

*Automatic Hybrid Cooling Fan  
End-of-Project Report*

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### **Elevator Pitch**

Global warming, pollution, and the energy crisis, are all caused by the overuse of our local power grids. We plan to combat this by taking one of these power grids' most reliant home-systems: the HVAC. Our project seeks to reduce the use of the local power grid.

## EXECUTIVE SUMMARY

To go against the effects of Global Warming, a system similar to heating and cooling units would have to be created, using alternative power. This system would have automation based on temperature, be customized to client preferences, and use only healthy, renewable energy. We believe that with a product like this, people would be encouraged to keep themselves comfortable in their homes without having to release greenhouse gases and break the atmosphere. After coming up with this societal problem, we came up with a design idea. Our design idea is an attempt to improve our way of keeping comfort within our homes and reducing the use of the local grid. This is how we conceived the idea of making an alternatively-powered fan. This Design Idea report will first talk about all measurable metrics and prototype features that are part of the project. Towards the end of our design idea section, we would also be given a bit more perspective on funding and what kind of budget we should hold for all components.

We started out this semester looking into societal problems and planned out a budget for our fan's components. We were then able to plan out all required tasks to complete for every piece of our hybrid fan's feature set. In our Work Breakdown Structure section of the report, we mention every assignment we have completed for our senior design class in the past two semesters. We were also able to gain insight on how we were doing in terms of planning and preparation for our project. After this, we continued to plan by setting timelines for ourselves. From the beginning of the first semester, we continued to schedule ourselves based on what was due in terms of class assignments. Without careful planning, this could have easily affected how much time we needed to work on our project. Therefore, we created a Gantt Chart, with dates set by us to keep ourselves on schedule, and a PERT diagram that would help us keep track of how long each part of the project should take. Setting this in stone through our Project Timeline Report gave us perspective of just how little time we have to complete our project and assignments, and allowed us to plan for any contingencies. With our project timeline complete, the planning stage for our senior project was nearing its end. All that was left was to plan for all of the specific contingencies that we should be ready for. With very little time left in the semester, we would have very easily been put into a tight spot. If we were not ready for any of the potential drawbacks, it would have affected our performance, as well as the performance of our product at the date of project submission. Therefore, we used the planning time we had left in our first semester to be ready for any and all drawbacks through our Risk Assessment Report.

After that point, we had completed our first semester of senior design and were quickly moving to our final stages. However, before moving forward, we took this time to step back, make sure we are reaching our goals, and actually striving to solve our problem statement. We found that we needed to become more specific with what exactly it was we wanted to solve, so that our project can become more of a verified and valid product. This is demonstrated in our Problem Statement Revision Report. After validating our project's purpose by revising our work breakdown structure and problem statement, we moved into the stages of verification of our project's measurable metrics and functions. We prepared to test each part, to see if it all properly contributed to the feature set of the overall project. Once all worked as intended and with little chance of failure, then we were in a good place with our deployable prototype, and ready for more prototype evaluations. This is stated in detail in our Deployable Prototype Status Report. After this, we knew the direction of our project as a prototype: its purpose, its validation, and verification, and took into consideration the direction our project would go as a marketable product. We performed research on the current market that is relevant to our deployable prototype. This Market Review Report shows our understanding of the type of market our product would reside in competition with. Finally, after completing our product's feature set, and going through all of our component tests, we then had these same tests from our previous deployable prototype status showing satisfactory results. We demonstrate our progress through the success of these tests, and showing that our project has just about reached its completion. From here on, we prepared ourselves for final presentations.

### **Abstract**

This End-of-Project Report will guide the reader into the one-year-long process of creating a deployable prototype, from the moment of its conception, to the final test results. The many sections and pages of this report demonstrate our dedication and careful planning to make this project the best it could be. These sections will act as a demonstration of the steps we took to complete our senior project. Whether that be planning our due dates, creating our timeline, calculating risk, or even just readdressing our societal problem, all of our work will be demonstrated as clearly as possible throughout the entirety of this large-scale report. Our Solar-Powered Automatic Cooling Fan is created in dedication to solving the issues of pollution and the energy crisis. We created this prototype from scratch and planned carefully to make absolutely sure that we meet its feature set, which was also verified by our professors. In meeting this feature set, we know that we did our job in solving our societal problem. The numerous tables, images, and charts in this report are all made to keep track of our progress and verify our project's purpose. This is all in the name of making sure our project meets its requirements in a timely manner, as this is still a class with assignments and due dates. After this report, in the appendix sections are the interesting specifications, code, diagrams, and images of what we used to create our prototype. We hope to convey all of the hard work we put into these past two semesters as clearly as possible.

### **Key Word Index:**

*Global Warming, Solar Power, Temperature, HVAC, Thermometer, Raspberry Pi, Microcontroller, Components, Design Philosophy, Servo Motors, Arduino, IDE, Energy Rationalization, Funding, Work Breakdown Structure, Milestone, Gantt/Timeline Chart, PERT Chart, Overlap, Risk, Mitigation, Deployable Prototype, Feature Set, Measurable Metric, Market, Consumer, Competitor, Market Forecast, SWOT Analysis, Inverter, Charge Controller, Solar Panel, Python*

## **I. Introduction**

### *A. Societal Problem*

In recent days, humanity has been proven to be destroying the earth. As a group of humans, we believe that we have an obligation to do our part in saving the world we live in. One of the most obvious, and most damaging, environmental effects humanity has had on the world would be global warming. This is due to our overuse of greenhouse gases. People release these environmentally harmful gases just by driving, cooking, and even to regulate the temperature in their homes. The everyday person owns a house that uses an electrically-powered HVAC system. But these days, most electricity is powered by nonrenewable resources, which also happen to negatively affect the earth's atmosphere. In summary, our current HVAC systems, which we use to cool and heat our homes to comfortable temperatures, are making the world more unpredictable and unbearable to live in. Therefore, humanity desperately needs an alternative way to cool and heat without damaging the earth. This report will give insight into why we decided to tackle this specific societal problem as a group of engineering students.

### *B. Design Idea*

This project is designed to combat the effect humanity is having on the planet. With our current HVAC systems, and our easy comfort, it can be difficult to remember that the power we use to keep ourselves warm or cool. We stated in our societal problem report that alternatives must be found quickly, as the earth's life is currently on a downhill trend. But as the previous report depicted why we chose to do this project, this report will give insight on how exactly we propose to go about it.

### *C. Work Breakdown Structure*

With our societal problem and design idea set in stone, with our parts purchased, our research ready, and our project officially approved, we are now able to plan all of the tasks we will be completing for the next two semesters. Our work breakdown structure will be based on our feature set and measurable metrics punch list from the design idea section of the report. This report should be able to show how we decided to split up the work, help us set deadlines for ourselves, and allow us to keep working on our project in a more organized fashion.

### *D. Project Timeline*

Now that we know exactly what we will be doing, our reason for doing so, and with everything prepared, we are now ready to plan out our work schedule in terms of dates and requirements. Through our project timeline, we will show what we have done so far, and what we will be doing until our project is complete. We would be using a Gantt Chart and PERT Diagram to demonstrate the timing, length, and due dates of everything we will be covering in terms of our project, and class assignments.

### *E. Risk Assessment*

Through the assessment of our potential risks, we would be able to better handle them as they come up. This report will give perspective of how we plan to mitigate these risks, if possible. If not, then we will at least prepare ourselves mentally so that if anything unpredictable happens, we would still be able to stick to our project timeline as best as we can. Whether it means spending more time per week on a feature, or pushing for better and faster methods, we plan to be ready for any and all drawbacks.



#### *F. Problem Statement Revision*

Last semester, we had decided to solve one of the most prevalent problems in modern society, Global Warming, through our project. Now, we have decided to become more specific on how exactly we mean to solve this problem. To do so, we needed to narrow down our target. There are many ways engineers can help solve the increase in surface temperature, one of the most prevalent being the creation of products that use solar energy. Thus, through this report, we mean to validate our project and make sure we are solving this problem.

#### *G. Deployable Prototype Status*

Our project is now becoming a deployable prototype. This means we will need to slightly shift our focus, making sure that every piece of the project works as intended, and put our minds into that of the user or customer. We will need to think about convenience, ease-of-use, reliability, and overall appeal. For this report, we will be verifying the reliability of our project's parts under different conditions, using various tools and equipment, to ensure that it lasts as long as the customer requires. We will be narrating how we finished the last semester, and where we will go in the current semester. We will be quantifying the results of device tests on performance of our prototype, and explaining where the project stands in terms of our overall design idea.

#### *H. Market Review*

The validation and verification of our project was critical in helping us figure out what we wanted to do to make our project into a product. As we move on to make it a deployable prototype, we need to consider how the product would do in the market. This is the reason we will be conducting research in our product's target audience, its possible performance in the market, any

possible competitors, and any strengths or weaknesses it has, as well as any opportunities or threats to become aware of. This report will convey how we intend to turn this, once-project, into something people can truly use in their everyday lives, and something that actively solves our overall societal problem

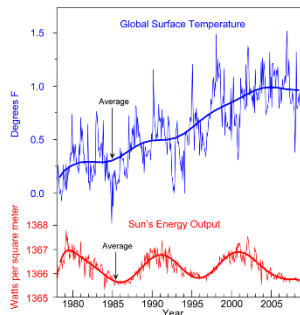
#### *I. Testing Results*

As our project approaches its end, we test the project as a whole and go through every individual component. The results we obtained were satisfactory and matched with the expected values we already had set up in the matrix table. This includes the testing of our solar panel and raspberry pi. Since all results were satisfactory, we then concentrated on being able to present the success of our project working.

## II. Societal Problem

### A. Awareness of Global Warming

The world is currently at a point where its people would be physically unable to do anything without electricity. Unfortunately, much of this electricity which we so desperately need is itself powered by resources that are both limited and environmentally damaging. Studies show that there is now a direct and obvious correlation between power use and global warming. The increase in global temperatures has become more prevalent and increasingly faster due to greenhouse gas emissions from power plants. Greenhouse gases are formed and expelled when coal, oil, natural gas, and nuclear power are burned to create power. When these gases are released into the atmosphere, they trap the sun's radiation within the earth's atmosphere. That radiation is damaging to the atmosphere's ozone layer, which is meant to protect us from the sun's otherwise harmful rays. When the heat from these rays passes through the ozone layer, it too has nowhere to leave. As a result, the earth only continues to get warmer. **Figure 1** shows this relationship, emphasizing that the sun's output is constant, but the earth's global temperature has only continued to rise since the 1980s. As more time passes, finding a solution continues to seem more impossible. This process and its damage will continue if no solid action is taken.



**Figure 1:** Sun's Output vs. Increasing Global Temperature Over the Years

### B. Businesses Against Global Warming

As previously stated, these gases are released when coal or oil are burned. These resources are non-renewable. This means that eventually, if not regulated properly, they would run out. This would be costly for any companies that would require this method of power. As a result, companies and manufacturers have searched for ways for their products to be eco-friendly. Not only would it eventually become the cheaper option, it extends the earth's lifespan. If power companies would decide to pay attention, they would also see that using a renewable resource for power would also increase the lifespan of their business. Automobile companies such as Ford, Toyota, Lexus, and most notably, Tesla, have all been front liners in leaning the world forward towards the everyday use of electric-powered vehicles. These companies' appeal has grown as alternatives to gas have become more popular among younger people. As of late, these companies have released their electric cars with cheaper asking prices. In recent years, the sales of electric cars have gone up, as shown in **Figure 2**. What is also shown in this figure is that if the sales of electric cars were to continue to increase, the use of gasoline would decrease, as would its prices. More people switching to an electric car would allow the use of oil in gasoline to become a more regulated, non-renewable resource. However, this is currently not the case. Due to the effects of COVID-19, gas prices have increased. As people became cautious, quarantine and lockdowns took over the motivation of people. Less people started going out, which means less cars were being driven. Although air quality had slightly improved, the economy of the US took a dip. This forced gas prices to increase recently, in the summer of 2021, only adding to the demand of alternative power.

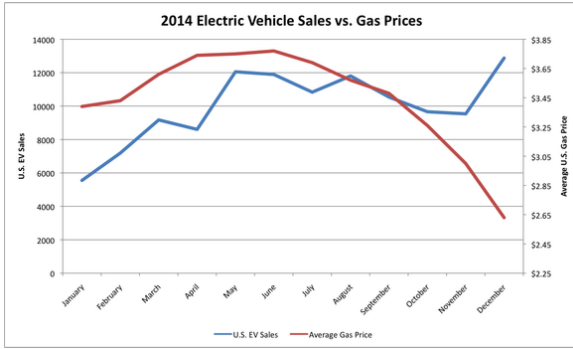


Figure 2: Relationship of EV Sales and Gas Prices

### C. Invention of Solar Power

One recent invention that has been used quite frequently to combat the effects of global warming has been solar panels. The growth in popularity has been steadily increasing as we find new ways to move from fossil fuels as mentioned previously. Within the past 20 years, more installations have been installed in more homes as well as infrastructural buildings. As shown in the chart in **Figure 3**, the surge in installations has dramatically increased.

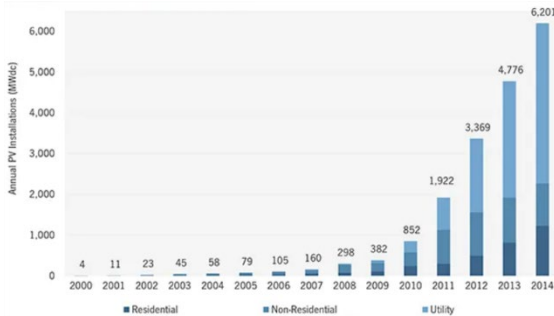


Figure 3: Solar Is Growing Faster Than Non-Renewable Energy in the US

Of course, the early stages of solar PV (photovoltaic) systems were not efficient at all. Mentioned by Amos Han from Lafayette College, they did not have good efficiency and were a bit costly. However, as technology improved, efficiency increased and cost decreased which plays a big factor in why today, we are seeing more solar panels on top of houses, buildings, and/or schools. Beginning in 1955, Hoffman Electronics-Semiconductor Division had their first product at 2% efficiency. Then in 1960, it increased to 14%, and finally in 1992, a 20% efficiency solar cell was

patented. As shown in **Figures 4 and 5**, efficiency is increasing over the years and in conjunction, its cost of buying a solar panel is steeply dropping per watt.

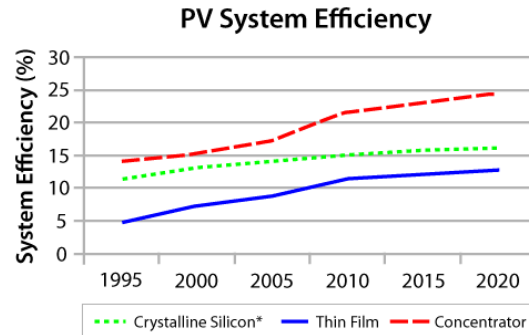


Figure 4: Efficiency Of Solar PV, Then, Now And Future

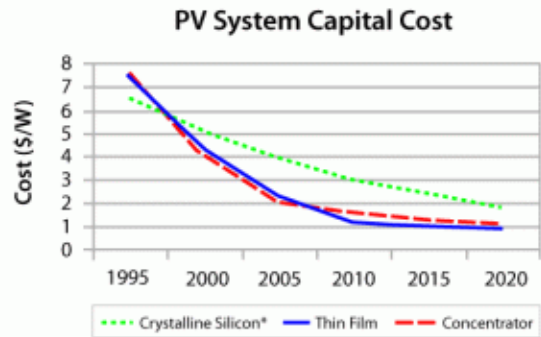


Figure 5: Efficiency Of Solar PV, Then, Now And Future

### D. Pros and Cons of Solar Power

With all this being said, there are pros and cons of using solar power. As mentioned, although the cost is reducing over time per panel, the initial cost can still be a factor a person is willing to pay for. This is especially the case if it is for a homeowner. Another drawback to solar power is that a home, or whatever a person is trying to use solar energy for, would have no power if the area's power grid is shut down. So if one is running solar and is connected back to the grid, they are not in an 'off-grid' setup. If there is a power outage, the individual would once again file a complaint to the electric company. The last downside of using solar panels is that the sun is required at all times for power. On top

of only having 20% efficiency, if one lives in an area that does not get much direct sun, solar may not be the best possible option.

Some advantages in using solar is that it would decrease the consumer's carbon footprint. This ties into humanity's main problem. We have been relying on fossil fuels to transport ourselves to and from places, heat and cool our homes, charge our devices, and even run servers for access to the internet. This evolution has caused more heating to the Earth than what is needed and we are starting to see long term effects such as glaciers melting at a faster rate than before as well as excessive heat waves being more common in places that do not have too many. Another pro about having solar panels is it will reduce the cost of a person paying for electricity from the grid. This works because you are using your own power before using energy from the grid, again assuming you are NOT in an 'off-grid' setup. Depending on how much electricity is used, the consumer can either end up paying less in electricity, having credit from the grid for the next month, or even being paid back for the electricity the consumer generated.

Now how will this tie in with our project? Solar will be the main source of power for our project. It will be running a controller which indicates when a fan should kick on in a house in order to bring cool air in, or to push hot air out, depending on temperatures outside and the inside. This project is essentially an 'off-grid' setup, and a proof-of-concept in order to prevent the dangers of messing with main power.

#### *E. Temperature and Current HVAC Systems*

HVAC (Heating, Ventilation, and Air Conditioning) systems are used all over the world today. According to the US census in 2019, 91% of all US households use air conditioning. It has largely improved the

lifestyle of humanity, so HVAC systems are now seen as a necessity. Without the use of AC systems, there can be a severe consequence especially concerning rising heat temperatures and climate change. However, studies have shown that the use of AC systems has largely contributed to rising temperatures worldwide. Since they are used to combat (extreme) heat environments and prevent health issues associated with such heat (ie heat strokes), we cannot simply opt out and get rid of air conditioning without providing an alternative solution. There is an urgent need for a more sustainable approach than using the traditional HVAC system.

Thus, in an effort to reduce greenhouse gas emission and negative health impact on the environment, we will be providing an alternative solution to HVAC (which will also reduce electrical energy expenditure) through the use of solar energy. This way not only will the environment improve, but also the cost of home living may be reduced as well. We will discuss the alternative solution and how it would improve the environment in further detail under "Temperature Regulation."

Now, there are many benefits to using an electrically powered air conditioner, but at the cost of what? Everyone knows the pros to using AC, but there are also disadvantages to using them. We will be studying what these negatives are. A glaring issue is the high cost of electrical energy that an AC uses. According to Energy and Buildings, "air conditioning accounts for 18% of residential electrical energy use in the U.S. and is the primary component of peak load." At the national level in the US, air conditioning was 12% of total household energy costs, it ranged greatly at the state level.

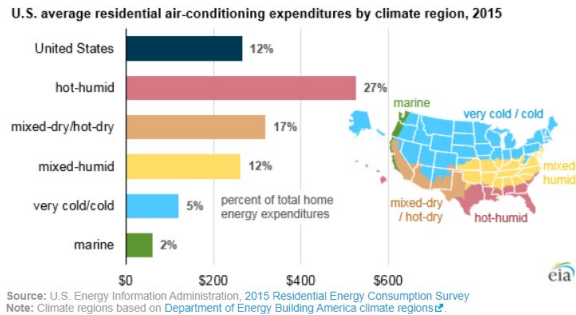


Figure 6: Air conditioning and energy expenditure costs

Nationally, \$29 billion is spent by homeowners on air conditioners alone. Due to this, about “117 million metric tons of carbon dioxide are released into the air each year,” according to Energy Saver. Air conditioners are at their peak when outside temperatures at 95 degrees Fahrenheit or above. Lowering the thermostat below 78 degrees will not change the temperature inside a household, but would still make the AC work harder than necessary. Assuming an AC runs 8 hrs./day, average costs can be around \$211/month, which translates to \$2532/yr. due to AC alone.

With that said, another issue with intensive use of air conditioning is the release of greenhouse gases. We may be cooling our homes but in truth, warming the Earth. Hydrochlorofluorocarbons (HCFC) is a type of refrigerant used for AC units; deemed as a Class 2 ozone depleting substance, it replaced as a better alternative, chlorofluorocarbons (CFC), a class 1 ozone depleting substance back in 1995. Although HCFC is now being phased out as the traditional refrigerant and will continue to phase out until 2030, there are many older AC units that rely on HCFC, which are still being used today. 100% of HCFC consumption is to be reduced under the Clean Air Act by 2030. But nine years is quite some time. Every decade since 1981, there has been about a 0.32F increase on

earth’s surface and ocean temperature.  
RECENT TEMPERATURE TRENDS (1990-2019)

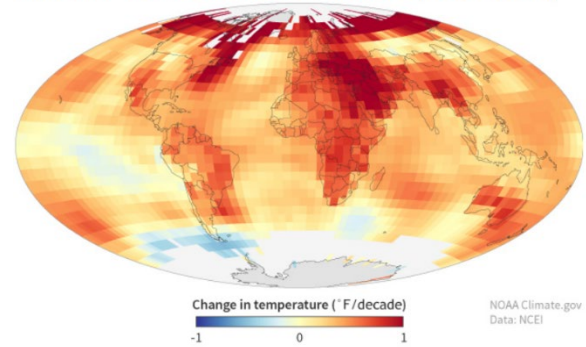


Figure 7: The top 10 warmest years have occurred since 2005 and 70% of those are even more recent since 2014. History of global surface temperature since 1880

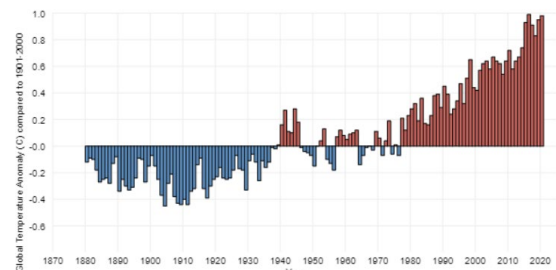


Figure 8: History of global surface temperature since 1880 While a phase out is necessary to reduce HCFC substances, we cannot simply get rid of them immediately because there is a heavy reliance on these substances for AC units to run. Thus, there is a need for alternative solutions now. For our project, we’ll be following along with the trend of reducing HCFC and finding alternative solutions to this societal problem.

#### F. Second Semester: Improved Interpretation of the Societal Problem

This section serves as a revision of our problem statement for our second semester. In the very beginning of the first semester of senior design, we focused more on the effects that current HVAC systems have on the environment. We stated that their use to cool and heat our homes contributes to the release of greenhouse gases, furthermore contributing to global warming. We saw this as a downward slope that would only get worse unless something was changed. This

is how we had initially thought of the concept of our project.

As shown in **Figure 8**, The trend of global warming began to increase since the 1980s due to a spike in industry, in which technology was engineered, not with regard for the environment, but for utmost efficiency. This is also explained in an original article from the New York Times that was released in the late 1980s. It explains that Dr. James Hansen of NASA was one of the first to notice the rising temperature trend using the 30-year period of 1950 to 1980, when industrial power plants were on the rise. This is the type of problem we mean to contribute change to. Now that we are more experienced and more sure of what kind of project we are doing, we are now also more set on what problem we should really be facing.

To become more precise on how to solve this problem, we had to become more specific about what it is we are trying to improve or change. We had touched on the benefits of solar power on the environment towards the end of our problem statement, but to become more specific, we had decided to focus more on the need for alternative energy for our project. There are many ways engineers can strive to solve the issues of global warming. Ours, through this project, is to create a way for people to cool their homes without any inconvenience and without having to use the main power grid, a source of power that, although reliable, does not use clean, renewable, energy.

Since this power grid and the methods of regulating temperature with an HVAC in our homes can be so reliable, it can be a difficult method to change. Our project would need to be more convenient, more reliable, more appealing, and must be able to fill our goals and metrics as a dependable product that has no need for the main power grid.

Last semester, we had gotten closer to reaching these goals. By making the product

able to detect temperature and react on its own, we made it user-convenient, and by adding solar power, a chargeable battery, and microcontrollers, this fan could technically run forever independently, so long as it can receive solar power every so often. This semester, with our new, revised societal problem, we hope to validate our project as a reliable product moving forward.

This change in our view of our societal problem will not cause many drastic changes to our design idea or work breakdown structure. However, it does mean that we will be dedicating more time to making this product more appealing and convenient to a user as the semester progresses, as an ideal toward product popularity. Thus, our Gantt timeline and Pert diagrams will have slight changes to them as our societal problem did. We now understand that for our project to become a product, we must not only think about the problems it solves, but also how a client or user would be positively affected by it.

### III. Design Idea

#### A. *Design Philosophy*

By using a new system with renewable and rechargeable energy, we lower energy use and as an added effect, we lower the release of greenhouse gasses. Air conditioners use approximately 6% of all the electricity produced in the United States. It may not appear to be a lot, but a traditional HVAC system is responsible for consuming the most energy of any unit for home use and tends to be the cause of power grids to be used at their peak, especially under extreme temperature. The average HVAC system consumes around 3500 watts per hour and annually costs about \$29 billion to homeowners and fossil fuels make up 79% of US energy consumption. In 2018, the US ranked 3rd among the top 15% of emitters and accounted for 15% of carbon dioxide emissions. While an AC unit doesn't directly release carbon dioxide, the heat produced by the high energy usage of AC adversely affects climate change. Now, instead of using an AC unit, we will be using a fan-based prototype that again, not only reduces energy consumption and cost, but also eliminates the adverse effect of AC systems on climate change. Consumers would not have to fear losing the thermal comfort of an AC unit, but reap the benefit of using an equally strong cooling method by using automated, solar-powered fans.

#### B. *Brainstorming Ideas*

Our project's initial ideas came from us brainstorming and sharing our own individual societal problems. The team ended up settling for a system that automatically regulates room temperature, depending on indoor and outdoor temperatures. Now depending on the temperature, we can change if a fan will push air in or pull air out of a home. We will also be using a solar panel, charge

controller, and some servo motors integrated as a power source to power this system. This portion of our idea initially came from both Jayven and David choosing to work on solar power in their individual societal problem choices. The overall idea came from Enoch and Naser joining the brainstorm and putting forth their ideas. As stated previously, these ideas would eventually conceive a new type of home heating and cooling system.

Because our focus would be on solving the societal problem of atmospheric pollution and energy consumption, our goals led us to concepts that would use renewable energy. Therefore, one of our main features of this project would be its use of solar energy. There are other possibilities for renewable energy to implement into this project. For instance, if there were some way to reuse the energy put into the spinning of a fan into a sort of wind turbine-like energy, this product would be completely renewable, and self-sufficient. Another possible substitute for solar power would be biomass power. This way, the product would not only act as an HVAC system, but also as a waste-powered disposal, making this product truly off-grid. However, out of all other methods of power, this is one that would always remain a concept, as of currently.

#### C. *Technology for our Concept*

With our project, we'll be using a variety of different technologies in order to make our project work. Our 'brain' of the project will be a Raspberry Pi with the use of an Arduino Uno to handle some smaller logic as well as sending signals to the Raspberry Pi as well as receiving signals from the Raspberry Pi in order to operate some logical code written. I would say most code will be written in C or Python on the Raspberry Pi and we would be compiling with the 'gcc' command in a terminal.

Python code would need to be run in a terminal with python installed via apt-get. We can use any text editor we like on the Pi or on our personal computer before transferring to the Pi. With the Arduino, we would be using C as well and we can use the Arduino IDE that is the included software to edit code and upload it to the microcontroller.

To add to this, we will be integrating the technology from a solar panel in order to power our project. In conjunction, a solar panel charge controller will be used to convert solar into something controllable such as DC or AC depending on how we approach the setup. The next step in this group would be a battery. Because we are not going to expect this to be on all the time with a budget in the project, we are projecting this battery to be small, but have the capacity to run a small fan. Specifically, we are looking into a battery with the capacity of 12v and 35AH life. Of course, if we need less/more, we'll adjust the battery size to fit what we need. Lastly, we'll need to use an inverter to change the battery charge into something we are familiar with, an outlet in our homes. This way, we can plug a standard plug of the fan, micro controller, or anything we may need for the project.

Lastly, we also have the smaller bits of technology we will be adding to the project. This will be the fan for one. The fan acts as a way to transport the air from outside to inside, or vice versa, inside to outside. We are also going to be using two thermometer modules that's compatible with an Arduino to fetch the temperatures between two different environments. With the Arduino also, we are going to use one or two servo motors compatible with the Arduino in order to adjust the angle of the solar panel to be aimed directly at the sun.

#### *D. What is Unique?*

While there have been alternative ways of using HVAC to reduce energy consumption and the release of greenhouse gases, we are relying solely on fans to cool the inside temperature of for example a house. The prototype we plan on making does not simply move air within a room or house, but brings in outside air, if it's cold inside and takes out cold air inside, if it gets too cold. In today's society, it's best to use an AC unit alongside ceiling fans to cool buildings, as that saves energy, but what if we only rely on fans themselves? Regular fans aren't as strong or useful for thermal comfort as AC, but with our proposition, it has the potential to compete with the likes of a traditional AC. But again, this may just be speculation for now since we have not built the prototype yet. If anything, a downside to this project may be just that, it could be that our project idea may not necessarily be as consistent as an AC unit. Fans can only spin up to a certain speed and the faster fans spin, the louder they get, so we also need to keep in mind how loud the fans will be. Fans also don't affect humidity, so we may want to add that depending on what direction we want to head towards. California, for example, is a dry state. Also, current AC systems are circulating harmful refrigerants such as HFCs out completely by 2030. Yet, nine years is a long time and many changes can occur within that period. Every decade, there's about a 0.32F increase in temperature worldwide. Extreme heat waves are expected to happen once per decade, when previously they only struck once every 50 years. This is all due to climate change and it's only getting worse with the increasing demand of human comfort at the cost of the environment.

#### *E. Required Resources*

To talk about the resources needed for the project, one big resource will be the team. Each one of us has had some type of



coding experience as well as some hands-on experience with circuits with personal projects or with labs with our CPE/EEE curriculum experience. Each person working on a separate project and slowly combining everything will make the project go by faster.

Another main part of this project to get it going will be the resource of money. We need to plan our budget, see where we all are in how much we can spend, and allocate and divide the parts list on each person.

Online resources will definitely be all of our main resources in order to look at similar setups in different 'zones' of the project. One zone could be hooking up the solar panel to the controller, to the battery, and to the converter. We might have an abnormal setup because of how our project is or we can have a straightforward setup. Another example of a zone would be the login in making the solar panel move in the path of the sun throughout the day with the photoresistors. Bringing this back to using online resources, we will definitely be needing to look for an open source project or existing libraries to have our servo motors work and move. We'll be using online resources, projecting a lot of git repositories to look for existing projects that we can replicate.

Another main resource we can use is the lab in Riverside in order to get together to work on the project. With this being said, this will greatly depend on which days we are available to get to campus as half of us live in Sacramento while others don't. One lives in Elk Grove and another lives in Stockton. The lab will help us all come to a general area and also have resources on campus like computers and internet in order to research about our parts and how we can make them work. On top of this, another main resource to get in the lab will be our FOB keys. Everyone does in fact have a key but this is a main piece of hardware in order

for us to get in a semi-restricted part of campus.

Lastly, a resource we'll be using throughout the next two semesters is our professors. They will be the resource to guide us in the right direction, provide feedback, as well as provide a different route to take just in case the group has an obstacle to make some part work correctly or as intended. During our lab time, Professor Cottle also mentioned he may have contacts to allow us to borrow a solar panel from the school or a manufacturer which will definitely help if we need it as well as take a chunk of our cost out and can allocate the saved money into new or different hardware for the project.

## *F. Prototype Features*

### *1. Solar Power*

We are still deciding on which solar panel we mean to purchase. In terms of parts, this would be a portable 100w 12v monocrystalline solar panel. The solar panel will be moving once stationary depending on the time of day and where the location is of the sun. We are planning on mounting several servo motors on the base of the panel to adjust the tilt of the panel throughout the day. This was an aspect Jayven had had when brainstorming for the individual problem statement, and would be great to implement this idea into the final project.

### *2. Chargeable Battery*

This solar panel will also roll over to a 12V 35Ah battery. In terms of a charge controller, we are looking into anything that will be compatible with our final decision of a purchase, as controllers are not as expensive as making something off-grid.

### *3. Sun Tracker*

On top of this, the way we will be tracking the sun's movement is through the use of photoresistors attached to the corners

of the solar panel. Periodically, the controller will check the values of the photoresistors and will either stay or adjust depending on the location of the sun.

#### 4. *Temperature Regulation*

Our project uses the temperature inside and outside of a room to determine the consumer's most comfortable temperature. The action of regulation would be done by a fan. This fan would turn on and off automatically by designing an electrical circuit that compares the signals from the temperature sensors, and drives the fan to force the air in or out of the building.

#### 5. *Electricity Rationalization*

This part of the project will require much planning and rationalizing of power. This can be calculated by measuring the current and voltage required to drive the fan and its associated circuit. We would then be able to compare that to the rating information on the AC system. The system should be able to run all day on solar power, and be able to store power to possibly run through the night as well.

#### 6. *Clean Indoor Air*

Of course, the air which would be pushed indoors would need to be clean. Naturally, we would try to implement an air filter. This feature can be observed and tested during the designing and testing process by using a suitable instrument, such as a particle counter or a room pressure monitor. We could also consult the biology department to advise on the best way to test the air indoor before and after running the product.

#### 7. *Other Possible Implementations*

There are a number of extra features that we have brainstormed to implement into this smart fan, other than renewable energy, temperature regulation, and filtered air. As of right now, these are all concepts. For

instance, this product can be developed to produce distilled water in the most hot and wet places by condensing the air entered indoors. We may also add an air purifier in any case where even the filtered air is not 100% clean. This would be especially essential during these times of pandemic. Another possible feature we may add is the ability to connect with Amazon Alexa, or being able to connect with an Android or iOS application, or even a web UI, in order to support customer convenience.

**Table 1: Punch List with Measurable Metrics**

Features	Measurable Metrics
Fan that does the most work cooling the indoor environment	Drives cool air indoors when the difference in temperature between the indoor and the outdoor is 5°C or more. Would work best with a room of about 132 sq. ft. with a standard insulation level within R-13 to R-23
Thermometer/Humidity sensors detect current environmental conditions	Checks temperature and sends an analog signal to the system about any change every ten seconds. The check is done both indoor and outdoor via two temperature/
Comfort adjustment uses the detected conditions and adjusts the temperature level	Temperature and humidity are adjusted according to the user's preference, or by an automatic default set within the code.
Attached Solar Panel with an attached charge controller takes energy from the sun and transfers it to the system as DC power.	Provides renewable energy to the automatic fan throughout the day. This is a portable 100w 12v monocrystalline solar panel, and with the help of a charge controller, will be able to convert the solar energy to usable power.
Chargeable Battery allows for life without being plugged in, and is powered solely by the sun	This 12V 35Ah battery would store solar power, or be plugged for electricity. This way, it would not have to be plugged in at all times. The battery should be able to last 2-3 hours without having any input of power.

**H. Team Member Skills & Responsibilities**

As a group of engineering students, we all have our own strengths and weaknesses in certain fields. We are a group of three computer engineering majors and one electrical engineering major. This project will take a lot of our own expertise. Jayven has the most experience in implementing microchips and their IDEs to create products, so he will be working on the integration between parts. Specifically, he would be able to bring the concept of servo motors tracking the sun to fruition. Just as well, since he and David had a concept of using solar power from the beginning, they will be the ones to integrate the solar panel. As two CpEs, David and Enoch will be working on the code development for the

temperature detection and adjustments, as well as the next following actions. They will also be working to try and implement the other software concepts, such as an app, or Alexa connection. As the one electrical engineer in our group, Naser would handle much of the circuitry and rationalization of power, as well as testing, making sure that every part works as intended. This covers the features in **Table 1**.

**Table 2: Estimated Hours for Implementing Main Functions**

<b>Function</b>	<b>Estimated Hours</b>
Temperature Detection with one Sensor	10
Temperature Detection with Two Sensors	5
Temperature Adjustment	30
Energy Rationalization	20
Cooling Simulation	5
Circuitry	15
Code	20
Code Cleanup	10
Assembly	15
Assembly Cleanup	3
<b>Total</b>	<b>130</b>

**Table 2** shows an estimation of how long we may all be spending in implementing each main function, with an estimated total of 130 hours. We estimated the cooling and heating aspect of the project to take the longest, as we would need to research better and cheaper ways to do so. And of course, coding and energy rationalization as well as circuitry would take more time as these are what we as engineering students will spend the most time perfecting. Finally, in terms of searching for parts and documentation, we will all be contributing as equally as possible. The same would also most likely be said in paying for those parts.

**IV. Funding**  
*Table 3: Project Parts Budget*

<b>Part</b>	<b>Cost</b>	<b>Buyer</b>
Solar Panel	\$150 +	Jayven
Alternative (Cheaper) Low Voltage, Solar Panel	\$12	Naser
Charge Controller	\$40	Jayven
Battery	\$150	Jayven
Inverter	\$30	Jayven
Arduino	\$20	David
Raspberry Pi	\$50	David
DHT11(Temperature and Humidity Module)	\$20	David
Servo Motors	\$10	Jayven
10x10 45W 120V 60 Hz Personal Box Fan	\$30	Naser
Solar Panel Support Wood	\$15	David
Power Strip	\$10	Enoch
Power Cables for Pi & Arduino	\$15	Enoch
Air Filter	\$10	Enoch
<b>Total Estimate</b>	~\$440-\$580	

**Table 3** shows all of the parts we will need to implement all main functions of our project, as well as all of their prices. As of right now, we have no benefactors, and because our classes are currently online, there is hardly any opportunity to find support. Therefore, our main source of funding will most likely be out of our own pockets. As the total is close to about \$560, we will likely be splitting the price equally,

making our individual budgets equal to about \$140.

And to depict how exactly all of this hardware would be implemented with one another, and connect the funding to our design idea, we created a connection schematic, as shown in **Figure A-1 in Appendix A.**

## V. Work Breakdown Structure

A. *Project Tasks List & Description*

Our Work Breakdown Structure Grid, which shows the relationships between all features and tasks of this project, can be found in **Appendix D**. Listed below are the descriptions of every task we will be completing based on the features in our punch list from the design idea report.

1. *Code Temperature Adjustment*

Temperatures between two different environments, in our case, outside and inside temperatures, will be compared with the thermometer module. If there is a difference of X degrees between the two environments, our fan will turn on or turn off if the inside temperature is at the client's preference.

2. *Integrate Microcontrollers*

Microcontrollers within this project have the purpose of controlling the logic between the different modules we are adding to the system. The raspberry pi, if we get the chance to integrate it, will act as a web server for a client to overwrite any existing conditions.

3. *Integrate Modules*

The system only has 2 specific modules that are the main pieces to making the system work: thermometers and relay. We'll have two thermometers to compare an outside and inside temperature. The relay will send a signal to the electric power to turn the fan on or off.

4. *Implement Solar Power*

Solar power will be the whole solar system of the project. Its main purpose is to provide electricity to the project's components in order to avoid using power from the grid.

5. *Implement Battery Charging*

Battery charging will be part of the solar system. The solar panel will be hooked to a charge controller to control the power. From here, the controller will convert the solar power to something usable and store this power inside of our battery. The battery will then be hooked to an inverter to change the battery charge to AC. At this point, we can plug a standard power strip to it and run our microcontrollers and fan.

6. *Build Integration Circuitry*

As mentioned before, the solar portion will be hooked up in the order of: solar panel to charge controller, charge controller to battery, battery to inverter, inverter to power strip.

We will have 6 wires total for thermometers hooked to the Arduino, vcc, gnd, and signal. Signal will supply the temperature to the Arduino and be controlled with the logic. The relay will have 3 wires hooked to the Arduino: vcc, gnd, and signal. Signals from the Arduino will be pushed to the relay and open or close the gate to activate or deactivate the fan.

The fan will be plugged into the power strip and we will be re-soldering the power controller on the fan itself to the relay to bypass the fans power switch.

7. *Rationalize Power*

Most of the power will be when the fan is actually turned on using at max 100w for any chosen fan. The only other devices that will have power are microcontrollers. Arduino will only take up to 2 watts.

8. *Connect all Hardware to Fan*

A good description of this is located in part 6, as well as in our design idea section of the report, and in **Figure 9** of our “funding” report.

Once we have an understanding or at least a small part coded, we will be conducting tests on campus in the lab to better help each other with coding and with each external module.

9. *Web-Based User Interface*

If time permits and we are able to integrate this we plan on creating a flask web app on a raspberry pi to control the logic on the Arduino. Arduino code will need to be edited to fix this integration. Base code can be used from a previous existing CPE 185 lab.

10. *Design Overall Look*

The design is small and close together for the project as a proof of concept. The panel, charge controller, battery, and inverter will all be relatively close together when built. The microcontroller, thermometers, relay, and fan will be a small distance away from the solar system.

If this product was to actually be implemented in a building, the solar system will be hooked on a roof with batteries nearby or connected to HVAC, and the controllers and the fan will be wired a farther distance away.

Or, if this product was to be meant for rooms, it would be installed directly into the opening of a window, which would require a much smaller vessel as well as a cleaner look.

11. *Tests and Trials*

Since most of us already have an Arduino, we can all work on code separately and attempt to get logic to run and compile correctly even if we do not have the smaller components.

*B. Project Tasks for Team Members*

**Table 4** is the list of tasks given to each of our team members, as well as how much time each feature would take to implement, and how much time each team member should spend on this task. We also have a table of our team members’ class assignment tasks in **Appendix E-1**.

**Table 4:** Team Member Task Responsibilities

Task	Task Time Estimated	Team Member - Time Estimated
Coding the Temp Adjustment	16 hrs	David & Enoch - 8 hrs each
Integrate the Microcontroller	5 hrs	Jayven - 5 hrs
Module Integration	3 hrs	Jayven, Enoch, David-3 hrs
Solar Power Implementation	6 hrs	Jayven & David-3hrs each
Battery Charge Implementation	3 hrs	Jayven-3hrs
Integration Circuitry	5 hrs	Naser - 5hrs
Power Rationalization	10 hrs	Naser - 10 hrs
Hardware Connection	5 hrs	Team- 5 hrs
Air Filter	3 hrs	David -3hrs
Web UI	10 hrs	Jayven & Enoch-5hrs
External Design	12 hrs	Team - 12 hrs
Post-Testing	Indef.	Team

**VI. Project Milestones and Timeline**

### A. Project Milestones

Below, in **Table 7**, are our project milestones, along with the month and year they were completed. This table shows that our start was a bit slow, but everything picked up by the time October started, and a lot more was accomplished.

**Table 7: Project Milestones**

Milestone	Date
Formed team	8/2021
Societal Problem	8/2021
Officially Began End-Of-Project Document	9/2021
Introduced the societal problem to Professor Cottle	9/2021
Presented our proposed project idea	9/2021
Design Process Report	10/2021
Created a list for hardware and software	10/2021
Set prices and the budget	10/2021
Established the skills and responsibilities of team individuals	10/2021
Purchased all required parts	10/2021
Work Breakdown Structure	10/2021
Filled the first team member evaluations	10/2021
Had project officially approved by Professor Cottle	10/2021
Discussed the safety and risk precaution with professor Cottle	10/2021
Safety Assessment	10/2021
Began implementation of microcontrollers	10/2021
Created Project Timeline	10/2021
Completed Risk Assessment	11/2021
Completed 1st Progress Evaluation	11/2021

Research Integration and Communication between Microcontrollers	12/2021
Revised Problem Statement and Presented to Lab Group and Pr. Cottle	1/2022
Created Web UI	

### B. Gantt Chart Explanation

To create a project timeline, we used a Gantt chart as a format. Using an excel sheet, we mapped out all of our project features in a column, as well as their predicted start and end dates as a row header. We then used these weeks as time units to predict how long each task would take to complete. This Gantt Chart can be found in **Appendix E-2**. The sequence goes from left to right, according to date, and top to bottom according to the project feature. Through this Gantt Chart, we were able to convey that our dismantling of the fan, and rewiring everything would take longer than everything else, and that this, as well as getting our code for detection and adjustment to work, are our priorities for the semester. This would be what we hope to show in our prototype presentations in November and December.

### C. PERT Diagram Explanation

Our PERT Diagram can also be found in **Appendix E-2**. Here, we would be showing any overlap between tasks and features, and how each feature completed leads to the next one being started. If there are any tasks being performed at the same time, either by design or due to any issues causing delay, they are shown next to each other, branched off from the previous step, and with both pieces leading to the next. This diagram is a way of showing the length of each task, and is based on the Gantt Chart, which in turn is based on **Table E-3** (also in Appendix E), which shows our class assignments and project features, as well as the dates (by weeks) we would be using to complete them.

## VII. Risk Assessment

### A. Task Interdependence & Critical Path



With our project, our main critical path for this project is very linear with some parts overlapping each other. One of the first things we need to do is work on the temperature module. This module has no risks as its low voltage at 5v max and just fetches current temperatures and humidity to the controller. The next part is the relay. For this part, although it is low-voltage just like the temperature module, has a risk of possibly causing some type of electric failure in the fan itself for the module that controls the speed. A short circuit can happen or possible surge to our power strip. Very similar to this, dismantling the fan to access the fans speed controller can be a risk to both fan and us working on it.

#### *B. Potential Project Hazards & Mitigation*

We might deal with sharp parts that can potentially cut us, and dismantling can cause various electrical problems since we are working with main electricity. Another part of this project that has the most risk is our solar panel system. The system has 4 parts: panel, charge controller, battery, and inverter. The most risk will be at the battery and inverter. Both these parts have a potential fire and electrical damage. Overcharging the battery can cause a leakage which can cause a fire since it's a lithium battery. Inverter is the same as the inverter converting the battery to 120v. This can cause an electrocution to us as well as electrical shock to our external controllers/modules. The last main risk we have within our project is connecting to our controllers wirelessly which can give off a very small amount of radiation to humans.

These potential hazards are all physical and dangerous, but there are also risks that can involve error on our part, including the software aspects of the project. The rest of the project is all software-based, being Python on our Raspberry Pi, communication between Pi and Arduino, logic for activating

the fan, as well as creating a final GUI for a web app. In terms of risks in this sense, there is always a chance that the hardware can malfunction, overheat, burn out, or just be incompatible with the software. To mitigate any drawbacks from this, we decided to buy multiple parts and chips and make our code as reliable as possible. As of right now, we have two people who are able to create the same temperature detection system; Jayven and David.

#### *C. COVID Risks & Following Protocol*

Each member of the team is aware about these potential technical issues and dangers within the project, but there are also dangers that may be out of our control and thus, can be impossible to mitigate. This includes the lingering effects of the pandemic. The pandemic, thus far, has kept us from interacting with one another physically, making planning for this project rather challenging. For instance, just until recently, about five weeks before our prototype progress review, we were unsure if we would be able to have such a meeting. Now that things seem okay at the moment, we are currently preparing our project in-person and on-campus. However, in the case that one of us gets sick, that person would absolutely be unable to meet with us until they are tested to be fine. They will just be caught up via video call or on Discord. Throughout all physical and in-person activities, the team will continue to follow federal COVID protocol, which involves practicing social distancing, wearing masks, and constantly washing our hands after we each handle hardware. We have also ensured that each of us has been fully vaccinated and/or officially exempted. Finally, anything that does not have to be done in-person can be completed through communication via Discord.

#### *C. Other Potential Environmental Risks*

Another potential drawback that would have a similar effect of keeping us from meeting is the weather. California’s weather has been recently unpredictable and spontaneous. Rain would definitely keep us from having a parts meeting, and the fires in California could close off roads or routes that we may need to take in order to meet with each other physically. There is not much for us to do to control this, other than to change our meeting plans. But we will have to be ready for those changes, and acknowledge this risk should the need arise.

**Note: the “impact” of these risks regards the probability in the delay to complete parts of the project**

*D. List of Significant Risks (Color coded on risk matrix)*

1. COVID Effects (recovery period): low likelihood, will jeopardize project
2. Minor Electric Shock: Likely, impact can be tolerated
3. Fire Hazards destroy Equipment: Not likely, will jeopardize project
4. Minor Injuries (Cuts, Burns): highly likely, impact can be tolerated
5. Equipment Overheats: highly likely, limited impact

**Table 9: Risk Matrix w/ Impact & Probability**

P						
5	0.9	1.8	2.7	3.6	4.5	
4	0.7	1.4	2.1	2.8	3.5	
3	0.5	1.0	1.5	2.0	2.5	
2	0.3	0.6	0.9	1.2	1.5	
1	0.1	0.2	0.3	0.4	0.5	
0	1	2	3	4	5	I

Level	Impact
1	Minimum or no impact
2	Impact can be tolerated
3	Limited Impact
4	May jeopardize project
5	Will jeopardize project

Level	Likelihood	Probability
1	Not likely	0.1
2	Low likelihood	0.3
3	Likely	0.5
4	Highly likely	0.7
5	Certain	0.9

*E. Risk Assessment Matrix Chart*

**VIII. Deployable Prototype Status**

As of the last semester, our Fall term, our deployable prototype is in a good place. By our first prototype evaluation, we had implemented every feature set in our project and checked out our measurable metrics. In this report, we will be introducing the tests we will perform on each part of our project, and how our project performs on a quantifiable level. We will also be specifying who in our group would be testing each piece. Finally, we will also explain how the prototype functions in terms of following our design idea.

The tests we will be performing will first be on every individual part of our project, such as our solar panel, inverter, microcontrollers, and sensors. The full list of tests for each part, as well as their time periods, testers, expected result and our found results, can be found in **Appendix A and B as Tables A-1 and B-1** of this document.

#### *A. Device Testing and Results*

##### Test 1: Solar panel:

Jayven performed the test by putting the solar panel out on a sunny day and plugged it to a battery through the charge controller. (Test conducted outdoors in 55F, 54 Hum). Expected results: 5A, 20 V (100 W). When Jayven performed the test he obtained 5.8A, 17.2V ( 99.76W). This proves that the Solar panel is working as expected.

##### Test 2: Battery

Jayven tested the Battery charging and discharging. The charging test: by measuring the battery voltage before starting to charge it, then connect the battery with the solar panel through the charge controller and measure the voltage of the battery again after the charging. Expected results: 12V, 35hA. Actual results: 12.6V. So, he concluded: the battery was in good condition.

##### Test 3: Inverter

Jayven performed the test by hooking up the inverter to the battery using 18-gauge alligator clips and measuring the output of the inverter using voltmeter on the AC position. The expected result is 120V, the actual result is also 120V.

##### Test 4: Microcontroller

David performed the test for the Arduino Microcontroller using USB type B and laptop running Arduino IDE, then loading the code and debugging it.

##### Test 5: Relay Modules

We had 4 relay modules which had to be tested individually. David tested these using a simple “blink” code to see whether it was on or off. With the code, David confirmed that the relay modules were in fact, working as expected.

##### Test 6: Temperature and Humidity Sensor

We had a DHT11 and a DHT12 temperature sensor that Jayven and David tested individually by writing simple test code on an Arduino IDE to display the temperature of a bedroom and comparing both results to the indoor temperature sensor in their respective homes. We hoped that both would work, but the DHT11 results were largely inaccurate while the DHT12 results were more comparable with the indoor temperature sensor in their homes. However, later on, the temperature sensors began to loosen in connection via a breadboard. So we decided to solder them straight to the GPIO pins of the Raspberry Pi

##### Test 7: Solar Power Distribution

Jayven tested to see if the 100W solar panel was able to charge the 12V battery itself as the individual components were all working, so we expected the same results. The results were positive and the controller showed that the battery is charged at 13.8V.

##### Test 8: Overall Power Test

Since the battery, panel, and inverters were all working individually, Jayven and David tested if they could work connected together. We used an 18-gauge wire from the charge controller to the battery, and another 18-gauge wire to the inverter. The environmental conditions were outdoors in the 70 degrees F, and 54% Humidity. All three were working perfectly as expected.

#### Test 9: Fan

We tested a couple of fans, and all of us got the chance to test them out. We ended up using a small desk fan. To test it, we plugged it into an outlet to test if the different speeds worked with the provided knob and then disassembled the fan to see if each individual wire worked and how much wattage it consumed. All three modes worked as expected.

#### Test 10: Wire Connections

With the wires exposed from the disassembled fan, David tested to see if the wires would work with the relay connected to an Arduino. All 3 wires worked with their respective fan speeds. However, as previously mentioned, we are soldering everything together, and setting all connections in stone. The wires were soldered by Jayven, and then tested by David.

#### Test 11: Raspberry Pi & Python Script

It took quite a bit of testing by David to get the Raspberry Pi working, as its language requirements and syntax are slightly different from that of an Arduino. However, after enough testing, it now works as the Arduino did, and now the logic can work the second the system is turned on.

#### Test 12: HTML Page

Now with the main hardware system working, we shifted our focus to the software side of our project, creating a user-

interactive HTML web page that allows users to input their temperature preferences and change the temperature accordingly from their phone or desktop. This was tested by Enoch and Jayven. They used their experiences with Computer Science to work and test this part of the project. It took many tries to get this part of the project working. From making a fitting background that looks appealing enough, as well as clear to the user, to the page itself functioning to control the system's input logic, much time was spent implementing this system with consideration for the user. Now, we have an HTML page that is capable of taking a response of temperature preference from the user and sending it to the system to adjust the fan's speed.

With all of these tests completed, the brains and integration of the system is complete. We are now focused on creating a shell for all of our components to fit in one place. At this point our project is about 92% complete. After completing the shell and overall look, and cleaning up the code, our project will reach its completion within the last couple of weeks.

## **IX. Marketability Forecast**

### *A. The Target Consumer*

Our deployable prototype is ideally planned to enter every house and building in society around the globe and cater to every consumer's comfort and at the same time reduce the consumption of electrical energy. However, the typical consumer for our product would most expectedly be adults that wish to save money on their monthly housing and operations bill.

For instance, when a new family is just beginning to grow and settle with a new home, the air conditioning working in the house may be a bit too expensive for their current income. This product would be perfect for them to install in the most frequently-used rooms in their homes. This brings us to our next typical consumer. This is the common home office worker. With at-home learning and working growing in popularity after the events of COVID, the home offices of remote workers could be filled with our product.

Finally, this product would be perfect for low-income families that typically do not have the monthly income to pay for operations and maintenance to cool their homes. If our product were to go international, it would most likely take its place in areas, cities or countries that do not have a strong electrical grid. Such as the Philippines, which would often have power outages at random times, unannounced and with the people often unprepared.

### *B. Market Competition Environment*

According to HomeAdvisor, the estimated cost to replace a traditional HVAC system averages to about \$7,000, from a common range of \$5,000 to \$10,000. This translates into \$25 to \$60 per square foot of coverage, depending on the brand and size. For a new installation, the expected pay can be around \$1,500 to \$12,500 and these statistics are just an understatement because

in 2020, the average square footage of a house according to the US Census Bureau was about 2,301 square feet, and normally that would be around \$3,500 – \$8,000. Today, the average house is getting bigger, and so are the costs in HVAC systems. There are many reasons as to the reason why this is the case. Naturally, inflation is one cause, but also the COVID-19 pandemic which is still ongoing since 2020 has decreased the available raw materials needed and labor shortages in the factories that produce these materials. Next, transportation costs are also increasing due to gas prices and especially with the current war and sanctions in Russia. According to CNN, Joe Brusuelas, chief economist at accounting and consulting firm RSM, that the Russia-Ukraine conflict could push inflation to 10 percent year over year, driven in part by gas. Last but not least, high demand for a product combined with short supply means higher prices for the end consumer and HVAC part manufacturers and technicians. According to the US Bureau, raw materials like lumber, steel, copper, aluminum, etc. All of these materials are needed for a typical HVAC system.

All in all, that is why we have decided to present a newer innovative product and alternative to the HVAC system with an automatic hybrid fan, which is large enough to cool or heat a room in a house and not so large to the point that it would be too expensive for the average household. It cost our team around \$300 to build our prototype, so the expected selling price for our fan could be around \$400. The price for our fan is plenty lower than an HVAC system which typically costs around the thousands. To ensure a low cost for the fan, it will be made out of plastic, there are different forms of plastic, but for now, we'll say natural high-density polyethylene (HDPE). The average price for HDPE is

around 61.63 cents per pound which is not a lot at all. The fans are around 10lbs, so it would be around \$5 of plastic needed to create the plastic fan. According to the government of Michigan, the minimum lifespan of HDPE is 50 years. That is longer than the average lifespan of an HVAC system which is typically 15-25 years. This means we are already saving costs for getting a replacement.

Our target demographic is those who would like to save finances and those who are in poverty, so the price value of the fan is affordable to all. There are alternatives to plastic, as there can be some concerns on the biodegradability of such material, but alternatives to plastic are more expensive than plastic itself, and HDPE materials are recyclable as well.

### *C. Competing Products*

In the current market, there are several products that exist but none have both of our systems together. In our system, we have the solar power portion which includes the solar system, and then we have the fan system which will auto turn on once a certain threshold is met. In the market as mentioned, none do not have both together. There are systems which just have a portable solar panel or just a large solar charger.

To first discuss the products that are just power, there are several reputable brands that are on Home Depot that a consumer can buy. All these are portable and can be used for almost any electronic that uses a 120v plug. Jackery, Natures Generator, Generark, EcoFlow, Expert power, Goal Zero, Kholer, Solar Synthesis are all brands that almost all work in the same way. All these brands have a solar panel that comes with the product that has either a stand or wheels to pull as well as its main unit that looks like a small outdoor cooler which holds the battery(batteries), charge controller, and charge inverter. All these brands differ in the amount of wattage they can deliver out of

wall outlets. Some range from 200 to 2000 watts of electricity. The benefits of these compared to ours is the amount of power that can be stored for future usage of our fans as well as anything else that may want to be powered. The drawback of these systems in which our system is at an advantage is being cost efficient. With what our product does, we will not need as much electricity drawn from the batteries. Our panel, battery, and charge inverted cost no more than \$200 while the other competitive brands cost around \$589 at minimum price.

On the other end, there are also some brands that offer window fans. There are about 30 different brands but some reputable brands from Lowes are Utilitech and Comfort Zone. Amazon carries the most window fans that work the same as well. These brands are almost identical but branded differently. Some names on Amazon are: Genesis, Beyond Breeze, JPower, Bionaire, and Holmes Group. Almost all these fans are very similar to our product. All the window fans have a fan that is controlled with some logical controller that has different speeds. Some offer wireless remotes to turn the system off or on and others have retractable ends that will fit in a window. Our system will have different speeds to be controlled automatically as well as wirelessly through an app rather than a controller. On some window fans that our product does not have and was not implemented was reversing the polarity of the fan in order to have it rotate the opposite way and this would be the only separation of product features since these brands and ours do the exact same thing. One benefit similar to the solar system is ours is much cheaper after materials than the cheapest option on Lowes and Amazon starting at \$50 while ours is \$40.

## D. SWOT Analysis

### 1. Strengths

To begin our product's list of strengths, as previously mentioned, it is the cheaper alternative to other products. The market for our product also happens to be relatively new, and is a growing trend as the world strives to become more eco-friendly, and more aware of global warming. As the overall goal is to find, not just an assistant of current HVAC systems, but a replacement to them, our product is a much cheaper product in terms of operation and maintenance. Current HVAC systems that are more than 10 years old happen to be far more expensive nowadays, with monthly costs of close to \$500. This is an advantage of our product as not even the initial building of it would cost so much.

Another strength of our product is that we plan to cater it most toward our consumer's needs. This is why our fan will have the ability to be remotely controlled from any area in their house. Every other product we had seen was only able to be controlled via buttons on the fan's housing. Users would only need to control our fan via signals from their phone or laptop, interacting with a user-friendly web-user interface. This makes our product different and more convenient to use than other products. This may be a strength to take advantage of and create an opportunity with.

Finally, there is a strength in our team's communication. We communicate rather efficiently via instant messaging and often receive our assignments and tasks within the same day they are given. Our team is composed of tech-savvy engineers

who care about the user's convenience, which means much effort will be driven into this aspect of the product.

### 2. Weaknesses

While there are many strengths in cost for our product compared to others and current HVACs, there can be weaknesses found in efficiency. For instance, the power of our system is far lower than that of a typical house's HVAC vents. The fan we created would only have the power to cool a room while the temperature reaches the required metrics to switch on. Also, our solar fan can have issues receiving the required power when the sun is not out for a long period of time. We have attempted to compensate for this with the battery and charge controller, so that the fan could run for about 8 more hours without receiving solar energy. However, considering that about 8 hours a day including night time, there is hardly any leeway for when the fan is able to run during a dark, cloudy day, unlike other fans that are connected to the grid, and can remain so for 24 hours a day.

To overcome these weaknesses, our team will need a new motivation to work diligently on the best features of our product, so that it is enough to convince buyers that ours can compete with today's growing alternative HVAC market.

### 3. Opportunities

As previously mentioned, most other products are less cost-efficient than ours. As we have rationalized our fan's energy input and output, we have found that ours has more

run time with the battery at full capacity, and no sun, at about 8 hours, while others only last around 6 without having to charge again. This can be quite an opportunity for our product, as ours seems to be the only one to run throughout a whole night without charging. Our fan is also the only one to be remotely controlled via Wi-Fi, adding even more convenience for the average consumer. An at-home office worker, for instance. This could be an opportunity to appeal to the at-home working audience. While a consumer is working and does not have time to deal with the operation of a fan, they can simply do so from the laptop they are working on, or their phone.

4. *Threats*

There are many things we can learn from our competitors, including their layout and features. Other innovators of products like ours are what we used to base our own, while we added new features. However, these same innovations can pose multiple threats to our products. As previously mentioned, ours has advantages against other products. But the biggest competitor we have, and to which we have the most weaknesses against, is the HVAC systems already installed in people’s homes. These come as a standard and have a monthly cost for operation and maintenance. Now, while we have the advantage in cost, our product wanes in efficiency in comparison.

The 24-hour, all-around service of current HVAC systems connected to the grid is the main threat to our product’s use. Why use a cheaper fan

that cools one room when you can pay extra to cool an entire home? However, our strengths do have the capability to overcome this threat. Our lower cost would be able to bring in consumers who have even older HVAC systems, which now cost even more per month for operation than 10-year-old HVACs; upwards of \$800. This is a threat that can be overcome as long as we keep our product appealing and fresh to the average consumer.

**Table 10: SWOT Analysis Chart**

		Positive	Negative
INTERNAL	<b>Strengths</b>		<b>Weaknesses</b>
	1	User-Friendly	1 Lower Energy Output
	2	Cheaper Cost	2 Lower Energy Conservation than HVACs
	3	Efficient Team Comm.	3 Inefficient Team Scheduling
	4	Tech-Savvy Teammates	
	5	Remote Features	
EXTERNAL	Opportunities		Threats
	1	Need for user-convenience on the market	1 Current on-grid HVAC systems’ efficiency
	2	Competition against older HVACs	2 Current HVAC energy output
	3	Growing market trend for eco-friendly HVAC alternatives	3 Consumers are so used to their current systems, they may be discouraged to change it



## X. Conclusion

### A. Societal Problem

Global warming is a result of the accumulation of greenhouse gases in the atmosphere caused by human activities. Fossil fuel combustion is the main source of these emissions. This increases the melting speed of snow and ice, which causes a rise in sea level. This causes floods and the sinking of cities near oceans, and strengthens the effects of hurricanes. One can contribute in solving this problem by rationalizing their consumption of electricity through reducing the use of air conditioners and heat in the buildings. Every person deserves a healthy, fresh and enjoyable home environment. But this should also be done while reducing the effects of global warming. These days, temperature is hardly predictable. This led us to the design of an automatic temperature-regulating fan. In the typical home, air conditioning uses more electricity than anything else 16% of total electricity used. In warmer regions AC can be 60-70% of your summer electric bill, according to Austin Energy. Not only would we contribute in solving the most challenging problem the world has been facing, you would save much on your electric bill. You would, therefore, be rewarded by paying less in your electricity bill and still have an enjoyable environment inside your home or building.

### B. Design Idea

After completing this report and setting into stone our design idea, we were better able to grasp both the possibilities of our project, as well as the difficulties that may come with it. We now know why we are doing this project as well as how we will implement all of our ideas. Now, the only thing we need to think about is our methods of paying for all of our hardware, software, and parts. As of right now, because everything seems to remain online due to the

pandemic, we may need to pay out of our own pockets for funding. However, we as engineering students, know the risks we would be facing with this project, and still aspire to see our project through until our graduation, and would push through every obstacle to do so.

### C. Work Breakdown Structure

Our Work Breakdown Structure allowed us to know exactly what task we should be completing. These tasks, based on the features they are meant to implement, as well as their subtasks and work packages, can all be found in **Appendix C**. Overall, we were also able to find out exactly how much we have done so far, and how much we have left to do. We were also able to gain some perspective on how little time we have to complete every aspect of this project, so with this report, we set in stone what we would be able to do within this semester. Finally, we were able to better plan and prepare for everything in our final semester of senior design.

### D. Project Timeline

Now that we have completed our Project Timeline, we are able to see just how much still needs to be done. Using the Gantt Charts and PERT Diagrams in the Appendix, we can make sure we meet all of our deadlines and take our senior design project all the way to the end of these next few months. We also know what we have accomplished so far with our list of Project Milestones. With this report, not only would we be able to keep ourselves on track, but we would also be able to demonstrate how we went about preparing ourselves for our final presentation.

### E. Risk Assessment

With our project planning nearly complete, we prepare ourselves for our first prototype review. After creating our risk

assessment, and after we find out what our progress is, we will be able to know how much time we have to complete our project, and learn about any potential risks and drawbacks. Finally, we are able to work on every feature of our project, and should any problems come our way, we will be ready for it.

#### *F. Problem Statement Revision*

With our design, the team had decided at the end of last semester and into break, we would change the way our final prototype would look like. We originally had the plan to make our project work with a bigger fan but decided to keep it using the smaller one and mimic similar window fans that can be bought today having it attached to a window with adjustable ends to fit the gaps. Our project still is scalable and can be used to cool a room but we decided to keep it small for cost as well as portability for the final project.

This second semester we have decided to make the project “smart” by allowing a user to remotely control the fan and override the current default logic we have embedded in the microcontroller. The way we plan on doing this is running a web server on a raspberry pi which will be hooked up to Wi-Fi with a spare router we have for the group. The user or consumer will be (assumed) connected to their home Wi-Fi (the router) and will connect to it via a local IP. From there a nice web GUI will pop up indicating to the user what temperatures they want it to be set to and then it will adjust the logic. We have not yet decided on the full list of controls we will give the user as ideas will keep popping up as well as bottlenecks on what we know how to code might be an obstacle.

Over break, most of the group did catch COVID-19 and was set back a couple weeks and couldn’t meet in person. Thankfully, most of the project now is coding and we

each have separate tasks to do such as making communication work between Pi and Arduino, communication between Web GUI to Pi code, and finally a Web GUI. This is the majority of the rest of the project since we are implementing the “smart” feature.

#### *G. Deployable Prototype Status*

Last semester, we were in a good place in terms of reaching all features of our feature set, all but our extra functions such as Wi-Fi connection and the addition of an appealing outer shell. However, in terms of main function and automation, we had completed our feature set.

Now, as we continue working to make our laboratory prototype a deployable prototype, we know the functions that must be tested include the overall voltage of our system as well as current flow throughout each individual part to ensure our system would never overpower or underpower itself. We also found that our solar panel would have to be tested for performance whenever it absorbs power from the sun, or artificial light.

Finally, we found that our weakest link would be our temperature sensor, in that if this does not work, a replacement would have to be made. We will have to be especially careful in our usage of microcontrollers, so that we do not burn them out. These, and the rest of our parts, will be tested by the time of our prototype verification within the next month.

#### *H. Market Review*

According to our research, our project has the potential to take the current alternative HVAC market by storm. With a cheaper cost, and a longer battery life, we may have every advantage over the current market. Now, we need to efficiently and cleanly put together our ideas to create a product that is worthy of such potential. Our main threat is the current HVAC system

itself. It can be difficult to convince an entire group of people who are used to their current system to change it. However, we can make this an opportunity by convincing our target demographic, which is most likely families that are hard on money, that there is a cheaper alternative for them. At that point, our only competition is with other products that mean to overtake the current system. With this, more people would be interested in our product and our societal problem can be solved.

### *I. Testing Results*

Now that our project has essentially reached its 90%+ mark after successfully completing our individual component tests, we are now working to make our product as user-friendly and as clean as possible. This requires putting all components into one cohesive system, and using the casing to encapsulate it all in a clean manner. After this is complete, our senior design project is essentially finished. All there would be left to do at this point is present it, and submit our project's official report documentation.

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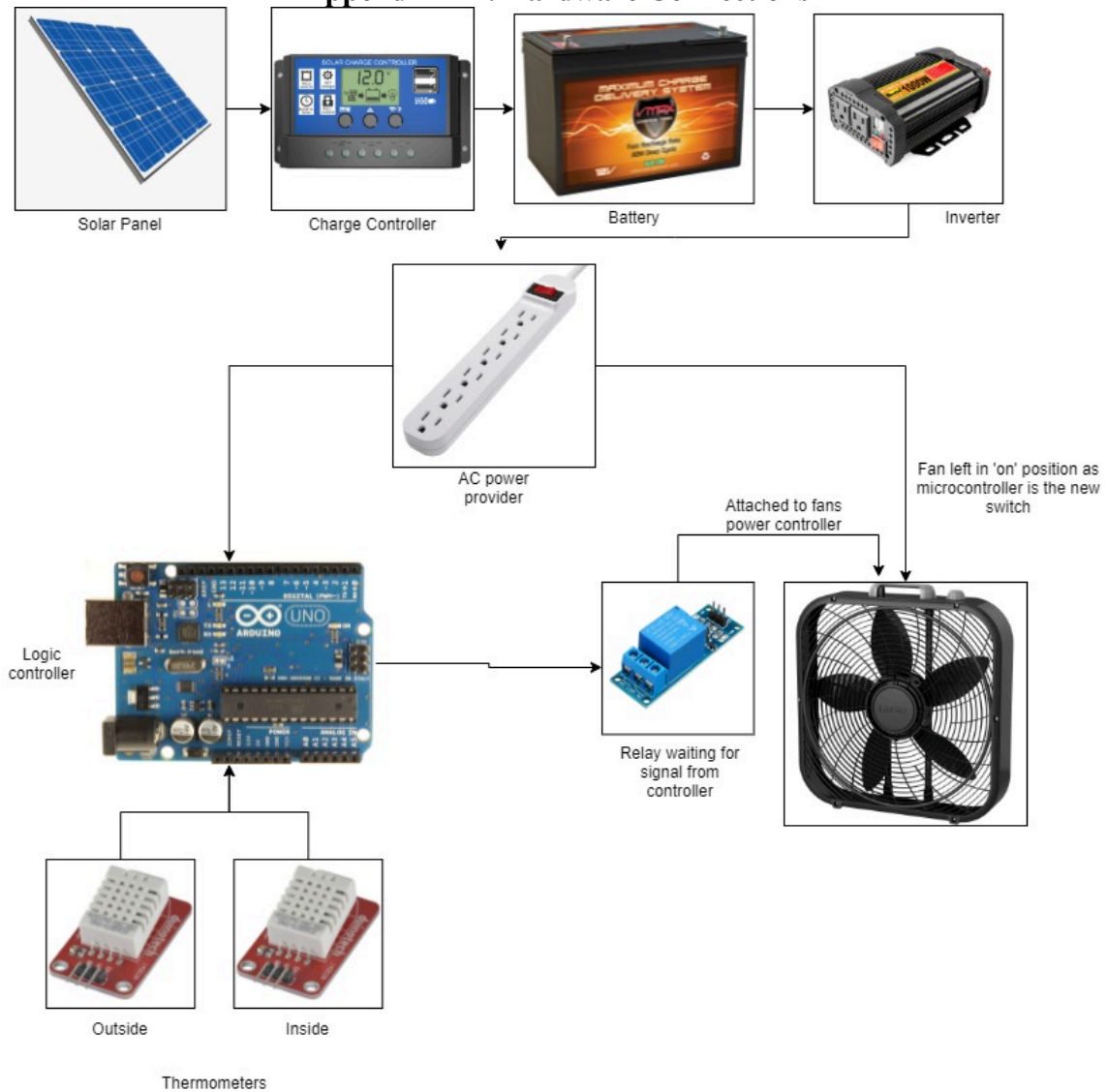
## Glossary

- **Global Warming** - A gradual increase in the overall temperature of the earth's atmosphere generally attributed to the greenhouse effect caused by increased levels of carbon dioxide, chlorofluorocarbons, and other pollutants.
- **Microcontrollers** - A control device which incorporates a microprocessor.
- **Solar Power** - Power obtained by converting the energy of the sun's rays and radiation
- **Temperature** - The degree or intensity of heat present in a substance or object, especially as expressed according to a comparative scale and shown by a thermometer or perceived by touch.
- **Humidity** - The state or quality of being marked by a relatively high level of water vapor
- **Module** - A piece of a set of standardized parts or independent units that can be used to construct a more complex structure
- **HVAC** - Heating, Ventilation, and Air Conditioning. It is a system that controls the humidity, ventilation, and temperature in a building or vehicle, typically to maintain a comfortable atmosphere in certain conditions.
- **Thermometer** - An instrument for measuring and indicating temperature
- **Raspberry Pi** - A low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python.
- **Design Philosophy** - The study of definitions of design, and the assumptions, foundations, and implications of design.
- **Arduino** - An open-source platform used for building electronics projects
- **Open-Source** - Characterization referring to being made freely available and may be redistributed and modified
- **IDE** - Integrated Drive Electronics is a standard electronic interface that connects to a computer motherboard and the computer's disk storage devices to perform functions from that interface
- **Interface** - A point where two systems meet and interact
- **User Interface** - A generated interaction between user and machine, typically via Wi-Fi or Bluetooth connection between devices
- **Energy Rationalization** - The planning and implementation of cost effectiveness and energy efficiency.
- **Funding** - The source of money which we would be able to use to buy our parts
- **Benefactor** - A personal source or sponsorship of resources
- **Work Breakdown Structure** - A chart where tasks of a project are shown to portray their relationships to each other and to the project as a whole
- **Milestone** - An event that marks a significant stage in development
- **Gantt Chart** - A chart that shows a series of horizontal lines, demonstrating the amount of work done or production completed in certain units of time in relation to the amount planned for those units
- **PERT Chart** - A visual representation of a series of events that must occur within the scope of a project's lifetime

- **Overlap** - This is when two tasks are being performed simultaneously
- **Risk** - A certain situation that has a possibility of causing danger, loss (such as of time), or prevention of actions
- **Mitigation** - A response that can be used to shield the blow or effect of a potential risk
- **Deployable Prototype** - The transition stage from our project's laboratory prototype, verified, quantified, and validated with the societal problem, our feature set, and actual use in mind.
- **Feature Set** - The list of functions the project is meant to perform
- **Measurable Metrics** - Quantifiable data that validates the function of a part or product
- **Market** - An area in which commercial dealings are conducted, containing factors of buyer, seller, producer, and consumer
- **Consumer** - A person who purchases goods and services for personal use
- **Competitor** - An organization engaged in commercial or economic competition with others in a market
- **Competitive Market** - A market in which there are numerous producers that compete with one another in hopes to provide goods and services we, as consumers, want and need
- **Market Forecast** - A core component of market analysis that projects the future numbers, characteristics, and trends in the target market.
- **SWOT Analysis** - A compilation of a product's Strengths, Weaknesses, Opportunities, and Threats. It is a process commonly used as part of strategic market planning introduced by Albert Humphrey at Stanford Research Institute (SRI) in the 1960's. Its primary objective is to help organizations develop a full awareness of all factors involved in making a business decision
- **Inverter** - An apparatus which converts direct current (DC) into alternating current (AC)
- **Charge Controller** - Also known as a charge regulator, or battery regulator, is essentially a rate limiter where current is added to, or taken from, batteries so as to prevent overloading.
- **Solar Panel** - A panel designed to absorb the sun's rays as a source of energy for generating electricity.
- **Python** - Python is an interpreted, object-oriented, and dynamic high-level programming language.

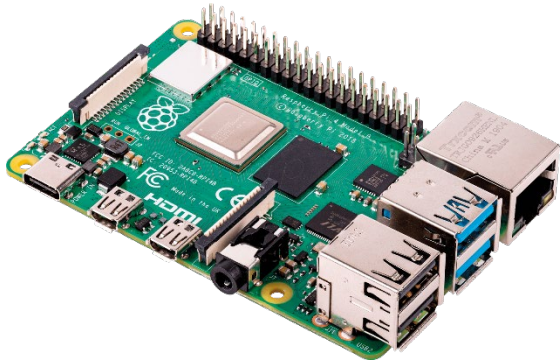


## Appendix A-1. Hardware Connections



**Figure A-1: Hardware Block Diagram**  
 Illustration created by Jayven Khoonsirivong, images referenced

## Appendix A-2: Hardware Logic Components



*Figure A-2: Raspberry Pi 4 Model B*



*Figure A-3: Arduino Elegoo Uno R3*

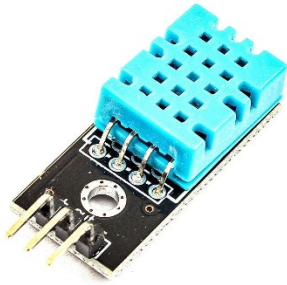


Photo by ElectroPeak

*Figure A-4: DHT11 Temperature Sensor*



*Figure A-5: 4-Switch Relay Module*



*Figure A-6: Breadboard Wires*

### A-3. Hardware Power Components



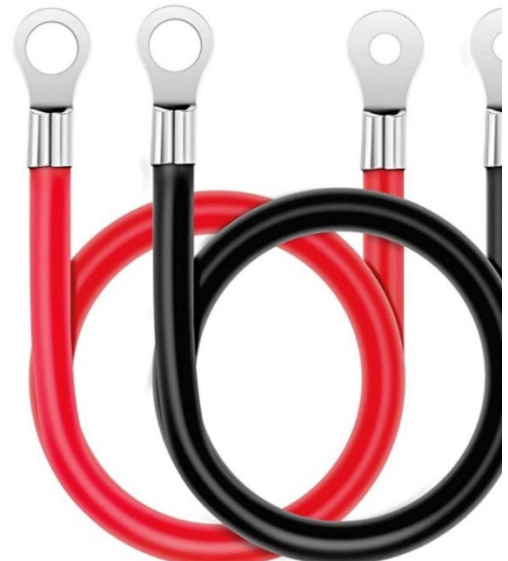
*Figure A-7: MLADY 12.8V Battery*



*Figure A-8: TWSOUL Solar Panel Kit*



*Figure A-9: 500W BESTEK Power Inverter*



*Figure A-10: Nilight 6 AWG 20-Inch Inverter Cables*

## A-3 Hardware Schematics According to Referenced Datasheets

### Solar Panel

- Monocrystalline Silicon
- 12v DC output
- Working current:5A
- Working Voltage: 20V
- Maximum power is 100W
- Conversion rate: 19.6-20%
- Working temp: -40C to 85C -40 to 185F
- Placement is True South for optimal sunlight
- Method to find:
  - Wait until noon and then look at your shadows. The edges of the shadows of things that are perpendicular to the earth/standing straight up line up with true south/north.
  - Ideal angle for a solar panel installation is close or equal to the latitude of your home (on a south-facing roof), somewhere between 30 degrees and 50 degrees.

What's special about this solar panel? There are tiny pyramid-like grooves built into the covering of the solar cells. The purpose of this is to deflect the sunlight from all angles and to equally disperse it through the cells. This is opposed to having no such cover, which would cause the cells to reflect about 5% of the light it means to use for power, making this particular solar panel 5% more efficient than other options.

### Charge Controller

- PWM (pulse width Modulation), NOT MPPT (Max power point tracking)
- PWM is usually applied to smaller systems, 12v/24v systems while MPPT does up to 36/48v
- PWM steps: bulk charge (*high current + voltage*), absorb charge (*wait for drop, then steady voltage*), float charge (*trickle charging at low rate*)
- MPPT steps: bulk charge, balance charge (*As the battery is charged to the boost voltage setpoint, the solar controller continuously adjusts the charging current to keep the battery charging process*), absorb charge (*as battery volt increase, charge current decreases*), float charge
- Max Solar Input = < 50 V
- Equalization
  - B01 Sealed = 14.4 V
  - B02 Gel = 14.2 V
  - Bo3 Flood = 14.5 V
- Float = 13.7 V
- Discharge Stop = 10.7 V
- Discharge Reconnect = 12.6
- USB Output = 5V/3A
- Self-Consumes < 10mA
- Operating Temperature = -35 ~+ 60 C
- Size/Weight 150\*78\*35mm/150g

## Arduino Elegoo Uno R3

- The ELEGOO UNO is a microcontroller board based on the ATmega328.
- Operating Voltage = 5 V, Recommended Input Voltage = 7-12 V, Limit Voltage = 6-20 V
- DC Current per I/O pin = 40mA, DC Current for 3.3V pin = 50 mA
- Flash Memory = 32KB, SRAM 2KB, EEPROM 1KB
- Clock Speed 16MHz
- USB connection to the computer to both power the board and transfer code
  - Operating Voltage is 5, which can be supplied just fine by USB connection
  - However, Input voltage of 7-12 V is recommended for larger project requirements
  - Requires 200 mA
- Or power it with an AC-to-DC adapter or battery through the power jack
- 14 digital input/output pins (6 of which can be used as Pulse Width Modulation outputs) which means it can control analog devices, like our temperature sensors, and give a digital output.
  - 6 analog inputs

## Raspberry Pi 4 Model B

- Quad core 64-bit ARM-Cortex A72 running at 1.5GHz
- 1, 2 and 4 Gigabyte LPDDR4 RAM options
- H.265 (HEVC) hardware decode (up to 4Kp60)
- H.264 hardware decoded (up to 1080p60)
- VideoCore VI 3D Graphics
- Supports dual HDMI display output up to 4Kp60
- 802.11 b/g/n/ac Wireless LAN
- Bluetooth 5.0 with BLE
- 1x SD Card
- 2x micro-HDMI ports supporting dual displays up to 4Kp60 resolution
- 2x USB2 ports
- 2x USB3 ports
- 1x Gigabit Ethernet port (supports PoE with add-on PoE HAT)
- 1x Raspberry Pi camera port (2-lane MIPI CSI)
- 1x Raspberry Pi display port (2-lane MIPI DSI)
- 28x user GPIO supporting various interface options:
  - Up to 6x UART
  - Upto6xI2C
  - Upto5xSPI
  - 1x SDIO interface
  - 1x DPI (Parallel RGB Display)
  - 1x PCM
  - Up to 2x PWM channels
  - Up to 3x GPCLK outputs
- ARMv8 Instruction Set
- Mature Linux software stack
- Actively developed and maintained

- Recent Linux kernel support
- Many drivers up streamed
- Stable and well supported userland
- Availability of GPU functions using standard AI

## DHT11 Digital Temperature and Humidity Sensor

- Uses a capacitive humidity sensor and a thermistor to measure the surrounding air and outputs an analog signal on the data pin as a value
  - Thermistor: an electrical resistor whose resistance is greatly reduced by heating, used for measurement and control.
- Sensor consists of a resistive element and a sense of wet NTC temperature measurement devices
- Humidity Measure Range 20%-95%, humidity measurement error: +-5%; Temperature Measure Range 10%-40% C, temperature measurement error: +-2 degrees
- Voltage range (DC): (2.7V-5.5V)
- Calculates relative humidity by measuring electrical resistance between 2 electrodes
  - RH: Relative humidity (RH) indicates the amount of water vapor (percent) that's actually in the air compared to the maximum amount that the air could hold under the same conditions
- Uses a substrate with surface moisture and electrons to measure humidity level
- When water vapor is absorbed from the substrate, ions are released and this increases conductivity between the electrodes
  - Electrode: conductor through which electricity enters or leaves an object, substance, or region.
- Uses standard I2C Bus digital interface
  - Inter-Integrated Circuit (I2C) Protocol is a protocol intended to allow multiple "peripheral" digital integrated circuits ("chips") to communicate

## Rechargeable Battery

Lighter than lead acid batteries, less maintenance so you don't need to refill the battery with distilled water.

- Brand: MLADY
- Model: LFP20AH
- Weight: 3.97 Pounds
- Dimensions: 5.94 x 3.9 x 3.7 inches
- Battery Type: Lithium Ion Battery
- Amperage: 20 A
- Voltage: 12.8 V
- Wattage: 256 Watts Temp range from 20C to 60C ~ 70 to 140F
- Charging temps is recommended to be at least 10C +- 45C with a max humidity of 90%
- Discharge temps is recommended to be at least -10C +-45C with a max humidity of 90%
- Storing temps that are safe for this battery depends on the length it will be stored/used
  - 3 months
    - -20C +-45C
    - Humidity 60% +- 20%

- 6 months
  - 23C +5C
  - Humidity 60% +- 20%
- Long term
  - 23C +5C
  - Humidity 60% +- 20%

About 6hrs direct sunlight to charge. 20% energy loss between panel to battery

### **Power Inverter**

- DC Input = 11-15 V
- AC Output = 115 V 60 Hz
- USB Output = 5V, 4.8A | 5V, 0-2.4Ax2
- Output-Short Circuit Protection
- Input Overvoltage Protection
- Output Overload Protection
- Overcurrent Protection
- Over-temperature Protection
- Input Under-Voltage Protection
- USB Output Over-Voltage Protection
- Input-Anti-Reverse-Connection Function
- High Voltage Protection = 15-16V
- Low Voltage Protection = 10-11V
- Insulation Strength = 1.5KV/5mA/1min
- Efficiency Rate  $\geq$  83%
- Working Environment: Temperature -5~40 C, Humidity: 10~90% RH
- Storage Humidity: Temperature -20~80 C, Humidity: 5~95% RH
- Cord Length = 0.8m
- Size = 185\*110\*62 mm
- Weight = 686g

### **Temperature Sensor**

- Uses a capacitive humidity sensor and a thermistor to measure the surrounding air and outputs an analog signal on the data pin as a value
  - Thermistor: an electrical resistor whose resistance is greatly reduced by heating, used for measurement and control.
- Sensor consists of a resistive element and a sense of wet NTC temperature measurement devices
- Humidity Measure Range 20%-95%, humidity measurement error: +-5%; Temperature Measure Range 10%-40% C, temperature measurement error: +-2 degrees
- Voltage range (DC): (2.7V-5.5V)
- Calculates relative humidity by measuring electrical resistance between 2 electrodes
  - RH: Relative humidity (RH) indicates the amount of water vapor (percent) that's actually in the air compared to the maximum amount that the air could hold under the same conditions

- Uses a substrate with surface moisture and electrons to measure humidity level
- When water vapor is absorbed from the substrate, ions are released and this increases conductivity between the electrodes
  - Electrode: conductor through which electricity enters or leaves an object, substance, or region.
- Uses standard I2C Bus digital interface
  - Inter-Integrated Circuit (I2C) Protocol is a protocol intended to allow multiple "peripheral" digital integrated circuits ("chips") to communicate with one or more "controller" chips
    - With I2C, data is transferred in *messages*
  - Drawbacks
    - Prolonged exposure to sunlight or strong ultraviolet radiation can decrease performance.
    - A. Salt spray B. Acidic or oxidizing gases, such as sulphur dioxide, hydrochloric acid C. Volatile organic solvents recommend gas storage environment Temperature: 10~40°C Humidity: 60%RH
- Features:
  - Compact Size
  - Low Power Consumption
  - Low Voltage Operation
  - Standard I2C and 1-wire interface.
- Sensing range:
  - Temperature: -20 ~ +60 C
  - Humidity: 20-95 RH
- Humidity:
  - Resolution: 0.1%RH
  - Repeat: +- 1%RH
  - Precision 25C @ +-5RH
- Temperature:
  - Resolution: 0.1C
  - Repeat: +-0.2C
  - Precision: 25C @ +-0.5C
  - Power: DC 2.7-5.5V
  - Normal current 1mA
  - Standby current 60uA
  - Sample cycle: > 2 seconds
- Pin interface: 1. VDD 2. SDA 3. GND 4. SCL (connect to GND when use as 1-wire)

## Relay

- Model: ELEGOO 4 Channel DC 5V Relay Module with Optocoupler
- A switch, typically incorporating an electromagnet, which is activated by a signal **current** in one circuit to open or close another circuit.
- This **current** is converted to a **digital signal**
- The cases in which these **signals** are outputted are specified by the Arduino and code.
- This open and closes its circuits electronically
- As shown in the relay diagrams, when the contact is normally open (NO) there is an open contact when the relay is not energized.



- Relays function as AC power switches and keep the control signals electrically isolated.
- This particular relay we're using is a multi-relay capable of switching between four states
- Its function in our project, overall, is to automatically switch between the three different fan speeds.

### **Box Fan**

- 10x10 in.
- Three speeds: Low, Medium, High
- 7 Amps, 0.7 Hertz, 45 Watts
- Air-Flow of a typical moderately-priced box fan is 2000 to 5000 CFM.
  - Air-flow and strength measured with CFM - Cubic Feet Per Minute
  - Low-Priced fan would perform with around 1500-2000 CFM
- Enough to cover a standard bedroom of about 132 sq. ft. with a standard cellulose or fiberglass insulation level within R-13 to R-23
  - R-Values: The capacity of an insulating material to resist heat flow. The higher the R-value, the greater the insulating power.
  - Recommended R-Values for standard rooms with 2x4 Walls in California, according to Energy Star, is around R-13 to R-19

### Appendix A-4. Hardware Testing

**Table A-1: Hardware Device Test Timeline Chart and Results**

Test ID	Start/End Date	Tester	Test Description	Expected Results	Actual Results	Pass/Fail Results
1	1/3/22-2/5/22	Jayven	<p><b>Solar Panel</b> Making sure solar panel is working by having it out on a sunny day plugged to a battery and solar controller. Test conducted outdoors in 55F 54Hum.</p> <p>SN: NA Model:HYG-120D</p>	Expected lower but close to 5A, 20V on a sunny day charging a 12v battery	Panel reads 17.2V which is roughly 5.8A to equal manufactured 100w panel.	Pass
2	1/3/22-2/5/22	Jayven	<p><b>Battery</b> Make sure the battery is working. We tested this by getting a multimeter and checking the voltage it was giving off.</p> <p>SN: NA Model:LDP20AH 74F 55Hum</p>	12v battery was expected to be a little more than 12v. Estimating maybe 12.5 or 13v	Battery had a charge of 12.6V so we knew the battery was live. The next test would be to plug it in an inverter.	Pass
3	1/3/22-2/5/22	Jayven	<p><b>Inverter</b> Make sure the inverter is working. We tested this by hooking up our battery to the inverter with 18gauge alligator clips. We plugged a nightlight to the output to see if it powered on, then added a small, low voltage portable fan. Test conducted outdoors in 70F 54Hum.</p> <p>SN:NA Model: Inverter-MRI5011BU Battery-LDP20AH 74F 55Hum</p>	Expected the nightlight to turn on as well as our fan plugged separately.	Light and power from the nightlight and fan was working correctly and power was being received.	Pass
4	10/3/21-12/11/22	David	<p><b>Microcontroller</b> Ensure the Arduino Microcontroller is working. Used USB type B and laptop running Arduino IDE. We used the default 'blink led' sketch to</p>	Expected built in LED to blink in a 5 second duration indefinitely	Our microcontroller was working and started programming other codes to	Pass

Test ID	Start/End Date	Tester	Test Description	Expected Results	Actual Results	Pass/Fail Results
			determine if the Arduino was able to read code uploaded to it  Model Arduino Elegoo Uno R3		fully ensure the gpio pins were working.	
5	10/3/21-12/11/22	David	<b>Relay Module</b> Make sure our relay module was working and all 4 activated and deactivated when necessary. We set up simple test code to just activate each similar to our blink but used GPIO pin 5 to test each at a time. Used USB type B and laptop running Arduino IDE.	Expected relay to just work and open and close periodically like our blink sketch.	Relay was working and opening and closing as intended when our code had it writing a digital high and low to the relays pin in.	Pass
6	10/3/21-12/11/22	David	<b>Temperature modules</b> Make sure our Arduino temperature module was working as intended. We had two different modules. One member has an already working DHT12 and another member bought a DHT11. Test code was set up for both and ran independently then together. Used USB type B and laptop running Arduino IDE.  Model: DHT11/DHT12	Expected both to work as code for both to operate was in theory supposed to work as the only thing that needs changing is the library that needs to be initialized.	Our existing DHT12 was working as intended but we had multiple fail rates with DHT11s. Whether it be our code or bad bunch of sensors we had, we resorted in just sticking with DHT12s as it was working.	Fail
7	1/30/22-2/1/22	Jayven	<b>Panel charging battery</b> Testing if the 12v battery will charge from the 100w solar panel together. We used existing clamps from the solar panel and plugged it from the solar controller to the battery. Test conducted outdoors in 70F 54Hum.  Model: Panel-HYG-120D Battery-LDP20AH SN:NA	Knowing the panel, battery, and solar controller were working independently, we expected the controller to indicate a charge.	Panel was actively giving the battery a charge btwn. 12.6-13.8V	Pass
8	1/30/22-	Jayven	<b>Panel, Battery, Inverter</b>	Since the panel	All 3 were	Pass

Test ID	Start/End Date	Tester	Test Description	Expected Results	Actual Results	Pass/Fail Results
	2/1/22		<p>Test if the solar panel, battery, and inverter all worked together. From the panel, we plugged 18-gauge wire from the charge controller to the battery, and another set of 18 gauge wires to the inverter. The inverter was also tested with the same nightlight and portable fan used in test 3. Test conducted outdoors in 70F 54Hum.</p> <p>Model: Panel-HYG-120D Battery-LDP20AH Inverter-MRI5011BU SN:NA</p>	and battery were at a charge and it previously worked independently, we were confident all 3 would work together.	working together. Panel was pulling in voltage, the battery was being actively charged, and the inverter was giving power to the nightlight and fan.	
9	12/5/21-1/22/22	Naser	<p><b>Fan</b> Our fan was provided by a team member to disassemble. To test, we plugged the fan into a wall outlet to make sure all 3 modes of the fan were working. After, we disassembled the settings module of the fan to see how it's controlled. Each mode had its own separate wire and the knob turning to the modes would complete a circuit which indicated the amount of wattage.</p> <p>Model: Mainstays 10x10" Box Fan</p>	We expected the fan to work as intended. After disassembly and with exposed wires, we expected each to work once one mode was touching the 'main' wire of the fan.	All 3 modes worked as intended and once each specific wire was touching 'main', it spun to the corresponding mode.	Pass
10	1/30/22-2/1/22	David	<p><b>Fan in relay connected to Arduino.</b> With the wires exposed, we tied the 'main' wire in the fans speed controller and one speed wire of the fan into a relay terminal and used our previous code to test and see if the fan will activate. Fan power plugged into 120v outlet.</p>	Knowing how the fan works, we were sure once the relay was activated from the Arduino, the fan speed would start to spin	Fan started to spin as expected. Now we needed to branch off the 'main' power for the other modes of the fan. We used 18gauge wires and several wire connector twists	Pass
11	4/12/22-4/13/22	Javen/David	<b>Solder wires to pi</b>	All wires have a strong solder	Signals all working	Pass

Test ID	Start/End Date	Tester	Test Description	Expected Results	Actual Results	Pass/Fail Results
			Model: Raspberry Pi 4 SN:	point		
12	4/5/22-4/24/22	Nassrallah	<b>Finish build of prototype</b>	Finish build	<b>Prototype Complete</b>	<b>Pass</b>

**Appendix A-5: Solar System Capability Calculations**

We will first calculate how much our panel can produce. Our panel is rated for a max of 20V and 5A. When testing under 2 conditions: sunny and cloudy/overcast, we actually had somewhat results. On a sunny day, we recorded a max of 17.2v coming from the panel under direct sun. On the overcast day, we had a result of 13.5v. We expected it to be half the amount or more from our max recording but surprised it was still pulling in somewhat near conditions of a sunny day.

Now in order to calculate how long it will take to charge our battery, we first divide panel wattage by battery voltage to estimate max charge current by charge controller:

$$100w/12v = \mathbf{8.33a}$$

Next to take account from system losses in charge controller to battery. Since we use a PWM controller for a smaller system, we use 75%.

$$\text{If MPPT, use 95\%: } 8.33a * (1-15\%) * 75\% = \mathbf{5.31a}$$

Next multiply battery capacity by 1 over battery charge efficiency. Lead acid is 85%, lithium 95%:  $20ah * (1/95\%) = \mathbf{21ah}$

Next divide battery capacity by current to charge the whole battery:

$$21ah/5.31a = \mathbf{3.95 \text{ hours}}$$

Now we have to take in account discharge levels and absorption charging stages. Our battery doesn't have documentation of depth of discharge but let's assume 50% of total battery capacity:

$$3.95 * 50\% = \mathbf{1.97 \text{ hours}}$$

Absorption would be an additional 2 hours to be sure battery is at max: **3.97 hours.**

With this information, it should take roughly 4 hours under max sunlight to achieve a full charge with our current setup. As mentioned before, we have a max at 17.2v for sunny days and 13.5v on a cloudy day. Let's take this in account. 17.2v from 20v max is roughly 15% and 13.5 from 20v is 39%. Adding this loss to the time taken, will include an additional time of **.60 hours for sunny days, and 1.54 hours on cloudy days.** This means our gross time is:

**4.57 hours on sunny days, 5.51 hours on cloudy days.**

## **Appendix B-1. Final Arduino Code: The Fan Adjusts According to Detected Temp**

```

#include "DHT.h"
#define Type DHT12
int tempMod1=A2;
int tempMod2=A3;
DHT HT(tempMod1,Type);
DHT HT2(tempMod2,Type);
float humidity;
float outTemp;
float inTemp;
int setTime = 500;
//int dt=1000;
int RELAY_LOW=5;
int RELAY_MEDIUM=6;
int RELAY_HIGH=7;

void setup()
{
  // put setup code here, to run once:
  Serial.begin(9600);
  HT.begin();
  HT2.begin();
  pinMode(RELAY_LOW, OUTPUT);
  pinMode(RELAY_MEDIUM, OUTPUT);
  pinMode(RELAY_HIGH, OUTPUT);
}
void loop()
{
  // put main code here, to run repeatedly:
  humidity=HT.readHumidity();
  inTemp=HT.readTemperature(true);
  outTemp=HT2.readTemperature(true);

  Serial.print("Humidity: ");
  Serial.print(humidity);
  Serial.print(" Outdoor Temperature: ");
  Serial.print(outTemp);
  Serial.print(" F ");
  Serial.print(" Indoor Temperature: ");
  Serial.print(inTemp);
  Serial.println(" F ");
  digitalWrite(RELAY_LOW, HIGH);
  digitalWrite(RELAY_MEDIUM, HIGH);
  digitalWrite(RELAY_HIGH, HIGH);

  // if inside temp is higher than outside, turn fan on
  // If higher by 10 or more degrees, turn on high state, 5-9 deg, turn
  on medium, if 1-4 deg, turn on low, else, fan off
  //Example: If inside temperature is 80 and outside is 67, turn fan on
  high

  float tempDifference = inTemp - outTemp;

```

```
Serial.print("Temperature Difference = ");
Serial.println(tempDifference);

if(tempDifference <= 4.99 && tempDifference >= 0.5){
  Serial.println("Relay ON LOW SPEED");
  digitalWrite(RELAY_LOW, LOW);
  delay(10000);
}
if(tempDifference <= 9.99 && tempDifference >= 5){
  Serial.println("Relay ON MEDIUM SPEED");
  digitalWrite(RELAY_MEDIUM, LOW);
  delay(10000);
}
if(tempDifference >= 10){
  Serial.println("Relay ON HIGH SPEED");
  digitalWrite(RELAY_HIGH, LOW);
  delay(10000);
}
}
```



## Appendix B-2. Pseudocode of Final Raspberry Pi Python Code

Import libraries

Define both sensors

Define GPIO pins

Set GPIO pins off

Write all files with python to directory in apache as writable

Write to the files with default values to trigger sensors

Close python files from being written

Infinite loop:

    Open the files and read each file then store in a variable (this will change from default or user

    preference on html page)

    Convert from file to float

    Sleep 3 seconds

    Get 2 temperatures from each sensor and store in separate variables

    Get difference between the two sensor temps and find absolute value

    Set conditions with low and high for all low, medium, high relays then turn on that specific relay

    Set runtime/exception errors in case sensors cant read since pi doesnt have native temperature

    Sensor support

    Sleep 3 seconds

### Appendix B-3. Working Raspberry Pi (Python) from Arduino (C) Code

```
import time
import board
import adafruit_dht
import RPi.GPIO as GPIO

#Temp Sensor and LED Setup
dhtDevice = adafruit_dht.DHT11(board.D27) #outdoor sensor
dhtDevice2 = adafruit_dht.DHT11(board.D4) #indoor sensor
GPIO.setmode(GPIO.BCM)
#GPIO.setup(22,GPIO.OUT) #test led
#Relay GPIO Setup
GPIO.setup(23,GPIO.OUT) #Low Setting
GPIO.setup(24,GPIO.OUT) #Mid Setting
GPIO.setup(25,GPIO.OUT) #High Setting
GPIO.output(23, True)
GPIO.output(24, True)
GPIO.output(25, True)

while True:
    try:
        file1 = open("/var/www/html/testing.txt", "r")
        #Read the file as a string and store in a new variable
        numAsString = file1.read()
        #Convert the string to int
        num1=int(numAsString)

        # Print the values to the serial port
        #GPIO.output(22,False)
        time.sleep(3.0)

        temperature_c = dhtDevice.temperature
        temperature2_c = dhtDevice2.temperature
        # new indoor sensor detection
        temperature_f = temperature_c * (9 / 5) + 32
        temperature2_f = temperature2_c * (9 / 5) + 32

        # If inside temp is higher than outside, turn fan on
# If higher by 10 or more degrees -> high state, 5-9 deg -> medium, if 1-
4 deg, -> low, else, fan off
        # Example: If inside temperature is 80 and outside is 67, fan
high

        tempDifference = temperature2_f - temperature_f
        absDifference = abs(tempDifference)
#print("Temperature Difference: {:.1f} F / {:.1f} C
".format(tempDifference))

        if absDifference >= 1.5 and absDifference <= 2.99:
            print("Relay ON LOW SPEED")
            GPIO.output(23, False)
```

```

        GPIO.output(24, True)
        GPIO.output(25, True)
    if absDifference >= 3 and absDifference <= 3.99:
        print("Relay ON MEDIUM SPEED")
        GPIO.output(23, True)
        GPIO.output(24, False)
        GPIO.output(25, True)

    if absDifference >= 4:
        print("Relay ON HIGH SPEED")
        GPIO.output(23, True)
        GPIO.output(24, True)
        GPIO.output(25, False)
    if absDifference <= 1.49:
        print("Off")
        GPIO.output(23, True)
        GPIO.output(24, True)
        GPIO.output(25, True)

    #check temp from file
    #if num1 > 50:
        #GPIO.output(22, True)

    print("temp 1: ", temperature_f, "temp 2: ", temperature2_f)
    #print(temperature_f)
    #print(temperature2_f)
    print(absDifference)
#print("Temp: {:.1f} F / {:.1f} C".format(temperature2_f,
temperature2_c))
    except RuntimeError as error:
        # Errors happen fairly often, DHT's are hard to
read,        print(error.args[0])
        time.sleep(1.0)
        continue
    except Exception as error:
        dhtDevice.exit()
        dhtDevice2.exit()
        raise error

time.sleep(3.0)

```

## Appendix B-4. Final Python Code working with HTML code

```
import time
import board
import adafruit_dht
import RPi.GPIO as GPIO
import os

#Temp Sensor and LED Setup
dhtDevice = adafruit_dht.DHT11(board.D27) #indoor sensor // David's Sensor
dhtDevice2 = adafruit_dht.DHT11(board.D4) #outdoor sensor // Jayven's
Sensor
GPIO.setmode(GPIO.BCM)
#GPIO.setup(22,GPIO.OUT) #test led
#Relay GPIO Setup
GPIO.setup(23,GPIO.OUT) #Low Setting
GPIO.setup(24,GPIO.OUT) #Mid Setting
GPIO.setup(25,GPIO.OUT) #High Setting

#GPIO is active
GPIO.output(23, True)
GPIO.output(24, True)
GPIO.output(25, True)

#Set default values on boot to the filesystem
fileLowH = open("/var/www/html/lowHighTemp.txt", "w")
fileLowL = open("/var/www/html/lowLowTemp.txt", "w")

fileMedH = open("/var/www/html/medHighTemp.txt", "w")
fileMedL = open("/var/www/html/medLowTemp.txt", "w")

fileHighH = open("/var/www/html/highHighTemp.txt", "w")
fileHighL= open("/var/www/html/highLowTemp.txt", "w")

fileLowH.write("4.5")
fileLowL.write("3.5")

fileMedH.write("6")
fileMedL.write("4.6")

fileHighH.write("6.1")
fileHighL.write("3.4")

fileLowH.close()
fileLowL.close()
fileMedH.close()
fileMedL.close()
fileHighH.close()
fileHighL.close()

#User will need to give write permissions???
os.system("chmod 777 /var/www/html/*.txt")
```

```

while True:
    try:
        #Start reading default and check if new values arrive
        fileLowH = open("/var/www/html/lowHighTemp.txt", "r")
        fileLowL = open("/var/www/html/lowLowTemp.txt", "r")

        fileMedH = open("/var/www/html/medHighTemp.txt", "r")
        fileMedL = open("/var/www/html/medLowTemp.txt", "r")

        fileHighH = open("/var/www/html/highHighTemp.txt", "r")
        fileHighL= open("/var/www/html/highLowTemp.txt", "r")

        #Read the file as a string and store in a new variable
        fileLowHAsString = fileLowH.read()
        fileLowLAsString = fileLowL.read()

        fileMedHAsString = fileMedH.read()
        fileMedLAsString = fileMedL.read()

        fileHighHAsString = fileHighH.read()
        fileHighLAsString = fileHighL.read()

        #Convert the string to int
        fileLowHInt=float(fileLowHAsString)
        fileLowLInt=float(fileLowLAsString)

        fileMedHInt=float(fileMedHAsString)
        fileMedLInt=float(fileMedLAsString)

        fileHighHInt=float(fileHighHAsString)
        fileHighLInt=float(fileHighLAsString)

        # Print the values to the serial port
        #GPIO.output(22,False)
        time.sleep(3.0)

        temperature_c = dhtDevice.temperature
        temperature2_c = dhtDevice2.temperature
        # new indoor sensor detection
        temperature_f = temperature_c * (9 / 5) + 32
        temperature2_f = temperature2_c * (9 / 5) + 32

        # If inside temp is higher than outside, turn fan on
        # If higher by 10 or more degrees, turn on high state, 5-9 deg,
turn on medium, if 1-4 deg, turn on low, else, fan off
        # Example: If inside temperature is 80 and outside is 67, turn fan
on high

        tempDifference = temperature2_f - temperature_f
        absDifference = abs(tempDifference)

```

```

        #print("Temperature Difference: {:.1f} F / {:.1f} C
".format(tempDifference))

        if absDifference >= fileLowLInt and absDifference <= fileLowHInt:
            print("Relay ON LOW SPEED")
            GPIO.output(23, False)
            GPIO.output(24, True)
            GPIO.output(25, True)
        if absDifference >= fileMedLInt and absDifference <= fileMedHInt:
            print("Relay ON MEDIUM SPEED")
            GPIO.output(23, True)
            GPIO.output(24, False)
            GPIO.output(25, True)

        if absDifference >= fileHighHInt:
            print("Relay ON HIGH SPEED")
            GPIO.output(23, True)
            GPIO.output(24, True)
            GPIO.output(25, False)
        if absDifference <= fileHighLInt:
            print("Off")
            GPIO.output(23, True)
            GPIO.output(24, True)
            GPIO.output(25, True)

        #check temp from file
        #if num1 > 50:
            #GPIO.output(22,True)

        print("temp 1: ",temperature_f, "temp 2: ",temperature2_f)
        #print(temperature_f)
        #print(temperature2_f)
        print(absDifference)
        #print("Temp: {:.1f} F / {:.1f} C".format(temperature2_f,
temperature2_c))

    except RuntimeError as error:
        # Errors happen fairly often, DHT's are hard to read, just keep
going
        print(error.args[0])
        time.sleep(1.0)
        continue
    except Exception as error:
        dhtDevice.exit()
        dhtDevice2.exit()
        raise error

    time.sleep(3.0)

```

## Appendix B-5 HTML Web User-Interface Code

### Home page/Main page

```
<!DOCTYPE html>
<html>
<head>

<!-- For search engine optimization (SEO) -->
    <title>Temperature Calculator</title>

<meta name="viewport" content="width=device-width, initial-scale=1" />

</head>

<style>
/* Set up a scaled BG image for any device */
body {
    background-image: url('https://techcrunch.com/wp-
content/uploads/2014/11/shutterstock_148264043.jpg?w=1390&crop=1');
background-repeat:no-repeat;
    background-attachment:fixed;
    background-position:top center;
    background-size: cover;
}

/*Global variable to include padding and border in any element's total
width and height */
* {
    box-sizing: border-box;
}

/*Create a button class w/ no borders */
button {
    background-color: #9ACD32;
    color: white;
    border: 0;
    cursor: pointer;
    width: 100%;
}

/*Create an input class and set width to 100% to fill screen */
input {
width: 100%
}

/*A center div class to center text within box, box margins 100px
top/bottom */
```

```

.center {
margin: 100px auto;
width: 27vw;
    text-align: center;
position: relative;
    }

/*Box div class */
.container {
    width: 100%;
    height: 100%;
    position: relative;
    }

/* Border for box div class, slightly transparent */
.border-box {
    width: 100%;
    height: 100%;
    border: 5px solid black;
    position: relative;
    opacity: 0.8;
    }

/* Set color of the background of the inside of the box */
.content-box {
    width: 100%;
    height: 100%;
    border: none;
    background: #006400;
    position: relative;
    }
</style>

<body>
<!-- Title of webpage -->
    <h1 style="text-align:center;">Automatic Hybrid Fan Calculator</h1>

    <!-- Navigation link, used as a container for the hyperlinks -->
    <nav>
        <ul>
<!-- Links to subpages -->
<li><a href="test.html">Home</a></li>
<li><a href="about.html">About Us</a></li>
<li><a href="changelog.html">Changelog</a></li>
        </ul>
    </nav>

<style>
/*Get rid of default margins and padding from browser */

```



```

* {
    margin: 0;
    padding: 0;
}

/*Style nav tag */
nav {
    width: 100%;
    height: 100px;
    background-color: firebrick;
}

/*Unordered list to move around the time and navigation around website */
ul {

}

/*To move around the individual links around the UL */
ul li {
/*Gets rid of the bullet points*/
    list-style: none;
/*Gets rid of the new line from each hyperlink to put them next to each
other*/
    display: inline-block;
/*Gets rid of the gaps between the hyperlinks */
    float: left;
/*Centers the navigation links no matter the text size */
    line-height: 100px;
}

/* Style text within links */
ul li a {
/*Be able to click above or below link, not just on the link itself */
    display: block;
/*Get rid of the underlines from the hyperlinks */
    text-decoration: none;
/*Change font, its size, and color */
    font-size: 14px;
    font-family: arial;
    color: #1e1e1e;
/*Spaces the links properly*/
    padding: 0 20px;
}
/*Set color of hyperlink when hovering over the hyperlinks */

ul li a:hover {
    color: aqua;
}
</style>

<!-- Nested div statements for the border and box -->
<div class="center">

```

```

<div class="container">
  <div class="border-box">
    <div class="content-box">

<!-- Change default color of text from black to white -->
<div style="color:#ffffff;">
<form method="post">
  <br>
Low Speed Config
<br>
    New High: <input type="text" name="lowHighTemp"><br><br>
    Low Temp: <input type="text" name="lowLowTemp"><br>
      <button type="submit">Submit</button>
    </form>

      </div>
    </div>
  </div>
</div>

<div class="center">
  <div class="container">
    <div class="border-box">
<div class="content-box">

<!-- Change default color of text from black to white -->
<div style="color:#ffffff;">
<form method="post">
  <br>
Medium Speed Config
<br>
    New High:<br> <input type="text" name="medHighTemp"><br><br>
    Low Temp:<br> <input type="text" name="medLowTemp"><br>
      <button type="submit">Submit</button>
    </form>
      </div>
    </div>
  </div>
</div>

<div class="center">
  <div class="container">
    <div class="border-box">
<div class="content-box">

<!-- Change default color of text from black to white -->
<div style="color:#ffffff;">
<form method="post">

```

```

    <br>
High Speed Config
<br>
    New High:<br> <input type="text" name="highHighTemp"><br><br>
    <button type="submit">Submit</button>
</form>
</div>
</div>
</div>
</div>
</div>

<div class="center">
    <div class="container">
        <div class="border-box">
<div class="content-box">

<!-- Change default color of text from black to white -->
<div style="color:#ffffff;">
<form method="post">
    <br>
Off Config
<br>
    If difference lower than, this, be off:<br> <input type="text"
name="highLowTemp"><br>
    <button type="submit">Submit</button>
</form>
</div>
</div>
</div>
</div>
</div>

<!-- PHP part -->
<?php
if ($_SERVER["REQUEST_METHOD"] == "POST") {
    // collect value of input field
    $lowHighTempPush = htmlspecialchars($_REQUEST['lowHighTemp']);
    $lowLowTempPush = htmlspecialchars($_REQUEST['lowLowTemp']);

    $medHighTempPush = htmlspecialchars($_REQUEST['medHighTemp']);
    $medLowTempPush = htmlspecialchars($_REQUEST['medLowTemp']);
    $highHighTempPush = htmlspecialchars($_REQUEST['highHighTemp']);
    $highLowTempPush = htmlspecialchars($_REQUEST['highLowTemp']);
    if (empty($lowHighTempPush)) {
    } else {
    $fileLowH = fopen("lowHighTemp.txt", "w");
    $lowHighTempUpdate = $lowHighTempPush;
    fwrite($fileLowH, $lowHighTempUpdate);
    fclose();
    }
}

```

```
if (empty($lowLowTempPush)) {
    } else {
        $fileLowL = fopen("lowLowTemp.txt", "w");
        $lowLowTempUpdate = $lowLowTempPush;
        fwrite($fileLowL, $lowLowTempPush);
        fclose();
    }
if (empty($medHighTempPush)) {
    } else {
        $fileMedH = fopen("medHighTemp.txt", "w");
        $medHighTempUpdate = $medHighTempPush;
        fwrite($fileMedH, $medHighTempPush);
        fclose();
    }
if (empty($medLowTempPush)) {
    } else {
        $fileMedL = fopen("medLowTemp.txt", "w");
        $medLowTempUpdate = $medLowTempPush;
        fwrite($fileMedL, $medLowTempPush);
        fclose();
    }
if (empty($highHighTempPush)) {
    } else {
        $fileHighH = fopen("highHighTemp.txt", "w");
        $highHighTempUpdate = $highHighTempPush;
        fwrite($fileHighH, $highHighTempPush);
        fclose();
    }

if (empty($highLowTempPush)) {
    } else {
        $fileHighL = fopen("highLowTemp.txt", "w");
        $highLowTempUpdate = $highLowTempPush;
        fwrite($fileHighL, $highLowTempPush);
        fclose();
    }
}
?>

</body>
</html>
```

## About Us Page

```
<!DOCTYPE html>
<html>
<head>

<!-- For search engine optimization (SEO) -->
    <title>About Us</title>

<meta name="viewport" content="width=device-width, initial-scale=1" />

</head>

<!-- Set up a scaled BG image for any device -->
<style>

body {
    background-image: url('https://techcrunch.com/wp-
content/uploads/2014/11/shutterstock_148264043.jpg?w=1390&crop=1');
background-repeat:no-repeat;
    background-attachment:fixed;
    background-position:top center;
    background-size: cover;
}

/*Create an input class and set width to 100% to fill screen */
input {
width: 100%
}

/*A center div class to center text */
.center {
margin: 0 auto;
width: 27vw;
    text-align: center;
}

</style>

<body>
<!-- Title of webpage -->
<h1 style="text-align:center;">About Us</h1>

    <!-- Navigation link, used as a container for the hyperlinks -->
        <nav>
            <ul>
<li><a href="Test.html">Home</a></li>
<li><a href="About.html">About Us</a></li>
```

```

<li><a href="Changelog.html">Changelog</a></li>
  </ul>
</nav>
<!-- Links to subpages -->
<style>
  /*Get rid of default margins and padding from browser */
  * {
    margin: 0;
    padding: 0;
  }

  /*Style nav tag */
  nav {
    width: 100%;
    height: 100px;
    background-color: firebrick;
  }
  /*Unordered list to move around the time and navigation around
website */
  ul {

  }

  /*To move around the individual links around the UL */
  ul li {
    /*Gets rid of the bullet points*/
    list-style: none;
    /*Gets rid of the new line from each hyperlink to put them
next to each other*/

    display: inline-block;
    /*Gets rid of the gaps between the hyperlinks */
    float: left;
    /*Centers the navigation links no matter the text size */
    line-height: 100px;
  }

  /* Style text within links */
  ul li a {
  /*Be able to click above or below link, not just on the link itself */
    display: block;
    /*Get rid of the underlines from the hyperlinks */
    text-decoration: none;
    /*Change font, its size, and color */
    font-size: 14px;
    font-family: arial;
    color: #1e1e1e;
    /*Spaces the links properly*/
    padding: 0 20px;
  }
  /*Set color of hyperlink when hovering over the hyperlinks */
  ul li a:hover {

```

```

        color: aqua;
    }
</style>
<p style="text-align:center;">
</p>

<p style="text-align:center; font-size:18px;"> David Santiago </p>
    <p style="display:block; text-align:center;"> A computer engineering
major in his fifth year, David has an interest in microcontrollers, and
hopes to find a future career coding in python and C; preferably for a
project that seeks to lead improvement for the environment. </p>

<br>

<p style="text-align:center; font-size:18px;"> Jayven Khoonsirivong </p>
    <p style="display:block; text-align:center;"> I'm a 5th year CPE major
and love working on small personal projects and tinkering with server
hardware </p>

<br>

<p style="text-align:center; font-size:18px;"> Enoch </p>
    <p style="display:block; text-align:center;"> A 5th year CPE major
who's interested in dealing with

hardware and being a data analyst. </p>
<br>
<p style="text-align:center; font-size:18px;"> Nasrallah Alnamrouti </p>
    <p style="display:block; text-align:center;"> An electrical and
electronic engineer, product design. hoping to find a job relating to this
major. </p>

</body>
</html>

```

## Changelog Page

```
<!DOCTYPE html>
<html>
<head>

<!-- For search engine optimization (SEO) -->
    <title>Changelog</title>

<meta name="viewport" content="width=device-width, initial-scale=1" />

</head>
<!-- -->
<!-- Set up a scaled BG image for any device -->
<style>

body {
    background-image: url('https://techcrunch.com/wp-
content/uploads/2014/11/shutterstock_148264043.jpg?w=1390&crop=1');
background-repeat:no-repeat;
    background-attachment:fixed;
    background-position:top center;
    background-size: cover;
}

/*Create an input class and set width to 100% to fill screen */
input {
width: 100%
}

/*A center div class to center text */
.center {
margin: 0 auto;

width: 27vw;
    text-align: center;
}

</style>

<body>
<!-- Title of webpage -->
<h1 style="text-align:center;">Changelog</h1>

    <!-- Navigation link, used as a container for the hyperlinks -->
        <nav>
            <ul>
<li><a href="Test.html">Home</a></li>
```



```

<li><a href="About.html">About Us</a></li>
<li><a href="Changelog.html">Changelog</a></li>
  </ul>
</nav>
<!-- Links to subpages -->
<style>
  /*Get rid of default margins and padding from browser */
  * {
    margin: 0;
    padding: 0;
  }

  /*Style nav tag */
  nav {
    width: 100%;
    height: 100px;
    background-color: firebrick;
  }
  /*Unordered list to move around the time and navigation around
website */
  ul {

  }

  /*To move around the individual links around the UL */
  ul li {
    /*Gets rid of the bullet points*/
    list-style: none;
    /*Gets rid of the new line from each hyperlink to put them
next to each other*/
    display: inline-block;
    /*Gets rid of the gaps between the hyperlinks */
    float: left;
    /*Centers the navigation links no matter the text size */

    line-height: 100px;
  }

  /* Style text within links */
  ul li a {
    /*Be able to click above or below link, not just on the link
itself */
    display: block;
    /*Get rid of the underlines from the hyperlinks */
    text-decoration: none;
    /*Change font, its size, and color */
    font-size: 14px;
    font-family: arial;
    color: #1e1e1e;
    /*Spaces the links properly*/
    padding: 0 20px;
  }
}

```

```

/*Set color of hyperlink when hovering over the hyperlinks */
ul li a:hover {
    color: aqua;
}

```

```

/*Table style */
table, th, td {
    border:1px solid black;
}

```

```

</style>

```

```

<!-- Create a table for our hardware test timeline and change BG to
transparent white -->

```

```

<table style="width:100%; background: rgba(255,255,255,0.8)">

```

```

<!-- Create a caption for our hardware test timeline -->

```

```

<caption style="text-align:center; font-weight: bold">Hardware Test
Timeline</caption>

```

```

<!-- Title of each column in table -->

```

```

<tr>
    <th>Test ID</th>
    <th>Start/End Date</th>
    <th>Tester</th>
    <th>Test Description</th>
    <th>Expected Results</th>
    <th>Actual Results</th>
    <th>Pass/Fail Results</th>
</tr>

```

```

<!-- Row 1 -->

```

```

<tr>
    <td> 1 </td>

```

```

    <td>1/3/22-2/5/22</td>

```

```

    <td>Javyen</td>

```

```

    <td>Solar Panel: Making sure solar panel is working by having it out
on a sunny day plugged to a battery and solar controller. Test conducted
outdoors in 55F 54Hum. SN: NA Model:HYG-120D </td>

```

```

    <td>Expected lower but close to 5A, 20V on a sunny day charging a 12v
battery</td>

```

```

    <td>Panel reads 17.2V which is roughly 5.8A to equal manufactures 100w
panel.</td>

```

```

    <td>Pass</td>

```

```

</tr>

```

```

<!-- Row 2 -->

```

```

<tr>
    <td> 2 </td>

```

```

    <td>1/3/22-2/5/22</td>

```

```

    <td>Javyen</td>

```

<td>Battery: Make sure battery is working. We tested this by getting a multimeter and checking voltage it was giving off. SN: NA Model:LDP20AH 74F 55Hum </td>

<td>12v battery was expected to be a little more than 12v. Estimating maybe 12.5v or 13v</td>

<td>Battery was being a charge of 12.6v so we knew the battery was live. The next test would be to plug it in an inverter.</td>

<td>Pass</td>

</tr>

<!-- Row 3 -->

<tr>

<td> 3 </td>

<td>1/3/22-2/5/22</td>

<td>Javyen</td>

<td>Inverter: Make sure the inverter is working. We tested this by hooking up our battery to the inverter with 18gauge alligator clips. We plugged a nightlight to the output to see if it powered on, then added a small, low voltage portable fan. Test conducted outdoors in 70F 54Hum.</td>

<td>Expected the nightlight to turn on as well as our fan plugged separately.</td>

<td>Light and power from the nightlight and fan was working correctly and power was being received.</td>

<td>Pass</td>

</tr>

<!-- Row 4 -->

<tr>

<td> 4 </td>

<td>10/3/21-12/11/22</td>

<td>David</td>

<td>Microcontroller: Ensure the Arduino Microcontroller is working. Used USB type B and laptop running Arduino IDE. We used the default 'blink led' sketch to determine if the Arduino was able to read code and upload to it. Model: Arduino Elegoo Uno R3</td>

<td>Expected built in LED to blink in a 5 second duration indefinitely</td>

<td>Our microcontroller was working and started programming other codes to fully ensure the gpio pins were working</td>

<td>Pass</td>

</tr>

<!-- Row 5 -->

<tr>

<td> 5 </td>

<td>10/3/21-12/11/22</td>

<td>David</td>

<td>Relay Module: Make sure our relay module was working and all 4 activated and deactivated when necessary. We set up simple test code to just activate each similar to our blink but used GPIO pin 5 to test each at a time. Used USB type B and laptop running Arduino IDE.</td>

<td>Expected relay to just work and open and close periodically like our blink sketch.</td>

```

    <td>Relay was working and opening and closing as intended when our
code had it writing a digital high and low to the relays pin in.</td>
    <td>Pass</td>
</tr>
<!-- Row 6 -->
<tr>
    <td> 6 </td>
    <td>10/3/21-12/11/22</td>
    <td>David</td>
    <td>Temperature modules: Make sure our Arduino temperature module was
working as intended. We had two different modules. One member has an
already working DHT12 and another member bought a DHT11. Test code was set
up for both and ran independently then together. Used USB type B and
laptop running Arduino IDE. Model: DHT11/DHT12</td>
    <td>Expected both to work as code for both to operate was in theory
supposed to work as the only thing that needs changing is the library that
needs to be initialized.</td>
    <td>Our existing DHT12 was working as intended but we had multiple
fail rates with DHT11s. Whether it be our code or a bad bunch of sensors
we had, we resorted to just sticking with DHT12s as it was working.</td>
    <td>Fail</td>
</tr>
<!-- Row 7 -->
<tr>
    <td> 7 </td>
    <td>1/30/22-2/1/22</td>
    <td>Jayven</td>
    <td>Panel charging battery: Testing if the 12v battery will charge
from the 100w solar panel together. We used existing clamps from the solar
panel and plugged it from the solar controller to the battery. Test
conducted outdoors in 70F 54Hum. Model: Panel-HYG-120D Battery-LDP20AH
SN:NA</td>
    <td>Knowing the panel, battery, and solar controller were working
independently, we expected the controller to indicate a charge.</td>
    <td>Panel was actively giving the battery a charge of 13.8v. 12.6</td>
    <td>Pass</td>
</tr>
<!-- Row 8 -->
<tr>
    <td> 8 </td>
    <td>1/30/22-2/1/22</td>

    <td>Jayven</td>
    <td>Panel, Battery, Inverter: Test if the solar panel, battery, and
inverter all worked together. From the panel, we plugged 18 gauge wire
from the charge controller to the battery, and another set of 18 gauge
wires to the inverter. The inverter was also tested with the same
nightlight and portable fan used in test 3. Test conducted outdoors in 70F
54Hum.

```

Model:

Panel-HYG-120D  
Battery-LDP20AH  
Inverter-MRI5011BU  
SN:NA</td>

<td>Since the panel and battery were at a charge and it previously worked independently, we were confident all 3 would work together.</td>

<td>All 3 were working together. Panel was pulling in voltage, the battery was being actively charged, and the inverter was giving power to the nightlight and fan</td>

<td>Pass</td>

</tr>

<!-- Row 9 -->

<tr>

<td> 9 </td>

<td>12/5/21-1/22/22</td>

<td>Naser</td>

<td>Fan: Our fan was provided by a team member to disassemble. To test, we plugged the fan into a wall outlet to make sure all 3 modes of the fan were working. After, we disassembled the settings module of the fan to see how it's controlled. Each mode had its own separate wire and the knob turning to the modes would complete a circuit which indicated the amount of wattage. Model: SN:</td>

<td>We expected the fan to work as intended. After disassembly and with exposed wires, we expected each to work once one mode was touching the 'main' wire of the fan.</td>

<td>All 3 modes worked as intended and once each specific wire was touching 'main', it spun to the corresponding mode.</td>

<td>Pass</td>

</tr>

<!-- Row 10 -->

<tr>

<td> 10 </td>

<td>1/30/22-2/1/22</td>

<td>David</td>

<td>Fan in relay connected to Arduino: With the wires exposed, we tied the 'main' wire in the fan's speed controller and one speed wire of the fan into a relay terminal and used our previous code to test and see if the fan would activate. Fan power plugged into a 120v outlet.</td>

<td>Knowing how the fan works, we were sure once the relay was activated from the Arduino, the fan speed would start to spin</td>

<td>Fan started to spin as expected. Now we needed to branch off the 'main' power for the other modes of the fan. We used 18-gauge wires and several wire connector twists</td>

<td>Pass</td>

</tr>

<!-- Row 11 -->

<tr>

<td> 11 </td>

<td>4/12/22-4/13/22</td>

<td>Jayven/David</td>

```

        <td>Solder wires to pi -> Model: Raspberry Pi 4
SN: </td>
        <td>All wires have a strong solder point</td>
        <td>Signals were all working</td>
        <td>Pass</td>
    </tr>
<!-- Row 12 -->
    <tr>
        <td>12</td>
        <td>4/5/22-4/24/22</td>
        <td>Naser</td>
        <td>Finish build of prototype</td>
        <td>Finish build</td>
        <td>TBD</td>
        <td>TBD</td>
    </tr>
</table>

```

```

<!-- Create a table for our software test timeline and change BG to
transparent white -->
<table style="width:100%; background: rgba(255,255,255,0.8)">
<!-- Create a caption for our software test timeline -->
<caption style="text-align:center; font-weight: bold">Software Test
Timeline</caption>
<!-- Title of each column in table -->
    <tr>
        <th>Test ID</th>
        <th>Start/End Date</th>
        <th>Tester</th>
        <th>Test Description</th>
        <th>Expected Results</th>
        <th>Actual Results</th>
        <th>Pass/Fail Results</th>
    </tr>
<!-- Row 1 -->
    <tr>
        <td>1</td>
        <td>2/07/22-2/14/22</td>
        <td>Enoch</td>
        <td>Set up a mock website (without using code) using JustInMind, a
design and prototyping tool for web and mobile apps</td>

```

```

        <td>Functional, basic website with multiple pages that appeals to
marketing side</td>
        <td>Website worked</td>
        <td>Pass</td>
    </tr>
<!-- Row 2 -->
    <tr>
        <td>2</td>

```

```

        <td>2/20/22-2/28/22</td>
        <td>Enoch</td>
        <td>Set up a mock webpage, using HTML and a form action to send input
data to a text file</td>
        <td>Functional HTML webpage that would send data to a text file</td>
        <td>Webpage worked, but the write to a text file failed</td>
        <td>Fail</td>
    </tr>
<!-- Row 3 -->
    <tr>
        <td>3</td>
        <td>2/28/22-3/6/22</td>
        <td>David/Jayven</td>
        <td>Get flask installed on Pi: Get a webserver running to host our
webpage. Model: Raspberry Pi 4 </td>
        <td>Everything to work out the box with python and php webpages</td>
        <td>Php not native to Flask. Switch from Flask to apache</td>
        <td>Fail</td>
    </tr>
<!-- Row 4 -->
    <tr>
        <td>4</td>
        <td>3/01/22-3/11/22</td>
        <td>Enoch</td>
        <td>Implement PHP code to write to a text file without using a web
server</td>
        <td>Successful integration of HTML and php code to write to a text
file</td>
        <td>Ended up only implementing a separate php-only code to write to a
text file. Had to use a web server with Visual Studio for it to work.
Could not integrate with HTML</td>
        <td>Fail</td>
    </tr>
<!-- Row 5 -->
    <tr>
        <td>5</td>
        <td>3/7/22-3/28/22</td>
        <td>David/Jayven</td>
        <td>Write logic from Arduino to Python: Convert old logic to new.
Model: Raspberry Pi 4</td>
        <td>Everything, to work out the box</td>
        <td>Logic worked. Encountered some issues with temp sensors failing to
read sometimes</td>
        <td>Pass</td>
    </tr>

<!-- Row 6 -->
    <tr>
        <td>6</td>
        <td>3/12/22-3/23/22</td>
        <td>Enoch</td>

```

```

        <td>Using skeleton code provided by Javyen, create and implement a
webpage using HTML and CSS. Also include a simple form method to read user
input</td>
        <td>Functional, more professionally appealing webpage with a working
HTML form</td>
        <td>Much more appealing webpage than initial first draft of our
webpage. PHP write to text file will be handled by Javyen</td>
        <td>Pass</td>
    </tr>
<!-- Row 7 -->
    <tr>
        <td>7</td>
        <td>3/28/22-4/03/22</td>
        <td>Enoch</td>
        <td>Research on how to scale inserted images and background images and
have them appear properly whether using a PC or mobile device</td>
        <td>Expected a properly scaled background image across any device
(mobile, tablet, PC). </td>
        <td>Using the same background image, got the code to scale the
background image, but the image used for the PC version ended up not being
compatible with smaller devices.</td>
        <td>Pass</td>
    </tr>
<!-- Row 8 -->
    <tr>
        <td>8</td>
        <td>4/4/22-4/8/22</td>
        <td>David/Jayven</td>
        <td>Migrate Enoch's html page to Pi's main logic
Enoch has provided us with an HTML page we will be using.

```

Model: Raspberry Pi 4

SN:

```

        </td>
        <td>Php logic is working in conjunction to main python script</td>
        <td>Php is writing correctly and producing expected results</td>
        <td>Pass</td>
    </tr>
<!-- Row 9 -->
    <tr>
        <td>9</td>
        <td>4/04/22-4/10/22</td>
        <td>Enoch</td>
        <td>Add a couple of pages to our webpage, including an About Us and a
changelog page</td>
        <td>Successful implementation of an About Us and changelog page using
HTML</td>
        <td>Worked</td>
        <td>Pass</td>
    </tr>
<!-- Row 10 -->
    <tr>
        <td>10</td>

```



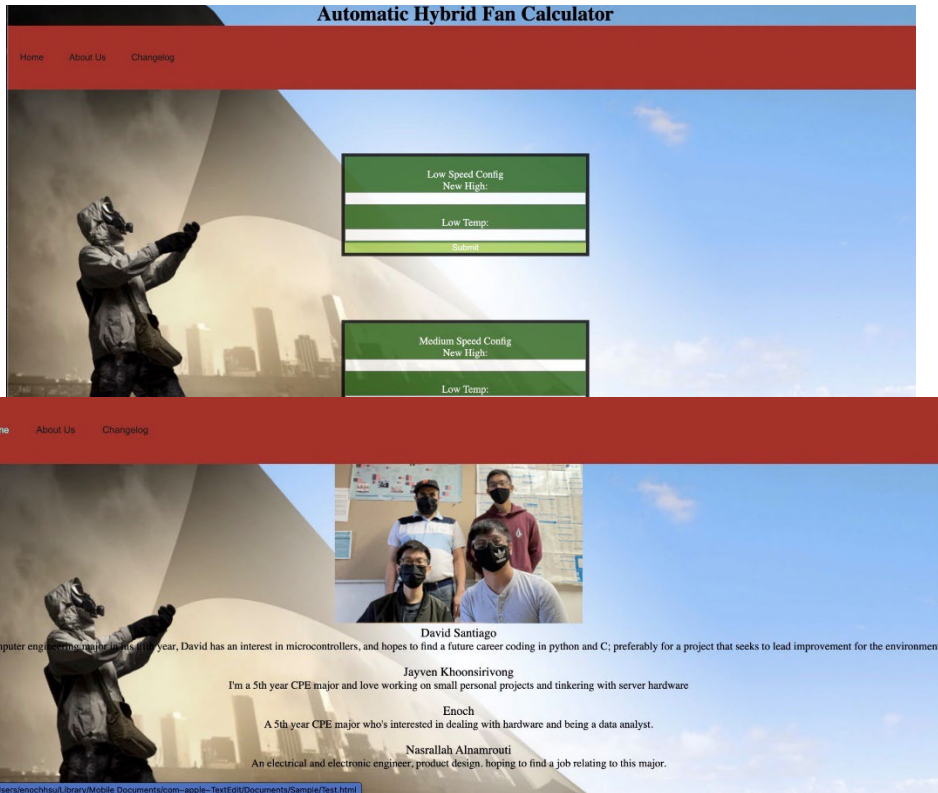
```

        <td>4/11/22-4/17/22</td>
        <td>Enoch</td>
        <td>Look for a separate background image for mobile-only version of
our website and have that properly scaled on a mobile device</td>
        <td>Properly scaled background image on viewing our webpage on a
mobile device while leaving the PC version the same</td>
        <td>It does scale, but not necessarily to the way I want it to be.
Decided not to have a separate mobile-only picture</td>
        <td>Fail</td>
    </tr>
<!-- Row 11 -->
    <tr>
        <td>11</td>
        <td>4/18/22-4/24/22</td>
        <td>Enoch</td>
        <td>Finishing touches on website to make it look professional</td>
        <td>Functional, professional website</td>
        <td>It's nice looking and functional, I just had a more grand picture
in my mind, but it fulfills our purposes</td>
        <td>Pass</td>
    </tr>
</table>

</body>
</html>

```

## Appendix B-6 Web UI Screenshots



Hardware Test Timeline						
Test ID	Start/End Date	Tester	Test Description	Expected Results	Actual Results	Pass/Fail Results
1	1/3/22-2/5/22	Javyen	Solar Panel: Making sure solar panel is working by having it out on a sunny day plugged to a battery and solar controller. Test conducted outdoors in 55F 54Hum. SN: NA Model:HYG-120D	Expected lower but close to 5A, 20V on a sunny day charging a 12v battery	Panel reads 17.2V which is roughly 5.8A to equal manufactures 100w panel.	Pass
2	1/3/22-2/5/22	Javyen	Battery: Make sure battery is working. We tested this by getting a multimeter and checking voltage it was giving off. SN: NA Model:LDP20AH 74F 55Hum	12v battery was expected to be a little more than 12v. Estimating maybe 12.5v or 13v	Battery was being a charge of 12.6v so we knew the battery was live. The next test would be to plug it in an inverter.	Pass
3	1/3/22-2/5/22	Javyen	Inverter: Make sure the inverter is working. We tested this by hooking up our battery to the inverter with 18gauge alligator clips. We plugged a nightlight to the output to see if it powered on, then added a small, low voltage portable fan. Test conducted outdoors in 70F 54Hum.	Expected the nightlight to turn on as well as our fan plugged separately.	Light and power from the nightlight and fan was working correctly and power was being received.	Pass
4	10/3/21-12/11/22	David	Microcontroller: Ensure the Arduino Microcontroller is working. Used USB type B and laptop running Arduino IDE. We used the default 'blink led' sketch to determine if the Arduino was able to read code and upload to it. Model: Arduino Elegoo Uno R3	Expected built in LED to blink in a 5 second duration indefinitely	Our microcontroller was working and started programming other codes to fully ensure the gpio pins were working	Pass
5	10/3/21-12/11/22	David	Relay Module: Make sure our relay module was working and all 4 activated and deactivated when necessary. We set up simple test code to just activate each similar to our blink but used GPIO pin 5 to test each at a time. Used USB type B and laptop running Arduino IDE.	Expected relay to just work and open and close periodically like our blink sketch.	Relay was working and opening and closing as intended when our code had it writing a digital high and low to the relays pin in.	Pass
6	10/3/21-12/11/22	David	Temperature modules: Make sure our Arduino temperature module was working as intended. We had two different modules. One member has an already working DHT12 and another member bought a DHT11. Test code was set up for both and ran independently then together. Used USB type B and laptop running Arduino IDE. Model: DHT11/DHT12	Expected both to work as code for both to operate was in theory supposed to work as the only thing that needs changing is the library that needs to be initialized.	Our existing DHT12 was working as intended but we had multiple fail rates with DHT11s. Whether it be our code or a bad bunch of sensors we had, we resorted to just sticking with DHT12s as it was working.	Fail
7	1/30/22-2/1/22	Javyen	Panel charging battery: Testing if the 12v battery will charge from the 100w solar panel together. We used existing clamps from the solar panel and plugged it from the solar controller to the battery. Test conducted outdoors in 70F 54Hum. Model: Panel-HYG-	Knowing the panel, battery, and solar controller were working independently, we expected the controller to indicate a	Panel was actively giving the battery a charge of 13.8v. 12.6	Pass

Software Test Timeline						
Test ID	Start/End Date	Tester	Test Description	Expected Results	Actual Results	Pass/Fail Results
1	2/07/22-2/14/22	Enoch	Set up a mock website (without using code) using JustinMind, a design and prototyping tool for web and mobile apps	Functional, basic website with multiple pages that appeals to marketing side	Website worked	Pass
2	2/20/22-2/28/22	Enoch	Set up a mock webpage, using HTML and a form action to send input data to a text file	Functional HTML webpage that would send data to a text file	Webpage worked, but the write to a text file failed	Fail
3	2/28/22-3/6/22	David/Jayven	Get flask installed on Pi: Get a webserver running to host our webpage. Model: Raspberry Pi 4	Everything to work out the box with python and php webpages	Php not native to Flask. Switch from Flask to apache	Fail
4	3/01/22-3/11/22	Enoch	Implement PHP code to write to a text file without using a web server	Successful integration of HTML and php code to write to a text file	Ended up only implementing a separate php-only code to write to a text file. Had to use a web server with Visual Studio for it to work. Could not integrate with HTML	Fail
5	3/7/22-3/28/22	David/Jayven	Write logic from Arduino to Python: Convert old logic to new. Model: Raspberry Pi 4	Everything, to work out the box	Logic worked. Encountered some issues with temp sensors failing to read sometimes	Pass
6	3/12/22-3/23/22	Enoch	Using skeleton code provided by Jayven, create and implement a webpage using HTML and CSS. Also include a simple form method to read user input	Functional, more professionally appealing webpage with a working HTML form	Much more appealing webpage than initial first draft of our webpage. PHP write to text file will be handled by Jayven	Pass
7	3/28/22-4/03/22	Enoch	Research on how to scale inserted images and background images and have them appear properly whether using a PC or mobile device	Expected a properly scaled background image across any device (mobile, tablet, PC).	Using the same background image, got the code to scale the background image, but the image used for the PC version ended up not being compatible with smaller devices.	Pass
8	4/4/22-4/8/22	David/Jayven	Migrate Enoch's html page to Pi's main logic Enoch has provided us with an HTML page we will be using. Model: Raspberry Pi 4	Php logic is working in conjunction to main python script	Php is writing correctly and producing expected results	Pass
9	4/04/22-4/10/22	Enoch	Add a couple of pages to our webpage, including an About Us and a changelog page	Successful implementation of an About Us and changelog page using HTML	Worked	Pass
10	4/11/22-	Enoch	Look for a separate background image for mobile-only version of our website and have that properly scaled on a	Properly scaled background image on viewing our webpage on a mobile device while leaving	It does scale, but not necessarily to the way I want it to be.	Fail

**Appendix B-6. Software Testing**  
**Table B-1: Software Test Timeline and Results**

Test ID	Start/End Date	Tester	Test Description	Expected Results	Actual Results	Pass/Fail Results
1	2/07/22 - 2/14/22	Enoch	<b>Set up a mock website</b> (without using code) using JustinMind, a design and prototyping tool for web and mobile apps	Functional, basic website with multiple pages that appeals to marketing side	Website worked	Pass

2	2/20/22 - 2/28/22	Enoch	<b>Set up a mock webpage</b> , using HTML and a form action to send input data to a text file	Functional HTML webpage that would send data to a text file	Webpage worked, but the write to a text file failed	Fail
3	3/01/22 - 3/11/22	Enoch	<b>Implement PHP</b> code to write to a text file without using a web server	Successful integration of HTML and php code to write to a text file	Ended up only implementing a separate php-only code to write to a text file. Had to use a web server with Visual Studio for it to work. Could not integrate with HTML	Fail
11	2/28/22- 3/6/22	David/Jayven	<b>Get flask installed on Pi</b> Get a webserver running to host our webpage Model: Raspberry Pi 4	Everything to work out the box with python and php webpages	Php not native to Flask. Switch from Flask to apache	Fail
12	3/7/22- 3/28/22	David/Jayven	<b>Write logic from Arduino to Python</b> Convert old logic to new  Model: Raspberry Pi 4	Everything to work out the box	Logic worked. Encountered some issues with temp sensors failing to read sometimes	Pass
4	3/12/22- 3/23/22	Enoch	Using skeleton code provided by Javyen, <b>create and implement a webpage using HTML and CSS</b> . Also include a simple form method to read user input	Functional, more professionally appealing webpage with a working HTML form	Much more appealing webpage than initial first draft of our webpage. PHP write to text file will be handled by Javyen	Pass
5	3/28/22- 4/03/22	Enoch	<b>Research on how to scale inserted images</b> and background images and have them appear properly whether using a PC or mobile device	Expected a properly scaled background image across any device (mobile, tablet, PC).	Using the same background image, got the code to scale the background image, but the image used for the PC version ended up not being compatible with smaller devices.	Pass
6	4/4/22- 4/8/22	Jayven/David	<b>Migrate Enoch's html page to Pi's main logic</b> Enoch has provided us with an HTML page we will be using.  Model: Raspberry Pi 4 SN:	Php logic is working in conjunction to main python script	Php is writing correctly and producing expected results	Pass
7	4/04/22- 4/10/22	Enoch	<b>Add a couple of pages to our webpage</b> , including an About Us and a changelog page	Successful implementation of an About Us and changelog page using HTML	TBD	TBD

8	4/11/22-4/17/22	Enoch	<b>Look for a separate background image</b> for mobile-only version of our website and have that properly scaled on a mobile device	Properly scaled background image on viewing our webpage on a mobile device while leaving the PC version the same	TBD	TBD
9	4/18/22-4/24/22	Enoch	<b>Finishing touches</b> on website to make it look professional	Functional, professional website	TBD	TBD

### **Appendix C. Mechanical Aspects**

The following is taken straight from A-5 as the only mechanical aspect of our side is solar powered. We had to calculate the amount of electricity we would be using with our fan and then work backwards in finding the best battery to use with capacity, and power inverter.

We will first calculate how much our panel can produce. Our panel is rated for a max of 20V and 5A. When testing under 2 conditions: sunny and cloudy/overcast, we actually had somewhat results. On a sunny day, we recorded a max of 17.2v coming from the panel under direct sun. On the overcast day, we had a result of 13.5v. We expected it to be half the amount or more from our max recording but surprised it was still pulling in somewhat near conditions of a sunny day.

Now in order to calculate how long it will take to charge our battery, we first divide panel wattage by battery voltage to estimate max charge current by charge controller:

$$100w/12v = 8.33a.$$

Next to take account from system losses in charge controller to battery. Since we use a PWM controller for a smaller system, we use 75%. If MPPT, use 95%:  $8.33a * (1-15%) * 75% = 5.31a$ .

Next multiply battery capacity by 1 over battery charge efficiency. Lead acid is 85%, lithium 95%:  $20ah * (1/95%) = 21ah$

Next divide battery capacity by current to charge the whole battery:  $21ah/5.31a = 3.95$  hours.

Now we have to take in account discharge levels and absorption charging stages. Our battery doesn't have documentation of depth of discharge but let's assume 50% of total battery capacity:

$$3.95 * 50% = 1.97 \text{ hours.}$$

Absorption would be an additional 2 hours to be sure the battery is at max: **3.97 hours.**

With this information, it should take roughly 4 hours under max sunlight to achieve a full charge

with our current setup. As mentioned before, we have a max at 17.2v for sunny days and 13.5v on a cloudy day. Let's take this in account. 17.2v from 20v max is roughly 15% and 13.5 from 20v is 39%. Adding this loss to the time taken, will include an additional time of **.60 hours for sunny days, and 1.54 hours on cloudy days.** This means our gross time is: **4.57 hours on sunny days, 5.51 hours on cloudy days.**

## Appendix D. Work Breakdown Structure

<b>Level 1 (Features)</b>	<b>Level 2 (Subtasks)</b>	<b>Level 3 (Work Packages)</b>
Feature 1: Humidity and Temperature Detection and Adjustment		
	Subtask 1.1: Write code for Raspberry Pi-compatible humidity and temperature module DHT11	
		Work Package 1.1.1: Write code to detect current and nearby environmental conditions
		Work Package 1.1.2: Write code that can adjust fan speed, air intake, and temperature conversion using RPi microcontroller
		Work Package 1.1.3: Write code that can use the detected conditions and adjust the user's comfort level accordingly
	Subtask 1.2: Test code with the microcontroller	
		Work Package 1.2.1: Connect PC to microcontroller IDE and test the output of detection code class
		Work Package 1.2.2: Connect PC to microcontroller IDE and test the output of adjustment code class
		Work Package 1.2.3: Test implementation of the two classes
Feature 2: Solar Power		
	Subtask 2.1: Test Power	

		Work Package 2.1.1: Test power intake and output with floor fan
		Work Package 2.1.2: Rationalize power for optimal intake and output
	Subtask 2.2: Connect Panel	
		Work Package 2.2.1: After power is optimized, connect the power to the system
Feature 3: Chargeable Battery		
	Subtask 3.1: Test Power	
		Work Package 3.1.1: Test the speed of charging and how much power the battery can hold
		Work Package 3.1.2: Rationalize power for optimal charging speed and capacity
	Subtask 3.2: Connect Battery with Solar Panel	
		Work Package 3.2.1: Connect the battery to the solar panel, and test power intake and output
		Work Package 3.2.2: Optimize battery so that intake is greater than output by at least 10%
Feature 4: Air Filter		
	Subtask 4.1: Test and Attach Air Filter	
		Work Package 4.1.1: Test air filtering so that air quality indoors is as pure as possible



		Work Package 4.1.2: Attach air filter between indoor and outdoor systems
Feature 5: User-Friendly Interfacing and Look		
	Subtask 5.1: Create web-based User Interface that asks for and implements user preference	
		Work Package 5.1.1: Write code that takes user preference on temperature and humidity level
		Work Package 5.1.2: Implement with this webUI with the system via bluetooth/WiFi
	Subtask 5.2: Final System Assembly	
		Work Package 5.2.1: Make all connections
		Work Package 5.2.2: Plan a schematic that converges all part into one system
		Work Package 5.2.3: Create a satisfying, clean look for the outside of the system

## Appendix E-1. Class Assignments

**Table E-1: Team Members & Class Assignments - Semester 1**

Week	Due Date	Assignment	Assigned Roles for Assignments	Time Taken to Complete Assignment
1	08-30	Team Member Confirmation First Team Leader Starts	1st Team Leader: Enoch - Submits team names	Took a few days to form a team to begin with
3	09-13	1- Individual Problem Statement Report	Everyone: Enoch, Javyen, David, Naser	Varied from each member
4	09-20	Selection of Team's Societal Problem  First Team Activity Report	Javyen submits Week 4 Team Activity Report (Aug 30 - Sept 20)  Javyen: Researched interesting project with a societal problem  Enoch: Research on social issue  David: Come up with and Share Societal Problem  Naser: Brainstorm a societal problem	<u>Individual Tasks</u> Javyen: 42.5 hrs Enoch: 32 hrs David: 42 hrs Naser: 35 hrs
5	09-27	2 - Team Problem Statement Report	Enoch - submits Team Problem Statement	1 hr
5	09-27	Team Activity Report	Enoch submits Week 5 Team Activity Report: Each team member fills out their tasks/activities  Javyen: Researched interesting project with a societal problem, wrote about solar power and use in project  Enoch: Research on social issue, temperatures, and HVAC  David: Formatting, Document Creation, Write about Global Warming  Naser: Cover design concepts and conclusions	<u>Individual Tasks</u> Javyen: 20 hrs Enoch: 11 hrs David: 17 hrs Naser: 15 hrs
6	10-04	3-Design Idea Report (Draft)	Enoch submits Design Idea Report (Draft)	1 hr

6	10-04	Team Activity Report	<p>Enoch submits Week 6 Team Activity Report: Each team member fills out their tasks/activities</p> <p>Javyen: Organize team a bit more, talk about project part alternatives, add to project reports</p> <p>Enoch: Contribute to design philosophy and what makes our project unique, familiarized overall project idea more: pros and cons</p> <p>David: Format, add intro, abstract, conclusion, brainstorming ideas, and tables for Design Process Report. Create and enter resume</p> <p>Naser: Punch List and Measurable Metrics.</p>	<p><u>Individual Tasks</u> Jayven: 13 hrs Enoch: 14 hrs David: 16 hrs Naser: 15 hrs</p>
6	10-08	Team Member Evaluations Due Friday midnight 10/08/2021	Everyone: Enoch, Javyen, David, Naser	Varied from each member
7	10-11	3-Design Idea "Contract" <u>Approval Due</u>	Finalized Design Idea Report	1 hr
7	10-11	Team Activity Report	<p>Enoch submits Week 7 Team Activity Report: Each team member fills out their tasks/activities</p> <p>Javyen: Finalize project parts and begin looking at potential libraries needed for creating logic</p> <p>Enoch: Discussed about difficulties with project details and aligned that to what Professor Cottle wanted, received feedback from teammates and edited final project report in response to feedback</p> <p>David: Attend team meetings with Professor Cottle and the lab group. Continue researching parts and discuss price distribution with the Professor and the team.</p> <p>Naser: Met with Cottle and received the feedback on the contract report, research for parts on the company's websites</p>	<p><u>Individual Tasks</u> Jayven: 12 hrs Enoch: 10 hrs David: 11 hrs Naser: 15 hrs</p>
8	10-18	Team Activity Report	<p>Enoch submits Week 8 Team Activity Report: Each team member fills out their tasks/activities</p> <p>Javyen: Look at hardware limitations/benefits of each microcontroller</p> <p>Enoch: Ensure communication with team is going</p>	<p><u>Individual Tasks</u> Jayven: 20 hrs Enoch: 12 hrs David: 18 hrs Naser: 14 hrs</p>

			<p>smoothly, research what arduino to use</p> <p>David: Research ways to implement a temperature and humidity module to the system, set up and format work breakdown structure document, make edits to previous reports, discuss project schematic with team</p> <p>Naser: Research for the parts, design the electrical connection of the circuit used to sense the temperature and the humidity of the air.</p>	
9	10-25	4-Work Breakdown Structure Report	Enoch submits WBS Report	1 hr
9	10-25	First Outgoing Team Leader Report	Enoch submits first team leader report	1 hr
9	10-25	Team Activity Report	<p>Enoch submits Week 9 Team Activity Report: Each team member fills out their tasks/activities</p> <p>Javyen: Looked into microprocessing and expected amount of code in the final project. Looked into potential web based apps</p> <p>Enoch: Work on WBS report: recorded team members' tasks for each assignment thus far and number of hours for each team activity report thus far. Completed team leader outgoing report</p> <p>David: Fill out Work Breakdown Structure sections: intro, conclusion, abstract, and executive summary, make updates as needed, make a list of our tasks, fill out team member responsibilities, and create the WBS grid</p> <p>Naser: Work on the breakdown structure, specifically on the course assignments we've done and those coming up.</p>	<p><u>Individual Tasks</u> Jayven: 17 hrs Enoch: hrs David: 16 hrs Naser: 14 hrs</p>
10	11-01	5-Project Timeline Team Activity Report	2nd team leader: Javyen takes over and submits Week 10 Team Activity Report	<p><u>Estimated Amount of Time Taken for Submission (TA Report):</u> Jayven: 15 hrs Enoch: 15 hrs David: 15 hrs</p>

				Naser: 15 hrs
11	11-08	6-Risk Assessment Report  Team Activity Report	Javyen submits 6-Risk Assessment Report & Week 11 Team Activity Report	<u>Estimated Amount of Time Taken for Submission (TA Report):</u> Jayven: 15 hrs Enoch: 15 hrs David: 15 hrs Naser: 15 hrs
12	11-15	<i>Prototype Progress Review</i>  Team Activity Report	Javyen submits Week 12 Team Activity Report	<u>Estimated Amount of Time Taken for Submission (TA Report):</u> Jayven: 15 hrs Enoch: 15 hrs David: 15 hrs Naser: 15 hrs
13	11-22	Team Activity Report  Complete team member evaluations by Friday midnight Nov 26, 2021.	Javyen submits Week 13 Team Activity Report	<u>Estimated Amount of Time Taken for Submission (TA Report):</u> Jayven: 15 hrs Enoch: 15 hrs David: 15 hrs Naser: 15 hrs
14	11-29	Last Team Activity Report for Fall semester Team Work Evaluation  Second Outgoing Team leader report	Javyen submits Last Team Activity Report for Fall semester	<u>Estimated Amount of Time Taken for Submission (TA Report):</u> Jayven: 15 hrs Enoch: 15 hrs David: 15 hrs Naser: 15 hrs
15	12-06  12-10	7 – Project Technical Evaluation Presentation  Public presentations will be on Friday 12/10 University Union, 9:30 am to noon.  Third Team leader takes over 12/11/2021	Javyen submits Project Technical Evaluation Presentation	<u>Estimated Amount of Time Taken for Submission:</u> 1 hr

**Table E-2: Team Members & Class Assignments - Semester 2**

<b>Week</b>	<b>Date</b>	<b>Topic to be discussed</b>	<b>Lab Assignments due</b>
1	01-24	Team-Instructor Meetings and Lecture	Team Activity Report
2	01-31	Team Presentations on problem statement revisions and Report Submission by David	Assign 1: Revised Problem Statement Team Activity Report
3	02-07	Team-Instructor Meetings	Assign 2: Device Test Plan Report Team Activity Report
4	02-14	Team Presentations	<i>Prototype Progress Review</i> Team Activity Report
5	02-21	Team-Instructor Meetings	Team Activity Report
6	02-28	Team Presentations	Assign 3: Market Review Team Activity Report
7	03-07	Feature presentations	Assign 4: Feature Report Team Activity Report Team Member Evaluations due by Friday March 11, 2022 at 5 pm
8	03-14	Feature presentations	Outgoing Team Leader Written Report Fourth Team Leader Starts on 3/15/2022 Team Activity Report Instructor feedback on team member evaluations
10	03-28	Team Presentations	<i>Prototype Progress Review</i> Team Activity Report

11	04-04	Team-Instructor Meetings	Assign 5: Testing Results Report Team Activity Report
12	04-11	Team-Instructor Meetings	Team Activity Report Team Member Evaluations due by Friday April 15, 2022 at 5 pm
13	04-18	Team-Instructor Meetings	Fourth Outgoing Team Leader Report Last Team Activity Report Instructor feedback on team member evaluations
14	04-25	Team Presentations	Assign 7: Deployable Prototype Eval Last date for prototype credit
15	05-02	Documentation review View end of project video	Assign 8: End of Project Report Viewing of your three-minute video and annotated team picture.
16	05-09 05-13	No lab	Assign: 9: Deployable Prototype Public Presentation Friday 5/13/2022 starting at 9:30 AM until 12:00 pm Location to be determined

## Appendix E-2. Project Timeline: Gantt Chart and PERT Diagram

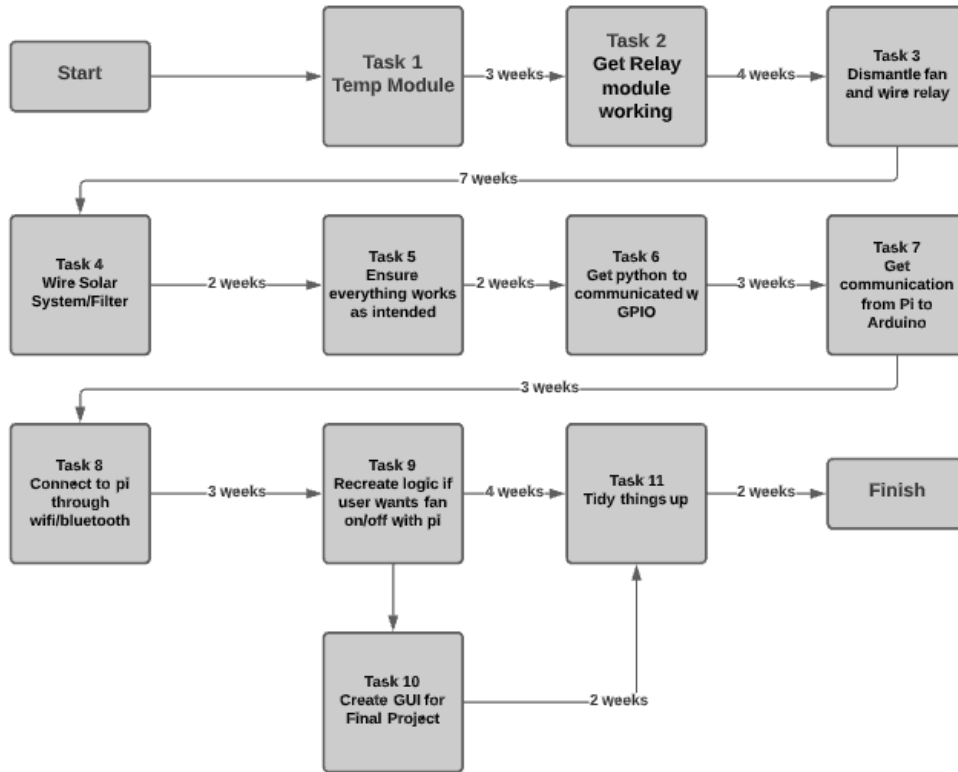
**Table E-3: Project and Assignment Dates with Individual Tasks**

Task/Designer(s)	Start Dates	End Dates	Notes	Designers	Team Leaders
Temp Module	11/1/21	11/15/21	Nov 15 prototype day	David, Enoch	Jayven
5 Project Timeline		11/1/21			
6-Risk Assessment		11/8/21			
Week 11 Team Act Report		11/8/21			
Get Relay module working	11/16/21	12/6/21		David, Jayven, Enoch	
Week 12 Team Act Report		11/15/21			
Week 13 Team Act Report+Team Leader Report		11/22/21			
Team Member Evaluations		11/26/21			
Week 14 Team Work + Team Member Evaluations		11/29/21			
Dismantle fan and wire relay	12/6/21	1/17/22	Rolls into Winter break	Naser	
Assignment 7 Project Technical Evaluation		12/6/21			
Assignment 8 Laboratory Prototype Presentation		12/10/21			
Wire Solar System/Filter	1/24/22	1/31/22		Jayven, David	
Sprint Semester Review		1/24/22			
Device Test Plan Report Device testing and validation		1/31/22			David
Ensure everything works as intended	1/31/22	2/7/22		Collectively	
Market review		2/7/22			
Get python to communicated w GPIO	2/7/22	2/21/22	Start on pi integration	Jayven	
Market review		2/14/22			
Lifelong learning		2/21/22			
Get communication from Pi to Arduino	2/21/22	3/7/22		Jayven	
Intellectual Property		2/28/22			
Connect to pi through wifi/bluetooth	3/7/22	3/21/22	This rolls into Spring break	Jayven, David, Enoch	Naser



Intellectual Property		3/7/22			
Engineering Ethics		3/14/22			
Recreate logic if user wants fan on/off with pi	3/21/22	4/11/22		Jayven,David,Enoch	
Engineering Ethics		3/28/22			
Engineering Ethics		4/4/22			
Create GUI for Final Project	4/4/22	4/11/22		Jayven,Enoch	
Post-Project Audit + End of Project Documentation		4/11/22			
Tidy things up	4/11/22	4/18/22	Finish	Collectively	
Assignment 6 Ethics quiz		4/18/22			
Quality Control		4/25/22			

**Figure E-1: PERT Diagram**



**Table E-4: Gantt Chart**

Task/Date	10/24/21-10/30/21	10/31/21-11/6/21	11/7/21-11/13/21	11/14/21-11/20/21	11/21/21-11/27/21	11/28/21-12/4/21	12/5/21-12/11/21	12/12/21-12/18/21	12/19/21-12/25/21	12/26/21-1/1/22	1/2/22-1/8/22	1/9/22-1/15/22	1/16/22-1/22/22	1/23/22-1/29/22	1/30/22-2/5/22	2/6/22-2/12/22	2/13/22-2/19/22	2/20/22-2/26/22	2/27/22-3/5/22	3/6/22-3/12/22	3/13/22-3/19/22	3/20/22-3/26/22	3/27/22-4/2/22	4/3/22-4/9/22	4/10/22-4/16/22	4/17/22-4/23/22	4/24/22-4/30/22	5/1/22-5/7/22	
Temp Module	█																												
Get Relay module working		█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
Dismantle fan and wire relay																													
Wire Solar System/Filter																													
Ensure everything works as intended																													
Get python to communicated w GPIO																													
Get communication from Pi to Arduino																													
Connect to pi through wifi/bluetooth																													
Recreate logic if user wants fan on/off with pi																													
Create GUI for Final Project																													
Tidy things up																													

## Appendix F. Resumes

# DAVID SANTIAGO

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davidsantiago@email.com

### Education

**Bachelor of Science: Computer Engineering, Expected in 05/2022**  
**California State University - Sacramento - Sacramento, CA**

### Professional Summary

Detail-oriented Computer Systems Engineer committed to improving system design and operations for reliable workflow management. Researches and implements budget-conscious solutions to find engineered solutions to societal problems. Skilled in many computer low and high level programming languages, as well as circuit building. Creates easy-to-follow guidelines and documentation for non-technical staff. Is, just as well, capable of following instructions given to him.

### Skills

- Account Posting
- Relationship Building
- Itemized Statement Preparation
- Categorizing and Classification
- Attention to Detail
- Analytical and Methodical
- Training Materials Development
- Error Identification and Correction
- Software Application Testing
- Web Development Software
- Agile/Scrum Methodology
- Programming Languages: Java, C#, .html, Python, C++, Assembly
- Source and Version Control: Git, Github
- Microchip Integration
- Circuitry Building
- Troubleshooting skills

### Work History

**Invoice Associate, 06/2017 to 05/2019**

**Almar Trucking – San Francisco, CA**

- Received and sorted mail, prepared packages for delivery and scanned documents.
- Monitored outstanding invoices and performed collections duties.
- Entered invoices requiring payment and disbursed amounts via check, electronic transfer or bank draft.
- Used data entry skills to accurately document and input statements.
- Managed invoicing and payment processing operations.
- Collected data to complete detailed financial reports for stakeholders and management.

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## Jayven Khoonsirivong

10233 Mono Ct Stockton, CA 95219 | 209-684-2876 | [jayvenkhoonsirivong@gmail.com](mailto:jayvenkhoonsirivong@gmail.com)

### EDUCATION

#### Sacramento State University

August 2017 - Present

Major: Computer Engineering | Degree: In Progress | Status: Full-Time

Relevant Coursework: Logic Design, Unix Programming, Algorithm Analysis, Java, Object Oriented Structures, Computer Interfacing

### SKILLS

#### Software:

- Strong knowledge of Java
- Basic knowledge of C, Swift, Obj-C, x86 Intel Assembly language, and bash
- Windows, MacOS, and Linux distro friendly

#### Hardware:

- FPGA, Nucleo board, Propeller board, Arduino
  - Pin declaration, stepper motors, LEDs, potentiometers, photoresistors
- Knowledge of circuits/breadboards
- Basic soldering skills
- Custom RJ-45 cable lengths with crimper/tester

### PERSONAL PROJECTS

#### Automated window blinds

July 2017

- This device is able to detect the sunlight and turn the blinds on my window open or close depending on the time of day automatically
- Blinds are also integrated with Alexa to be controllable with the smart home device

#### Smart Garage Opener

July 2017

- Used an ESP8266-based arduino board to control a relay to open/close a garage
- Fully functional with Alexa to open/close

#### Home Media Server

December 2019

- Automatically fetches content, downloads, and stores in correct storage containers through various custom scripts

#### Functional 4-way Stop Light Intersection

- Using both the Nucleo Development board as well as the Parallax Propeller board, a simulation of a vehicle intersection was created. Logic coded with just the Nucleo Board with leds, and Parallax Propeller board integrated the same logic but included a push button for a crosswalk, 7 segment display as a timer, as well as a piezo beeper.

#### Custom Stream Deck (Macro Keyboard)

June 2021

- Used Flask, HTML, CSS, Javascript, and Python to have custom macros for my computer to activate certain events while streaming.
- Used iPad as main unit but allowed Flask to run on any machine pointed to my local computer's IP hosting the server

### EXPERIENCE

#### Chipotle; Stockton, CA - Crew

June 2018 - Present

- Persistently completing hundreds of customer's orders per shift accurately
- Responsible for online, in-store orders, and catering orders
- Successfully can complete the store's throughput goal during major rushes
- Trained new hires on their position in the store

#### Self-Employed iPhone Screen Service - Technician

Jan 2015 - Jan 2019

- Repaired iPhone screens in a timely manner with accuracy
- Recognized devices suitable for repair and issued quotes
- Responded to clients, recorded appointment times, and logged schedules into excel

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#### Informational Technologies; Sacramento, CA - Student Assistant

Jan 2021 - Present

- Maintain staff computers and run any required updates on organization software
  - 375 workstations, 100 mobile devices, 25 digital signs, 30 printers, 180 cameras, 2 nvr
- Make and run scripts for imaging computers
- Have a mastery in troubleshooting technical issues

### Qualifications

- Knowledge of graphic design, video editing, and computer utilization
- Ability to evaluate obstacles and proceed to problem solve
- Passionate to improve self-efficiency and complete tasks in a timely manner individually and with a team



# Nassrallah Alnamrouti

✉ naser1namrouti1@yahoo.com

## PROFESSIONAL SUMMARY

Highly motivated Sales Associate with extensive customer service and sales experience. Outgoing sales professional with track record of driving increased sales, improving buying experience and elevating company profile with target market.

## SKILLS

- Handling and sorting mail
- Postal law proficiency
- Post office operations
- Mailing restriction expertise
- Workplace safety
- Problem-solving skills
- Federal guideline proficiency
- Responsible

## WORK HISTORY

### MAIL HANDLER ASSISTANT

12/2015 to CURRENT

#### UPS

- Loaded letters onto processing equipment, removed non-processable letters and maintained continuous sorting feed.
- Released registered and special delivery letters and packages to designated recipients and obtained signatures for release.
- Used automated mail processing equipment to sort and collate mail.
- Sorted and placed mail into mailboxes and post office boxes with high levels of accuracy.
- Improved operations through consistent hard work and dedication.
- Quickly learned new skills and applied them to daily tasks, improving efficiency and productivity.
- Demonstrated respect, friendliness and willingness to help wherever needed.
- Worked flexible hours; night, weekend, and holiday shifts.



# Enoch Hsu

📍 Cordova, CA 95670 📞 (916) 834 - 1390 ✉ enochhsu5@gmail.com

## PROFESSIONAL SUMMARY

Student IT on campus with 2 years of experience in data management, troubleshooting, communications, and customer service. Successful at managing multiple priorities with a positive attitude. Willingness to take on added responsibilities to meet team goals.

## SKILLS

- Performance improvement
- Individual and group instruction
- Scheduling
- Repair
- Technical Support
- Sorting
- Administrative support
- Interpersonal Communication
- Teambuilding
- Organization and Time management

## WORK HISTORY

**ATHLETICS IT STUDENT ASSISTANT** 09/2018 to CURRENT

**California State University | Sacramento, CA**

- Installation of computer stations.
- Configure Windows operating system.
- Troubleshoot for athletics staff.
- Manage inventory of office supplies.
- Reported back to instructor to receive day-to-day tasks and responsibilities.
- Performed administrative duties and staff support tasks.
- Sorted and organized files, spreadsheets and reports.

**STUDENT INTERN IT** 06/2018 to 08/2018

**California State University, College Readiness**

- Installation of computer stations.
- Troubleshoot for Student Affairs staff.
- Manage inventory of office supplies.
- Answered incoming telephone calls, took down messages and provided information.
- Greeted incoming office visitors, answered questions and directed individuals to office locations.
- Communicated effectively with faculty and staff and accepted critiques and suggestions for areas of improvement.

**STUDENT INTERN** 01/2017 to 03/2017

**Walgreens | Sacramento, CA**

- 140 hour paid internship.
- Assisted customers to ensure satisfaction.
- Analyzed problems, identified solutions and made decisions.
- Maintained organized inventory by checking stock to determine supply levels, expediting orders and delivering materials to work stations.
- Collaborated in professional team to solve workflow issues.

## EDUCATION

**Bachelor of Science | Computer Engineering** EXPECTED IN 12/2022

**California State University of Sacramento, Sacramento**

**High School Diploma** 06/2017

**John F. Kennedy High School, Sacramento**

- Four-year marching band
- Member of PACE: Program in American and Californian Exploration

**Appendix G. Team Photo**

