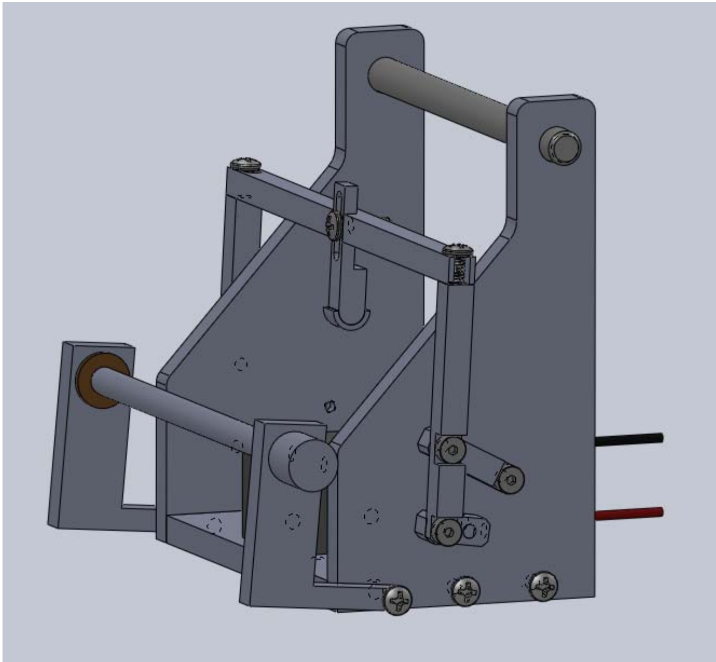
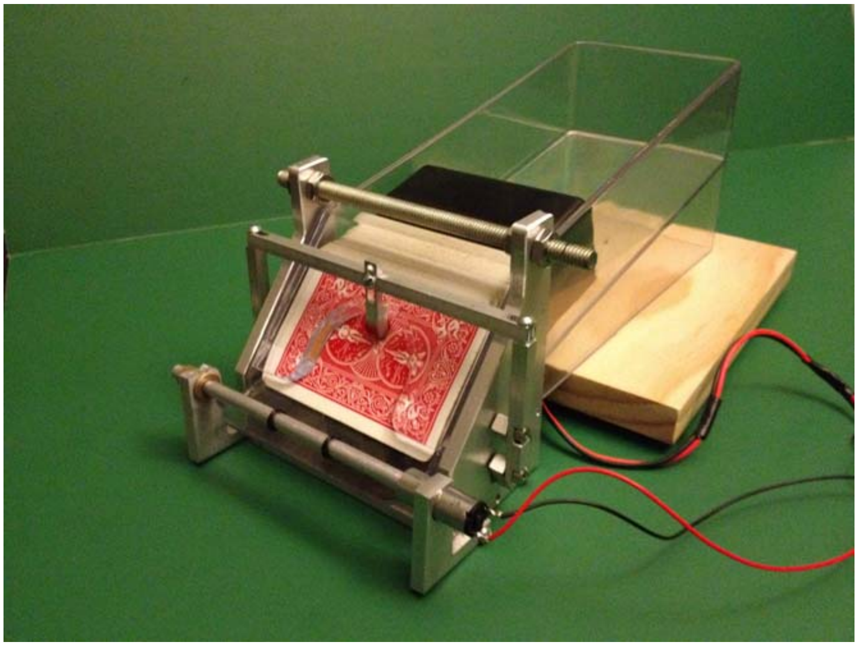


Dealer…Card Dealer



Group 007

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ME 130

Prepared For Prof. Ken Youssefi

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I. Background

The casino and gambling industry is a multi-billion dollar market, and according to the Bureau of Labor Statistics, the average base pay for a casino dealer is between $32,000 and $58,000 including tips and benefits [1]. These dealers need to be highly trained and are much sought after for their ability to accurately and effectively deal cards to each player. However, despite their extensive training, human error can still occur when dealing to players, which could, if serious enough, result in costly lawsuits.

This is why we at Group 007 saw the need for an automatic card dealer (ACD). Our goal was to create a simple, cost effective, and easily operated card dealing device intended for casinos as well as at-home use. In casinos, our mechanism could replace a casino dealer, thereby reducing the chance of error and labor costs. And because the once loathed job of being the dealer can now be replaced by a machine, our dealer could also be marketed for at-home use.

We understood that the design process for an automatic card dealing device could be separated into two phases: planar machinery and mechatronic design. For our project, we focused on the planar machinery aspect of our dealer, and we were able to effectively and reliably distribute a card from the card shoe to the table with our mechanism. The next step in our design process would be a more mechatronic centered design phase that would add intelligent dealing capabilities to our dealer; this would entail developing dealing capabilities such as varying dealing distances, the number of players being dealt to, and the sequence of dealing.

The following report outlines the design process, analysis, and discussion of the planar machinery design phase of our automatic card dealer.

II. Project Outline and Performance Specifications

We at Group 007 first outlined the various steps of our design phase and a general timeline to follow for this project. We were to complete this project in 13 weeks, and we outlined our schedule in a Gantt chart (Figure 1) detailing the amount of time alloted to each task and when each task was to be completed. Weekly meetings helped our group stay organized and on track throughout the 13 weeks. All tasks for this project were the responsibility of all group members; everyone helped with designing, analysis, machining, etc.

ME 130 Design Project The Automatic Card Dealer Project Timeline	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13
	Sep 12	Sep 15	Sep 26	Oct 03	Oct 10	Oct 17	Oct 24	Oct 31	Nov 07	Nov 14	Nov 21	Nov 28	Dec 05
Background of Problem and Goal Statement													
Performance Specifications													
Ideation and Invention													
Detailed Design and Analysis -Kinetic Analysis -Kinematic Analysis													
Prototyping and Testing -Machining/Assembly -Testing/Analysis													
Presentation and Final Report													

FIG 1. Gantt Chart outlining the schedule Group 007 followed for the ACD project.

With the goal of creating a simple, cost effective, and easily operated card dealing device, we at Group 007 first formulated a set of performance specifications desired for our ACD design. These specifications define what our system must do, thereby constraining the problem so that it can be solved and can be proven to have been solved [2].

The following is the set of performance specifications decided upon for our design:

- Device to reliably deal cards face down
- Device to deal cards when prompted by the user
- Device to deal at least 6 decks of cards without reloading
- Device to easily attach to existing card shoes
- Device to be portable
- Device to weigh less than 5 pounds
- Device to cost less than $100.00 to manufacture
- Device to produce noise less than 50 dB (50dB ~ typical conversation level)
- Device to deal a single card in less than 5 seconds
- Device to deal a minimum distance of 1 ft

The standard card shoe that we utilized in our design is shown in Figure 2; the right is a promotional image of the card shoe and the left is a computer-aided design (CAD) part file of the card shoe. The card shoe is made out of clear plastic and is 11.5 inches long by 4.25 inches tall and 4 inches wide. We found that there is some size difference between different card shoes; thus our mechanism must adjust to various sizes of card shoes so that it can be used with other casino or personal card shoes.

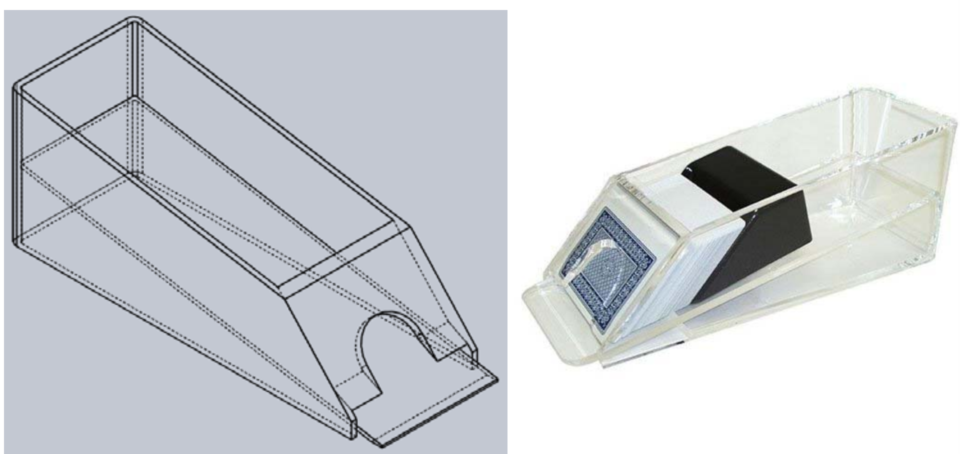


FIG 2. (left) CAD part file of the card shoe and (right) Image of the standard card shoe

<u>III. Design Process</u>

Ideation

With these performance parameters in mind, we first brainstormed various solutions to our problem. Figures 3-5 illustrate some of the initial ideas for mechanism designs. One of our first ideas was to use a four bar mechanism to push the cards against a pair of rollers that would spit the card out onto the table; this mechanism is further detailed in Figure 3. Another initial design concept was to use a cam with some sort of spring that would drag a single card away from the deck and then into a pair of rollers;

this mechanism is further detailed in Figure 4. Our final idea was to use a simple four bar, path generation mechanism that would approximate a straight line path along the face of the card shoe; this design is detailed in Figure 5.

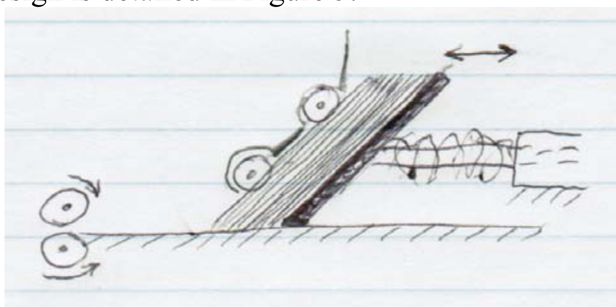


FIG 3. Hand sketch of an initial design idea; the four bar mechanism is shown on the right pushing the cards onto a pair of rollers. The rollers would roll a single card away from the deck and into another pair of rollers that would spit the card out onto the table.

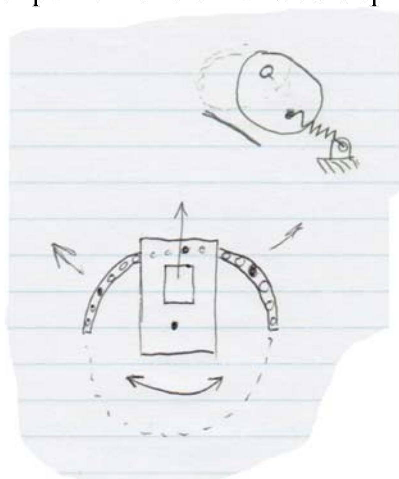


FIG 4. Hand sketch of an initial idea for a cam design. (Above) shows a cam that would have intermittent contact with the deck of cards and drag a single card away from the deck to the rollers. A spring would work to restore the cam to an initial set position not in contact with the cards. (Below) shows pins or a sort of mechanical trigger that would release said spring.

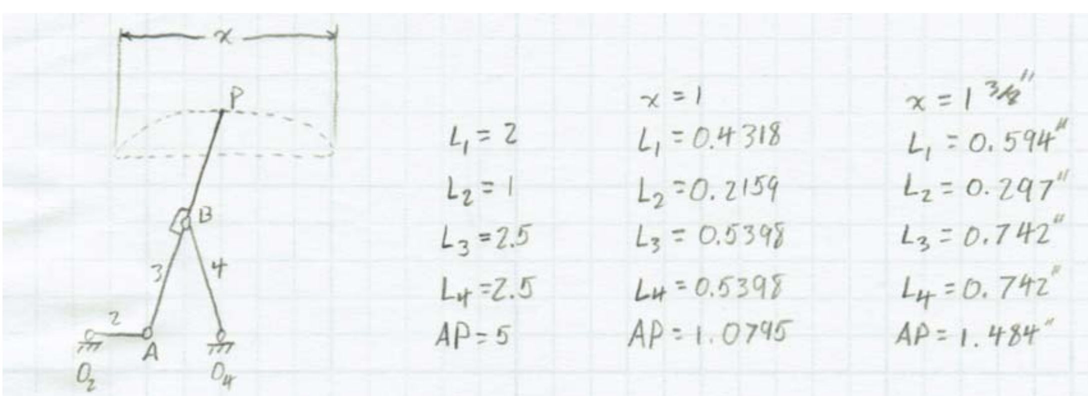


FIG 5: Hand sketch of an initial idea for a four bar design. Design would be a path generation mechanism that would drag the card out of the card shoe and into the rollers.

Selection

Considering all of these designs, we selected the Hoeken straight-line linkage to further develop, analyze, prototype, and test. Figure 6 is a detailed drawing of a Hoeken straight-line linkage.

We chose this mechanism for various reasons. For one, it is a simple design, based upon link length ratios, that approximates a straight-line path. This straight-line motion is optimal for dragging a point along the card shoe face. This motion is also in one direction, as the return stroke is not along the same forward path; this was necessary for our design because any reverse motion would draw a card back into the card shoe. We also chose this design because one full rotation of the input link would correspond to one card being dealt; therefore timing would be dictated by the speed of our motor.

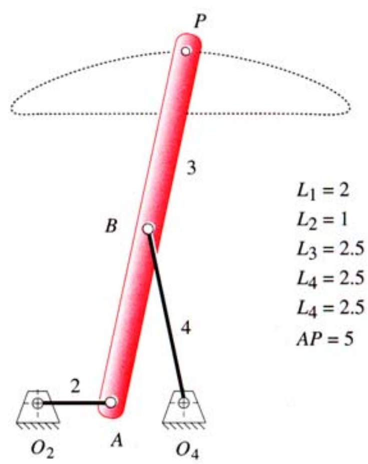


FIG 6. Detailed drawing of a Hoeken straight-line linkage showing the necessary link length ratios to achieve the straight-line approximation [2].

<u>IV. Final Design</u>

Introduction

Our ACD design emphasizes functionality, reliability, and simplicity. Our design utilizes a simple Hoeken straight-line, four bar mechanism to drag the card out of the card shoe and into the roller that deals the card to the table. To initiate dealing, the user only needs to hold down the dealing button, which runs the input link motor, and release it once all desired cards are dealt. The dealer has a maximum capacity of six decks of cards, and it is a battery powered motorized mechanism with analog control. Our design frame is also adjustable so that it can attach onto existing card shoes of differing sizes.

Design Details

Figure 7 shows the assembly of our final four bar mechanism design. There are two adjustable plates that compress the card shoe in order to stay in place. The motor is attached to the bottom plate, and the card shoe rests above the motor.

There are two symmetric Hoeken straight-line linkages on either side of the card shoe. The crossbar that connects these two linkages follows the straight line path along the face of the card shoe. In the middle of the crossbar, an adjustable finger with a rubber tip touches the card and drags it along the straight line path until it reaches the roller. At this point, the roller catches the card and spits it out onto the table. The roller is on an adjustable mount that is attached to the side of the mechanism frame. There is also an exploded assembly drawing of our final design with all parts labeled in the appendix. All detailed assembly and part drawings are also included in the appendix.

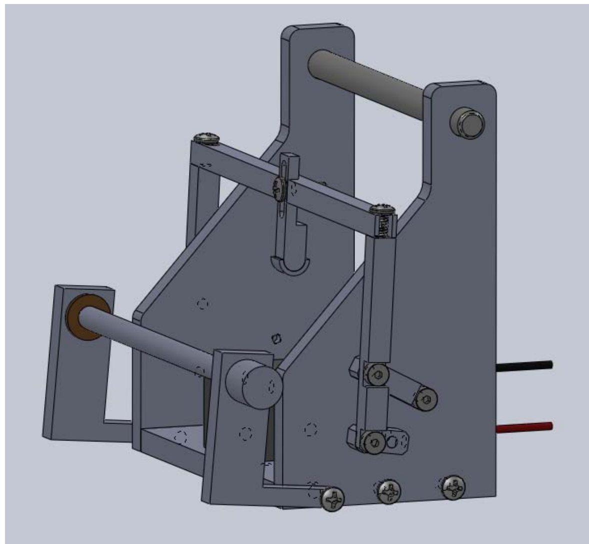
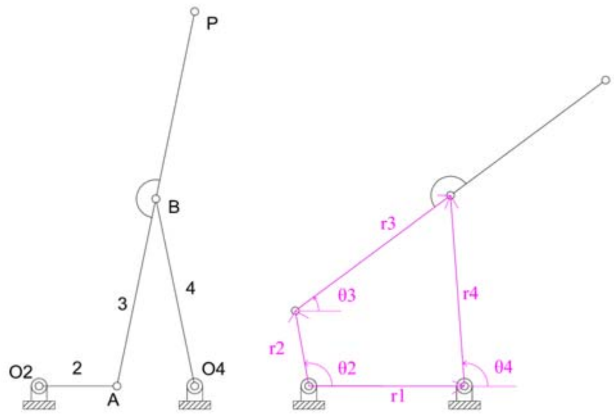


FIG 7. SolidWorks model of prototype design

Analysis

Next, we performed some kinematic and kinetic analyses on our design in order to examine its performance. First, we performed a simple position analysis on our design. The linkage design with labeled links and joints is shown in Figure 8. The vector loop equation used for the position analysis of the linkage is also included in Figure 8.



$\theta_1 = 0$, $\theta_2 =$ input
θ_3, $\theta_4 =$ unknown

$$\vec{r}_1 + \vec{r}_4 = \vec{r}_2 + \vec{r}_3$$
$$r_1 + r_4 e^{i\theta_4} = r_2 e^{i\theta_2} + r_3 e^{i\theta_3}$$
$$\mathrm{Re} \rightarrow r_1 + r_4 \cos(\theta_4) = r_2 \cos(\theta_2) + r_3 \cos(\theta_3)$$
$$\mathrm{Im} \rightarrow r_4 \sin(\theta_4) = r_2 \sin(\theta_2) + r_3 \sin(\theta_3)$$

FIG 8. Labeled links and joints of Hoeken straight-line linkage, and vector loop equation used in our analysis.

We utilized the program *Linkages* to perform this position analysis, and Figure 9 shows the obtained results. With our standard card shoe, we measured that the necessary distance the card needed to travel to be caught by the roller was 1⅜ inches. We were able to scale and constrain the straight line approximate motion so that it would travel the required distance and also so that it would not interfere with the shoe. The link lengths that were determined necessary for these above constraints are also showed in Figure 9.

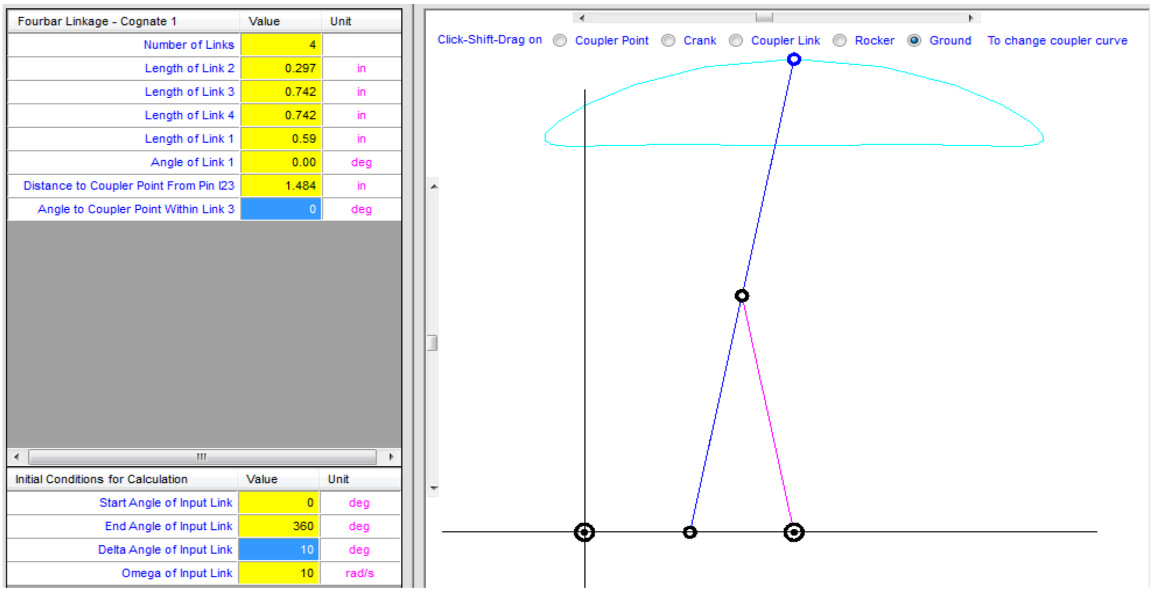


FIG 9: Results of our position analysis on our four bar linkage design. Shows the approximate straight-line motion of point P on link 3.

We next performed a velocity analysis on our design in order to determine the input angular velocity necessary to obtain our timing performance specification. The following equations detail the angular velocities of all links in Figure 8. To obtain one card dealt in 5 seconds, we determined that we would need an input angular velocity of 1.26 radians/sec or 12 rotations/minute (RPM). The input motor that we chose based on cost and availability operates at 38 RPM which will result is approximately one card dealt in 1.6 seconds, thereby meeting our timing specification. The roller motor that we chose based on cost and availability operates at 1270 RPM which results in an approximate dealing distance of 2 feet.

$$\omega_1 = 0,\ \omega_2 = \text{input}$$
$$\omega_{2,}\ \omega_3 = \text{unknown}$$

$$\vec{r}_1 + \vec{r}_4 = \vec{r}_2 + \vec{r}_3$$
$$r_4\omega_4 ie^{i\theta_4} = r_2\omega_2 ie^{i\theta_2} + r_3\omega_3 ie^{i\theta_3}$$
$$\mathrm{Re} \rightarrow -r_4\omega_4\sin(\theta_4) = -r_2\omega_2\sin(\theta_2) - r_3\omega_3\sin(\theta_3)$$
$$\mathrm{Im} \rightarrow r_4\omega_4\cos(\theta_4) = r_2\omega_2\cos(\theta_2) + r_3\omega_3\cos(\theta_3)$$

Finally, we performed a kinetic analysis of our mechanism in order to understand and determine the forces present during operation. A major concern in any design is the deflection of parts; deflection can greatly reduce the effectiveness and performance of a mechanism, as it creates issues with torque, material stress, fatigue, and more.

We first chose a link thickness of ¼ inch in order to optimize weight, cost, and performance. We performed our deflection analysis using the SolidWorks program Simulation Xpress. We approximated the coefficient of friction between the card and the finger as 0.8 (the coefficient of Plexiglas to Plexiglas) [3]. The card weight was approximated as 0.00394 lbs, resulting in an actual expected applied force of 0.00315 lbf. We considered all forces to be statically loaded, applied perpendicular to the link, and transmitted through the pin shafts; Table 1 outlines the results of this deflection analysis. We first considered the deflection of all links under 1 lbf, and all link deflections were negligible. We then considered the force required to obtain 1 mm deflection on all links; all forces were determined to be outside the range of possible loads in our mechanism. We finally considered the applied frictional force from the card and deemed that link deflections were once again negligible in our design.

Part name	deflection with 1 lbf applied (mm)	force required for 1mm defl (lbf)	expected deflection (mm)
link 2	0.00034	2918.00	1.07951E-06
link 3	0.01364	73.31	0.000042966
link 4	0.00251	399.04	7.8939E-06
crossbar	0.00838	119.40	2.63813E-05
finger	0.05774	17.32	0.000181881

TABLE 1. Results from the deflection analysis performed on our design using SolidWorks Simulation Xpress.

Prototype

In order to demonstrate our design's functionality and feasibility, we constructed a to-scale prototype of our mechanism. An image of our prototype is shown in Figure 10.

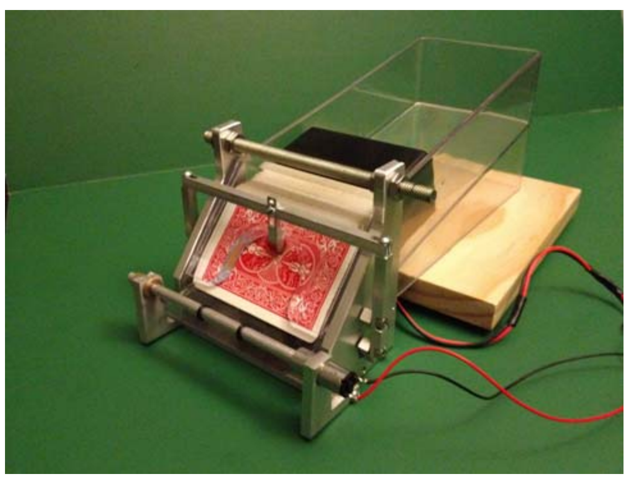


FIG 10. Image of constructed prototype of our ACD design.

Table 2 is the complete bill of materials (BOM) of our prototype. We chose our materials considering availability, cost, our kinematic and kinetic analyses (forces and loads on our design), and the performance of the materials (fatigue, reliability). Table 3 is a comprehensive data sheet detailing all of the design specifications of our prototype.

Item #	Part Name	Description	Qty	Material	Cost	Purchased/Custom	Process
1	Side Plate		2	Aluminum	$2.31	Custom	Machined
2	Bottom Plate		2	Aluminum	$1.65	Custom	Machined
3	Link 2		2	Aluminum	$0.07	Custom	Machined
4	Link 3		2	Aluminum	$0.13	Custom	Machined
5	Link 4		2	Aluminum	$0.34	Custom	Machined
6	Cross Bar		1	Aluminum	$0.34	Custom	Machined
7	Finger		1	Aluminum	$0.07	Custom	Machined
8	Finger tip		1	Rubber	$0.01	Custom	Hand-cut
9	Clamp bar		1	Steel	$3.00	Custom	Machined
10	Roller Motor Plate		1	Aluminum	$0.15	Custom	Machined
11	Roller Bushing Plate		1	Aluminum	$0.15	Custom	Machined
12	Roller Bushing		1	Bronze	$1.57	Purchased	-
13	Roller		1	Aluminum	$0.42	Custom	Machined
14	Roller Wheel		2	Rubber	$0.02	Purchased	-
15	Drive Motor	38RPM gear motor	1	n/a	$13.00	Purchased	-
16	Roller Motor	1270RPM motor	1	n/a	$2.00	Purchased	-
17	Shoulder Screws	McMaster	6	Stainless Steel	$7.50	Purchased	-
18	Coupler	Motor-to-Crank Coupler	2	Aluminum	$0.42	Custom	Machined
19	6-32 x 3/16” set screw	McMaster 92313A143	4	Stainless Steel	$0.43	Purchased	-
20	Motor hold down screw		2	Steel	$0.20	Purchased	-
21	6-32 screw x 1/4”		1	Steel	$0.10	Purchased	-
22	6-32 x screw 1/2”		4	Steel	$0.40	Purchased	-
23	6-32 screw x 3/4”		2	Steel	$0.20	Purchased	-
24	5/16” nut		4	Steel	$0.60	Purchased	-
		Total	47	**Total**	$35.06		

TABLE 2. Complete bill of materials of our mechanism design.

Prototype Specification Sheet	
Dimensions	4" long x 4.5" tall x 6" wide
Weight	5 lbs
Roller Motor	1270 RPM
Driver Motor	38 RPM at 3V
Links	1/4 " Aluminum
Plates	1/4 " Aluminum
Clamp System	Adjustable for different sized card shoes
Cost	~$35.00
Power Supply	Battery (2 AA Batteries)
Sound	~80 dB
Time to Deal 1 Card	2 sec
Dealing Distance	24 inches

TABLE 3. Comprehensive design specification sheet of our prototype.

V. Discussion

With our prototype, we have demonstrated the functionality and reliability of our ACD planar machinery design. Our four bar mechanism is able to effectively distribute cards to the table when prompted by the user; thus the planar machinery aspect of our design is essentially complete. It is currently able to fulfill all of the performance specifications that we have outlined for this prototype stage in our design.

The next step in our design process would be a more mechatronic centered phase. If microcontrollers were incorporated into our ACD design, then our dealer could also perform intelligent dealing tasks. This would entail varying dealing distances, the number of players dealt to, and the sequence of dealing. If these performance specifications were accomplished, then the dealer could become completely automated.

Another improvement to be made to our design concerns the power source. Currently, the prototype is battery powered, but we plan for our final product to have both battery and ac power supply capabilities. This would make our ACD both portable with battery capabilities and convenient if it could plug into any standard outlet.

Also, when considering mass production, we would also like to manufacture links out of plastic instead of aluminum. This would lower the cost of production and the weight of the product, and it would also make our final product sensible when considering shipping, transportation, and wear. A complete performance analysis of plastic links under the design loads would need to be completed in order to ensure that there would be little wear on our four bar design. If, however, links do fatigue, they would be easy to replace. There would also be minimal packaging costs as parts could be shipped separately and assembled easily and quickly by the user.

For our prototype we had a limited choice of motors due to cost and availability. For our final product, we would like the input, driver motor to operate around 50 RPM in order to achieve one card being dealt every second. We would also like the roller motor to have a range of 800 to 1500 RPM in order to achieve a range of dealing distances from 1 to 3 feet.

We would also like to decrease the sound produced by our mechanism. Currently it produces sound at around 80 dB. A typical conversation is around 50 dB, so for our final product we would like our mechanism to produce sound below this level in order to minimize noise pollution in casinos or at home. This can be accomplished by using a quieter motor or soundproofing the casing of the current motor using dense, sound absorbing materials.

A summary of all of these desired specifications of our final product is given in Table 4.

Final Product Specification Sheet	
Dimensions	around 4" long x 4.5" tall x 6" wide
Weight	less than 5 lbs
Roller Motor	800-1500 RPM
Driver Motor	~50 RPM
Links	1/4 " Plastic
Plates	1/4 " Plastic
Clamp System	Adjustable for different sized card shoes
Cost To Manufacture	less than $100.00
Product Price	order of $200.00
Power Supply	Battery (2 AA Batteries) and AC Power Options
Sound	Lower than 50 dB
Time to Deal 1 Card	1 sec
Dealing Distance	1 to 3 feet

TABLE 4. Comprehensive design specification sheet of our final product

We have estimated a probable lifetime of our product of 40 years. We wish for our final product, a completely automated card dealer, to cost within the range of $15 to $40 to be manufactured, and sold in the range of $50 for a consumer version and $200 for a deluxe casino version, with a final profit margin of 20% to 40%. We believe that this cost of mass production is sensible and the price of the product is competitive considering that our device acts to replace the job of a $32,000 to $58,000 salary worker.

VI. Conclusion

Our goal was to create a simple, cost effective, and easily operated card dealing device intended for casinos as well as at-home use. Our design analyses and prototype demonstrated the ability of our final design to fulfill all of our outlined performance specifications. The next step in our design process would be a more mechatronic centered design phase; incorporating intelligent dealing would be an attractive and unique feature of our final product. Our predicted costs for our design are both sensible and competitive, and we feel that our final product has immense potential for consumption in the casino and at-home markets.

VII. References

[1] "Gaming Services Occupations." *Bureau of Labor Statistics*. United States Department of Labor, 17 Dec. 2009. Web. 6 Dec. 2011. <http://www.bls.gov/oco/ocos275.htm>.

[2] R. Norton, *Design of Machinery*, 5th ed, The McGraw-Hill Companies, Inc., 2012.

[3] "Friction Coefficients." *Engineers Handbook*. 2004. Web. 8 Dec. 2011. www.engineershandbook.com/Tables/frictioncoefficients.htm

Appendix