Department of Mechanical and Mechatronics Engineering

ME100: Moving Basketball Net Project Report

A Report Prepared For:
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Ms. Jameson,

This report, entitled ME100: Toy Design Project Report, was prepared as our design project submission for ME100: Introduction to Mechanical Engineering Practice I. The intent of this report is to provide you with the concept that we have selected, and to outline the progress we have made towards developing this product.

The overall goal for this project outlined by our professor is to display sound mechanical engineering judgement through the design and report of a toy of our choosing, for a selected range of children between the ages of 6 and 12. As all of us are sports fans, we decided to go the basketball route by designing a miniature basketball net that can move, keep score, and return the ball to the player. This idea was appealing as it meshed mechanical design with something we all enjoy, making the report seem like an activity we would choose to do, not one we were forced to.

Please note and understand that this is still an early prototype and has an immense amount of potential in terms of additions that can be made. We wanted to design something that could continuously be improved upon, be made even more exciting, time and time again. We believe this has been accomplished.

This work was completed entirely by the undersigned, and has not been submitted for credit at this or any other institution. Thank you for taking the time to review this work. If you have any questions or concerns, please do not hesitate to contact any of us.

Best Regards,

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Summary

This report covers the design and prototype process for a moving, score counting, and ball returning basketball net. This report's objectives were to offer an analysis of the toy's economic potential and build a rough, working prototype. This was determined by projections for effective manufacturing methods and the toy's safety determines its long-term viability. The toy was, and is, intended for active play and has mechanical functions as a substitute for the traditional basketball net, offering experiences for both single and multiple players. It lacks space requirements and is not weather dependent, making it an affordable option for the full-size game. The age range of 6 to 12 was chosen as they are most likely to find it captivating. Its adaptable as different challenges can easily be added, which attracts a wider spectrum of users. This innovative design allowed for the toy to have many features and enhanced functionalities at similar prices to other goods like door basketball hoops and basketball return systems.

In terms of design, there are three primary functions: autonomous electronic movement along the x-axis, an electronic scorekeeping system, and a rigid structure that must support all components. Some main constraints that were vital to the design were having a net speed greater than or equal to 0.4 m/s and a total prototype cost under $120. The electronic movement along the x-axis leveraged the design of a generic FDM 3D printer design by using a stepper motor, gears, and a GT2 timing belt to allow for precise movement. All the parts for this portion were custom designed in Fusion 360 and 3D printed. Some commercial parts, such as knurled M3 brass inserts and M3 machine screws were implemented into the design. This system works alongside a linear bearing that the net sits on, which reduces translational friction. After several prototyping stages, models, and tests, it was determined that the horizontal translation mechanism was successful and could be used in the rest of the project. Moving on, there were two important electronic components of a net, the score counter and Arduino. An Arduino Uno R3, an LCD screen, a potentiometer, push buttons, cables, a breadboard, and a 12 V wall adapter were all used to display and control the electronic features of the game. The potentiometer allowed for the control of the speed of the stepper motor to vary difficulty. All these components are fully coded, but only the stepper motor functionality has been integrated. Finally, the structure consists of two wooden components: the main board for the basketball net and return net, and the bottom legs to add height and stability to the game. These components have been assembled using screws, nuts, corner braces, and double-sided tape for lighter parts.

In summary, it was determined that this toy is not yet viable due to safety issues, however, the final product does look promising. Once the inherently dangerous pieces have been covered and/or revised, cost reduction has been considered, and a disassembly-friendly design has been completed, this project has the potential to succeed in the commercial market. This is still many prototyping hours away, making this project not a product but instead an interesting idea.

1.0 Introduction

This report covers the design process of self-rebounding, score-counting, and moving basketball net (Figure 1). The toy can electronically move along the x-axis in specific patterns, keep track of the score, and return the ball to the player after making a basket. The basketball net size is miniature with similar sizing to the popular door nets and is designed for indoor use. These features make for a more engaging and elevated version of basketball that is meant to increase toy interaction time and frequency of play. Furthermore, this toy provides an alternative to outdoor basketball and compensates for the lack of space with unique gameplay.

Figure 1 – Completed prototype assembly of the moving basketball net

In terms of movement, the net is on a *linear bearing* for low translational friction and uses a similar belt system to a 3D printer for movement. The score can be kept track of using an Arduino Uno and can be displayed on a small LCD screen for the player to see.

1.1 Play Pattern / Age Range

The play pattern for this basketball net is activity, like sports. The design is meant to provide the user with a basketball alternative while keeping the single-player and multi-player aspects of the game. It lacks the requirement for space and clear weather, while reducing costs, providing an enticing substitute for the full-size game that a large population enjoys. The age range is between 6 – 12 years old as the interest in sports on a smaller scale typically falls in this age range. The game will ideally have multiple difficulty levels allowing for a broader user engagement age range.

1.2 Comparable Products

There are several comparable products on the market, namely a door basketball hoop and a basketball return system. Firstly, the door basketball hoop (Figure 2) is typically mounted on the back of a door and played with using small rubber basketballs [1]. They range in cost from $25 to $100+, depending on their build quality and chosen materials. These are meant to be a small-scale replacement for those who do not have access to a basketball court or are limited to indoor activity due to the weather. Secondly, a basketball return system (Figure 3) is a mechanism designed to return a full-sized basketball to the shooter, using either gravitational potential energy or electric motors. The first version of this system (Figure 3a) is cheap at a cost of approximately $50, but it requires the basket to be made by the player and drops the ball in one direction, with low velocity, from the net [2]. These are typically used for close-range practice from directly in front of the net as they are otherwise impractical to use. The second tier of this product includes a net that surrounds the net's rim, collecting shots thrown near the net (Figure 3b). These typically cost $700+ and still return the ball in only one direction [3]. The final basketball return system is one that includes a ball collection mesh and electric return motor (Figure 3c), and typically costs over $2500. These are designed for a niche market of basketball enthusiasts and professional teams [4]. The basketball toy in this report is meant to combine the size of the door basketball hoop with the automatic return feature present in the net return system. This can be done for a significantly lower cost than what manufacturers currently make them for as the weight of a small rubber ball is much less than that of a regulation-size basketball, allowing for smaller, cheaper components.

Figure 2 – SKLZ door-mounted basketball net.

a) b) c)

Figure 3 - Various full-size basketball return systems.

1.3 Background Information and Language

Linear bearing: A bearing system that allows for low-friction translation of parts.

Stepper motor: A motor designed to make a precise number of rotations (rotate in a series of small angular steps), controlled by a computer chip.

Arduino: A circuit board that takes inputs like pressing a button and outputs a specific function such as displaying the score count on an LCD screen.

Timing belt: A precision-designed ribbed belt used to make accurate movements/translations.

HTM: Horizontal translation mechanism. The system that moves the net left and right.

1.4 Objective

The objective of this report is to design and build a rough prototype for a moving, score-counting, and ball returning basketball net and generate a report covering the viability of the toy in a commercial market. The prototype should be a play-ready toy, meaning each component must be functional enough to be used as a toy as-is. This does not mean shelf-ready by any means. The viability is determined by projections for efficient manufacturing techniques and the safety of the toy. All these objectives have been quantified by the constraints and criteria (Section 2.3).

2.0 Problem Definition

This section will cover the most important functions considered for the basketball net and the constraints and criteria that must be fulfilled for the product to be considered viable for the market. The functions have been broken up into two levels of priority: Primary Functions (2.1) and Secondary Functions (2.2). The primary functions focus on the minimum requirements for the game to work. If these are not achieved, the toy is incomplete and potentially unusable. The secondary functions build on the primary function's foundational aspects. They are there to make the game objectively more enjoyable and interactive but are not essential to the viability this report aims to achieve. In terms of criteria, this list is made to maximize and minimize aspects of the functions. Constraints provide specific quantitative goals the functions must fulfill for the toy to be considered viable.

2.1 Primary Functions

There are three primary functions this toy requires; movement of the net along the horizontal axis, the ability to collect and return the ball to the user, a scorekeeping function, and a frame to hold everything together.

1. The net must be able to move along the x-axis electronically. The span of movement will be approximately one meter, controlled by an electronic chip. The net must be able to move left and right autonomously.
2. The ball must be able to automatically return to the player upon a make, or near make. The ball will be collected then rolled back towards the player with a set velocity.
3. A rigid structure to support all the components.

The segregation of these functions allows for continuous prototyping and updating without threatening the integrity of the other components designs. Moreover, it is the optimal way to prototype a multifunction toy as it allows for multiple designs for each function on the toy. Then a final prototype can be created by taking a design from a "function bank," forcing the optimal design.

2.2 Secondary Functions

Once a prototype implements the three primary functions smoothly, secondary functions can begin to be considered. Some feasible options for this include:

1. A scorekeeping system must be implemented. This needs to be displayed to the player in some way to indicate the number of makes they have.
2. Game timing function.
3. Specific game modes, providing various difficulty levels.
4. Vertical movement to provide an even more unpredictable game.

These are not essential for the toy to work but can be small tweaks in the final product that make the toy exponentially more interactive. Furthermore, they are inexpensive, especially ones done electronically through the onboard computer chip, allowing for a greater shelf price.

2.3 Constraints and Criteria

In order to appropriately assess the toy prototype iterations, constraints and criteria must be used. Expanding on criteria, these are the main aspects that the toy will be designed around. All the potential solutions in Section 3 use the criteria to guide design iterations. The constraints are numerical goals that must be achieved for the toy to be successful. Table 1 lists the most important constraints and criteria for the basketball net.

Table 1 - Constraints and criteria of the toy design

Criteria	**Constraints**
Minimize motor noise: Quieter means more indoor-friendly	Power the system using a 12V 2.5 A wall adapter
Minimize computer failures	Total cost of under $120 for prototype
Maximize durability: Improves longevity of toy	Net speed of greater or equal to 0.4 m/s
Minimize inherent danger: Limit pinch points, visible wires, and sharp points	A ball return speed of under 5 seconds from shot release
Maximize ease of use: Design for intuitive use by a young child	Complete coverage of all electronic components

3.0 Technical Progress

This section covers the design process and iterations of the three primary functions: the HTM (3.1), Electronic Components (3.2), and the Overall Structure (3.3). These sections were designed to the point of a viable, working product, but were not optimized by any means. They have been narrowed down to specific solution categories (ex. the HTM will use a stepper motor) but still require prototype improvement.

3.1 Solutions Considered for Horizontal Translation Mechanism (HTM)

The first solution considered for movement was using a brushless motor connected to a rubberized wheel, which would rotate against a ledge, moving the net left and right (Figure 4). The motor would be connected to the net itself, which would sit on a linear bearing. A linear bearing is a good solution for translational movement as it is both low friction and easily accessible. After extensive testing of brushed motors, it was determined that they lacked the accuracy desired in this application and did not allow for easy automation, so this solution was considered unviable. However, it was proved that linear bearings provided consistent ease of movement without caveats; this feature became a key part of the HTM.

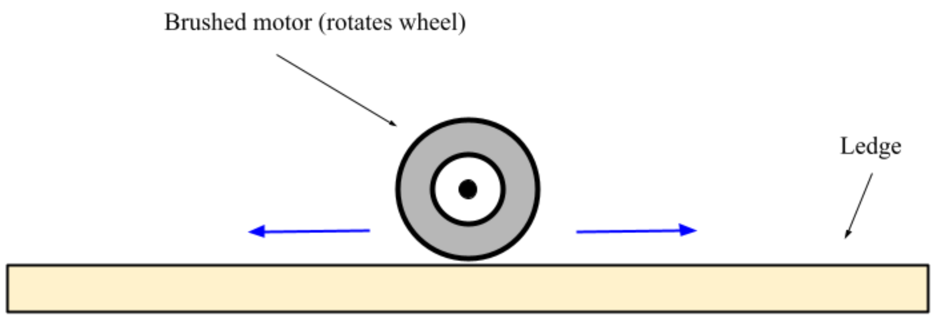


Figure 4 - HTM solution idea 1. A brushless motor that rotates against an edge to propel the net.

The second solution considered was leveraging technology from 3D printers using stepper motors, gears, a timing belt, and a linear bearing. As 3D printers make small, precise movements by nature, it made sense to select this technology. The precision that stepper motors can operate at makes it viable to omit specific sensors from the project, like end stop sensors, reducing the overall cost. Upon inspection and testing, seemed to be a viable approach, so the design extensively prototyped. The following parts were designed for this assembly, and manufactured in polylactic acid, PLA, using 3D printing:

a) Motor-side gear: The gear was designed with teeth that work on a standard GT2 timing belt from a 3D printer. The design was split up into two pieces, one that connects to the axle (Figure 6ai) and another that interacts with the timing belt (Figure 6aii). The part connected to the motor axle was designed to include heat sunk M3 inserts, allowing for screws to apply pressure onto the axle, preventing slippage. The first iteration allowed for too much movement in the belt making it fall off, so a small rim was added around the gear to prevent the belt from sliding off.

b) Bearing-side gear (Figure 6b): A single-piece design with a small hole for an axle to pass through. Nearly identical to the motor side gear.

c) Bearing-side mount (Figure 6c): Designed to insert a standard bearing for the axle to rotate on, which holds the bearing-side gear. Printed at an infill of 50% for strength. Two of these are required for the toy.

d) Stepper motor mount (Figure 6d): Has holes spaced to allow for M3 screws to hold the stepper motor in place. Printed at an infill of 50% for strength. Upon testing, it was determined that the PLA used was not an ideal solution for the stepper motor as they can reach temperatures above 60 degrees Celsius, the warping temperature of the plastic. This caused unwanted bending during use. A solution to this would be implementing a heat resistant material between the motor and the mount, or printing using ABS. This was not implemented during the timeframe of this project.

e) Bearing-side gear axle (Figure 6e): Machined out of aluminum at a diameter appropriate for the bearings and bearing-side gear.

The rest of the parts used (M3 inserts, M3 screws, 608-2RS bearings, and a 42x42x48 mm stepper motor) were acquired separately and designed around. Figure 5 depicts the overall assembly of the HTM. The assembly file for this system is available in the references section of this report [5].

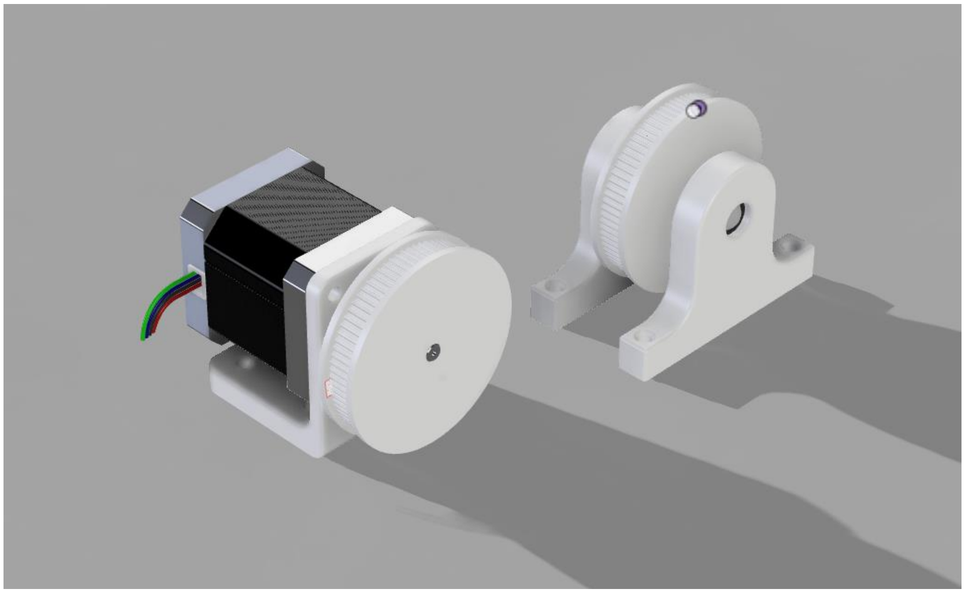


Figure 5 - General assembly for horizontal translation mechanism (HTM) designed in Fusion360

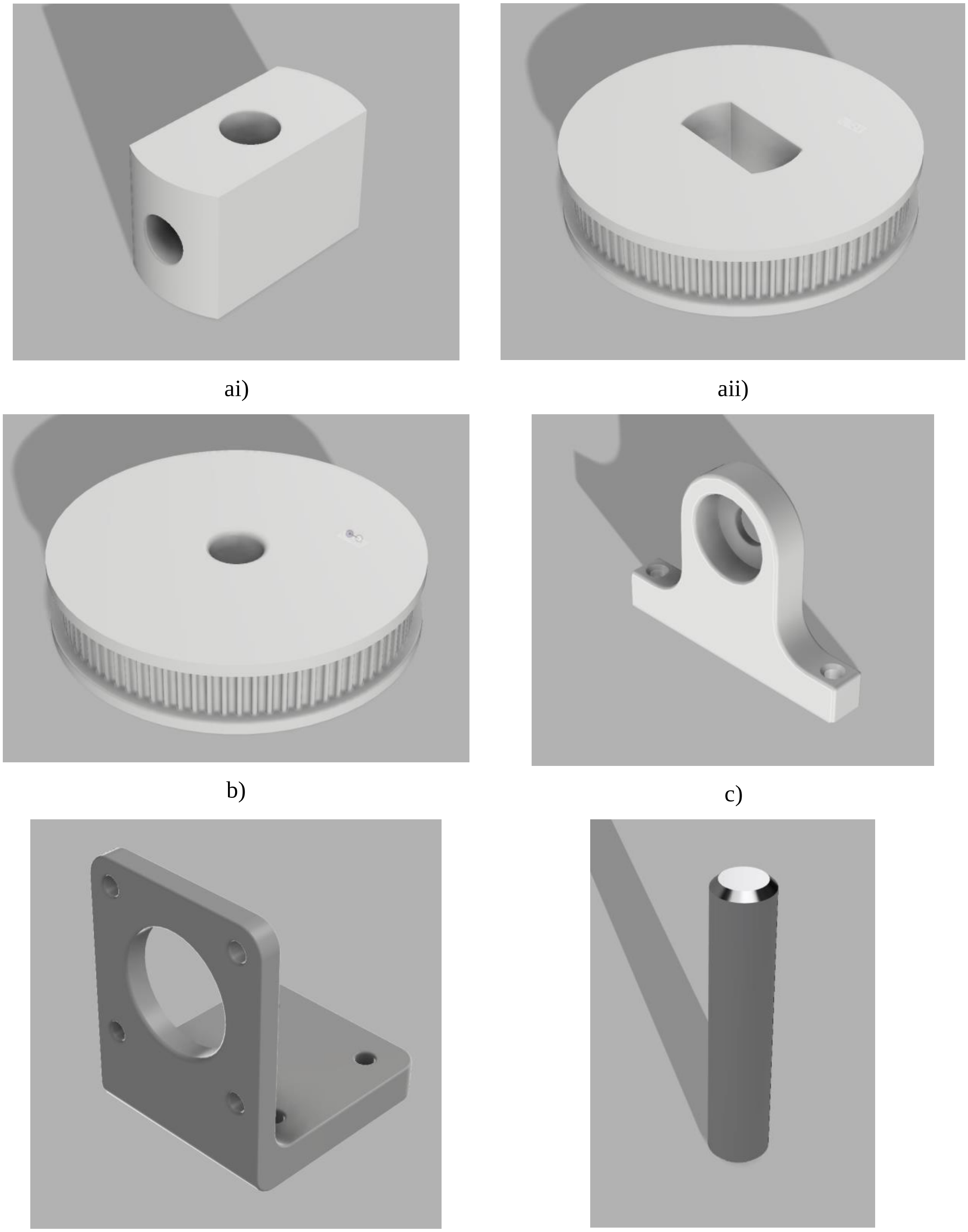


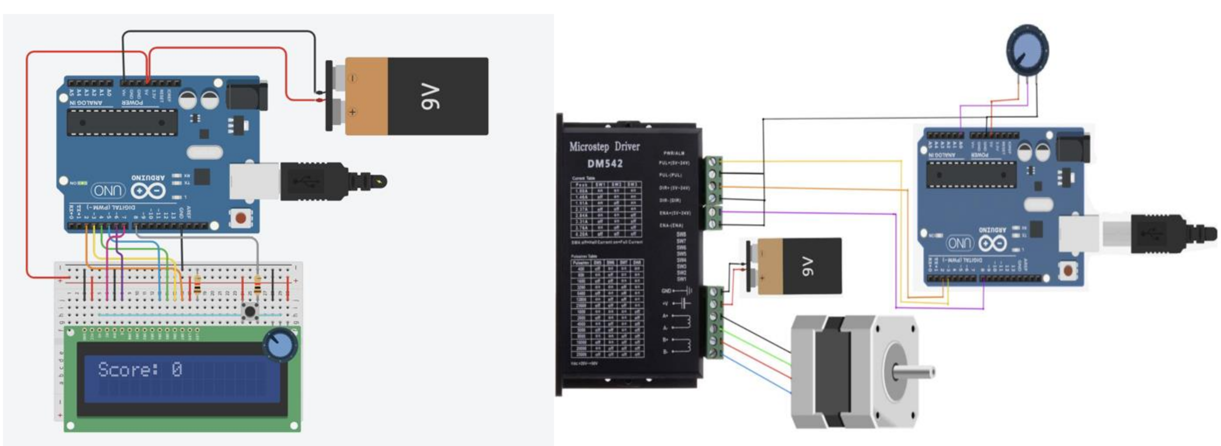
Figure 6 - All the custom designed parts for the HTM

3.2 Solutions Considered for Electronic Components

There are two major electronic features to be controlled are the score counter displayed on an LCD screen and the stepper motor:

1. Score Counter: The score counter includes an Arduino Uno R3, LCD screen, potentiometer, push buttons, wires, breadboard, and batteries (Figure 7a). Ideally, there will be a lever that is pushed down when the ball goes through the basket which then leads to the push button being pressed and displaying an extra point on the LCD screen. The score counter design was developed using the Tinkercad circuit software and ideas from an online tutorial [6]. Moreover, the ideas and software made the physical assembly of the circuit run smoothly without any issues.
2. Stepper Motor: The stepper will arbitrarily move the net along an x-axis and at a controlled speed. The components will include a stepper motor, potentiometer, TB6600, Arduino Uno R3, wires, and breadboard (Figure 7b). The stepper motor design was first tested on the circuit simulator website Tinkercad. Moreover, this is where the trial-and-error code was developed to make the physical process of building the circuit run smoothly. The only challenge encountered was during the physical building of the circuit where the TB6600 would not power. Through further research, the problem was found to be a lack of voltage and current from the original power source of 4 AA batteries which was replaced with a 12 V and 2.5A wall charger.

Both systems have been tested to ensure they work properly. Given the fact a stepper motor must be controlled by a computer, research was done to determine what is the most common and user-friendly system to use. An Arduino was chosen for the electronic components as it is relatively easy to use and is capable of a diverse range of functions.



a) b)

Figure 7 - Wiring diagram for electronic components

3.3 Solutions Considered for Overall Structure

The overall structure consists of a piece of plywood coupled to two legs constructed out of 2x4s. The plywood backing was chosen to give ample surface area to mount the linear bearing, return net, HTM, and the electronics without the components being crowded. The plywood is approximately 3.5 ft x 2 ft, and the legs are approximately 3 ft wide and 5 ft tall; these measurements do not have to be particularly accurate. The legs are screwed together using 2.5" deck screws and take advantage of angled corner braces to keep the toy balanced. The linear bearing is mounted using multiple short wood screws to prevent penetration through the plywood, and the HTM is mounted using nuts and bolts that completely penetrate the plywood and lock in place (Figure 8). The remaining pieces, such as the electronics, are mounted using double-sided tape. This structure is much stronger and heavier than its application requires, which is good for maximizing strength but inhibits weight minimization.

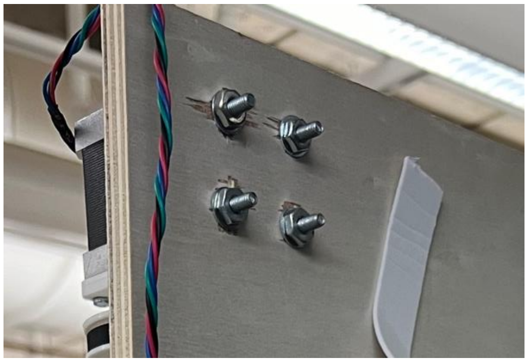


Figure 8 - The backside view of the HTM fasteners

3.4 Validation Testing

This subsection summarizes the testing of each of the three systems and evaluates them using the constraints and criteria in Section 2.3. The following analyzes the prototype in terms of the criteria:

1. **Minimize motor noise:** Using a decibel measuring app on a cell phone, it was determined that the motors emit a peak sound intensity of 68 dB. This is typical of stepper motors and could be further reduced through a soundproofing process. This could consist of covering the motor in soundproofing foam; however, this could be problematic as the motor can run hot after extended use. This criterion was met but can still be improved.
2. **Minimize computer failures:** During testing, there were no issues when running the code uploaded to Arduino. This criterion was met.
3. **Maximize durability:** Upon rough gameplay (shots with relatively high velocity from adults), the toy showed no signs of wear or breakage. This was due to the rigid build materials. This criterion was met.

4. **Minimize inherent danger:** The final prototype had exposed wires and electronics at the backside of the toy and potential for injuries related to wood handling (ex. splinters). This criterion was not met. This is discussed more in the safety section (4.1).
5. **Maximize ease of use:** Once the toy was plugged in, the game operated without any interaction from the user. This criterion was met.

In terms of constraints, they were all met except for the covering of electronic components. The overall cost is estimated to be $60.26, as given by table 2. This cost would go up without the supplies from the MESS hall, however, this toy consists of unoptimized components in terms of cost efficiency, meaning production cost would be significantly lower upon further design. The toy could move the basketball net a length of 1 meter in 2 seconds, which implies it can reach speeds of up to 0.5 m/s, bettering the planned 0.4 m/s. Furthermore, the ball return speed averaged to be approximately 4.2 seconds, as given by 3 separate timed shots. This is beneath the 5 second goal. Solutions to any problems in this section are discussed in section 3.6 and 4.3.

Table 2 - Estimated cost of complete prototype

Lumber for legs	3 x $3.97 = $11.91
Lumber for backboard	$23.36
Basketball net	$19.99
Linear bearing	Free from MESS hall
Electronic components	Free from MESS hall
Miscellaneous	$5
Total:	$60.26

3.5 Progress to Date

Overall progress can be broken down into the three primary functions of the toy:

1. **Horizontal translation mechanism:** All the parts have been printed, tested, and assembled. This system has been fully integrated into the rest of the project. Further testing must be conducted in terms of strength testing and part longevity to see if they are viable for long term use. The mounting bracket for the stepper motor should be redesigned or constructed out of a more heat-resistant material to avoid the heat warping that occurred during testing.
2. **Electronic components:** The code to operate the HTM's motor and the score-counting system are finished and uploaded to an Arduino Uno. The stepper motor portion of the electronics has been integrated into the HTM and works without problems. Although tested and found to be functional, the score-counting system and display still need to be fastened to the toy.
3. **Overall structure:** As shown in Figure 1, every component used for the construction has been put together, including the wood, linear bearings, ball, backboard, and basketball rim. Although every part of the toy works, more prototypes are required to optimize its weight and form factor.

3.6 Remaining Challenges

The remaining challenge of this toy is to continue to optimize the raw solutions to better fit the constraints and criteria. Currently, the prototype is much too rugged, bulky, and crude to go to market, which can be fixed by continuing to cycle through the design process. Aside from general design cleanup, the challenges can be broken down uniquely into the three main functions:

1. **Horizontal translation mechanism**
    a. The stepper motor mount must be made from a more heat resistant material to avoid warping after extended use. Figure 9 depicts such warping after a running period of 15 minutes.
    b. The system may have to be covered at the end components (where the belt meets the gears) to reduce the likelihood of injury due to moving parts. The gears themselves are the primary pinch point of this system.
    c. The linear bearing should be optimized in terms of weight. The current one is designed for industrial applications and its robustness is not required.
2. **Electronic components**
    a. The Arduino must be converted into a more cost-effective and task-specific chip. This can be done using custom printed circuit boards (PCBs) along with computerized components.
    b. All wires must be permanently soldered together and sealed for durability and safety purposes.

c. Component housing must be created to cover computer chips and wiring to reduce inherent danger. This could be as simple as a plastic box.

3. **Overall structure**

   a. The structure must be optimized in terms of minimizing weight and maximizing ease of disassembly. This likely means the main build materials would have to be something lighter like hollow aluminum and/or plastics.

   b. The legs should be redesigned to allow for height adjustment so the toy can cater to a broader skill and age category.

   c. The ball return system could be funneled to allow for a more accurate ball return or made electronic using a brushed motor rotating a rubberized wheel. The latter would require lengthy testing and prototyping to achieve.

In addition to the previously mentioned, the secondary features outlined in section 2.2 could also be implemented in the design to improve toy marketability.

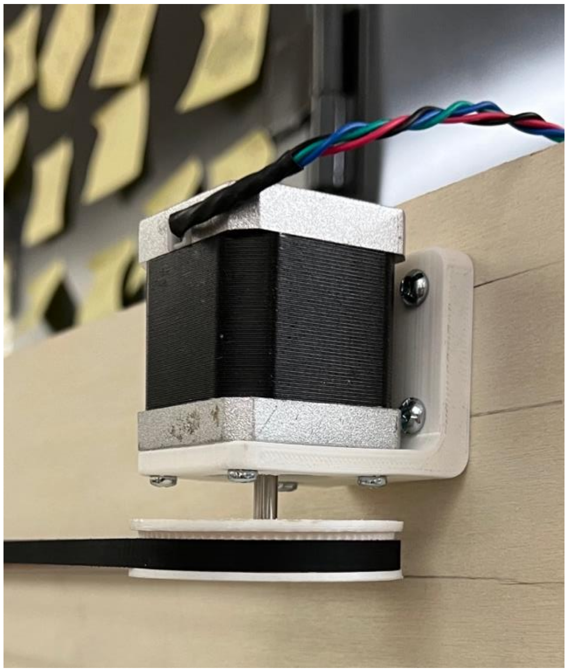


Figure 9 – Mild warping in the stepper motor mount seen after extended use

4.0 Conclusions and Final Statements

This section covers the conclusions with respect to the general solutions devised and the overall viability of the moving basketball net. In addition, the inherent safety and dangers of the toy and the recommendations for further improvements are discussed.

4.1 Toy Safety

This toy has minimized dangers as much as possible but is still a rough prototype, so there are multiple points of improvement that can be considered in future models. The following lists contain some of the safety measures implemented into the toy and potentially dangerous features:

Safety Implementations:

1. The net feature incentivizes children to shoot the ball from a distance rather than dunking, preventing the user from using the toy in a dangerous manner.
2. Electronics were placed behind the board where the ball rarely goes, minimizing the chance of kids touching them while playing with this toy.
3. The HTM has been placed out of reach for younger children making it more difficult for them to touching moving parts.

Potential Dangers:

1. The wooden frame and base have not been adequately sanded, which could potentially cause splinters. This is only dangerous in the case of a child who uses the toy improperly as the return net covers most of the wood.
2. There are multiple screws that extrude beyond the wooden surfaces at the back of the game, which are sharp and unsafe. This could be fixed by using shorter screws.
3. Stepper motors can reach high temperatures upon extended use, which could potentially be a burning hazard. This motor is placed out of reach for most children but could be solved by adding a cover to the motor.
4. The wires at the back of the net were poorly secured by tape which can result in damage to the toys functionality. To prevent this, the electronic components can be enclosed.
5. The weight of the toy is very heavy and if it was purposely pushed over, it could cause injury. This damage can be minimized by minimizing weight.
6. The net at the bottom of the overall structure could be a tripping hazard. This is an inherent danger and cannot be avoided. As the net is already neon, this should not pose an irrational problem.

4.2 Conclusion

In summary, several separate designs have been created and integrated to make a promising moving basketball net, but it is still a rough prototype and requires many more optimization hours. In terms of the horizontal translation mechanism, a working and efficient prototype has been created. This was completed using multiple custom-designed 3D printed parts, a standard stepper motor, and a timing belt salvaged from a 3D printer. This allowed for seamless, accurate, and precise movement during testing. There has been limited testing done in terms of durability, but there are no preliminary signals that indicate premature wear. The stepper motor mount needs to be manufactured with a more heat resistant material. The HTM is relatively safe, given the user does not deliberately climb into the toy and put their fingers into a moving gear. As the age range for this toy is 6 – 12 years old, this should not be an issue.

Moving on, the code for the electronics has been completed and optimized to work alongside the HTM. Code for an LCD score display, movement, and basket counter has been uploaded to an Arduino Uno and is set up to work with the stepper motor. Furthermore, the motor and the code have been connected to each other and are operational; the score display has yet to be added. This system is powered by a standard 12 V wall adapter.

Finally, the overall structure and ball return system have been designed, assembled, and have the other systems mounted to it. Materials used consist of plywood, 2x4s, and deck screws as fasteners. Due to these material choices, the structure is much too heavy robust for this toy’s application, meaning it still requires streamlining and more design hours. This should be relatively easy as there are not any moving parts or complex mechanics involved.

Taking everything into consideration, the moving basketball net has not yet reached its objective and is not yet a viable toy. The main functions have been integrated together in a working manner, which is a defining feature of the objective of this report. However, this toy is not yet safe enough as discussed in the toy safety section (4.1). The final prototype achieved had exposed electronics and wiring, several screw ends exposed, and unfinished wood that could potentially cause splinters. This makes it unreasonable to release this toy on the market. Nevertheless, these components can be made safer given more time to optimize and test. Additionally, both the electronics and HTM have been developed to the point that the only point of improvement is reducing the cost of the parts. In summary, this basketball toy is unviable as of now, but has been projected to be viable in the future given more cycles of design.

4.3 Recommendations

As this toy idea was designed to be easily upgraded and improved upon, there are several recommendations that can be made for further prototypes and final products. The following list summarizes some possible ideas and upgrades that could significantly improve the overall design, given time:

1. **Adding wheels for transportation:** Realistically, it is more convenient and time-efficient for this toy to be transportable, as the construction now relies on disassembling and then reassembling it for transportation. To achieve adequate transportation, the addition of wheels on the bottom wooden piece can prove useful.
2. **Redesigning the HTM:** In a commercial setting, the cost of stepper motors is significantly larger than that of a brushed motor of equivalent size; this means that this system may have to be updated to reduce production costs, increasing viability. The manufacturer will have to decide if they value quality at a higher price or quantity at a lower price.
3. **Overall structure material:** To cut costs and weight, a different material, or combination of materials, should be used in the production of the build. As the selected wood is thicker and denser than required, the cost and weight are significantly more than they could be. Perhaps utilizing a blend of hollow aluminum tubing and plastic could lead to a more optimal design.
4. **More electronic features:** It would be relatively easy to code in game modes that move the net at various speeds or continue to prototype a score counting sensor to improve score count accuracy.
5. **Custom chip components:** As an Arduino has much more computing power than required and is costly, if this product was to go to a commercial market, custom printed circuit boards (PCBs) could prove useful. This would reduce the cost of the system and allow for permanent hard wiring.
6. **Introducing vertical movement:** A premium version of this product could include vertical movement in tangent with the horizontal movement. This would add another layer of dimension and complexity to the product allowing for a higher selling cost.

As mentioned above, there are many additions that can be made to this toy, allowing it to continuously improve over time.

References

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