Wearable Biomechanical Energy Harvesting Device

Phase 6 Presentation

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Project Objectives

Goal:

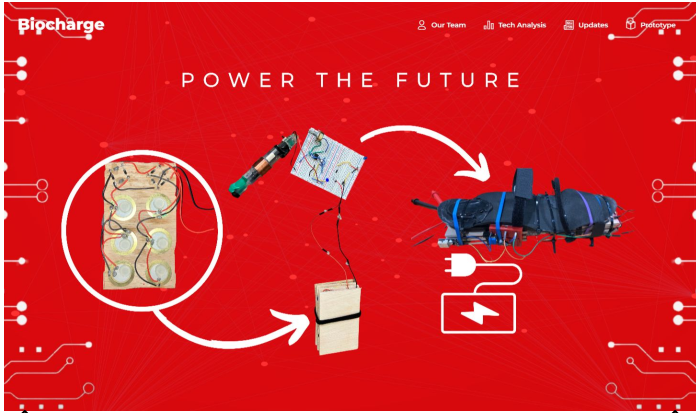
To design and produce a device that captures biomechanical energy sufficient to charge a modern day smartphone.

Objectives:

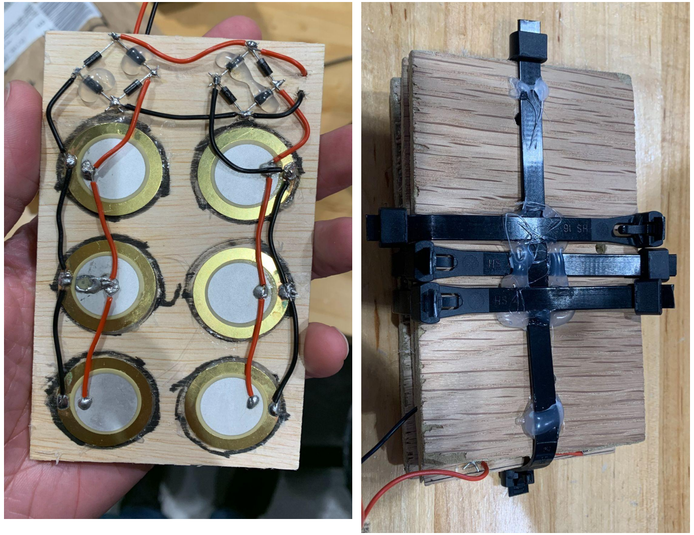
- ➢ Combine different sources of energy conversion to maximize efficiency
- ➢ Reliable long term performance
- ➢ Comfortable enough for extended use

Phase V Recap

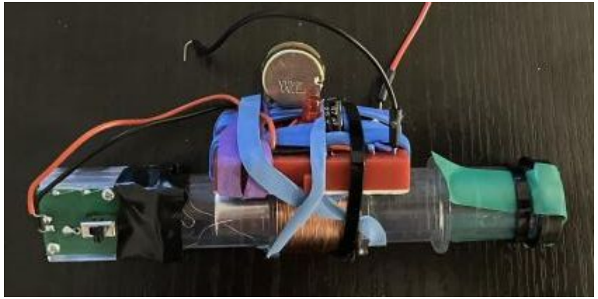
- Finished final design and developed fabrication process for both piezo and induction coil designs
- Final design for a combined system was employed
- Final website edition was created



https://biocharge1870.github.io

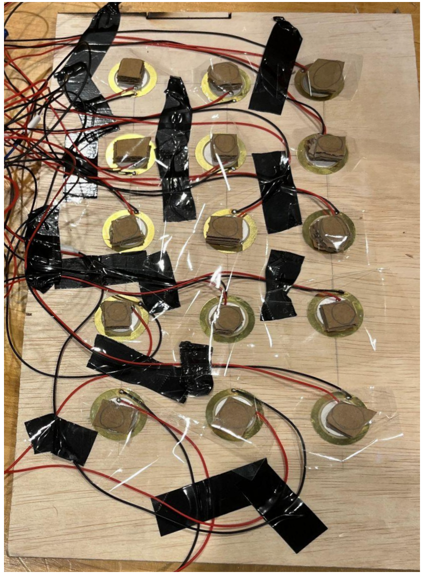


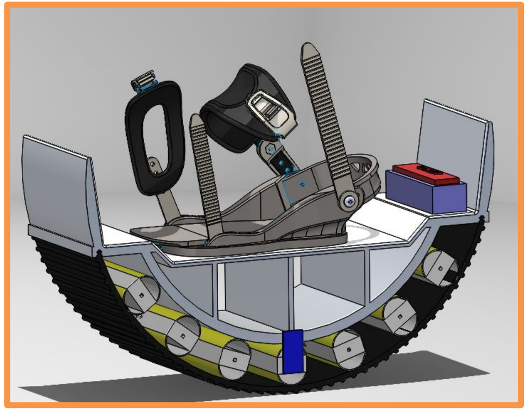
Final Design for Piezoelectric Model



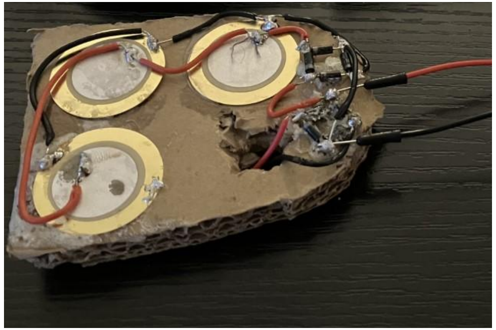
Final Design for Induction Coil Model

Shortcomings of Previous Designs





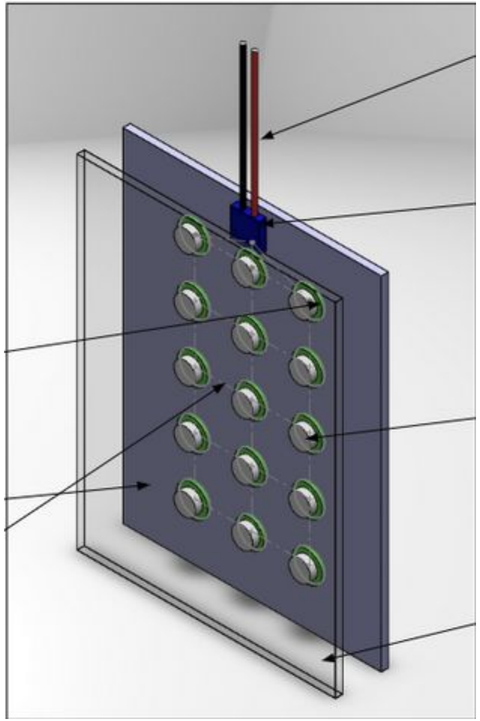
Phase I Concept Selection



- ➢ Material selection for mounting of piezo material was too stiff
- ➢ Wiring configurations did not produce enough current
- ➢ Inefficiencies in design to optimize amount of piezo on each plate
- ➢ Original design was too bulky to be worn comfortably

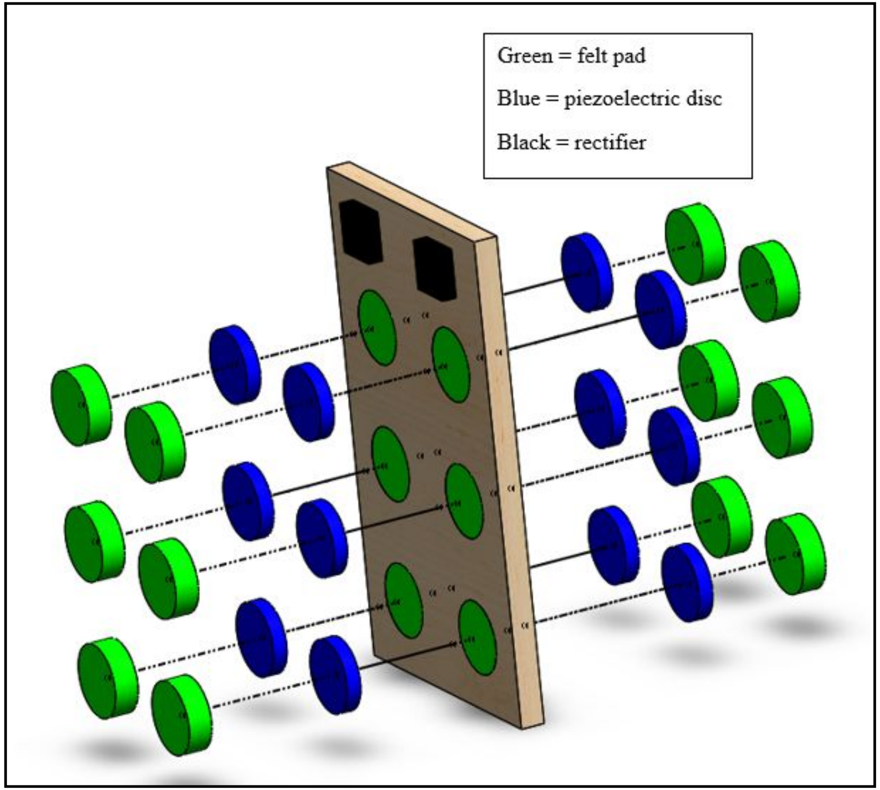
Steps Taken to Overcome Shortcomings

- ➢ Torsional stress on piezoelectric cylinders
  - ○ Converted design from a U-shaped sole to a flat plane
- ➢ Inefficient loading of piezoelectric material
  - ○ Incorporated felt padding to protect sensitive piezoelectric components while evenly distributing forces applied
- ➢ Original design was too bulky
  - ○ Reduced design volume by compressing it into a rectangular space directly underneath shoe sole
- ➢ Insufficient amount of piezoelectric material
  - ○ Incorporated a stacked design with thin piezo material in each layer
- ➢ Design did not produce enough current
  - ○ Induction coil technology was studied and integrated

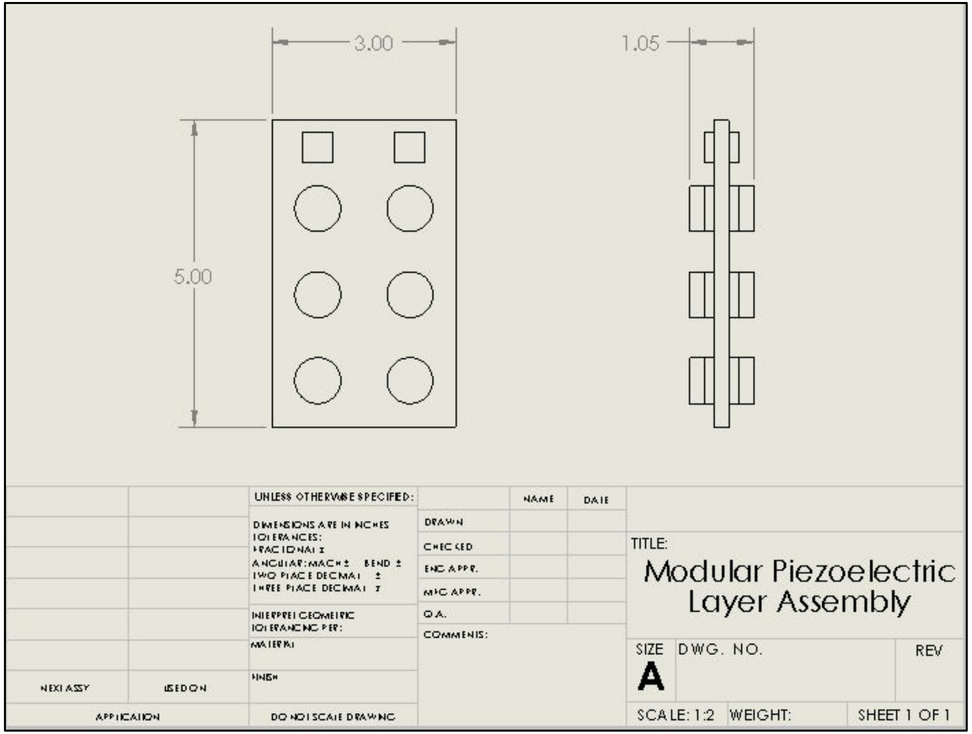


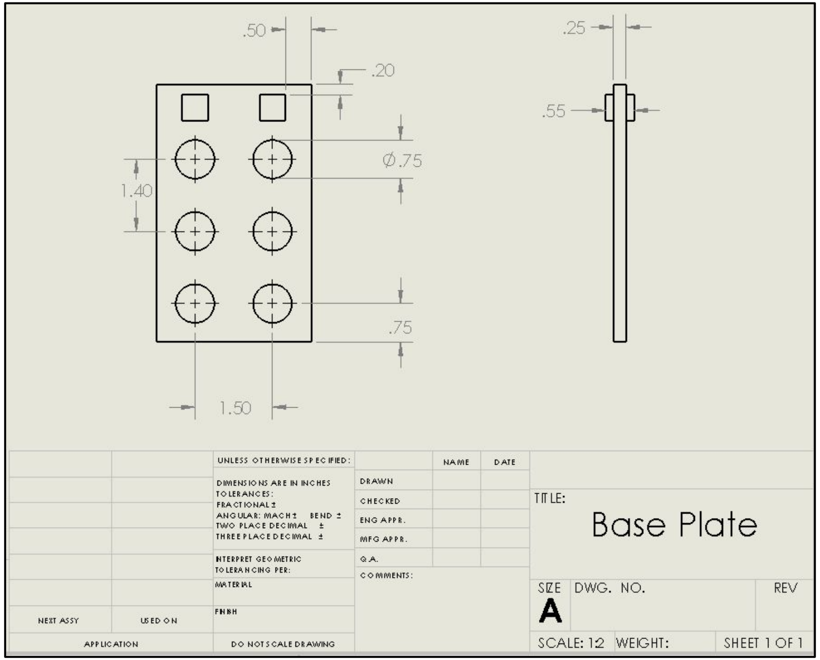
Final System Design: Piezoelectric

- Piezoelectric discs are 0.15 mm thick and the felt pads are 0.25 mm thick
- Final design uses 12 discs per base plate and includes 2 of these plates totaling 24 discs.
- Multimeter reads average values of 50V and 30mA during max force of a step.



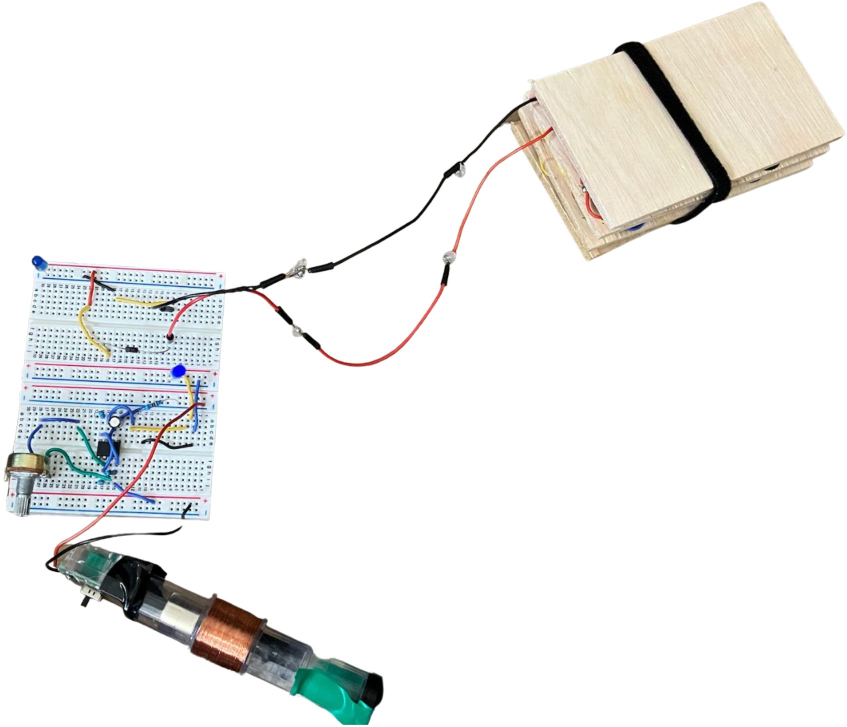
Final System Design: Piezoelectric Dimensions





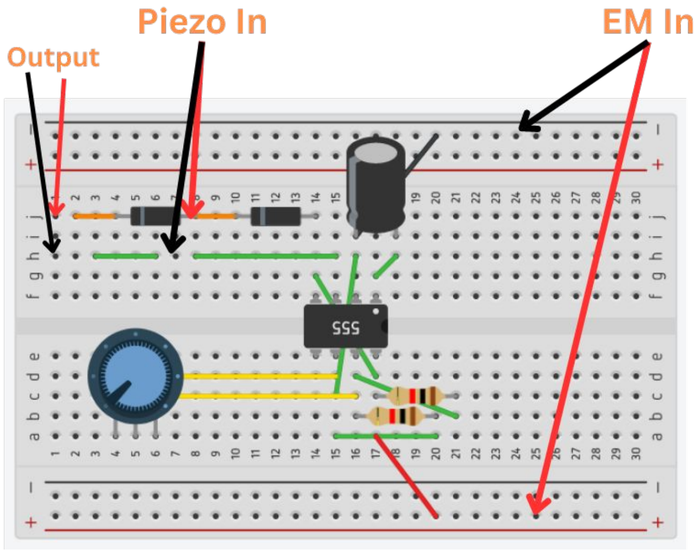
Final System Design: Induction Coil

- Produces constant 1.2A and 0.4V
- Constant power output: 480 mW
- 22mm in diameter
- 84mm in length



Combining the Two Generators

- ➢ Alternate between constant and variable inputs
- ➢ Prioritize high input values from Piezoelectric generator
- ➢ Provide constant passive power from electromagnetic induction coil



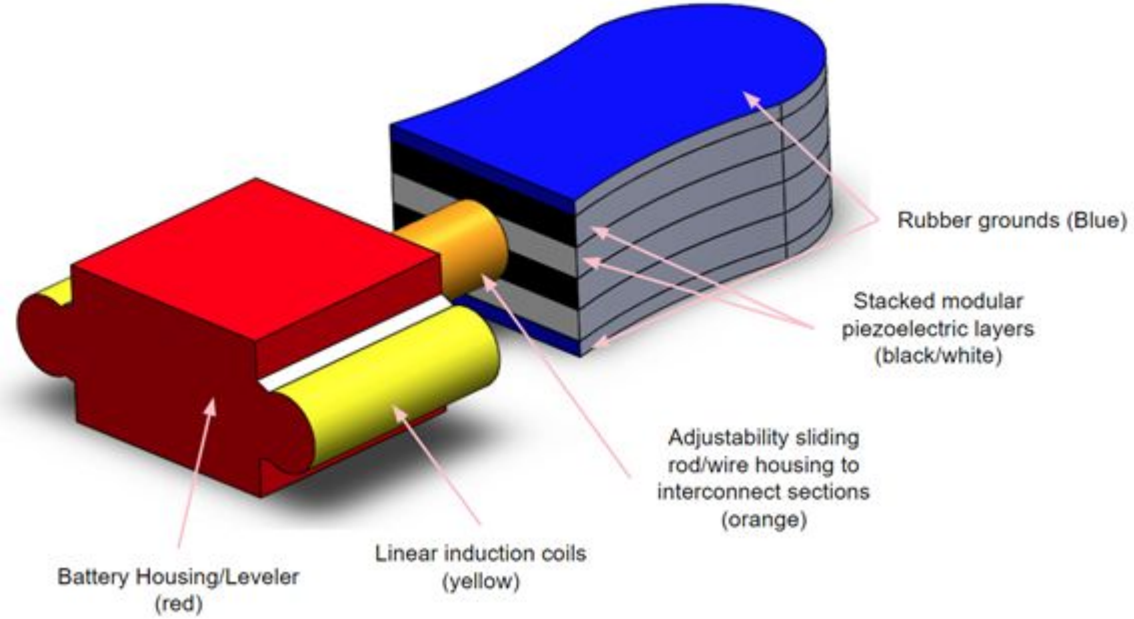
Final Prototype Demo

Final Prototype Power Figures

- Given the power being sent into the battery is constantly fluctuating, it is difficult to state a singular figure which describes the output of the system.
- On average the power being received at the lithium ion battery is about 15V and 1.3A which $\approx$ 20 Watts
  - The system has charged a 7.4 Wh battery in less than 2 minutes to a reasonable point where its stored energy can be stored
- The goal of the project is to provide charge to a smartphone, and with a USB plugin that provides at least 5 V and 1.2 A
- The group is proud of this achievement coming from $<$1V and $<$1A power generation in Phase 1, the group is confident these figures could continue to improve with the implementation of piezoelectric material specifically designed for power generation

Concept for Final Product/Future Prototypes

While the group focused primarily on optimizing the power generation function of the project, this shows a very general representation of how the group would have liked to build the housing for said components. *Labeled section are not to represent actual shape, but rather layout and location*.



Key Insights and Lessons Learned: Induction Coil

- List of Harvester performance variables:

Voltage	mV
Current	Amperes

Experimental Set-Up

- List of Harvester parameters used for experiments:

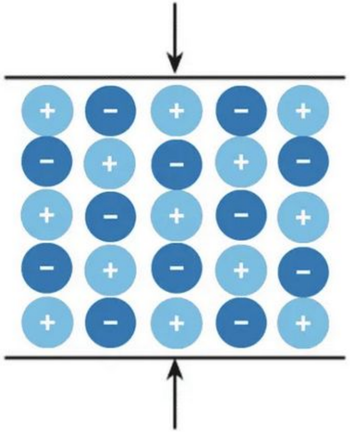
Stator Length	mm
Mover Size	mm
Wire Coil Density	mm^2
Winding Direction	North, South
Winding Spacer	mm
Wire Circumference	AWG
Iron Pole Pieces (both ends of stator)	

Key Insights and Lessons Learned: Induction Coil (cont.)

- Increasing the stator length, and effectively travel distance of the mover, increases power output.
- Decreasing the mover size had negligible effect on the system, but did increase oscillation (Hz), reduced weight and cost
- Increasing wire coil density increases power
- Windings in variable direction had negligible effect
- Winding must be continuous wire strand
- Separating windings had negligible effect
- Increasing wire circumference (decreasing wire gauge) negatively effected power output
- Iron pole pieces improve power production

Key Insights and Lessons Learned: Piezoelectric

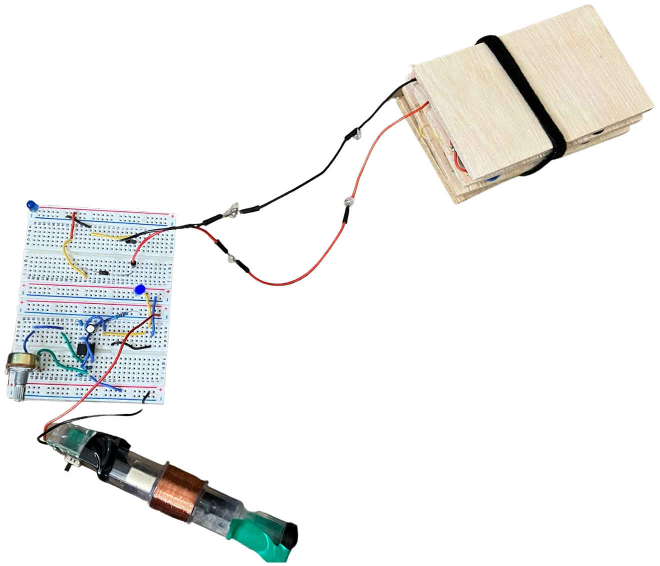
- ➢ The significance of a piezoelectric high Young's Modulus and a high charge constant
- ➢ Aligning piezoelectric strips in series to maximize voltage
- ➢ Budget can extremely limit the piezoelectric materials as they can be costly, requiring a resourcefulness in achieving energy goals
- ➢ Simulating bending moments within a sandwiched piezoelectric disc can cause extreme bending in the center during a linear force, significantly increasing power output
- ➢ Sufficiently charging a power source requires constant power, a feature not accompanied by piezoelectric frequency-based materials, complementing the decision to use two power sources
- ➢ Assigning a rectifier to each subsystem of piezoelectric discs can improve energy harvesting capabilities



Areas of Improvement for Current Design

Moving Forward:

- ➢ Implementing more efficient piezoelectric material
- ➢ Condensing the overall design to fit into the sole of a shoe
- ➢ Testing the implementation of additional layers of piezoelectric material
- ➢ Testing the implementation of additional linear coil generators as well as adjustment of their length and amount of copper wire on the coil
- ➢ Generally optimizing all components of the current design further



Thank You!
Questions?

Final Budget Breakdown - Phase 6

Project Budget & Materials					
Mechanical Materials	**# Used**	**# Ordered**	**Cost Per Unit**	**Budget Used?**	
Rubber Bumpers	15	1	$9.49	Yes	$9.49
Cork Sheet	1	1	$10.50	Yes	$10.50
Magnet Wire	1	1	$9.35	Yes	$9.35
Magnet Wire	1	1	$11.82	Yes	$11.82
7/8" Magnet	5	5	$6.19	Yes	$30.95
Enameled Copper Wire	1	1	$11.45	Yes	$11.45
Enameled Copper Wire	1	1	$23.99	Yes	$23.99
Hiking Boots	1	1	$69.99	Yes	$69.99
Soft Iron Rod	1	1	$4.99	Yes	$4.99
Electrical Materials					
Piezo Pickups	15	1	$9.00	No	$0.00
Piezo Pickups	15	7	$8.00	Yes	$56.00
Converter Module	1	1	$8.39	Yes	$8.39
Solder Spoole	1	0	$0.00	No	$0.00
Soldering Iron	1	0	$0.00	No	$0.00
MultiMeter	1	0	$0.00	No	$0.00
Wires	N/A	0	$0.00	No	$0.00
Rectifier	1	0	$0.00	No	$0.00
Breadboard	2	0	$0.00	No	$0.00
Roll of Electrical Tape	1	0	$0.00	No	$0.00
Testing Battery	1	0	$0.00	No	$0.00
DC-DC Step Up Power Module	1	1	$10.99	Yes	$10.99
Laser Pointer	1	1	$8.99	Yes	$8.99
Step Up Boost Power Converter	1	1	$9.99	Yes	$9.99
Lithium Battery 18650 Charger	1	1	$8.99	Yes	$8.99
Buck Boost Converter Module	1	1	$12.99	Yes	$12.99
Buck Converter Step Down	1	1	$16.99	Yes	$16.99
Flashlight	1	1	$19.65	Yes	$19.65
Balance Left:					**$434.53**