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11/25/2024

Steel Ball Slalom Project Final Report

Team Name: ABA Salom

Abstract

The Steel Ball Slalom project is centered on creating a 3D printed design that efficiently transports a steel ball from an input point to an output point. This report details the work completed throughout the project, from initial brainstorming and design sketches to part fabrication and assembly. The project consisted of creating sketches, designing the model in Fusion360, printing the 3D parts, and assembling the final product.

Introduction

The goal of this project was to design and build a machine that meets specific functional and structural criteria. The Steel Ball Slalom design needed to follow the specifications for Design A, which includes:

- Safely moving a steel ball from input to output.
- Compact functionality within a 4" x 4" area.
- Incorporating fasteners for assembly and easy disassembly.
- Using primarily 3D-printed parts.
- A mechanical component in the design.

Additionally, to achieve the bonus criteria, the steel ball needs to follow a path that is an inch below and above the input point and two balls should run through the design. The first ball will be stored securely within the system, while the second ball will exit through the design while ball one is stored. Our team aimed to create a design that not only met these specifications but also incorporated innovative features to stand out.

Methods and Materials

Design Process

We worked through four major milestones, each contributing to the refinement of our design:

- **Milestone 1**:
  - Our team created a team name and began by brainstorming ideas and creating sketches on paper. (Figures 1-2).

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    - We decided on the mechanical component, where the ball was initially stored, the placement of the fasteners and how the ball will enter and exit the design.
- **Milestone 2**:
    - The initial design was developed on fusion to be able to start printing parts and testing them for dimensions and possible complications.
    - Initial parts were fabricated using 3D printing. Testing of these parts revealed some flaws, including issues with alignment and internal support. These findings helped us refine our design. (Figures 3-6)
- **Milestone 3**:
    - A finalized CAD design was created. (Figures 7-10)
    - Cost estimation was calculated including material cost, machine operating cost, and labor cost.
- **Milestone 4**:
    - All parts previously designed on fusion were printed (Table 1) and some adjustments were made based on the printed parts.
    - The fasteners were redesigned since the laser cutter machine was not available. We decided against using any screws and instead changed the base to a 3D printed part with pins.
    - All 3D printed parts were tested before the presentation to assure for a functional design.
    - When the original CAD design was not functional, a new design was made. (Figures 11-14)

Materials and Tools

- PLA filament for 3D-printed components.
- Steel ball.
- Fusion360 for design and CAD modeling.
- 3D printers for part fabrication.
- Battles Bucks

Assembly Process

First step is to connect Tube 1 and Chamber to Base. Then we place the lever in the Chamber. Our design is modular and designed for easy assembly and disassembly.

Design Process

Ball Directions:

1. The 1st ball enters at the input position.

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2. Travels down the tube.
3. Lands on the lever in the chamber.
4. Manually lifted to fall into the tube
5. Rolls down the tube and falls into the storage area.
6. The 2nd ball enters at the input position and follows steps 2-4.
7. The 2nd ball rolls through the tube to the output position.

Results

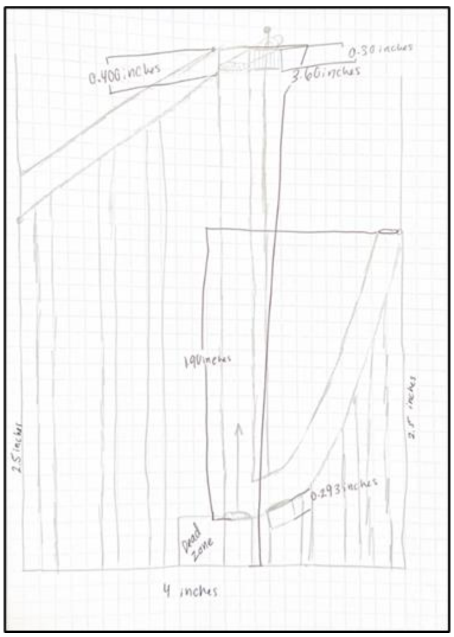

Figure 1: Sketch of Design from Front View

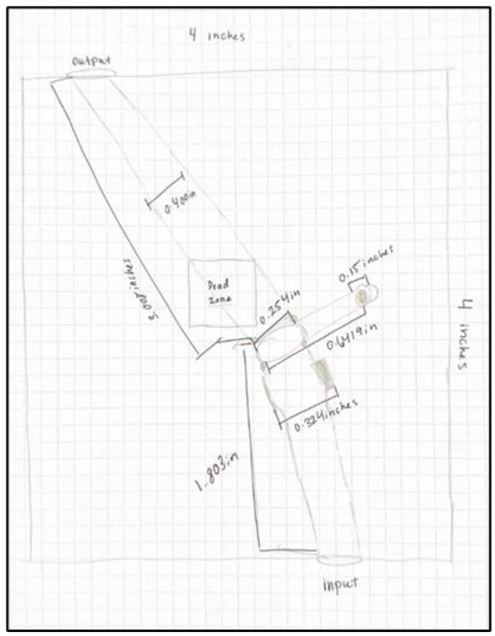

Figure 2: Sketch of Design from Top View

Figure 3: Printed Part from View 1

Figure 4: Printed Part from View 2

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Figure 5: Printed Part from View 3

Figure 6: Printed Part from View 4

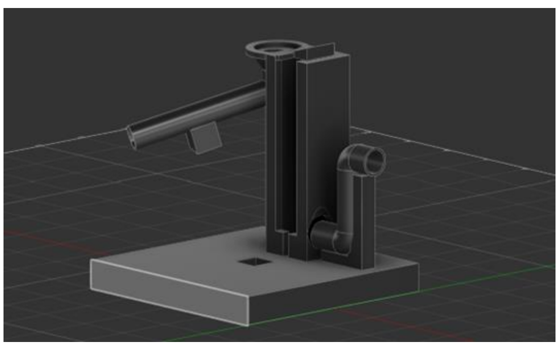

Figure 7: First CAD Design from View 1

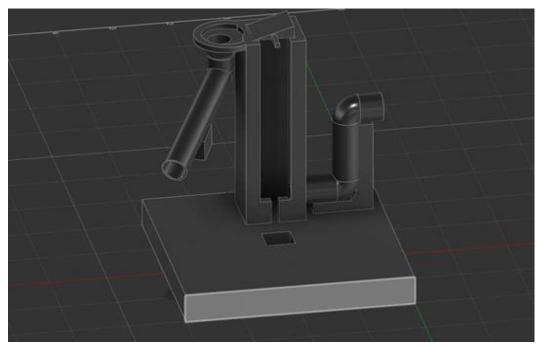

Figure 8: CAD Design from View 1

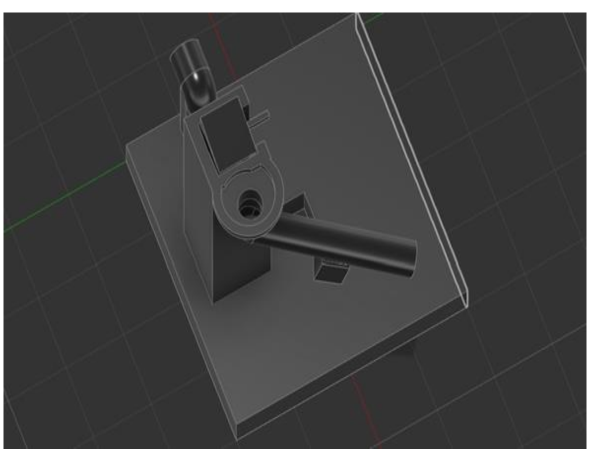

Figure 9: CAD Design from View 3

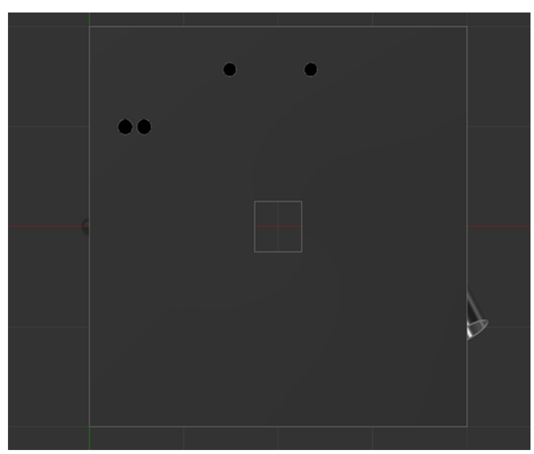

Figure 10: CAD Design from View 4

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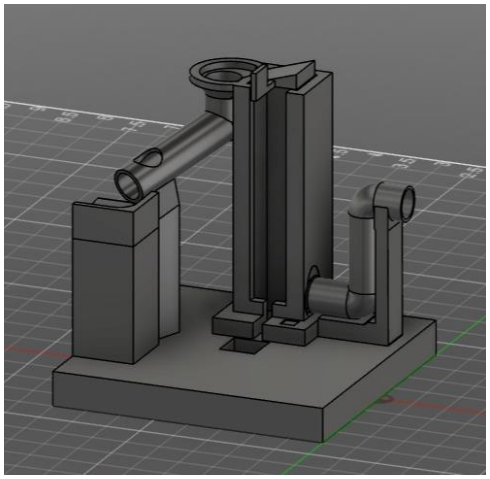

Figure 11: Second CAD Design from View 1

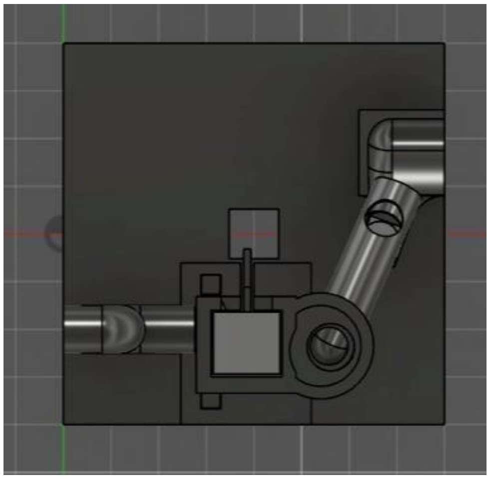

Figure 12: Second CAD Design from View 2

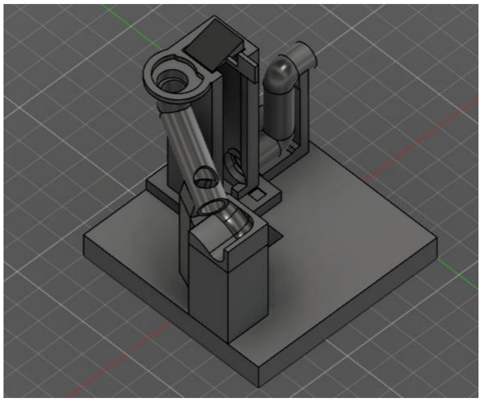

Figure 13: Second CAD Design from View 3

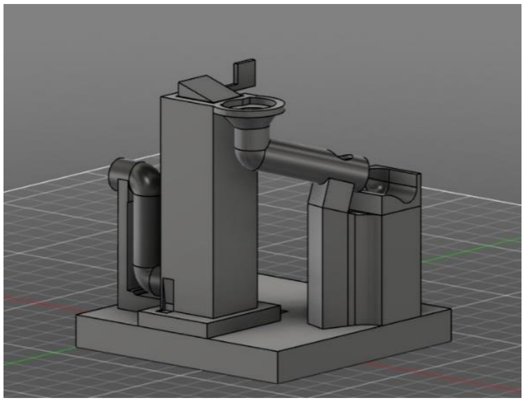

Figure 14: Second CAD Design from View 4

Table 1: Images of the completed design and its individual components.

Part	Image

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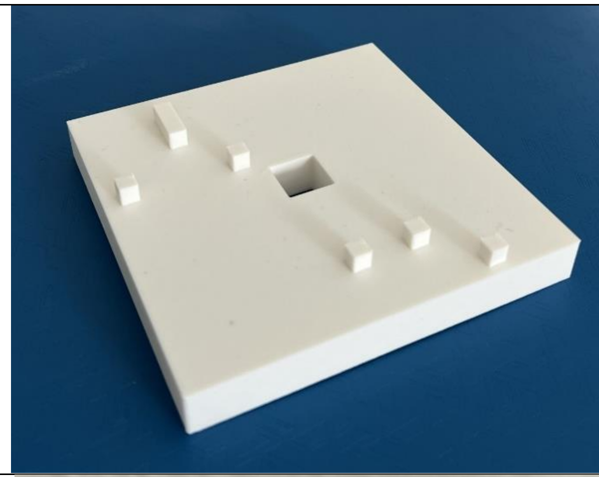
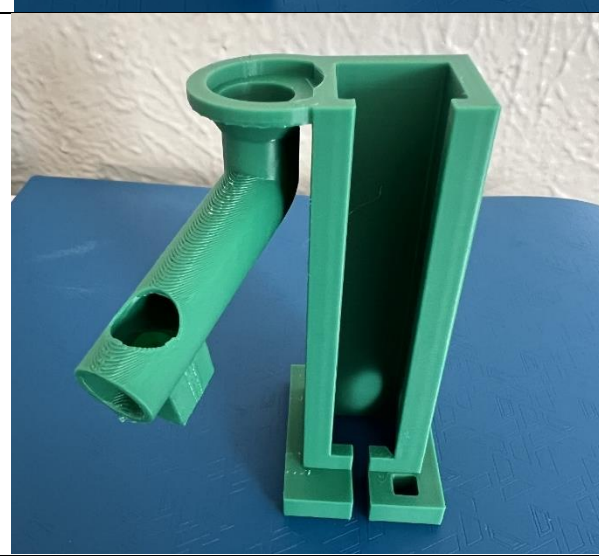
Base	
Tube 1	
Chamber w/ Tube 2	

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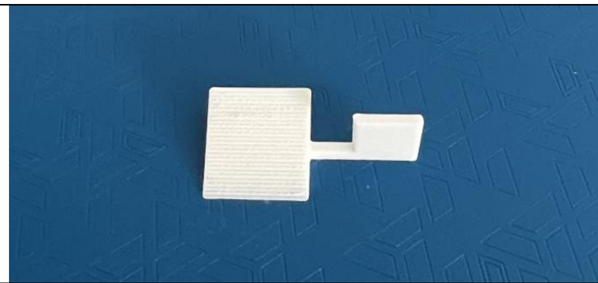
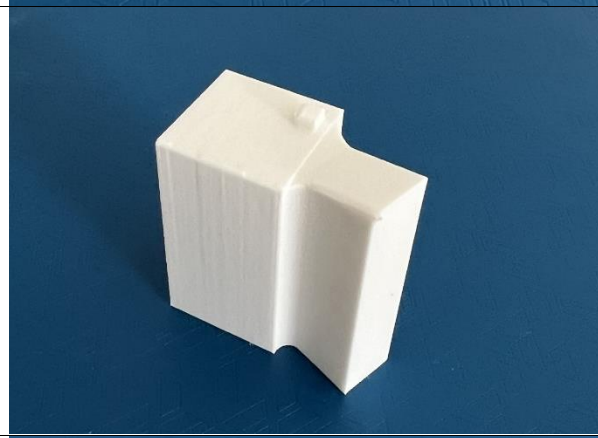
Lever	
Support 1	
Support 2	

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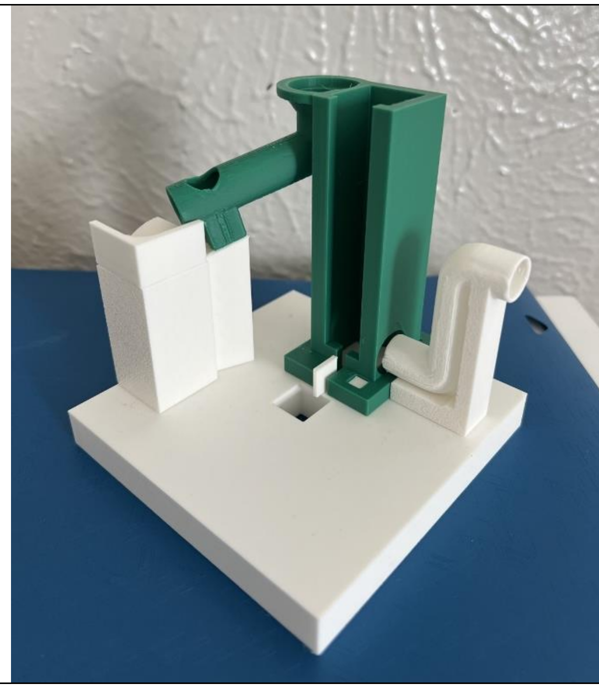
Assembled Design	

Cost Analysis

The total estimated cost of the Steel Ball Slalom is $13.94, broken down as follows

Cost Component	Cost ($)
Material Cost	0.22
Machine Cost	3.72
Labor Cost	10.00
Total	**13.94**

This low cost reflects careful material selection and efficient manufacturing methods.

Discussion

In Milestone 1, we focused on developing the foundational design of the Steel Ball Slalom. Key decisions included defining the ball's path through the machine, which involved entering through a tube at the

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input, transitioning to a storage area secured by a removable panel, and interacting with a lever mechanism featuring a magnetic plate for controlled lifting. To ensure stability and modularity, fasteners were strategically placed at the base and along the chamber edges, with snap-fit joints and removable panels facilitating assembly and disassembly.

In Milestone 2, we transitioned from conceptual design to fabrication by developing the initial model in Fusion360 and starting the 3D printing process for critical components. This phase aimed to test the dimensions and identify any potential complications in the design. The initial part, as shown in Figures 3-6, were fabricated and tested. However, the testing process revealed certain flaws, such as issues with alignment and insufficient internal support. These findings provided valuable insights and guided us in refining the design to address these challenges, ensuring that future iterations would function as intended. We decided, with the help of Professor Battles, to remove the magnetic aspect, and change the functionality of some of our designs. Some parts of the design were edited or removed entirely. To constrain the part we decided to use a chamber that attached to the first tube rather than a pole that constrained the lever. We added an angled lever in place of the magnetic plate to ease in use and limit parts that could possibly cause issues in the future design. We followed a secure timeline shown below:

Timeline:

- Nov 3, 2024: **Create our group name** -Antonieta
- Nov 4, 2024: **Plan our design** -Ayla
- Nov 6, 2024: **Milestone 1** -All
- Nov 10, 2024: **Sketching our design on Fusion360** -Ayla, Barbara
- Nov 13, 2024: **Print our first part** -Ayla
- Nov 13, 2024: **Milestone 2** -All
- Nov 16, 2024: **Laser training** (For Laser Cutter 2) -Barbara
- Nov 16, 2024: **Print our design in separate pieces** -Ayla
- Nov 17, 2024: **Have the laser cut piece done (**If Laser Cutter 1 is available) -Barbara
- Nov 17, 2024: **Assemble our design -**Antonieta
- Nov 18, 2024: **Discuss cost estimate of the parts and methods** -All
- Nov 20, 2024: **Milestone 3** -All
- Nov 25, 2024: **Start preparing for our presentation** -All
- Dec 02, 2024: **Presentation** -All

In Milestone 3, the finalized CAD design was completed (Figures 7-10), marking a significant step toward the realization of the Steel Ball Slalom. During this phase, a detailed cost estimation was conducted, encompassing material costs, machine operating costs, and labor costs. This provided a clear understanding of the overall project budget and ensured cost-efficiency in fabrication. We followed a secure timeline for assembly as well, as shown below:

Assembly Timeline:

November 21- Purchase Fasteners

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November 25- Print All Parts
November 26- Test Design
November 27- Re-print any failed Designs
November 27- Test Final Design
November 27- Assemble all pieces

In Milestone 4, all parts of the previous design were printed but we found errors in the first attempt. With help from Professor Battles we were able to redesign and add parts. This led to the successful 3D printing of all parts as shown in Table 1. Adjustments were made based on observations from the printed parts, ensuring proper alignment and functionality. As the laser cutter was unavailable, the fasteners were redesigned to accommodate alternative methods of fabrication. The screw fasteners were replaced with pins that could be printed with the base design. Following these adjustments, all components were thoroughly tested to verify their performance and compatibility within the overall assembly.

Despite these challenges, we learned that iterative testing and clear communication were critical to overcoming obstacles. Collaboration within the team ensured that tasks were completed on time and to a high standard.

Conclusion

The Steel Ball Slalom project has been a rewarding challenge that allowed us to apply design, fabrication, and problem-solving skills. Through brainstorming, CAD modeling, and iterative testing, we developed a functional design that met the project specifications and incorporated innovative features. Despite challenges, such as misalignment and equipment limitations, we successfully refined the design and prepared it for final assembly and testing. This project has demonstrated the importance of teamwork and adaptability, and we are proud of the progress we have made.

References

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Business Analytiq. (2024). Polylactic acid (PLA) price index. Retrieved from https://businessanalytiq.com/procurementanalytics/index/polylactic-acid-pla-price-index/