About Us

Our Story

We were motivated to create a pendulum that would be both creative and practical. With those goals in mind, CAPITOL was born. The sleek design blends into any modern or traditional decorating scheme, making a perfect fit in any home. Walking outside one day, the creative team was struck by just how many distinct sounds they noticed in nature. This line of thinking led them to discuss the impact of sound, and later music, on their everyday lives. This inspired them to develop an interactive, adaptable music experience in CAPITOL. They knew that everybody has a favorite playlist they hold dear to their heart, and so the opportunity to physically manifest that love would be valued. CAPITOL is a pendulum that swings at the frequency of your Spotify music, dancing the night away at your command.

Engineering Plan

Standing on a 3'x3' platform of plywood, four .92m legs suspend a platform which holds a Nema 17 stepper motor driven by an Arduino/motor shield pairing. This motor rotates the arm of the pendulum, a .89m long dowel rod. A string wrapped around the top of the motor/arm interface runs down the arm to a second motor (driven by the Arduino and motor shield), which uses the string to adjust its position along the arm, changing the frequency to match the desired input. Figures of 3D designed parts are seen in figures 1-7.

A solar cell wired to a Raspberry Pi through an Analog-Digital converter (MCP3008) and a 4.64kΩ resistor rests in a housing suspended between two of the legs, facing inwards. Opposite the solar cell is a flashlight which can be turned on, activating the cell. As the pendulum swings, the arm breaks the line of contact between the cell and the light. The rate at which the arm breaks contact is measured and used to determine the actual frequency of the swings.

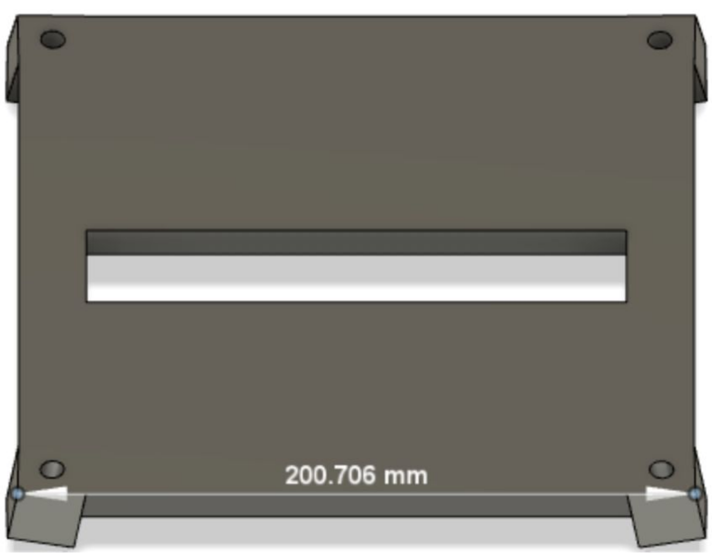


Figure 1: Platform used to mount rigid arm to driving motor and house electronics.

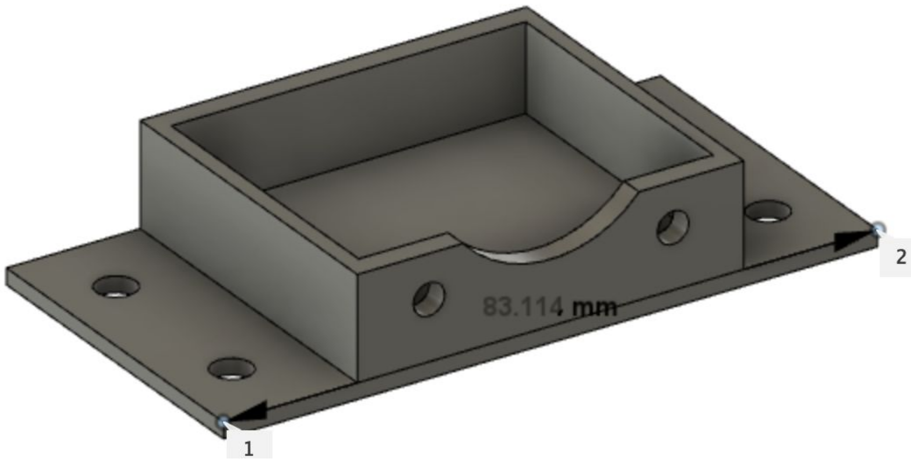


Figure 2: Mounting bracket for driving motor.

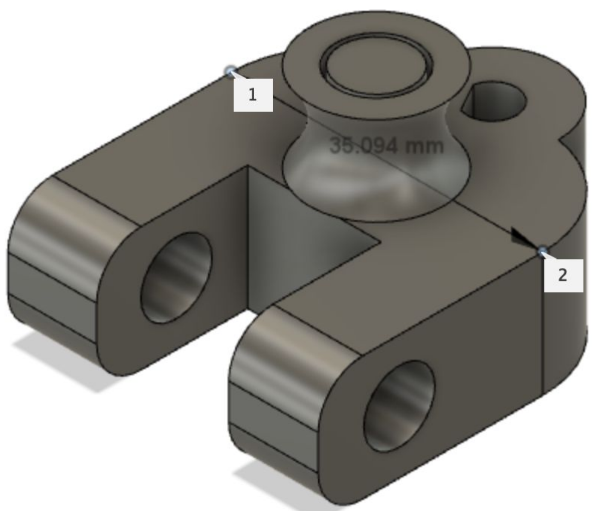


Figure 3: Connector to mount rigid arm to driving motor and pulley system for adjustable length feature.

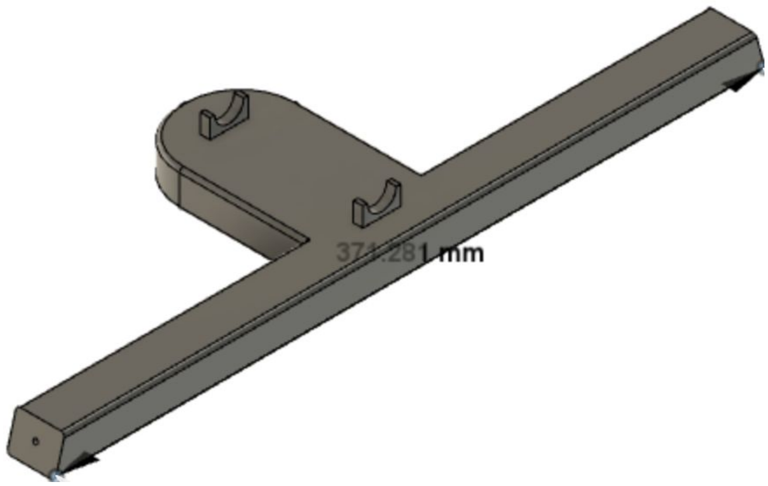


Figure 4: Mounting platform for laser source and structural feature for stability reinforcement.

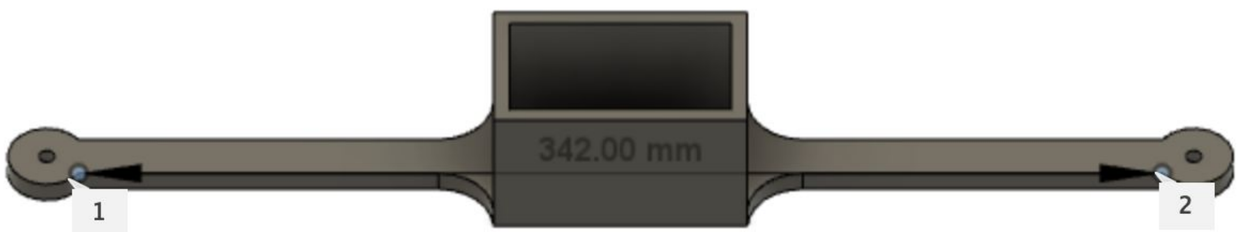


Figure 5: Housing for photocell and structural feature for stability reinforcement.

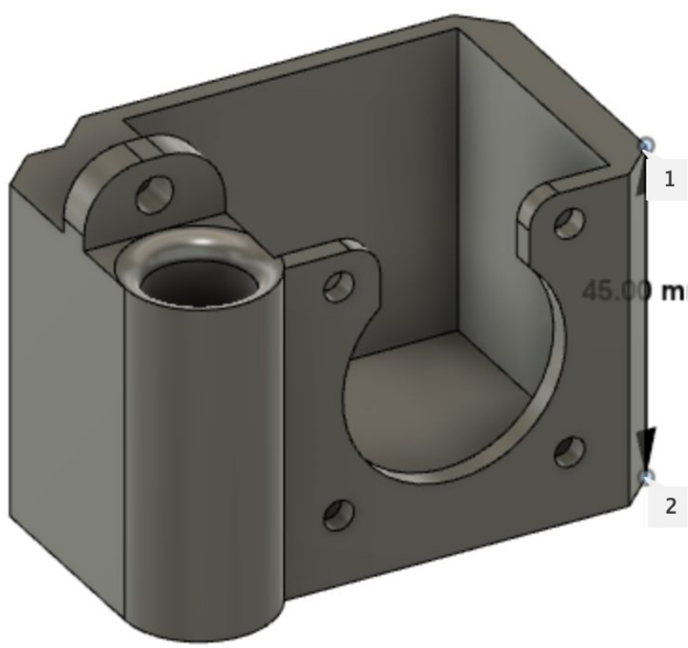


Figure 6: Mounting bracket for motor that serves as pendulum mass as well as driver for adjustable length pulley system.

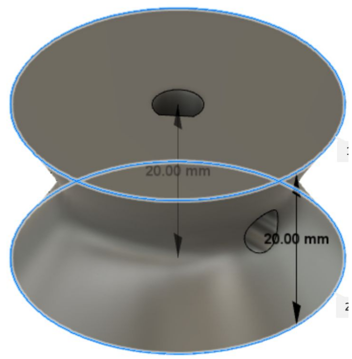


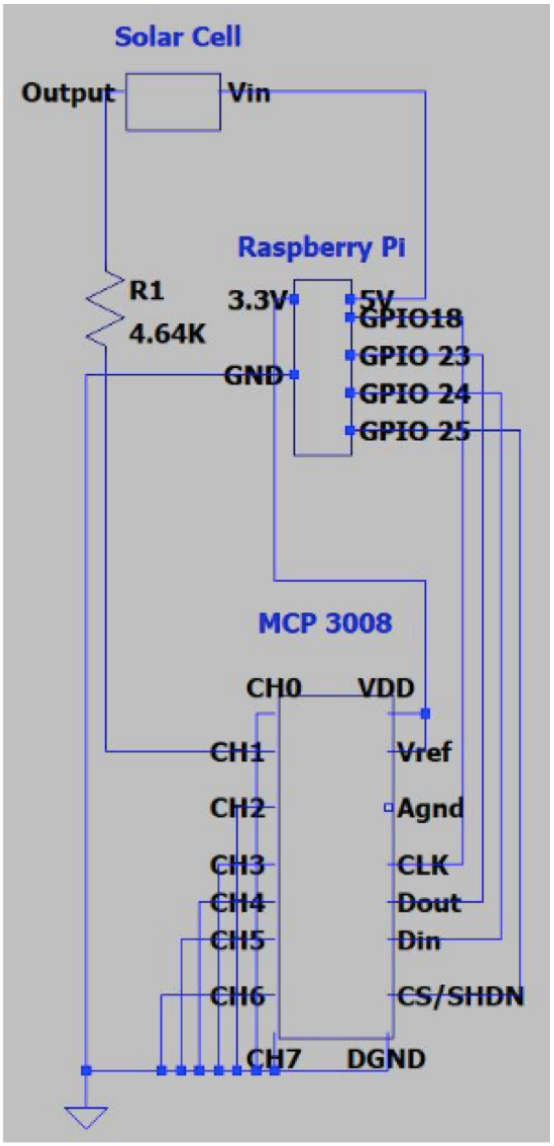
Figure 7: Spool for string used in adjustable length pulley system.

Design Plan/Features

- Rigid arm chosen to reduce noise
- Housing components 3D printed for ease of manufacturing as well as weight of material (which made it easier on our motor to raise up and down the arm)
- Plywood base added to prevent system from tipping
- Four legs chosen for pendulum stability
- Length of legs chosen to allow for large variance in frequency
- Arduino/Motor Shield pairing was chosen because it was the easiest way to drive the stepper motors
- Stepper Motors selected due to high holding torque required to suspend the mass on the rod
- Solar Cell chosen due to greater surface area for capturing a signal
- Flashlight selected because of the intensity of the light, which could create signal across the necessary distance
- MCP3008 chosen due to ease of integration with the RPi
- Raspberry pi selected because of familiarity with system and versatility of the RPi
- Base spray painted black/legs wrapped in black electrical tape to create cohesive aesthetic
- Capitol building designed to sit on top of pendulum as both protective cover and aesthetic finish
- Adjustable weight can guarantee frequency locking to a wide range of frequencies
- Light-based frequency measurement system works in either dim or bright environments
- Capitol building lights up when frequency measurement is being taken
- Dimensions**:** Height of 93.5 cm, width of 55 cm, length of 61 cm

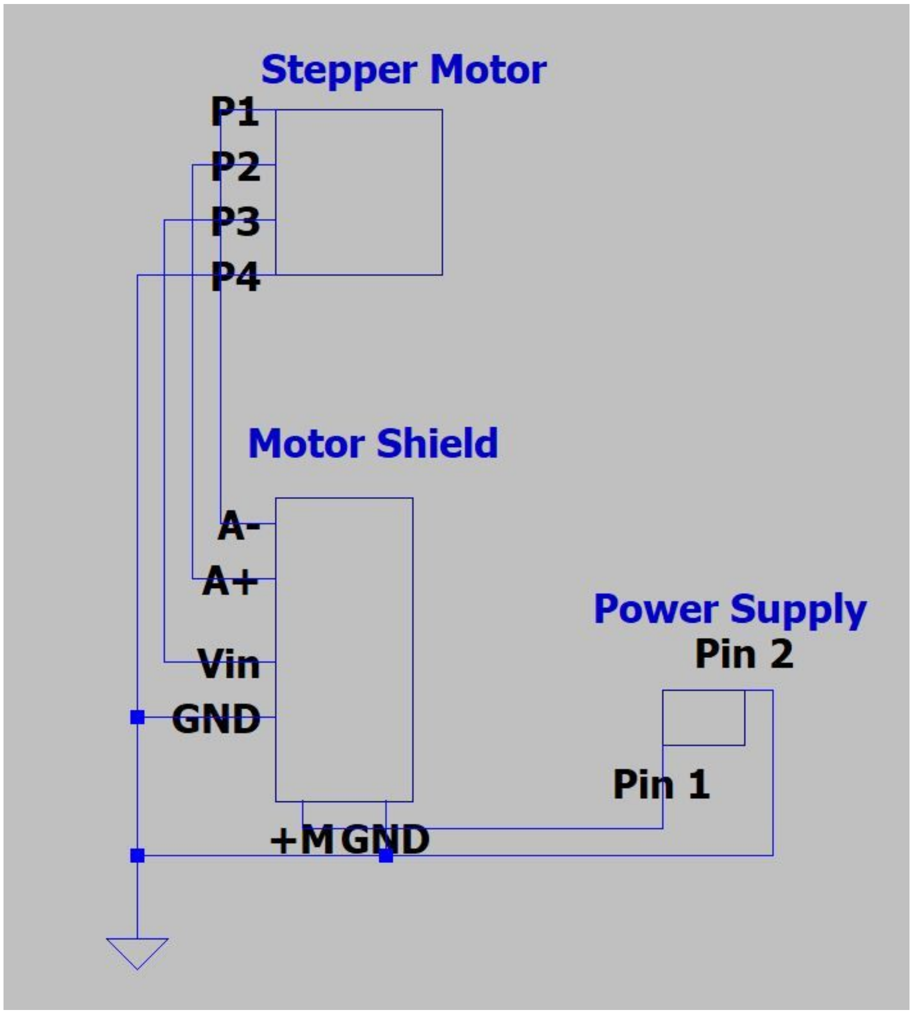
Circuit Diagrams:

#1: Frequency Measurement System



The frequency measurement system consists of a MCP3008 analog digital converter (ADC), a Raspberry Pi, and a photocell. The ADC is wired to the RPi so that signals that enter into channel 1 are readable. The other 7 channels are grounded. The ADC receives signals from a photocell, which is illuminated by a flashlight (not pictured). When the pendulum arm passes between the light and the cell, the difference in brightness is recorded as an event and used to calculate the frequency.

#2: Stepper Motor



The stepper motor is connected to an Arduino motor shield as pictured. The configuration consists of two motors; one is used to drive the pendulum arm, while the other moves the mass up and down the arm.

Tutorial

Instructions for Use

Driving the Pendulum

1. Access the Raspberry Pi (either through remote desktop access or with a monitor)
2. Open file named PenDriveTest.ino in Arduino IDE
3. Input the current location from the top of the rigid arm in centimeters to the top of the mass on the rigid arm after loc =
4. Input the desired driving tempo in beats per minute after bpm =
5. Click upload

Note: There are markings on the rigid arm in 5cm intervals to aid in location measurement.

Measuring Frequency

1. Access the Raspberry Pi (either through SSH connection or with a monitor)
2. Navigate to the directory ~/pendulum
3. Run adc.py
4. The program will return the frequency of the pendulum

Note: The program will take several seconds to take data. To ensure an accurate reading, do not change the operating frequency while the frequency measurement is ongoing.

Use Spotify to Match Song Frequency

1. Ensure the Raspberry Pi is connected to the Internet and logged in to a Spotify account.
2. Navigate to the directory ~pendulum
3. Open spotify_demo.py as a text file
4. Change SONG_URI to match the desired song
5. Save the file, close, and run spotify_demo.py
6. Open an internet browser and navigate to http://localhost:8080/
7. After the terminal prints "Successfully extracted parameters!", press Ctrl+C to terminate the program

Safe Operating Conditions

- Safe frequencies: 80-105 BPM
- Use on level ground
- Do not raise mass higher than 7.5cm or lower than 70cm from the top platform
- Do not use near water
- The string may slip off the spool; if this happens, replace the string and rerun the program to get the mass to the correct location, if necessary.

Appendix

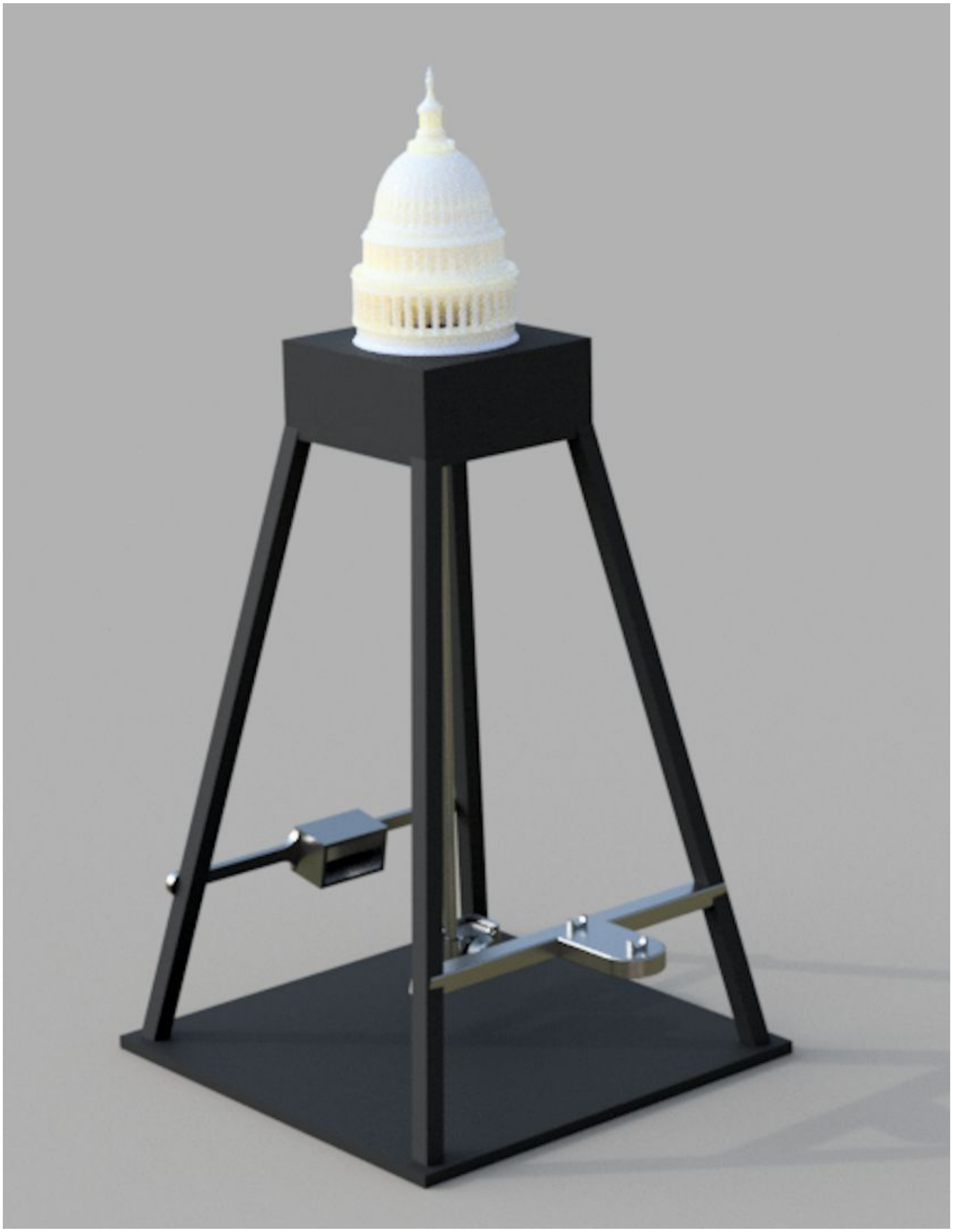
Team Members and Roles
Carrington Metts- Team Leader
Nate Winneg- Hardware/Building Specialist
Justin Dulaney- Designer
Danny Smyth- Coder
Auggie O'Connell- Electronics Specialist

List of Components

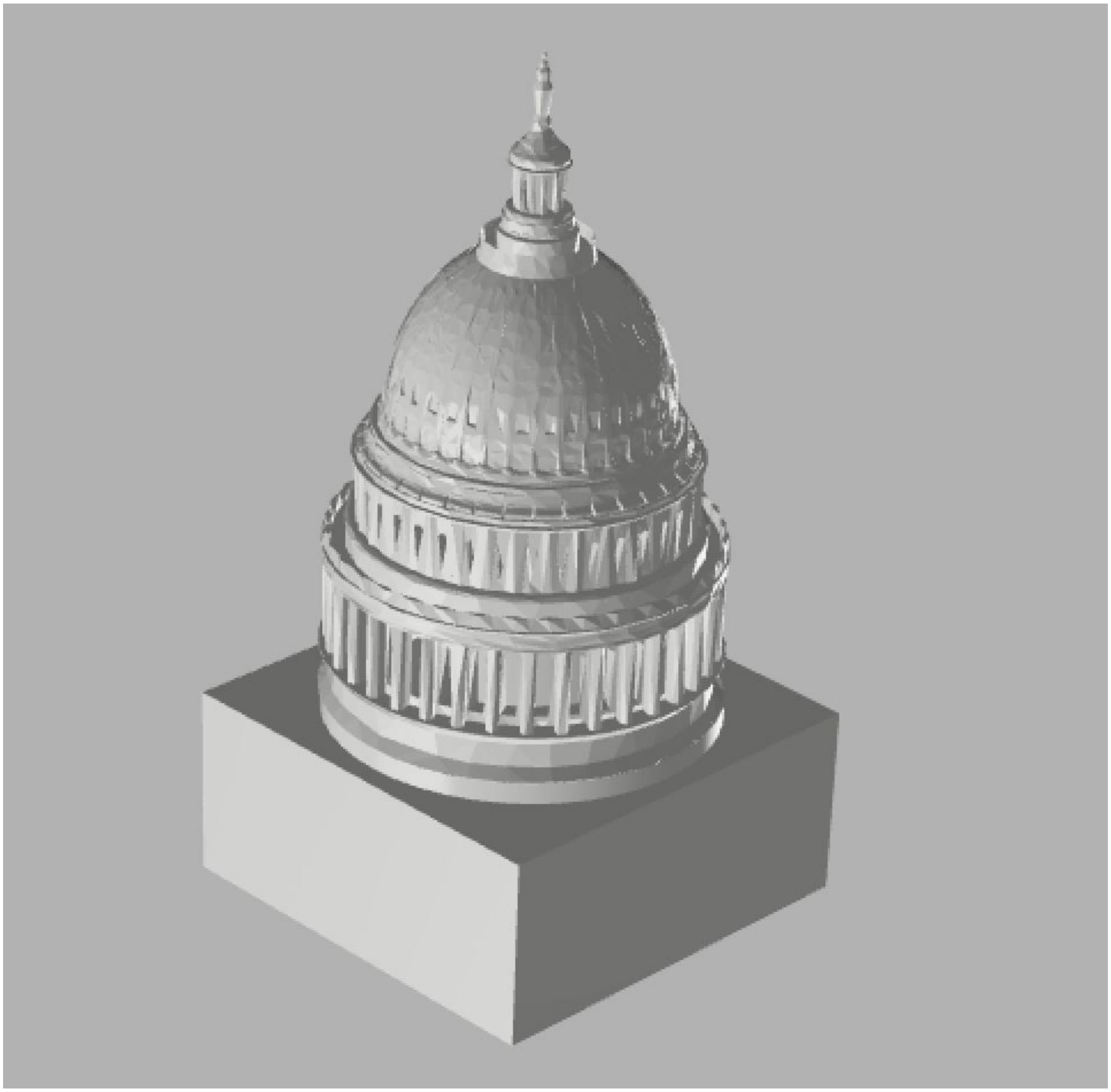
Name	Vendor	Price	Availability
Raspberry Pi 4 Model B	Multiple (Cana Kit)	$35	Available
Solar Cell	Amazon	$14	Available
Arduino	Amazon	$16	Available
Stepper motor(Nema 17) (x2)	Amazon	$26	Available
Flashlight/laser	Amazon	$5	Available
Motor Shield	Adafruit	$20	Available

List of Software
Frequency measuring system
Python packages: Adafruit_MCP3008, Adafruit_GPIO.SPI, RPi.GPIO, time
Spotify
Python packages: bottle (route, run, request), spotipy (oauth2), json, os
Motor driving system
AFmotor.h

Code
Link to Github:
adc.py: measures and computes frequency
PenDriveTest.ino: drives the motors
Run_Motor.py: calculates mass location; designed for use with RPi, so not used in the final design
Spotify_demo.py: extracts BPM for a Spotify song



The above three images are CAD renditions of the final assembly of the pendulum.



This image is a CAD rendition of the structure mounted on top of the pendulum.