GNG 2101

Design Project User and Product Manual

Human Powered Lights

Submitted by:

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Table of Contents

List of Figures

List of Tables

List of Acronyms and Glossary

Table 1.1. Acronyms

Acronym	Definition
UPM	User and Product Manual
DC	Direct Current
USB	Universal Serial Bus
USB-C	Universal Serial Bus Type-C
LED	Light Emitting Diode
BOM	Bill of Materials
CAD	Canadian Dollars

Table 1.2. Glossary

Term	Acronym	Definition
Diode	N/A	Electrical component that allows for current flow in 1 direction
Buck converter	N/A	DC-DC power converter
Quick release skewer	N/A	Bike feature that allows removal and reinstallation of the wheels to be easy.

1 Introduction

This User and Product Manual (UPM) provides the information necessary for biking enthusiasts, people who want to support environmentally friendly and sustainable methods to generate power to effectively use the Light support system and for prototype documentation. It is assumed that people who purchase the Light Support system will know how to bike, and how to follow simple instructions to set up the system with their home bike. The following document is structured so readers can understand how the system was built, how it works, how well the system works (with the use of testing data), and how to troubleshoot the system if any issues arise. The purpose of this document is to effectively explain how the system functions, and then provide an overview of how a reader could rebuild and replicate the system if they wish to build it at home. This system does not require the user to input any important personal information as there is no software component, the only consideration associated is physical strain considerations. Injuries that occur from improper or overuse of the bike.

2 Overview

The project provides a unique method to generating renewable energy while allowing the user to be physically active. This is a viable alternative to other sources of renewable energy such as solar panels, which is resource-intensive to manufacture and is difficult to recycle.

The product is designed such that the user will not have to replace the rear wheel of their bicycle for every instance of use. This was done to allow a dynamic fitness lifestyle of cycling indoors or outdoors. The addition of a quick-release skewer allows the user to easily mount and dismount their bicycle on the product. In the event that your bike does not have compatible quick release skewers, you can swap your skewers with ones included with the system.

This is also favourable compared to other bicycle-oriented generators on the market, most of which implement a V-belt. The objective of this product is to simplify the start-up process for users with hypermobile joints, who may experience discomfort when configuring the product. As a result, the modularity of the assembly provides an advantage over other products on the market.

Fundamental needs from the user include the knowledge of knowing how to ride a bike, and how to follow simple instructions that are listed in the user manual.

Light Support differentiates itself from other products because of its ability to be adaptable to the user's bike. More specifically, not only does the light support system allows the users to use their own bike. It also allows users to remove the bike from the system, giving them the ability to choose if they want to bike indoors or outdoors. This allows the system to be very versatile. The system was designed so users can remove and reassemble the bike to the system very easily.

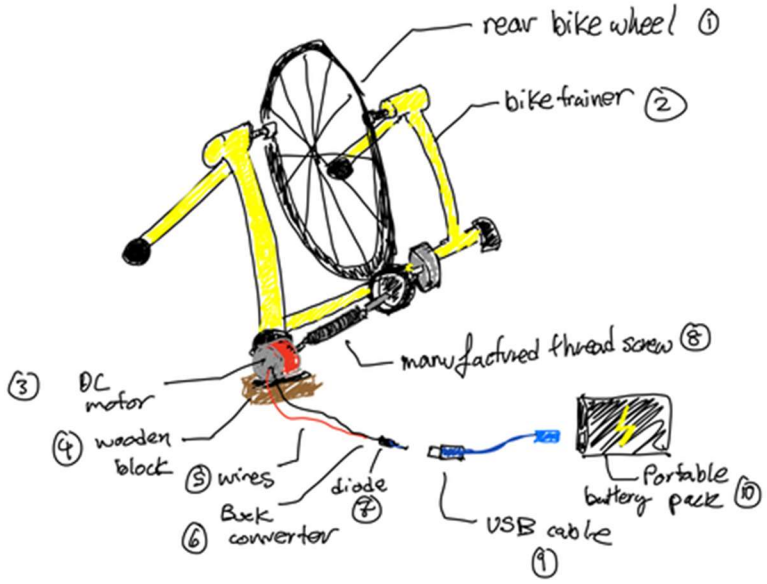

Figure 2.1: Sketch of Final Prototype

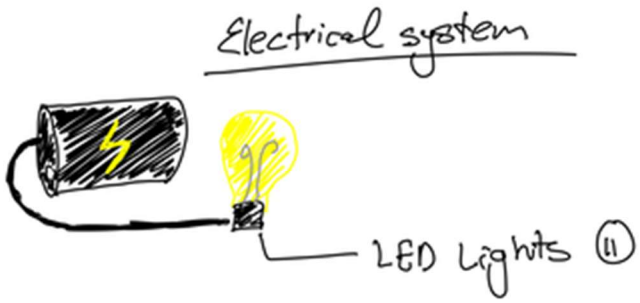

Figure 2.2: Sketch of Final Prototype Electrical components

The product consists of a bicycle trainer, DC motor, specifically manufactured screw thread, battery pack and wires. Deciding to make the system pedal powered was a major feature because there are more muscles in the legs and making it a power pedal system will allow users of the system to generate more power, with less effort. The bicycle trainer has a metal frame, with metal rotating

parts that provide the rotational motion required to power the DC motor, generating power. The user access mode includes applying rotational power into the pedals, and the back wheel meshing with the shaft on the bike trainer.

Below are block diagrams that the Light Support created during brainstorming sessions for general functional decomposition, User flow chart, and system flow chart.

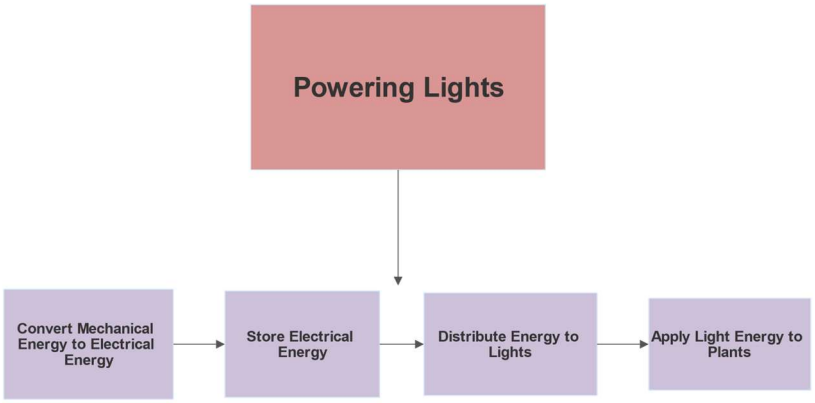

Figure 2.3: General Functional Decomposition

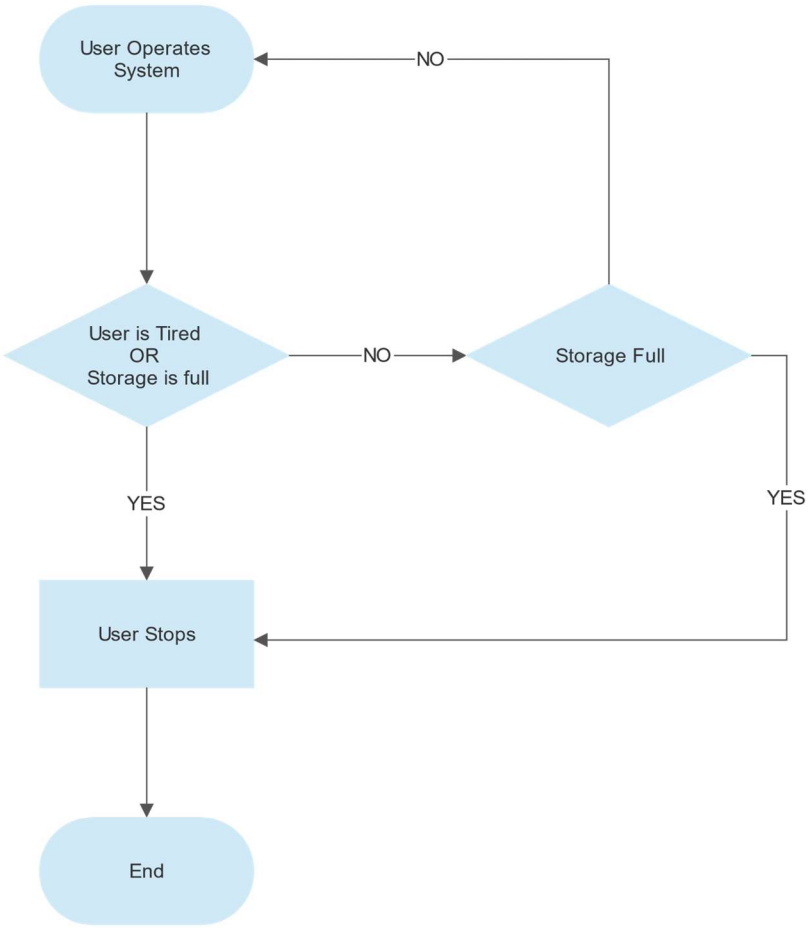

Figure 2.4: User Flow Chart

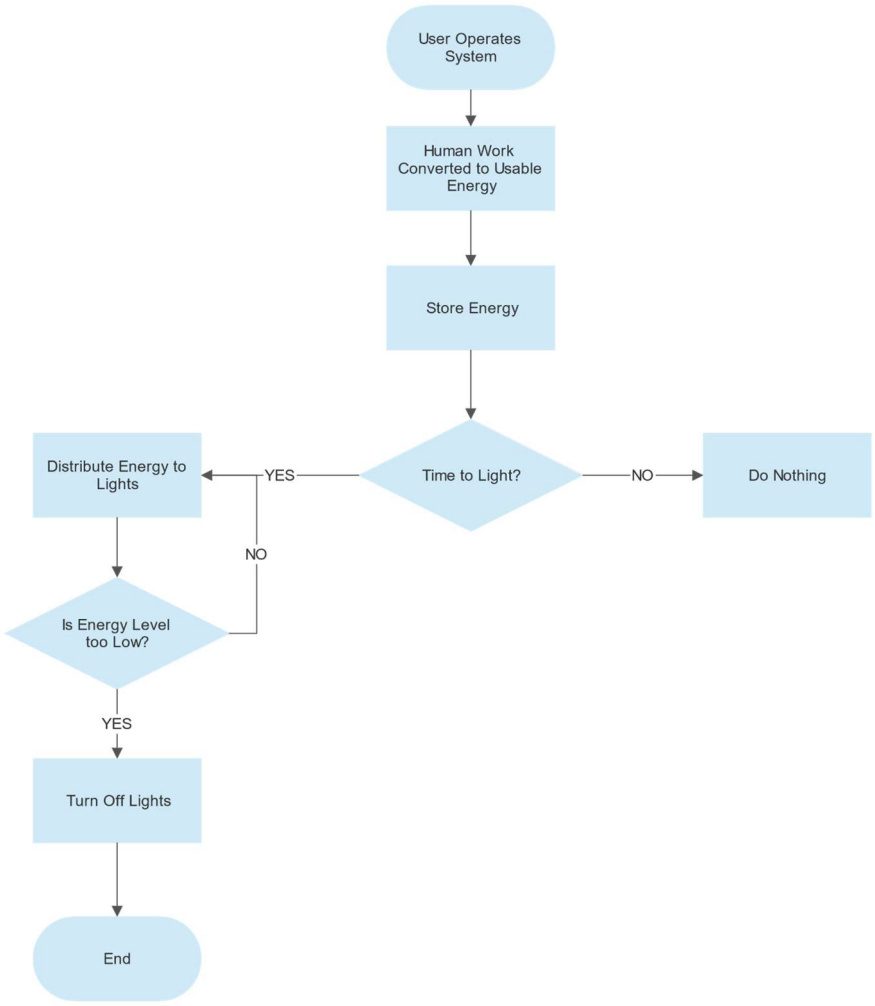

Figure 2.5: System Flow Chart

2.1 Cautions & Warnings

Light Support users should know how to use a bike properly. It is advised those users know their limitations when riding the bike, Users should not overexert themselves and stop when they are tired or feel any physical pain. The Light support system is relatively heavy, so users should be careful when moving the system. Users should make sure quick-release fasteners are tightened properly, and that the back wheel is mating/ in contact with the bike trainer shaft when pedalling. Improper mating of the wheel and the shaft will result in incomplete rotational energy transfer to the dc motor, resulting in the battery pack not charging.

3 Getting started

3.1 Configuration Considerations

For configuration, the user should ensure that they have a bicycle to use with the system, and that the bicycle uses quick release skewers to connect the wheels. Furthermore, before configuration, the user should ensure that there is enough working space for the bicycle, bike trainer, electromechanical system, and themselves. Additionally, before configuration, the user should check if any of the components seem to be damaged. If during configuration, a part becomes damaged, the user should not attempt to use it and should instead obtain a replacement part.

3.2 User Access Considerations

The users who this system would be suited for is as follows. First, users who are physically able to ride a bike can use this system. Therefore, this system is suitable for ages 9+ and all genders. This system is not suited for people who are not able to ride a bike. Furthermore, this system is not suitable for people who cannot lift their rear wheel to put in the bike trainer. Additionally, if a potential user has cardiovascular issues, they should consult a physician before using the system. If a current user has had a recent injury, they should also consult a physician before using the system as well.

3.3 Accessing/setting-up the System

System set up begins with threading the shaft to the trainer the externally threaded male component on the trainer is lined up with internally female component of the shaft.

Figure 3.1: Threaded Components

To thread the components together the silver wheel on the trainer should be turned clockwise while holding the saft inline while the trainer.

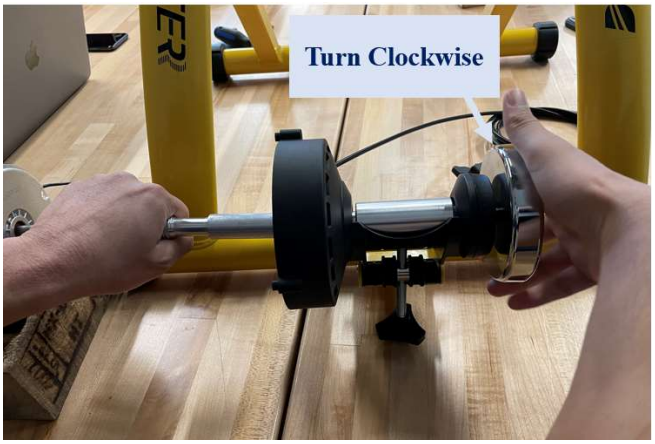

Figure 3.2: Threading to Trainer

Next plug the battery pack into the electrical components using the provided cable.

Figure 3.3: Plug in Battery Pack

To add the bike to the sytem. Place the back tire into the trainer. The bike should have quick release skewers to be compatible for this system. If the bike doesn't have quick release skewers replace with it them to make it compatible. Alight the center of the back tire to be concentric with the attachments on the trainer. Twist the handle into clockwise.

Figure 3.4: Turn Handle

On the opposite side secure the wheel in place by pulling the other handle down.

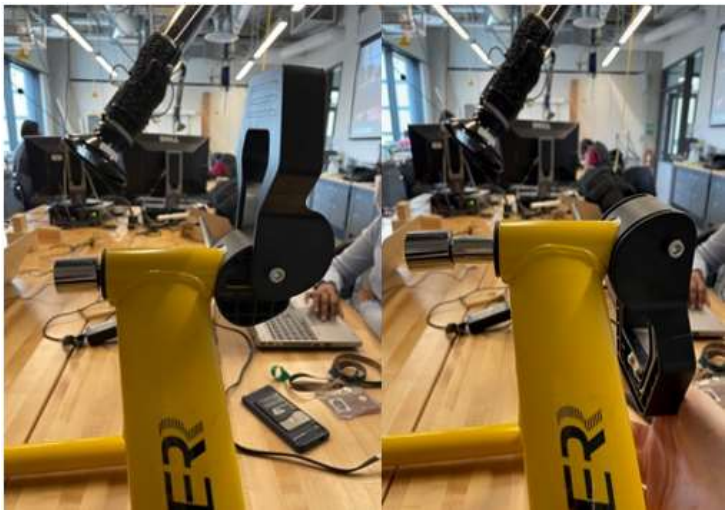

Figure 3.5: Pull Handle Down

Next make sure the back wheel meshes with the back bar, to ensure it spins. Twist the back knob to keep it at the selected height.

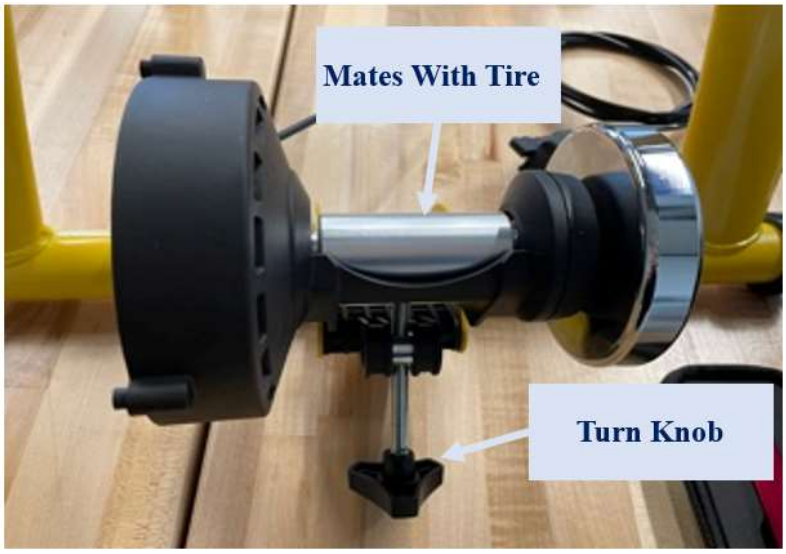

Figure 3.6: Mech Bar with Back Tire

The system is now good to be used and users can ride their bike as a normal stationary bike. The user can bike until the whole paw turns blue.

Figure 3.7: Charging Level of the Battery

Once the system is fully charged it is good to be unplugged from the charging subsystem and now be plugged into the light.

Figure 3.8: Light in Use

3.4 System Organization & Navigation

The first sub system of components is the electrical charging components. It consists of the DC motor, Diode, Buck convertor and the power bank. The only part of this system the user will need to adjust is the plugging and unplugging the battery pack when they are charging versus when they are powering the lights. The individual components are shown below.

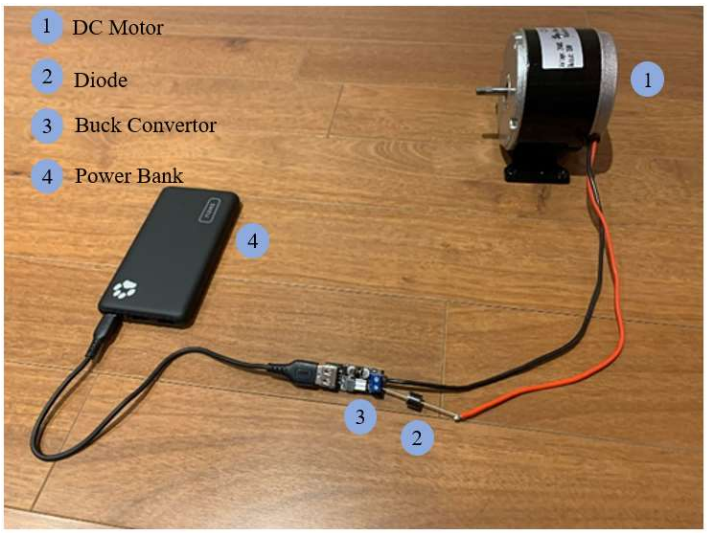

Figure 3.9: Electrical Components

Attached to the electrical components is the energy generation subsystem it is composed of the trainer and the shaft which is coupled to the DC motor. The uses easy can navigate this subsystem by taking the bike in and out of the trainer based on the instructions in the previous section. The image below outlines the components.

Figure 3.10: Energy Generation System

Finally, there is the light powering subsystem the user will need to plug/unplug the battery when they are using versus charging the lights. Additionally, the lights have an on and off switch.

Figure 3.11: Lighting Components

3.5 Exiting the System

If the user wishes to stop charging the bike, the user should slowly stop pedaling and eventually stop pedaling. Next, the user should carefully dismount the bicycle. After the user has safely dismounted the bicycle, the user will then unplug the power bank from the system. For stopping the powering of the grow lights, the user should first turn off the grow lights and then unplug the power bank.

4 Using the System

The *LightSupport* Human Powered Lighting System is easy to use and is compatible with any adult-sized bike with quick release skewers (Note: your bike may not have compatible quick release skewers. In the event that this occurs you can swap your skewers with ones included with the system). The system consists of four components and its use can be described in two phases. The system takes energy from pedaling the bike as input and charges a battery pack as output in the first phase. In the second phase it uses a charged battery pack as input and then illuminates a light as output.

4.1 Mounting your bike onto the system

1) Make sure the battery pack is connected to the system and disconnected from the grow lights
2) Lift up the handle so it is pointing upwards
3) Line your bike up so the rear tire is touching the central metal shaft
4) Place the clamp handle in the downward position
5) Twist the knob so the gromets are flush around the skewer
6) Adjust the positioning of the shaft so it mates with the rear tire.
7) Tighten the rear screw so the shaft stays mated with the rear tire.

4.1.1 The Trainer

The bike will mate directly with a trainer. The trainer serves to connect the bike to the electromechanical system. The bike can be easily attached and detached from the trainer without having to modify or alter the bike. The trainer used in this system is only compatible with bikes that have quick release skewers. The trainer can be seen in the figure below:

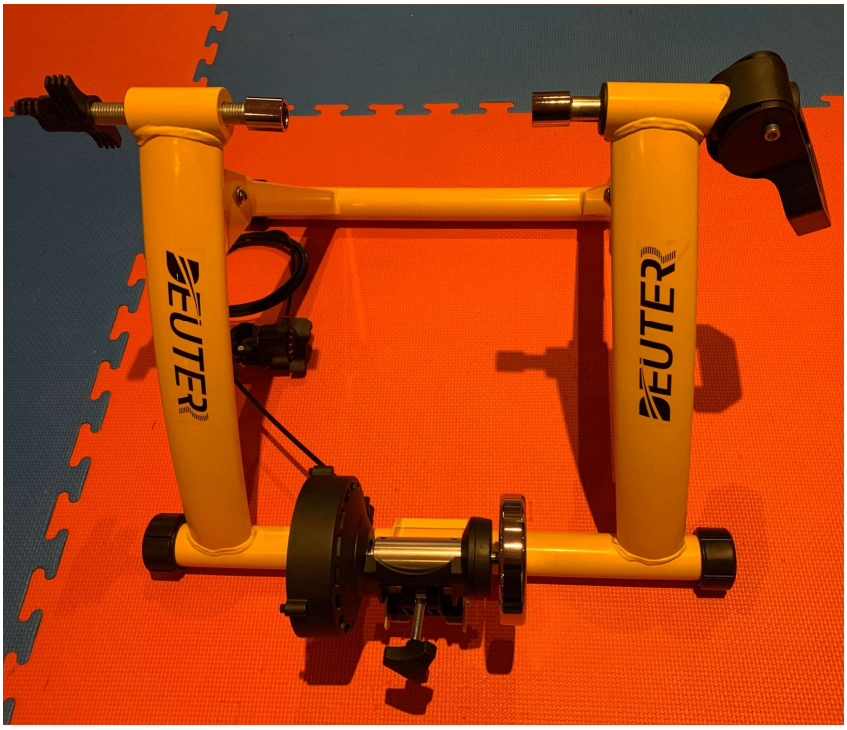

Figure 4.1: Bike Trainer System

4.1.2 The Electromechanical System

The electromechanically system takes mechanical energy produced by the rotation of the bike tire against the trainer and converts it into electrical energy. It consists of a shaft, a motor, a diode and a buck converter. The electromechanical system further connects to a battery pack. It is depicted in the image below:

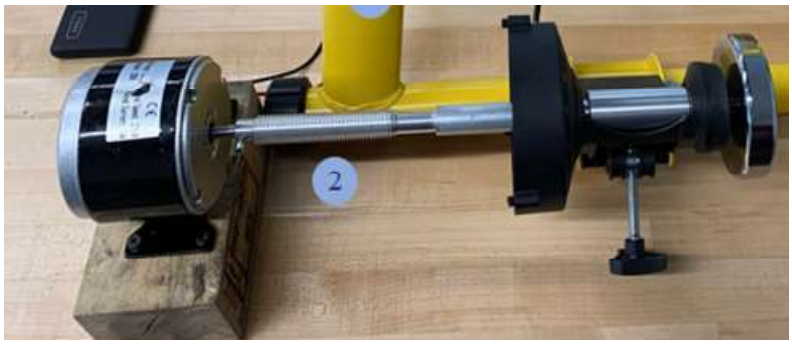

Figure 4.2: Electromechanical System

4.2 Providing Light to your Plants

1) Disconnect the battery pack from your system by removing the battery pack from the system cable.
2) Connect the light cable to the battery pack. DO NOT connect the battery pack to the light and the human drive train system at the same time. Turn on the lights by pressing the button corresponding to the mode you would like. The ode is explained on the text in the button.
3) Enjoy growing your plants!

4.2.1 The Grow Lights

The grow light is a 10 W red and blue light that is ideal for growing succulents or small seedlings. The grow light features a USB port that can be connected to the battery pack. The grow light can also be connected to other USB power sources if the user wishes to do so. The grow light can be depicted in the figure below:

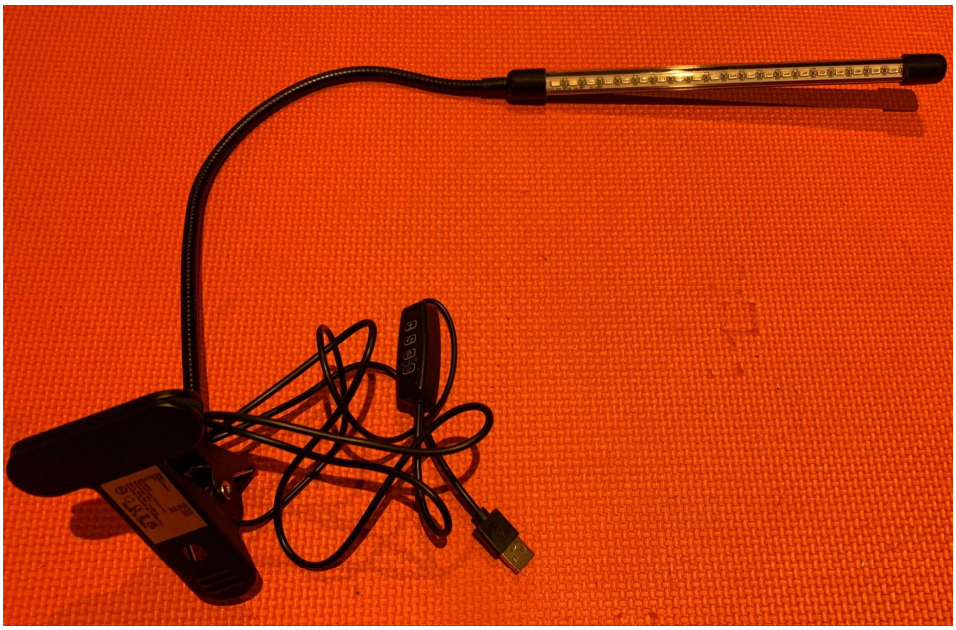

Figure 4.3: Grow Light

4.2.2 The Battery Pack

The battery pack is an individual self-contained unit that stores power generated by the system and uses it to power the grow light. The battery pack MUST NOT be simultaneously connected to the grow light and the electromechanical system as for it to not become overloaded. The battery pack must be connected to the electromechanical system while the user is cycling as to be able to accumulate the power. When the user wishes to illuminate the plants the battery pack must be connected to the lights. The battery pack is shown in the figure below:

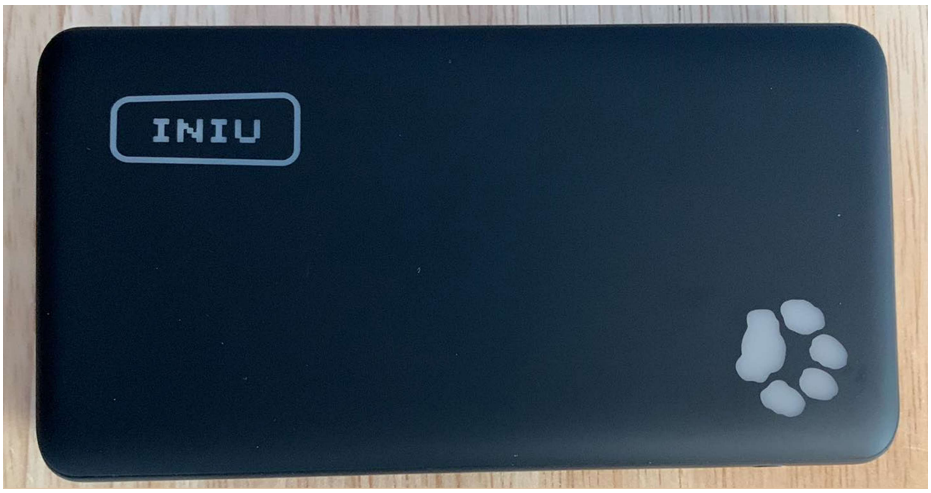

Figure 4.4: The Battery Pack

5 Troubleshooting & Support

This section will describe how to troubleshoot any errors that may come up in the setup and operation of the system. First, behaviors of the system that may indicate errors, and how to deal with them will be described. Then, the special considerations and expected maintenance of the system will be outlined. Finally, information on support will be provided.

5.1 Error Messages or Behaviors

The mechanical error behaviors and how to deal with them will now be outlined. If the coupling shaft is not rotating smoothly or vibrating, make sure it is securely threaded on the bike trainer thread. Similarly, if the rear bike wheel is vibrating, ensure the trainer clamp is tightly secured onto the rear wheel. If the quick release skewers are not fitting on the bike trainer properly, swap out the quick release skewers on the bike with the ones included with the trainer.

The electrical error behaviors will now be described. If the power bank is not lighting up during operation, ensure that the USB-C connector is securely connected to the power bank. When using the power bank to power the grow lights, if the grow lights are not turning on, and the lights on the power bank are not on, the power bank must be recharged.

5.2 Special Considerations

When charging the power bank or powering the lights with the power bank, if the power bank becomes swollen/puffed or if it is emitting an abnormal amount of heat, immediately unplug the power bank. If when using the system, the coupling shaft becomes fracture or partially damaged, do not attempt to use the system. Additionally, never connect the grow lights to the power bank

when the power bank is being charged. Furthermore, if the rear tire is low on air, ensure that is appropriately pumped.

5.3 Maintenance

Before and after using the system, ensure there is no obstructions in the path of the bike pedals or near the DC motor, coupling shaft or electrical components. Regularly remove dust that may develop on the trainer, DC motor, or electronic components. If there is a squeaking noise when clamping the trainer, lubricant can be added to the steel rods on the trainer. Furthermore, if components are damaged, they should be replaced as soon as possible.

5.4 Support

In the unlikely event of very serious injury that requires immediate medical attention, call 911. In the case of a fire, call 911. For issues with the bike trainer, consult the bike trainer manual or contact the Amazon seller distributing the bike trainer. For issues with the power bank, contact INIU (power bank company).

6 Product Documentation

6.1 Electromechanical Subsystem

The electromechanical assembly is the means of converting the rotational kinetic energy from the bicycle's rear wheel into harvestable electrical energy.

Because the rear wheel mates directly with the flywheel, there is no need to consider a spring to induce full contact.

6.1.1 BOM (Bill of Materials)

Table 6.1: BOM Electromechanical

Description	Unit	Quantity	Unit Cost (CAD)	Cost (CAD)
2016 Liv Rove 2 Bicycle	each	1	0	0
CXWXC Bike Trainer	each	1	0	0
Wood	kilograms	1	0	0
Yaegoo 24 V DC Motor	each	1	0	0
Shaft	each	1	0	0
Set screw	each	1	0	0

6.1.2 Equipment list

- Lathe
- Drill press
- Screwdriver

6.1.3 Instructions

1. Design the coupling shaft.
    a. The coupling shaft is essentially modelled as an extruded cylinder with threaded holes at both of its ends. The main things to consider are the cylinder height, type of

threaded hole to attach to the DC motor, and the type of threaded hole to attach to the trainer.

b. An engineering drawing of the coupling shaft is included in Appendix II with all dimensions needed to manufacture it.

2. Manufacture the coupling shaft.

    a. The material of the shaft should be sufficiently robust to be able to withstand the torsional force brought by the user when cycling. In our case, we used a scrap aluminum rod, though a new one is evidently recommended.

    b. Holes are initially drilled with the lathe. The drill press was used to create a hole for the set screw that secures the shaft with the DC motor.

    c. Threading to create tapped holes with the lathe is optional but would only be recommended if one were to have proficiency in doing so. If this is not the case, it would benefit to thread it manually, which is what was done for this prototype.

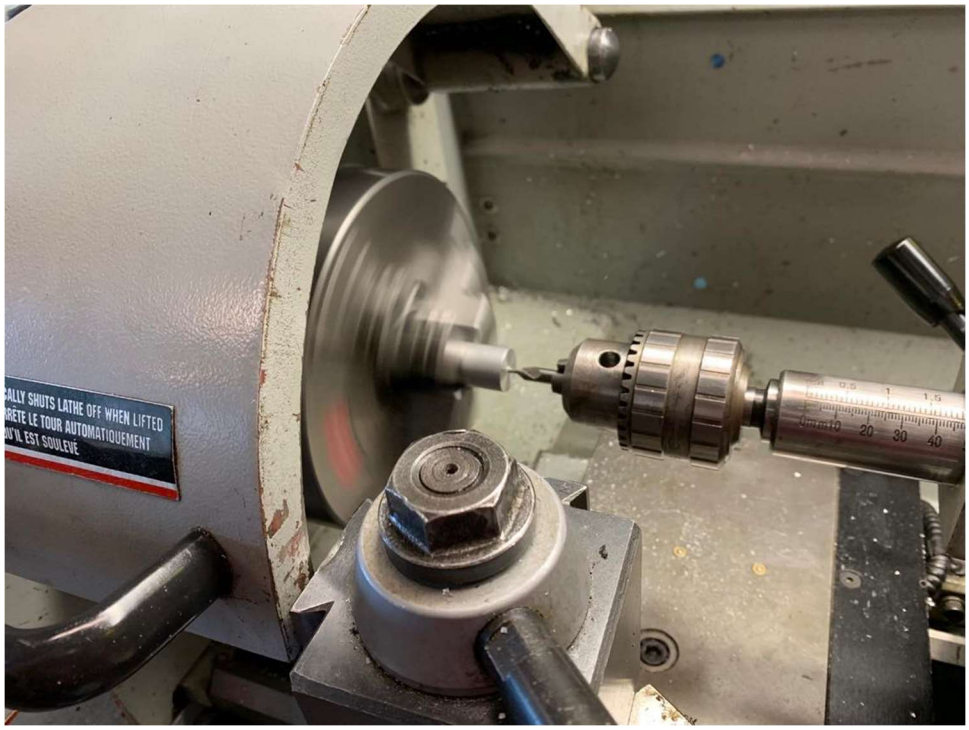

Figure 6.1: Drilling a Hole Using the Lathe

3. Attach the coupling shaft to the DC motor and trainer.
    a. Should everything be done properly, the DC motor and coupling shaft should thread properly. Insert the set screw into its designated hole.
    b. Following this, remove the cover for the flywheel and attach the shaft to it.
    c. Turn the trainer wheel to ensure the shaft drives the motor.

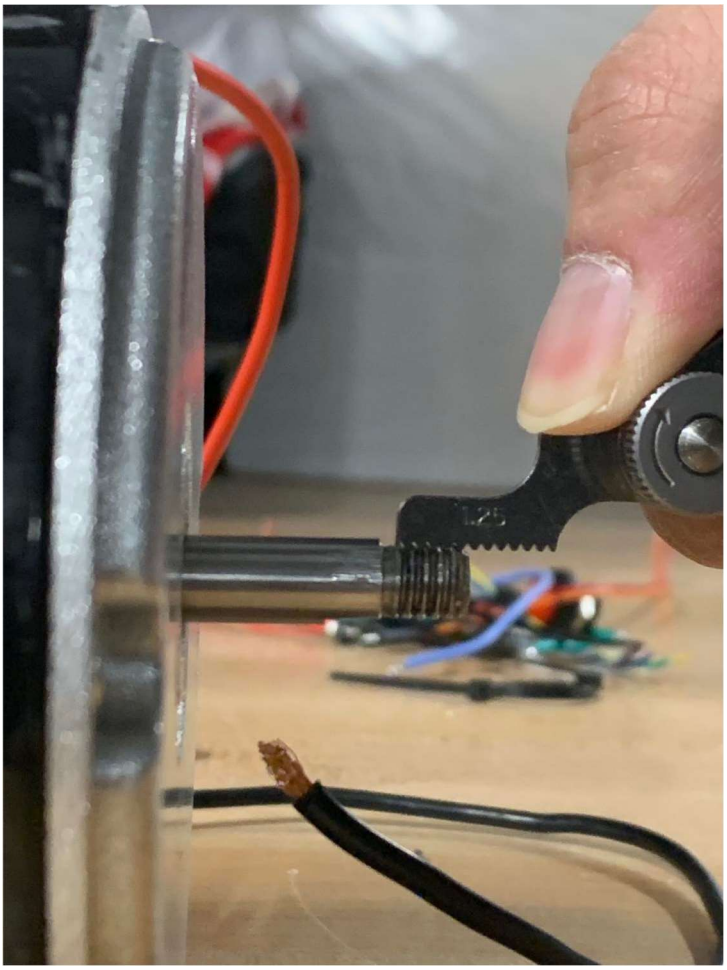

Figure 6.2: Using a Thread Gauge to Determine the Pitch of the DC Motor Thread

4. Mount the DC motor on a block of suitable height.
    a. Find a material that is suitable for the DC motor to be threaded into. The material of choice for this prototype was wood. Ensure that the wood places the motor at the correct height to prevent eccentricity.
    b. Thread the motor into the block of suitable height.

6.2 Electrical Subsystem

The electrical assembly serves to convert the DC power from the motor to stepped-down AC power for the power bank, which is subsequently used to power the user's grow lights.

6.2.1 BOM (Bill of Materials)

Table 6.2: BOM Electrical

Description	Unit	Quantity	Unit Cost (CAD)	Cost (CAD)
Diode	each	1	6.99	6.99
Buck Converter	each	1	11.99	11.99
Power Bank	each	1	29.99	29.99
Tonpvou 10W LED Grow Light	each	1	27.95	27.95
Wiring	kilograms	1	0	0

6.2.2 Equipment list

- Soldering kit and solder
- Screwdriver

6.2.3 Instructions

1. Solder the diode to the power wire of the DC motor.
    a. This is the red wire.
2. Attach the diode to the buck converter.
    a. This can be soldered or, for the simplicity of prototyping, connected via the screw-adjustable connectors.
3. Plug the power bank to the buck converter via the USB port.
4. Once power has accumulated in the power bank, remove it from the buck converter and plug it in the USB grow lights for use as needed.

6.3 Testing & Validation

Each subsystem was tested separately to ensure their function. The electromechanical subsystem was tested through two ways; first, by manually turning the flywheel as a unit test for the DC motor. The second integration testing implemented a bicycle rear wheel to turn the flywheel, while a multimeter measured the current rating and voltage. With overcurrent protection built into the buck converter, the test recorded peak values of 2A and 5V.

As for the electrical subsystem, the integration test was performed to ensure that power is being converted and stored into the power bank. Once this was done, a test was done to determine the duration the grow lights will remain powered through the power bank. This was measured to be 3.7 hours.

7 Conclusions and Recommendations for Future Work

Lessons learned include learning how to budget time and resources, how to quickly adapt and pivot project ideas when thrown curveballs of new constraints and restrictions, and how to properly empathize with clients when interviewing. Future prototypes steps would be to use the client's bike and perform tests on it. Light Support had been conducting proof of concept tests using hand drills as the rotational input energy, having the client’s actual bike would help Light Support accurate data. Testing the system with the bike was abandoned because lack of resources, testing if the LED grow lights would grow plants well over a long period of time was also not conducted because of lack of funds and time.

APPENDICES

8 APPENDIX I: Design Files

Previous Design iterations can be found in the past reports, Deliverable C, Deliverable D Deliverable F. The business plan for transforming this concept to a startup and any economics to go along with it are found in Deliverable G.

The make repo link for this project:

https://makerepo.com/AliNan/1117.gng2101-lightsupport-human-powered-light-c11

Table 8.1: Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
Deliverable A	MakerRepo	2022-04-01
Deliverable B	MakerRepo	2022-04-01
Deliverable C	MakerRepo	2022-04-01
Deliverable D	MakerRepo	2022-04-01
Deliverable E	MakerRepo	2022-04-01
Deliverable F	MakerRepo	2022-04-01
Deliverable G	MakerRepo	2022-04-01
Deliverable H - Design Day Slides	MakerRepo	2022-04-01
Deliverable H - Design Day Summary	MakerRepo	2022-04-01
Deliverable J	MakerRepo	2022-04-06
Coupling Shaft.SLDPRT	MakerRepo	2022-04-06

Coupling Shaft.DRW	MakerRepo	2022-04-06

9 APPENDIX II: CAD Drawing

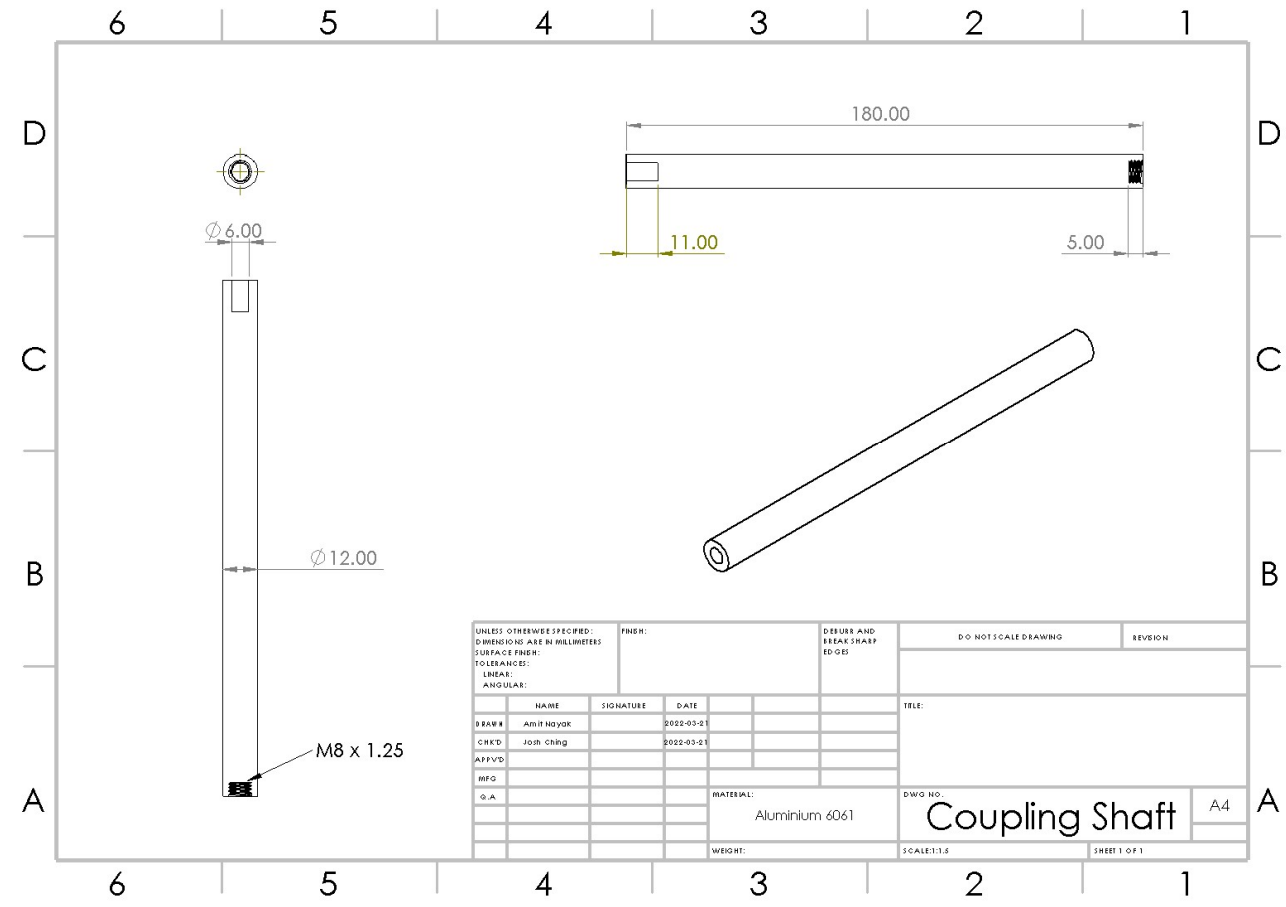

Figure 9.1: Custom Shaft CAD Shaft Drawing