The Candle Extinguisher

ECE 445 Spring 2017
Design Review

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1. Introduction

1.1 Objective

Candles have been used around the world for thousands of years. They were the main source of light before electricity and the common light bulb were discovered. Today candles are still used, not as much as a source of light, but instead to give off different scents. Candles come in all kinds of different shapes, scents, and colors, and can be found in almost every household. Many users believe that candles are a very simple and safe device, but there are many precautions that must be taken. When candles are left unattended, unexpected fires can occur. These fires can spread quickly and can easily destroy an entire house. Another issue that is often forgotten is the fact that candles need to have a cool down period and should not be burned for a long period of time.

Our goal is to create a device that can monitor the use of a candle. This will be used to ensure that the candle does not burn for too long and that it is safely extinguished. A majority of the fires started by candles occur because the user simply forgets about the candle. The Candle Extinguisher does exactly what its title states, it will safely extinguish a commonly sized candle. Through our device, the user will be able to input a desired time (within a set range) that the candle will be extinguished. In order to accommodate the different candle sizes, the device is based around a one-gallon glass jar. Any candle that will fit into this jar will be extinguished. Once the inputted time has been reached, power will be sent to a motor that will rotate the lid to the top of the jar creating a seal. This seal will cut off oxygen and suffocate the flame of the candle. A temperature sensor will also be implemented to ensure that the flame has been successfully extinguished.

1.2 Background

As mentioned above, candles can cause many house fires. For the five year period from 2009 to 2013, candles cause an average of around twenty-five house fires every day. These fires have cost millions in property damage and haven taken the lives of many users [1]. Many of these fires occur when the user is asleep. With our device the user can have their candle safely extinguished while they are sleeping. Another reason why candle fires are so common, is due to drafts that may occur in the room. These drafts can cause nearby items to move into the path of the candle. This could then create an unwanted fire that can easily spread [2]. Since the Candle Extinguisher is based around a glass jar, unexpected items cannot be blown into the path of the flame.

Another key issue with candles that many users do not realize, is that candles should not be burned for more than four hours at a time [3]. Major candle companies stress the importance of this idea because candles need a chance to cool down. Constantly burning a candle for more than four hours can cause damage to the candle and can cause too much liquid wax to form on
the surface. Most importantly candles should not be left unattended. With our device we still stress this idea. The Candle Extinguisher should not be neglected and should still be in the same room as the user.

1.3 High-Level Requirements

- Device must successfully extinguish the candle within five minutes after the desired time has been reached.
- Device must urge user to not burn the same candle for more than four hours at a time.
- Device must extinguish the candle immediately during a power outage.

2. Design

2.1 Block Diagram

![Block Diagram of the Candle Extinguisher](image)

Figure 1: Block Diagram of the Candle Extinguisher
2.2 Physical Design

![The Candle Extinguisher Concept Design](image)

*Figure 2. The Candle Extinguisher Concept Design*

2.3 Block Description: Power

2.3.1 AC Power Supply

The power supply will take in power from an AC wall outlet rated for 120V at 60Hz. This power supply is also part of the converter that converts the AC power into DC power. The power from the wall outlet will be the main primary source of power for each component. A standard two prong plug will be used to connect our device to a typical wall outlet.

2.3.2 Backup Batteries

The backup batteries will provide the necessary power to the device to make the necessary electronics work properly when there is a power outage. Four AA batteries will need to be able to power the device long enough that it can automatically seal the container. The battery will have to power the microcontroller and motor. These two components are needed to create the seal on the jar and extinguish the candle’s flame.

2.3.3 Converter

The converter is needed to convert the battery voltage and wall outlet voltage to voltages that the other electronic components can use. It will also be needed to convert the AC voltage from the wall outlet into a DC voltage. This component will output 9 Volts, which will then be regulated to 5V in order to power all of our components. The output needed to be 9 Volts due to a loss of voltage over a diode.
2.4 Block Description: Body

2.4.1 Servo
The motor is a very important component to the candle extinguisher. The motor will be a servo motor that is controlled by the microcontroller. The motor will rotate the lid 180° in order to be placed on top of the jar. The motor also needs to be able to do the opposite so that the user can place a candle within the jar.

2.4.2 Lid
The lid will be attached to the top of the jar. This is used to create a seal with the top of the jar, which will then suffocate the flame. It will be constructed of a lightweight material to lower the value of the starting torque required to move the lid. The lid also needs to have a high heat tolerance.

2.5 Block Description: Input/Output

2.5.1 User Interface
The user interface will be mounted on the bottom of the candle extinguisher. There will be an LCD screen which displays the time remaining on the alarm system. The user interface will also have an on/off button, arrows to increase/decrease time, arrows to increase/decrease brightness, and a button to start the timer. The user will enter the amount of time they want the candle extinguisher lid to stay open. This information will be transmitted to the microcontroller for how long to keep the lid open on the device. The dimming feature of the user face is key part of our alarm system. If the alarm were to be triggered, then the screen will flash rapidly to add to the warning of the user.

2.5.2 Alarm
The alarm will be triggered once the allotted time on the user interface has expired and the temperature sensor detects a flame. There will be an audio alarm and also a visual alarm. If the temperature sensor detects, the microcontroller will send power to the audio buzzer and the screen will flash rapidly.
2.6 Block Description: Sensors

2.6.1 Lid Position Sensor
The lid position sensor is a pressure sensitive sensor that will detect if the lid is open or closed. The sensor will be on the edge of the lid. When the sensor is pressed, the lid is closed, when the sensor is not pressed, the lid is open. The lid position sensor will communicate with the microcontroller.

2.6.2 Temperature Sensor
The temperature sensor will detect if a flame is present in the candle extinguisher. Once the initial alarm goes off, the microcontroller will communicate with the temperature sensor to determine that the flame has been extinguished.

2.7 Block Description: Microcontroller
The microcontroller will be the brains in our device. The chip chosen will be the Atmega328P-PU, the same that can be found on an Arduino UNO development board. The microcontroller will be placed on our design PCB board and will be connected to the rest of our components. This microcontroller is needed to carry out all of the functions of The Candle Extinguisher. This microcontroller will communicate with the user interface to determine how long before the candle needs to be extinguished. Once the time has been reached the microcontroller will send a signal to the lid motor to rotate the lid to the top of the jar. After this has been achieved, the microcontroller will communicate with the temperature sensor to ensure that the flame has been successfully extinguished. Lastly, the microcontroller will also communicate with the lid position sensor.

2.8 Tolerance Analysis
The block that provides the most risk to our implementation is the motor block. If the motor doesn’t work properly, the user will not be able to use the device. The motor moves the lid into position in order to create a seal on the top of the jar. The motor will powered by the power supply and also by the backup battery if needed. The motor can fail in a couple of different ways. The motor can burn out from excessive use. Another issue is that the motor may not be able to provide enough starting torque. Lastly, the motor may have issues communicating with the microcontroller. It is a necessity to test the motor with the microcontroller to ensure that the motor achieves its goal.

The motor also needs to be very precise with its movement. This stepper motor must be able to rotate the lid to make sure that the area on top of the jar is fully covered or completely open. The starting position is at 0°, which will be when the lid is on top of the jar. This will make
sure that lid will always make a perfect seal with the jar. The motor must be able to rotate 180° with a tolerance of ten degrees. This will ensure that the lid closes enough so that a sufficient amount of oxygen is cut off from the jar to extinguish the flame. The tolerance also ensures that the user has enough room to light or replace the candle when the lid is opening. Lastly, the lid that will be manufactured will be slightly oversized to make certain that there is enough surface area to create a seal between the jar and the lid.

2.9 Supporting Material

2.9.1 Circuit Schematics

![Power Block Schematic](image)

**Figure 3:** Power Block Schematic
Figure 4: Microcontroller Schematic

Figure 3 shows the power block in the block diagram. The power is provided through a wall outlet. The power then goes through the converter that brings it down to 9V. The power then goes through a switching regulator which brings it down to 5V. The schematic also uses a backup battery system for when the wall outlet power fails.

Figure 4 shows the microcontroller and the connections to different components. One connection is the force resistor sensor. A second connection is the temperature sensor. These sensors obtain input from external forces that allow The Candle Extinguisher to be controlled. Another connection is the alarm, where the microcontroller will be provided the information to allow the alarm to sound when a problem arises. The microcontroller connects to the user interface as well, where it will show the user the given data. Finally, the microcontroller connects to the motor, so that the motor can be turned on when the lid needs to change position.

2.9.2 Calculations

Minimum Motor Torque
In order to find the minimum torque required to move the lid into position, the following two equations were used. Equation (1) is used to find the moment of inertia of a disk that has an axis passing through the edge of the disk. The torque can then be found using equation (2).
\[ I = \frac{3}{2} \cdot M \cdot R^2 \]  \hspace{1cm} (1)
\[ \tau = I \cdot \alpha \]  \hspace{1cm} (2)

Plugging in the following data will give the final result that can be seen in equation (4). The aluminum lid has a weight of about 2kg and we want the angular acceleration (\(\alpha\)) to be around 0.5 rad/s\(^2\). The radius of the lid was measured to be around 0.165m.

\[ I = \frac{3}{2} \cdot 2 \cdot .165 = 0.817 kgm^2 \]  \hspace{1cm} (3)
\[ \tau = .0817 \cdot .5 = .0408 Nm \]  \hspace{1cm} (4)

2.9.3 Measurements

**Jar Measurements**
Height = 10 inches
Top Diameter = 7 inches
Weight = 3.5 lbs
Volume = 1 Gallon
2.9.4 Software Flow Chart

Figure 5 shows how the microcontroller will operate using a flow chart. The first step is the user will input a time between 0 and 4 hours. The next step will not happen...
until this first step is met. The next step is then to have the time displaying on the screen. Once the time hits zero, it is time to move onto the next step. The lid is then closed. Once the lid is closed, the microcontroller will use the thermal sensor to determine if a flame is still present. If there is a flame still present, then the alarm will activate.

3. Requirements and Verification

<table>
<thead>
<tr>
<th>Points</th>
<th>Requirements</th>
<th>Verifications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Power</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1. Must be able to take in a range of 118V - 122V AC at 58 - 62Hz.</td>
<td>A. Connect positive terminal of the multimeter to positive wire of the AC power cord.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B. Connect negative terminal of the multimeter to negative wire of the AC power cord.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C. Connect ground terminal to ground wire of the AC power cord if available.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D. Measure voltage at load end using voltage multimeter.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E. The requirement is verified if the voltage and frequency measurements are found within range.</td>
</tr>
<tr>
<td>2</td>
<td><strong>Backup Battery</strong></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1. The battery must be able to power the microcontroller, motor, and alarm for at least five minutes.</td>
<td>A. Have the batteries connected to the motor, microcontroller and alarm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B. Have the microcontroller send a signal to the motor for the lid to close.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C. Determine if the motor is able to close the lid using the power from the batteries within 5 minutes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D. If the batteries were able to power all these parts for five minutes, then the requirement is verified.</td>
</tr>
</tbody>
</table>
|   | 2. Battery must be able to withstand heat other components, the candle, and itself. | A. Measure temperature of unit that has been running for at least 15 minutes with candle lit in the area where the candle is to be placed.  
B. Check datasheet to see if battery can tolerate up to 1.5 times that temperature.  
C. Test battery’s operation using oscilloscope to measure voltage and current when part of device.  
D. The voltage should remain within the voltage range of the battery within ±5% if the battery is new.  
E. Also take temperature measurement every minute for 15 minutes to graph to see how battery changes with heat. Measure at different times of operation, both start-up and after running for time greater than 30 minutes.  
F. Requirement is verified if battery is able to withstand the heat and power the components within the specifications of the battery. |
|---|---|---|
| 2 | 3. The battery must not be a fire hazard. | A. Read datasheet to determine if battery is fine to operate near a source of fire.  
B. Requirement is verified if the datasheet does not indicate it is a fire hazard. |
| 3 | **Converter** |   |
| 1 | 1. The converter must be able to withstand heat of other components, the candle, and itself. | A. Measure temperature of unit that has been running for at least 15 minutes with candle lit in the area where the candle is to be placed.  
B. Check datasheet to see if converter can tolerate up to 1.5 times that temperature. |
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C.</td>
<td>Test converter’s operation using oscilloscope to measure voltage and current when part of device.</td>
<td></td>
</tr>
<tr>
<td>D.</td>
<td>Voltage and current should be within specifications given on datasheet.</td>
<td></td>
</tr>
<tr>
<td>E.</td>
<td>Also take temperature measurement every minute for 15 minutes to graph to see how converter changes with heat. Measure at different times of operation, both start-up and after running for time greater than 30 minutes.</td>
<td></td>
</tr>
<tr>
<td>F.</td>
<td>Requirement is verified if the converter is able to operate in heat conditions and still meet specifications on datasheet.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2. The converter must be able to convert the AC power from the wall outlet to 5V±5% DC power to be used by the motor, sensors, and microcontroller. The current should be limited to 2.0±5%Amps.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A. Connect converter to AC power source</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B. Connect output to multimeter and measure for voltage.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C. Check to see if voltage outputs are within range of given voltages in requirements.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D. Measure output current using a controlled DC load and confirm it is limited to less than 2.0 Amps. The voltage will also be monitored to ensure that a voltage drop does not occur under full load.</td>
<td></td>
</tr>
</tbody>
</table>

### Body

#### I. Servo

<table>
<thead>
<tr>
<th></th>
<th>1. Must be able to output at least 0.048 Nm to move the lid into either positions.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A. Research using datasheet to see if motor can supply the output force.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B. Connect the motor to the apparatus that moves the lid.</td>
<td></td>
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<tr>
<td></td>
<td>C. Have the motor attempt to turn the lid 180 degrees. A marking will be made on the lid to be used as a reference when measuring the degrees of rotation.</td>
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<td>---</td>
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</tr>
<tr>
<td><strong>D.</strong></td>
<td>Requirement is verified if the motor is able to turn the lid 180 degrees ±5%.</td>
<td></td>
</tr>
</tbody>
</table>
| **2** | 2. Must be able to operate using four 1.5V AA batteries. | A. Connect four AA batteries to motor power terminals.  
B. Make sure lid is in the open position.  
C. Make sure AC power is disconnected.  
D. See if motor is able to complete the 180 degree rotation under the test program. |
| **1** | 3. Must be able to operate using 5V±5% from AC-DC converter. | A. Connect converter output to motor power terminals.  
B. Make sure lid is in open position.  
C. Connect microcontroller output to the signal part of the motor.  
D. Have the microcontroller use a test program to send signal to motor to close.  
E. See if motor is able to complete the full 180 degree rotation under the test program.  
F. Requirement is verified if the lid is rotated 180 degrees ±5% |

**II. Lid**

<p>| | | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
</table>
| **2** | 1. Must be able to rotate 180°±5%. | A. Check to see if lid can rotate 180° without hitting the jar when it is rotated.  
B. Have it start as illustrated in Figure 2.  
C. Have it end with the lid on top of the jar completely covering the opening.  
D. Requirement is verified if the lid is rotated 180 degrees ±5% |
| **5** | 2. Must create a good enough seal with the jar to extinguish the candle within five minutes. | A. Light candle in jar.  
B. Put lid on top of the jar.  
C. Set timer to see if candle extinguishes within five minutes.  
D. Requirement is verified if candle extinguishes within five minutes. |

**Input / Output**
# User Interface

| 1 | 1. Ability to turn on and off backlight. | A. Turn off all lights so the test is completed in the dark.  
B. First have screen backlight on using test program from microcontroller.  
C. Determine if the screen can be seen in the dark when it is lit.  
D. Then use the assigned button to turn backlight off using a test program from microcontroller.  
E. Determine if the screen cannot be seen in the dark when backlight is off.  
F. Requirement is verified if the screen can be seen in the dark when the backlight is on, and cannot be seen in the dark when backlight is off. |
|---|---|---|
| 4 | 2. Ability to increase time on alarm for up to four hours. | A. Program microcontroller to keep track of time.  
B. Use assigned up and down buttons to input up to four hours.  
C. See if time entered displays up to four hours on the screen by it showing 4:00.  
D. Then, set the time for 10 minutes.  
E. Set a different timer using a stopwatch for 10 minutes.  
F. Observe if timer completes around same time as the stopwatch within ±5%.  
G. Requirement is verified if the steps listed above are met. |
| 1 | 3. Constantly display the time remaining on the display. | A. Program microcontroller to keep track of time.  
B. Verify that time display on LCD screen agrees with time that is being tracked by the microcontroller. |

# Alarm

| 1 | 1. Audio buzzer must emit a sound that can be heard twenty meters away. | A. Measure twenty meters away from audio buzzer with the audio buzzer facing the other direction. |
| 1 | 2. Screen flashes on and off with a period no greater than 2 seconds when the alarm goes off. | A. Perform test in a room that has natural lighting.  
B. Perform test about 2 feet away.  
C. Program microcontroller so that when alarm goes off, the screen flashes.  
D. Have the alarm go off when time expires.  
E. Have screen flash in response.  
F. See if the screen brightness adjustment can be seen from at least 20 feet away.  
G. Measure the time it takes for the screen to be on, then off, then on again.  
H. Requirement is verified if the screen is able to complete the period time given in the requirement. |
|---|---|---|
| 2 | 3. Alarm will always sound if it is triggered by the microcontroller. | A. Have microcontroller send signal to alarm to have it emit a noise.  
B. See if alarm actually makes noise  
C. Test 25 times total.  
D. Check that alarm passes all 25 times.  
E. Requirement is verified if alarm passes all 25 times. |

Sensors

**I. Lid Position Sensor**

| 2 | 1. Must detect a force of at least 0.2N. | A. Have the lid in complete open position, make sure sensor is not triggered.  
B. Have the lid rotate to the closed position. While it is in the process of closing, make sure the sensor is not triggered.  
C. When the lid reaches the closed position, make sure it activates the |
|   |   | sensor to send the signal that it is now closed.  
|   |   | D. Make sure the lid does not continue past the closed position after the sensor is activated.  

## II. Temperature Sensor

|   |   |   |   
|---|---|---|--- 
| 2 | 1. Detect the difference between when a candle is lit and when there is no lit candle. | A. Place a lit candle in front of the sensor at the distance the sensor will be from the candle in the product. Record data sent from sensor.  
B. Place a candle that has not been lit for at least a day in front of the sensor at the distance the sensor will be from the candle in the product. Record data sent from sensor.  
C. Place a recently lit candle that is then extinguished in front of the sensor at the distance the sensor will be from the candle in the product. Record data sent from sensor.  
D. Compare results to confirm is sensor is able to measure a difference of at least 30 degrees between the different states of the candle.  

|   | 2. Sensor must be able to read temperatures from 0° to at least 250°F | A. Confirm using datasheet if sensor is able to read within range.  
B. Requirement is verified if sensor is able to operate in the temperature range according to the datasheet.  

|   | 3. Sensor needs to be able to read temperatures from 1 inch to 6 inches away from the flame. | A. Look at temperature results from different distances within the required range.  
B. Requirement is verified if the temperature is read by the sensor and the information from the sensor is sent to the microcontroller and the data agrees.  

**Microcontroller**
| 1 | 1. Needs to operate on 5V±5%. | A. Supply the microcontroller 5V±5% and try to run a program. Then use a multimeter to determine the input voltage to the microcontroller  
B. Check datasheet  
C. Requirement is verified if the microcontroller is able to complete a program using the power given. |
|---|---|---|
| 4 | 2. Needs to turn on and communicate with the temperature sensor 5 minutes ±5% after the candle has been extinguished. | A. Have microcontroller receive readings five minutes after candle is supposed extinguished from temperature sensor.  
B. Use that data to determine if the candle has been extinguished by sensing a change in the temperature data. |
| 5 | 3. Needs to turn alarm on within five minutes ±5% if temperature sensor detects a flame. | A. Remove the lid from the top of the jar and the servo motor.  
B. Produce a test that has candle still burning even though the position of the lid is read as closed by the microcontroller. Lid will be removed from the servo to ensure this.  
C. Have temperature sensor send data that shows candle is still burning after five minutes.  
D. Have microcontroller send signal to alarm as a result to warn user that candle is still burning.  
E. Make sure alarm is audible and continues until the sensor sends data to suggest flame has been extinguished.  
F. Requirement is verified if the alarm goes off in the given time range for a candle that is still burning. |
## 4. Cost and Schedule

### 4.1 Cost Analysis

#### 4.1.1 Labor

<table>
<thead>
<tr>
<th>Name</th>
<th>Rate (Per Hour)</th>
<th>Overhead</th>
<th>Hours (Per Week)</th>
<th>Total (16 Weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casey Labuda (Electrical Engineer)</td>
<td>$32.00 [6]</td>
<td>*2.5</td>
<td>20</td>
<td>$25,600</td>
</tr>
<tr>
<td>Aaron VanDeCastelele (Computer Engineer)</td>
<td>$40.50 [6]</td>
<td>*2.5</td>
<td>20</td>
<td>$32,400</td>
</tr>
<tr>
<td>Matthew Nee (Electrical Engineer)</td>
<td>$32.00 [6]</td>
<td>*2.5</td>
<td>20</td>
<td>$25,600</td>
</tr>
</tbody>
</table>

#### 4.1.2 Parts

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Part Number</th>
<th>Quantity</th>
<th>Manufacturer</th>
<th>Vendor</th>
<th>Cost/Unit</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Torque Servo Motor 5VDC</td>
<td>155</td>
<td>1</td>
<td>Adafruit Industries LLC</td>
<td>Digikey</td>
<td>$12.00</td>
<td>$12.00</td>
</tr>
<tr>
<td>AC to DC Power Converter</td>
<td>VSK-S15-9U</td>
<td>1</td>
<td>CUI Inc.</td>
<td>Digikey</td>
<td>$21.25</td>
<td>$21.25</td>
</tr>
<tr>
<td>LCD Shield Kit</td>
<td>772</td>
<td>1</td>
<td>Adafruit Industries LLC</td>
<td>Mouser</td>
<td>$19.95</td>
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<td>One Gallon Glass Jar</td>
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<td>Target</td>
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<td>Energizer</td>
<td>Target</td>
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<td>Fairchild/ON Semiconductor</td>
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4.1.3 Grand Total

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<tr>
<td>Labor</td>
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<td>Parts</td>
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<td><strong>Grand Total</strong></td>
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4.2 Schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Task</th>
<th>Responsibility</th>
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</thead>
</table>
| **Week 1**  
(1/15/17-1/21/17) | -Brainstorm Project Ideas  
-Discuss strengths and weaknesses of each member  
-Each member complete initial post | Casey Labuda  
Aaron VanDeCasteele  
Matthew Nee |
| **Week 2**  
(1/22/17-1/28/17) | -Decide on single project idea  
-Discuss different solutions to idea  
-Brainstorm different components and features to solution | Casey Labuda  
Aaron VanDeCasteele  
Matthew Nee |
| **Week 3**  
(1/29/17-2/4/17) | -Use Web Board to discuss project idea and get feedback from TA’s and professors  
-Finalize and hand in request for approval (RFA) | Casey Labuda  
Aaron VanDeCasteele  
Matthew Nee |
| **Week 4**  
(2/5/17-2/11/17) | - Meet with assigned teaching assistant and obtain feedback  
-Research possible components | Casey Labuda  
Aaron VanDeCasteele |
| Week 5  | -Complete and hand in project proposal  
|         | -Discuss project with Scott from Machine Shop  
|         | -Laboratory safety training due.  
|         | Matthew Nee |
| Week 5  | -Research Parts  
|         | -Meet with Machine Shop  
|         | -Complete Eagle assignment  
|         | Casey Labuda |
| Week 6  | -Research Parts  
|         | -Complete Eagle assignment  
|         | -Sign up for Mock Design Review  
|         | Aaron VanDeCastelee |
| Week 6  | -Research Parts  
|         | -Meet with Machine Shop  
|         | -Complete Eagle assignment  
|         | Matthew Nee |
| Week 6  | -Work on Design Review Document  
|         | -Mock Design Review  
|         | -Order parts  
|         | -Work on circuit schematics  
|         | Casey Labuda |
| Week 6  | -Work on Design Review Document  
|         | -Mock Design Review  
|         | -Create software flowchart  
|         | Aaron VanDeCastelee |
| Week 6  | -Work on Design Review Document  
|         | -Mock Design Review  
|         | -Work on circuit schematics  
|         | Matthew Nee |
| Week 7  | -Design Review  
|         | -Receive parts  
|         | -Continue working on circuit schematics  
|         | -Soldering assignment  
|         | Casey Labuda |
| Week 7  | -Design Review  
|         | -Download Arduino software  
|         | -Soldering assignment  
|         | Aaron VanDeCastelee |
| Week 7  | -Design Review  
|         | -Continue working on circuit schematics  
|         | -Soldering assignment  
|         | Matthew Nee |
| Week 8  | -Fix Design Review issues  
|         | -Start Testing Parts  
|         | -Go through circuit schematic with TA  
|         | Casey Labuda |
| Week 8  | -Fix Design Review issues  
|         | -Start Testing Parts  
<p>|         | Aaron VanDeCastelee |</p>
<table>
<thead>
<tr>
<th>Week 9</th>
<th>-Start writing basic code to test components</th>
<th>Matthew Nee</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-Fix Design Review issues</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Start Testing Parts</td>
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<tr>
<td></td>
<td>-Go through circuit schematic with TA.</td>
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<tr>
<td></td>
<td>-Create PCB layout</td>
<td>Casey Labuda</td>
</tr>
<tr>
<td></td>
<td>-Finalize lid and base design with machine shop</td>
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<tr>
<td>Week 9</td>
<td>-Continue coding</td>
<td>Aaron VanDeCasteele</td>
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<tr>
<td></td>
<td>-Create PCB board layout</td>
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</tr>
<tr>
<td></td>
<td>-Finalize lid and base design with machine shop</td>
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<tr>
<td>Week 10</td>
<td>-Finalize and send out PCB layout</td>
<td>Casey Labuda</td>
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<tr>
<td>Week 10</td>
<td>-Start individual progress reports</td>
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<tr>
<td>Week 10</td>
<td>-Finalize most of code</td>
<td>Aaron VanDeCasteele</td>
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<td>Week 10</td>
<td>-Start individual progress reports</td>
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<tr>
<td>Week 10</td>
<td>-Finalize and send out PCB layout</td>
<td>Matthew Nee</td>
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<tr>
<td>Week 10</td>
<td>-Start individual progress reports</td>
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<tr>
<td>Week 11</td>
<td>-Test with first PCB revision</td>
<td>Casey Labuda</td>
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<tr>
<td>Week 11</td>
<td>-Order more parts if needed</td>
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<tr>
<td>Week 11</td>
<td>-Upload final code to first PCB revision</td>
<td>Aaron VanDeCasteele</td>
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<tr>
<td>Week 11</td>
<td>-Debug issues</td>
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<tr>
<td>Week 12</td>
<td>-Test with first PCB revision</td>
<td>Matthew Nee</td>
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<tr>
<td>Week 12</td>
<td>-Send out final PCB revision</td>
<td>Casey Labuda</td>
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<tr>
<td>Week 12</td>
<td>-Debug and finish final code</td>
<td>Aaron VanDeCasteele</td>
</tr>
<tr>
<td>Week 12</td>
<td>-Send out final PCB revision</td>
<td>Matthew Nee</td>
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<tr>
<td>Week 13</td>
<td>-Test and debug prototype</td>
<td>Casey Labuda</td>
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<tr>
<td>Week 13</td>
<td>-Fix issues</td>
<td>Aaron VanDeCasteele</td>
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<tr>
<td>Week 14</td>
<td>-Finalize final prototype</td>
<td>Casey Labuda</td>
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<tr>
<td>Week 14</td>
<td>-Present prototype to Mock demo</td>
<td>Aaron VanDeCasteele</td>
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<tr>
<td>Week 14</td>
<td>-Sign up for final demo</td>
<td>Matthew Nee</td>
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<tr>
<td></td>
<td>-Demonstrate The Candle Extinguisher</td>
<td>Casey Labuda</td>
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5. Safety and Ethics

Candles should always be attended and have someone present in case of a problem. The Candle Extinguisher will come with warnings to inform the user that they should not leave the candle unattended. However, the user can ignore these warnings and still leave the candle unattended, causing the risk of fire to increase. There is not a solution to prevent the user from leaving the room and leaving the candle unattended. The features built into the Candle Extinguisher will help keep the user safe. The time limit on the Candle Extinguisher will make sure that the candle does not burn for time periods greater than four hours. The container surrounding the candle will also help mitigate the risk of the flame spreading to a nearby flammable object. There will always be risks and we unfortunately cannot account for everything. We believe though that the features offered with the Candle Extinguisher provide safety for the user.

Due to the nature of the product, there is the issue of fire and the fire causing damage. The important first step in dealing with this problem is addressed in the IEEE Code of Ethics #1: “to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment.”[4] To follow this code, the Candle Extinguisher will need to be made to comply with the rules for health and safety with both the fire and the electronic components. The Candle Extinguisher will also need to provide warnings of the danger of fire provided with the product.

Another issue that arises is the result of an injury occurring. Fire can be dangerous in certain situations if the correct conditions occur, resulting in injury to a person or property. This product could then be used maliciously by someone to cause this event to occur, going against the IEEE Code of Ethics #9 “to avoid injuring others, their property, reputation, or employment by false or malicious action.”[4] While this event could occur, we believe that the probability of the Candle Extinguisher being used maliciously is very low, and that the standard use of this product makes the pros outweigh the cons. The warning of fire and not to misuse the product in combination with fire will be included with the product.
As mentioned before, there are both positive and negative aspects to the Candle Extinguisher. Positive points include the ability to have candles lit for the desired amount of time and for an extra safety of extinguishing a forgotten candle. Negative points include the risk of the fire spreading outside of the candle. This follows #5 in the IEEE Code of Ethics: “to improve the understanding of technology; its appropriate application, and potential consequences.”[4] The goal is to improve the understanding of technology working in combination with candles to provide a safe and enjoyable experience for the user. Potential consequences have been addressed and will be handled accordingly.

The project and design process will address these issues in several ways. The first issue is in the design process. While designing and testing the product, the proper safety will be taken in both dealing with the electronics and with fire. The next issue is the product. We will address this issue in two ways. The first way is providing warnings to the user through a provided means, such as a pamphlet or on the product itself. The second way is by having different ways of the product addressing the issue of fire, through means such as the lid rotating and suffocating the flame, if the power fails, then the backup battery will power the motor to rotate the lid in order to put out the fire, preventing the user from burning candles for too long within a time period, an alarm to warn the user if the fire is still not extinguished, and having the electronic equipment as protected as possible from the fire and heat to prevent them from becoming too hot and failing.

Finally, since the product is using not only electronics, but the candle itself, the product will have to meet all candle safety and regulatory standards. The candle will have to follow ASTM standards for candles, specifically the following few mentioned. Cautionary Labeling Standard (ASTM F-2058)[5] addresses that the product will have to provide a label with the appropriate warnings. Heat Strength of Glass Containers Standard (ASTM F-2179)[5] will address the all specifications pertaining to the container. Finally, Candle Accessories Standard (ASTM F-2601)[5] will address the procedures and practices that must be followed since the Candle Extinguisher is an accessory to the candle.
6. References


