ENGI 1103: Projectile Motion

Final Design Project

Group 50

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Figure 1: Final cart render

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Table of Contents

Table of Figures

1. Introduction

ENGI 1103 students were tasked a project aimed to introduce them to engineering by applying essential topics and techniques. They had to work in teams to design, build, digitally create and present their results. We were Group 50, tasked with creating a cart to move and shoot a hacky sack autonomously. Having limited materials to work with, we first worked on design concepts and spent much time designing and testing the mousetrap and other items. By working together as a team, we overcame issues that we faced during the process.

2. Project Background

The goal of this project was to develop a device that would move forward and fire a projectile on its own. A specific list of materials must be abided, and the three hours during the ENGI 1103 lab must be used to design and build the device.

The device has precise specifications to be able to score points. Firstly, it must only be powered by either the electric motor or elastics. Second, no outside help may exist once the cart is let go. Third, the device must stop within the two by two meter stop zone and fire the projectile there. Some other things to note are that no parts can leave the device once it begins moving. The size was also limited by the bin that it had to fit in after each lab day.

The course for the device is a big rectangle. The device must travel six meters into a two by two-meter stop zone. It must then fire a projectile approximately two meters depending on where the device positions itself in the stop zone. Accuracy is critical as the different squares in the target zone are worth different amounts of points, with five points being the max. *See Figure 1.*

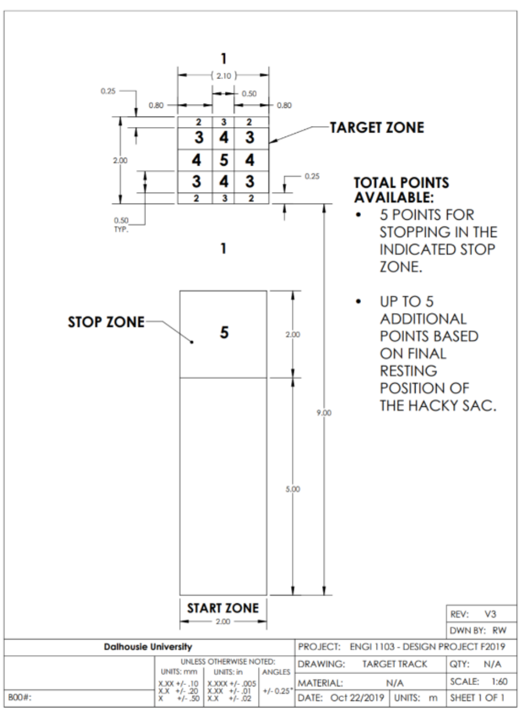

Figure 2: Target track

3. Methods/Design Process

This project had several processes that required an elegant solution. The first day, after introducing ourselves, we decided on straightforward guidelines to follow while creating a solution to the objective. We decided to:

- Design most of the robot before starting construction.

This was decided because we knew if we messed up a cut, we could not get a new piece of wood to replace it. We also knew it would be easier to share our ideas since there is a visual along with the explanation. Since everything was dimensioned in the drawings, it was easy to cut out the wood; we had no guesswork when cutting. Before construction, we had our wheel bearing holder, launcher assembly, the wheels, and our propulsion system designed. *See Figures 2 & 3.*

Our launcher assembly was an idea from one of our group members. They were inspired by a design seen at a robotics competition and by a linear rail. It resembles a crossbow except more compact and suited better for this project. An anticipated flaw was the friction between the grooves and the sliding piece. This was quickly mitigated by sanding down the sides of the sliding piece and making it a little thinner. Though some friction still remained, it did not impact the function enough to cause any problems.

Figure 3: Launcher assembly

Figure 4: Wheel bearing holder

- Avoid using electronic components provided

This was decided because we thought it would be more fun, and we were looking for an extra challenge. We cannot say for sure if it was more challenging or not, but we initially thought it would be a more natural route because of the experience one of our members has with small hobby motors similar to the one provided.

- Create a straightforward design (simple mechanical elements, only straight-line cuts)

This was a big topic that we always reminded ourselves of. We tried our best to eliminate all complicated designs quickly after they were brought up. We believe that all the designs on our final product are very simple and were very easy to manufacture.

- Test the mousetrap to see if it will shoot far enough

The entire first lab day we dedicated to testing the mousetrap to determine if it will fire the hacky sack far enough. We concluded that it was underpowered, and we needed to make a new design. *Seen in Figure 3.*

- Position the axles above the base

This was decided after we determined how we would propel and trigger the launcher. If the axles were positioned below the cart, the fishing line would drag along the floor while being wound up; after unwound, the elastics would also drag on the floor. With our design, they would sit nicely on top of the base. This design meant for less flipping of the device while resetting, and we could visually see what was happening while the device was moving.

3.1 Construction

Because of our preconstruction design work, the build process took very little time. All it took was to draw the cut lines on the wood and divide up the cutting work. *See Figure 4 & 5.* It took about one and a half lab days to complete all of the cutting and construction. We had seven total lab days to work on the project; each was around three hours.

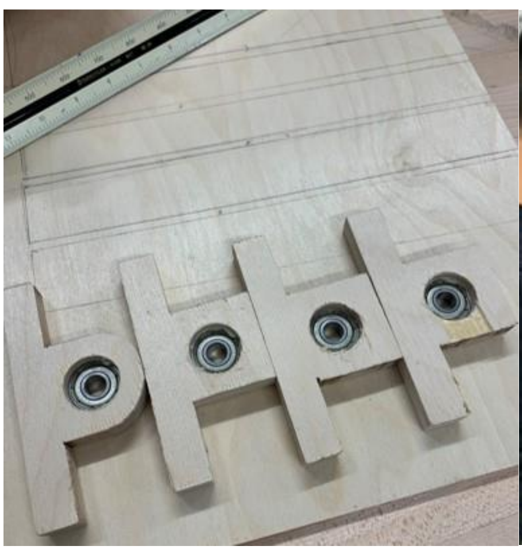

Figure 5: Discussing who will cut out which parts

Figure 6: Drawing out all the cut lines

3.2 Testing

Once we completed the construction, we ran into an oversight with our propulsion system. We initially decided to fix the elastic to both axles, which would unwind to propel the device forward. This actually caused the elastic to unwind until an equilibrium with the opposite axle was formed; this caused the device to stop moving to early and to start rolling backwards. We solved this problem by fixing the elastic to only one axle.

Once we had the launcher assembly constructed, we decided to test it and determine its max launching distance. It shot the hacky sack way farther than we needed it to. To fix this, we adjusted how far the hacky sack holder was pulled back.

The rest of the testing was dedicated to finding the correct length of the fishing line to get the cart to the stop zone, stop and then trigger launcher.

4. Results and the final design

Through many trials and tribulations, the overall outcome of the project was excellent, with the final design going for a simplistic choice. The final scoring result was a nine out of ten, which could have been improved with less than one more hour of testing as the exact calculations for how many wheels turn was a bit of estimation (between five and six).

The final build of the device was a simplistic design. It had four equal wheels with four bearing holders connecting the axles to a plywood base giving it a sturdy build. The device was powered by an elastic wrapped from the back bearing holder around the bottom and around the back axle, causing it to move the cart forward when released.

The launcher had a crossbow like design with four elastics wrapped around the dowels and then around the back of the holder for the hacky sack. A pin was held in a drilled hole to keep the hacky sack holder from flying forward.

Figure 7: Final device build

As the device rolls forward, the fishing line wraps up around the front axle, causing the tension in the string to get tighter and tighter until it eventually pulls out the pin holding back the launcher, thus firing the hacky sack. The fishing line goes through a ninety-degree L-bracket to keep it from unevenly wrapping around the axle. This design was simple and easily reset, allowing for clean and quick tests over and over. It also allowed for easy replacements of parts such as elastics and fishing line.

Recommendations

A finished project would not be complete without having a few things to change for next time. First, we would suggest fixing the axles to prevent them from moving back and forth along the fixed axis created by the axle bearings. We also suggest doing the proper calculations for how much fishing line is needed to stop the cart at the correct distance.

Conclusion

All in all, the whole project itself took a few weeks to be completed, including the designing, adjusting, testing and the final presentation. Even though we spent a lot of time designing at first, we believe that we saved much time in construction because of it and still finished on time. We believe that the whole group has done their best with their assigned work and are satisfied with the final test and score.

Appendix A – Assembly Drawings

Appendix B – Part Drawings