

Cooling Humidified Umbrella For Multiple Sclerosis Patients

Team # 6

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Sponsor: Community Partners, Multiple Sclerosis Patients, and Sinus Problems Patients

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## **Executive Summary**

The problem that must be solved in this project is concerning patients with multiple sclerosis. These patients are unable to leave the house during summer as warmer temperatures cause respiratory issues and hot flashes. As of currently, the only solution to this problem is placing a cold vapor humidifier in front of the breathing organs. This is a problem as well as all humidifiers are electric and must be plugged into an outlet to function. A portable cold vapor dispenser will allow these patients to leave their houses even on hot days.

Currently, all humidifiers are electric and must be supplied with constant electricity to function. This is ineffective as this forces patients to constantly be near a power source. The main problem is to create a lightweight portable vapor dispensing device that will allow these patients to have more freedom in their daily life. The needs of the patients are for those leaving their house on a hot day. Thus, what should be considered is a way to address the issue of patients having difficulty breathing and staying out in the heat for too long in patients with multiple sclerosis that will allow for these patients to have more opportunity to leave their houses during hot weather.

The key requirements for this project are: creating an umbrella that is the same weight or near to the same weight as an average umbrella, battery-powered, portable/easy to carry, and safe cold vapor dispenser. In addition, this dispenser must be cost-effective, contain a water storage unit and function for an hour.

The proposed market for this device will be anyone suffering from respiratory issues, hot flashes, multiple sclerosis or the general public on a hot day.

Social impacts for this device will lead to improved quality of life as well as allowing patients to be more independent. The economic impacts will be increased as this device can be purchased by not only hospitals and patients suffering from respiratory diseases but also regular people who will want to cool down. Clinically, this will allow for patients to be able to leave the house causing them to be healthier and happier. Also, globally, people in hot and dry climates can use this device to live a better life as air-conditioning is not common in many other countries.

## Table of Contents

Title	I
Executive Summary	II
Problem Statement	1
Background and Market Research	2
Requirements/Specifications/Metrics/Standards	8
Proposed Budget	10
Project Management	10
References	14
Appendix A	16
Appendix B - Interview Questions	18
Appendix C - Deliverables	19

## Problem Statement

MS affects roughly 400,000 individuals within the United States in 1975 [5]. Since then, it has been reported that the number of individuals with MS more than doubled in the United States from the 1975 data and has been estimated that 2.3 million people are living with MS worldwide [7]. Currently, there is no known cause for how individuals develop MS; however, there has been statistical evidence showing certain demographics and characteristics can increase one's chances of being diagnosed with MS.

The main problem MS patients face is often being home-bound due to the inability to withstand hot weather. Currently, MS patients are constricted during periods of extreme heat. As a consequence of MS patients being exposed to too much heat, they experience nerve pain and muscle weakness [3]. Furthermore, chances of hot flashes and shortness of breath are likely as well. This is linked to how damaged myelinated nerve cells will disperse signals at a slower velocity [6]. As a result, communication issues arise between the brain and the body.

Presently, methods to lessen the pain caused by MS symptoms have been through medication and therapy. However, with medication, there are many side effects that cause many MS patients with milder symptoms to abstain from them [3]. In regards to therapy, it does not target all of the symptoms faced when patients are exposed to too much heat, such as hot flashes, and shortness of breath [3]. Because of this, there needs to be a way to relieve the pain MS patients face in extreme temperatures.

## Background and Market Research

### Multiple Sclerosis: What is it?

Multiple sclerosis (MS) is believed to be an autoimmune<sup>1</sup> disease that affects the individual's central nervous system (CNS) [3]. The antibodies within the body would target the myelin sheath found on nerve cells, specifically attacked nerve cells part of the CNS [6]. Due to the damage to the myelin sheath, the message delivery speed or the conductive velocity lower<sup>2</sup> [6]. This leads to various symptoms that vary from patient to patient. It is also known to be a chronic disease referring to where symptoms come and go throughout the patient's life [6].

MS is characterized as being both inflammatory and neurodegenerative<sup>3</sup> and the cause of MS is currently unknown [1]. It has been theorized that genetic<sup>4</sup> and environmental factors<sup>5</sup> are causes for MS [6]. Furthermore, research shows that those who are Caucasian will have a greater chance of being diagnosed with MS. Patients will usually receive their first symptoms between the ages of twenty and forty [6]. However, there is a chance for an individual to be diagnosed earlier or later.

There are four types of MS and each type refers to the severity of the condition [6]. The first type is known as clinically isolated syndrome (CIS) [6]. Technically, it is not MS but is usually categorized with MS due to its similarities in symptoms and how it raises the risk of MS

for the patient<sup>6</sup>. Those with CIS will have 24-hour episodes and have a myelin sheath that is damaged or swollen [6]. The second type of MS is known as relapsing-remitting MS (RRMS)<sup>7</sup>. RRMS is the most common of the four types and as stated in the name, is accompanied by relapses<sup>8</sup> of symptoms [6]. Such relapses can be triggered by factors like infections but symptoms do not worsen in between the relapses<sup>9</sup> [6]. Unlike with CIS, there is a period in which symptoms get better or go away<sup>10</sup> [6]. Primary Progressive MS (PPMS)<sup>11</sup> is the third type of MS. Those with PPMS is where MS gets worse over time [6]. Lastly, secondary progressive MS (SPMS)<sup>12</sup> is the final type of MS and the worst type of MS [6]. With SPMS<sup>13</sup>, ongoing relapses and remissions<sup>14</sup> occur where the level of disability of the patient will increase over time [6]. What each of these types all have in common is the various symptoms it shares<sup>15</sup>.

### Multiple Sclerosis: Symptoms

Symptoms for MS derive from the affected CNS. The CNS is made up of the brain, spinal cord and optic nerves [9, Fig. 1],[6]. Its main function is to send messages to the body and back to the brain [6]. Most patients are found to have mild symptoms [6]. However, more severe cases can lead to paralysis, and loss of ability to walk, read, write or speak [6]. The first indicator of MS is the change of eyesight [4]. The change may be, and not limited to, blurriness in vision, color distortion or blindness found in one eye [4]. Other symptoms will have normal sensations, thinking and movement [6]. A few examples include muscle weakness, fatigue, tremors, thinking issues, and balance issues. The graveness of these symptoms is also affected by external factors such as heat [8].

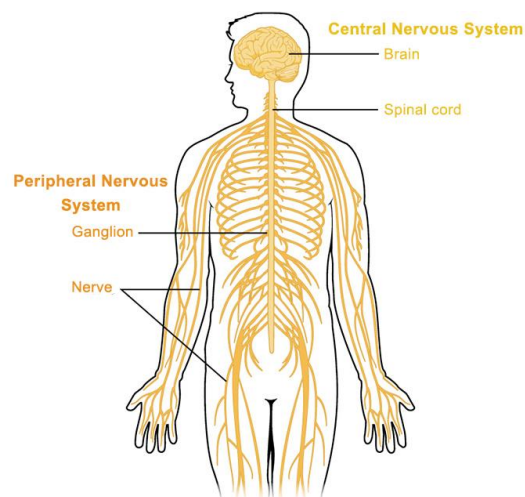


Figure 1. Central Nervous System (CNS)

### Multiple Sclerosis: Thermal Regulation

Thermal regulation has a large impact on the extremity of symptoms<sup>16</sup> [8]. Heat intolerance is related to temperature change on action potential propagation [8]. Because of this, MS patients will undergo worse symptoms exposed to heat such as being outside on a hot

summer day [8]. Exposure to increased temperature will cause an increased temperature on the action potential propagation in the demyelinated axons [8]. As a result, the speed of conduction is either blocked or decreased [8]. It may also produce impaired autonomic and endocrine<sup>17</sup> neural control [8]. This is due to the part of the brain where body temperature regulators and thermoregulatory effectors are found and affected [8]. This leads to daily life limitations for the MS patient and results in many unable to go outside depending on the temperature and humidity [8]. Because of this, MS patients are warned not to be exposed to too much heat due to the chances of nerve pain and muscle weakness occurring.

## Multiple Sclerosis: Diagnostics and Treatment

Diagnostics of MS are done with physicians examining the patient's medical history and a full exam [3]. The full exam includes a blood test, a neurological test<sup>18</sup>, a spinal tap test<sup>19</sup>, and an MRI scan<sup>20</sup> [3]. The purpose of the full exam is to rule out any other possible diseases to avoid misdiagnoses [3]. Furthermore, to be diagnosed with MS, the patient must have two or more areas of the CNS with demyelinated axons [3]. Additionally, the patients must have experienced at least two relapses that caused any damage to the CNS [3].

Currently, there is no cure and one cannot avoid MS<sup>21</sup> [3] Current treatment involves relieving the symptoms and slowing down the progression of MS to be able to live a decent life [3]. Treatments include medication, and occupational, physical or speech therapy [3]. Medication is used to suppress the symptoms and vary depending on the symptom [3]. Furthermore, the severity of MS will also affect the type of medication used [3]. However, such medication usually comes with potential risks or side effects including depression, shortness of breath and increase of relapses [3]. Because of this, many with mild MS have opted out in taking medication and alternatively done therapy [3].

Therapy has been used to aid MS patients in completing daily life tasks in a more effective manner [3]. For example, physical therapy has been used to help with coordination, balance, and pain MS patients face [3]. Depending on the needs of the patient, patients may attend one or a combination of the three different therapies [3]. Nevertheless, therapy is not a cure and can only lessen the pain MS patients feel when relapses occur [3].

## Current products: Heat Relieving Products

To relieve fatigue and symptoms inflammation caused by heat, a few products have been developed to help MS users when faced with high-temperature environments. A few products that have been made are:

- The SunBlok umbrella
- The cooling vest and scarves

The sunBlok umbrella is just like a regular umbrella except for the fact that it supposedly keeps MS users ten or more degrees cooler than regular umbrellas [10]. The diameter of sunBlok

umbrellas are recorded to be 38 inches and can be noted in the figure below as the silver umbrella [10, Fig. 2]. For comparison, it is only found to be twelve inches smaller than a golf umbrella which can be seen in the figure below as a red and white striped umbrella [10, Fig. 2]. It is tested to have helped block most of the heat in a long time (45 minutes) [10]. “After 10 minutes, temps hovered in the rather cool environs of 90.5 degrees. Even after 45 minutes, the SunBLOK shadow registered only 93 degrees--a full 11 degrees cooler than the Conde Nast offering and 8.5 degrees cooler than the larger golf umbrella” [10]. The main advantage of this product is easy to carry around and come in a variety of sizes and designs [10]. However, they are only able to reduce a small quantity of heat [10]. The current method cannot block the heat that is directed towards the customer’s face and leads to the issue of shortness of breath for the user [10].



Figure 2.

Sunblock Umbrella

Cooling vests and scarves have also been used as a cooling relief for MS patients [11]. Such vests can vary in accessories and design [11]. For example, in the figure below, the vest has the cooling packs separate from the vests to allow less space to be taken up in the freezer [11, Fig. 3]. All vests and scarves do require water or ice [11]. Despite this, they are able to help cool the body, despite not covering the face, and help to breathe easily [11]. An advantage of this design is the large diameter that will allow full coverage of the user [11]. However, this also causes inconvenience to the user as well for certain occasions such as parties, or weddings [11]. Similarly to the sunBlok umbrella, it does not provide direct cooling to the face and results in symptoms like short breaths to still be severe [11].



Figure 3. Cooling Vest and Scarf

### Interviews

Interviews were also collected from those who experience hot flashes, respiratory issues, or has MS. Each interview has been recorded and a summarized statement has been recorded below. All questions asked can be found in Appendix B.

Name: Nathalia Peixoto<sup>22</sup>

Dr. Nathalia Peixoto spoke with a 60-year-old patient who was suffering from lung cancer. She was not able to leave her house, due to excessive cough from the hot winds in summer. The patient has tried many types of equipment with different shapes and sizes, they were helpful, but not effective enough for her to spend more than 20 minutes outside. She wanted a portable device like an umbrella with water storage operated with solar panels and which must work for at least one hour.

Dr. Nathalia Peixoto advised the group to create a website for the project and to get in touch with some old- age facilities like Sunrise, to gather more information about their needs.

Name: Louise Albert-Yaffe<sup>23</sup>

Ms. Albert-Yaffe is an individual that has a respiratory disease and a skin disease. It is important to address both as from these two different diseases, she is faced with symptoms that MS patients would face in hot temperatures. Questions asked were regarding what diseases she had as well as the symptoms that come with it. Furthermore, questions regarding how heat affects the symptoms had been asked and how she copes with these symptoms.



Ms. Albert-Yaffe faces a respiratory disease known as reactive airway disease. She had been diagnosed over 5 years ago and explains that the disease is similar to asthma as they share common symptoms. Furthermore, she explains that the disease was chronic and the severity depended on certain triggers including viral infections, humidity, chemical fumes, and extreme weather. She explains that in heat, she experiences shortness of breath, a heavy chest, feelings of bronchial spasm and more fatigue. She also explains that such changes in symptom severity are also found in weather of extreme cold and times of humidity as well. To cope with symptoms she takes medication- specifically an inhaler to ease the respiratory issue. However, the main method she copes with extreme heat is avoiding it. She explains how this is inconvenient for her as she cannot complete the necessary daily tasks and is constantly avoiding areas of extreme heat when traveling.

The other disease that she had mentioned was rosacea. She explains that it is a skin disease that causes flaring of the blood vessels on the face. As a result, swollen red bumps are found on her face and are more severe in hot weather. With this disease, she experiences symptoms including hot flashes and the feeling of a painful sunburn on areas where the bumps are found. To cope with these symptoms, she uses ice packs and places them around her neck to cool down her internal body temperature. Similarly, she uses a fan and cooling scarf to bring down the body temperature. However, she explains how inconvenient this is as the cooling can only last for 30 minutes as the ice packs melted quite quickly. Furthermore, she states that she is not able to use this method during certain events such as dinner parties.

Name: Andera Frick<sup>24</sup>

Ms. Andera Frick is a woman in her early 50, who is going through menopause. Due to which she faces hot flashes in her face and her upper thorax. She does not have any other breathing or health conditions that could cause or affect hot flashes. These hot flashes do not have any trigger and occur daily in the mornings. Sometimes, these tend to skip a day or a week but come back in less than two weeks. She has suffered from these hot flashes for two years and does not take or plan to take any medication to better her situation. Her hot flashes are manageable when she is in an air-conditioned room or air-conditioned car. She finds these to be unmanageable when she is taking a walk outside on a hot day. After 15 minutes of her walk, she either looks for an air-conditioned room or shade under a tree. According to Ms. Andera Frick, her hot flashes have the same intensity either inside or outside her house.

Ms. Andera Frick has tried using cooling packs and splashes water over her face from time to time during these flashes. After a walk outside with hot flashes, she prefers to have a frozen bag over her face for a few minutes. She finds these methods to be effective to some extent, as the cooling effects wears off after some time.

## Market size: Proposed Market Size and Target Market Size

Customers for this project are individuals with Multiple Sclerosis, who suffer from hot flashes and respiratory issues over the summer, or during times of high temperatures. Since there are almost 400,000 people affected by MS in the United States, or 90 cases per 100,000 people [12], the market products for helping MS patients should be expanded. Most cooling products for MS patients are helping them cooling in the body, but not protect their faces, and helping them breathing in hot weather. There are some tips for them to staying cool, but not specifically. These articles recommended them to stay inside with air-conditioner. However, this will prevent them to do a lot of activities outside, especially in the summertime. The market for MS patients is lacking products that can help them enjoy activities outside.

The cooling products can be used not only by MS patients but also other patients with respiratory issues such as asthma or Chronic Obstructive Pulmonary Disease (COPD). Since patients of all issues have the same problem with shortness of breath under high temperature, a cooling umbrella will be an effective solution for them in summer days. This will also make them key customers besides MS patients.

## Potential Impact

The potential impact of heat on MS patients are detrimental. It inhibits them from ongoing daily life and causes them to be mainly homebound during hot weather. Heat and its effects on those with MS, respiratory issues, and the elderly can be quite dangerous depending on the duration of being in the heat or the severity of the condition. Current development, though found positive results, are not practical enough for daily use. Because of this, the development of an alternative method would be beneficial that allows convenience to the user. The user for this product is not only patients suffering from MS or any other respiratory issues, but also people who tend to overheat such as pregnant women, young children or anyone in general who needs to cool off during the hot weather. As in MS patients, patients suffering from other heat related diseases and respiratory issues are unable to stay out in hot temperatures for too long. In addition, this leads to them being dependent on others as well as staying indoors for the summer. As such, this allows those impacted by extreme heat conditions to at least endure the heat much longer without too much severity in their symptoms.

## Requirements, Specifications, Metrics, and Standards

### Requirements

The key requirements for this project are: creating a light weight, battery powered, portable/easy to carry, and safe cold vapor dispenser. In addition, this dispenser must be cost effective, contain a water storage unit and function for an hour. Deliverables can be found in Appendix C that states the components that are necessary for the final product.

### Objective Tree

The figure below displays the objective tree for the development of the humidified umbrella [Fig. 4]. It is branched out initially by practical to make, safe and easy to use and is then further broken down.

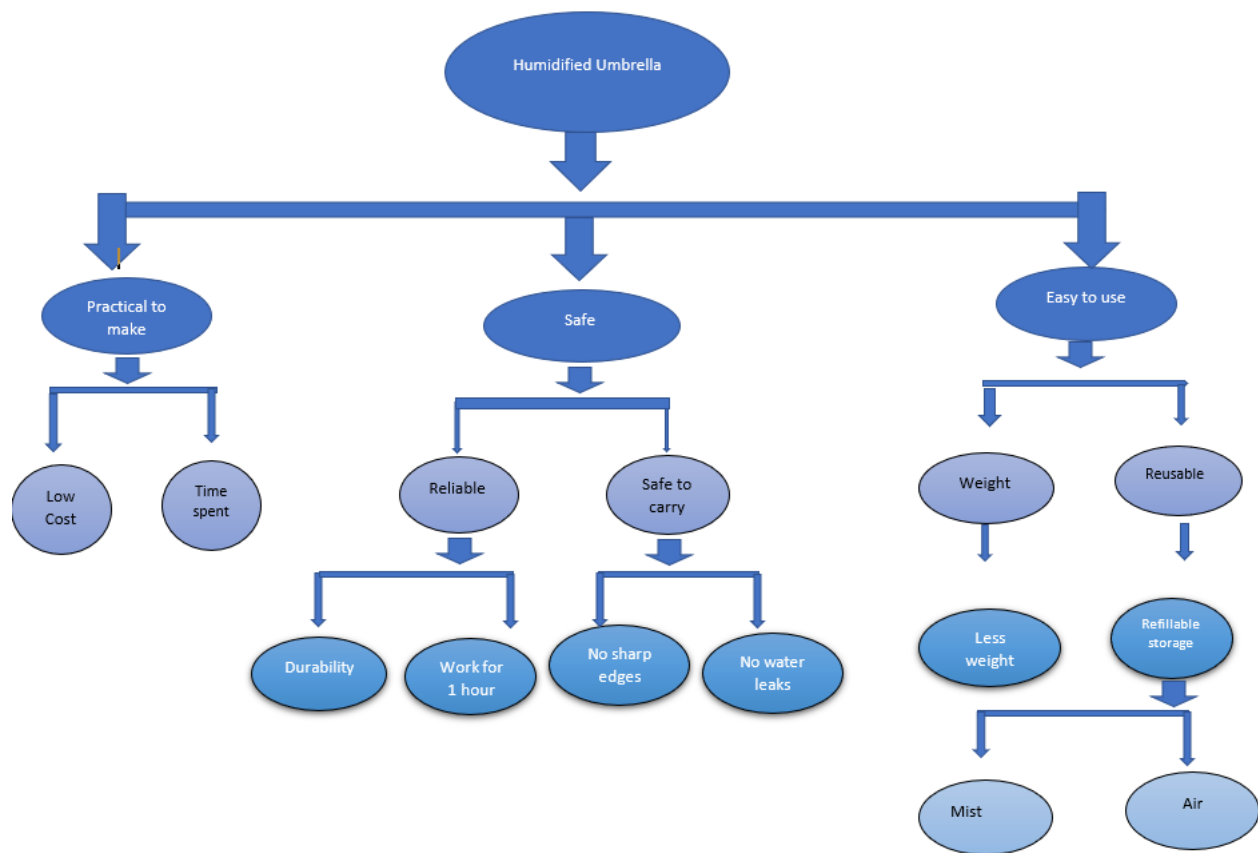


Figure 4.

Objective Tree

## Metric Standards

The final model of our project should follow metric standards that result in a reliable and easy to use the product. For this product, some metrics are:

- Umbrella height
- Umbrella diameter
- Umbrella Weight
- Length of extending handle
- Durability test

## Specification

Specifications were based on current solutions and metrics.

- Umbrella height: The height of the humidified umbrella is no more than 50 centimeters.
- Umbrella weight: The weight of the humidified umbrella is no more than 2 lbs.
- Umbrella diameter- The diameter of the humidified umbrella is no more than 1.5 meter.
- Length of extending handle: The extension length of the humidified umbrella is approximately 50 centimeters.
- Durability test: The humidified umbrella will withstand a 5 meters fall.

## Proposed Budget

The budget for this project is \$100. This will include buying materials such as the umbrella, possibly solar panels, vaporizers, storage containers, tubing, battery, control charger, and 3D printing materials.

## Project Management

### Gantt chart with Major Milestones

Gantt Charts were created to indicate the major milestones for the senior design project this semester. The major milestones were split into four gantt charts labeled as: opening, requirements, preliminary and critical. Each gantt chart displays the range of dates of which each task is worked on as well as the designated individual who will be leading the task. Asterisk (\*) represents that everyone will be working on the assignment and the assigned name is the lead for the assignment.

The preliminary gantt chart displays tasks that are composed of setting up groups and project selection process [Fig. 5]. All duties has since been completed and were tasked out to all members. Secondly, the requirements gantt chart displays the first set of work in relation to client interviews, research, and the writing and presenting of the requirement review draft [Fig. 6]. The third gantt chart is known as the preliminary gantt chart where tasks that are related to preliminary designing process is located [Fig. 7]. Lastly, the critical gantt chart represents the different tasks that are in relation to the critical design as well as the inclusion of material purchasing [Fig. 8]. Each gantt chart represents the different phases for this semester and are subject to change depending on the situational factors.

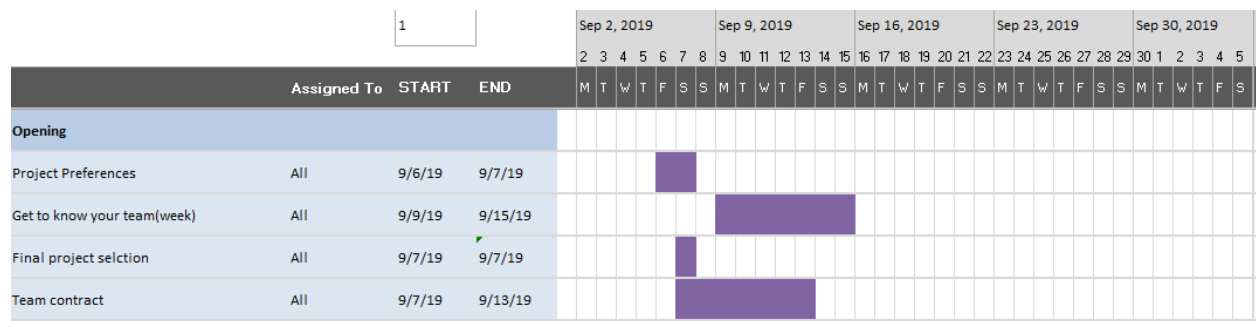


Figure 5. Opening Gantt Chart

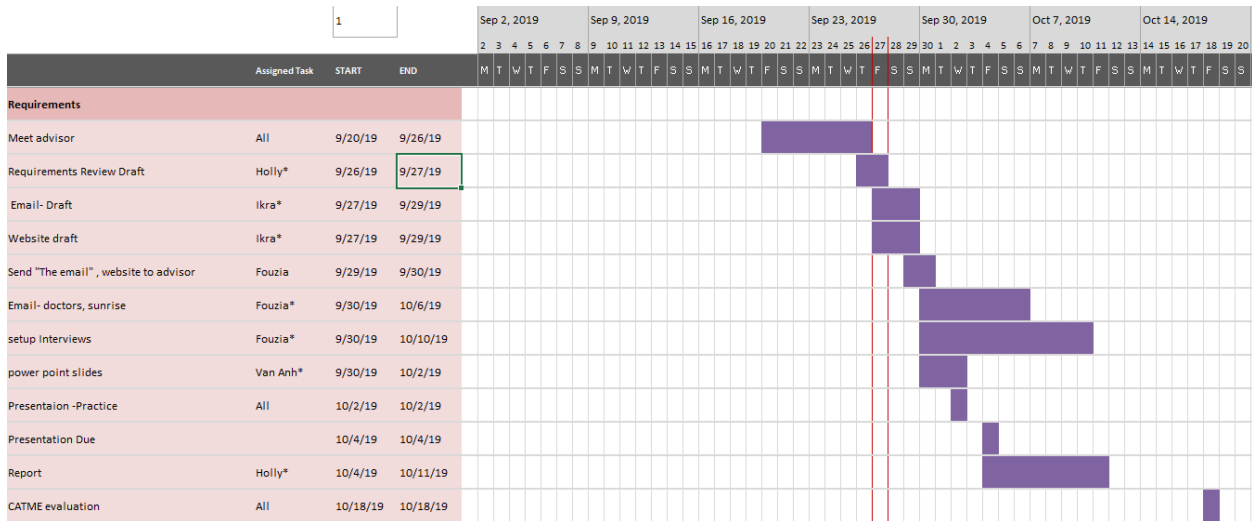


Figure 6. Requirements Gantt Chart

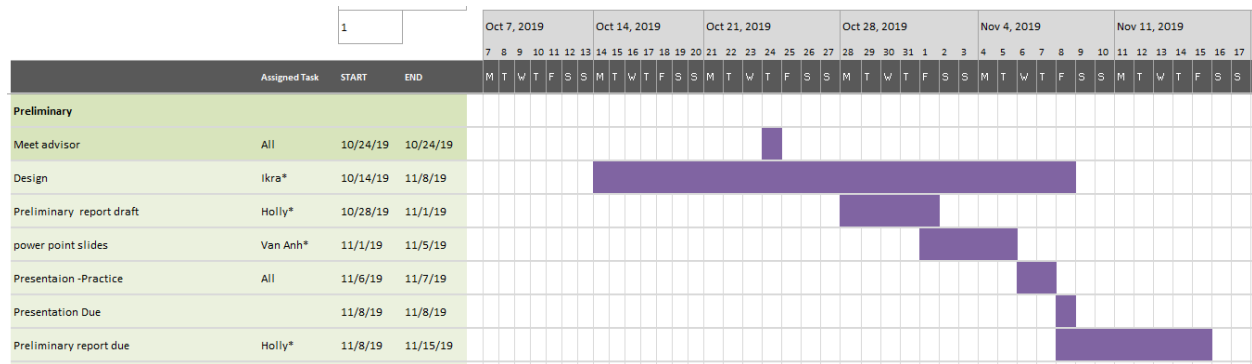
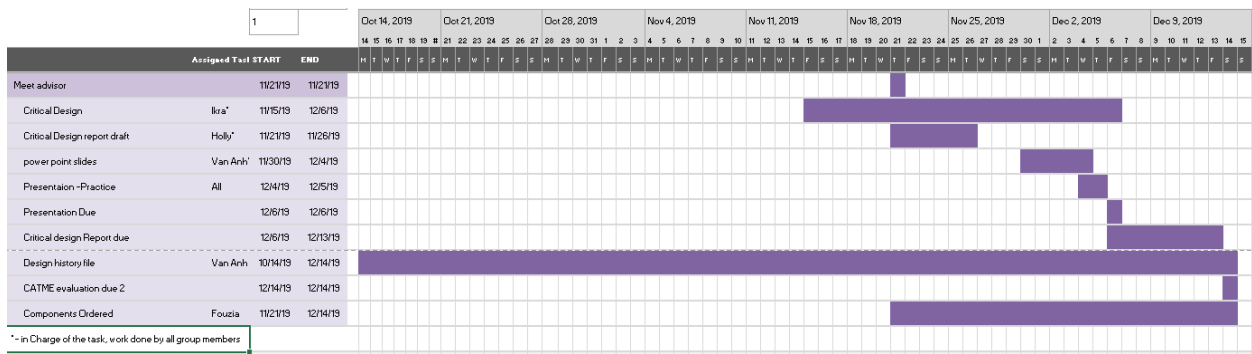


Figure 7. Preliminary Gantt Chart



\* - in charge of the task, work done by all group members

Figure 8. Critical Gantt Chart

## Task Assignment:

Tasks has been divided out amongst the team members. The tasks include and are not limited to: scheduling of meetings, 3D printing process, website development, and budget regulation. Tasks that contain an asterisk (\*) will be completed by all members but is led by the member the task if placed under. This can be seen with the table below [Table I].

Table I  
Divided Tasks for Group Project

Name	Task Assignment
Ikra Chaudhry	<ul style="list-style-type: none"> <li>● 3-D printing: Being present during the printing process and setting up printing process.</li> <li>● Circuit: Main circuit maker.</li> <li>● “The Email ”*: Development of an email sent out to those we plan to interview.</li> <li>● Website *: Development of the team project website for those involved to view.</li> </ul>
Van Anh Tran	<ul style="list-style-type: none"> <li>● Submission of work: Making sure all work is turned in on time for each assignment.</li> <li>● Inventor: In charge of developing the CAD file.</li> <li>● Note-taker: Taking notes during interview and maintain all the required paperwork, Recording minutes during meetings.</li> </ul>
Fouzia Syed	<ul style="list-style-type: none"> <li>● Interviews set up*: Ensuring interviews are set up and allow at least two team members to be present during the interview.</li> <li>● Inventor: In charge of developing the CAD file.</li> <li>● Budget*: Monitoring budget use and final decision maker for certain materials.</li> </ul>

Holly To	<ul style="list-style-type: none"> <li>● Main Writer -Reports*: Focused on making sure reports are coherent and have all the required information.</li> <li>● 3-D printing: Being present during the printing process and setting up printing process.</li> </ul>
All	<ul style="list-style-type: none"> <li>● Research: This includes annotating articles, journals, etc. regarding information about MS, humidifiers or anything that is deemed useful for the project.</li> <li>● Design: Designing of the product will be done as a group.</li> <li>● Coding(if applicable): Coding will be done if applicable depending on the route taken for the design and the parts used.</li> <li>● Safety: Certain trainings will be completed by all members to ensure safety in the project. Furthermore, ensuring that the product is user safe and will not cause any risks or hazards will also be done collectively.</li> </ul>

Note- \* In charge of the task (work done by all students)



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## Appendix A

1. Normally antibodies would protect and attack foreign substances. When an individual has an autoimmune disease, the individual's antibodies would mistake its own body as a threat and begin to attack healthy cells.
2. Demyelination specifically affects the saltatory conduction which in turn decreases conduction velocity possibly cause conduction blockage [8].
3. There have been various theories on the development of MS as well. For example, one theory revolves around the inflammation of the CNS occurring first and transitions to neurodegeneration [1].
4. There have been statistical data that shows that those with one autoimmune disease will likely have another. This makes it possible for these individuals to gain MS in the future. Furthermore, the risk of being diagnosed with MS increases if someone in your family has MS [6].
5. Those who live in milder climate regions will have a higher risk of being diagnosed with MS [6].
6. For the risk of MS to raise, a lesion should be present and can be identified by taking an MRI scan [6].
7. 50% of untreated MS patients will likely have RRMS after ten to fifteen years with the disease [6].
8. Relapses are defined by having relapses occur for 24 hours and have the symptoms to occur thirty or more days after the last relapse [6].
9. Older symptoms can worsen during the relapses or newer symptoms can be gained [6].
10. This period in RRMS allows the characterization of partial recovery as symptoms can get better or disappear [1].
11. 15% of MS patients will likely have PPMS after ten to fifteen years with the disease [1].
12. 50% of Patients with RRMS, will develop SPMS [6].
13. Patients with SPMS will have a higher chance of new lesions to form [6]. This is dangerous as lesions can cause permanent damage to the nerves [6].
14. The period in which symptoms get better or go away [6].
15. The severity of the symptoms, the presence of lesions, relapses, and remissions will determine the type of MS a patient.
16. Most symptoms- such as dizziness, and muscle fatigue- branch from fatigue which often increases with the warm environment [2].
17. An example of an endocrine gland is the eccrine sweat gland [8]. In MS patients, the reduction of sweating is caused by the changes in the eccrine sweat gland [8].
18. The neurological test ensues how well the CNS is working by observing the movement of the eye, coordination, reflex, and speech [3].

19. The spinal tap, also known as lumbar puncture, reveals the number of abnormalities of the blood cells or proteins [3]. For this test, a fluid sample is taken from the spine and analyzed [3]. This rules out any viral infections or any other possible conditions [3].
20. MRI scans are done for the patient's brain and the spinal cord [3]. Lesions found in these areas are detected [3]. However, the presence of a lesion does not guarantee that the patient has MS [3].
21. MS is not gained based on lifestyle changes but can worsen with lifestyle changes [3].
22. Dr. Peixoto is the advisor to our senior design project. The interview took place on September 26<sup>th</sup> and was the first meeting with our advisor. Interview was completed in person.
23. Ms. Albert-Yaffe is a coworker of Holly where she agreed to be interviewed on October 1<sup>st</sup>. Interview was completed in person.
24. Ms. Frick is a former coworker of Fouzia where she agreed to be interviewed on October 3<sup>rd</sup>. The interview was taken over a phone call.

## Appendix B - Interview Questions

1. Questions used for the interview with Dr. Peixoto:
  - a. Who was the client you had spoken to and what were their disease condition?
  - b. What is the issue that she faced?
  - c. What were her coping mechanisms and what issues did she face with them?
  - d. What improvements would she like based on the current equipment or methods she tried?
  - e. For the group project, what would you advise to interview individuals with similar issues?
2. Questions used for the interview with Ms. Albert-Yaffe:
  - a. What is the disease that you have and what does it entail?
  - b. What are the symptoms for the disease you face and how does it affect you in heat?
  - c. Do symptoms worsen when you are in heat and do new symptoms emerge?
  - d. What have you done to cope with this disease? Please explain.
  - e. What are the advantages and disadvantages you have found with your coping methods?
3. Questions used for the interview with Mr. Frick:
  - a. What disease do you have?
  - b. Do you have any disease that relate to breathing difficulty?
  - c. Do you have any other disease that we need to know about?
  - d. How long did you have hot flashes?
  - e. When and where do you have them?
  - f. Does the intensity change from time to time?
  - g. Any incidents that may trigger these hot flashes?
  - h. How long do the hot flashes last?
  - i. How do hot flashes affect you on a hot day on the street?
  - j. Have you taken any medication to improve this?
  - k. Have the methods found to be effective and why do you think so?
  - l. Have you used any other products that you think will be helpful?
  - m. Any other extra information that you found very useful or that we should know?

## Appendix C - Deliverables

After discussion with our advisor and sponsor, we have concluded that the final product should be a device that has a battery-driven humidifier. This device should work for one hour and does not cause more strain to the user.