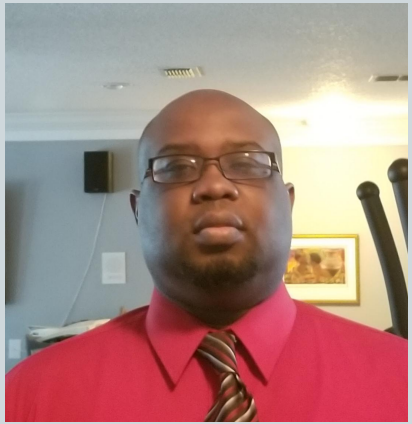
# The Smart Cooler

Clarence Scott and Reuben Taveras

# Team Members



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- Electrical Engineering Tech
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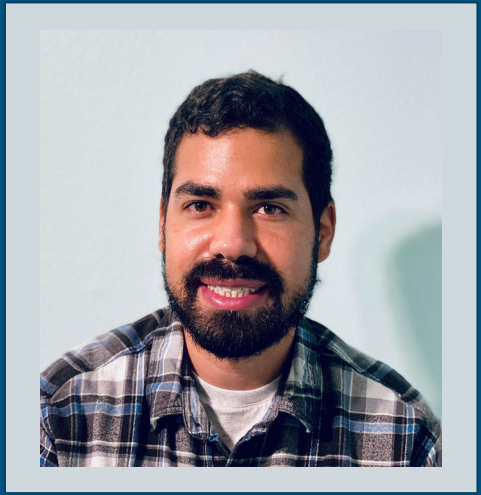

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# The Smart Cooler

# Overview

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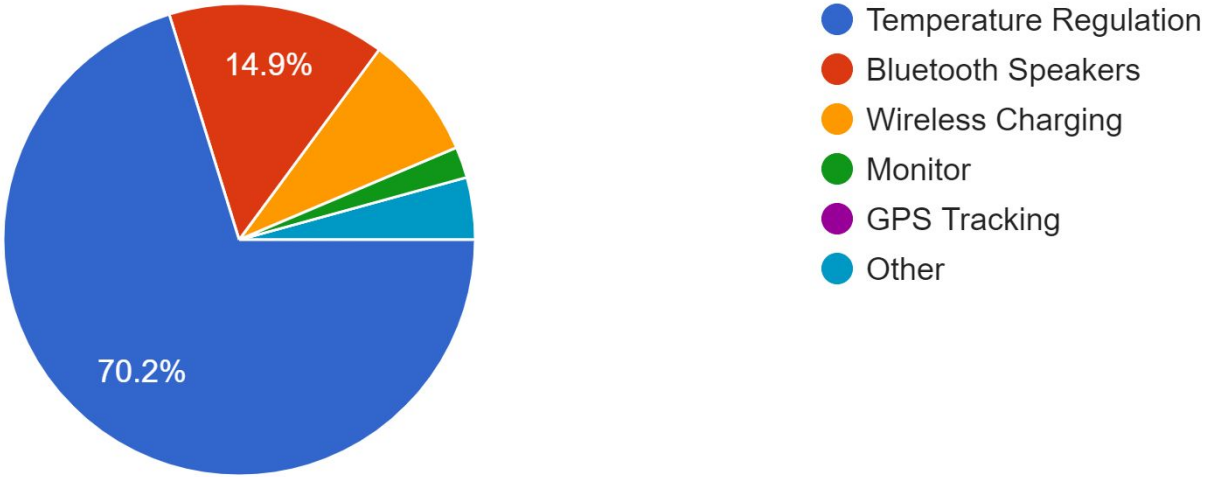
# Motivation

- Cooler design hasn’t really improved since Coleman introduced their first styrofoam cooler in 1957 [18]
- Completely dependent on ice
- Simply used to keep things cold
- Taken to the beach, camping, party, etc…
- Efficiency can be improved by integrating
  - Speakers
  - Power Banks
  - Lights

# Smart Cooler Survey

What feature would you be most excited to have?

47 responses



# What other features would you like in a smart cooler?

- Wheels that work on multiple surfaces
- Temperature monitoring through app
- Removable freezer blocks
- Notification when ice melts
- Maintain different temperatures for different compartments
- GPS tracking and way to contact emergency services
- Screen to play games
- LED light inside

# Features

## Electrical Features

- Temperature regulation for multiple compartments
- Bluetooth speakers
- Wireless and USB charging
- GPS tracking
- RFID locking mechanism
- Automated lid
- Interior LED light
- Touchscreen interface
- Rechargeable batteries

## Software Features

- Android and iPhone Support
- Temperature monitoring and setting through app
- Show GPS location
- Editable features
- Low-power mode

## Other Features

- Ice retentions for at least 7 days
- Waterproof
- Durable
- Wheels for any terrain
- Cupholders
- Flashlight holder
- Can opener
- Retractable cutting board

# Design Engineering Requirements

## High-Level Requirements

- Temperature regulation in both compartments
- Ice retention for a minimum of 7 days
- Minimum active operation of all systems 12 hours
- Multiple exterior input charging options
- Mobile app functionality
- RFID Keyless entry

## Mid-Level Requirements

- Wireless/Wired charging options
- GPS tracking
- Locking mechanism
- Bluetooth speakers
- Mechanized lid for automated opening and closing
- Solar panel integration for battery trickle charging

## Low-Level Requirements

- Cup holders *
- Wheels *
- Storage space *
- Interior LED
- Retractable cutting board
- Flashlight holder

*Denotes features that will be covered in the Shell of the cooler

# Responsibilities

Clarence

- Fabrication
- Mechanical
- Electronic

Reuben

- Mobile App
- Software Programming
- Electronic

# Similar Products

INFINITE Smart Cooler [1]

## INFINITE Smart Cooler

- Indiegogo campaign with 581 backers [1]
- Features
  - Blender
  - Camera
  - Multifunctional utensils
- Does not feature
  - Active refrigeration
  - Locking mechanism

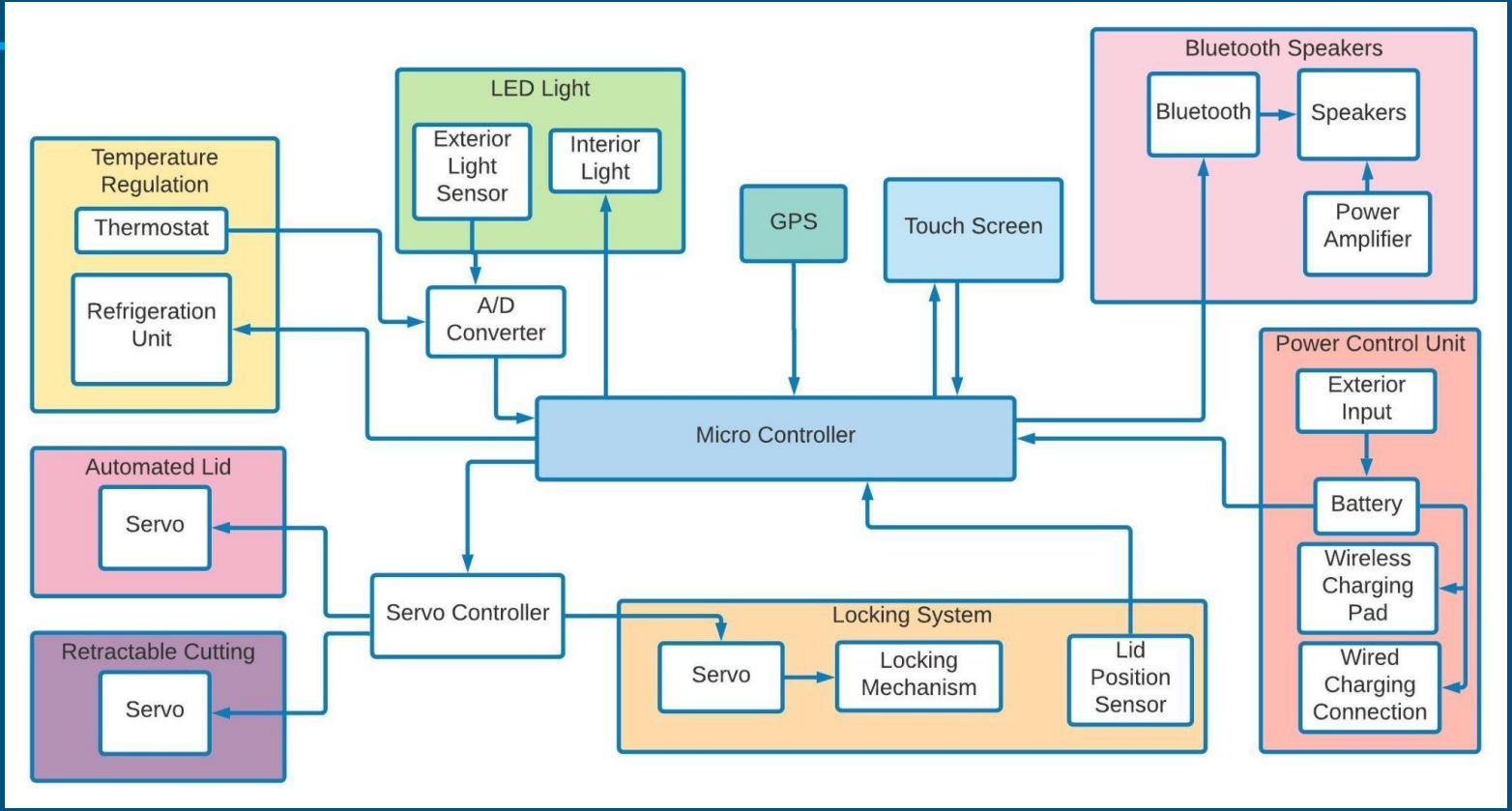
# Similar Products


The Coolest Cooler [2]

The Coolest Cooler

- Over 62,000 backers pledged $13,000,000 [2]
- Considered one of Kickstarter's biggest successes
- Also considered one of Kickstarter's biggest failures

# Block Diagram



# Design Engineering Specifications

Shell
Microcontroller
Mobile Application
Refrigeration Unit
Speakers
Temperature Sensor
Light Sensor
Lid Opening Mechanism
Power Input Voltage Regulator
Power Output Voltage Regulator
Battery
Solar Panel
USB Charging
Wireless Charging
GPS Module
RFID
Touch Screen
Cutting Board

# Shell

Coleman 100qt Cooler [3]

| | | | | |
|---|---|---|---|---|
| Shell | Coleman 100qt | Should have cup holders, wheels, and be large enough to support multiple compartments.<br><br>Exterior walls should be at least 2’ thick. | **Justification:**<br>Anyone should be able to move or load the Smart Cooler.<br><br>**Verification:**<br>Smart Cooler should be lightweight, have large carrying capacity, and wheels to help with transportation and loading. | Clarence |

# Microcontroller

Raspberry Pi 4 [4]

| | | | | |
|---|---|---|---|---|
| Control | Microcontroller: Raspberry Pi 4 | Controller will provide SPI (Serial Peripheral Interface) used for communicating with other boards or modules.<br><br>Bluetooth will connect with app at a range of 15m, and microcontroller will operate between 3.5-5.5V. | **Justification:**<br>The Pi 4 can handle the input and output traffic, and communicate with the other modules. While connecting to the HDMI touch screen.<br><br>**Verification:**<br>The microcontroller will be able to handle the six primary inputs, and four primary outputs, and communicate with the other modules.<br><br>Testing will ensure the microcontroller is communicating with the application. | Team |

# Mobile Application

| | | | | |
|---|---|---|---|---|
| Mobile Application | Apple or Android Smartphone | Bluetooth will communicate with microcontroller at a range of 15m.<br><br>Application will monitor temperature of each compartment, ability to set temperature for each compartment, ability to change settings (GPS enable, locking mechanism enable, LED light enable, low-power mode enable), and able to save profile. | **Justification:**<br>Providing Android and iPhone support allows for the majority of users to use the app. The app communicating with the microcontroller allows for remote monitoring and setting of the cooler.<br><br>**Verification:**<br>Testing will ensure the microcontroller is communicating with the mobile application using an Apple Smartphone. | Reuben |

# Refrigeration Unit

ESUMIC 12V Thermoelectric Refrigeration Unit [5]

| | | | | |
|---|---|---|---|---|
| Refrigeration | Thermoelectric Cooler: ESUMIC 12V | Regulate refrigeration in both compartments.<br><br>Refrigeration unit will be able to lower the temperature in a compartment to a minimum of -2.0°C. | **Justification:**<br>Use active refrigeration to extend the ice retention of the cooler.<br><br>**Verification:**<br>Monitor the temperature with a separate thermometer in the compartments, and verify that it can be cooled to -2.0°C. | Team |

# Recommended Storage Temperatures

According to the Food Safety, Sanitation and Personal Hygiene textbook found online at the Open Library Website [17]:

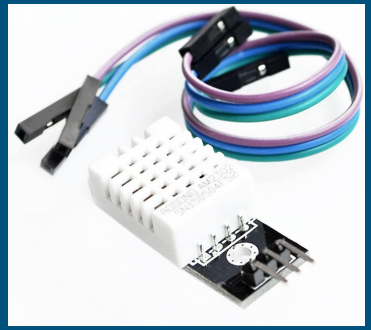
- Dry Foods: 10°C to 15°C (50°F to 59°F)
- Refrigerated Products: 4°C (39°F) or colder
  - Dairy: 2°C to 4°C (36°F to 39°F)
  - Produce: 2°C to 4°C (36°F to 39°F)
  - Meat: 2°C to 4°C (36°F to 39°F)
  - Seafood: -1°C to 2°C (30°F to 34°F)
- Frozen Products: -18°C (0°F)

# Speakers


Pyle Low Profile Marine Speakers [6]

| | | | | |
|---|---|---|---|---|
| Entertainment | Pyle Marine Speakers | Speakers should be no deeper than 2’<br><br>Speakers should operate between 50-200W | **Justification:**<br>Narrow footprint so that they can be placed in the walls of the Smart Cooler.<br><br>**Verification:**<br>Speakers should be able to be heard at least 5 meters away. | Clarence |
| | Amp: TPA3116 DAMGOO | Provide at least 200W for Speaker operation. | **Justification:**<br>Exceed minimum Wattage needs for both Speakers.<br><br>**Verification:**<br>Speakers should properly operate with the wattage provided from the AMP. | Clarence |

# Temperature Sensor



DHT11 Temperature Sensor [7]

| | | | | |
|---|---|---|---|---|
| Sensors | Temperature: DHT11 Temp. and Humidity Sensor | Monitor Temperature in compartments to an accuracy of ± 1.0°C in real time | **Justification:** The Temperature of the compartments is used to govern when the refrigeration units are turned on.<br><br>**Verification:** Monitor the temperature with a separate thermometer in the compartments. | Reuben |

# Light Sensor

CdS Photoresistor
[8]

| | | | | |
|---|---|---|---|---|
| Sensor | Exterior Light: Photo-sensitve Sensor | Exterior light sensor will change output voltage in low light conditions in real time. | **Justification:** Interior lights are needed for operation after dark.<br><br>**Verification:** Will test and confirm that output voltage changes when ambient light is low. | Reuben |

# Lid Opening Mechanism


BETU 25kg Servo [9]

| | | | | |
|---|---|---|---|---|
| Lid Opening Mechanism | Servo:<br>BETU 25Kg<br><br>Gusodor Led Strip Lights | Allow the user to remotely open and close the lid.<br><br>Track lid status and change output voltage based on lid position in real time. | **Justification:**<br>The opening mechanism will open and close the lid quickly.<br><br>**Verification:**<br>Mechanism shall correctly trigger interior LED during opening tests. | Clarence |
| | Servo Controller:<br>SunFounder PCA9685 | Shall drive the servos for the lid opening, cutting board, and lock in less than 3 seconds. | **Justification:**<br>Provide the input and outputs required for the servos.<br><br>**Verification:**<br>Servo operation will be tested and cycled no less than 25 times. | Team |

# Power Input Voltage Regulator

| | | | | |
|---|---|---|---|---|
| Power Input Control Module | Battery Charger<br><br>Voltage Regulator<br><br>12VDC input power socket | Shall provide the cooler multiple charging options to accept 120V AC and 12VDC. | **Justification:**<br>Allow for battery charging from Solar Panel, outlet plug, or automobile barrel jack.<br><br>**Verification:**<br>A digital multimeter will be used to confirm that the module is supplying the correct voltages when both inputs are used to pass. | Team |

# Power Output Voltage Regulator

| | | | | |
|---|---|---|---|---|
| Power Output Control Module | Voltage Regulator | Convert stored energy in the battery into voltages required for operation, 5V and 12V. | **Justification:**<br>The Voltage Regulator will ensure that the voltages supplied by the batteries are the correct voltages to ensure the modules of the Smart Cooler operate properly without damaging components.<br><br>**Verification:**<br>A digital multimeter will be used to confirm that the voltage regulator is allowing the correct voltages to pass. | Team |

# Battery


Miady LFP16AH 12V 20Ah LiFePO4 Rechargeable Battery [10]

| | | | | |
|---|---|---|---|---|
| Battery | Battery: LiFePO4 | Provide 12V to the Smart Cooler modules.<br><br>Battery shall maintain active operation for at least 12 hours | **Justification:**<br>Needed to power active cooling systems when outside power is not available.<br><br>**Verification:**<br>A digital multimeter will be used to confirm that the battery is supplying the correct voltages to pass. | Team |

# Solar Panel


Eco-Worthy 12V 10W Solar Panel [11]

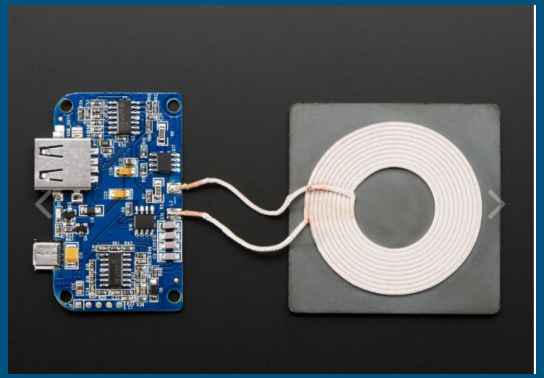
| | | | | |
|---|---|---|---|---|
| Solar Panel | Solar Panel: Eco-Worthy 12V 10W<br><br>Dimensions: 8.6” x 13.8” x 1.3”<br><br>3D printed parts | 12-20V output voltage, at least 1.5A current output, at least 14.4W power output, at least 9.6Ah output | **Justification:**<br>The solar panel will provide power to the battery during daylight hours and assist with charging for night time operation.<br><br>**Verification:**<br>A digital multimeter will be used to confirm that the module is supplying the correct voltages when both inputs are used to pass. | Clarence |

# USB Charging


Damavo USB C and USB A Charger Socket [12]

| | | | | |
|---|---|---|---|---|
| USB Charging | Exterior USB Charger: Damavo YM1218 USB C and USB A Charger socket | Should operate using either 5V or 12V input voltage.<br><br>Will output 5V 2.1A for USB A & 5V 3A for USB C | **Justification:** The charger will allow wired charging of devices.<br><br>**Verification:** Plug will be tested with several USB devices | Clarence |

# Wireless Charging



Qi Wireless Charging Transmitter [14]

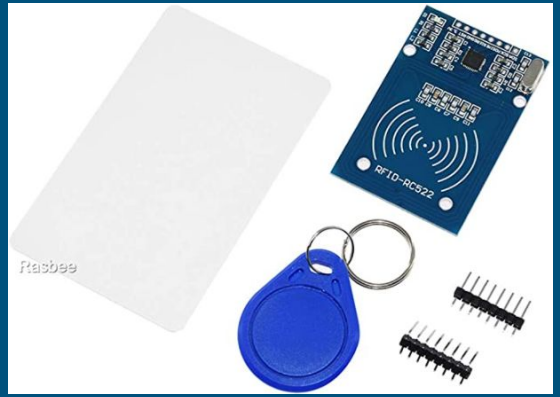
| | | | | |
|---|---|---|---|---|
| Charging Module | Qi Wireless Charging Transmitter | Output at 5W at a minimum of 100 KHz<br><br>Charging distance 2-8mm | **Justification:**<br>Allows the user to charge other mobile devices in a timely manner.<br><br>**Verification:**<br>Capable of charging modern Smart devices especially cell phones. | Clarence |

# GPS Module


BN-880 GPS Module [13]

| | | | | |
|---|---|---|---|---|
| GPS Module | BN-880 GPS Module | Module will accurately track location to within 3 meters. | **Justification:** Allow the user to mark the Smart Cooler and possible camp site.<br><br>**Verification:** Google Maps will be used to confirm the accuracy of the GPS location. | Team |

# RFID




RC522 RFID Module [19]

| | | | | |
|---|---|---|---|---|
| Lock | Locking Mechanism | Close and lock the Smart Cooler using the APP touch screen or RFID Keyless entry. | **Justification:** Secure the lid so that it can not be opened on accident, unauthorized people, or animals.<br><br>**Verification:** The lock should engage and disengage when signalled by the Touch screen, Mobile app, and RFID keyless entry. | Team |

# Touch Screen

SunFounder 7” Touch Screen [15]

| | | | | |
|---|---|---|---|---|
| Touch Screen | Sunfounder 7 inch<br><br>Dimensions: 4.92” x 6.5” x 0.59” | Shall support touchscreen functions and at least Wide SVGA resolution. | **Justification:**<br>Allows the user to interact with the Micro controller and control the operation of the cooler.<br><br>**Verification:**<br>Should respond to the inputs of up to 5 fingers at once. | Clarence |

# Cutting Board

FarberWare Plastic Cutting Board [16]

| | | | | |
|---|---|---|---|---|
| Cutting Board | Dimensions: 15.5” x 10”<br><br>BETU 25Kg Servo<br><br>3D printed parts | Supply the user with a retractable cutting board that is in the lid. | **Justification:**<br>In camping settings a cutting board could be very useful.<br><br>**Verification:**<br>Should extend and retract cutting board no less than 25 times without fouling. | Team |

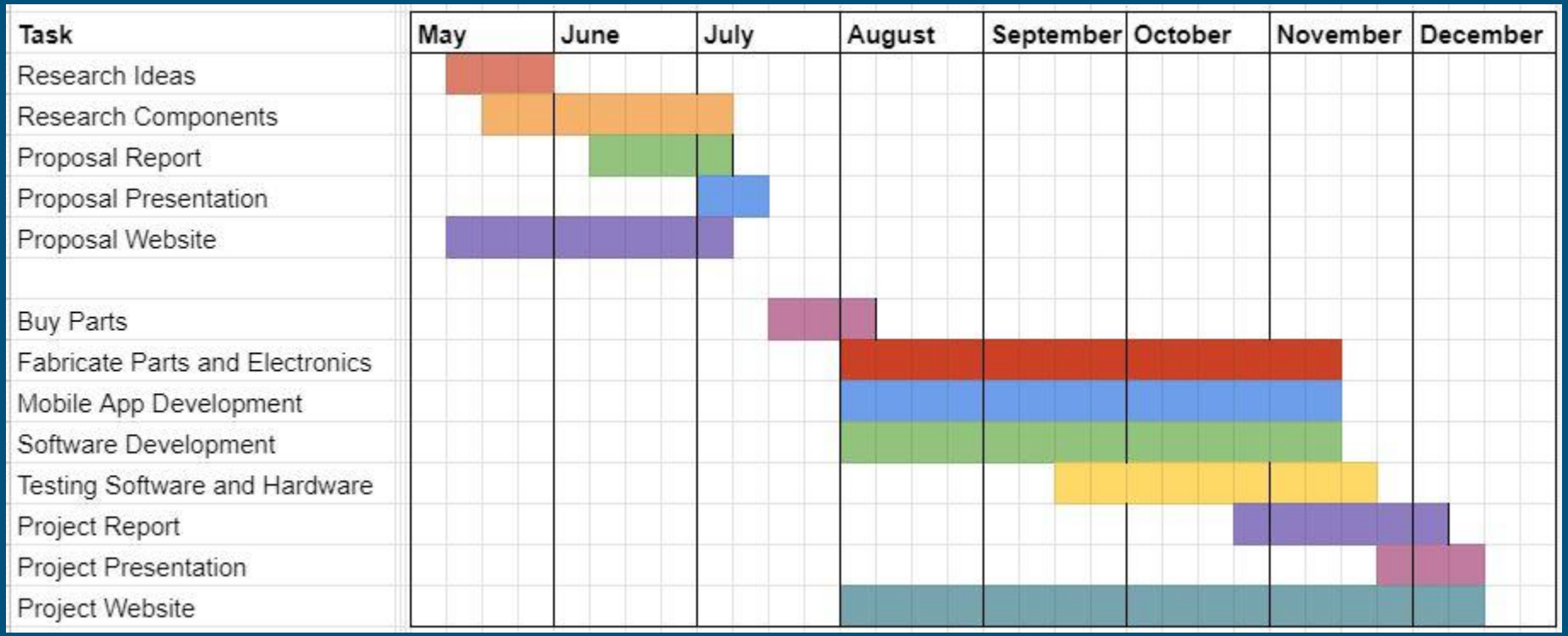
# Success Criteria

| Subject | Success Criteria |
|---|---|
| Shell | Does the Cooler retain Ice for a minimum of 7 days 5/6 times? |
| Refrigeration | Can refrigeration units lower temp to -2.0°C? |
| Touch Screen | Does the touch screen respond to touch inputs correctly 9/10 times? |
| Controller | Does the microcontroller properly control the system without errors 19/20 times? |
| App integration | Does the App take full control of the system without interference 9/10 times? |
| Power System | Does the system properly power on and off 95% of the time 19/20? |
| GPS | Does the GPS module accurately track the cooler's location 95% of the time? |
| Locking mechanism | Does the lock engage and disengage when signalled by the Touch screen, Mobile app, and RFID keyless entry module 9/10 times? |
| Servos | 1) Does the lid properly open 95% of the time?<br>2) Does the cutting board extend and retract properly 95% of the time? |

# Power Budget

| Component | Model | Voltage | Amp | Watts |
|---|---|---|---|---|
| Microcontroller | Raspberry Pi 4 | 5V | 3A | 15W |
| Temperature Sensor | DHT11 | 5V | 0.3mA | 1.5mW |
| Refrigeration Unit | Thermoelectric Refrigerator x2 | 12V | 6A x 2 = 12A | 144W |
| Wireless Charging | Qi Wireless Charging Transmitter | 5V | 1A | 5W |
| Wired USB Charging | YM1236 Dual USB Charger | 5V | 2.1A x 2 = 4.2A | 21W |
| Solar Panel | Eco-Worthy | 12V | 0.833A | 10W |
| Servo | Betu DS3225 | 5V | 1.9A x 3 = 5.7A | 28.5W |
| RFID | RC522 | 3.3V | 26mA | 85.8mW |
| GPS Module | BN-880 | 5V | 50mA | 250mW |
| Touch Screen | Sunfounder 7” | 5V | 480mA | 2.4W |
| Amp Board | DAMGOO | 5-27V | >3A | Up to 200W |
| Analog to Digital Converter | MCP3008 | 5V | 500uA | 2.5mW |
| Servo Controller | PCA9685 | 5V | 25mA | 125mW |
| **Total** | | | **30.81A** | **426.13W** |

# Timeline


Task
May
June
July
August
September
October
November
December
Research Ideas
Research Components
Proposal Report
Proposal Presentation
Proposal Website
Buy Parts
Fabricate Parts and Electronics
Mobile App Development
Software Development
Testing Software and Hardware
Project Report
Project Presentation
Project Website

# Timeline

| Task | Length (Days) | Start Date | End Date |
|---|---|---|---|
| Buy Parts | 20 | 07/12 | 07/31 |
| Fabricate Parts and Electronics | 111 | 08/01 | 11/19 |
| Mobile App Development | 111 | 08/01 | 11/19 |
| Software Development | 111 | 08/01 | 11/19 |
| Testing Software and Hardware | 44 | 10/11 | 11/23 |
| Project Report | 40 | 10/25 | 12/03 |
| Project Presentation | 17 | 11/24 | 12/10 |
| Project Website | 132 | 08/01 | 12/10 |

# Summary/Conclusion

- All-in-one multifunctional smart cooler
- Mobile active refrigeration, entertainment, and utilities
- Multiple use cases in several different fields
- Food prep/Transportation
- Medical field
- Outdoor event planning

# Equations

Power Equation:  P=V*I

Celsius to Fahrenheit: Fahrenheit = (Temp_in_Celsius * 9/5) + 32

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