EE327 Final Report

Spring 2025

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### Abstract

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### Introduction

This quarter, we embarked on building a self-stabilizing unicycle. The goal of this project was to design and build a unicycle that could remain standing without support and be remotely controlled to move freely around a room.

### Design Requirements & Constraints

Our design had several important requirements that we needed to fulfill. First and foremost, the unicycle needed to be self-stabilizing, meaning that it could bring itself back to an upright position in response to any reasonably sized disturbance, both in the coronal and sagittal planes.

The challenge of the design was meeting these requirements while also remaining within the following constraints. The most significant constraint was our budget: 300 dollars, or 100 dollars per person. This restricted us from using the highest quality components. For some components, such as IMUs, this led to lower quality data, which necessitated better filtering and sensor fusion. Another consideration we had was the size and weight of the components. Because everything would eventually need to be mounted to a small unicycle, all the components, especially the motor and servo motor, needed to be reasonably small and light.

### Engineering Standards

**Section 6.1**

Initially, we had hoped to build a unicycle capable of keeping itself upright with no outside assistance, in addition to being able to move in arbitrary directions based on control inputs from our website.

**6.2**

Michael Kim worked mainly on the electrical components of the project, much of which took place in the second half of the quarter. Specifically, this involved putting together the circuitry for components like the motor, motor driver, servo motor, voltage regulators, microcontroller, and more. This included soldering components to the final protoboard, revising and improving the circuitry for better performance and safety, and debugging a myriad of issues while trying to integrate all of the different parts onto the unicycle itself. Debugging became the priority of all three group members toward the end of the quarter as something seemed to malfunction quite often during testing. It also included tuning PID controllers for both the motor and the servo arm to optimize the unicycle’s stability.

### Broader Considerations

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### Design Description

#### System Overview

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#### Block Diagrams

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#### Algorithms & Code

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#### 3D Printing

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### Final Product

#### Initial Goal vs. Final Product

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#### Performance & Limitations

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### Challenges Encountered

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### Planning & Organization

#### GANNT Chart

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#### Bill of Materials

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#### Team Communication

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#### Workload Distribution

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### Market Research

#### Technical Interviews

We conducted several interviews with experts in the field of electronics and electrical engineering to learn about tools and techniques with which we were not familiar. First we spoke with Professor Alan Sahakian of the ECE department. With him, we discussed topics involving power electronics, including batteries, voltage regulators, and wires. Some important points included different types of batteries (for example, LiPo) and the advantages and disadvantages of each type. We also discussed charging and discharging mechanisms for different types of batteries and safety protocols to ensure that the battery is not damaged during charging.

Next we spoke with Royce Morris, the electronics specialist and ECE lab director. Given his background, we focused our conversation on safety considerations, both for us working with the electronics and the components themselves. Our conversation touched on power supply separation for the motor (12V) and the logic (3.3V), proper wiring for high current components, and more on battery charging and discharging.

#### Non-Technical Interviews

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### Conclusion

Individual

### References (if needed)

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### Appendices (if needed)

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### Class Feedback

As mentioned previously, I wish that we had gotten to go more in-depth on the electrical engineering topics rather than spending so much time putting things together and debugging mechanical and circuit problems. That being said, I think I still learned a lot from this project, especially since I had had very little experience with anything mechanical before this.

I think the class structure works fine. One thing I would suggest is having a really small assignment just to make us read our presentation feedback because I completely forgot to look at that until about two weeks after we did them.

I liked using the ESP32 for our project just because it was simple and so familiar to us. Using a different chip might be good in that we’ll learn how to use a different IDE (like in 326) rather than just using Arduino in VSCode On the other hand it would add more work to the project that isn’t completely pertinent to our specific project, which could be a negative.

Overall I wish we could’ve gotten our project to be more functional than it ended up being. Again this comes back to it being such a large project that we spent the bulk of our time putting it together and debugging. I also wish we had tried more formal methods to develop control systems, similar to what we learn in classes like EE360, rather than just guessing and checking.