Assignment 8 – End of Project Report
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Contactless Classroom Delivery Robot
Team 6
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ABSTRACT

This paper will focus on mitigating the spread of germs and potential viruses in classrooms. Our method of achieving this is a contactless classroom delivery robot (CCDR), which will eliminate the need for close contact between teachers and students while distributing classroom materials. Since transmission can occur when teachers are unable to be socially distanced, our CCDR will perform these interactions on its own. Some of the main features that will be focal to our CCDR are its wireless controls, contactless door opening, UVC sanitizing, and grid/barcode route pathing. Our CCDR will also be funded by each of our group members. The work breakdown structure we created helped us divide tasks between members. We created a Gantt Chart and PERT diagram to represent our project timeline, which was critical to keeping us on track. After assessing the possible risks, the team categorized them into three categories: specific technical risks, broader technical risks, and systematic risks. Assessing these risks helped us prepare for them. As we further interpreted our societal problem, we learned that the robot should be stronger to carry all the supplies. After upgrading the chassis, we began our test plan. This included over 44 tests revolving around the components of our design. We performed a market review that allowed us to understand the interest levels in our product and its marketability. Lastly, the process of completing our testing results provided a capstone view of how our robot has improved to address our societal problem.

KEYWORD INDEX

Academic Institution, Arduino, Autonomous Robot, Barcode, Breakdown, Bluetooth, COVID-19, Cases, Classroom, Contactless Delivery, Education, Elementary School, Gantt Chart, Hands-on learning, IR Sensor, Interlock, Market Review, Outbreak, Pandemic, PERT Diagram, Remote Learning, Reopening, Robot, Robotics, Safety Lock, PIR Sensor, School Closure, Self-Sanitizing, Social Distancing, UVC Radiation, UV Sanitization, Vaccine, Virus, Wireless Controls

EXECUTIVE SUMMARY

Elevator Pitch

In efforts to mitigate the COVID-19 spread in classrooms and ensure a safe return to in-person learning, we will build a contactless delivery robot.

Within the past few years, COVID-19 has changed the way that many people live their lives quite dramatically. Although many have done their best to reduce nonessential contact with others it has not been sufficient to promote a full “normal” return to school for Elementary students. As a solution to this problem, we are building a robot that can be controlled by the teacher and do the task as asked. This robot will help the teacher deliver papers and supplies to their students without risking contamination and providing a contactless way to keep hands-on activities present in the classroom. The work breakdown structure entails work from the beginning of the fall semester, up until the end of the project when we deliver the final product. Each team member has features that they are responsible for both building and testing.

For the project timeline we created a Gantt chart, as well as a PERT diagram to show the relationship between various tasks and create a timeline which expresses our plan for completing our contactless classroom delivery robot. This project timeline is crucial in making sure that everyone knows what they are responsible for, how much time they have to accomplish it, and what other steps are dependent on them. The PERT diagram particularly emphasizes the relationships between various tasks and will be important in helping us avoid bottlenecks and other setbacks. The risk assessment of our project contains in detail, what risks we face as a group according to our project scope. There are many risks involved with our project which encapsulate the events that any of our features do not work as intended. There is also the risk that we have not encountered or discovered yet. During a project many things can happen that may not allow the group to complete a task, so we must be prepared for this and tread carefully to be able to address these risks as they arise.

Testing consists of different steps performed at different stages including acceptance test, integration test, unit test and debugging. Similarly, we are going to perform these steps to test our prototype. We need to test every single part of the robot such as the processor, sensors, motors, wheels, keypad, LCD etc. individually, as well as when connected to each other. Moreover, we are also going to document our expected results and the actual test results with each team member name responsible for that particular test, and it will help us compare and see the difference. We have also strengthened our robot with a new chassis to hopefully improve the reliability of our project.

Our design pertains to the market of autonomous delivery robots. Due to social distancing, people must maintain a safe distance to be safe from contracting the COVID-19 virus, therefore limited interaction with other humans is important. Thus creating a big market for our robot and with schools wanting to do whatever they can to keep students safe, we believe that our robot will be highly marketable.

To wrap up our project, our team conducted collaborative tests such as stress testing the robot, and testing the robots battery life, which we found to be sufficient for classroom settings. The IR sensors were tested on different patterns and on different surfaces such as; hexagonal, round, and with sharp turns. We also tested the motors which were able to work on the grid without fail, and the UVC was able to sanitize the items. Overall, everything functioned as expected and although we do still have some issues with reliability, we were able to complete our feature set.

I. INTRODUCTION

A. Societal Problem

With COVID-19 and the new variants being discovered, many are concerned with the reopening of schools and how to keep themselves and their family safe. Additionally, since there is not an approved vaccine available for young children yet, they are especially susceptible to catching COVID-19 at school and bringing it home to their families. Schools are already a known breeding ground for germs and other viruses like the flu, and despite safety measures being in place, they are not enough to keep the students safe. For instance, although masking is enforced, social distance cannot be if the teacher is distributing materials to the student. Problems like this are exactly what we are trying to solve. With the amount of robotics technology available to us, our solution is to build a robot which can help kids have a safe environment in the classroom. This paper will discuss why our solution is necessary and why more safety precautions must be in place to aid the reopening of elementary schools amidst COVID-19.

B. Design Idea

To assist teachers in providing a safe method of receiving and delivering supplies or papers, our contactless robot will have a box compartment to carry supplies or objects. Within the enclosed box compartment will be a UVC radiation device to disinfect the surface of the classroom supplies. In the design of the box compartment, our team will research and determine the material necessary for creating the enclosed box. For the safety purposes, the material used must be able withstand and contain the UVC radiation. The robot will travel to each student's desk and move in line with the grid created by magnetic tape attached to the floor which guides the robot. This will help keep the robot moving on a given path. The robot will identify its position using the barcodes placed under each student's desk.

It is also unsafe for the door of the box compartment to be open while sanitization is in progress, or the robot is in motion due to possible UVC exposure and crashes into students. Therefore, we are implementing an interlock mechanism to keep the door closed. In addition, a servo will be attached to the door as the mechanism to open and close the door. In efforts to maintain our contactless design, we are adding a PIR sensor which students can hover their hands over to activate and therefore open the door. Furthermore, the robot will use wheels, motors, an Arduino Uno, and a DC Stepper motor controller board to allow the robot to move around the classroom. The team has considered the size and material of the large chassis required to carry the 1 cubic foot compartment and concluded that we need a large metal chassis for the robot. The teacher will control the robot using a wireless control system.

C. Work Breakdown Structure

Now that we have introduced the societal problem we are addressing for our senior design and also designed a solution which provides a safe environment in the classroom for teachers and the students, we must break down the steps necessary to completing this task. By breaking down the work in several parts and distributing among all the team members, we are able to increase our efficiency and make each task more feasible. For making the CCDR, we first need to build a chassis to install the processor and all the other parts of the robot. Next, we would add the wheels, and contactless door which opens using servos. These tasks have been divided among all the four members of the group, so as to split up the costs of the materials and the workload. We can each write our separate codes related to the features we are working on and compile them once we are ready to test.

We all will meet on campus to build the chassis and the body for the robot. Once the robot building is done, we can start testing our codes. First we will run and test separately and that can be used for our prototype presentation of the project. Furthermore, by testing the work separately it will be easy to recognize the part of code or robot not working as per the expectations or giving error and debug it. Once the code and different parts will start working separately, we can combine our codes to test them together and make sure that the robot is working properly, as per our expectations, as whole. The work breakdown structure also applies to the other more administrative assignments throughout this semester. As we will dive into further in this report, each assignment has a set of tasks required in its completion and our work breakdown structure breaks down each of these tasks to ensure that we understand what is expected at each point in the project.

D. Project Timeline

A project timeline is essential to maintaining progress on a long term assignment such as this one. This consists of what tasks and work packages must be accomplished, in what order, by who, and at what time. Additionally, the goal is to provide a chronological time sequence by which actions pertaining to our project will occur. Knowing what needs to be done at soft and hard deadlines, will help us stay up to date and lessen the feeling of being overwhelmed with everything that needs to be done. Overall, the project timelines is a tool to help us organize our work and strategically determine how we can get everything done.

Complementary to our written project timeline, we have included a Gantt chart and PERT diagram as a visual representation. Both of these figures show a detailed plan of how we are going to be splitting up work between team members, what work needs to be done, the duration of time it will take, the relationship between each task, and when they need to be completed. More specifically, the Gantt chart is a calendar-like schedule that shows all of these details by week. It is a graphical representation of what will be worked on and for how long, displayed across a period of time in weeks. At a quick glance, each team member can easily see when they will be working on what tasks and how much time they will have to complete it. The Gantt chart is a working document that will be updated throughout this semester and next as we progress through our project. The Gantt chart that we have created for our project can be found in Appendix E.

The PERT diagram is also a visual representation of our project timeline, but it is more in the form of a flow chart. This diagram more directly shows the relationship between each task and where potential roadblocks may lie. The PERT diagram analyzes the tasks and shows how steps are dependent on the previous steps, as well as how they are connected to each other. PERT focuses on network representation and highlights potential bottleneck areas. It shows events and corresponding milestones as applicable to the different aspects of our project. Our PERT diagram can also be found in Appendix E.

With both the Gantt chart and PERT diagram and our written project timeline to follow we have planned out how our next two semesters in senior design should pan out. These visual aids will also track our progress as we meet more milestones and complete more work. These key tools will help us stay caught up with the project deadlines and ultimately, improve the likelihood of our project's success.

E. Risk Assessment

This project contains many risks, so we must address them and be able to react and prevent them from interfering with the completion of our project. We have categorized these problems into three different categories. The first of the three is the "specific technical risks" category which contains risks that stem from bad initial choices. This set of risks includes not having the correct amount of pins needed for our features on our arduino board, as well as the risk of the chassis not being able to support the entire weight of the fully built robot. The second category of risks is known as "broader technical risk" which is a risk that comes from a failure in design of components. An example of a broader technical risk is the risk of the PIR sensor detecting wrong inputs, as well as the robot moving while the door remains open, causing a hazard with the sanitization feature of the robot. The last risk we identified in this category is that the robot may not receive our inputs from the wireless keypad, this is a risk that may occur due to the keypads having a short life span. The final category of risks is known as "systematic risks" which contains problems that may happen outside of the project, like personal issues. This risk can include family problems that may prevent a team member from completing their tasks. This category contains the risks that come from the pandemic restrictions and other problems involving the pandemic interfering with our ability to complete the project. The final risk we identified is the risk of problems arising at any given time, for example there may be a risk that we have not thought of yet, or have not had to encounter yet so we need to be prepared to deal with anything that may get in the way of us completing our project.

F. Problem Statement Revision

During the first semester of senior design we were required to design something to solve a societal problem. The societal problem we focused on was the problem with in person learning during the pandemic for children, we wanted to focus on creating a way of reducing contact between students and teachers. We then created a robot to travel from desk to desk to retrieve and deliver learning materials to every student. As the semester progressed we became more familiar with our societal problem and how we could tailor our design to the specifics of our problem. Since the problem has only worsened since the beginning of last semester we decided to adjust our robot and make it more robust to be able to handle the weight of materials better. We had to change the motors to some with a higher torque because it is essential that the robot operates smoothly with the materials inside of it. Our first semester design had problems with the acrylic as well, therefore we needed to get a thicker piece of acrylic to be able to take the weight of the box and the materials. With new evidence supporting that students learning in person are not having the best results, it is crucial that we create a design that can help students feel more comfortable with returning to in person education.

G. Device Test Plan

In efforts to move our project forward to a deployable prototype, it is crucial that we develop a device test plan. This device test plan will outline the tests that we will run to ensure that our project is consistently successful. It highlights the features of our prototype and showcases their functionality independently, as well as integrated into the full design of our project. Our device plan spans across both the previous semester and this one and describes what our tests will be conducted on, how they will be conducted, what we expect to see from the tests, and in the future it will show our results as well.

There are a multitude of key components of our device plan. These main categories that we will be performing testing on are the motors, robot movement, IR sensors, barcode scanner, keypad, LCD display, servos, PIR sensor, the UVC light, and the stability of our chassis. For the motors, we will be testing the voltage, current, speed, direction, and torque. Additionally, the robot's movement will be analyzed in terms of its forward, right, left, and backward motion. The IR sensors will have tests of their own on their tape detection, ability to direct the robot right and left, the stability of the motion, circular and hexagonal movement, and lastly their functioning on various surfaces. Similarly, the barcode scanner will be tested on its capability to scan the barcodes, print them on the LCD display, the speed of its scan, the time interval between scans, and the ability to maintain movement unless a barcode is scanned, by which it will stop.

Regarding the test plan for the keypad we will test it on its ability to start the robot with an input and control the function the robot will perform (all desks, specific row, specific desk, etc.). The LCD display will also undergo tests to ensure that communication with the user is consistent (welcome messages, function updates, etc.). The servo and PIR sensors will both be tested on their functionality independently as well as integrated with the overall prototype. They will be tested to ensure they are communicating properly with each other and that the PIR sensor detects the hand motions accurately. We will test the UVC light to ensure that it works with the rest of our code so that when the robot is stopped or the door opens, the UVC will automatically turn off. Finally, we will test the overall stability of our robot on its battery life and obstruction detection.

H. Market Review

Now, as we have created our test plan for our robot, we need to move to the other important part of the product life cycle, which is the market review of the product. Like all the industries, manufacturers need to be sure about what they are producing, who are the potential customers and what should be the reasonable price of the product. Similarly we need to research and figure out who is the potential buyer of our product and what should be the reasonable price of our product. Our prototype is ready and we are still working on its efficiency, and the test plan, but we need to start looking for the market reviews alongside for our product. First we need to focus on problem solving, is our product actually solving any problem and if yes, then what kind of problems it is actually solving and it will help us in moving forward in the market review stage.

We are creating a robot, Contactless Classroom Delivery Robot (CCDR), and the problem we are trying to solve is in person learning especially for elementary and middle school kids. Due to the increase in Covid cases, all the schools started online classes, which is affecting kids' social and mental growth. The potential customers for our product are schools and the market is Autonomous robot delivery. There are various kinds of existing robots which deliver things like food but are not able to provide complete contactless delivery. Therefore, we are building this robot to provide complete contactless exchanges between students and teachers by sanitizing the items inside the box using UVC and to make in-person learning more safer.

I. Testing Result

As testing is an important phase of a product, testing results are very important documentation. Testing results decides the future of the product because only if the results are good, as expected, the product can take place in the market. Why would a consumer buy a product which isn’t even doing what it is supposed to do, that product is no more than junk. Company has to show some results, positive and good results, to attract the investors to invest in their product, consumers to buy their product, to create a market for their product and win over their competitors.

After creating a test plan we started working towards the testing of the robot’s individual features. We have recorded all test results in our test plan excel sheet over the period of time of testing. All team members were assigned some features for testing. We tested every feature considering some scenarios like floor type, room lighting, distance, accuracy, and battery life. We had some expected results to compare with for each scenario. Our actual results turned out to be good as they all met their expectations. In the further section, we have provided a detailed excel chart with all the features of the robot with other important details needed for testing results such as start and end date, expected and the actual result, and all the

different scenarios we have considered for
testing every particular feature.

II. SOCIETAL PROBLEM

A. First Semester Interpretation of the Societal Problem

Our societal problem is the closure of grade schools around the world due to the COVID-19 pandemic. For many students learning remotely is a viable option, but for most, in-person learning is the most effective way of obtaining a quality education. This can only be done in a safe environment. With so much of elementary school learning completed using a hands-on method, it is critical that this can be done without enforcing the spread of COVID-19. In addition to sanitizing hands and wearing masks, our contactless delivery robot will keep classrooms functional while reducing the spread of COVID-19 and other viruses. The robot will deliver any learning materials necessary to the student, thus preventing contact between students and teachers and mitigating the transmission of COVID for a safe learning environment.

The effects of the COVID-19 pandemic are seen worldwide. One place that has been affected specifically is Ghana, where when the pandemic broke out the president decided that the best way to approach the problem was to shut down entirely. The president demanded all educational institutions be closed, affecting about 9.2 million grade school students in the country [3]. Out of the students that were left without in-person schooling, 205 were surveyed to see how they were getting along with their education without attending school. Of the 205 students surveyed, 176 were under the age of 15, which means they attend grade school. Also, over 75% of the surveyed students struggle learning on their own and even dislike schooling from home. This is a significant number of students, and it proves that many younger children value their in-person education highly.

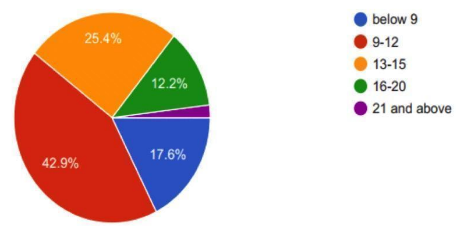


Figure 1 Age Distribution as referenced in [3]

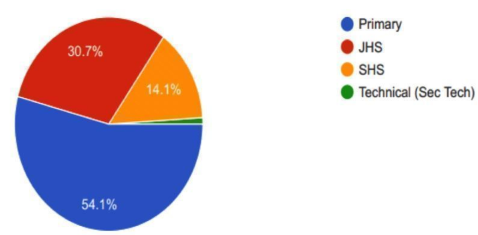


Figure 2 Education Levels as referenced in [3]

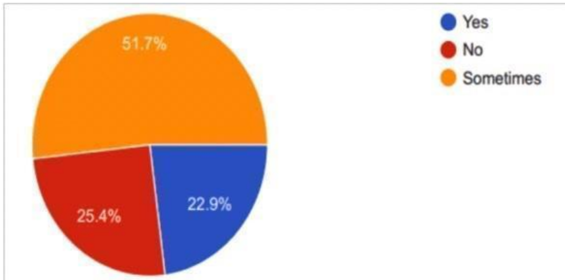


Figure 3 Students Who Enjoy Studying from Home as referenced in [3]

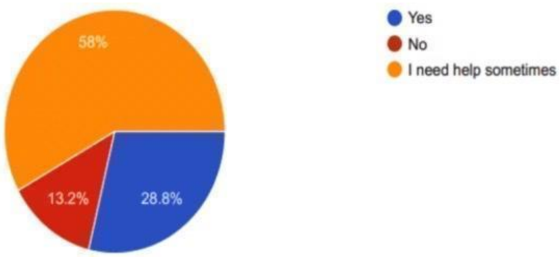


Figure 4 Students Who Can Study From Home as referenced in [3]

Another problem faced by students in this study was that the students did not have the proper resources to resume their studies from home. From the same group of students surveyed, it was concluded that most students did not have a proper internet connection. This is a big problem; some students struggle with internet access or computer access due to a lack of resources. These types of problems are often overlooked, thus leaving the students with little control over their education. According to the study, 78 students did not have a stable internet connection. Also, 28 students could not focus/keep up with their instructors' lectures [3]. Many students also only have school to learn from, that is, not many other resources are available to them outside of what they are able to learn at school. Approximately 75% of the students surveyed were only learning from school, while very few students had access to other online courses and government-provided education systems.

The negative effects of not attending in-person schools are noticeable as well, some students have fallen behind their expected level for both Mathematics and English.

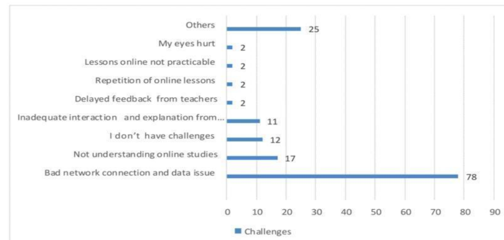


Figure 5 Challenges Faced By Students as referenced in [3]

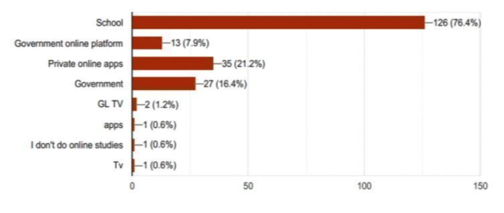


Figure 6 Organizing Instructions as referenced in [3]

According to the study done in "Projecting the potential impact of COVID-19 school closures on academic achievement." students at the K-12 level of education lost a significant amount of learning gains they would have made while in-person [4]. Under 100% closures in schools, the students were expected to lose about 30% of their gains for math and reading at the end of the 2019-2020 school year due to the lack of in-person learning. Projecting to the next school year, 2020-2021, students would start the school year with much less knowledge. Some students who participated in the tests saw a loss of about 10-20 points on average, for standardized tests from the previous year.

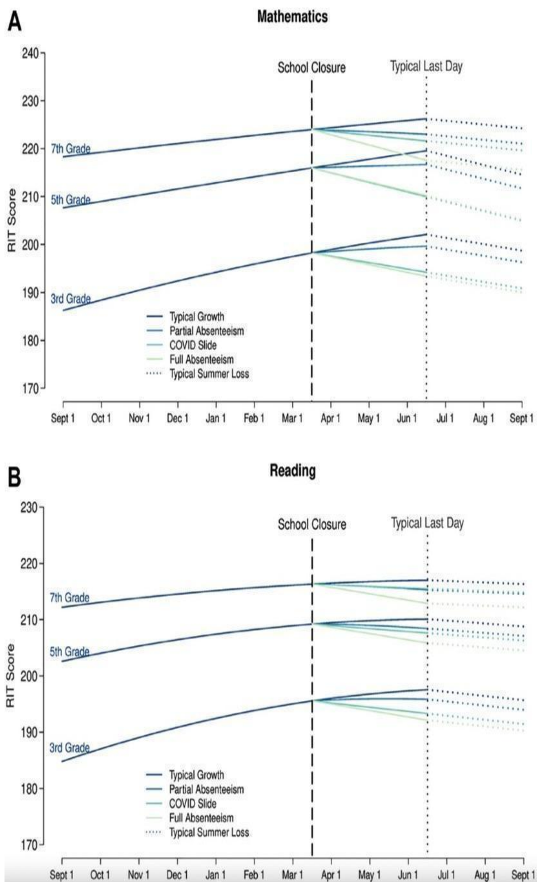


Figure 7 Projected Fall of Students Not Attending In-Person Classes as referenced in [4]

There is also a need for schools to return to in-person learning safely, reports of COVID-19 outbreaks in schools are very common. One report in Israel stated that just 10 days after a schools reopening, an outbreak emerged. This outbreak started with 2 unlinked positive cases, and then rapidly spread to 153 students and 25 instructors who tested positive for the virus [2]. This is a good example of why returning to classes with a set plan to try to avoid the spread of the virus is important. The precautions they had in place were masks and social distancing, but even then, that is

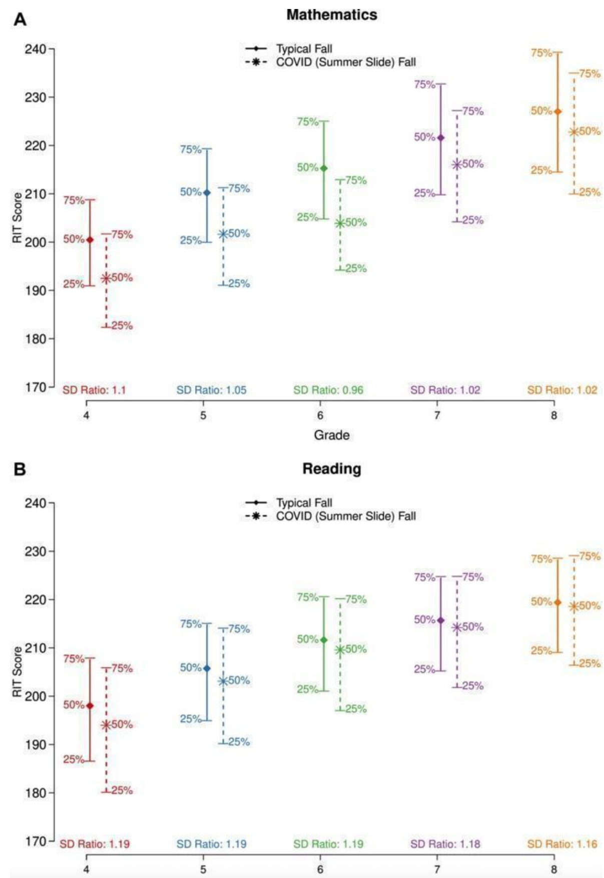


Figure 8 Projected Difference Between In-person and Closure of Schools as referenced in [4]

not enough when dealing with a virus this contagious. The virus mainly spread to middle schoolers, in grades 6-8. In all of Jerusalem one of the most affected age groups of residents were from age 10-19, in other words, grade school aged locals were the most affected. This can be attributed to the openings of schools when it was unsafe to do so, or it can be because the proper safety precautions were not taken. About

20% of those infected in Jerusalem were aged 10-19, after a while of low cases the percentage jumped up to 40% indicating schools were to blame.

Table 1 Age group of students at the Educational Institution and Confirmed Cases as referenced in [2]

Group	Number of persons	Number tested	Males		Confirmed cases		Males, of confirmed cases		Median age in years (cases)	Symptoms	
			n	%	n	Rate (%)	n	%		n	%
7th grade	197	197	106	53.8	40	20.3	25	62.5	13	19	47.5
8th grade	197	197	102	51.8	34	17.3	19	55.9	14	15	44.1
9th grade	187	187	94	50.3	61	32.6	32	52.5	15	30	49.2
10th grade	200	200	110	55.0	9	4.5	6	66.7	16	2	22.2
11th grade	195	194	98	50.5	6	3.1	3	50.0	17	0	0
12th grade	188	186	87	46.8	3	1.6	1	33.3	18	0	0
All students	1,164	1,161	597	51.4	153	13.2	86	56.2	15	66	43.1
Staff	152	151	51	33.8	25	16.6	9	36.0	40	19	76

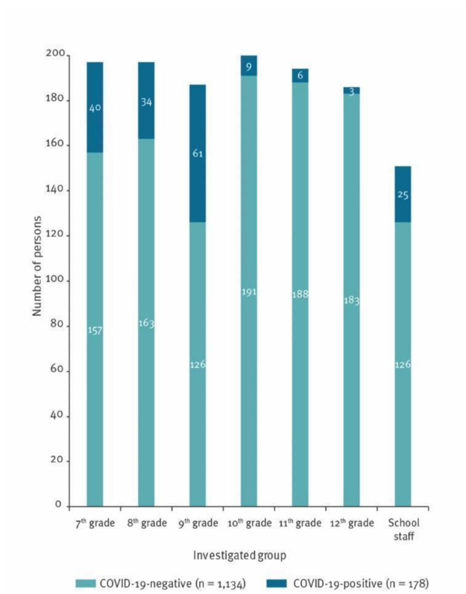


Figure 9 Ratio of Students and Confirmed Cases as referenced in [2]

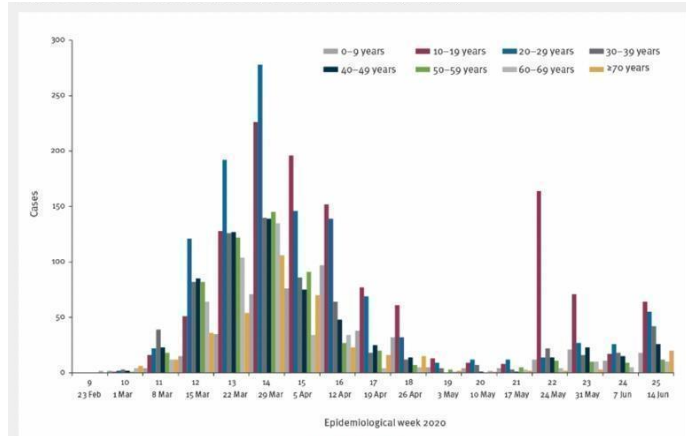


Figure 10 Confirmed Cases in Jerusalem, Israel as referenced in [2]

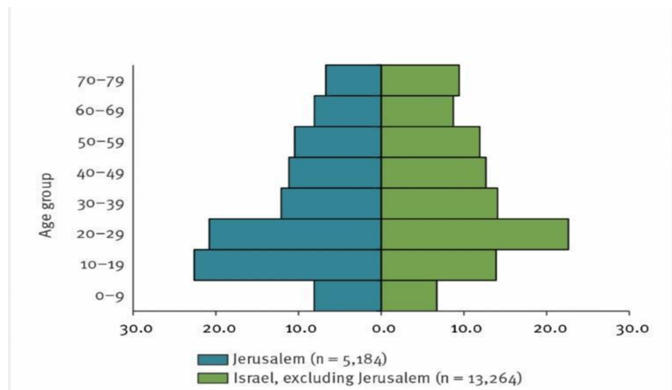


Figure 11 Age Groups of Confirmed Cases in Israel and Jerusalem as referenced in [2]

Educational institutions around the world have been closed for months and although this is effective in stopping the spread of the virus at school, this is impacting students in negative ways because they are not able to fully invest themselves in learning. As explained in an article published by IEEE, “Activity cancellations (workplace closure, school closure, event cancellations) is a more effective way to reduce mobility, having a negative correlation with the change in mobility (reduction in workplace mobility)” [5]. However, since mobility restrictions are being lifted, solutions to preventing the spread of COVID-19 must be in place. A few of these that have been implemented already are mask mandates and social distancing. Unfortunately, some students can still be affected by the virus when close contact is necessary, making these solutions ineffective. As stated by Guo et. al and referenced by Berry et. al, "one recent study reported that COVID-19 can travel up to thirteen feet from patients and be widely distributed on daily objects" [1]. Robots can help by limiting human contact, which is the most significant method of transmitting the virus. In addition to delivering materials between student and teacher and therefore reducing the close contact involved in that transaction, we will also include a self-sanitizing feature built into our robot. This feature will remove the virus from the surfaces of the delivery material before delivering it to either the student or teacher using UVC radiation. We will create a small, enclosed compartment on our robot that will be able to carry delivery materials through a classroom and sanitize the interior of the compartment along with the materials inside of it while in use. It will also contain a door with an interlock feature to keep students from opening it while sanitization is in progress, consequently protecting them from UV light rays.

B. Second Semester Improved Interpretation of the Societal Problem

Although our societal problem maintains the same focal point as before, our understanding of it has improved immensely over the course of the past semester. Furthermore, as we have been working toward a solution to this problem with our current prototype, we have learned more about the requirements and needs of our societal problem in more depth. We now know what aspects we need to prioritize over others and how much attention they require. Throughout the next few paragraphs, we will delve even deeper into our societal problem and how our understanding of it has changed coming into the second semester of our project.

Firstly, it is important to reiterate why our societal problem is even a problem in the first place. As we have previously discussed, with children going back to in-person learning, it is imperative that they return to a safe environment where the spread of COVID-19 is mitigated where possible. One article expresses, "our result does not imply that K–12 schools should be closed. Closing schools can have negative impacts on children's learning (36) and may cause declining physical and mental health among children and their parents (35–37). On the other hand, there is emerging evidence of long-term harm on children's health induced by COVID-19" [6]. This accentuates the dilemma that while children continuing to miss out on in person learning can be detrimental to their development, socialization, and mental health, however returning to school will evidently increase their exposure to COVID-19. The article concludes with a hopeful remark about prioritizing vaccines. Figure 12 shows a graphical representation of the association between school re-opening and the spread of COVID-19 in K-12 schools. It is obvious to see that attempting to mitigate the spread of the virus upon the return to in person learning is much needed. This validates our societal problem and shows a true use for our design.

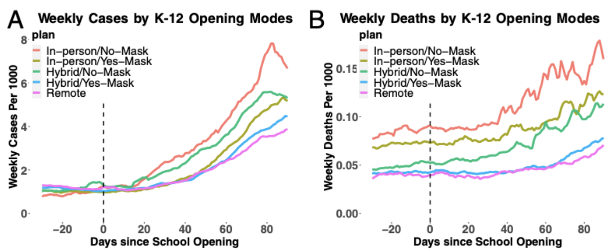


Figure 12 Weekly Cases/Deaths by K-12 Opening Modes as referenced in [6]

The increase in cases upon school reopening is also discussed in the article, "Association of Elementary School Reopening Status and County COVID-19 Incidence," which emphasized the increase in COVID-19 incidents in remote vs. in-person and hybrid learning counties. This article stated, "among children 0 to 9 years, COVID-19 incidence in counties with remote learning increased after school started (56%, 95% CI 32−85). Compared with remote learning, increases were 48% (95% CI 12−94) steeper in hybrid counties and 60% (95% CI 32−95) steeper in in-person counties. Among children 10 to 19 years, the incidence in counties with remote learning increased 71% (95% CI 46−101). Increases were steeper by 41% (95% CI 9−83) in hybrid counties, and 75% (95% CI 45−110) steeper in in-person counties (Supplemental Figure 2). Similar results occurred in adults 20 to 59 years and in adults 20 to 59 years and ≥60 years." [7]

Table 2 Summary of COVID-19 Case Statistics as referenced in [6]

Table 1. Summary statistics

	Wkly case growth	Wkly death growth	Wkly cases per 1,000	Wkly deaths per 1,000	K–12 sch. visits	Workplace visits	Restaurant visits
In person							
Before opening							
Mean	0.091	0.013	0.571	0.060	0.045	0.047	0.185
	(0.011)	(0.003)	(0.031)	(0.003)	(0.002)	(0.001)	(0.007)
N	52,258	52,258	54,995	54,995	67,070	67,070	67,070
After opening							
Mean	0.143	0.034	3.038	0.104	0.161	0.073	0.188
	(0.014)	(0.006)	(0.200)	(0.005)	(0.005)	(0.001)	(0.006)
N	45,749	45,749	45,827	45,827	46,030	46,030	46,030
Difference in means	0.052	0.021	2.467	0.044	0.116	0.026	0.003
	(0.018)	(0.007)	(0.203)	(0.004)	(0.004)	(0.001)	(0.004)
Hybrid							
Before opening							
Mean	0.096	0.024	0.664	0.035	0.036	0.045	0.242
	(0.012)	(0.006)	(0.031)	(0.001)	(0.001)	(0.0004)	(0.005)
N	234,820	234,820	243,321	243,321	260,573	260,551	260,573
After opening							
Mean	0.121	0.042	2.368	0.057	0.126	0.064	0.249
	(0.012)	(0.006)	(0.132)	(0.002)	(0.003)	(0.001)	(0.004)
N	166,605	166,605	166,660	166,660	167,206	167,206	167,206
Difference in means	0.025	0.019	1.703	0.022	0.090	0.019	0.007
	(0.016)	(0.008)	(0.136)	(0.002)	(0.003)	(0.001)	(0.004)
Remote							
Before opening							
Mean	0.099	0.035	0.742	0.032	0.032	0.045	0.278
	(0.012)	(0.008)	(0.035)	(0.002)	(0.001)	(0.0004)	(0.008)
N	76,796	76,796	78,581	78,581	82,165	82,165	82,165
After opening							
Mean	0.103	0.033	1.944	0.047	0.088	0.058	0.287
	(0.012)	(0.009)	(0.115)	(0.003)	(0.003)	(0.001)	(0.007)
N	50,127	50,127	50,048	50,048	50,183	50,183	50,183
Difference in means	0.004	–0.002	1.202	0.015	0.056	0.013	0.009
	(0.017)	(0.012)	(0.120)	(0.002)	(0.003)	(0.001)	(0.006)

Additionally, Table 2 from the previous article summarizes an observation of the weekly case/death growth due to various conditions. From both of these studies, it is apparent that in person learning presents a higher growth in COVID-19 cases than both remote/virtual and hybrid learning.

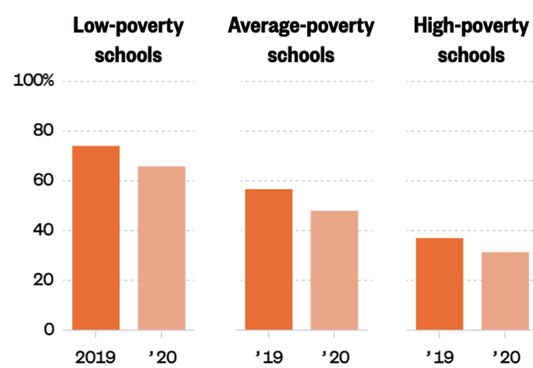
Moreover, schools have been hesitant to return back to in person learning, especially with the rise of variants like Omicron. However, continuing distance learning has been shown to have negative impacts not only on children's mental health but their parent's as well. The same observation is discussed in the article, "Relationship between Parenting Stress and School Closures Due to the COVID-19 Pandemic." Specifically, this study measured volunteers' stress scores prior to school closures and compared them to current stress scores. They found that "current (i.e., after school closures) childrearing stress scores were significantly higher (t = 9.17, P < 0.01, d = 0.20) than before school closures had occurred. Finally, total parenting-stress scores before and after school closures were 2.24 (SD = 0.66, min. = 1.02, max. = 4.40, sum = 80.69) and 2.35 (SD = 0.61, min. = 1.08, max. = 4.29, sum = 84.64), respectively. Current (i.e., after school closures) total parenting stress scores were significantly higher ($t = 7.79$, $P < 0.01$, $d = 0.17$) than before school closures had occurred." [8]

This increase in stress scores could be due to having to facilitate and assist with online learning, as well as the increased stress that almost everyone is facing due to COVID-19. One study found, "when young people are suffering from toxic stress, they have lower cognitive functioning abilities, and therefore correlates with lower achievement rates." [9] This further emphasizes the importance of reducing stress in students upon their return to school. Keeping them out of school may hinder their learning, but bringing them back to school without taking the proper precautions to ensure that they will be in a safe environment may hinder their learning all the same.

An interview that NPR conducted even expressed "when people are feeling just that much more overwhelmed with the demands on them, that can have long-term impacts on their functioning, on their well-being, on their lives …over 40% said they'd gained weight during the pandemic. Nearly a quarter said they are drinking more. And nearly two-thirds are sleeping too much or too little." [10] Many of the articles we have sited have highlighted the negative effects COVID-19 has had on mental health, however this is the first to connect it to physical detriment.

With so much stress and anxiety present due to COVID-19, reducing the amount of close contact in classrooms will be integral in providing safer environments to return to. Our societal problem has gone from protecting the physical wellbeing of the students, to also including protection of their mental health and decreasing the amount of stress and self-destructive habits as a result of being overwhelmed for the people around them. This confirms our design idea and has shown us how important it will be toward the wellbeing of K-12 children and their families.

In addition to the added stress on parents due to remote learning, it is important to reiterate the educational challenges that it poses. This is exemplified by figure 13, which shows that "students in grades 3-8 who took a math test this fall scored lower in a national percentile ranking compared to last year." [11]



Note: Numbers reflect schools' median percentile ranking on the NWEA MAP math assessment in fall 2019 and fall 2020. At low-poverty schools, less than 25 percent of students qualified for free or reduced-price lunch. At high-poverty schools, more than 75 percent did.

Source: NWEA
Graphic: Naitian Zhou / NBC News

Figure 13 Math Assessment Scores Prior to and Amidst Remote Learning as referenced in [11]

One of the main changes in our design that we have made was strengthening it. After performing many tests, we realized that our original design did not account for as much weight as we had initially anticipated. This led us to reassess our societal problem. Our societal problem requires a solution that will be practical for classroom use. A robot that cannot carry all the supplies necessary to distribute to each student in one trip would not be effective. Knowing this, we had to think back to whether our design actually solved our societal problem. With the minimal weight capacity that we had at the close of the previous semester, we decided that with our better understanding of our societal problem and what was required to solve it, we needed to modify our design.

In efforts to better solve our societal problem, we have been working toward improving the strength and stability of our robot. Using our initial design, we ran into problems with the acrylic pieces bending, putting pressure on the wheels, and ultimately causing the wheels to fall off constantly. With these problems, our robot would not be very successful at delivering items to students efficiently. Additionally, the acrylic flexed without any classroom supplies in it. Full of supplies, it is possible that the robot would not even get to one desk before the wheels fell off. As a solution, we are now working with a thicker piece of acrylic, and a new method of mounting our motors that is more secure. Since the acrylic is much thicker, it will be less flexible and with a more secure motor mount, the wheels will be less likely to wobble. These improvements in our design will better our solution to our societal problem and highlight all of the necessary components to effectively reducing the spread of COVID-19 in K-12 classrooms.

It is becoming more and more clear that school are expected to begin reopening. Miguel Cardona, Secretary of the Center of Disease Control and U.S. Education reported to KTLA news that "99% of schools were open in-person in December, compared with 46% last January. Out of more than 13,000 school districts nationwide, relatively few have announced plans to start remotely after winter break" [12] Despite the spike in cases from winter break, most schools in Los Angeles, California will continue to stay in-person with mask mandates and new testing initiatives. Furthermore, "the more coronavirus safety measures a school implement, the safer it is." [13] As a result, our design will be an additional COVID-19 safety measure accessible to schools and consequently help facilitate a safe return back to school for K-12 students.

III. DESIGN IDEA

Design Philosophy

Table 3, Punch List

Features	Measurable Metric
Wireless Controls	After user inputs the desk assignment, the robot will follow the given path to that location
IR Grid Path Routing	Sensor detects tape from 11 to 60 mm height with 10ms update rate
Bar Code Path Routing	It can scan 1D and 2D barcodes with decoding speed 500 times per second
Materials Sanitizer Using UVC Radiation with Safety Interlock	The UVC light should be able to disinfect with 99.9% within 275 nm wavelength [6]
Contactless Door Opening using Motion Sensor	This sensor responses with delay time and blocking time of 2 seconds and ≤100-degree cone angle, range of 3-5 m

We are going to build a contactless classroom delivery robot to mitigate the effects of COVID-19 in classrooms. We have chosen to build a robot on 4 wheels that will follow a strip of tape to a barcoded location where it will deliver the items inside of it. Our robot will feature a 1 cubic foot storage box that will be used to store the items that will be delivered to students. The teacher will wave their hand above a PIR sensor, which will control the opening of our door. This will then allow the teacher to hand load an item in the box and then the box will close while the UVC sanitizing process occurs in the box. When the box is done being sanitized, it will then be ready to receive an input from the teacher, as to which student's desk to go to. The robot will then follow a strip of tape to the barcode it is supposed to go to, and it will stop at the desk. After this is complete, the student will wave their hand over the PIR sensor to open the door and remove their items and the robot will repeat this process.

We will accomplish these tasks by writing code for our Arduino UNO to carry out each specific task. The door will receive an analog high input when a hand is waved in front of it and if the robot is not moving or in the process of sanitization, the normally open switch will close, unlocking the door and allowing the servos to gently open it. This safety interlock will make sure that the door can only be opened when the motors and the UVC light are off. Another feature is the tape following feature, in this feature we will add IR sensors that will steer the robot in the right direction if it is too far off to one side of the tape. The self-sanitizing will be controlled by a process where the robot will close its door after receiving items and it will then sanitize by turning on a UVC light that will rid the item of any potential germs.

B. Specific Design Components

The contactless delivery robot will use a large metal chassis with an Arduino Uno microcontroller connected to an Arduino sensor shield and a L298N H-bridge. The 4 wheels will be attached to the 2 DC motors which will connect to the L298N H-bridge. It will be necessary to implement code to program the robot on how to move using basic directions. We will install a battery to power the Arduino Uno and the L298N H-bridge.

In addition, we will build a 1 cubic foot box for the supplies to be held in. Within the enclosed box will be a UVC radiation device to disinfect the surface of the classroom supplies. The enclosed box will protect students from the UVC radiation and help provide a safe learning environment. As an additional safety measure, the box compartment door will have a lock to ensure the door cannot be opened while the UVC radiation device is active nor when the robot is moving. Code will be written to allow the door to be unlocked when the robot is parked or no longer moving but the door will remain closed. To open the door, students will activate the PIR sensor by waving their hand across the sensor. The PIR sensor will communicate with the servo connected to the door which will be used to open and close the door.

Furthermore, another sensor that will be implemented is the 3-elements line sensor module which uses an infrared transmitter and receiver to detect a black line. Using magnetic tape on the classroom floor, we will help prevent the robot from crashing into unknown objects and to only travel on the guided path. Barcodes will be placed under each student's desk for the robot to scan. With a barcode scanner attached to the robot, the robot will be able to scan the barcode to identify its location. We intend on using wireless controls for the teacher to direct the robot with.

Our team has decided how to divide the projects into different tasks and has assigned tasks to each team member. Sakshi will be working on grid mapping to help guide the robots' movements and a wireless system to control the robot's movements. Edgar will work on creating the 1 cubic foot compartment, as well as implementing the PIR sensor to open and close the door to the box compartment. Harshad will be working on the robot body components/interface and installing the UVC radiation sanitizer. Lastly, Lindsey will be working on creating the wireless control system.

IV. FUNDING

The funding for our project will come from internal team members. The cost of the project will be split evenly between the team members. To help improve our robots' stability and movement, our team has invested more money into upgrading the chassis, motors, and wheels. Due to the upgrades, the cost of the project will increase from $66 to $104.8 per person.

Table 4, Funding Breakdown

Part	**Price**
Arduino Mega	$19.38
Chassis, Wheels, DC motors	$172.62
PIR Sensor	$10.00
LCD screen/Keyboard	$10.00
Jumper wires	$7.00
DROK motor driver	$17
IR sensor	$10.00
Relay Module	$7
1 cu. Ft. box	N/A
Tape	$16.00
Servo	$20.00
Batteries	$124.08
UVC Lights	$86
Normally open switch	$8.00
Barcode Scanner	$50.00
Black tape	$25.00
3-6 V DC motor with chassis	$20

We will also be prepared to purchase extra materials in case we need to get new parts.

V. WORK BREAKDOWN STRUCTURE

An important feature of the contactless delivery robot is being able to move around the classroom which is reliant on the robot body. Certain factors come into consideration when building the robot body such as the dimensions of the chassis, size of the motors, size of the wheels, compatible motor drivers, and compatible microcontroller. As we have been working on the robot since last semester and throughout the winter break, we realized that just not the size of the components of the robot that matters but also these parts have to be strong enough to carry the weight of supplies including the box and should be able to move around the class without its wheels falling off.

At the end of last semester when we were testing our robot for a prototype presentation, we noticed our robot was wobbly as the acrylic sheet chassis we used for our robot base was thin and flexible which was, due to weight on it, causing the wheels to spread out and fall off pretty often. Currently, we are facing certain issues such as the size and strength of the chassis and wheels requiring us to custom build these components. Building the robot body and completing this task will take 56 hours. However, to have the robot moving around the classroom requires creating and implementing code using the Arduino Mega. To have this feature fully operational will require 60 hours. Harshad Singh is responsible for working on the robot body.

In addition, the contactless delivery robot will travel around the classroom using a guided path of black tape and scan barcodes to determine its locations. This task will utilize black tape, infrared sensor, barcode scanner, and creating barcodes for each student's desk. This task will need 43 hours to complete, however this task cannot be completed and added onto the delivery robot until the robot body is built. This feature involving the guided travel path and determining its location using barcodes will require 53 hours because of the code needed for the infrared sensors, testing, and calibration. The testing and calibration are required to help keep the robot traveling accurately using one IR sensor to read the left side of the tape and the other IR sensor to read the right side of the tape to determine if a desk has been reached. While testing the IR sensors we noticed that the Robot is not moving uniformly in a straight line. This caused an issue with the barcode scanner since the robot will often miss scanning the barcode. This feature will be completed by Sakshi Garg.

The next feature of the contactless delivery robot involves carrying supplies in the box compartment. The 1 cubic foot box compartment will be made of cardboard and will include an interlock to keep the door of the box compartment closed while the robot is moving or sanitizing supplies. The PIR sensor and servo will provide a contactless method to open and close the door of the box compartment. The servo will use string or wire to physically open and close the door of the box compartment. During our testing we noticed that the servo and PIR sensors would work as expected standalone but would not open or close the door while testing or running the program with integrated code. We tried to debug and resolve it by making changes in the code and even reported it as one of our deficiencies at the end of the last semester. We worked on this deficiency during the winter break, by changing code or replacing the existing servo with the new one, but the servo still would work fine standalone but causes problems when tested as a part of a robot. After a couple of trials and research we came up with a solution, which was that the Arduino was not providing enough power to servo. So we powered servo through a separate power supply and only provided control through the Arduino. The code for this feature will connect the interlocking mechanism, PIR sensor, and servo to allow the door to be unlocked when it is opened. The task will take 54 hours and will be completed by Edgar Lagunas. Although this feature will need 56 hours to complete because of the additional time required to attach the box compartment to the chassis of the robot and to implement code.

The final feature of the delivery robot is the wireless controller. This feature will require at least having the robot body to be completed for the wireless controller to control where the robot moves to. This task will take around 35-40 hours and will be completed by Lindsey Gong.

As each team member has worked on their assigned tasks, helped incorporate all features together and presented a prototype which was due on November 15th. The technical evaluation helped us determine how complete each feature was. Our last assignment of the fall semester was a prototype presentation. The Public Lab Prototype Presentation was submitted and presented by December 6th.

Over winter break, our team determined and addressed the critical problems. Based on this, we revised our problem statement and will submit the revised problem statement on January 31st. Beginning January 31st, the team will determine which parts need to be tested and create a device test plan report. The device test plan report will be submitted on February 7th.

On February 7th, our team will begin researching marketing techniques and determine which environments our prototype could be profitable in. We will create a presentation to demonstrate the prototype's marketability. Along with the presentation, we will create a summary of the market review presentation which will be completed by February 27th. The market review presentation will take place on February 28th. Starting February 28th, our team will work on the feature report. Each team member will explain their tasks and components used in detail and contribute to the oral presentation. The feature report will be turned in on March 7th and the presentation will be held on March 7th as well.

The next assignment will require testing the prototype to check the progress of the project beginning March 7th. Each team member will test their assigned tasks and features. If needed, the team will explain why we have fallen behind and will provide a solution to get back on track. The results of testing will be discussed during the lab on March 28th for the prototype progress review.

For the following week, the team will analyze the effectiveness of the testing from the previous week and record any modifications made to the prototype during the testing. After testing and analyzing, our team will develop a report discussing the testing results. The testing results report will be submitted on April 4th.

Furthermore, the ethics quiz will be taken the following week by each teammate. From April 4th, our team will be working on completing the prototype and preparing it for demonstration on April 25th. While working on completing the prototype and preparing it for demonstration, our team will create a deployable prototype evaluation discussing the success, issues, and the practicality of the project from an economic viewpoint.

The deployable prototype evaluation will be submitted on April 25th. The next assignment is the end of the project report which our team has been working on since the first semester of senior design. Also, the team will create a PowerPoint and a video presentation discussing our design. The team will complete and submit the end of project report by May 2nd. Our last assignment for senior project is the prototype public presentation and our team will begin working on it by May 2nd.Our team will create a one-page handout, poster, and a summary discussing both technical aspects and milestones reached during the project. The prototype public presentation will be held on May 13th.

VI. PROJECT MILESTONES AND TIMELINE

To track the progress of our project, we have milestones and a timeline which we will follow. The project ranges from August 2021 to May 2022. During this window of time the group must design, build, and test the project. To aid with that, there are timelines in place that will help keep track of who will do what, and when these things will be done.

The timeline begins with thinking of a team societal problem. The team allocated 63.5 hours, over the course of 2 weeks. Our group began to work on this assignment on September 13th and turned it in by the September 27th due date. We discussed many different solutions, and different individual problem statements to find which worked better with our skillset. Next, our team had to create a viable design with real world features that we could measure in a lab setting. This specific task took the team 46.5 hours through 1 week. We began work on September 27th and ended that assignment on October 4th, when the assignment was due. The milestone our team was focusing on achieving with these 2 assignments was being approved for our societal problem and proposed solution. Once our team's ideas were approved, we could move onto the next task, which was creating a work breakdown structure. The work breakdown structure separated big chunks of work into small manageable pieces that could be completed and compiled to move the project along. Our team allocated a total of 25 hours to this task, over many weeks. We began our work breakdown structure on October 11th and completed the assignment on October 25th. The goal was to complete a good work breakdown structure to ensure our project would be manageable. As soon as this assignment was completed, we switched team leaders, so the 2nd team leader is now in charge. After this, we began working on the project timeline. We began work on this assignment on October 25th and we will finish it by November 1st.

We have worked on the project timeline for 30 hours, and the goal of the project timeline is to make the best use of our time when working on our project. Once this assignment is completed, the group will focus on working on the risk assessment assignment. The team will determine what risks follow our project design. We will have to allocate around 25 hours through 1 work week, to complete this task. We will start working on this assignment on November 1st and end work on November 8th. Shortly after completing the risk assessment the team will shift focus into completing a prototype that can be demonstrated for progress reviews. So far, the team has allocated around 228 hours into building this prototype that will be demonstrated on November 15th. This will be our next milestone; we plan on having a semi-functional prototype to show our progress. Having good progress is important with meeting deadlines and completing the project within the allotted time for senior design. Then, we will have to begin preparing for the Public Lab Prototype Presentation. This assignment will be due on December 9th, while the presentation is due on December 10th. By the time our presentation is due, we will need a fully functioning prototype that meets all of our features from the beginning of the semester.

Throughout winter break the team will focus on improving the design and ways we can make upgrades where needed. We will also need to see what parts of our design were useful and worked the way we wanted them to, and which parts did not meet our requirements. In addition, we will be switching team leaders and the 3rd team leader will be taking over. The beginning of the semester is where we will revisit our initial problem statement. We will reflect on the initial problem statement and see what details need to be improved or need to be removed. On January 31st we will submit our revised problem statement. This is the next milestone our team will have, we want to make sure our project's problem statement is accurate and we want it to represent our project properly. We are expecting to spend around 30 hours on this assignment. Also, on January 31st we will begin working on the device test plan report, which will be due on February 7th. For this assignment we are expecting to spend around 35 hours, because we want to ensure we are selecting the correct parts for testing. Once this assignment is turned in, we can begin to work on the Market review assignment. Work on this assignment will begin on February 7th and will end on February 27th. Along with the written assignment we will be making an oral presentation that will encapsulate the written report and make it easier to understand for peers. The presentation will be due February 28th, we expect to spend around 40 hours on this assignment. Also starting on February 28th will be the feature assignment. This assignment will explain each feature of our design in detail. The point of this assignment is to show our expertise with our design, and with our own features that we contributed into the final project design. We will also have feature presentations that will be due on March 7th, which is the day the report is due as well. Once we finish this assignment, we will have to quickly focus on beginning our upgraded prototype presentation. We will begin working on this on March 7th, and finish the presentation on March 28th. We will need to allocate many hours, around 35, to this assignment because we need to get a better idea of what we can improve on, before it is too late to make adjustments.

On March 15th, the final team leader will take over and complete the rest of the semester. The team will then create a report throughout the week immediately after our prototype presentation for test results that will be due on April 4th. This report will consist of data collected from testing our device, and data collected from components that may be modified or added. April 4th also will be the day our ethics quiz will be held, each team member will have to do it individually. From April 4th, up to April 25th which will be the day our final prototype is due, we will be working on tuning and fixing our project. During this time we will have to make our final adjustments and our final corrections. The team should be working on these corrections and adjustments for 50 hours to ensure our final demonstration is as expected.

April 4th also will be the day our ethics quiz will be held, each team member will have to do it individually. From April 4th, up to April 25th which will be the day our final prototype is due, we will be working on tuning and fixing our project. During this time we will have to make our final adjustments and our final corrections. The team should be working on these corrections and adjustments for 50 hours to ensure our final demonstration is as expected.

VII. RISK ASSESSMENT

Next in our project, we must assess what risks are present in our project and determine strategies for mitigating these risks. The ability to assess the risks of any project an individual is working on, taking precautions, and trying to minimize them is essential to project management. Our risk management will consist of multiple steps. The first is to identify the project's critical paths, identify potential events and risks that may delay or prohibit the completion of that path, possible mitigation strategies, and lastly a risk assessment chart which will pictorially represent how these risks will impact our project.

Referring back to our project timeline PERT diagram, we can identify that our critical paths include: Design idea contract to prototype progress report, prototype progress report to device test plan, work breakdown structure to deployable prototype evaluation presentation. With this in mind, we can identify the possible events and risks that may occur while working through these critical paths.

The first type of risks to address are "specific technical risks," which are risks that are caused because of a poor initial choice. One of these risks that we have actually run into already, therefore it is highly likely, is not having enough pins on the Arduino Uno for all of our features. As a solution to this, we have researched methods of using the analog I/O pins as digital pins, since those are the type that we are running short of. Another risk could be that the robot chassis we have made is not strong enough to hold up the box or materials placed inside of it. We do not expect this risk to be very likely to occur but to mitigate the probability of it, we have made the box very light, purchased extra spacers to reinforce the chassis, and can include a maximum weight capacity so whoever is using the robot knows what its limit is. Also, in the case that the robot doesn't know when to stop, which from our testing is fairly likely to occur, we can troubleshoot the code and hardware set up to the best of our ability and worst case scenario we can map out the classroom and the duration of time the motors need to be on before turning off at a desired location.

A "broader technical risk," is that since we don't have a lot of experience with the barcode sensor, there are a few risks involved with that itself. It is fairly likely that the first couple of times we test it, the robot may register the wrong barcode as an acceptable code and open the box for the student to take out materials at the wrong desk. For instance, if the robot is assigned to go to "desk 4," but it scans the code at "desk 3" and opens the door. To mitigate this we will try to minimize the amount of light reflecting off of the barcode so that the scanner can read it as clearly as possible. We can use a matte transparent tape to attach the barcode to the floor, as opposed to a glossy tape to achieve a less reflective surface.

Another "broader technical risk," could be that the PIR sensors detect too much motion and open the door without someone waving their hand over it. We expect that we will have to play around with the PIR sensor, because we ran into problems already with our IR sensors. To mitigate this, we have researched how to adjust the sensitivity of the PIR sensor and by doing this we can hopefully calibrate it to a point where it will only detect a wave of motion directly in front of it and within a reasonable distance. Our box design is also based on the PIR sensor being on the side of the robot, rather than on top so if students are passing things back and forth above the robot for any reason, the PIR sensor will not be triggered.

There is also the case that the robot may start moving with the door open and to mitigate this we will make sure to test our interlock switch and make sure that this is fully operational before integrating the UVC radiation light. Since the box opens upward, if the robot moves while the box is open, there is not much of a safety risk. However, if the light is installed and turned on while the robot is moving and the door is open, this could cause harm to one of our team members while testing. Therefore, we must ensure our box remains closed while in motion before installing the light.

The final "broader technical risk," that we have identified is that the robot does not respond to the input from the keyboard. While doing research on various Arduino bluetooth modules, we found that many of them have a fairly short life span, others are unreliable, and some do not even work out of the box. To mitigate the risk of us receiving one that didn't work properly, we ordered multiple. This was our general rule of thumb when ordering parts, as it is very likely that they may arrive defective, break, or be inconsistent in terms of quality. We selected a bluetooth module specifically for Arduino that had many reviews from people who used them for Arduino projects and so far it is working quite well.

There are also "systematic risks," involved with the completion of our project. Although this risk is very low and we are hopeful that an individual or family crisis does not occur to any of our team members, in the case that this does occur the other team members are willing to put in extra work to help the project still be a success. With campus still having restrictions and all of us having a busy schedule during the week, it has been and will likely continue to be challenging to meet in person to work on things. This risk is more realistic as we continue to go back and forth between Riverside and our homes with our project components, therefore in the case that we need to have access to Riverside we have keyfobs that allow us to enter the building. Additionally, we will be sure to prepare things in advance so that when we meet in person we can use our time as effectively as possible. Also, maintaining good communication and following along with our project timeline will increase the likelihood that we can adjust to crisis situations without it being detrimental to the project. Lastly, there are also unknown risks that we haven't addressed. Despite analyzing our critical paths and identifying possible risks, there are also risks that may become apparent later in our project that we just don't know about right now. Therefore, as this report is a living document throughout our project, it will change as more risks are identified.

Table 5, Risk Matrix

PROBABILITY	5		G			
	4					
	3		F	B		
	2		C	A		E
	1					D
		1	2	3	4	5
	IMPACT					

Each Alphabet in the risk chart maps to the following risks:

A. Robot starts walking with the door open
B. Not taking input from Keyboard
C. PIR sensors are not working properly
D. Robot doesn't know when to stop
E. If the robot body is not strong enough
F. Barcodes scanner
G. Not enough digital I/O pins to satisfy our features

VIII. DEPLOYABLE PROTOTYPE STATUS

For our design idea to become a deployable prototype we must test the design. We have created a device test plan for our design to get an idea of how our features perform both individually and collectively. To help us create a concise testing strategy we have listed the features and all of the measurable metrics for our project.

Our device test plan has 12 main components which have successfully been tested. We assigned categories to every member of our group to ensure we are effective with our testing and we have every feature tested. Along with that we kept track of testing using a timeline. To ensure we have a good range of data, we tested the robot in different conditions.

The first component from our robot we tested are the motors. More specifically, we will be tested the Voltage, Current, Speed, Direction, and Torque. The team member responsible for testing the motors is Harshad Singh, his expertise with motors helped with interpreting data.we tested the robot with items loaded inside of it to get an idea of how much weight it can take and determined the robot can hold a maximum of 49 lbs. Once the weight exceeds 49 lbs, then the motor shafts which connect to the wheels begin to bend causing performance issues. We tested the 12V 5 RPM motors for 25 hours and supplied them with a 24V DC power supply. The motors successfully operate up to a maximum of 10 RPM with a 100% repeatability rate. Also, the 24V power supply can constantly power all 4 motors for 1 hr. According to the datasheet, the motors have a rated current of .8A and while testing we measured the current to be in a range of .75A to .8A.
Another category tested by Harshad are the Robot Movement. Robot movement will be the capacity of the robot to move Forward, Right, Left, and Backwards. The robot can efficenttly move Forward, Right, Left, and Backward with a 100% repeatability rate. Without the use of IR sensors or black tape, the robot is able to make 90 degree turns. Next, Harshad will be testing the UVC sanitizing feature, he tested how often it turns off when the door closes, and turns on when the door opens. From testing the UVC light, I can confirm with a a 100% repeatability rate that the UVC light turns on when box compartment door is closed and the UVC is off when the box compartment door is opened. In addition, the datasheet provided the UVC lights operating current of .3A and operating voltage of 12V. Using a digital multimeter, I confirmed the operating values and received the same values provided by the datasheet. Also, the 12V power supply can power all 4 UVC lights for 25 hours.

The next categories have been tested by Sakshi Garg, who is responsible for these categories because of her expertise and knowledge with sensors and coding. The first of which are the IR Sensors. The IR Sensors have been calibrated using a potentiometer to follow our black tape grid. Since the IR Sensors are responsible for the movement of the robot, Sakshi tested its ability to follow a circular, and hexagonal pattern on the floor, to be able to create different paths within a classroom. We noticed the robot can perform better hexagonal turns than circular turns because the robot is less stable when performing a circular turn. However, the robot is incapable of making 90 degree right or left turns. The IR sensors have been tested on different surfaces that could be found in classrooms such as; Light Carpet, Dark Carpet, and other flooring. As a result, the IR sensors successfully operate on light carpet or tile with a 5 percent chance of error. Although when the robot operates on dark carpet or tile, we determined the IR sensors to have a less than 50 percent chance of functioning properly. The next feature Sakshi tested was the Barcode Scanner's ability to scan and print the barcode at different speeds of the robot, as well as the minimum interval between scans. We determined the barcode scanner is capable of successfully scanning the barcodes from the minimum speed to the maximum speed of the robot (10 RPM). Furthermore, we noticed the robot is quite successful in scanning all the barcodes and in displaying the recently scanned barcode to the LCD screen. We believe the robot performed better at scanning all the barcodes than expected because we improved the overall stability of the robot using hexagonal turns instead of circular turns throughout the path. In addition, we tested the barcode scanner to see if it would stop the robot when scanning a requested barcode. Using the datasheet for the barcode scanner, we determined that the barcode scans repeatedly every .1 second. This allowed us to ensure two consecutive scans are separated by .1 second. While testing, we created 10 barcodes associated with a students desk and requested the robot to stop at each one. The robot scanned each barcode and stopped at every desk location.

Another feature we tested is the keypad on our robot which determines where the robot will move to. This feature was tested by Lindsey Gong, the keypad required testing to ensure our robot can move properly in a classroom setting. Lindsey's knowledge about the keypad is extensive and she knows how the keypad functions individually and collectively with the rest of the robot. The keypad has been programmed to execute different functions. Initially we tested the every key on the keypad because by pressing any key, the robot should begin to move. This was 100% successful and repeatable with any key on the keypad. The next function we tested required pressing only the "0" key which allows the robot to stop at every desk. We expected a repeatability rate of 80% but after testing, we concluded that the robot performed 10% better than expected. This function has a repeatability rate of 90%. The third function we tested allows the robot to stop at every desks for a specific row. We programed three keys: A repersnts row A, B repersnts row B, and C represents row C. We tested each row and and the robot performed 20% better than expected. The robot has 100% repeatability rate using this function. The last function we tested causes the robot stop at a specific desk. We setup 10 desks and tested the robot over 10 times to go to a certain desk. The robot was very successful and we determined that this function has a 100% repeatability rate. The next feature that Lindsey tested is the LCD Screen. The

LCD screen will display important information on the robot such as what desk it will be moving to. For this reason the LCD display has been tested to be sure the robot will display a welcome message and the function being run. After testing, we noticed a 100% repeatability rate for the displaying the welcome message “what function to perform”, which function is in progress, which row the robot is being sent to and which desk the robot is being sent to. Testing on these features began on October 4th, 2021.

The next features have been tested by Edgar Lagunas. These features are the servo for the door opening mechanism, as well as the PIR sensor that will activate the servo. Edgar worked on these features because of the extensive research he has done with servos and PIR sensors. The servo and PIR sensor have been tested separately using an arduino uno. The servo rotated from 0 to 90 degrees which is the necessary range to open the door of the box compartment. From testing the PIR sensor, we determined the best range of distance for the PIR sensor to detect hand motion is 2 ft from the sensor. Beyond a range of 2ft, the PIR sensor's ability to accurately identify movement reliably decreases by 20%. Both the PIR and Servo were activated 50 times simultaneously for stress testing. In addition, the servo uses a separate 7.2V power supply which allows the servo to operate for 1 hour. Furthermore, Edgar tested the servo working in correspondence with the PIR sensor. The PIR sensor accepts the input hand motion and outputs a high signal to activate the servo. This allowed us to analyze how efficiently the PIR sensor outputs a high signal to activate the servo under different conditions. Initially, we tested the robot under the situation that it is stopped at a certain desk. After testing the robot at each student's desk, we determined that the PIR sensor successfully activates the servo for 95% of the time. Once again, due to the overall improvement of the robots stability has helped increase the reliability of the PIR sensor activating the servo by 5%. Also, we tested the robot under the situation that it is still moving. As a safety measure, we programmed the PIR sensor to always output a low signal to the servo while the robot is moving. This will prevent students from being exposed to the UVC radiation. We tested the safety measure implemented in the code and received 100% accuracy from the robot. Testing on the Servo and PIR sensor began on December 21, 2021.

IX. MARKETABILITY FORECAST

The uniqueness of our contactless delivery robot has helped create its own market space within the market of autonomous robots. Our robot is very similar to autonomous delivery robots but the contactless delivery is quite unique due to its feature set. Our Contactless delivery robot is capable of moving in a grid format using IR sensors and black tape, disinfects items of Covid-19 using UVC sanitizing, uses a PIR sensor to help provide contactless delivery, and to ensure safety from the UVC, the door of the box compartment must stay closed. As you can see, the feature set of our robot makes our product quite unique and therefore allows us to control a new market which falls under the overall market of autonomous delivery robots. Many of the other autonomous delivery robots are quite similar to our robot and some of the autonomous robots are contactless as well. However, there are still some differences in the robots performance compared to our contactless delivery robot and therefore the producers of autonomous delivery robots are our closest competitors. Since there are a few competitors and large number of suppliers for robot components, our new market could be flooded with competitors who could build our same product.

Currently our main customers for our product are schools and universities. Our mission for building our contactless delivery robot is to help provide a safe learning environment for students by limiting the amount of contact between students in the classroom. Our current robot is successful in providing assistance to teachers in classrooms while limiting the spread of Covid-19. This has helped maintain our good relationship with schools and using these positive reviews, we can create more sales with good customer satisfaction guaranteed. Many of our competitors have benefitted my team by keeping the market at a high pricing potential. This allows many of our competitors to a price range from $3,000 to $15,000. This is a great benefit for our team because we could choose to meet exceptional profit margins or we could help lower the market price of contactless delivery robots for all customers. We have calculated the production cost of our robot to be $579.08 only including components. We could choose to begin selling our product at $3,000 or higher for a beginning price and increase the price over time as the demand keeps increasing. Furthermore, our team could make slight modifications to our current robots code and have it be used churches, hardware shops, or even food delivery services such as doordash. With slight modifications to our current robot, we could create new products that could be marketed to different groups of customers such as schools, churches, and even businesses.

X. CONCLUSION

A. Societal Problem

COVID-19 has required us to make many adjustments in life to help protect ourselves against this dangerous virus. Many of these adjustments have involved how we get our education and remote learning has proven difficult for many students. Younger children, especially, require more attention from teachers, socialization in classrooms, and hands-on projects, and with all of this on pause or altered it has become increasingly more difficult learning from an online setting. Younger children are also at a higher risk when it comes to their safety and protection against the COVID-19 virus since a vaccine hasn't been approved for them yet. Due to the many struggles with online teaching, there has been a push for the return to in-person schools. In-person education is vital to teaching younger students in their formative years, but with this comes a price. This price is an increased risk for COVID-19. To limit the spread of this and other viruses in classrooms, we are proposing a robot that can deliver classroom supplies to students while minimizing physical contact between students and teachers. The robot, with a self-sanitizing feature using UVC radiation, will disinfect the surface of the classroom material it is delivering before it is passed around to students. This solution will help students gain a better education and obtain an improved learning experience in the classroom while making their environment safer and reducing the risk of infection.

B. Design Idea

Our contactless classroom delivery robot will consist of a battery powered, wireless, 1 cubic foot box on wheels. These wheels are going to be driven by the motors, which will help the wheels to rotate using voltage generated by H-bridge which will be connected to our processor, Arduino. We are going to use magnetic tape and sensors to provide our robot the sense of direction. This box will have a compartment to hold assignments from teachers or children. This compartment will be protected by a door connected to the PIR sensor, so that nobody will have to touch the door. Lastly, it will sanitize the materials within the enclosure using UVC radiation.

C. Work Breakdown Structure

The work breakdown structure created will be implemented to aid the group with completing individual tasks leading up to the final product. Every group member has tasks that they will be completing before compiling them and creating the robot. To summate the breakdown of these features again, the robot body will be designed and then implemented by Harshad Singh. Along with the robot body, Harshad will be making the UVC sanitizing feature that will disinfect the inside of the robot box and the materials inside the box. The robot will also follow a path with tape and infrared sensors, this will make it easy for the robot to move around in the classroom. Sakshi Garg will be responsible for designing the path feature, and she will also design the barcode scanning function to identify each student's desk. The robot will receive inputs from a wireless controller that the teacher will have

access to. The robot's wireless controls system will be executed by Lindsey Gong. Finally, the robot will have a 1 cubic foot box that will be used to enclose the items loaded in it, and it will have a door that will be activated by a PIR sensor. Edgar Lagunas will create this box, and the door.
The cardboard will be reinforced to protect it from potential damage that can happen when loading and unloading the box.

With the work breakdown structure we have developed, we will be able to maintain on our track to completing our project by its due date. We will also have the steps written out for us so we will be careful not to miss anything. Therefore, this work breakdown structure will prove to be quite handy throughout the rest of the semester.

D. Project Timeline

The project timeline is an important tool to help the team manage and organize all the tasks required for the project. Creating the project timeline allows the team to determine a chronological order for which tasks need to be completed. This way the team can divide the tasks up over two semesters and manage to work 15 hours per week on average. The Project timeline consists of all the tasks, duration of time required for each task, team members assigned to each task, current team leader, start date of each task, and end date for each task. This allows for the team to stay calm, focused, and organized while working to complete each task over the course of two semesters leading to a finished final prototype by April 25th. In addition, we created a Gantt Chart and PERT diagram to visually represent all the details entailed in the written project timeline. The Gannt chart is very similar to a calendar format to display which tasks are still incomplete, tasks that are work in progress, and tasks that are complete. This chart allows the team to see the individual progress of each task and the overall progress of completing the project. Furthermore, the PERT represents the project timeline in the form of a flowchart including both tasks and features. The PERT diagram focuses on the relationship between steps necessary for the project such as displaying which steps are dependent on other steps. Also, the PERT diagram helps the team identify and display milestones and possible bottlenecks of the project. The project timeline is an excellent tool to help the team meet deadlines, provide an organized method of viewing all required tasks, and determine the project's overall progress.

E. Risk Assessment

After the Project timeline, comes the risk assessment and it plays a vital role in completing our senior design project. By assessing the possible risks, their impact and the probability, it will help our team members to be ready for the discrepancies that might arise in future. After making a risk assessment chart, we can easily find out which are the most severe risks that could jeopardize our project and we can try taking cautions and all the preventive actions to minimize the risks from the beginning. As we described different risks earlier in this report, there are a couple of risks that we should be prepared for in advance. Like what if the chassis or the body is not strong enough, that could fail our whole project so we should have some kind of backup plan, maybe an extra chassis or an extra box for the robot's body. Also what if it won't take the user input from the keyboard, we can have a manual switch connected to the robot body with some kind of default code. Similarly, there are very good chances that the robot will start walking with its door open or PIR sensors will not work properly meaning the sensors won't be able to detect the motions in 1 go, it will take 2-3 tries.

There are few more risks that could occur while building our design, and though they are not very critical for our project, we can still try to avoid them or to find an alternative solution on time with the help of this risk assessment report. Moreover, the risk assessment chart can help us know the impact of a certain risk on our design with possible probability. This way we can decrease the total percentage of negative effects of the unpredictable results emerging from the practicable risks, as no project is risk free.

F. Problem Statement Revision

COVID-19 is still a significant problem for our society and continues to evolve by creating variants of the virus such as the Delta or Omicron variants. As COVID-19 continues to grow in our society, the amount of research relating to COVID-19 has increased and has helped us improve our understanding of our societal problem. From the recent data collected on COVID-19, we are able to observe how the number of cases increase when students attend school in person vs remote learning. Furthermore, we are able to learn about the increase in stress levels for both students and parents due to remote learning from home during a pandemic. Understanding this situation of students has helped us improve our understanding of our societal problem because in addition to protecting students' physical well being, we are also protecting students' mental health and stress levels.

To better solve our societal problems, our team has upgraded the motors, wheels, and chassis to improve the stability of the robot. With our first semester prototype, we noticed the 1/16th in acrylic chassis would begin to bend as we added more weight to the robot and would often cause the wheels to fall. Additionally, we have upgraded our 6 volt motors with 12 volt motors. The 12 volt motors have higher torque to help provide better stability and movement for the robot. With these improvements, our design is more effective in limiting the spread of COVID-19 in classrooms.

G. Device Test Plan

In order for our project to successfully become a deployable prototype, we have developed our device test plan, which has been outlined in our "Deployable Prototype Status" portion of this report. Additionally, a detailed table interpretation of our device test plan will be included in the appendices. This device test plan highlights each of our features, as well as the fundamental parts of our robot that are essential to its functioning. It precisely iterates how we expect each aspect of our project to perform and outlines the steps that we will take to ensure that each and every component is working as intended.

Furthermore, we have detailed how we will be confirming that each feature works both independently and in conjunction with the rest of our project's components. Overall, our test plan will be crucial in making sure that our robot is repeatedly successful and would properly solve our societal problem. These steps will be crucial in developing our project into a deployable prototype.

H. Market Review

Now we have completed one more step of our product's lifecycle, the market review. After performing the market review of our product we gathered all the data and knowledge about the targeted market for our product and how to reach that. We know the societal problem we are trying to solve through CCDR which helped us discover the potential customer of our product which are schools. Furthermore, on the basis of our cost of the robot, we calculated the price we can charge from the customer. Then we asked around to know the price the customer is willing to pay for the same. Moreover, we did some research on who the competitors are and what we need to do to make our robot unique. Also, we did SWOT (strength, weakness, opportunity and threat) analysis, and how to use our strength and opportunities to overcome our weakness and threats.

I. Testing Result

We designed a test plan to be able to test our robot for accurate measurements, and we have executed those tests to determine the capability of our robot. Each team member was responsible for testing certain features on the robot and capturing the data to log each feature's performance. However we also had collaborative testing where we all tested the robot together once it was assembled. The items tested included the motors of the robot, the IR sensors that guide it, the barcode scanner, the keypad and LCD display, and finally the PIR sensor and servo.

Through our testing we found that the IR sensors work better on hexagonal shapes, and on tile or light carpet. Also, the PIR sensor has a maximum distance of 2 ft. for accurate readings. Another item we tested was the LCD display, which could display the row and desk accurately. Moreover, the keypad could accurately start the robot and send it to any desk we input on it. The motors were also tested for the voltage, current, speed, direction and torque. In addition, we tested the motors ability to move forward, backward, right and left. The motors and robot were also tested under different circumstances, and with different items inside of it to determine the maximum amount of weight it could take and still work reliably.Through testing we were able to find that the motors require .75A-.8A. The motors can also move the robot in every direction efficiently and at a 100%repeatability rate. In addition, the UVC light was found to be 100% repeated through our testing with the door closed and also with the door open, while also confirming the values from the datasheet.

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GLOSSARY

Barcode: a machine-readable code in the form of numbers and a pattern of parallel lines of varying widths, printed on and identifying a product
Breakdown: division into categories
Bluetooth: a standard for the short-range wireless interconnection of mobile phones, computers, and other electronic devices
COVID-19: a new coronavirus that has spread throughout the world. It is thought to spread mainly through close contact from person-to-person.
Grid-mapping: a family of computer algorithms in probabilistic robotics for mobile robots which address the problem of generating maps from noisy and uncertain sensor measurement data, with the assumption that the robot pose is known
H-Bridge: is a circuit that allows voltages to be applied across a load in either direction
Interlock: a device or mechanism for connecting or coordinating the function of different components
IR Sensor: a radiation-sensitive optoelectronic component with a spectral sensitivity in the infrared wavelength range 780 nm to 50 µm. IR sensors are now widely used in motion detectors, which are used in building services to switch on lamps or in alarm systems to detect unwelcome guests.
Remote Learning: the education of students who may not always be physically present at a school
PIR Sensor: a passive infrared sensor is an electronic sensor that measures infrared light radiating from objects in its field of view
Robot: a machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer
UVC Radiation: UV light with wavelengths less than 290nm are considered to have "germicidal" properties, meaning it can kill germs. This kind of light is commonly used to kill microbes on surfaces, in air, and in water
Wireless: using radio, microwaves, etc. (as opposed to wires or cables) to transmit signals.

Definitions from Oxford Language Dictionary: https://languages.oup.com/google-dictionary-en/

APPENDIX A. HARDWARE

	Test Id:	Component Tested	Test Devices/Description	Start date	End date	Member resposible	Expectation	Percent Repeatability Expected	Results from testing	Passing Score	Status	Details
Motors	Test 1	Testing how much voltage is conumed by the motors	Voltage	January 20, 2022	March 27, 2022	Harshad Singh	The motors will operate at a maximum of 24V	100%	100%	The motors will operate at a maximum voltage of 24V or less depending on the PWM value	Complete & Met Expectations	motors are operated at a maximum 24V
	Test 2	Testing how much current is conumed by the motors	Current	January 20, 2022	March 27, 2022	Harshad Singh	The motors have a rated current of .8 A	100%	100%	The motors will operate at a maximum current of .8A or less depending on the PWM value	Complete & Met Expectations	The motors have a total maximum current draw of .32 A
	Test 3	Testing the RPM of the motors based on the PWM value.	Speed	January 20, 2022	March 27, 2022	Harshad Singh	The maximum RPM of the motors is 10 RPM	100%	100%	The motors will operate at a maximum of 10 RPM or less	Complete & Met Expectations	When the motors operate at a PWM value of 255, then the motors operate between 9 to 10 RPM
	Test 4	Testing to see if motors operate in the clockwise and counter-clockwise direction	Direction	January 20, 2022	March 27, 2022	Harshad Singh	The motors rotate counterclockwise and clockwise	100%	100%	The robot moves in the forward direction and in the reverse direction	Complete & Met Expectations	The robot moves in the forward and reverse direction at 9.6 RPM
	Test 5	Testing how much weight the robot can carry	Torque	January 20, 2022	March 27, 2022	Harshad Singh	Each motor has a torque of 35 kg.cm and limits the maximum amount of weight the robot can carry.	100%	100%	The robot is able to move with maximum weight	Complete & Met Expectations	The robot can carry a maximum weight of 49 LBS
Robot Movement	Test 6	Testing to see if the robot can move in the forward direction	Forward	January 20, 2022	March 27, 2022	Harshad Singh	All wheels have a RPM of 4.87	100%	100%	In the forward driection, the robot has a rpm of 9.6	Complete & Met Expectations	In the forward driection, the robot has 9.6 RPM
	Test 7	Testing to see if the robot can make a right turn	Right turn	January 20, 2022	March 27, 2022	Harshad Singh	The left side wheels have a RPM of 3.23	100%	100%	when the robot turns right, it has a rpm of 4.6	Complete & Met Expectations	when the robot turns right, it has a rpm of 4.6
	Test 8	Testing to see if the robot can make a left turm	Left turn	January 20, 2022	March 27, 2022	Harshad Singh	The right side wheels have a RPM of 3.23	100%	100%	when the robot turns left, it has a rpm of 4.6	Complete & Met Expectations	when the robot turns left, it has a rpm of 4.6
	Test 9	Testing to see if the robot can move in the backwards direction	Backwards	January 20, 2022	March 27, 2022	Harshad Singh	All wheels have a RPM of 4.87	100%	100%	e reverse driection, the robot has a rpm of 9.6	Complete & Met Expectations	In the reverse driection, the robot has 9.6 RPM
IR Sensors	Test 10	test the sensors reflectivity while going straight	Follow tape - Forward	October 1, 2021	March 26, 2022	Sakshi Garg	should follow the tape and go forward	95%	100%	the robot should go straight following the black tape	Complete & Met Expectations	follows the tape and starts moving
	Test 11	test the sensors reflectivity while turning right	Right turn	October 1, 2021	March 26, 2022	Sakshi Garg	follow the tape and turn right	95%	100%	the robot should turn right and follow the tape	Complete & Met Expectations	follows the turning tape and turn right
	Test 12	test the sensors reflectivity while turning left	Left turn	October 1, 2021	March 26, 2022	Sakshi Garg	follow the tape and turn left	95%	100%	the robot should turn left and follow the tape	Complete & Met Expectations	follows the turning tape and turn left
	Test 13	test how smooth the robot is running on the floor and the carpet	Stabilitty	October 1, 2021	February 28, 2022	Sakshi Garg	should run straight	95%	100%	should be more stable on the floor than carpet, but the wheels should not come off or robot should not fall down in any case	Complete & Met Expectations	follows the line of black tape and go straight
	Test 14	test if the IR sensors are able to reflect the infrared light and detect the tape	On Floor	October 1, 2021	February 28, 2022	Sakshi Garg	Detects the reflectivity of the tape	95%	100%	should ne able to run very smoothly on floor	Complete & Met Expectations	runs smoothly on hard floor
	Test 15	similarly the sensors should be able to reflect the infrared light and detect the tape on light colored carpet	On Light Carpet	October 1, 2021	March 1, 2022	Sakshi Garg	Should be able to run on carpet	95%	100%	might need the speed to be adjusted on carpet but should be able differentiate between the reflectivity of carpet and the black tape	Complete & Met Expectations	runs smoothly on carpet too and detects the black tape on light carpet
	Test 16	on dark colored carpet, its hard to differentiate between the tape and the floor, so need to test how the reflectivity will work	On Dark Carpet	October 1, 2021	March 2, 2022	Sakshi Garg	Might not able to differentiate between the reflectivity of the carpet and the tape	<50%	<50%	It might be hard for IR sensors to detect the black tape and might go off the path	Complete & Met Expectations	its hard to detect black tape on dark carpet but we can use white tape instead
Barcode Scanner	Test 17	testing if scans the barcode and how often	Scans Barcode	October 1, 2021	March 3, 2022	Sakshi Garg	Should be able to scan all the barcodes	75%	90%	should be able to scan all the barcodes	Complete & Met Expectations	the barcode scanner scans all the barcodes as far as they are aligned
	Test 18	print the scanned barcode number as output on LCD	Print barcode on LCD	October 1, 2021	March 3, 2022	Sakshi Garg	Print the recently scanned barcode on LCD	97%	90%	it prints the last scanned barcode on the LCD screen	Complete & Met Expectations	it prints the last scanned barcode on LCD
	Test 19	scan speed should be 500 times per sec. as per the spec	Scan speed	October 1, 2021	March 3, 2022	Sakshi Garg	Sould be .1 sec per scan (from barcode scanner datasheet)	70%	90%	The barcode scanner should be able to scan the barcode in .1 sec	Complete & Met Expectations	it scans the barcodes pretty fast but like 90% - 95% of the times
	Test 20	need to adjust the speed of robot in miles per hr to scan the barcode and fast enough to be practical	Robot Speed	October 1, 2021	March 24, 2022	Sakshi Garg	Robot speed must be sufficent enough to allow the barcode scanner to scan the barcode	85%	95%	The robot should move fast enough but should not miss the barcode	Complete & Met Expectations	robot speed and the size of barcodes are good enough for the barcode scanner to scan the maximum number of barcodes.
	Test 21	ensure 2 consecutive barcode scans are separate by >.1 sec (from barcode scanner datasheet)	Minimum interval between 2 scans	October 1, 2021	March 24, 2022	Sakshi Garg	ensure 2 consecutive barcode scans are separate by >.1 sec (from barcode scanner datasheet)	80%	100%	The interval between 2 scans should be greater than .15 sec	Complete & Met Expectations	the interval between 2 scans is much bigger then .15 sec, around 14 sec
	Test 22	testing if robot stops at barcode scan only	Stops at barcode	October 1, 2021	March 25, 2022	Sakshi Garg	Should stop at barcode as soon as it scans it	90%	99%	The robot should stop after scanning the barcode	Complete & Met Expectations	as soon as barcode scanner scans the barcode, the robot stops for further action
	Test 23	testing if robot stops due to any other reason	Do not Stop Otherwise	October 1, 2021	March 25, 2022	Sakshi Garg	Should keep running untill scans the barcode or there is a end of that path	90%	100%	the robot will stop only in the given 2 scenarios	Complete & Met Expectations	robot only stops at the valid barcode or at the blacktape T point
Keypad	Test 24	Testing communication between controls system (keypad) and robot movement	Starts with key press	October 1, 2021	March 25, 2022	Lindsey Gong	Robot starts moving, following input to keypad	100%	100%	The robot starts moving when the correct input is given to the keypad	Complete & Met Expectations	The robot began moving, upon being given input from the keypad
	Test 25	Testing ability of robot to complete the function of stopping at each desk after being given specified input	Goes to all desks	October 1, 2021	March 25, 2022	Lindsey Gong	Robot will move forward and attempt to follow the black tape/scan all barcodes	80%	90%	The robot starts moving and upon the correct input, when it scans a barcode it will stop. After the door is opened and closed, it will resume motion	Complete & Met Expectations	The robot scanned the barcodes most of the time (about 90%) and stopped and resumed motion after scanning the correct barcode associated with the function
	Test 26	Testing ability of robot to complete the function of stopping at a specific row after being given specified input	Goes to specific row	October 1, 2021	March 25, 2022	Lindsey Gong	Robot will move in a path to the designated row	80%	100%	The robot starts moving and upon the correct input it will go to the correct row then it will scan the barcodes and stop when it is at the designated location with the expected repeatability	Complete & Met Expectations	The robot began moving and scanning all barcodes but only stopped at those designated by the row function, as expected
	Test 27	Testing ability of robot to complete the function of stopping at a specific desk after being given specified input	Goes to specific desk	October 1, 2021	March 25, 2022	Lindsey Gong	Robot will go from its designated row toward a designated desk	80%	100%	The robot starts moving and upon the correct input it will go to the correct row, then it will scan the barcodes and stop when it is at the designated location with the expected repeatability	Complete & Met Expectations	The robot began moving and scanning all barcodes but only stopped the designated desk, as expected
LCD Display	Test 28	Testing that the LCD displays the correct message upon the robot being turned on	States welcome message	October 1, 2021	March 25, 2022	Lindsey Gong	Upon start up, LCD will display a welcome message and ask what function to perform	100%	100%	The LCD will display the correct welcome message upon the robot being turned on.	Complete & Met Expectations	The LCD displayed "Function" upon starting up the CCDR
	Test 29	Testing that the correct function is associated with the keypad input and the message is displayed on the LCD for user to read	Shows function being run	October 1, 2021	March 25, 2022	Lindsey Gong	The LCD will print the function that is inputted to keypad	100%	100%	After the keypad receives input, the LCD will display the name of the function that is correlated to this input (EX: Input-0, LCD Display "All Desks")	Complete & Met Expectations	The LCD display printed the function associated with the input given on the keypad
	Test 30	Testing that once the specific row function is called, the LCD will call out that row	Shows row that it's being sent to	October 1, 2021	March 25, 2022	Lindsey Gong	If a specific row is the input, the LCD will display Row X, where X is the input A-C	90%	100%	In the case that the user calls for a specific desk, the LCD will display a message that shows the function associated with the input (EX: Input-A, LCD Display "Row A")	Complete & Met Expectations	The LCD display printed "Row X" where X was the specified input A-C
	Test 31	Testing that once the specific desk function is called, the LCD will display a message which calls out that desk	Shows desk that it's being sent to	October 1, 2021	March 25, 2022	Lindsey Gong	If a specific desk is the input, the LCD will display Desk X, where X is the input 1-9	90%	100%	In the case that the user calls for a specific desk, the LCD will display a message that shows the function associated with the input (EX: Input-2, LCD Display "Desk 2")	Complete & Met Expectations	The LCD display printed "Desk X" where X was the specified input 1-9
Servo	Test 32	Hardware testing the servo to make sure it works as expected	Works Seperately	December 21,2021	March 30, 2022	Edgar Lagunas	Move to any given angle	100%	100%	The servo will work independently without being attached to robot and will move 180 degrees.	Complete & Met Expectations	The servo could move to positions at 90° and 180°
	Test 33	Servo is able to work with a PIR sensor	Works in corespondence of PIR sensor	December 21,2021	March 30, 2022	Edgar Lagunas	Detects input from PIR	100%	90%	PIR sensor and servo can function independently from the robot	Complete & Did Not Meet Expectations	The servo would not work with the PIR sensors rarely, but it worked the majority of the time
	Test 34	Servo moves to desired angle given an input by the PIR sensor	Works after Integration	December 21,2021	March 30, 2022	Edgar Lagunas	Will move 90 degrees when PIR sensor is active high	90%	90%	Integrating the code and the servo being able to work with the PIR sensor	Complete & Met Expectations	The servo moved to the proper angle when the PIR sensor received an input consistently, however there were instances where the servo went to a higher or lower angle
	Test 35	We are testing the servo's ability to function with different power sources supplying different amounts of current and voltage	Voltage / Power supply	December 21,2021	March 30, 2022	Edgar Lagunas	Follows the data specified by manufacturer	100%	100%	The servo can work with different voltages and current ratings within the datasheets specifications	Complete & Met Expectations	When the servo has the 2A & 7.4V required it will function properly.
PIR	Test 36	Testing the PIR sensor to work alone as expected without integration to our robot	Reads Hand Motion	December 21,2021	March 30, 2022	Edgar Lagunas	Will output a "1" when active	90%	100%	The PIR sensor can detect motion and set off the servo or an LED light to test its functional	Complete & Met Expectations	PIR sensor worked by itself any time it detected motion within the 2ft. range
	Test 37	Testing that the servo can function with a PIR sensor as an input	Servo Activates only when Motion detected	December 21,2021	March 30, 2022	Edgar Lagunas	Will output a "1" when active	100%	100%	Integrated PIR sensor and servo can work in the robot as expected	Complete & Met Expectations	The PIR sensor would detect motion and set off the servo consistently
	Test 38	We are testing the PIR sensors ability to activate when the robot is stopped at. a students desk	Detects motion when Robot Stops	December 21,2021	March 30, 2022	Edgar Lagunas	Activates servo when robot is not in motion	90%	85%	The robot will be stopped at a students desk and the PIR sensor will activate when it senses motion	Complete & Did Not Meet Expectations	The PIR activated when integrated on the robot as expected, however in some instances it did not pick up the signal immediately during the first pass
		We will test that our PIR sensor will not take an input while the robot is in motion to prevent injury from UVC					Servo will not move unless the robot is			The robot will be in motion and the PIR sensor will detect motion but it will not set off		The PIR sensor was never set off when the robot was
UVC	Test 40	Testing how much voltage is consumed by the UVC light	Voltage	October 1, 2021		Harshad Singh	Power supply must be adequate to run UVC light on separate supply	100%	100%	The UVC light uses 12V to operate	Complete & Met Expectations	The power supply will last for 25 hours and the UVC lights draw a total current of 120 mA
	Test 41	Testing if the light turns off when the door opens	Turns off when door opens	October 1, 2021		Harshad Singh	When the door opens, UVC light turns off	100%	100%	When the relay is active, then the light will be on	Complete & Met Expectations	when box compartment is open, then the UVC light is off.
	Test 42	Testing if the light turns on when the door is closed	Turns on when door closes	October 1, 2021		Harshad Singh	When the door closes, UVC light turns on	100%	100%	When the relay is off, then the light will be off	Complete & Met Expectations	when box compartment is closed, then the UVC light is on.

Table 6, Work Breakdown Structure Overview

Level 1	Level 2	Level 3	Level 4
Assignment 1: Individual Problem Statement	Conduct research on a societal problem that each individual member would like to solve with our senior project	Research many societal problems and technical solutions and choosing one that we would like to research further and potentially work on throughout the next 2 semesters	Finding multiple academic sources that present why the societal problem is actually a problem that needs to be solved (due September 13th)
Assignment 2: Team Societal Problem Report	Conduct more extensive research to determine what our societal problem is in detail and what our plan for solving this will be	Selecting one problem statement, as a group, that we feel would be best to focus on for the senior project	Find multiple academic sources that present why the societal problem we chose is so pressing (due September 27th)
Assignment 3: Design Idea Report / Contract	Compile a set of features and components that we will be committing to completing for our prototype	Confirming that we have a strong feature set and measurable metrics and obtain approval from our lab professor	Research & determine what features we will be delivering on in our final prototype, detail what will be accomplished (due Oct 4th)
Assignment 4: Work Breakdown Structure	Compile a list of all assignments and tasks needed to be completed from August 2021 to May 2022	Breakdown what subtasks are necessary to complete the assignments listed in the WBS, as well as a plan for completing them	Detail what each assignment and task entails, what we need to do before other things can be accomplished (due Oct 25th)
Assignment 5: Project Timeline	Complete work breakdown structure to decide what needs to be accomplished	Determine in what order things must be done and how much time to allot to each	Create Gantt & PERT diagrams, as well as a written timeline, which shows the relationship between tasks, who is working on them, how long it should take, and when it is due
Assignment 6: Risk Assessment Report	Figure out what steps in our project could potentially cause hazards	Determine these risks and devise a plan to mitigate them if possible	Detail the possible risks in a written format and what our plans are to reduce these/how we will

			respond if a problem occurs (due Nov 8th)
Assignment 7: Lab Prototype Technical Evaluation	Functioning Robot Chassis	Build a lightweight base for the robot	Design CAD file for cut chassis shape out of acrylic using CNC machine (soft deadline Oct 27th)
			Drill holes for mounting Arduino, h-bridge, and various sensors (soft deadline Oct 30th)
		Connect and coordinate all four wheels and motors	Connect two right-side motors together, repeat for left-side motors, and attach wheels (soft deadline Oct 30th)
			Test 3-6V motors to make sure that they are powerful enough for all of our features (soft deadline Nov 3rd)
		Mount H-Bridge, Arduino, and other components	Determine where wires, LCD display, and other components will be placed (soft deadline Nov 5th)
	Wireless Controls System	Complete Barcode + IR Path Routing	Write code for IR sensors to keep it on track (Oct 30th), write code for barcode scanners to match desk locations (soft deadline Nov 7th)
		Assign each desk location to a place	Figure out the number of desks we want to use and create barcodes for each location (soft deadline Nov 10th)
	UV Sanitizer	Mount sanitizer to robot	Research UV sanitizers to find one that has some

			research behind its effectiveness, mount to chassis (Nov 10th)
			Write code to turn on UV sanitizer when the door is closed (Nov 10th)
	Contactless Door with Safety Lock	Configure PIR sensor to detect hand motion	Write code for PIR sensor to open the door when motion is detected (Nov 7th)
		Add interlock switch to act as safety lock	Write code for door detector so that the robot will only move/sanitize when the door is closed (Nov 10th)
Assignment 8: Public Lab Prototype Presentation	Create a presentation slide deck to present our prototype	Complete measurable metrics to show the progress of our design	Prepare measurable metrics to demonstrate our prototype, ensure that features are working to some degree (due Dec 10th)
Assignment 1: Revised Problem Statement	Determine what worked and didn't work from the Fall semester	Revise our statement such that it reflects the current state of our problem and how our understanding of it has grown	As a group, evaluate the progress we have made on our prototype and ensure it still reflects a solution to our problem statement (due Jan 30th)
Assignment 2: Device Test Plan Report	Determine what will be tested and which will be most essential for our deployable prototype	Compile these into the device test plan report	Create a game plan based on each feature for how we will be testing them to show our measurable metrics (due Feb 7th)
Assignment 3: Market Review	Research marketing techniques and in which environments our prototype could be profitable	Prepare a presentation that demonstrates our prototype's marketability and our understanding of it	Research what aspects/features of our prototype are marketable (due Feb 28th)

		Generate one page summary of marketability presentation	Summarize analysis of the marketability of our prototype (due Feb 28th)
Assignment 4: Feature Report	Create and format a standalone report for the feature report	Explain societal problem, complete set of components, technical solution to components, and illustrations (this report should be creative)	Utilize visual aids to highlight the components and features we have developed to solve the societal problem that we researched (due March 7th)
		Complete oral presentation with elevator pitch included	Practice with group members to make sure the presentation goes smoothly (due March 7th)
Prototype Progress Review	Have prototype and testing prepared to check the progress	If behind, explain why and how to get back on track	Check-in with lab instructor to ensure we are either on time with our timeline or if we are behind, what we need to do to make sure we are able to complete the project (due March 28th)
Assignment 5: Testing Results Report	Complete Revised Test Plan	Analyze the effectiveness of the test plan and record any modifications made throughout the testing of our prototype	Discuss what worked and didn't work within our test plan and how we adjusted it so that it was successful (due April 4th)
	Complete Testing Results Report	Compile a report which includes the results of the tests that occurred	Record and analyze the results of our tests and the steps we made to obtain these results (due April 4th)
Assignment 6: Ethics Quiz	Each group member must individually take the engineering ethics quiz	Think about engineering ethics and how it pertains to our project.	Ethics quiz due April 18th during lecture time

Assignment 7: Deployable Prototype Evalutation	Post project audit	Discuss how well our project succeeded in terms of our problem statement and feature set, how practical it is from an economic standpoint, and any issues that we had	Analyze whether or not our prototype was a success, weigh out the cost/benefit of our project and what problems we ran into (due April 25th)
	Prototype Demonstration	Have prototype fully functioning and ready to be presented as our final project, show measurable metrics + feature set	Test and make sure that each feature is working properly and is ready to be demonstrated (due April 25th)
Assignment 8: End of Project Report	Complete End of Project report that we have been working on throughout the year	Include team member photos, and prepare a presentation video that highlights our design	Check formatting, detail level, and proofread full end of project report. Make sure that the final copy is our best work that we want to turn in (due May 2nd)
Assignment 9: Deployable Prototype Public Presentation	Prepare materials and demonstrations to display to the public in a "tradeshow" manner	Create a one-page handout, poster, and summary to supplement our elevator pitch. The summary should include the main technical aspects and milestones reached while completing the project	Prepare all team members to present our project, make sure everyone knows our elevator pitch, test plan, measurable metrics, and can describe the project milestones well (due May 13th)

APPENDIX E. PROJECT TIMELINE

Project Timeline

Task	Team Leader	Assigned Team Members	Duration	Start Date	End Date
Individual Problem Statement	Lindsey Gong	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	60 Hours	30-Aug-21	13-Sep-21
Team Societal Problem Report	Lindsey Gong	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	63.5 Hours	13-Sep-21	27-Sep-21
Design Idea Report / Contract	Lindsey Gong	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	46.5 Hours	27-Sep-21	4-Oct-21
Work Breakdown Structure	Lindsey Gong	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	25 Hours	11-Oct-21	25-Oct-21
Project Timeline	Harshad Singh	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	30 Hours	25-Oct-21	1-Nov-21
Risk Assessment Report	Harshad Singh	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	25 Hours	1-Nov-21	8-Nov-21
Lab Prototype Technical Evaluation	Harshad Singh	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	228 Hours	27-Sep-21	15-Nov-21
Functioning Robot chassis		Harshad Singh	60 Hours	27-Sep-21	15-Nov-21
Wireless Controls System		Lindsey Gong	53 Hours	27-Sep-21	15-Nov-21
UV Sanitizer		Harshad Singh	9 Hours	27-Sep-21	15-Nov-21
Contactless Door with Safety Lock		Edgar Lagunas	56 Hours	27-Sep-21	15-Nov-21
Public Lab Prototype Presentation	Harshad Singh	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	30 Hours	15-Nov-21	9-Dec-21
Revised Problem Statement	TBA	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	30 Hours	1-Jan-22	31-Jan-22
Device Test Plan Report	TBA	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	35 Hours	31-Jan-22	7-Feb-22
Market Review	TBA	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	40 Hours	7-Feb-22	28-Feb-22
Feature Report	TBA	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	30 Hours	28-Feb-22	7-Mar-22
Prototype Progress Review	TBA	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	35 Hours	7-Mar-22	28-Mar-22
Testing Results Report	TBA	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	30 Hours	28-Mar-22	4-Apr-22
Ethics Quiz	TBA	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	1 Hour	4-Apr-22	11-Apr-22
Deployable Prototype Evalutation	TBA	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	50 Hours	4-Apr-22	25-Apr-22
End of Project Report	TBA	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	405 Hours	13-Sep-21	25-Apr-22
Deployable Prototype Public Presentation	TBA	Lindsey Gong, Harshad Singh, Sakshi Garg, Edgar Lagunas	30 Hours	2-May-22	13-May-21

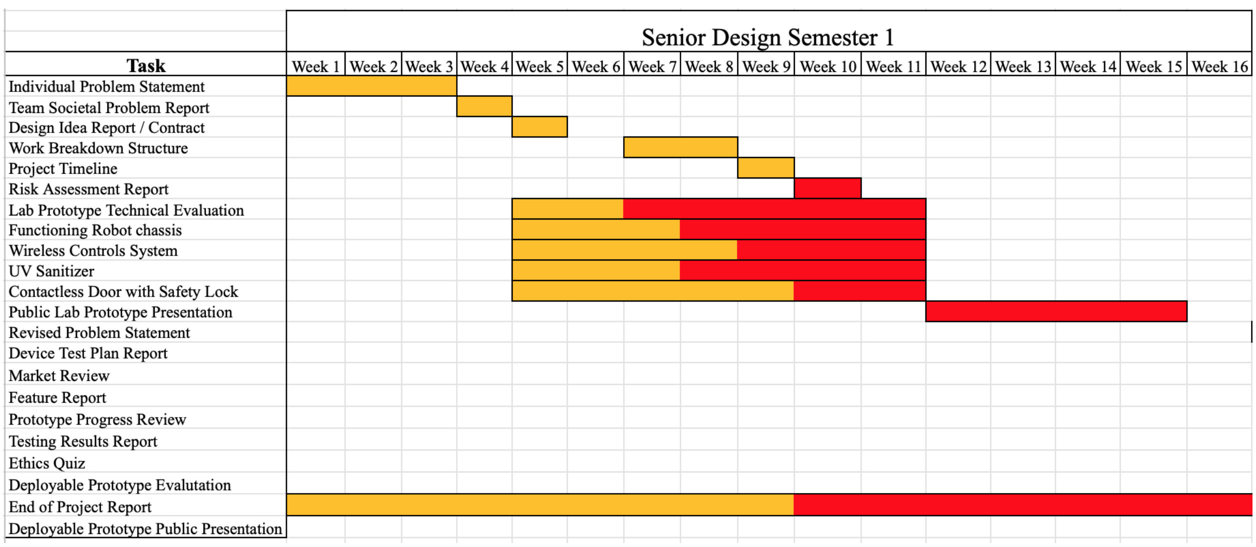

Figure 14 Gantt Chart Semester 1

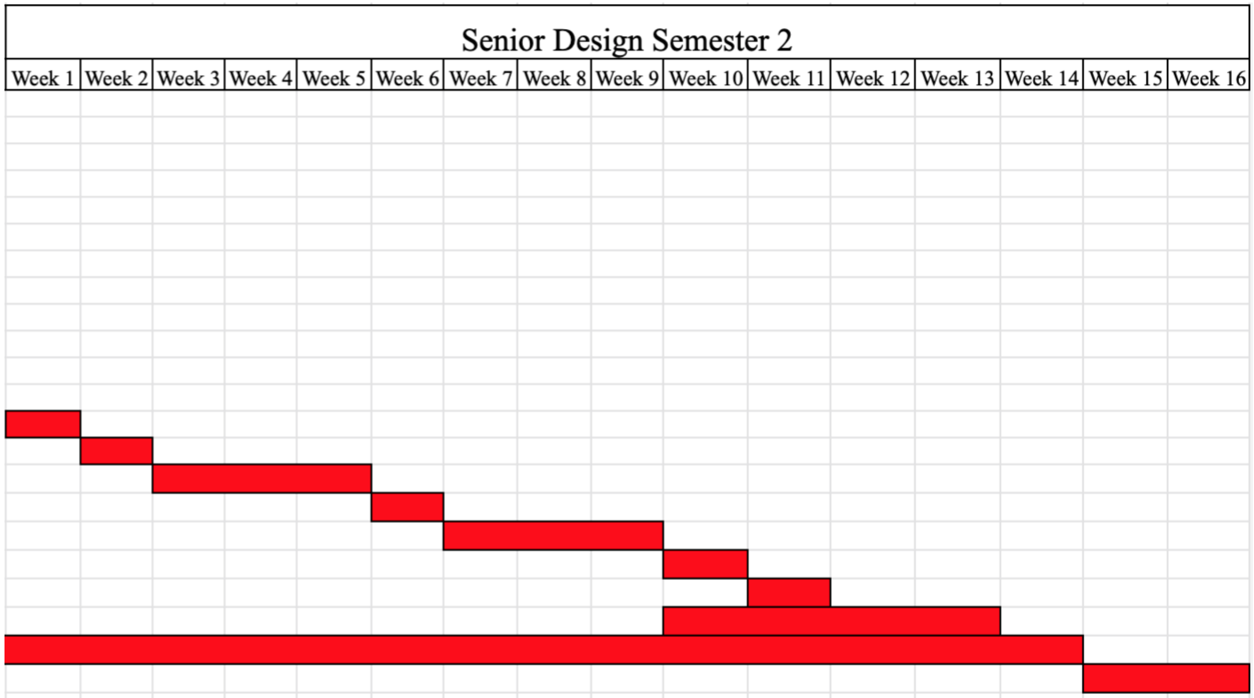

Figure 15 Gantt Chart Semester 2

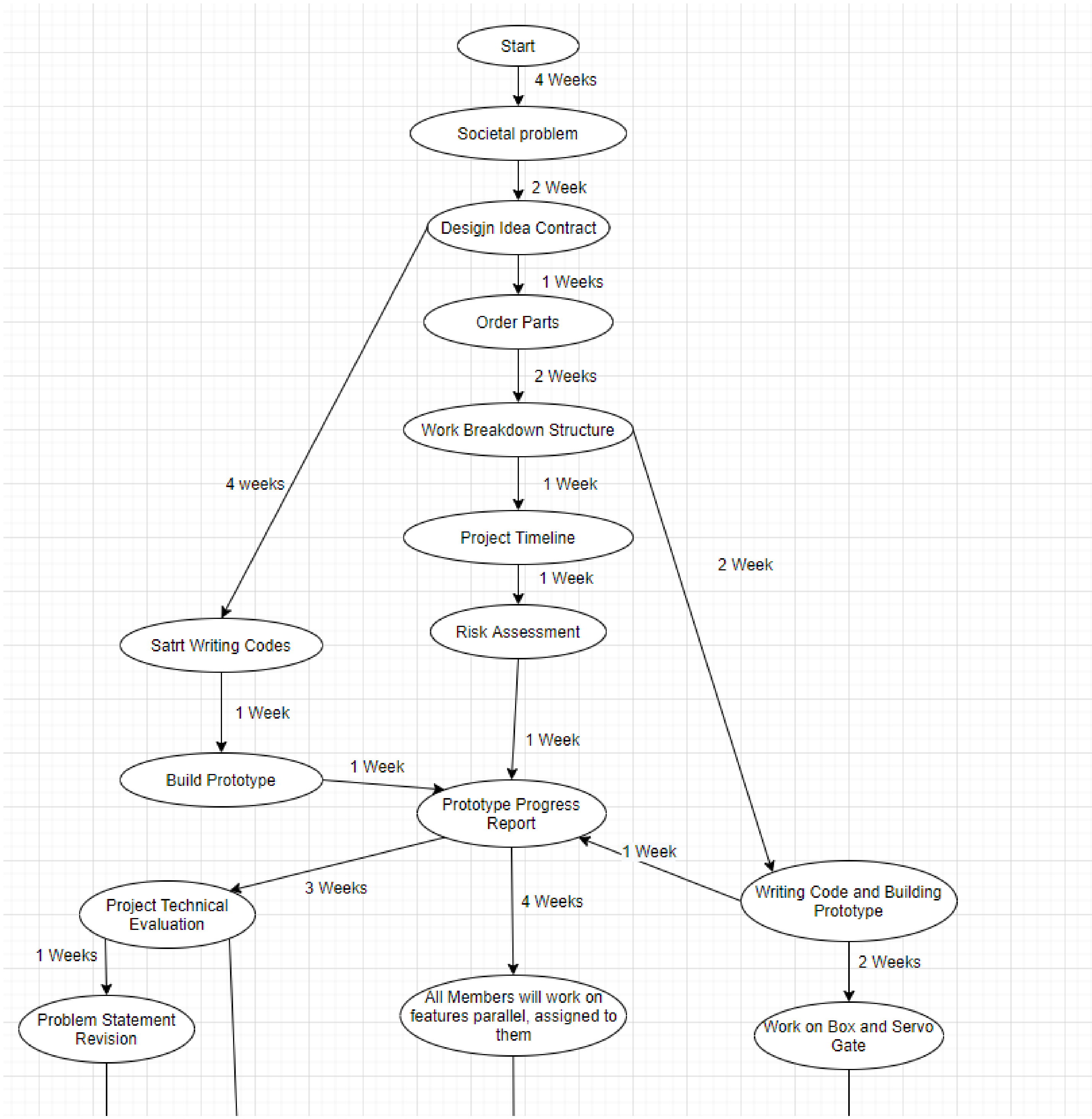

Figure 16 PERT Diagram Page 1

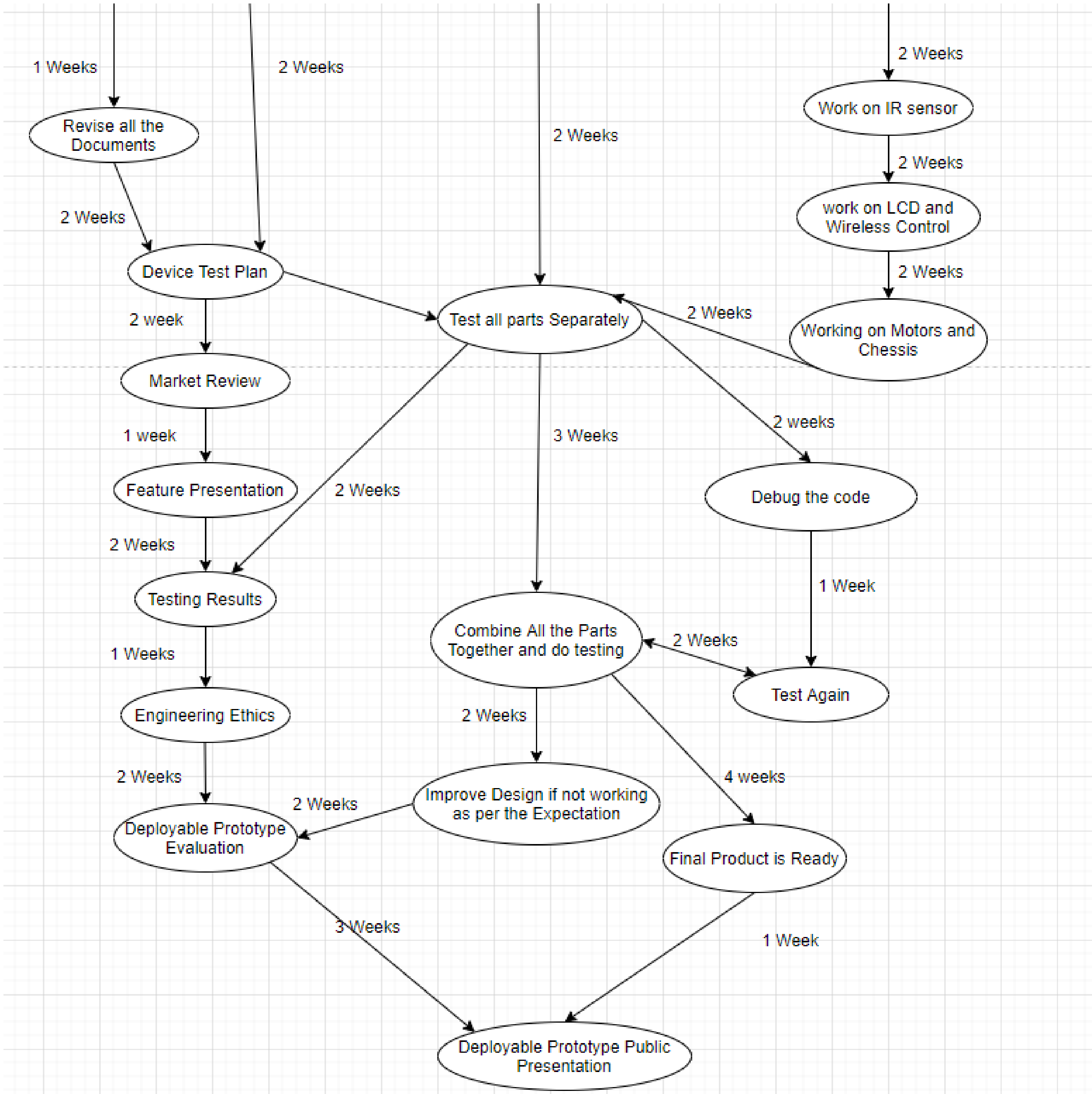

Figure 17 PERT Diagram Page 2

APPENDIX F. RESUMES

Lindsey Gong

Summary

I attend CSU, Sacramento and expect to graduate in May of 2022 with a B.S. in Electrical Engineering. My concentration is in power systems, but my breadth of study involves controls and electronics, as well. I love problem solving and work well with others. I am a fast learner and strive for perfection in all my work.

Related Coursework

- Physics 1 & 2, Applied Electromagnetics, Calculus 1-3 and Differential Equations
- Intro to Logic Design (Verilog/FPGA Design), Circuit Analysis, Network Analysis, Signals & Systems
- Intro to Microprocessors, Feedback Systems, Electromechanical Conversions, Electronics 1 & 2, Communication Systems

Work Experience

Electrical Engineering Intern - Stantec (May 2021-Current)

- Utilized AutoCAD and Revit for EE related drafting, panel schedules & one lines
- Completed Arc Flash Coordination Studies using SKM PTW Power Tools
- Intern Design Challenge: Designed renewable energy and lighting systems (AGI) and formatted an electrical room layout per NEC standards.

Engineering & Computer Science Tutor – CSU, Sacramento (February 2021-Current)

- Mentored students from a variety of backgrounds to increase understanding of coursework and facilitate effective study habits

Education

CSU, Sacramento - Electrical Engineering (Expected Graduation: Spring 2022) GPA: 3.8

Pleasant Grove High School – Innovative Design & Engineering Academy (2018) GPA: 4.2

Skills

- Strong organization, time management, excellent communication skills
- Proficient in AutoCAD, Inventor, and Revit, Strong skills in Microsoft Office and G Suite
- Experience in MATLAB, Simulink, Verilog HDL FPGA logic design, Analog Discovery 2/Waveforms, ADS, OrCAD/PSpice Simulations, STM Microcontrollers, Microchip, PTW Power Tools, AGI32

Honors and Awards

Dean's Honor Roll (All Semesters) - CSU, Sacramento

Vice President, Tau Beta Pi, Engineering Honors Society – California Upsilon Chapter

Projects

- Engineering Mentorship Program (In progress)

References

Tim Mathein, AECOM Senior Engineer

Kevin Kinoshita, Stantec Electrical Engineer

EDGAR LAGUNAS

edgarlagunas@csus.edu

Skills

HTML certified from UC Berkeley

70 WPM

Fluent in English and Spanish

Proficient in Microsoft Office

Education

California State University Sacramento 2018-2022

Electrical & Electronic Engineering
3.4 GPA

Experience

LH Construction Co.

Project Manager 2019-current
Writing estimates and creating plans for future projects
Working to meet deadlines
Speaking to homeowners to discuss ideas for renovating their home

Harshad Singh

Electrical and Electronic Engineering

CONTACT

[illegible]

PROFILE

I am a fourth year Electrical and Electronic Engineering Major at California State University, Sacramento. While attending Sacramento State, I have grown interested in Electrical Engineering and plan to pursue a career in Analog/Digital electronics.

EDUCATION

2022

California State University, Sacramento

Bachelor of Science in Electrical and Electronic Engineering

Honors and Awards

- Dean's Honor Roll - ALL Semesters

TECHNICAL SKILLS

- Analog IC design
- AutoCAD
- Microsoft Office Suite
- C, MATLAB, Verilog VHDL FPGA logic,
- Analog Discovery 2/Waveforms, Advanced Design System, OrCAD/PSpice Simulations

Organizations

- Tau Beta Pi, California Upsilon
  - Engineering Honor Society
  - Alumni Liaison

Course Work

- Physics 1&2, Applied Electromagnetics
- Calculus 1-3 and Differential Equations
- Intro to Logic Design: Verilog & FPGA Design
- Circuit Analysis, Network Analysis,Signals & Systems
- Intro to Microprocessors, Feedback Systems, Electromechanical Conversion, Electronics I
- Advanced Logic Design, Electronics II, Power System Analysis I, Modern Communication System, Product Design Project

EXPERIENCE

06/2019 - PRESENT

Engineer Architect Student Intern, Department of Water Resources | Sacramento County

- Data Analysis, Research, and problem solving
- Collaborative Group working with Engineers
- Designing underground systems using GIS (Geographic Information Systems)

06/2016 – 06/2018

Manager | Mountain Mikes Pizza

- Interview, hire and train new employees.
- Supervise employees and evaluate their performance.
- Responsible for revenue and inventory control.

Projects

- Robotic Hand with Glove Control
  - STM32 Nucleo ADC configuration
  - Servo and PWM configuration
  - Data collection utilizing Raspberry Pi Interface

References

- Rod Goss Senior Civil Engineer
- Susan Yang Supervising Engineering Technician
  - [illegible]

Sakshi Garg
Email: sakshi1088@gmail.com
LinkedIn: https://www.linkedin.com/in/sakshi-garg-38a36957

EDUCATION

California State University, Sacramento, CA
Aug 2018 – May 2022
Bachelor of Engineering in Computer Engineering. GPA - 3.7/4.0
Dean's List for Fall 2020 and Spring 2021

Folsom Lake College, Folsom, CA (May 2013 – July 2015)
Associate of Science in Computer Science with Highest Honors
- GPA of 3.7/4.0. A in all Engineering/Mathematics Courses

RELEVANT COURSES

- Computer Architecture
- Data Structures & Algorithms
- Software Engineering
- Object Oriented Programming
- RTL Design & Validation
- Logic Design
- Microprocessor Design
- Advanced Circuits

SKILLS

- Proficient in: Verilog, VHDL, C++, C, Assembly Language, Quartus ||, Linux
- Familiar with Python, Perl, JavaScript, MATLAB
- Computer Skills: Microsoft Word, Excel, PowerPoint

EXPERIENCE

Student Intern – Intel Corporation, Folsom, CA (Sep. 2021 – May 2022)

IT Administrator - Kan Heritage, Folsom, CA (2016 - 2018)
- Responsible for maintaining the company's IT network, servers and security systems
- Manage company website and online customer relationship

Student Assistant - Office of Legislative Counsel State of California(Oct. 2015 - Feb. 2016)
- Responsible for testing various legislative forms and bills for correct selectable entries