DEPARTMENT OF MECHANICAL ENGINEERING

TEAM 14

Solar Sluggers

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Problem Definition

Hiking and camping are very common recreational activities across the U.S. and many other countries. It is essential that hikers and campers have access to a reliable power source for their safety and currently there are very few, if any, reliable power sources that run on renewable energy. According to the North American Camping & Outdoor Hospitality Report of 2023, 92 million U.S. households (average of four members each) identified themselves as campers, with 58 million of which stating they had been camping within the last year. From this we can estimate that roughly 100 million U.S. citizens are affected by this, and likely many more in foreign nations.

The objective of this project is to engineer a versatile and sustainable power generation and storage solution tailored specifically for the unique needs of campers, hikers, and outdoor enthusiasts. The final product must be able to store at least 25 watt-hours of electricity, output 6 watts of electricity, be extremely compact and weigh approximately 1 kilogram. By addressing these basic requirements, the project aims to enhance the safety, environmental responsibility, and overall experience of individuals engaging in remote outdoor activities.

Design Calculations & Analysis

Solar Power Calculations

Calculations were conducted to find the amount solar power required to charge a standard iPhone 15 Pro Max to 20%.

$$V_{Solar} = 5.5\,V \quad I_{Solar} = 0.364\,A \quad n = 3 \quad Battery\ Capacity = 37\,Wh$$

$$P = IV = (5.5\,V)(0.364\,A) = 2\,W \qquad P_{Total} = Pn = (2\,W)(3) = 6W$$

$$Time\ To\ Charge = \frac{Battery\ Capacity}{P} = \frac{37\,Wh}{6\,W} = 6.16\,h \approx 6\ hours\ 9\ minutes$$

As charging continues, heat causes the efficiency of the charger to drop. For these calculations the assumption is that this decreased efficiency is not present for only 20% charging, so .238Wh / 1% battery life will be used.

$$P_{Solar} = 6W \quad Charging\ Rate = \frac{0.238\,Wh}{1\%\ Battery\ Percentage}$$

$$Charging\ Rate * 20\% = 0.238\,Wh/\% * 20\% = 4.76\,Wh$$

$$t = \frac{4.76\,Wh}{P_{Solar}} = \frac{4.76\,Wh}{6\,W} = 0.79\ hours = 47.6\ minutes$$

The final result found that it takes 47.6 minutes of solar power generation to charge an iPhone 15 Pro Max to 20%

Hinge calculations were conducted to find the torque produced by the weight of the solar panel to ensure that the friction hinge could hold the solar panel in place.

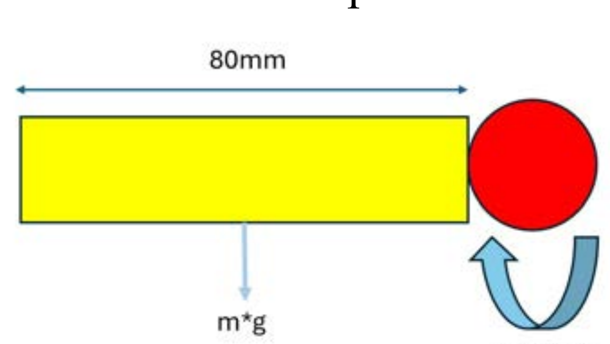
$$m = 0.075\,kg \quad T_{Friction} = 1.3\,in * lbs \quad g = 9.81\,m/s^2$$

$$F = mg = (0.075\,kg)(9.81\,m/s^2) = 0.735\,N$$

$$M = F(d/2) = (0.735\,N)(0.08\,m)/2 = 0.0294\,Nm$$

$$M = (0.0294\,Nm)(8.51\,in * lbs)/(1\,Nm) = 0.261\,in * lb$$

$$1.3\,in * lbs > 0.261\,in * lbs \therefore T_{Friction} > M$$



Thermal Analysis

The average temperature coefficient (% decrease in efficiency per +1°C from 25°C in operating temperature) is roughly -0.35% / °C.
Even if the panels were to increase up to 40°C (104°F), the efficiency of the panels would only decrease by 5.25% or down to 5.685W from a max output of 6W.
In high temperatures of 104°F it would only take 50.23 minutes to charge an iPhone 15 Pro Max to 20%.

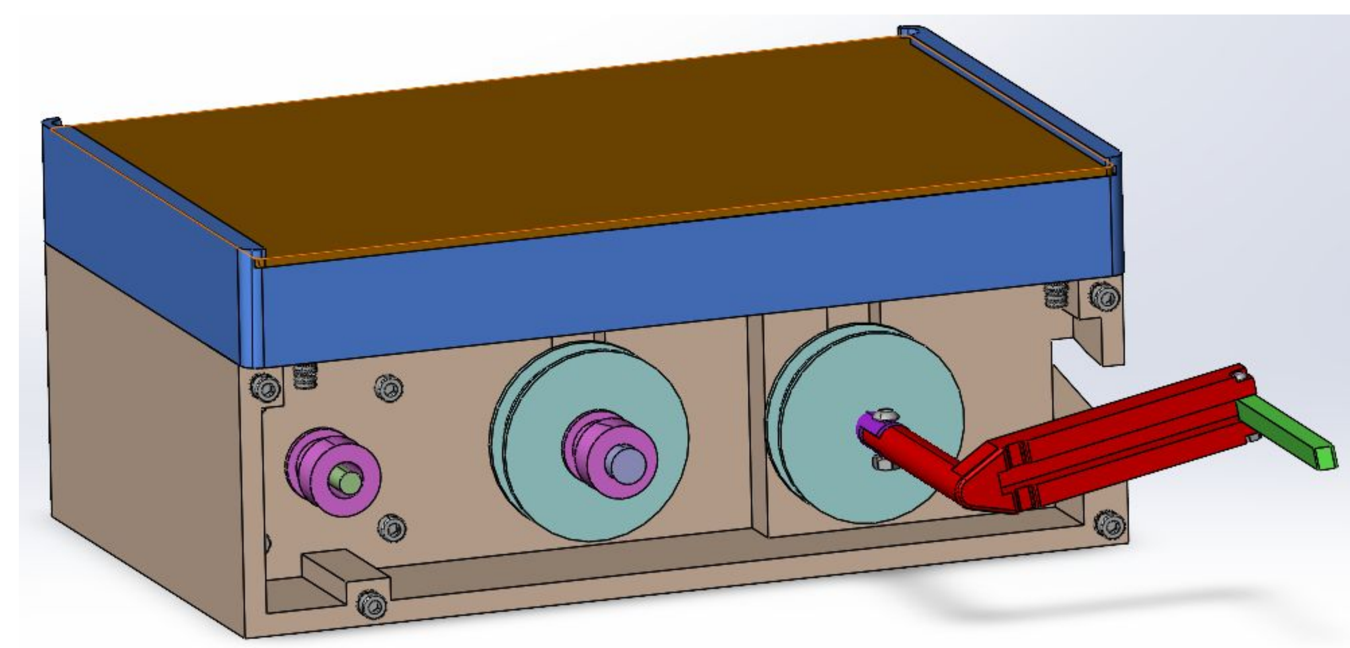
Battery calculations were completed to evaluate the total energy storage of the device.

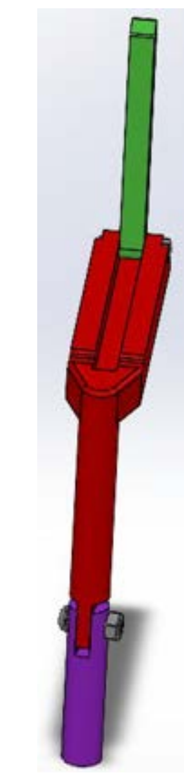
$$V = 3.7\,V \quad Capacity = 10,000\,mAh$$

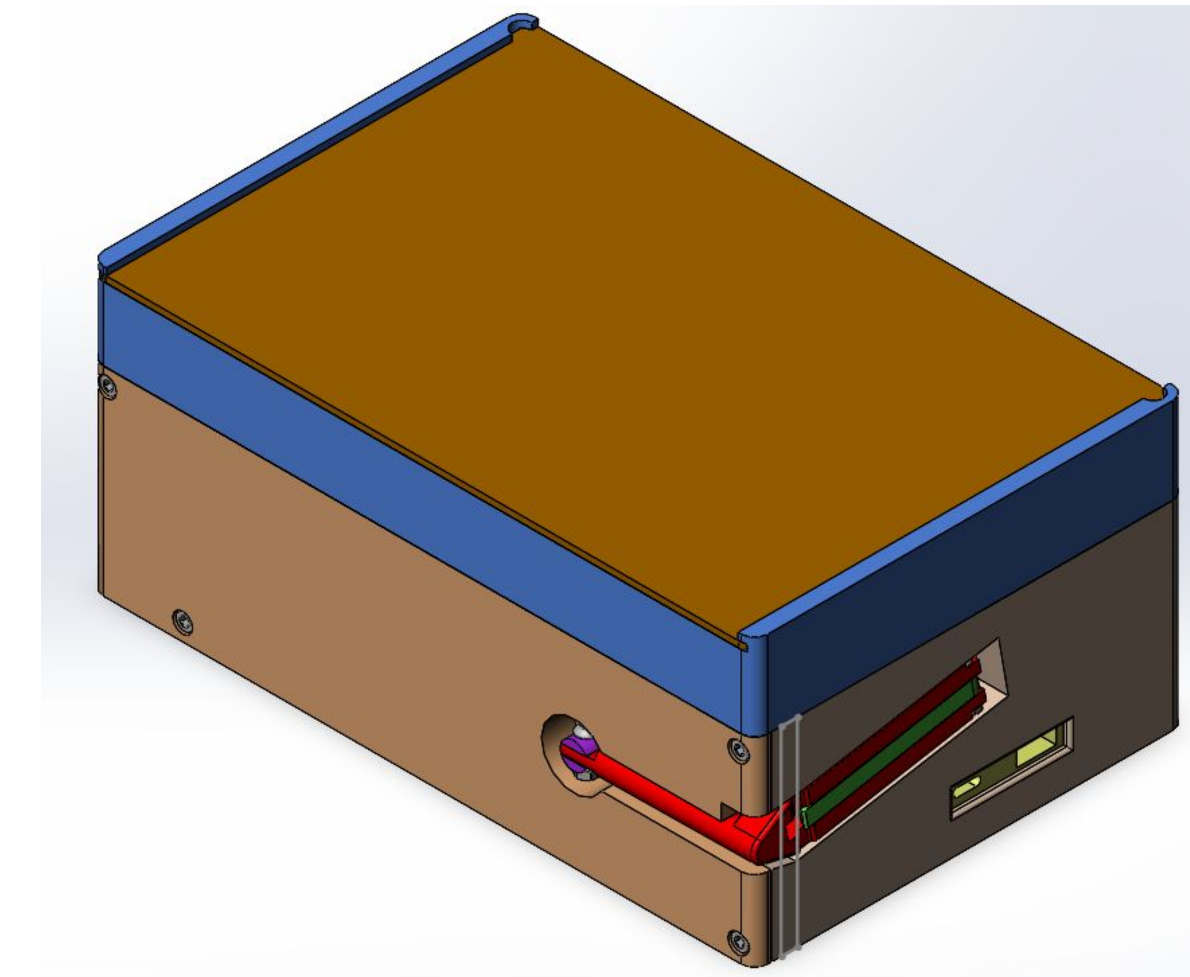
$$E = V * Capacity$$

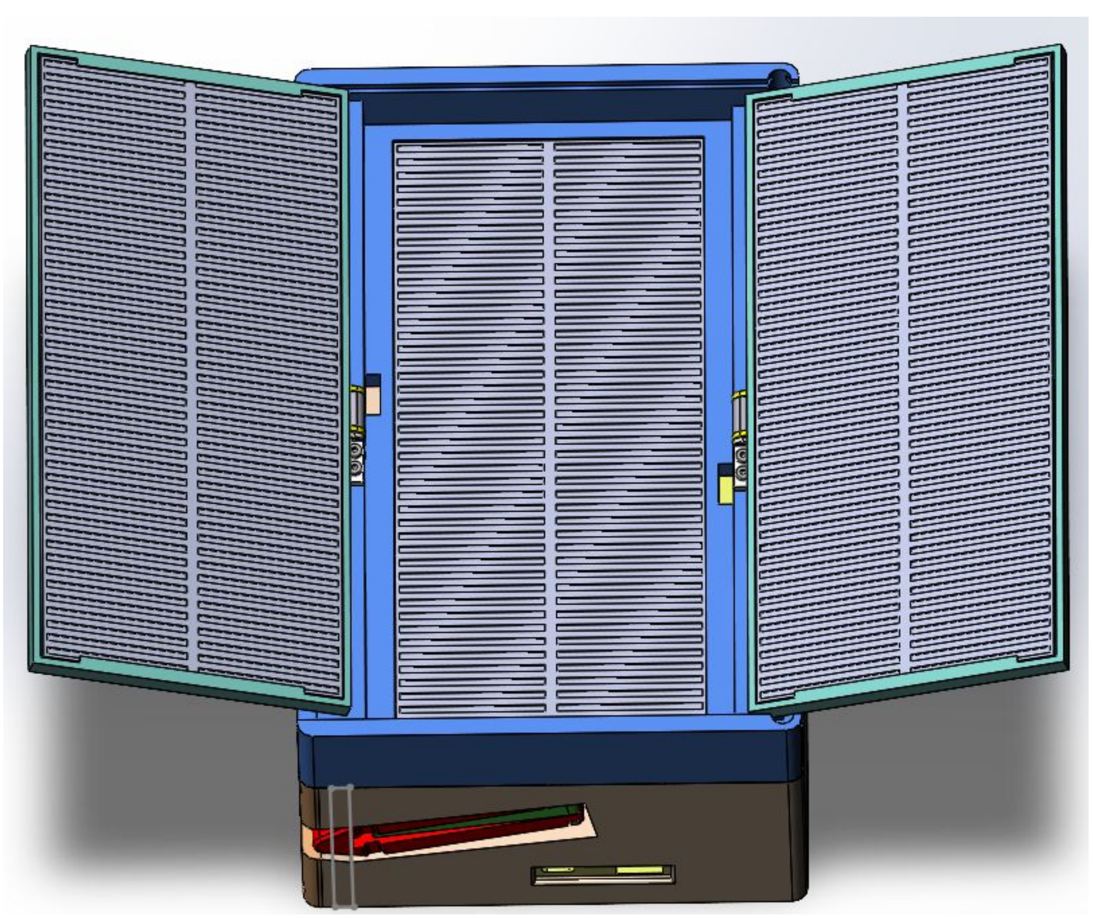
$$E = (3.7V)(10\,Ah) = 37\,Wh$$

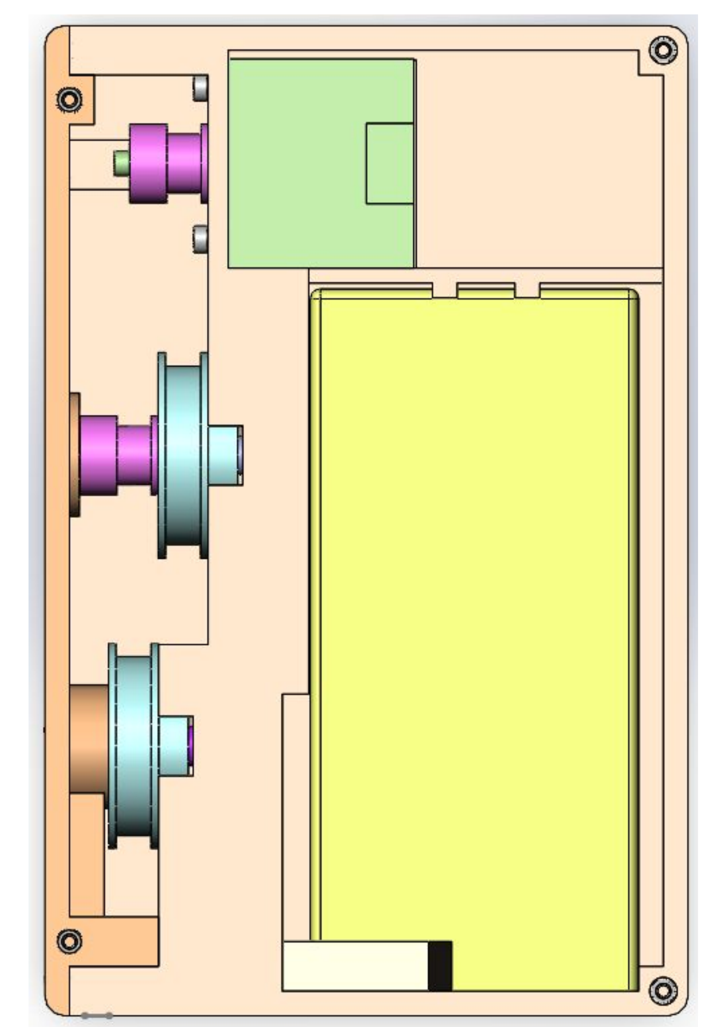
Final Design

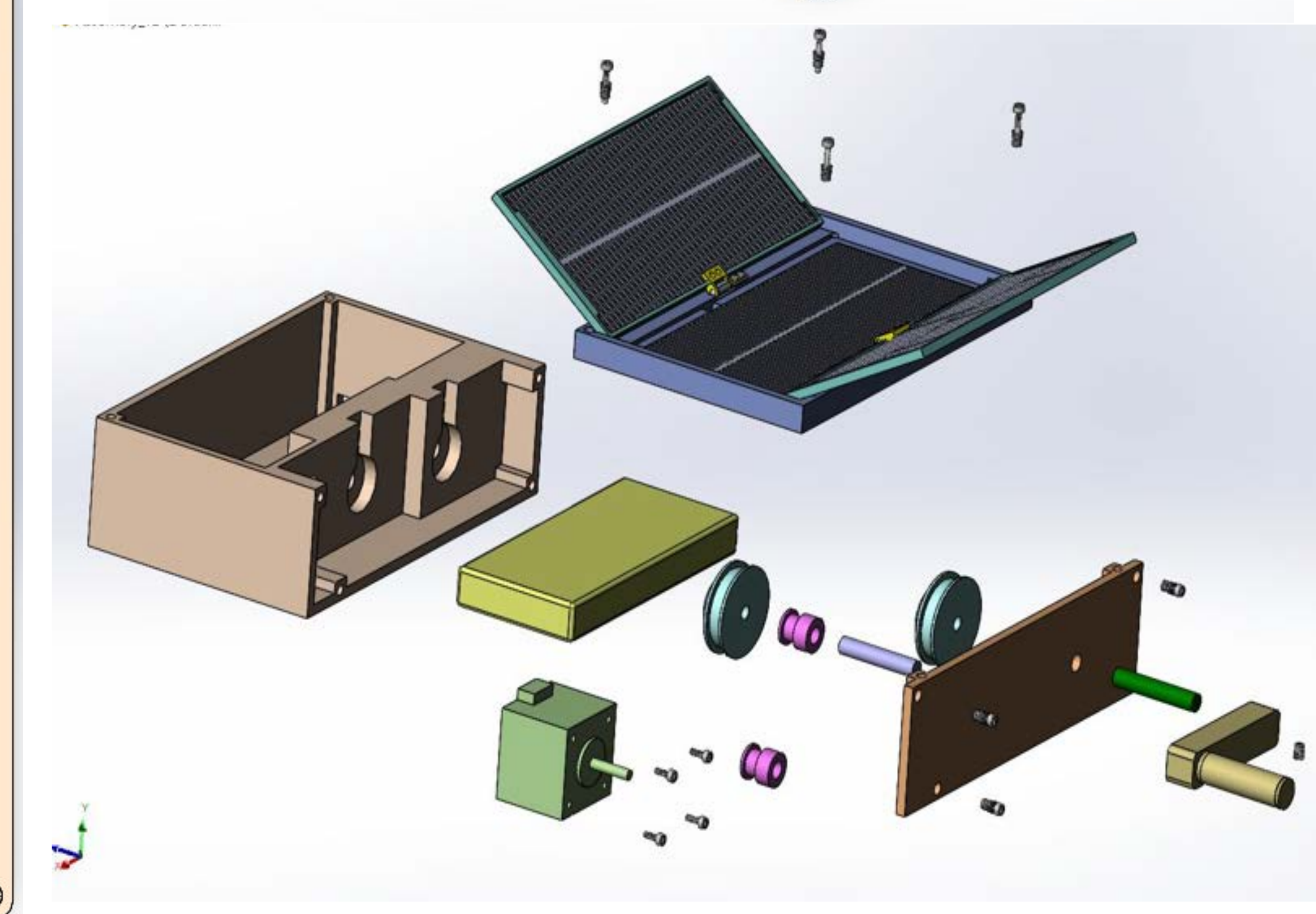




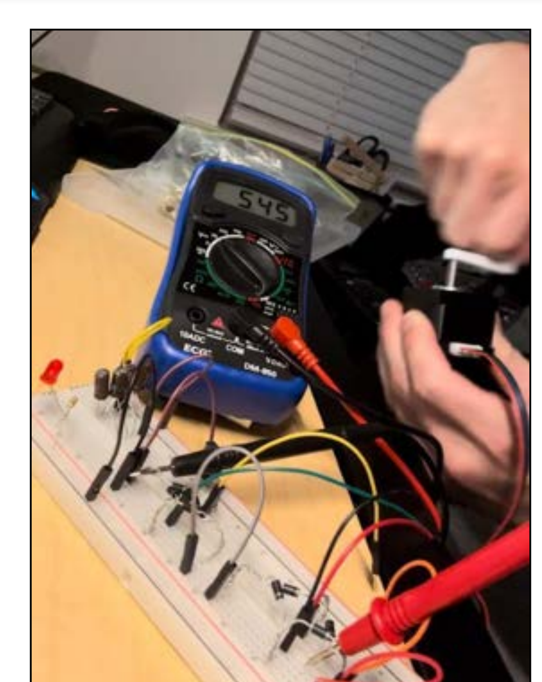








Prototype & Test Results



The tests that were conducted mainly had to do with electrical production from both the hand crank and the solar panels. The hand crank and stepper motor circuit was able to generate 5V consistently without any sort of gear reduction and over 9V when attached to a gear and pulley system. The solar panels were then tested and generated close to 2W of power each on a day with full cloud cover outside. We also conducted small drop tests with parts of the 3-D printed casing and everything held up when dropped from about 5 feet.