DUKE UNIVERSITY, PRATT SCHOOL OF ENGINEERING

ME421 - State Fair Project

The Crazie Toss

Mehmet Guvenilir, Kaelyn Gridley, Eric Huang, Sam Feldstein, Anya Gupta

October 24, 2025

Professor . . . . Dr. Sophia Santillan, Dr. Nico Hotz

THE CRAZIE TOSS

Based on the popular carnival game hole toss, The Crazie Toss is suited for visitors of all ages, and tests your skills in basketball and accuracy while demonstrating mechanical engineering principles.

Score points by shooting through the cutouts! Or will you go all-in on the hoop?

Each player gets four basketballs. A ticket is awarded for every 50 points earned.

Four basketballs.
Four shots at glory.

* Behind The Scenes:

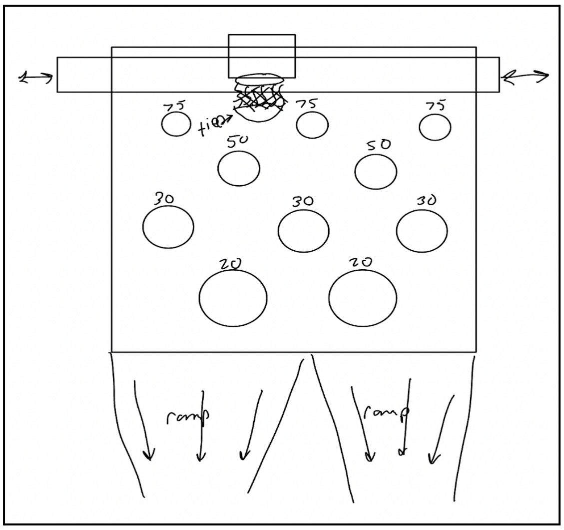
The hoop is mechanically actuated by an operator using an in-line crank linkage to continuously and effectively translate rotational to linear motion. The hoop & backboard are attached to a rolling gantry for smooth movement.

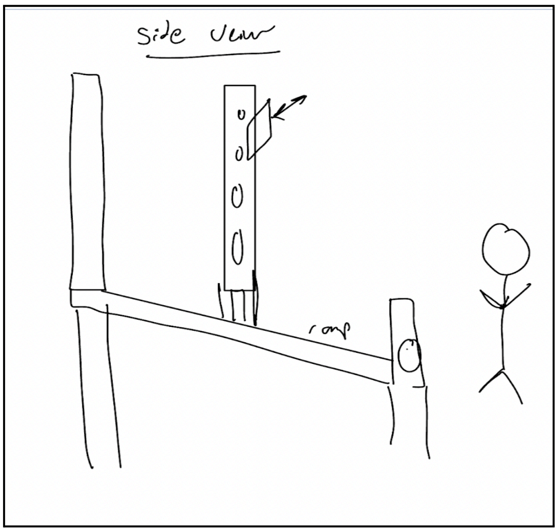
As a safety precaution, a net is set up around the game to prevent any basketballs from bouncing out. The frame was built sturdily from aluminum extrusions to allow for the best user experience.

Proudly presented by 421 Group 1:

Kaelyn Gridley, Eric Huang, Sam Feldstein, Anya Gupta, Mehmet Guvenilir

Initial Design Sketches:

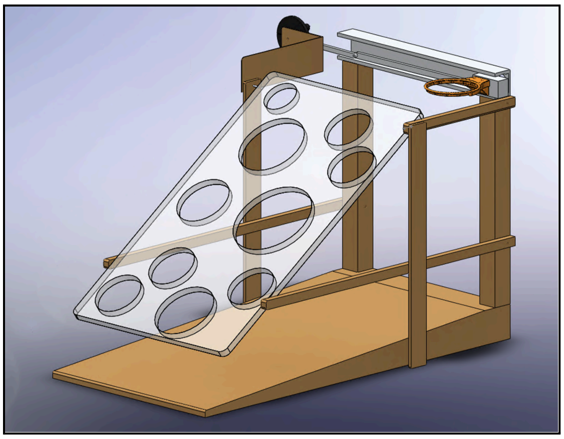


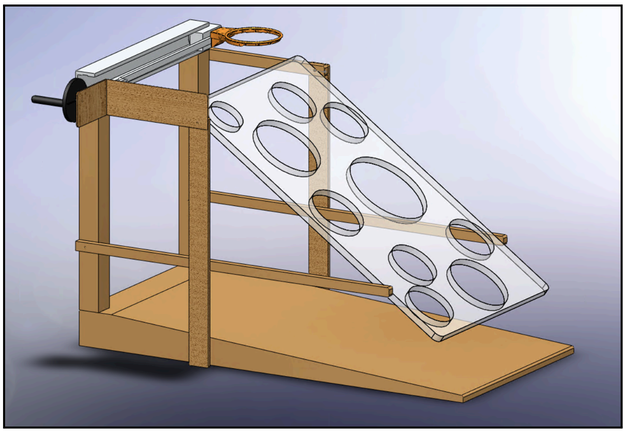


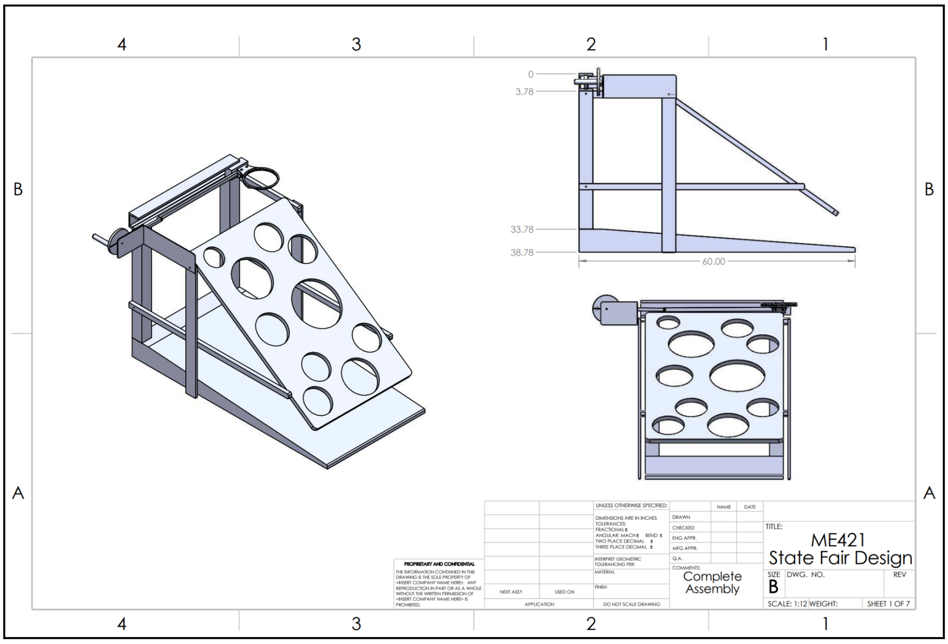
The initial design sketches displayed the overall concept for the carnival attraction. It accounted for the cutout holes on the wall up front, where players can score a variety of points. These sketches displayed a broad illustration of the ramp and supports. It was also determined that the basketball hoop at the top would be the highest possible score in the game, and that it would move from side to side as the participants attempted to shoot the basketballs through it. A variety of mechanisms were discussed at this stage for the motion of the hoop. These ideas included a pulley system, a rack and pinion design, a simple crank that would be rotated in opposite directions, and a horizontal slider mechanism attached to a handle, allowing the hoop to be pushed and pulled along a tunnel to move it back and forth.

Initial Technical Drawings + CAD:

A few images of the first CAD model and technical drawings are provided below. At this stage of the design, an in-line shift crank was picked to move the basketball hoop from side to side. This was viewed as the best option since a continuous rotational movement would be easier for the team member in control of the hoop while participants play. This mechanism was simple enough to build accurately and adjust to our design, while effectively translating the rotational motion to the desired linear motion at an adjustable speed. Wood was discussed as the best option for the ramp and supports since it would be low-cost and sturdy enough to carry the weight of the components. The panel with the hole cutouts was designed from thin PVC plastic, both for aesthetic reasons and ease of machining.







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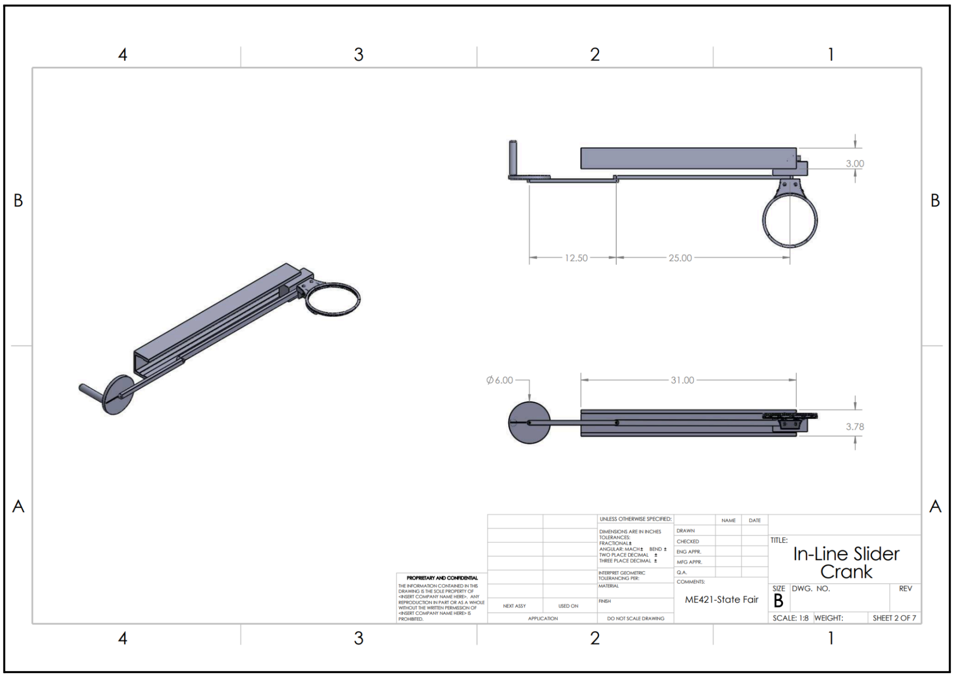

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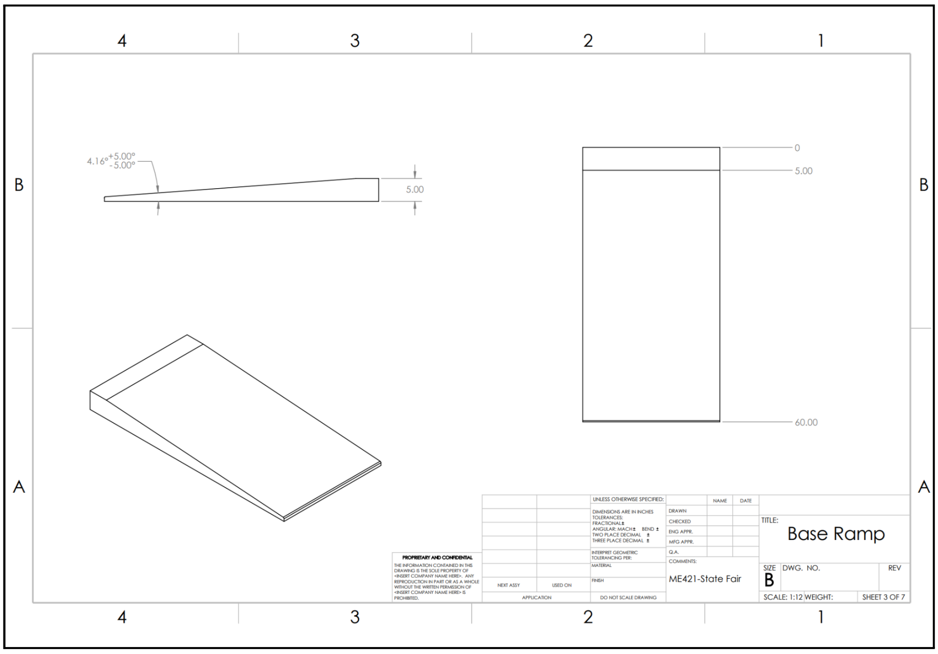

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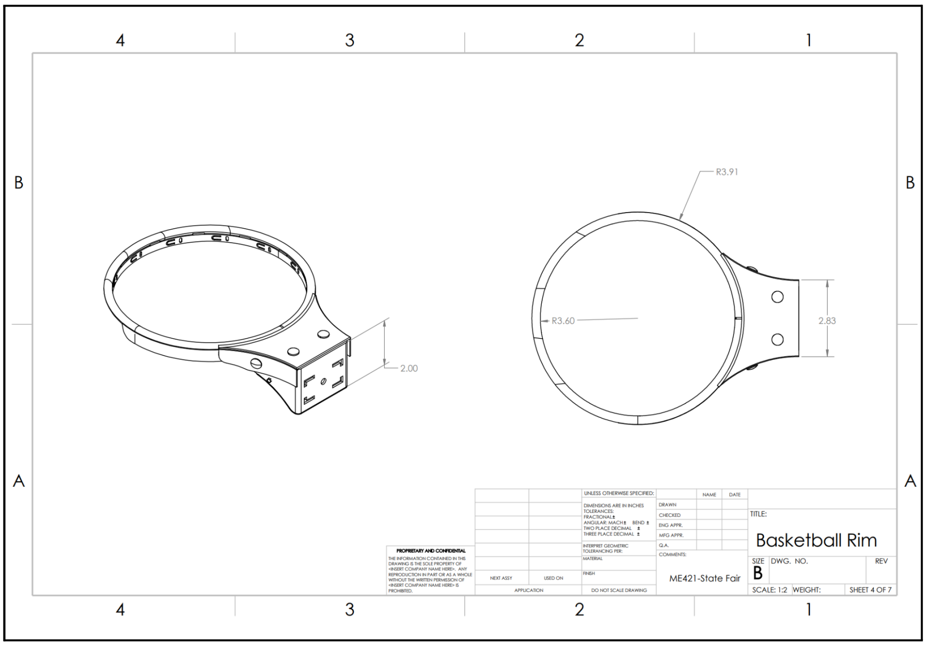

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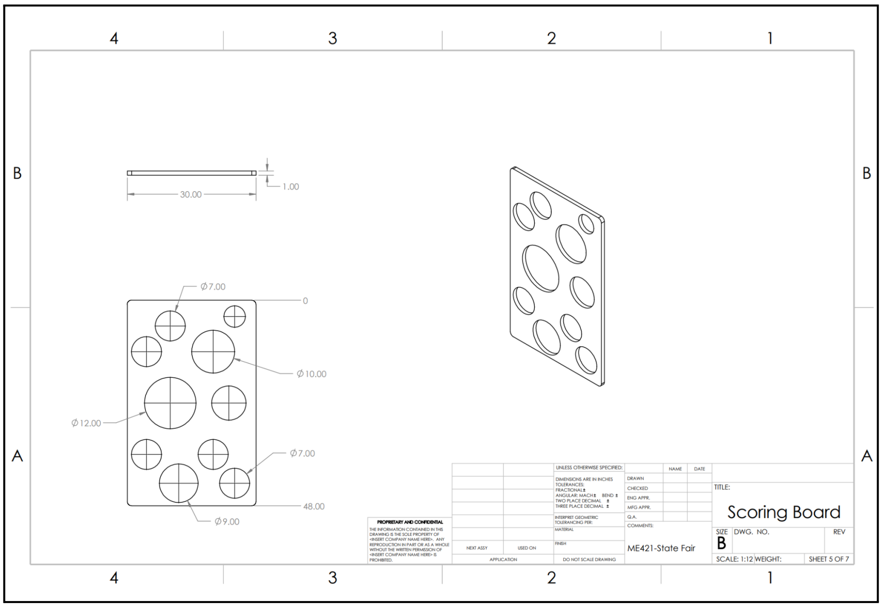
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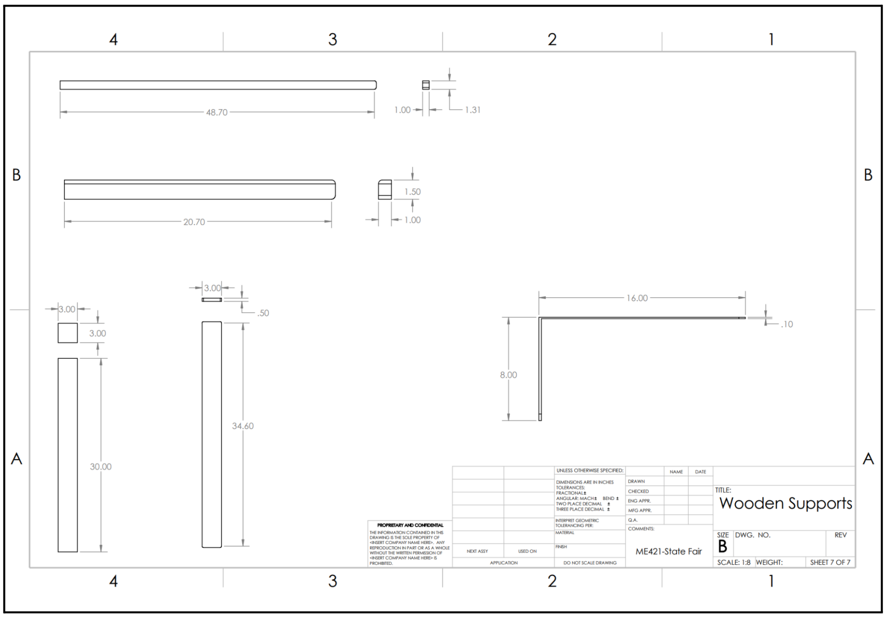
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SHEET 7 OF 7

Initial Bill of Materials:

Part Number	Description	Quantity	Supplier	Price
619375	1/8 in. Wood Sheet (2ft x 4ft)	1	Home Depot	$6.99
166014	1/4 in. Wood Sheets (4ft x 8ft)	1	Home Depot	$30
B0B1T2 YFHK	Mini basketball hoop and ball set	1	Amazon	$24.99
47065T10 1	Aluminum extrusion for slider mechanism, main support (3ft, 1 in. x 1 in.)	3	McMaster-Carr	$47.70
B0B99W TBSY	Gantry plate + rollers (to hold basketball hoop)	1	Amazon	$18.99
-	Crank	1	3D Printed	-
8975K59 1	Crank linkage bars: 6061 Aluminum bar (¼ in. x ½ in. x 1ft.)	2	McMaster-Carr	$5.04
B0C2KJF TNP	Netting	1	Amazon	$16.99
91268A1 06	¼ in. Bolts	25	McMaster-Carr	$6.46
97801A5 02	Nails (1-½ in.)	275	McMaster-Carr	$3.99

Early Notes of Safety and Design Concerns:

The vertical structure of the game must be sturdy to preserve the structural integrity of the design and prevent the game from tipping. Considering the game is for children, and they will be throwing the small basketballs at the structure, it must be entirely resistant to tipping or wobbling. Furthermore, nets will likely have to be added to the sides of the game to prevent any balls from falling out of the game and posing a tripping hazard. To prevent people from getting splinters in the wooden board, we will be sure to sand down the parts that the player will contact. Another concern is that the ball could potentially bounce off the slab and hit the player. Using standard basketballs or harder balls could be a potential risk. We will be sure to acquire small, lightweight blow-up basketballs that pose no threat to the participants.

Since the game will be rather tall, the hole-wall will have to be rigidly fixed in multiple places to prevent it from wobbling around. There will also likely be some challenges associated with making the sliding mechanism work and be reliable. We will likely have to experiment with tolerances and materials to get it working smoothly.

In terms of the game mechanics, the design will be optimized for a consistent and safe playing experience. We will focus on angling the ramp at an ideal angle to provide a consistent roll for the ball back to the player. The sizes of the holes will be carefully thought out. The holes must be large enough that the ball can easily go through them, but the varying sizes must be challenging enough to ensure captivating gameplay. We will incorporate a simple way to keep score, such as a small whiteboard or verbal score keeping to make the game engaging and competitive.

Low Fidelity Prototype:

The low-fidelity prototype was designed to experiment with the in-line shift crank design and have a better understanding of how to build one for the final design. For easier and faster manufacturing of the parts, the crank and the linkage bars were 3D printed based on the dimensions from the SolidWorks design. Instead of attaching the hoop to one singular wheel, it was decided to attach the moving part to two wheels to provide a smoother and more stable movement. An aluminum extrusion provided the necessary pathway for this motion. Two wheels and a frame for them were also 3D printed according to the dimensions of the available extrusion from Hudson. An aluminum shaft, 1/4in bolts, washers, and nuts from the Garage Lab were utilized to attach the components and form the assembly. To mimic the support which was planned to be built from wooden panels, a thick cardboard roll was used for a temporary base for the assembly. This cardboard was sturdily taped to the floor in order to prevent any slips. The biggest problem that was observed was that the aluminum shaft would damage the hole of the 3D printed parts and eventually get loose, as it had significant stress on it. To fix this issue with the low-fidelity prototype, the short linkage bar was tied to the shaft with a string and supported with hot glue. This setup gave us insight into how the mechanical components of our design would function, and which parts require adjustments and modifications for the final product.

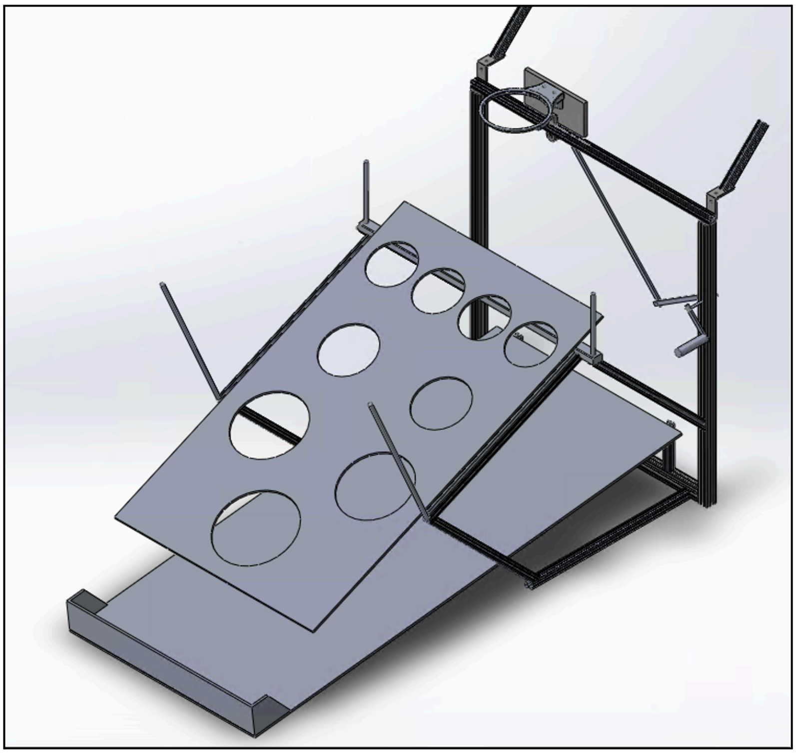
Modifications to Design:

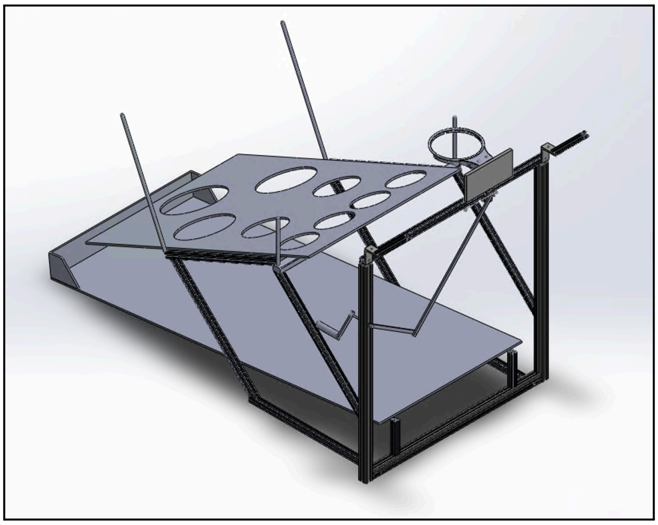
Based on the prototype and further research, several changes were made to the original design. Since the aluminum extrusion used in the prototype proved to be efficient for the motion of the hoop, the C-channel pathway was replaced with a thin aluminum extrusion. The prototype displayed that the wheels sitting upright on the pathway and not bending were crucial for the smooth movement of the crank. For this purpose, it was determined that an officially manufactured linkage for the extrusion would be more efficient than personally designing/printing wheels. Therefore, a gantry plate and rollers were added to the order list. This structure would also be perfect for holding up the basketball backboard due to its robust structure. Since we were already going to be using aluminum extrusions, it was discussed that replacing the wooden supports of the assembly with more aluminum extrusions would allow the parts to be connected more efficiently and require fewer adjustments. This would also most likely form a stronger skeleton for the assembly while maintaining the design's lightweight. The aluminum extrusions were available for usage at the Garage Lab and the Hudson metal rooms. This also provided more flexibility in the budgeting of the necessary components.

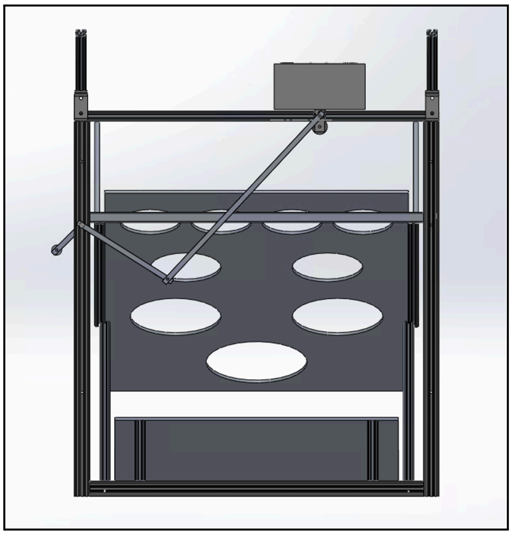
Certain modifications were also made to the in-line shift crank mechanism. Due to the fundamentals of this mechanism, the crank needed to be offset to the side of the carnival game at the top to allow complete motion for the basketball hoop along the pathway it is attached to. This design required additional supports at the top of the carnival game, as can be observed in the original CAD models. This design choice required complex geometry to be designed to support the crank. Since the attachment of the crank being stable is pivotal to the motion of the basketball hoop, this seemed like a risky approach. Additionally, this would mean that the overall design would exceed the required footprint unless the game itself was shrunk, which would make the game drastically harder to play and aesthetically less appealing to the participants. Hence, a new approach to the crank mechanism was designed. Instead of offsetting the crank handle to the side of the frame to make space for the shorter linkage arm when the hoop shifts all the way to the right, the crank was attached lower on the frame. This new placement allowed for enough space for the crank to move the basketball hoop to the furthest points on both sides of the aluminum extrusion without exceeding the provided size limitations for the overall carnival attraction. The new arm lengths required for this design were determined through experimentation on SolidWorks.

Additionally, the thin PVC plastic was replaced with a thin wooden panel for the wall that consists of the hole cutouts in order to allow for easy laser cutting. Using wooden panels for this part would also allow us to decorate and paint the design more aesthetically, instead of the transparent look of the PVC.

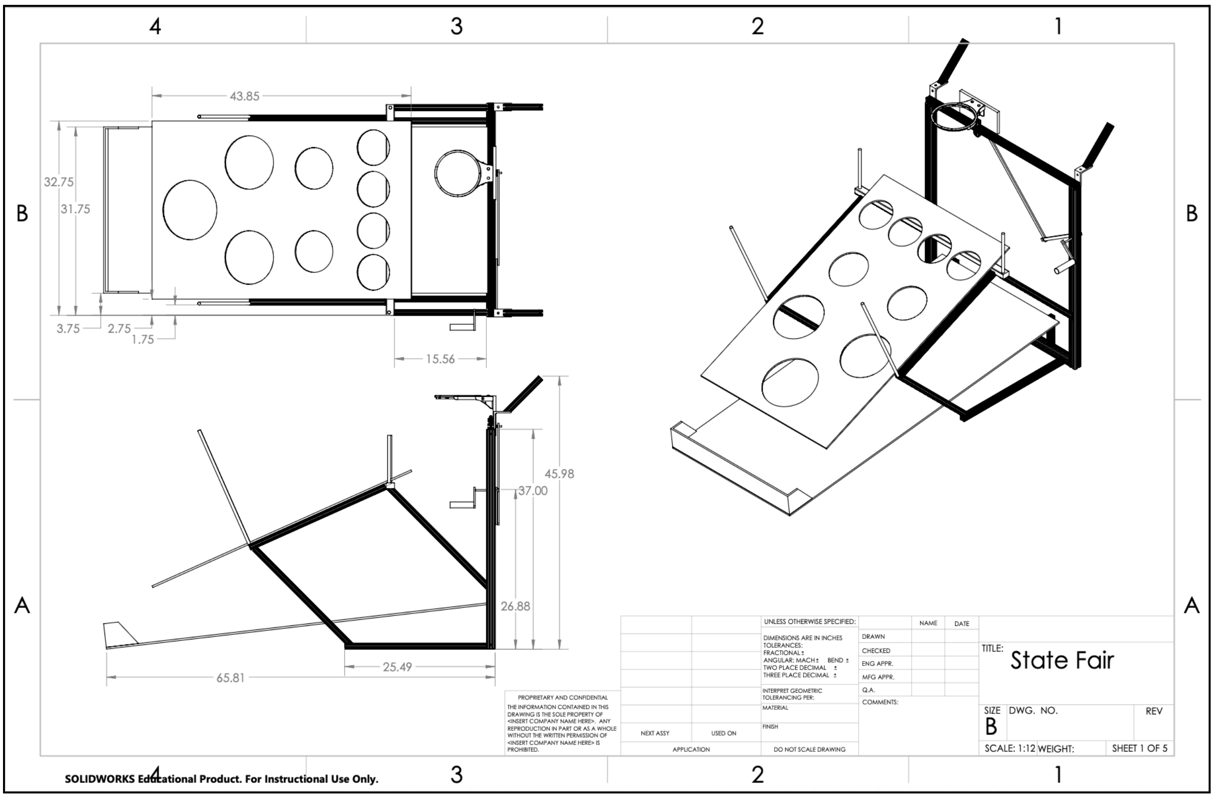
Final CAD Images:

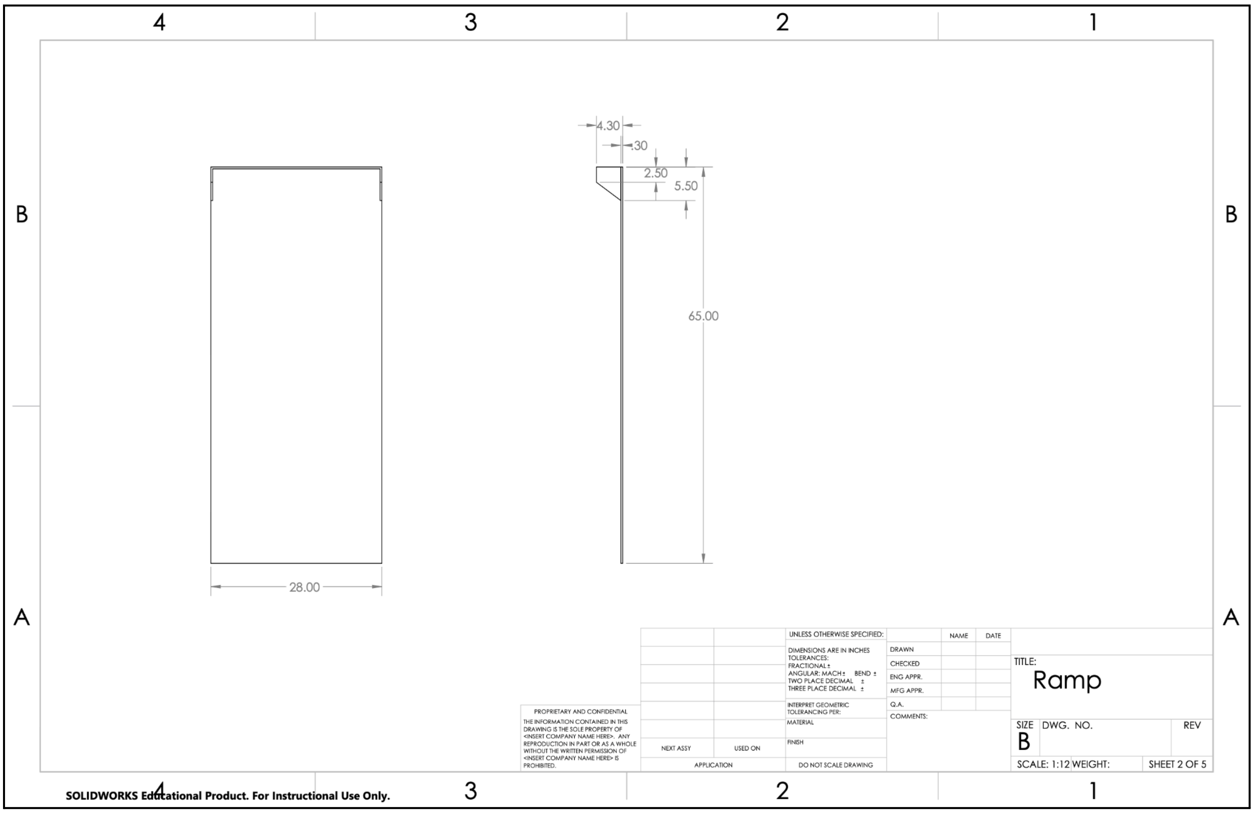






CAD Drawings:

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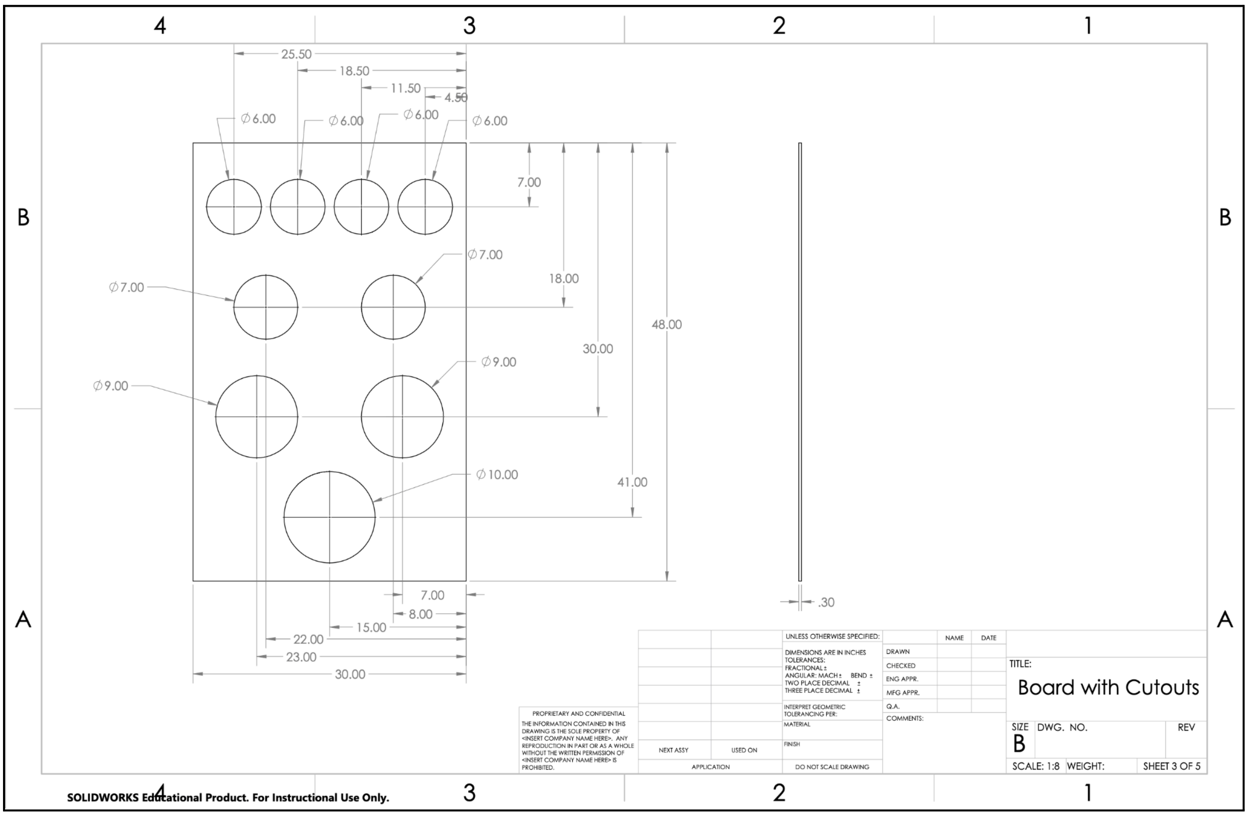
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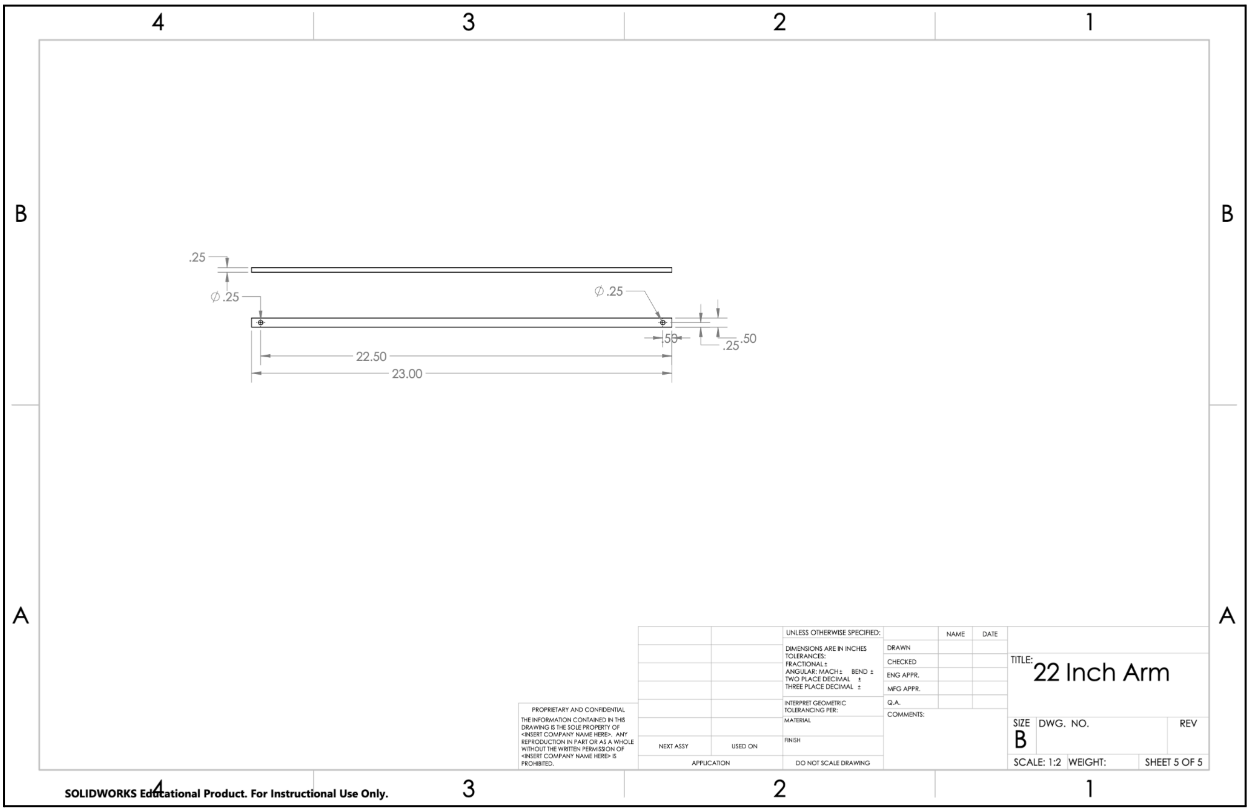
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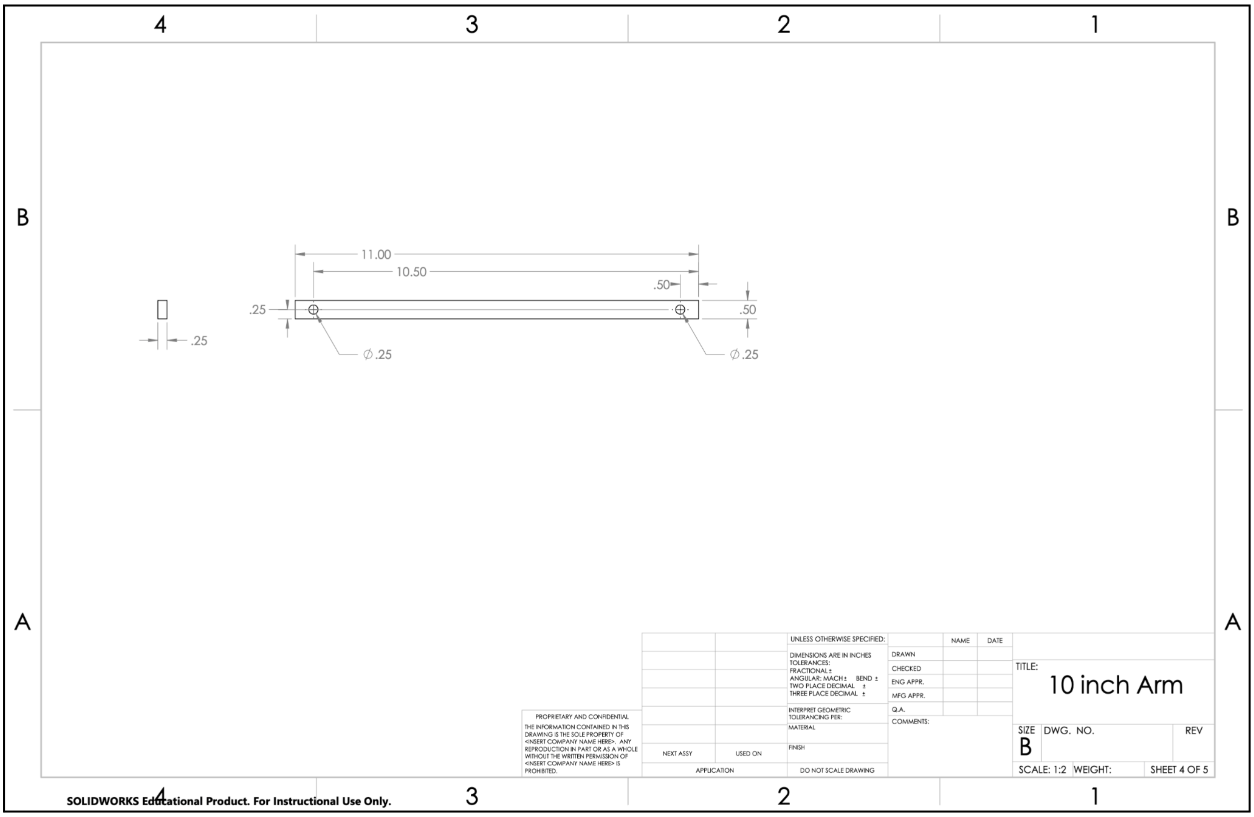
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Final Bill of Materials:

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166014	1/4 in. Wood Sheets (4ft x 8ft)	1	Home Depot	$30
B0B1T2 YFHK	Mini basketball hoop and ball set	1	Amazon	$24.99
47065T10 1	Aluminum extrusion for slider mechanism, main support (3ft, 1 in. x 1 in.)	3	Available at Hudson	-
B0B99W TBSY	Gantry plate + rollers (to hold basketball hoop)	1	Amazon	$18.99
-	Crank	1	3D Printed	-
8975K59 1	Crank linkage bars: 6061 Aluminum bar (¼ in. x ½ in. x 1ft.)	2	McMaster-Carr	$5.04
B0C2KJF TNP	Netting	1	Amazon	$16.99
91268A1 06	¼ in. Bolts	25	Available at garage lab	-
97801A5 02	Nails (1-½ in.)		Available at garage lab	-
			Total	$96.01

Final Assembly:

Certain adjustments were made during the manufacturing process due to difficulties that weren't accounted for in the original design. To fix the issue with the rigid connection of the shaft to the crank and the linkage arm, a key was utilized. The top of the aluminum shaft was shaved off, and the crank was once again 3D printed with the center hole designed to account for the key. Additionally, extra fittings were 3D printed, which would be attached to the linkage arm to change the hole to the necessary shape. However, this approach did not fix the problem. Although it seemed stronger in the beginning and did not require the components to be tied together with a rope, after several trials, the aluminum shaft damaged the inside of the 3D parts and once again caused these parts to move separately. The goal was to keep these parts rigid on the shaft; however, there were no setscrews at our disposal to build this design.

Therefore, a new approach was required, and the crank print also needed to be fixed in place from both sides instead of just being placed on the shaft. As an alternative solution, the aluminum shaft was replaced with a ¼ in fully threaded rod. All components were placed on this rod and stabilized in place via locknuts. This design was strong enough for all components to rigidly move together without any malfunctions. Nevertheless, to make sure that the crank design would not fail during the fair after repeated usage, it was determined that a component this pivotal should not be 3D printed. The crank was redesigned via the excess aluminum from the linkage bars, and once again, bolts and locknuts. Only the handle was later 3D printed to make it more comfortable for the person using the crank.

Once the crank mechanism was put together, it was realized that the linkage arms were not aligned properly. For all the fittings, nuts, and spacers to fit on the threaded shaft, the linkage arms also needed to be moved further away from the backboard. Using a bolt this long would cause the structure to not be as sturdy as needed, since all of the load would be at the free end of the bolt, while the bolt is only attached at the other end. This would result in too much deflection over time, potentially risking the crank mechanism to malfunction in the long run. To fix this issue, an aluminum standoff was used as a connection between the backboard and the linkage arm, allowing it to be stabilized from both sides and providing a stronger assembly.

Another crucial problem was figuring out the details of how to attach the front panel to the rest of the frame at the desired angle. Thin aluminum extrusions were attached to the backside of the wooden panel with the hole cutouts. Additionally, angled aluminum extrusions were attached to the frame based on the determined angle of the wall for ideal shooting. These structures were bolted together, and this design worked quite effectively. However, certain parts of the panel seemed too loose and were bending due to the weight of the assembly and the impact from the balls. This was due to the wall being formed of four different wooden panels attached to allow for laser cutting of each segment individually. To prevent this panel from breaking as participants played the game, a thicker wooden piece was attached to the bottom at the weaker points via wood glue.

For aforementioned safety reasons, it was necessary to attach a netting around the design. At the front, wooden sticks were hot-glued to the aluminum base to hold the net up to prevent the balls from bouncing out. At the back, extra angled aluminum extrusions were added to make sure there is enough space for the crank to function without getting tangled in the net.

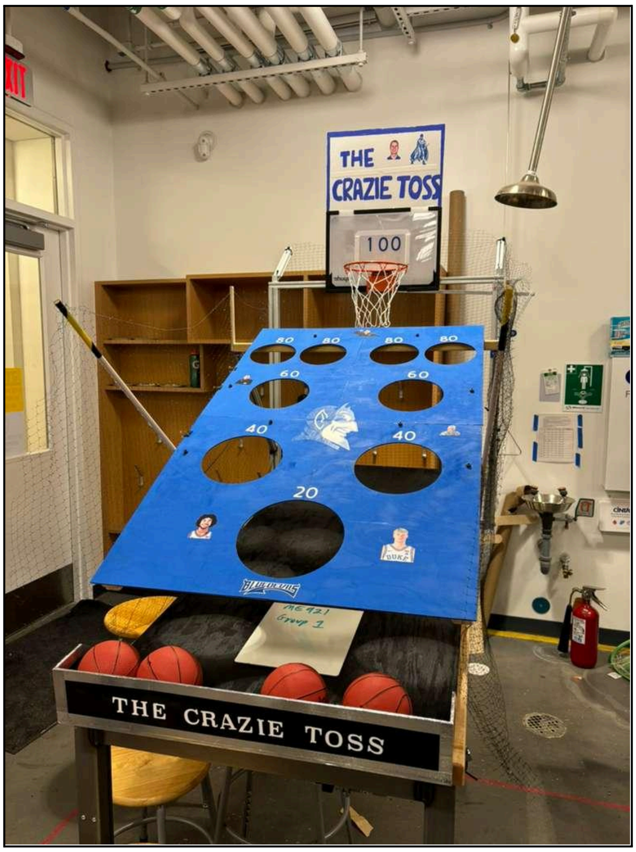
The net was attached by zip-ties and staples, and supported by hot glue. To prevent the top sections of the net from sagging, a thin string was tied through the netting to keep it in place as desired. The rest of the netting was attached to the base via binder clips.

The ramp was cut from the ordered thicker wooden panel and painted. To create a design that will be easier to transport on the day of the fair, it was decided to keep the ramp separate from the rest of the design. The ramp would simply sit on the aluminum base and be held in place by gravity. An additional wooden block was attached to the backside to prevent it from sliding down at any point. This made both the manufacturing of the ramp and the transportation of the carnival attraction easier for the team.

The final challenge that needed to be approached was figuring out how to store the basketballs in place. A small barrier was constructed at the front using foam boards. This was then covered with tape to make sure it matches the rest of the aesthetic. It was hot-glued to the ramp while making sure that there was enough space for participants of all ages to reach in and grab the balls without hitting or scraping their hands on the remaining components.

Finally, the whole design was decorated in various ways using paint, stickers, and drawings. The end goal was to make sure that the Duke Basketball theme was effectively integrated into the final design and to make it as aesthetically appealing as possible.

Final Product:

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