Interactive Charging Station

Midpoint Report

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This report was prepared by students as part of a university course requirement. While considerable effort has been put into the project, it is not the work of licensed engineers and has not undergone the extensive verification that is common in the profession. The information, data, conclusions, and content of this report should not be relied on or utilized without thorough, independent testing and verification. University faculty members may have been associated with this project as advisors, sponsors, or course instructors, but as such they are not responsible for the accuracy of results or conclusions.

EXECUTIVE SUMMARY

This summary was created to see if the interactive charging station team was able to generate ideas to solve the project problem of ME476C Mechanical Engineering Design I course and to be able to replace the bicycle like machine in the second floor of the engineering building. Most machines that are interactive and can capture the energy used by the user are found in gyms. We found that to be able to measure the same readings that these machines output we needed to look at their sensors. Some of the sensors that they use are the tachometer, time module, and a heart rate sensor. After looking into the sensors, we needed a motor that capture the movements being made. Our group was unsure on picking between two concepts. We had a treadmill and a rowing machine, both have their benefits and shortcomings. For example, a person needs to run at a pace of 7.2 mph for the entire hour to be able to generate 48 Watts of power. With the elliptical that was donated, we were able to narrow down our project into one specific machine. We were able to generate multiple designs to implement into the elliptical after we removed the plastic covering the mechanical parts.

ACKNOWLEDGEMENTS

We would like to thank Dr. Trevas for being our instructor and helping us create design ideas to implement in the building of this device. Our team would also like to thank Shirley Hatcher for helping find a device that the team could build around without having to go out and buy something expensive.

TABLE OF CONTENTS

[Use your word processor to delete the following Table of Contents and insert a new TOC. Include front matter (except for the cover page), body of the report, and all appendices. The Table should include four levels of headings, e.g., down to 2.2.1.3, as illustrated below. Front matter should be in Roman numerials.]

Contents

Introduction

NAU students are constantly on their electronic devices and have a need for a charging station in the engineering building. There is currently an out-of-date charging station located on the second floor and our team is looking to replace it with an upgraded one. This upgraded one will sit in the spot of the current charging station and will serve NAU students for years to come. Having an interactive charging station in the engineering building will allow students to create their own energy and it will give students the ability to cut the amount of energy used and overall slightly reduce the cost of electricity.

Design Requirements

Some design requirements of the interactive charging machine were assigned. The first design requirement was to have the interactive charger have the ability to track the power created. The second design requirement was to make sure the charger has updated charging capabilities. The third design requirement was to include a variety of charging cables and female power inlets like a 3 prong plug and USB port. The charger must also be user friendly and durable. The interactive charger must also have a small screen that displays power created, the students rpms that were created, the students initials, and calories burned. Lastly, the interactive charger must be a fun way for students to charge their electronic devices.

Design 1

Without having the materials and knowing exactly what to build, it was difficult to design a product and finalize what our team was going to build. At first our team looked at treadmills and rowing machines and found that there was an existing treadmill that can capture energy from runners and output that power back into the grid. Our team got a used elliptical from Flagstaff Athletic Center, we took the ellipticals plastic cover to see how the mechanical part of the moves. After seeing the inside of the elliptical, we were able to come up with several designs that utilizes what the elliptical already has. The first one is the inner thigh workout; this design will employ the inner thigh and glutes muscles to move the two of the vertical bars towards each other like a thigh adductor seen on appendix ______ Figure _______. By using this design, our group would only have to change the two feet pedals into the two vertical poles. A downside to this machine is that it is easy for a person to quickly become fatigued. A machine like this is also meant to be done in slower repetitions, due to this there will be less power output by the user.

Design 2

The second design would be to completely scrap the feet part of the current elliptical machine and to implement a whole new system. The new system would mount a chair onto the back of the frame with a small desk connected to it that allows students to work while they charge their electronic devices. The part that would actually create the energy would be two small foot pedals. The small foot pedals would be connected onto two small cranks that would be connected to the existing belts. As the person using the device would tap their feet, the cranks would start to spin, pulling the belts causing the flywheel to spin. Having the flywheel connected to a small generator would then allow the team to create energy. The generator would then store the energy in a small battery and the battery would be able to charge electronic devices. A small screen on the top of the charging station would allow students to track how much energy they have created and then they would be ranked on a small list according to how much power they created. Design 2 can be seen in Figure _____ below in Appendix ______.

Design 3

The third design would be to leave the machine as is. Instead, we will be adding a power generator which will be used to provide charging ports for laptops, tablets, and other electronics. We will also add a small table between the handlebars and a screen above the table. The screen will allow users to sign in so they can keep track of their energy production. There is also the option to not sign in and simple use the machine for exercise or to charge electronics without recording progress. The screen will also display the top 5-10 energy production scores, which could serve as motivation for competitive students.

The primary audience for the elliptical machine would be students. There are a few reasons that students might be interested in using it. Since the machine generates energy while it is being used, students can use to charge their dying phone, tablets, or laptops. Students might also be interested in using the machine as they wait between classes. It would be an easy way to get a short exercise out of the way and there is the added bonus of charging electronics. Students might also want to use the machine if they are in a competitive mood. The screen at the top of the elliptical records the highest energy production scores. It is a healthy way of engaging people in exercise through competition. The table that is below the screen is flexible, which means that it can be adjusted for different heights and uses. The small table can move at different angles depending on the person’s needs. For example, it can lie flat and allow them to place a laptop on the table or it can be at an angle which could hold a tablet, phone or book for better use. Design 3 can be seen in Figure _____ below.

Electrical Components

The first thing we did in designing the electrical components of the interactive design was to come up with a plan of how to convert mechanical energy into electrical energy. We decided that the best way to create electrical energy from mechanical energy was to use a pulley system that connected our fly-wheel to the generator. Our pulley system will use a fan belt and open belt drive design. There are several different types of belts you can use for a pulley system, the reason why we chose the fan belt was because it was the most commonly used belt and what rectangular in design. The rectangular design makes it easy to mount the belt onto the fly-wheel as well as the pulley that is mounted on the axil of the motor. We decide that buying a normal generator would be bigger and more expensive than what our project required. Instead, we decided to make a generator out of a motor by keeping the current flowing in only one direction. Normally a motor works by applying voltage to create a torque, we're applying a torque to create a voltage. We had two ideas of how we would keep the current from flowing back into the motor. The first idea was to use a fuse and diode. The diode would act as the wall that would stop the current from flowing backwards toward the motor, the fuse would be used to control the amount of current flowing towards the battery. If there is a surge in the electrical system the fuse will blow and create a gap in the circuit or what Electrical Engineers call an open circuit. Of the two ideas this one is the cheapest, the only problem is that if the fuse blows you have to physically replace it with a new one. For long term low maintenance purposes this is a big issue. The second idea, which is the one we have decided to use, is the charge controller. A charge controller limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may protect against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk. It may also prevent completely draining a battery, or perform controlled discharges, depending on the battery technology, to protect battery life. The charge controller is more expensive than buying a fuse and a diode, but it is more durable and will last a lot longer.

Regardless of what device we use to control the current, the next step was selecting a battery to be charged by the generator. We decided to go with a Lead Acid battery called Mighty Max, it can hold up to twelve volts and thirty-five amperes. We chose this battery because it held more than enough current and voltage to charge a phone or computer. This battery was also one of the cheapest options and even though the battery was on the heavier side, it wasn't cause for much concern because it was going to be mounted at the front of our interactive charging station. The next step was to identify a way to connect the battery to a phone or computer. We decided on an inverter for three reasons, the first reason is that the inverter allows us to create an interface to charge your phone or computer. The second reason is that the inverter provides a safeguard for a phone or computer to insure that they get the proper voltage and current. The third and final reason is that the inverter allows us to convert the DC voltage from the battery to the AC voltage required for phones and computers.

Subsystems

Sensors

An array of sensors will be needed to monitor power creation and provide feedback to the user. This interactivity is necessary to ensure usage unlike the previous bike iteration of a human powered charger. To calculate power it is necessary to measure either resistance, current, and or voltage. With the load of the machine being variable if there is a device being charged the most accurate method would be with measuring current and voltage as can be seen in equation 1 below.

$$P = IV \quad \textit{eq.1}$$

Since arduino is being used there are a number of sensors that already exist to measure current with minimal losses. The sensor eventually chosen is the ACS712 which has three submodels that can handle various amperages 5A, 20A, and 30A. The 30A model was purchased, but after preliminary testing it was shown to be insensitive at lower amperages since it is a first order linear sensor that outputs a readable voltage based on measured current, due to limitations of Arduino this means that the readable voltage must be less than 5v otherwise it will damage the Arduino. To then calculate voltage a voltage divider will be utilized to step the power down to be read and interpreted by the Arduino on a 0v - 5v interval to again prevent electrical damage. A tachometer will likely be utilized as well to monitor safe operating levels and to provide the user with an equivalent distance, velocity, or acceleration if applicable. Depending on the accuracy of the tachometer RPMs can be used to find the angular acceleration which then can be used to find torque.

Display

To provide interactivity data will need to be relayed to the user by use of a display. It will be best to minimize power usage by the display and as such use a screen the smallest screen that will not inhibit usage. A number of manufactured screens exist for Arduino and quite a few of them are touch screen as well. Touch screen is another source of power loss however the amount may be worth it with the interactivity and intuitiveness that the lend. Once further information is known about the electrical system a decision can be made with respect to the screen, however at this juncture a 7” display with integrated capacitive touchscreen display seems to be the ideal solution. Power restrictions may affect this decision in the future.

Appendix A: 3 Concept Designs

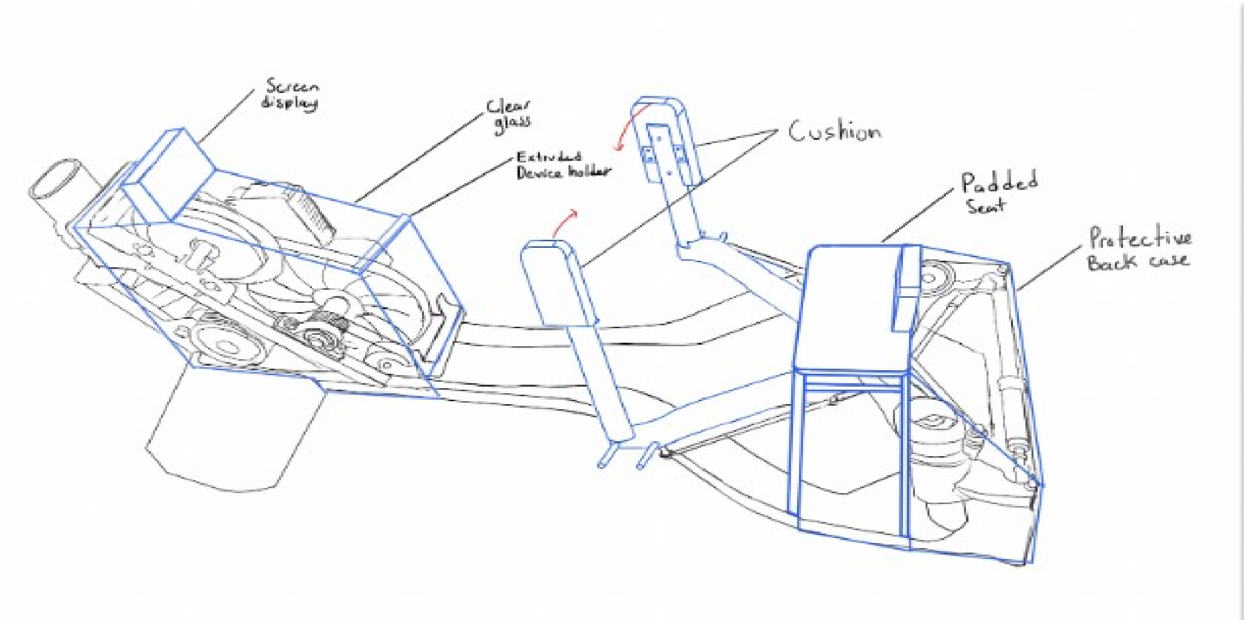

Figure 1: Design 1

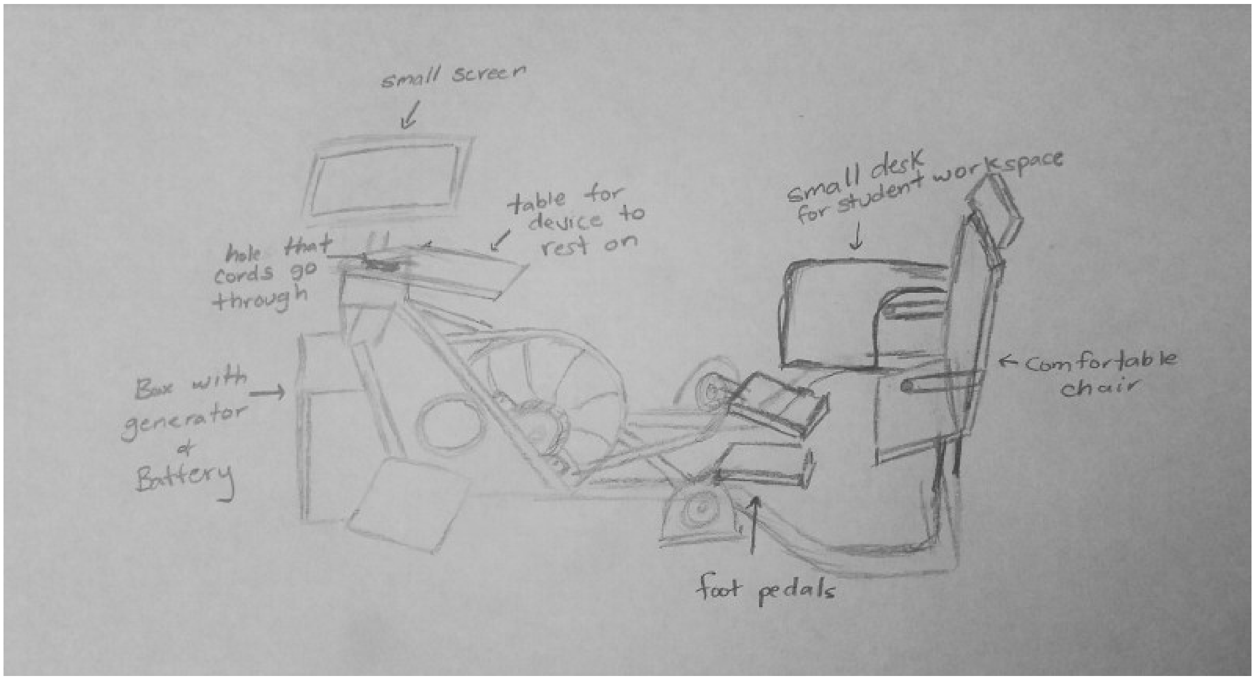

Figure 2: Design 2

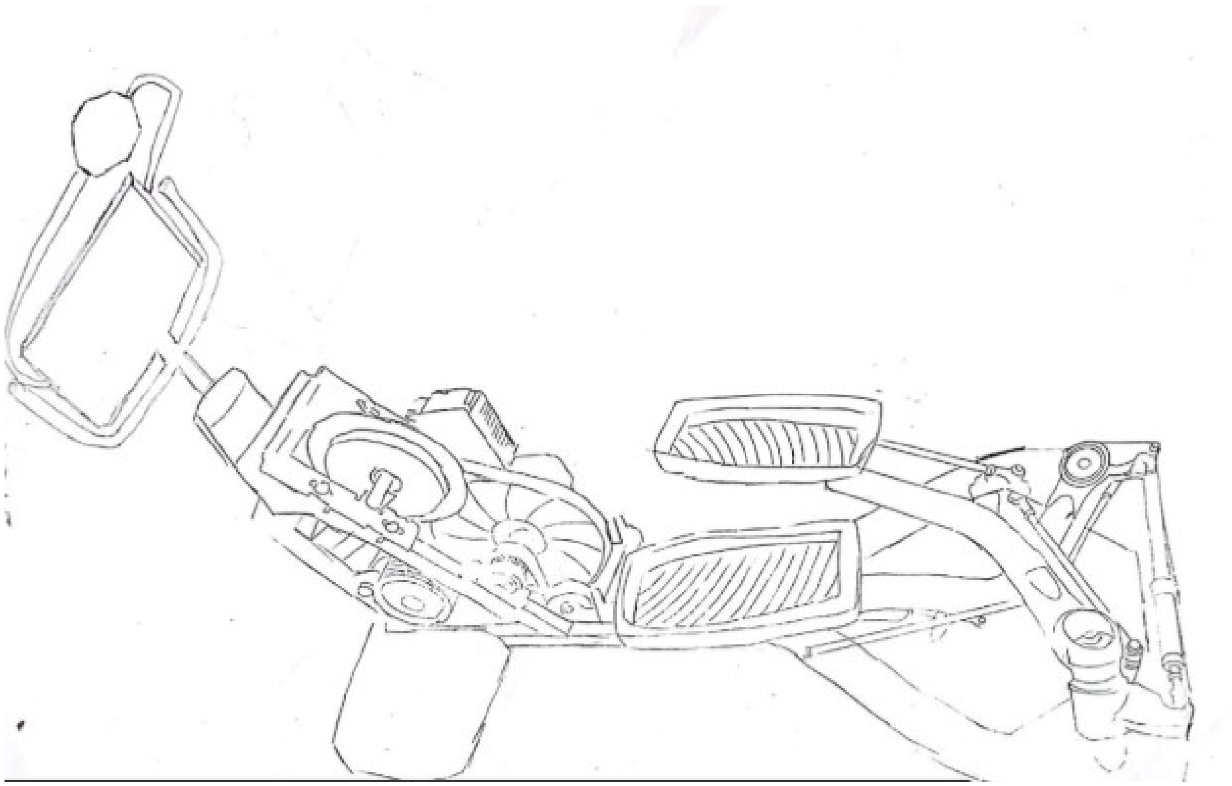

Figure 3: Design 3