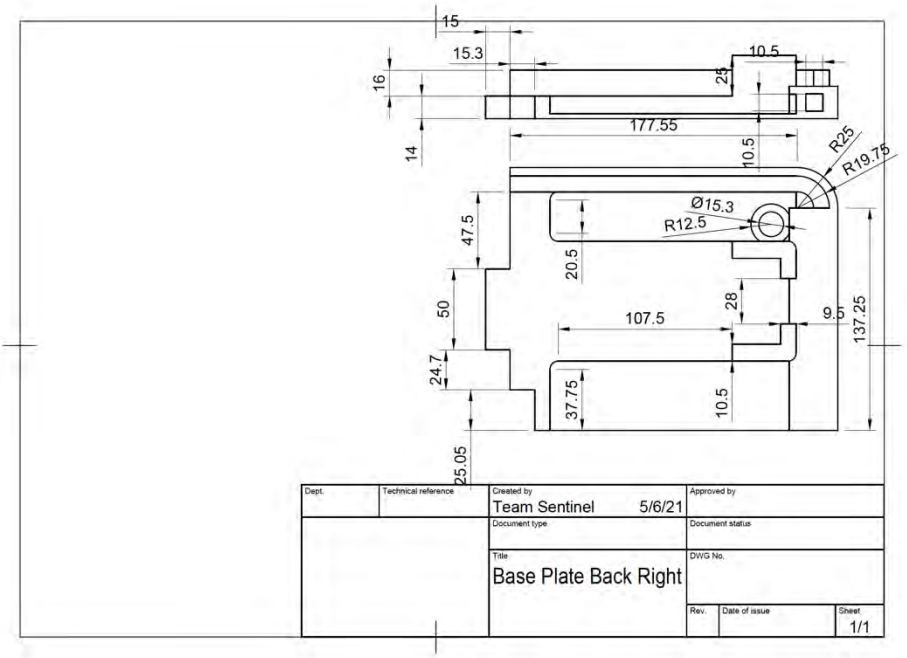
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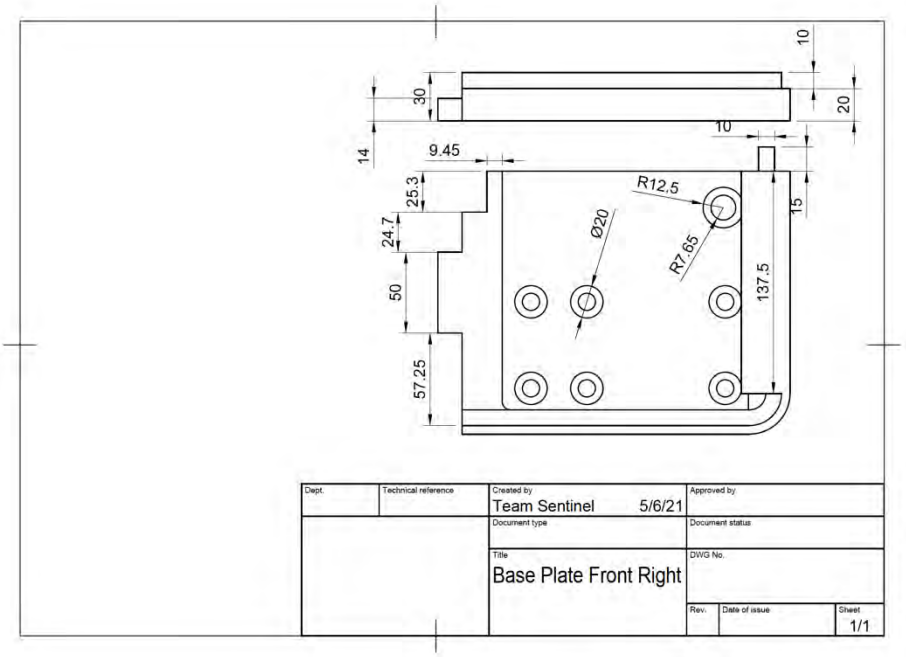

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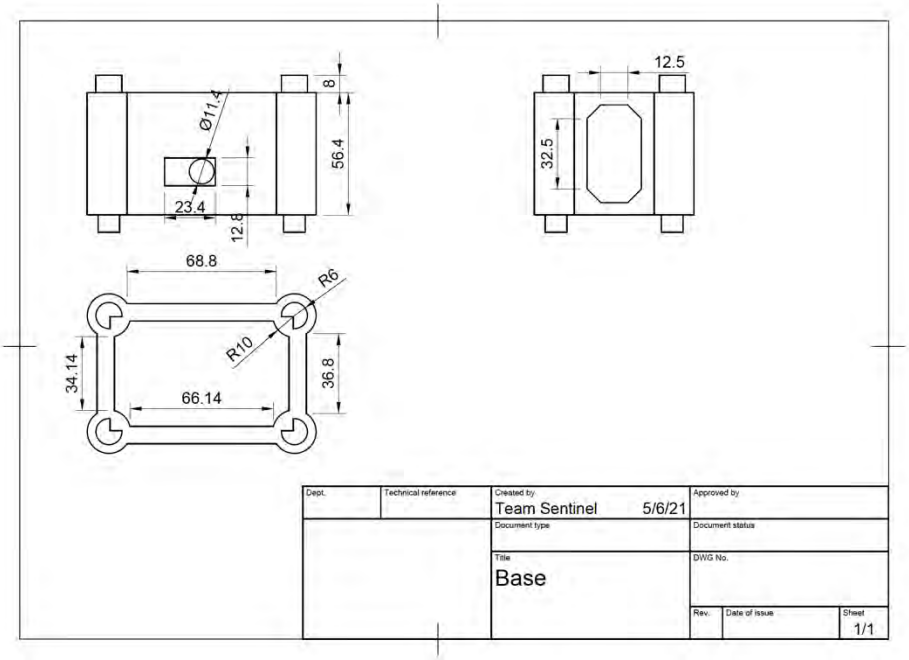

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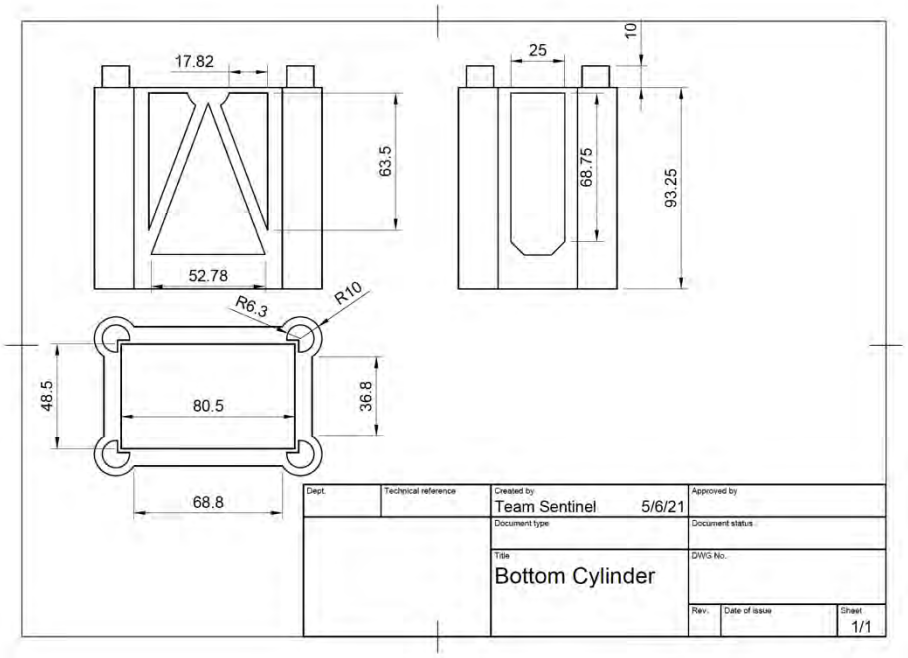
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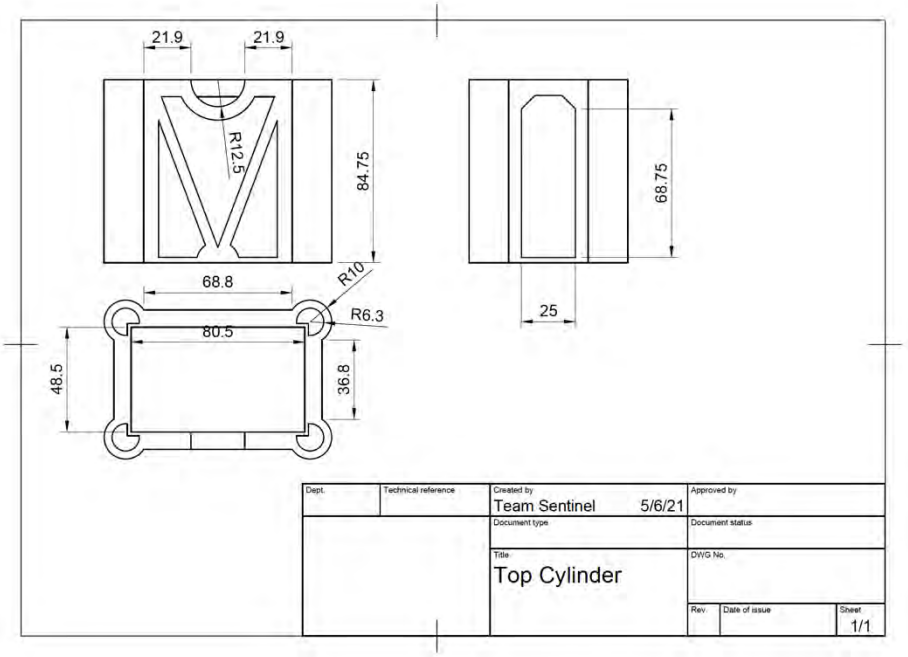
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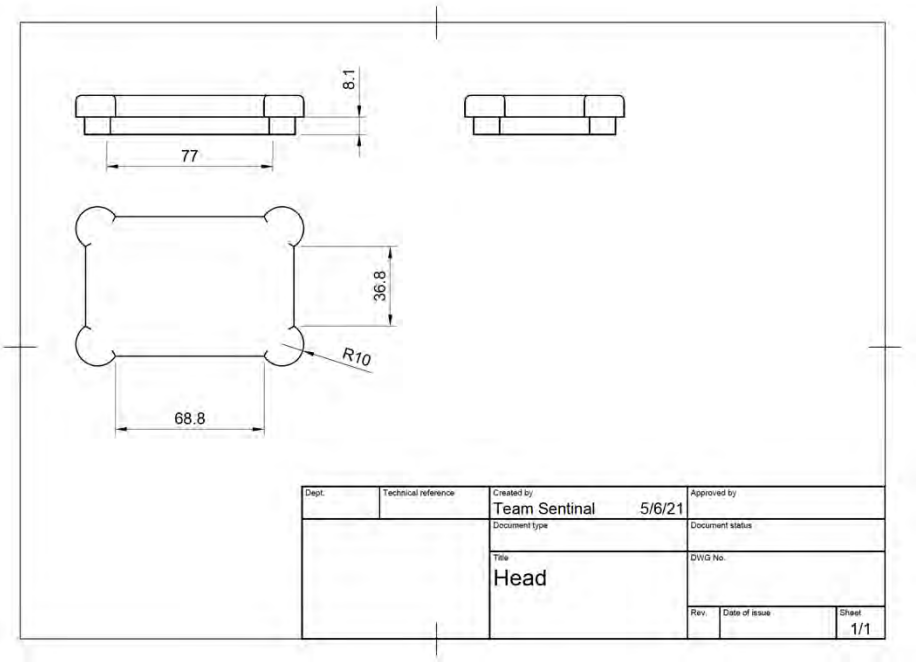

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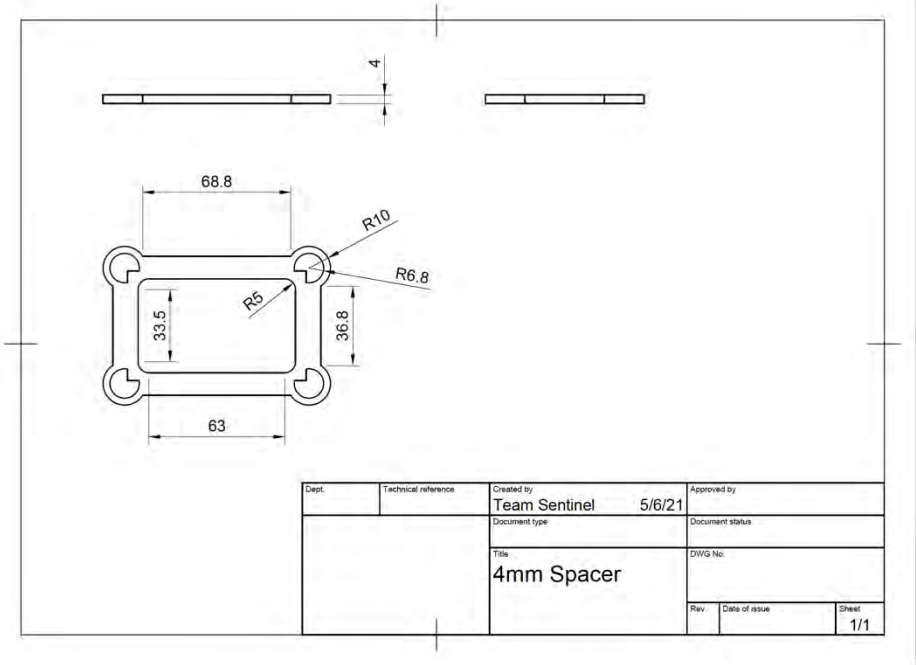

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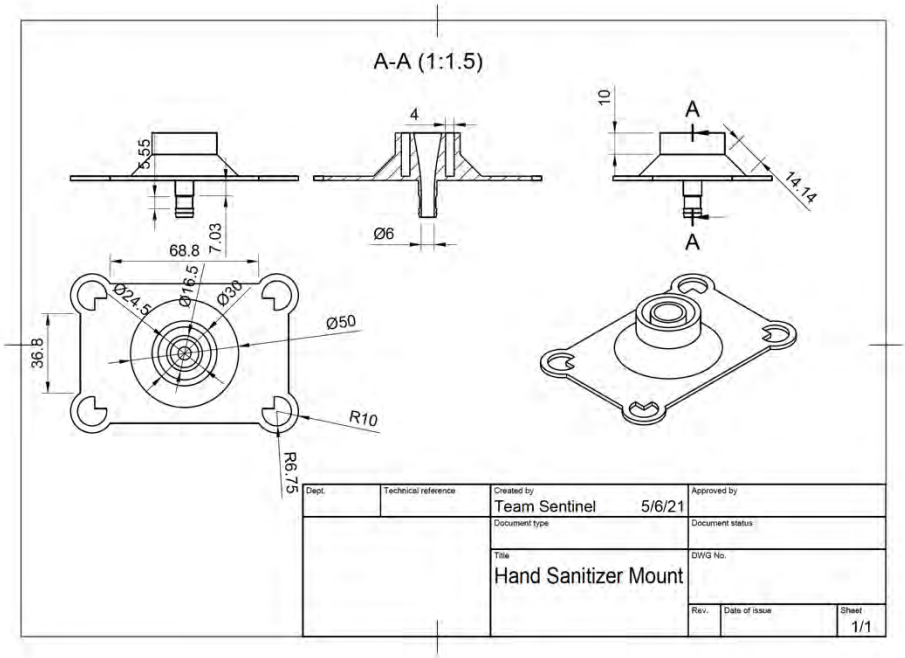
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Rev.
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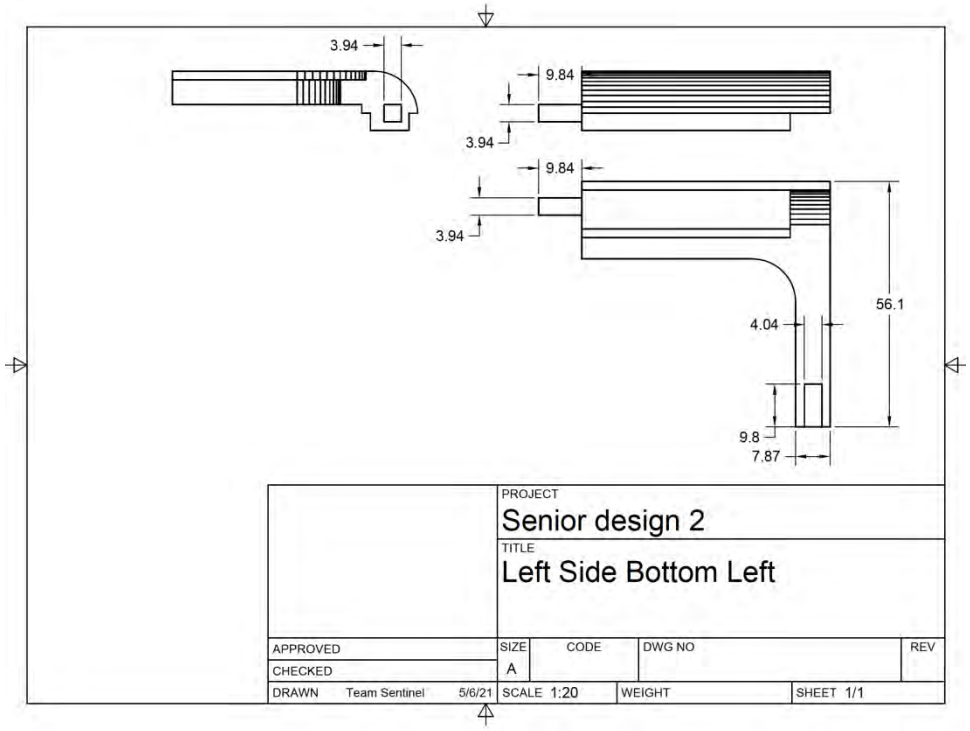
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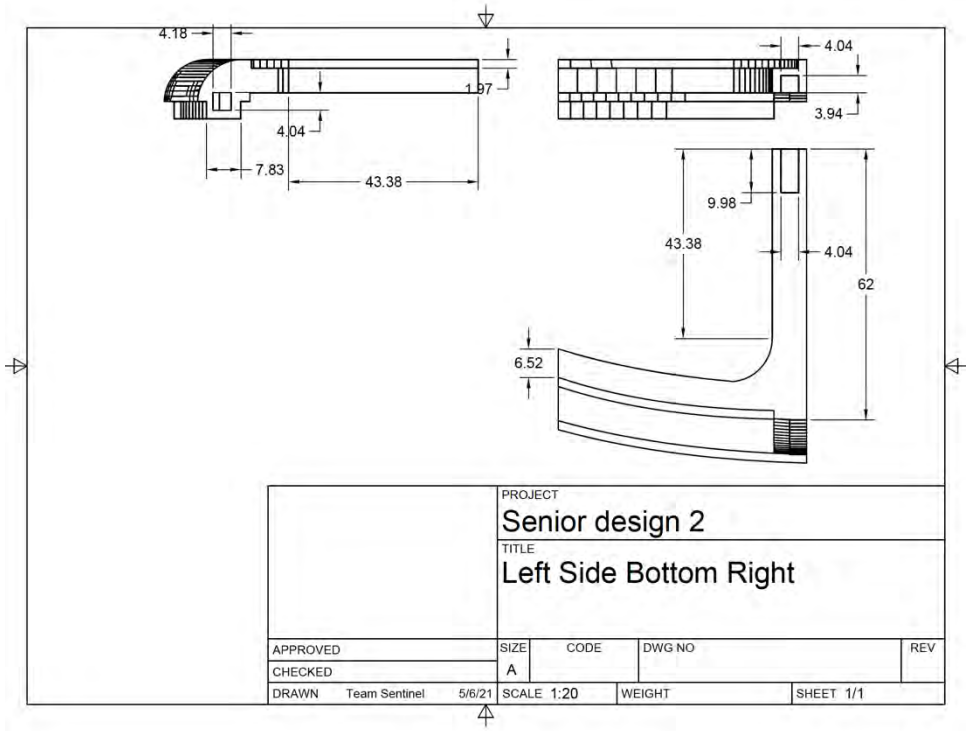

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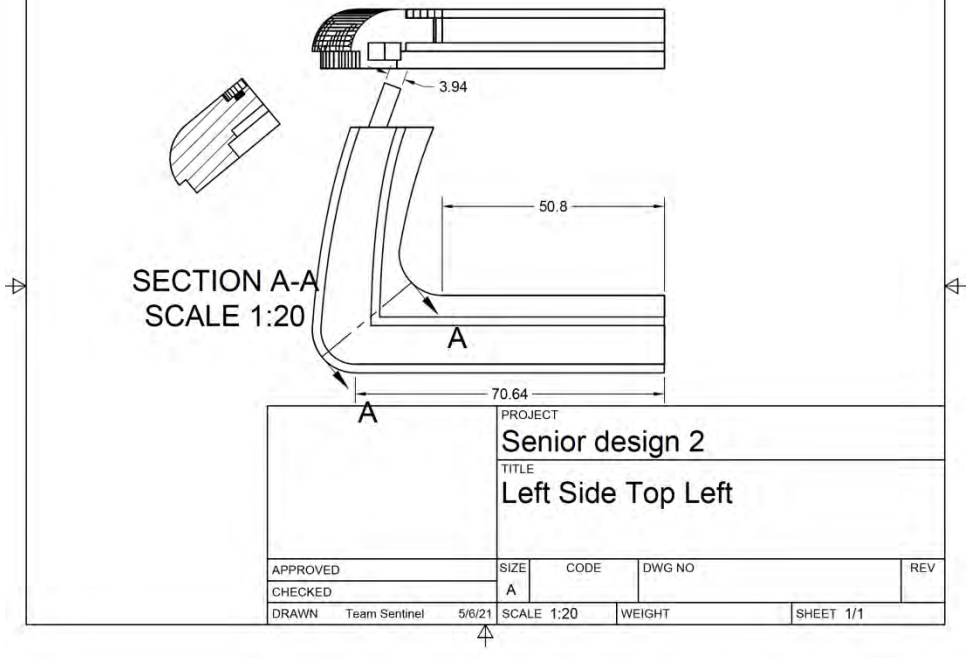

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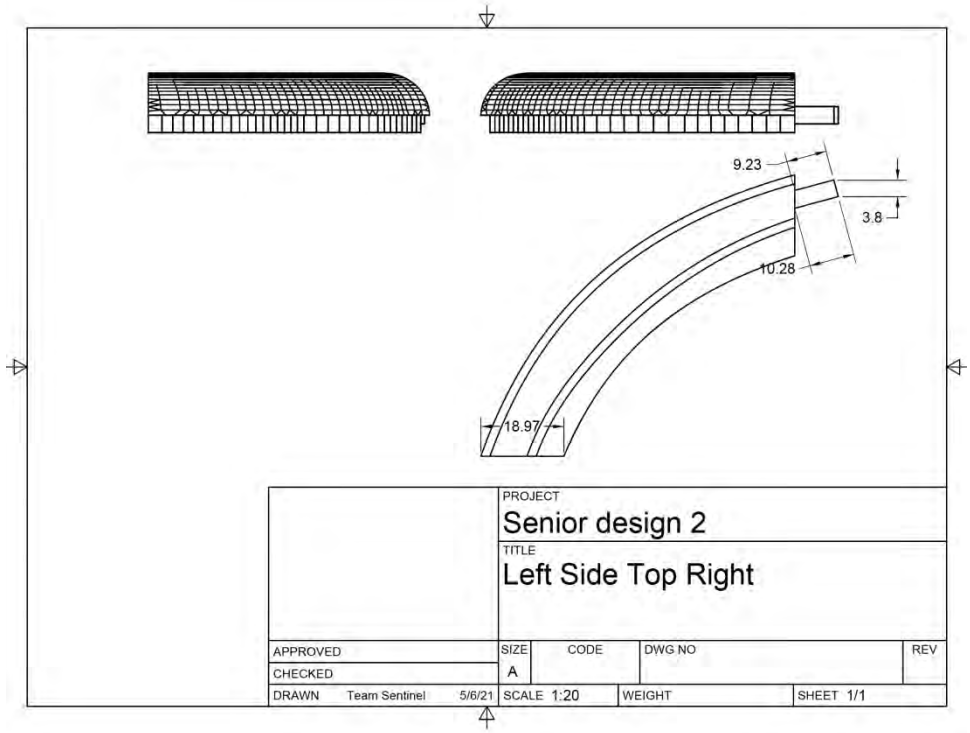

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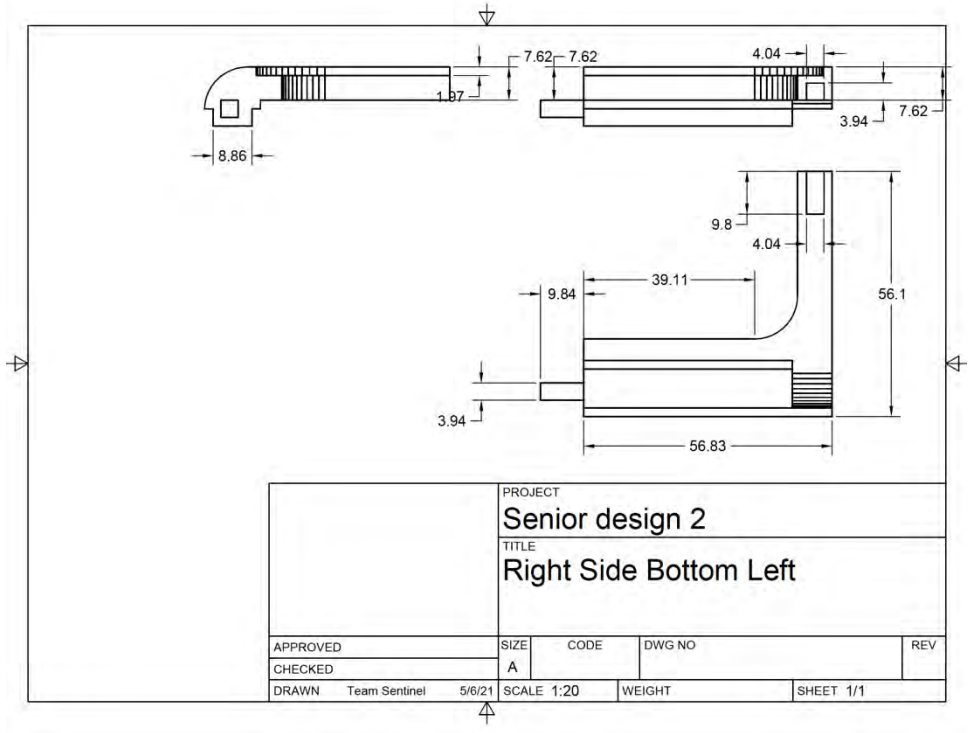

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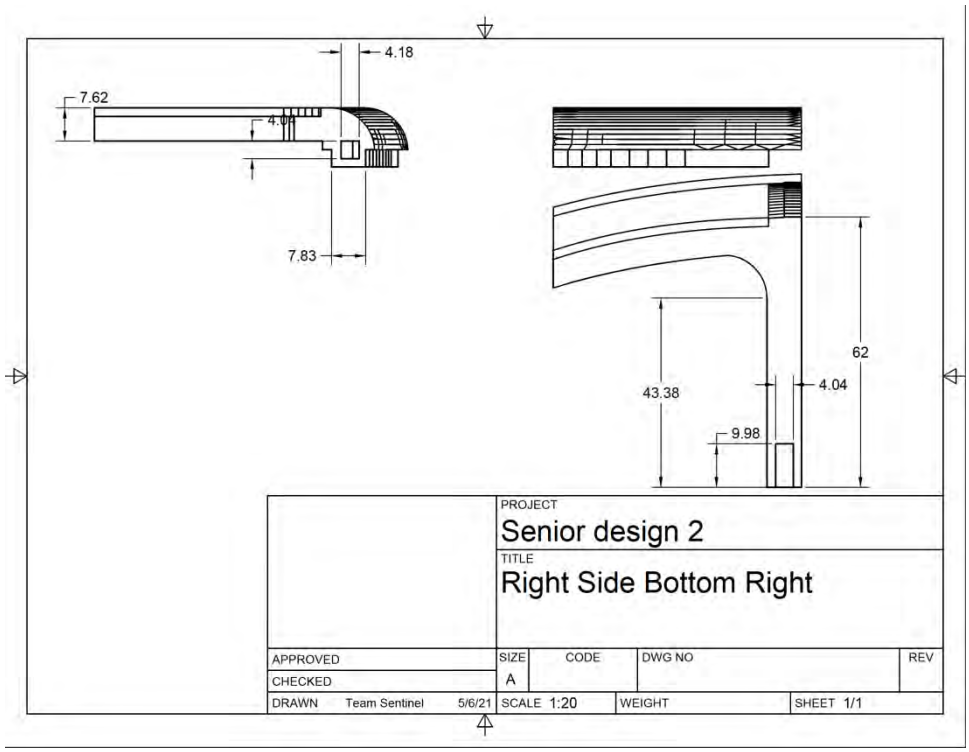

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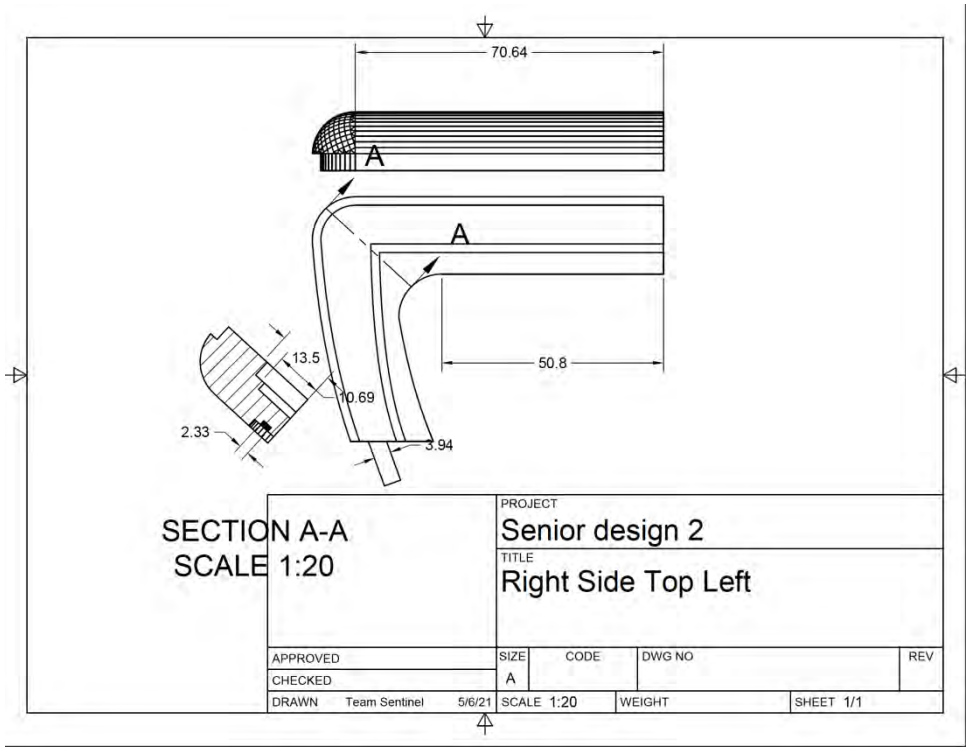

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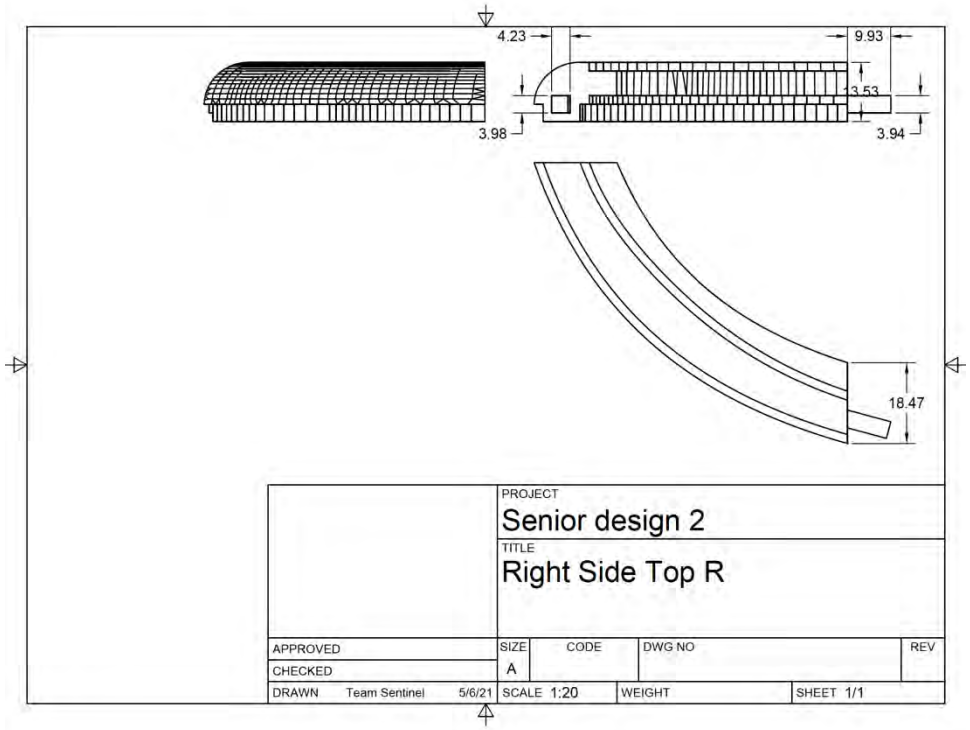

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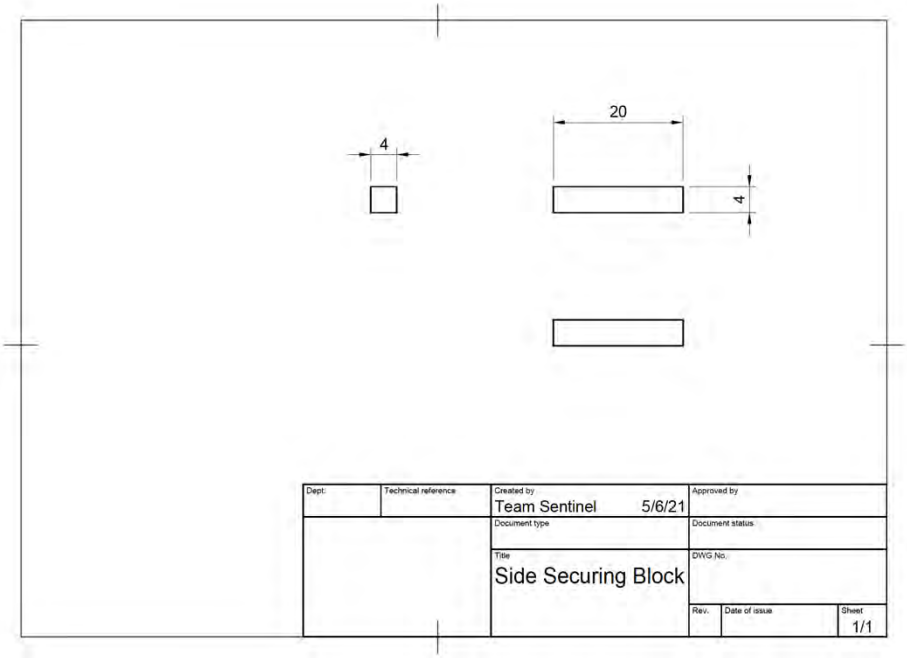

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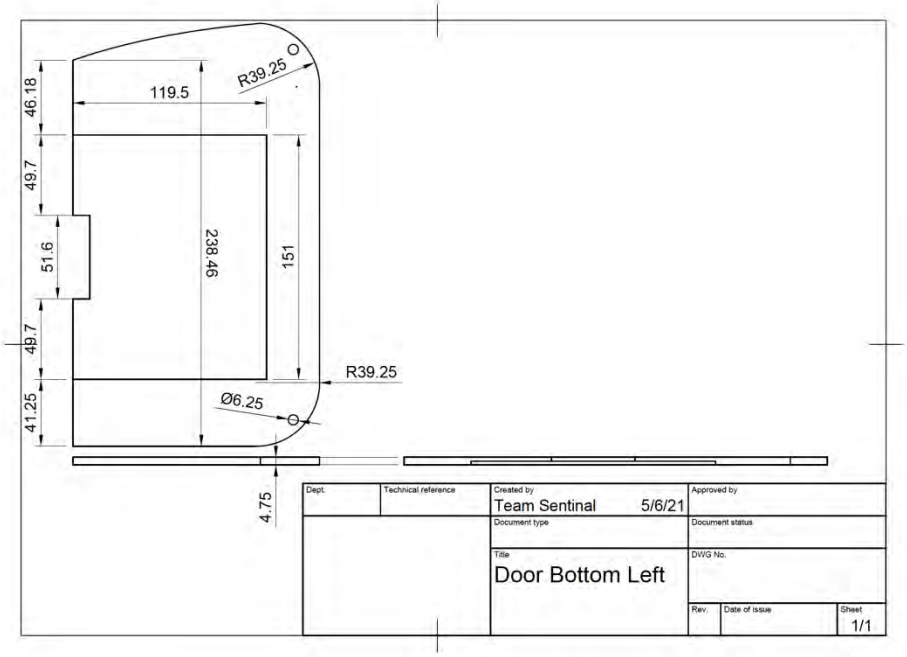

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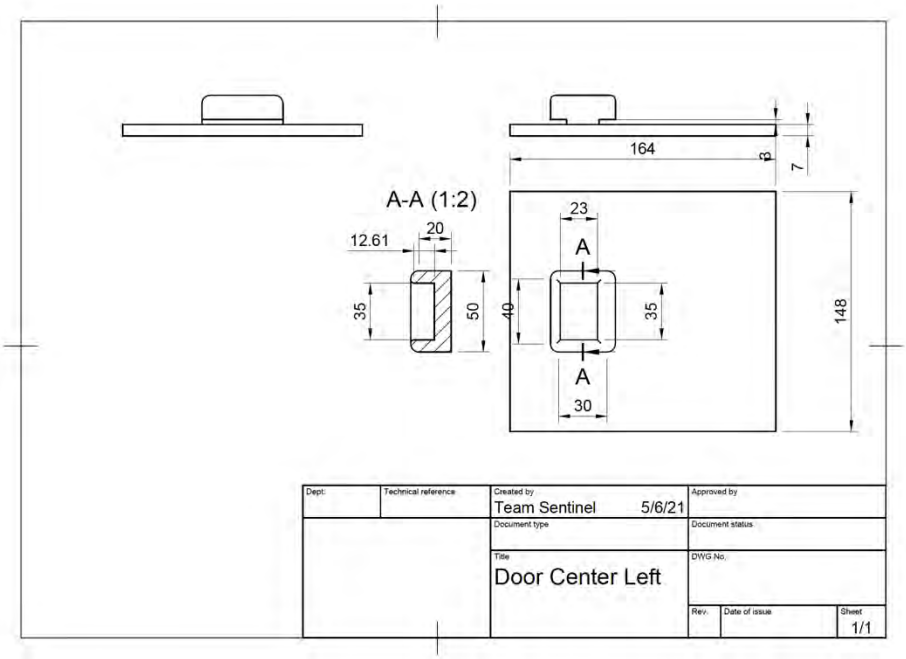

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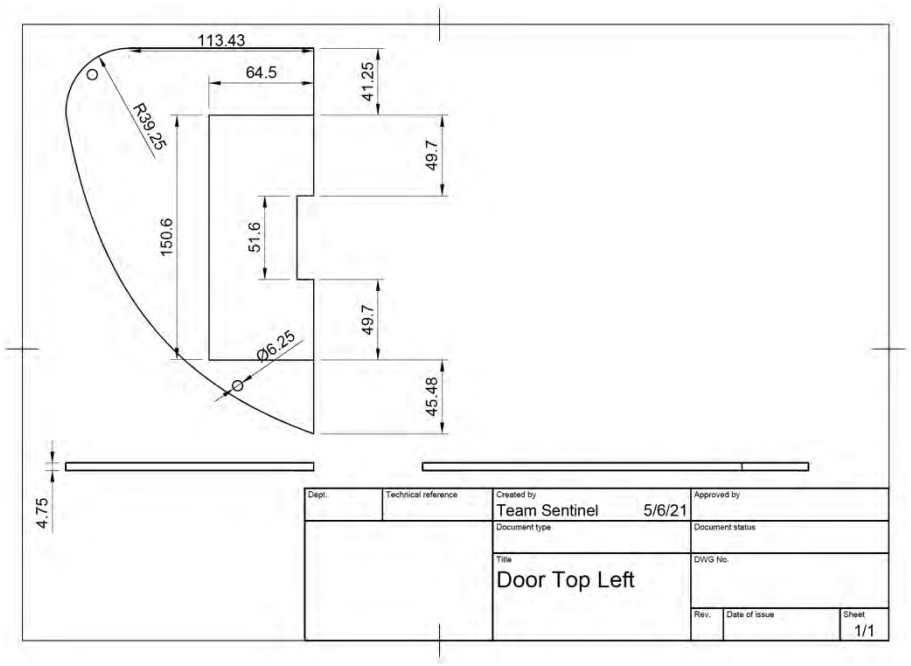
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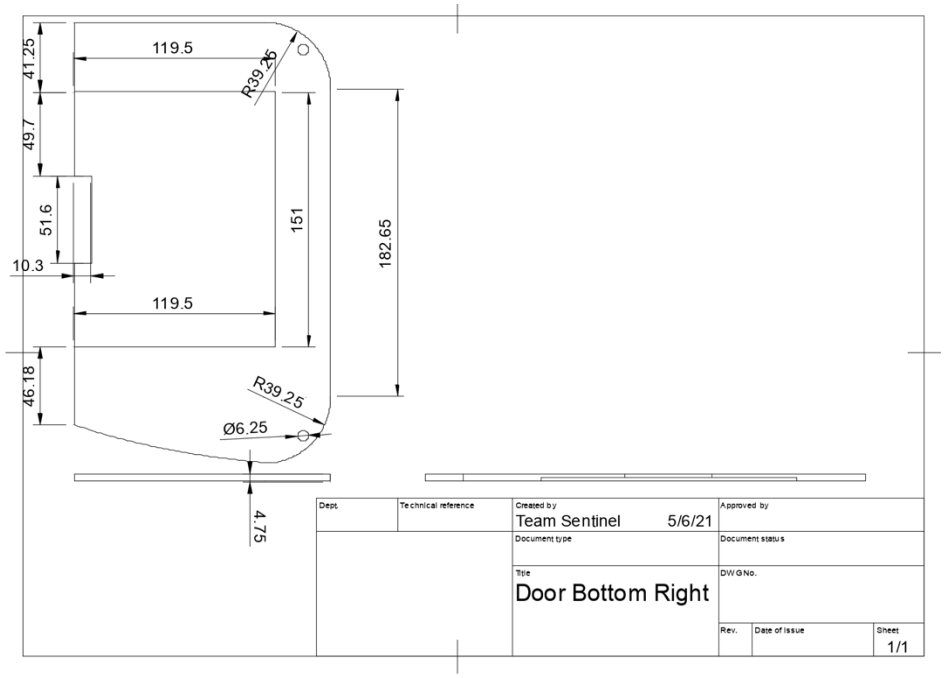
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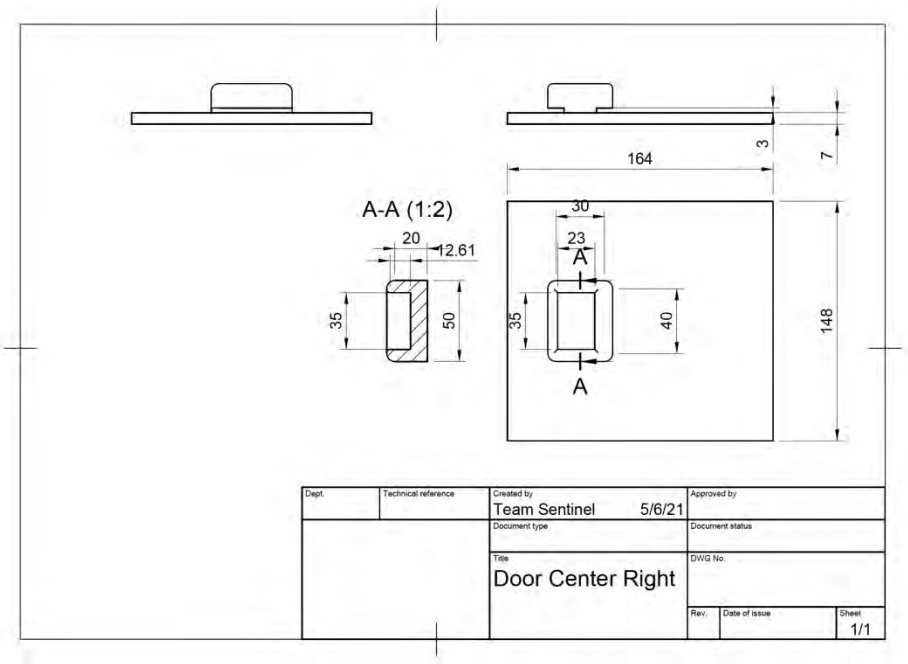

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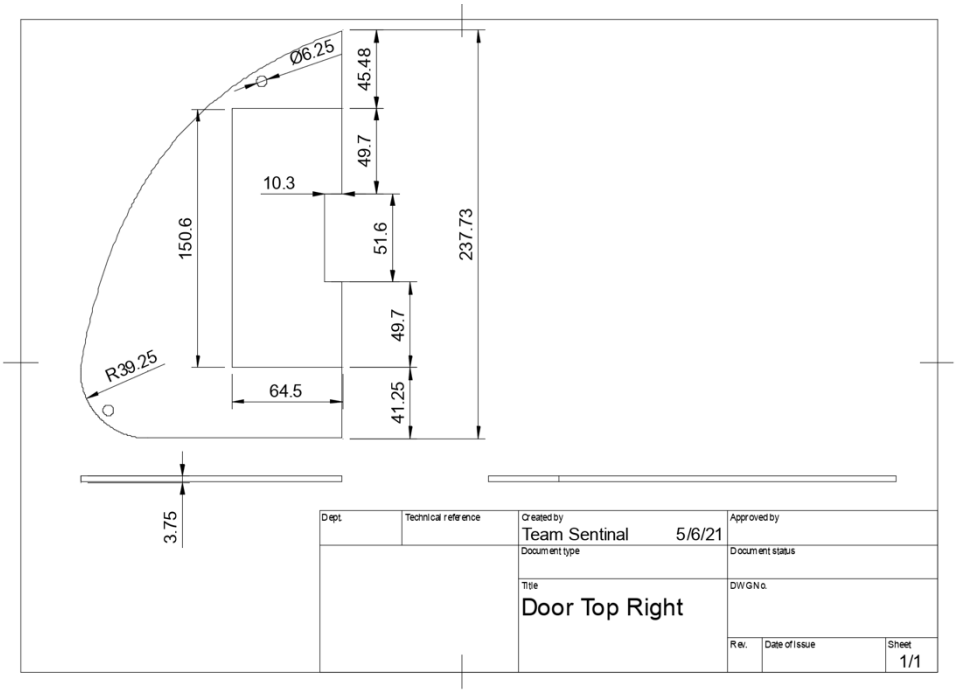

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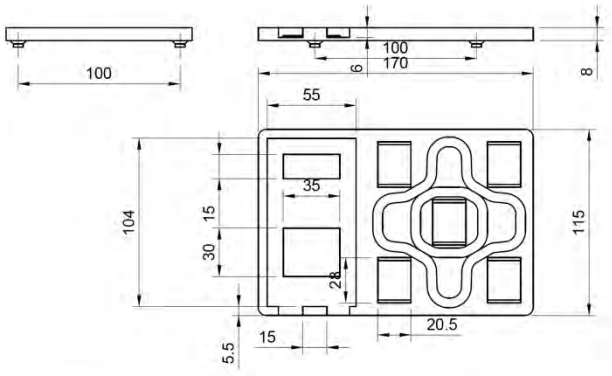

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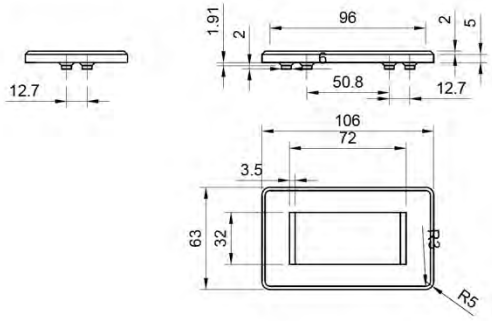

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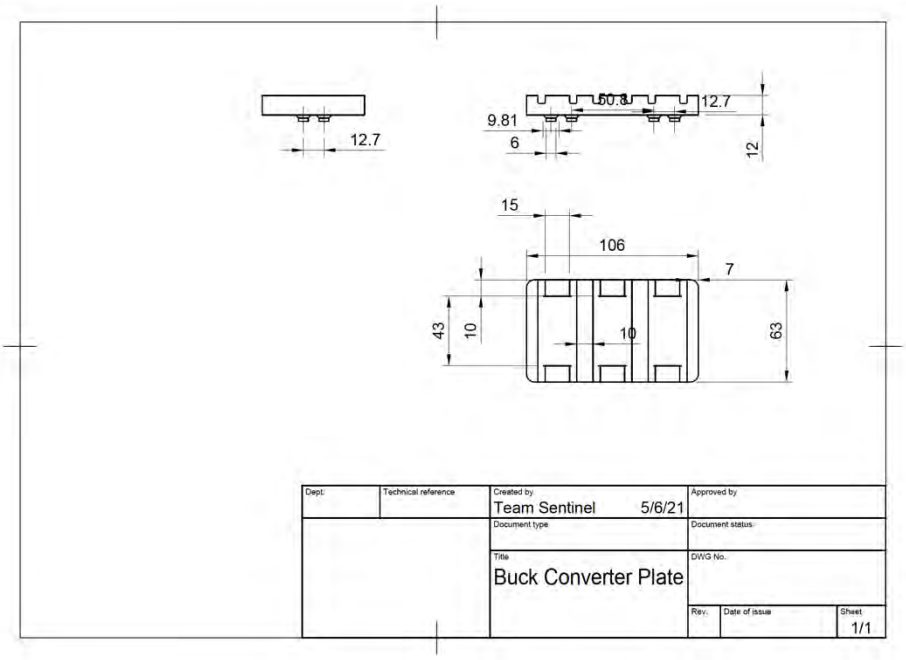

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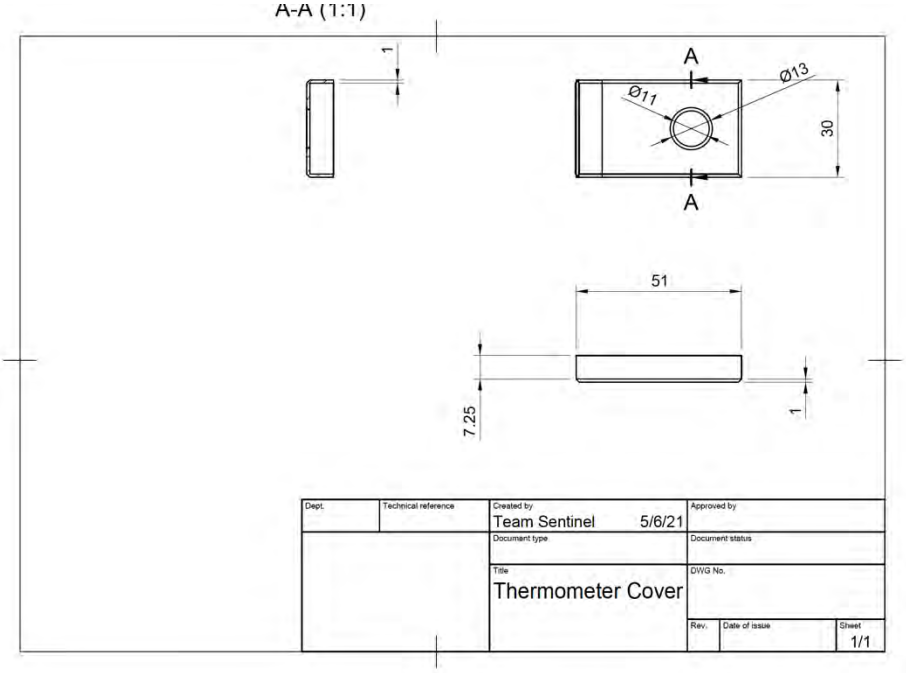

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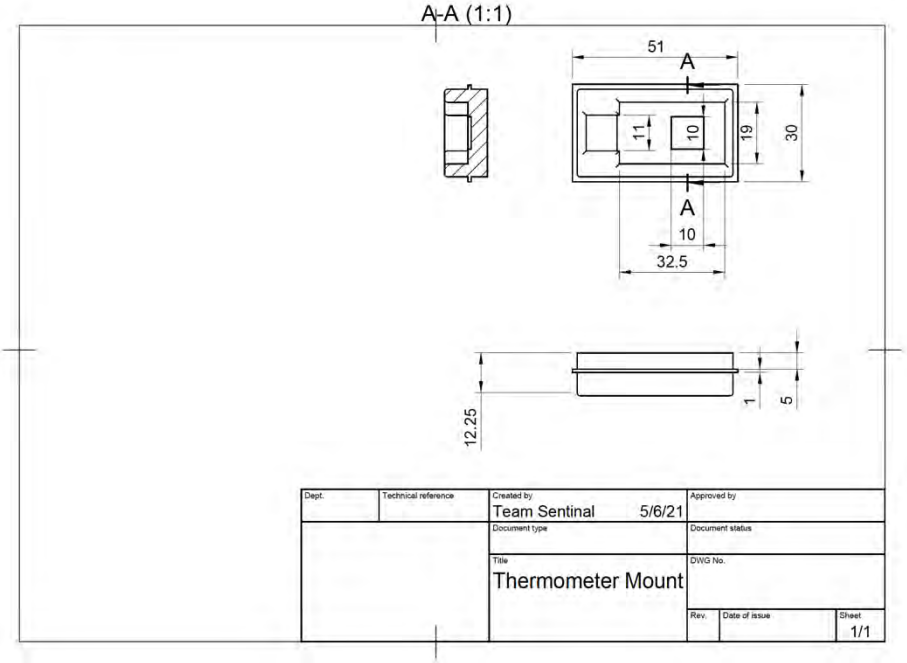

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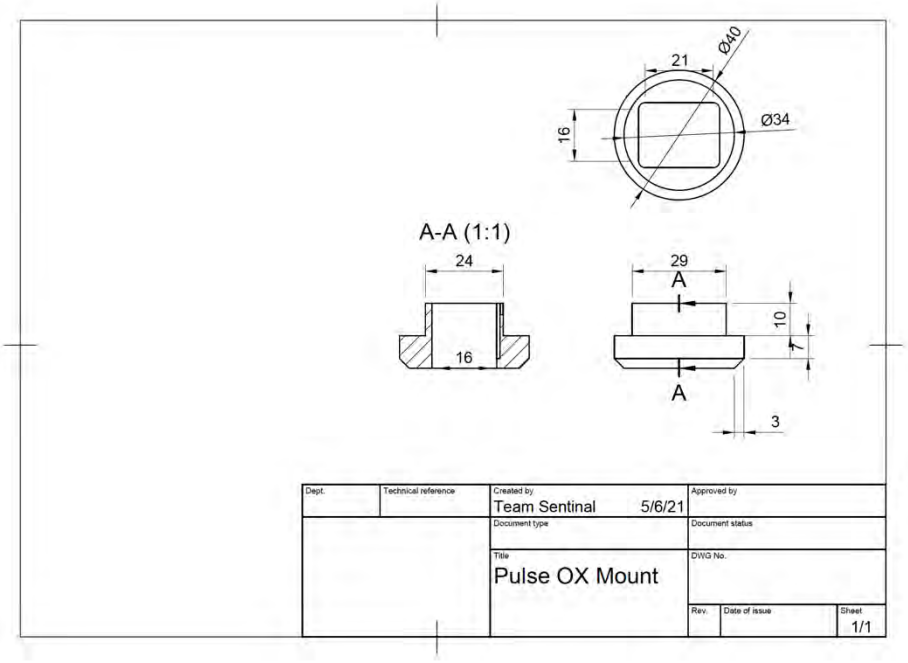
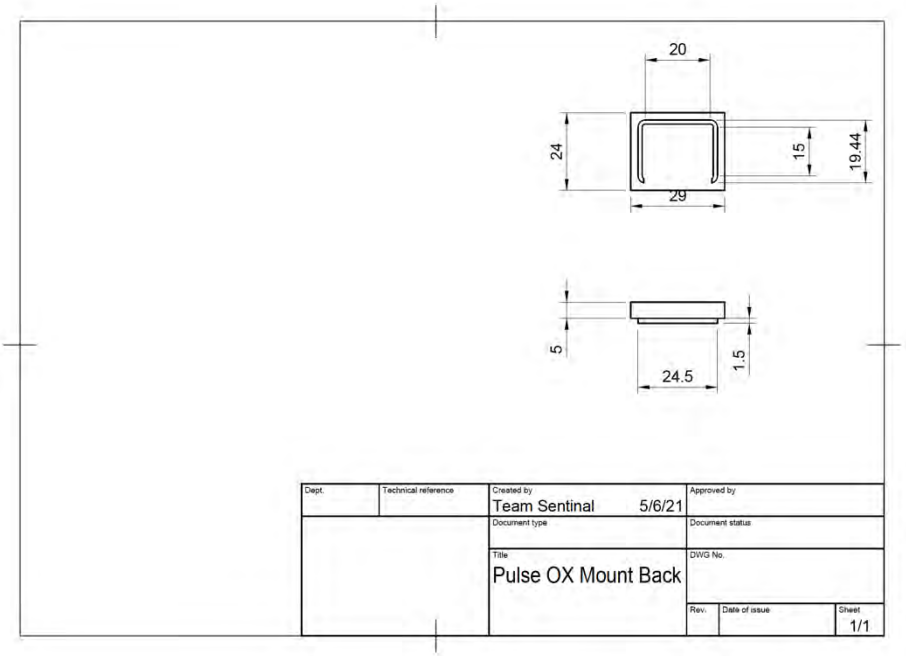
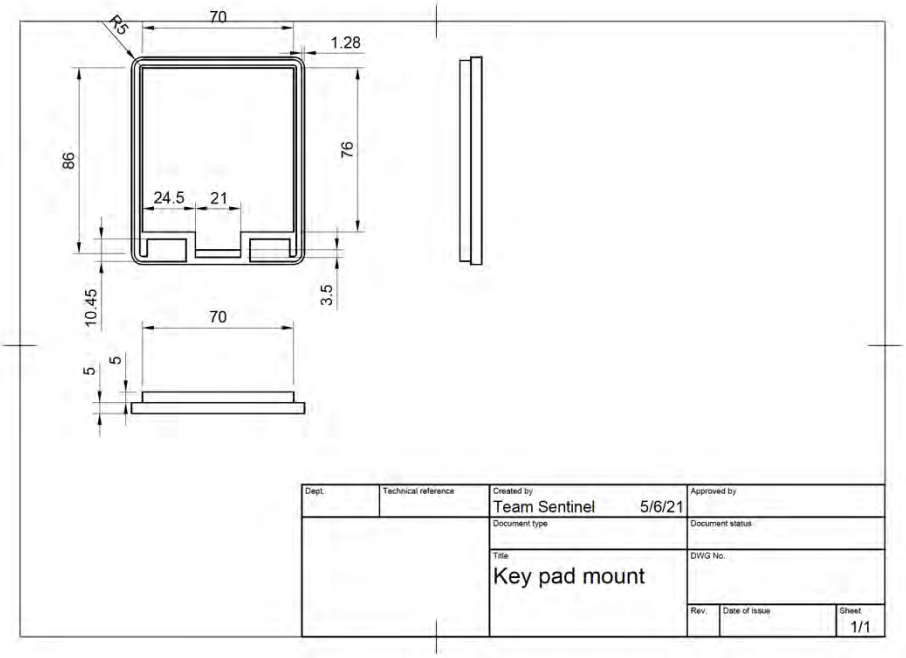
		Title: Thermometer Mount	DWG No.
			Rev. / Date of issue / Sheet: 1/1



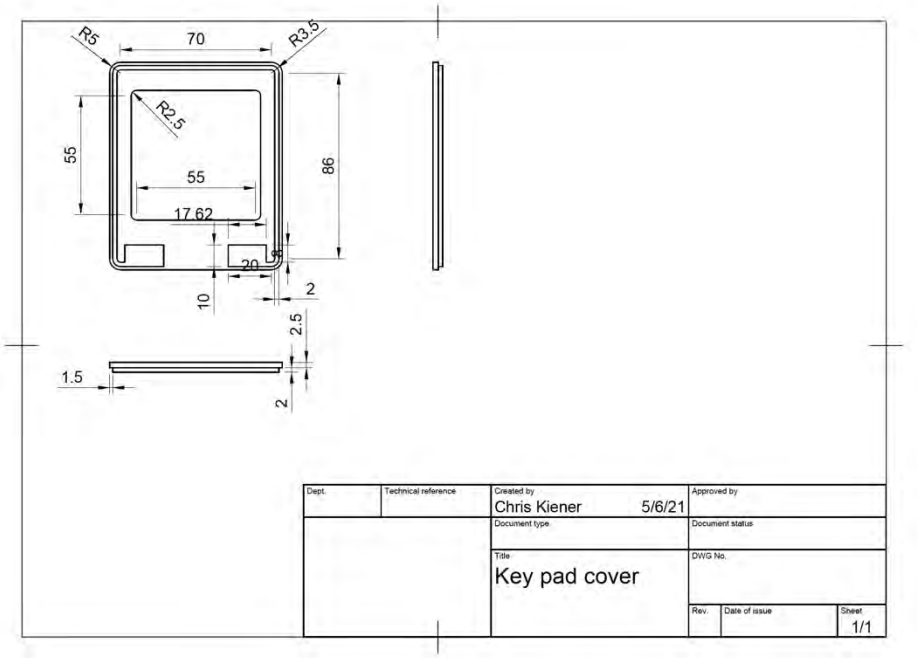
Dept.	Technical reference	Created by: Team Sentinal 5/6/21	Approved by
		Document type	Document status
		Title: Pulse OX Mount	DWG No.
			Rev. / Date of issue / Sheet: 1/1



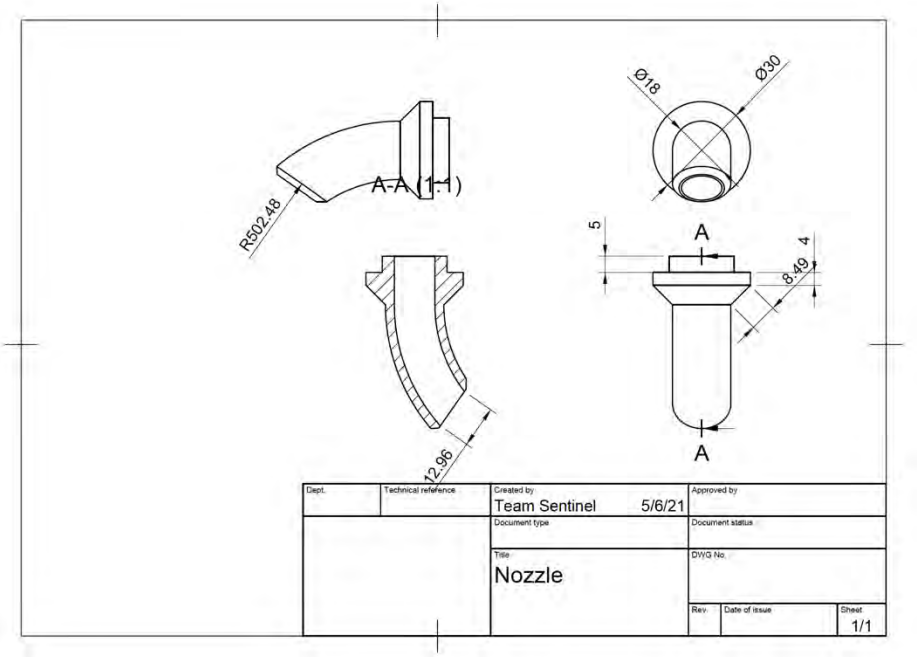
Dept.	Technical reference	Created by: Team Sentinal 5/6/21	Approved by:
		Document type:	Document status:
		Title: Pulse OX Mount Back	DWG No.:
			Rev. / Date of issue / Sheet: 1/1



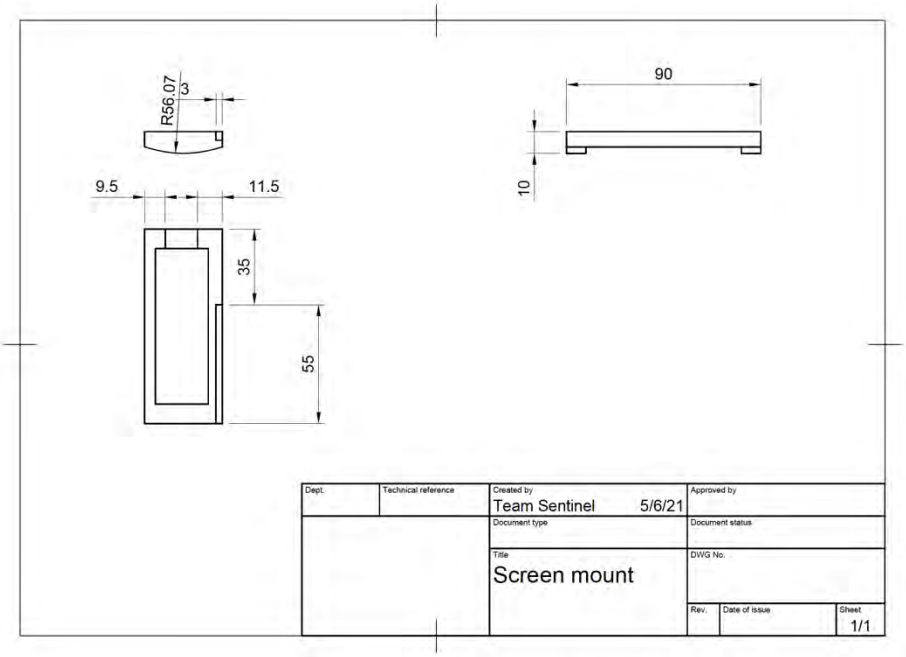
Dept.	Technical reference	Created by: Team Sentinel 5/6/21	Approved by:
		Document type:	Document status:
		Title: Key pad mount	DWG No.:
			Rev. / Date of issue / Sheet: 1/1



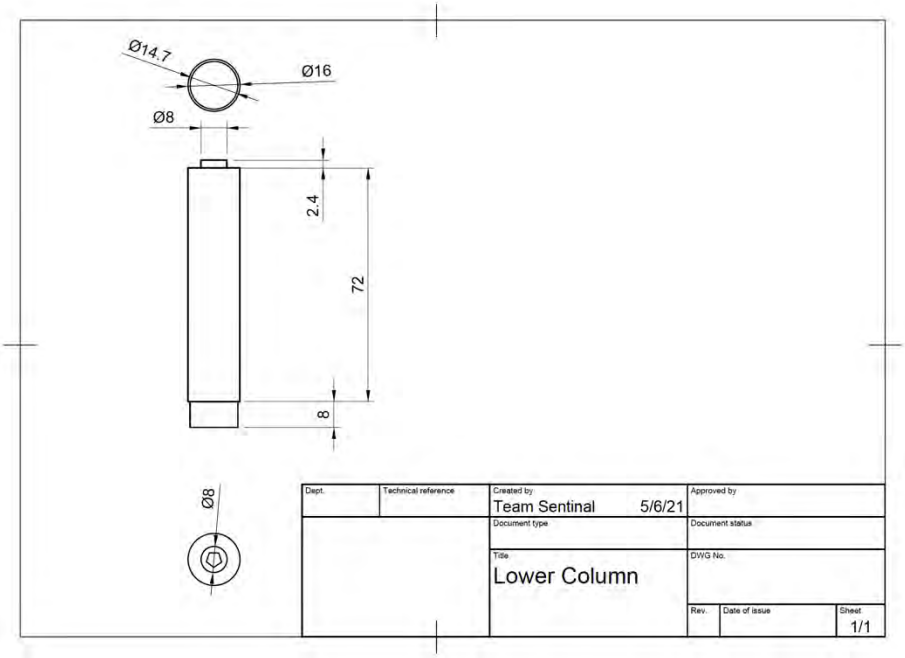
Dept.	Technical reference	Created by: Chris Kiener 5/6/21	Approved by:
		Document type:	Document status:
		Title: Key pad cover	DWG No.:
			Rev. / Date of issue / Sheet: 1/1



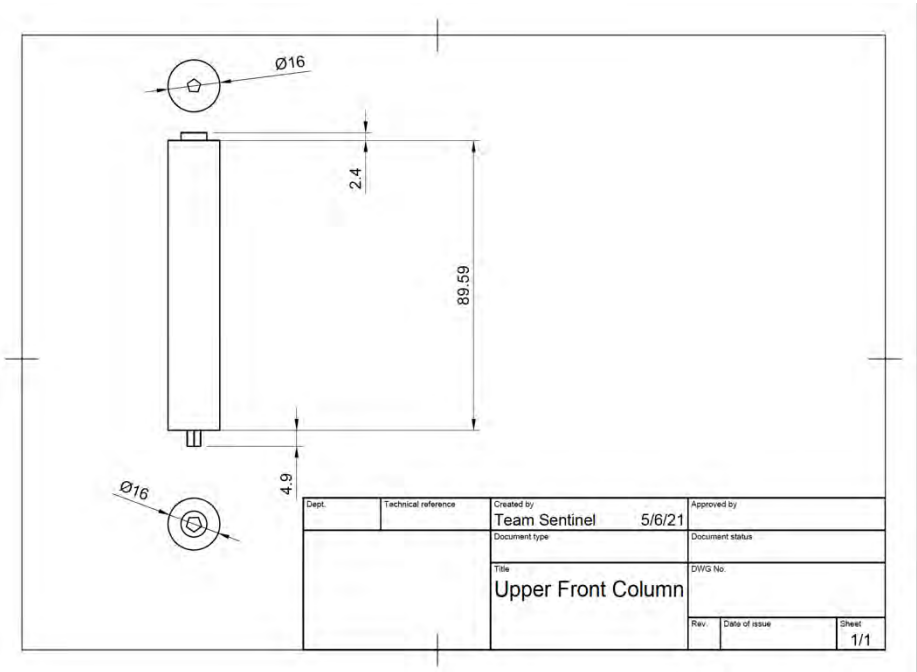
Dept.	Technical reference	Created by: Team Sentinel 5/6/21	Approved by:
		Document type:	Document status:
		Title: Nozzle	DWG No.:
			Rev. / Date of issue / Sheet: 1/1

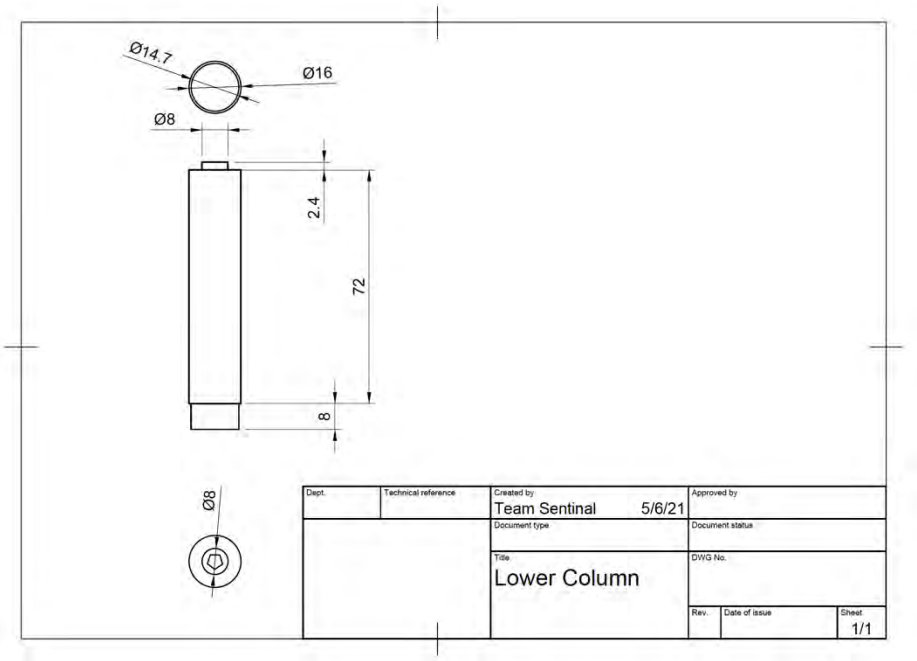


Dept.	Technical reference	Created by: Team Sentinel 5/6/21	Approved by
		Document type	Document status
		Title: Screen mount	DWG No.
			Rev. / Date of issue / Sheet: 1/1



Dept.	Technical reference	Created by: Team Sentinal 5/6/21	Approved by
		Document type	Document status
		Title: Lower Column	DWG No.
			Rev. / Date of issue / Sheet: 1/1


Ø16
2.4
89.59
4.9
Ø16
Dept.
Technical reference
Created by
Team Sentinel
5/6/21
Approved by
Document type
Document status
Title
Upper Front Column
DWG No.
Rev.
Date of issue
Sheet
1/1


Ø14.7
Ø16
Ø8
2.4
72
8
Ø8
Dept.
Technical reference
Created by
Team Sentinal
5/6/21
Approved by
Document type
Document status
Title
Lower Column
DWG No.
Rev.
Date of issue
Sheet
1/1

Appendix (9)

```
#include <Wire.h>
#include "MAX30105.h"
#include "spo2_algorithm.h"
#include <Adafruit_LiquidCrystal.h>
#include <LiquidCrystal_I2C.h>
#include <Adafruit_MLX90614.h>
#include <Servo.h>
#include <Keypad.h>


//temperature sensor
#define BACKLIGHT_PIN 23 // Declaring LCD Pins
#define En_pin 22
#define Rw_pin 1
#define Rs_pin 0
#define D4_pin 24
#define D5_pin 25
#define D6_pin 6
#define D7_pin 7
Adafruit_MLX90614 mlx = Adafruit_MLX90614();
int tempcount;  //loop counter for temperature sensor
int temppass;   // pass call for temperature sensor

LiquidCrystal_I2C lcd(0x27, 16, 2); // set the LCD address to 0x27 for a 16 chars and 2 line display


// pulse ox

MAX30105 particleSensor;

#define MAX_BRIGHTNESS 255

#if defined(__AVR_ATmega328P__) || defined(__AVR_ATmega168__)
//Arduino Uno doesn't have enough SRAM to store 100 samples of IR led data and red led data in 32-bit format
//To solve this problem, 16-bit MSB of the sampled data will be truncated. Samples become 16-bit data.
uint16_t irBuffer[100]; //infrared LED sensor data
uint16_t redBuffer[100];  //red LED sensor data
#else
uint32_t irBuffer[100]; //infrared LED sensor data
uint32_t redBuffer[100];  //red LED sensor data
#endif

int32_t bufferLength; //data length
int32_t spo2; //SPO2 value
int8_t validSPO2; //indicator to show if the SPO2 calculation is valid
int32_t heartRate; //heart rate value
int8_t validHeartRate; //indicator to show if the heart rate calculation is valid

int pulseLED = 21; //Must be on PWM pin
int readLED = 20; //Blinks with each data read
int pulsepass;          //pass call for pulse ox
int pulsecount;         // count how many times 25 samples have been taken for pulse ox.

//(smell test)

const byte ROWS = 4; //four rows
const byte COLS = 4; //four columns
char keys[ROWS][COLS] = {
  {'1', '2', '3', 'A'},
  {'4', '5', '6', 'B'},
  {'7', '8', '9', 'C'},
  {'*', '0', '#', 'D'}
};

byte rowPins[ROWS] = {5, 4, 3, 2}; //connect to the row pinouts of the keypad
byte colPins[COLS] = {9, 8, 7, 6}; //connect to the column pinouts of the keypad

Keypad smelltestkeypad = Keypad( makeKeymap(keys), rowPins, colPins, ROWS, COLS );

const int pump1 = 41;
const int pump2 = 42;
const int pump3 = 43;
int ranNum;  // random call for smell test for pump.
int smelltestresponse;
```

```
void setup() {
  while (1) {
    lcd.init();                      // initialize the lcd
    lcd.backlight();
    lcd.setCursor(0, 0);
    lcd.print("Student ID");
    lcd.setCursor(5, 0);

    Serial.println("Input Student Number to begin");
    int starttest = smelltestkeypad.waitForKey();
    delay(3500);
    lcd.setCursor(0,0);
    lcd.print("Starting Test    ");
    delay(1500);

    //pulse ox
    {
      Serial.begin(115200); // initialize serial communication at 115200 bits per second:

      pinMode(pulseLED, OUTPUT);
      pinMode(readLED, OUTPUT);
```

```
// Initialize sensor
if (!particleSensor.begin(Wire, I2C_SPEED_FAST)) //Use default I2C port, 400kHz speed
{
  Serial.println(F("MAX30105 was not found. Please check wiring/power."));
  while (1);
}

byte ledBrightness = 60; //Options: 0=Off to 255=50mA
byte sampleAverage = 4; //Options: 1, 2, 4, 8, 16, 32
byte ledMode = 2; //Options: 1 = Red only, 2 = Red + IR, 3 = Red + IR + Green
byte sampleRate = 100; //Options: 50, 100, 200, 400, 800, 1000, 1600, 3200
int pulseWidth = 411; //Options: 69, 118, 215, 411
int adcRange = 4096; //Options: 2048, 4096, 8192, 16384

particleSensor.setup(ledBrightness, sampleAverage, ledMode, sampleRate, pulseWidth, adcRange); //Configure sensor with these settings

bufferLength = 100; //buffer length of 100 stores 4 seconds of samples running at 25sps
```

```
//read the first 100 samples, and determine the signal range
for (byte i = 0 ; i < bufferLength ; i++)
{
  while (particleSensor.available() == false) //do we have new data?
    particleSensor.check(); //Check the sensor for new data

  redBuffer[i] = particleSensor.getRed();
  irBuffer[i] = particleSensor.getIR();
  particleSensor.nextSample(); //We're finished with this sample so move to next sample

  Serial.print(F("red="));
  Serial.print(redBuffer[i], DEC);
  Serial.print(F(", ir="));
  Serial.println(irBuffer[i], DEC);
}

//calculate SpO2 after first 100 samples (first 4 seconds of samples)
maxim_heart_rate_and_oxygen_saturation(irBuffer, bufferLength, redBuffer, &spo2, &validSPO2, &heartRate, &validHeartRate);

//Continuously taking samples from MAX30102.  Heart rate and SpO2 are calculated every 1 second
```

```
    for (int c = 0; c < 4; c++) //loop counter for pulse ox
    {
      pulsecount++;
      Serial.print(pulsecount);
      for (int i = 25; i < 100; i++)
      {
        redBuffer[i - 25] = redBuffer[i];
        irBuffer[i - 25] = irBuffer[i];
      }

      //take 25 sets of samples before calculating the heart rate.
      for (int i = 75; i < 100; i++)
      {
        while (particleSensor.available() == false) //do we have new data?
          particleSensor.check(); //Check the sensor for new data

        digitalWrite(readLED, !digitalRead(readLED)); //Blink onboard LED with every data read

        redBuffer[i] = particleSensor.getRed();
        irBuffer[i] = particleSensor.getIR();
        particleSensor.nextSample(); //We're finished with this sample so move to next sample

        if (spo2 >= 90) { //pass range for pulse ox
          Serial.print(F(", Pass/Fail=   "));
          pulsepass = 1;
          if (pulsepass == 1) {
            lcd.setCursor(5, 0);
            lcd.print("PASS            ");

          }
          Serial.print(pulsepass);
        }
        else {
          Serial.print(F(", Pass/Fail=   "));
          pulsepass = 0;
          Serial.print(pulsepass);

        }


        //send samples and calculation result to terminal program through UART
        Serial.print(F("red="));
        Serial.print(redBuffer[i], DEC);
        Serial.print(F(", ir="));
        Serial.print(irBuffer[i], DEC);


        Serial.print(F(", SPO2="));
        Serial.print(spo2, DEC);

        Serial.print(F(", SPO2Valid="));
        Serial.println(validSPO2, DEC);
        //Print spo2 values on LCD
        lcd.setCursor(0, 0);
        lcd.print("SPO2-           ");
        lcd.setCursor(5, 0);
        lcd.print(pulsepass);
        if (pulsepass == 1) {
          lcd.setCursor(5, 0);
          lcd.print("PASS        ");
        }
        delay(1000);
        break;
      }

      //After gathering 25 new samples recalculate HR and SP02
      maxim_heart_rate_and_oxygen_saturation(irBuffer, bufferLength, redBuffer, &spo2, &validSPO2, &heartRate, &validHeartRate);
    }
  }

  //temp


  Serial.begin(115200);
  mlx.begin();               //Receive data from the sensor
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("TEMP-          ");
```

```
for (int c = 75; c < 100; c++) //loop for counter for temp sensor.
{
  Serial.println(mlx.readObjectTempF());
  tempcount++;
  //Serial.print(count);


  if (mlx.readObjectTempF() > 93.5 && mlx.readObjectTempF() < 99.4) { //range for pass/fail for temp sensors.
    temppass = 1;
    Serial.println(temppass);

    // LCD for temperature sensor
    lcd.setCursor(5, 0);
    lcd.print(temppass);
    if (temppass == 1) {
      lcd.setCursor(5, 0);
      lcd.print("PASS");
    }
    delay(3000);
    break;
  }
  else {
    Serial.println(0);
    lcd.setCursor(5, 0);
    lcd.print(temppass);
  }
      delay(1000);



    }

    //Smell test

    Serial.begin(115200);
    randomSeed(analogRead(0));
    pinMode(pump1, OUTPUT);
    pinMode(pump2, OUTPUT);
    pinMode(pump3, OUTPUT);

    //Loop
    pinMode(pump1, HIGH);
    pinMode(pump2, HIGH);
    pinMode(pump3, HIGH);

    ranNum = random(1, 4);// random number generates for hand sanitizer
    while (ranNum < 5) {
      if (ranNum <= 1) {
        lcd.backlight();
        lcd.setCursor(0, 0);
        lcd.print("Scent 1 Disp");
        lcd.setCursor(5, 0);
```

```
277         //smellt test for scent 1 one
278         Serial.println("scent One is dispensed ");
279         delay(3000);
280         Serial.println("select 1 if it smells like cherry cough syrup ");
281         Serial.println("select 2 if it smells like garlic ");
282         Serial.println("select 3 if it smells like lemon ");
283         Serial.println("select 4 if it smells like coffee ");
284         delay(1000);
285         digitalWrite(pump1, HIGH);
286         delay(1500);
287         digitalWrite(pump1, LOW);
288
289         //Smell test LCD screen for scent 1.
290         lcd.backlight();
291         lcd.setCursor(0, 0);
292         lcd.print("What Smell");
293         lcd.setCursor(0, 0);
294         lcd.backlight();
295         lcd.setCursor(0, 0);
296         lcd.print("1) Cherry        ");
297         delay(4000);
298         lcd.setCursor(0, 0);
299         lcd.print("2) Garlic        ");
300         delay(4000);
301         lcd.setCursor(0, 0);
302         lcd.print("3) Lemons        ");
303         delay(4000);
304         lcd.setCursor(0, 0);
305         lcd.print("4) coffee        ");
306
307         //Person answers smell test
308         delay(4000);
309         lcd.setCursor(0, 0);
310         lcd.print("1,2,3,4          ");
311         lcd.setCursor(0, 1);
312         lcd.print("Ch,G,L,Co        ");
313
314         Serial.println("waiting for response ");
315
316
317         int waitforresponse = smelltestkeypad.waitForKey(); //waiting for response from person on keypad
318
319
320         Serial.println("response received ");
321
322
323         // If Correct.
324         Serial.println(waitforresponse);
325         if (waitforresponse == 49) {
326           Serial.println("correct response");
```

```
      lcd.backlight();
      lcd.setCursor(0, 0);
      lcd.print("Correct!         ");
      lcd.setCursor(0, 1);
      lcd.print("                  ");
      smelltestresponse = 1;
      break;
    }

    //If Wrong.
    else {
      Serial.println("incorrect response");
      lcd.backlight();
      lcd.setCursor(0, 0);
      lcd.print("Incorrect :(     ");
      lcd.setCursor(0, 1);
      lcd.print("                                  " );
      smelltestresponse = 0;
      break;
    }
  }

  //
  else if (ranNum >= 3) {
    lcd.backlight();
    lcd.setCursor(0, 0);
    lcd.print("Scent 3 Disp");
    lcd.setCursor(5, 0);

    //Smell test for scent 3
    Serial.println("scent Three is dispensed ");
    delay(3000);
    Serial.println("select 1 if it smells like fish ");
    Serial.println("select 2 if it smells like mustard ");
    Serial.println("select 3 if it smells like mint candy cane ");
    Serial.println("select 4 if it smells like coconut  ");
    delay(500);
    digitalWrite(pump3, HIGH);
    delay(1000);
    digitalWrite(pump3, LOW);


    //Smell test on LCD scree for scent 3
    lcd.backlight();
    lcd.setCursor(0, 0);
    lcd.print("What Smell");
    lcd.setCursor(0, 0);
    lcd.backlight();
    lcd.setCursor(0, 0);
    lcd.print("1) Fish     ");
    delay(4000);
    lcd.setCursor(0, 0);
```

```
    lcd.print("2) Mustard     ");
    delay(4000);
    lcd.setCursor(0, 0);
    lcd.print("3 Mint Candy Cane");
    delay(4000);
    lcd.setCursor(0, 0);
    lcd.print("4) Coconut     ");


    //Person answers for smell test.
    delay(4000);
    lcd.setCursor(0, 0);
    lcd.print(" 1,2,3,4          ");
    lcd.setCursor(0, 1);
    lcd.print("F,M,MCC,Co        ");

    Serial.println("waiting for response ");


    int waitforresponse = smelltestkeypad.waitForKey(); // waiting for response on key pad.

    //If Correct.
    Serial.println("response received ");
    lcd.setCursor(0, 0);
    lcd.print("response received ");
    Serial.println(waitforresponse);
      if (waitforresponse == 51) {
        Serial.println("correct response");
        lcd.backlight();
        lcd.setCursor(0, 0);
        lcd.print("Correct!         ");
        lcd.setCursor(0, 1);
        lcd.print("                              ");

        smelltestresponse = 1;
        break;
      }
      //If Wrong.
      else {
        Serial.println("incorrect response");
        lcd.backlight();
        lcd.setCursor(0, 0);
        lcd.print("Inorrect :(      ");
        lcd.setCursor(0, 1);
        lcd.print("                                      " );
        smelltestresponse = 0;
        break;
      }

    }

    else {
```

```
        lcd.backlight();
        lcd.setCursor(0, 0);
        lcd.print("Scent 2 Disp");
        lcd.setCursor(5, 0);


        //Smell test for scent 2.
        Serial.println("scent Two is dispensed ");
        delay(3000);
        Serial.println("select 1 if it smells like lavander ");
        Serial.println("select 2 if it smells like vanilla ");
        Serial.println("select 3 if it smells like coffee ");
        Serial.println("select 4 if it smells like oranges ");
        delay(1000);
        digitalWrite(pump2, HIGH);
        delay(1350);
        digitalWrite(pump2, LOW);

        //Smell test on LCD screen for scent 2.
        lcd.backlight();
        lcd.setCursor(0, 0);
        lcd.print("What Smell");
        lcd.setCursor(0, 0);
        lcd.backlight();
        lcd.setCursor(0, 0);
        lcd.print("1) Lavander     ");
```

```
    delay(4000);
    lcd.setCursor(0, 0);
    lcd.print("2)Watermelon     ");
    delay(4000);
    lcd.setCursor(0, 0);
    lcd.print("3) coffee     ");
    delay(4000);
    lcd.setCursor(0, 0);
    lcd.print("4) Oranges     ");



    // Persons answers for smell test
    delay(4000);
    lcd.setCursor(0, 0);
    lcd.print("1,2,3,4       ");
    lcd.setCursor(0, 1);
    lcd.print("L,W,C,O        ");

    Serial.println("waiting for response ");

    int waitforresponse = smelltestkeypad.waitForKey(); //waiting for persons response on key pad.


    Serial.println("response received ");
    Serial.println(waitforresponse);
```

```
      //If correct
      if (waitforresponse == 50) {
        Serial.println("correct response");
        lcd.backlight();
        lcd.setCursor(0, 0);
        lcd.print("Correct!         ");
        lcd.setCursor(0, 1);
        lcd.print("                                " );
        smelltestresponse = 1;
        break;
      }

      //If wrong.
      else {
        Serial.println("incorrect response");
        lcd.backlight();
        lcd.setCursor(0, 0);
        lcd.print("Incorrect:(     ");
        lcd.setCursor(0, 1);
        lcd.print("                                " );
        smelltestresponse = 0;
        break;
      }
    }
  }
  delay(3000);
//OVERALL PASS FAIL
  // If pulseOx is in range, and temperature is in range and smell test is correct then => low risk
  // If temparture is in range, and pulseOx is in range and smell test is incorrect then => mid risk
  // If pulseOx is in range, and temperature is in range and smell test is incorrect then => mid risk
  // If smell test is correct, and pulseOx is in range and temperature is out of range then => mid risk
  // If smell test is correct, and temperature is in range and pulseOx is out of range then => mid risk
  // If pulseOx is in range, and temperature is out of range and smell test is incorrect then => high risk
  // If temperature is in range, and pulsOx is out of range and smell test is incorrect then => high risk
  // If smell test is correct, and temperature is out of range and pulseOx is out of range then => high risk
  // If pulseOx is out of range, and temperature is out of range and smell test is incorrect then => GO TO DOCTOR

  bool pulseOxInRange = pulsepass == 1;
  bool tempInRange = temppass == 1;
  bool smellTestPassed = smelltestresponse == 1;

  lcd.setCursor(0, 0);

  if (pulseOxInRange) {
    if (tempInRange ^ smellTestPassed) {
      lcd.print("MID RISK         ");
    } else if (tempInRange && smellTestPassed) {
      lcd.print("LOW RISK         ");
    } else {
      lcd.print("HIGH RISK        ");
    }
```

```
536       } else {
537         if (tempInRange ^ smellTestPassed) {
538           lcd.print("HIGH RISK        ");
539         } else if (tempInRange && smellTestPassed) {
540           lcd.print("MID RISK         ");
541         } else {
542           lcd.print("GO TO DOCTOR       ");
543         }
544       }
545
546
547       delay(5000);
548       Serial.println("break test");
549
550
551
552     }
553   }
554
555
556   void loop() {
557   }
```