SENIOR DESIGN PROJECT PROPOSAL
EE/CpE 4096 – Fall 2019

Project title: Squeaky Skate

Team members: **Sean Martin (stm3h8@mst.edu, EE)**
Andrew Hauck (aahzx3@mst.edu, EE)
Brian Dahlman (bdahlman@mst.edu, CpE)

Customer(s): Roller rink owners and Roller derby participants

Advisor(s): Dr. Stanley

Estimated cost: $200.00

Instructor: Dr. Woodley

Presented to the
Electrical & Computer Engineering Faculty of
Missouri University of Science and Technology

In partial fulfillment of the requirements for
SENIOR DESIGN PROJECT I (EE/CpE 4096)
Dec 2019 (FALL 2019)

Table of Contents

Introduction

1.1 Executive Summary

The product, squeaky skate, is an automated roller skate wheel cleaner. There is no current market competition for this product. There is an expired patent for an automated device like what we are creating. The squeaky skate serves roller rink owners and roller derby participants. Squeaky skate cleans the wheels of a pair of quad wheel roller skates.

1.2 Background and Problem Statement

Roller skate rinks across the country all clean their skates by hand. There is no automated solution to wheel cleaning. We interviewed rink owners and roller derby participants after selecting our project. The interviews informed us that rinks regularly have to clean 30 or 40 roller skates a day, a task that takes up an hour or more. Roller derby participants commented that having clean wheels gives them an advantage each round of competition. With this knowledge, we began designing the squeaky skate to be a product that will aid our customers and solve the problems they mentioned.

1.2.1 Existing Works

- In 1979, a patent was filed for a “Roller skate wheel cleaning apparatus” [1]. The product used two rollers with cleaning pads on them to clean the wheels of the skate. As of today, this patent is fully expired. This patented device uses no electronics, and is operated manually. Our device will use a microcontroller and motors to automate the cleaning process.

1.2.2 Global and Societal Context and Motivation

- The squeaky skate provides an automated service to customers for a reasonable price. For this reason, the squeaky skate is accessible to all types of skating groups, large and small.

Design And Methods

Our original project plan included a device that is a self-contained, mains voltage powered, automatic cleaning device. In our plans, we included the possibility of using computer vision to sense when wheels are cleaned fully. Currently, our design does not include this feature and it is still only a possible future add-on to the product.

1.3 Goals and Tasks

1.3.1 Goal 1: Squeaky Skate with timed stop feature

The base squeaky skate design will clean a skate for a fixed amount of time each run. The user will place a skate in and push a button, the squeaky skate runs for a fixed amount of time that allows for complete cleaning.

1) **Task 1.1: Electrical & Software Design**

   Description: To complete the electrical & software development, the PCB must be printed and assembled, and the Arduino microcontroller code must be developed. Before assembly, the circuit board must be completely populated and laid out. The team will create a bill of materials and order all board parts along with the board itself. With the parts received, the team will assemble the full PCB. The microcontroller code can be written while the board is being developed, and can be tested when the board is fully assembled.

   Challenges (if applicable): The design should be as low cost as possible without sacrificing quality. All electrical design should be isolated from liquids in the squeaky skate.

2) **Task 1.2: Hardware Design**

   Description: The hardware for the squeaky skate mainly consists of the 3D printed enclosure for the device. The enclosure is modeled in Solidworks. The skate is cleaned by rotating cleaning brushes against the wheels. The 3D modeled design includes the enclosure and cleaning brushes. The enclosure of the squeaky skate should be accessible for service through a panel or door.

   Challenges (if applicable): The difficulty of modeling an enclosure in Solidworks comes from the lack of experience by the team in 3D modeling. The main requirement of the enclosure is that it must keep water or any liquid separate from any electronics. The team must learn to use Solidworks to the point that all needed parts can be modeled.

1.3.2 Goal 2: Squeaky Skate with auto-stop feature

As time allows, the squeaky skate could be implemented with a computer vision auto-stop feature. This feature would stop cleaning when a vision sensor can detect that the wheels are clean.

1) **Task 2.1: Computer vision development**

   Description: A computer vision sensor implementation. This feature would use a visual sensor to monitor the skate wheels throughout cleaning. The sensor would be driven with code from an existing library such as openCV.

Challenges (if applicable): Computer vision is very challenging to implement at a collegiate level. The team does not have expertise in computer vision and would have to learn how to implement it.

1.4 Deliverable(s)

The deliverables of the project include the Squeaky Skate enclosure with all the electronics inside and a AC/DC power supply.

1.5 Specifications and Requirements

The squeaky skate project has several criteria to be measured to determine project completion. Table 1 below details each requirement and the criteria for assessing whether that requirement is met.

Table 1: Requirements Matrix

Requirement	Description	Criteria	Verification
Cleans Wheels	Removes visible dirt and objects	80% of original wheel color	pass/fail
Automatic	Operates without outside assistance	One button/switch; starts and stops on its own.	pass/fail
Fits Shoes	Multiple sizes of shoes allow for normal operation	Can fit adult male 8-12s (kids 5-10s)	pass/fail
Doesn't Damage	The operation does not harm the shoe or skate.	Shoe is dry and not damaged. No nicks on the skate or wheels.	pass/fail
Product Lasts	The project does not break with extensive or frequent use.	Runs without fail for thousands of 2 minute runs	pass/fail
Clean Bearings	Removes grime from bearings	Wheels spin freely (no visible lock ups)	pass/fail
Auto Stop (if time allows)	Detects when wheels are clean and stops to save time and energy.	Properly stops when wheel is clean.	pass/fail

Technical Approach

1.6 Overview

The squeaky skate design has two main parts, electrical and mechanical design. The electrical design was approached with some experience in circuit design and PCB design. The hardware design consists of modeling an enclosure to be 3D printed. Squeaky Skate uses rollers driven by DC motors, with a custom motor control board driving the motors. The 3D printed enclosure keeps the electronics separate from any liquids. All design choices for mechanical and electrical were based on what the team members have experience with.

1.7 Methods Details

The team's design method is very straightforward. Initially, the team brainstorms ideas until one is selected as the best option.

The 3D printed enclosure is designed in Solidworks. It is designed to contain all electronics and fit a roller skate on top. The enclosure is dimensioned to fit within a cubic foot, the limits of the campus 3D printing service. The motor controller is designed to control DC motors and spin them at the required speed.

1.8 Tools Details

The team will use available tools and equipment on campus for the project. The senior design lab has electronic equipment available for electronics assembly and testing. There will be some mechanical components that will be 3D printed. Any 3D printed parts can be printed at the Makerspace on campus. All software used for project development is available through Missouri S&T. The 3D modelling software used is Solidworks, and the PCB CAD program used is KiCAD, an open source application available through apps anywhere.

1.9 Hardware Design Detail

The Squeaky-Skate is powered off of a wall AC to 12volt DC power converter. The power goes to the custom PCB which uses a VNH5019 brushed dc motor driver to drive the brushed dc motor. The PCB is also connected to the microcontroller, fluid sensor and the LCD display.

1.10 Software Design Details

The Energia IDE will be used to program our product since we are using a TIVA microcontroller and energia is specifically designed for them. The Squeaky-Skate will start in idle state awaiting to be activated. Once activated the cleaning state will begin and the motor will turn on, spinning the cleaning cloth which will run until the wheels are clean and then shut off. While in the cleaning state the LCD will be constantly displaying time left until the end of the cleaning session as well as outputting the fluid levels which will also be displayed during the idle state.

Management

All team communication takes place on a Discord server. The entire team meets to work on each assignment. Group members work on tasks outside meeting times as well.

1.11 Project Milestones

The major milestones of the squeaky skate project include completing a prototype, testing the prototype, completing a final version, and testing of the final product. Table 2 shows a gantt chart of the second semester milestones for the project.

Table 2: Project Timeline and Milestones (Gantt chart)

#	Task	Responsibility	Month	January				February					March				April				May	
			Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Design prototype			x	x	x	x															
2	Assemble prototype							x	x													
3	Test electronics									x												
4	Test full prototype										x	x	x									
5	Design Final revision													x	x	x	x	x				
6	Assemble final revision																		x	x		
7	Test electronics																				x	x

1.12 Estimated Budget

The cost of this project is mainly the materials and components themselves. Any equipment needed for assembly is available freely on campus. There will be a cost to print mechanical parts and to print a circuit board. The AC/DC converter is purchased online. Parts to be 3D printed will be printed at cost on campus at the Makerspace.

Table 3: Project Timeline and Milestones

	Items	Unit cost ($)	Quantities	Total cost ($)	Comments
Parts	PCB print	$0.40	5	$2	
	Board components	$20	2	$40	
	AC/DC converter	$15	1	$15	
	Cleaning supplies	$10	1	$10	
	Motor	$15	1	$15	
Equipment	Solder/reflow station	$ 0		$ 0	Available on campus
	3D printing	$ 0.00		$ 0.00	Makerspace 3D printing services used
Software	Energia	$ 0.00		$ 0.00	Software IDE is free
			Total cost	**$ 82.00**	

1.13 Funding Source

Main source of funding is from volunteer work on campus. The team has earned about 200$ from discovery day volunteering and the starting 100$ given to the team.

1.14 Human Safety Assessment

The only risks to human safety presented by this project are electrical shock risk. Electric shock has a higher probability of occurring during development than when the product is in use by the customer. Electric shock risk is higher during development because the team will have to assemble the board and test it outside of an enclosure. This risk could result in burns but the voltage used by the device is not high. To alleviate this risk, the team will use best safety practices while working on any electronics for the project.

1.15 Risks Assessment

There is a risk of going over budget during the project. A lack of funding could prevent the team from being able to complete the project. The team has a budget in place and has a plan to ensure there is enough funding for the project, there is a low chance of this occurring.

The project could be slowed down by print imperfections in the 3D printed enclosure pieces. The design does not require that much precision but print errors would add delays to the project. Printed parts will be made on campus so the turnaround time should be quick, making this a less severe risk.

1.16 Member Credentials, Responsibilities, and Career Plans

1.16.1 Teamwork

- Our team has a very strong skill-set when it comes to electrical system design because we are all experienced electrical leads of design teams. We also all have a lot of experience in embedded systems software.
- This project requires the ability to make custom PCBs, write embedded software and make mechanical 3D models.
- Andrew and Brian are working on the PCB and Software while Sean is making the 3D models since he has some 3D modeling experience.
- The main knowledge that we are missing is the mechanical concepts such as statics and material properties. We are overcoming this by doing our own research and by consulting various mechanical engineers that we know.

1.16.2 Sean Martin(stm3h8@mst.edu, EE major):

Member profile: Sean Martin will serve as our **team leader** and arrange our regular team meetings to discuss our progress and is an Electrical Engineering major with PCB CAD experience and 3D CAD experience. He will be involved in the 3D CAD modeling of the base of the project, keeping the Gantt up to date, and ensuring deadlines are met. Due to his prior experience with 3D CAD, he volunteered to do the CAD modeling. He works to ensure all the parts come together.

1.16.3 Andrew Hauck (aahzx3@mst.edu, EE major):

Member profile: Andrew is an Electrical Engineering major with PCB CAD experience. He has contributed to the board design and has been a part of creating all written assignments

for the project. Andrew will help with assembly and testing of any printed circuit boards created during the project. He will help with initial debugging after hardware assembly and testing of the electronics in the fully assembled, squeaky skate product.

1.16.4 Brian Dahlman (bdahlman@mst.edu, CpE major):

Member profile: Brian is a Computer Engineering major with PCB CAD experience. He has contributed to the board design and to the writing of the software. He will help with the electrical assembly as well as the software testing of the machine.

Lessons Learned and Conclusions

Mechanical designs are our teams biggest issue since we are having to teach ourselves mechanical concepts and implement them. The design benefitted from us using components and methods we were familiar with. This made the electrical design much faster than the mechanical design.

References

[1] Hoos Richard E, “Roller skate wheel cleaning apparatus”, US patent 4225996A. [Accessed Dec 2, 2019].