

Final Project: Final Report
MCHE 201: Intro to Engineering Design
Spring 2016

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I. Abstract

The Festival International de Louisiane requires each robot to complete five tasks, with the completion of each task gaining points to advance in the bracket. The five tasks are to 'keep the crowd rocking', 'dismiss the hecklers', 'move the merchandise to the merchant account', 'collect the festival pins', and 'move the band members to the main stage.' To succeed, the robots needed to have a robust design that can withstand changes in the course and interference from other competing robots. Each team was responsible for designing, building, and testing a robot that met the customer requirements and could successfully compete in the final competition. Problem understanding documents were used to determine the requirements the robot needed to satisfy, and the final design was picked using an evaluation matrix to analyze which concept better suited the requirements. A performance evaluation of the design was completed after the final competition to determine the effectiveness of the robot.

The abstract should summarize what is presented in the report, including key results.

i) Your design
ii) The results

I. Introduction

The Festival International de Louisiane contest held in the spring semester of the MCHE 201, Introduction to Design Class, presented many challenges. Teams of three students are given the task of building a robot with limited supplies, and a limited budget of \$100. The ultimate goal of the competition is to compete and advance through the double elimination, bracket style contest and win first place. A robots place in each run is gauged by counting the total amount of points attained during the run; points can be gained by completing tasks or subtracted by failing to complete tasks.

Points are achieved by successfully completing five tasks on the course shown in Figure 1: 'keep the crowd rocking', 'dismiss the hecklers', 'move the merchandise to the merchant account', 'collect the festival pins', and 'move the band members to the main stage'. For 'keep the crowd rocking,' the robot must ensure that the middle bowling pin remains standing throughout the run. To 'dismiss the hecklers,' the robot must completely remove the two bowling pins to the right and left of the middle pin from the zone. In 'moving the merchandise to the merchant account,' the three sponges near the secondary stage are to be moved into the gray box in front of the start zone. To 'collect the festival pins,' the lego blocks located in between the team zones need to be moved fully into one zone. The 'band members' are five lego men that need to be moved into or above the inner circle to gain full points; half points are gained by moving them to the outer circle or secondary stage. Each team was tasked with designing, building, and testing the robot to ensure success in the final competition.

The next section discusses the final design chosen to compete in the International Festival de Louisiane. The design was chosen from three concepts assessed using an evaluation matrix; the design had the potential to gain the most points. Section 3 discusses the process of problem understanding used to determine the customer requirements and engineering requirements presented by the competition. Section 4 discusses the development of the final design and two alternate designs ~~using the morphological chart shown in Figure 9.~~ The final performance of the robot is discussed in Section 5, Performance Evaluation.

II. Final Design

The final design chosen for the robot to compete in the International Festival de Louisiane, shown in Figure 2, completes four main tasks: keep the crowd rocking, remove the hecklers, get the band to the main stage, and collect the festival pins. The robot remains stationary during the entire run and relies on falling or extending arms to complete the tasks. The robot is made using wood and metal drawer slides. A square wooden base houses the motor and arduino board that control the robot.

To remove the hecklers, two wooden arms are used that rely primarily on gravity to function. The arms, shown in Figure 4, are attached by metal bolts to each side of the base and held up by one string attached at the front of each arm during setup. This allows the arms to be long enough to reach the pins, while still fitting in the size requirement. The arms are angled slightly forward at roughly 75 degrees measured from the ground. This forward position allows the

arms to store potential energy, and is prevented from releasing until the strings holding them up are triggered releasing the tension. When the DC motor turns, a trigger pin is pulled releasing the string. Releasing the string allows the two arms fall forward and knock the outside pins out of the zone. The front of each wooden arm is slanted on the bottom to ensure the pins shoot at an angle, not directly forward.

The component that moves the band members to the main stage, shown in Figure 3, is made of wood and three metal drawer slides. During setup, the three drawer slides are collapsed to fit in the one foot by two foot size requirement. The back side of the slide is attached to a hinge that allows it to pivot at that point. The front of the slide rests atop a small plastic release pin that is $\frac{3}{4}$ inch tall. The pin sits atop a 1x4 piece of wood. Attached to the release pin is a string that is connected to the motor. Once the motor spins, the pin is released allowing the front of the slide assembly to fall $\frac{3}{4}$ inch on to the top of the 1x4 piece of wood. This causes a jolt in the slides, and the slightly downward angle of the slides begins the cascading of the telescopic drawer slides. The three drawer slides telescope forward one at a time, starting from the largest to the smallest. The smallest drawer slide which is the last to deploy, contains two 6 ounce weights that increase the forward momentum of the assembly. Finally, the top of the small slide contains a catapult that is triggered when the last slide has roughly one inch left to slide outward. Braided fishing line is attached to the front of the catapult, and runs through two pulleys, and then onto a small plastic reel on the base of the robot. The line runs out on the reel once the slides reaches the "one inch left" mark. The string then pulls tight causing the catapult to rotate forward. The catapult has two 6 in x $\frac{1}{2}$ in boxes that contain 5 lego men. The lego men are connected to flat lego pieces, two on one side and three on the other, and tied to the catapult by fishing line. Once the catapult is fully deployed, the lego men are thrust forward. The added two strings prevent the lego men from flying over the stage, and cause them to fall straight down into the middle of the main stage.

To collect the festival pins, two swinging arms shown in Figure 5 were attached to the backside of the falling wooden arms. The pivot point of the rotating swing arms was attached close to the top of the backside of the falling arms. The arms are made of two 17 inch long pieces of thin wood. The opposite end that pivots is curved at the end in order to "hook" the festival pins dragging them inward towards the front of the stage. The two arms are powered by the potential energy of a falling counterweight. The falling counterweight is triggered by the release of a pin that is pulled out in the last second of the wooden arms falling. The falling arms pull the pin, releasing the weight, which in turn rotates both arms 180 degrees simultaneously.

III. Problem Understanding

In fulfilling the tasks necessary to win the Festival International de Louisiane Contest, a robot that has the ability to complete the tasks and a way to prevent other teams from interfering with the robot is ideal. Composing the House of Quality shown in Table 2 showed finding the right material to use in building the robot provides the ability to complete the tasks and interfere with the other teams, yet leave the stage and bystanders unharmed. The Specification Sheet in Table 3 highlights the demands and wishes of the design. Some of the most important specifications include the physical volume, absence of stored energy (elastic springs), and the autonomous

to team
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Just report it
as feedback

OK

starting and stopping of the machine without the need of human interference. The Function Tree in Figure 8 reveals the importance of the coding of the robot. Without the code sensing the closed circuit, nothing will be able to be accomplished. It also shows the significance of the code having the ability to run multiple motors and coordinate the timing of these motors. To complete all of the tasks within the limited time frame, the more functions that are able to run simultaneously, the better, as long as their paths of motion do not interfere.

ok

IV. Concept Evaluation

The first alternate design shown in Figure 6 completes four of the five tasks. It uses falling arms made of pvc to knock the heckler pins out of the zone. The falling end of the pvc pipes contain jumping jacks that fling across the stage into other team zones to interfere with their robot's tasks. The pvc pipes are long enough to reach two of the sponges and fall on top of them. Tacs are attached to the end of the pipes that stab into the sponges, securing them to the pipe. The machine then rolls backwards far enough to drag the sponges into the merchant account. On the top of the robot, the extending scissor arm rotates and extends over the main stage. The lego men are contained in a bowl facing down at the end of the extender arm. The bowl is designed to detach on top of the main stage, leaving the men over the area, and also creating an obstacle that impedes other teams from dropping lego men into the area.

ok

The second alternate design shown in Figure 7 attempts to complete four of the five tasks, as well. It is a stationary robot that uses a catapult, crane arms, and falling metal arms. When released by the motor, the falling metal arms knock the heckler pins out of the zone. The catapult is designed to do two tasks, fling the lego men into the main stage and launch squash balls into the other teams' zones. Strings attached to the lego men allow them to drop into the main stage at the correct distance while the squash balls are untethered and can travel over the stage. Two crane arms that are operated by motors and servos can extend outward to pick up the two outermost sponges and place them into the merchant account.

ok

The evaluation matrix seen in Figure 10 was utilized to compare customer requirements to the design performances of each robot. The design was chosen based on how well each design performed tasks to complete customer requirements. The rolling component of the first alternate design would be difficult to maintain with the unpredictable nature of the course. The second alternate design would be difficult to build within the height dimensions since it contains a catapult and crane arms. The crane arms are difficult to build within the height constraint while still being able to extend the distance needed to reach the sponges. The final design also proved to perform the tasks the fastest since all moving parts are triggered immediately, and do not last more than three seconds. Although the alternate designs have the ability to gain a similar amount of points, the quickness of the final design allows less time for interference from other teams. The final sums reflected the versatility and effectiveness of the final design.

Is it really an alt design, then?

good

V. Performance Evaluation

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/

Discussion of the final design's performance analysis will be divided into five segments: Contest Placement, Judges scoring, Analysis of Individual Tasks, Expected Results, and Design Shortfalls. Through initial testing, the robot proved to score points every run, so it was expected to be competitive in the final contest. The robot ran four times, winning first place on two runs, third on another, and fourth place in it's final round eliminating it from the contest. After the final results of the competition were tallied, the robot placed eighth out of fifteen teams.

The judges scoring was broken down into three main sections shown in Table 4: Ingenuity, Aesthetics, and Presentation. These three scores were averaged into a total score. The robot's total score matched its performance in the contest, ranking eighth out of fifteen teams shown in Figure 11. Although it ranked lower on ingenuity, coming in 13th out of 15 teams, it ranked much higher on aesthetics and presentation finishing 4th out of 15 teams and 6th out of 15 teams respectively.

Overall, the performance of the three main systems of the robot was as expected. The deployment of each system was consistent throughout the competition. The first of these systems, the telescopic slide with catapult, was the most effective. Of the four runs, the catapult placed all five of the lego men into the center stage three of the runs. On the fourth run, only three made it to the center while the rest fell into the secondary stage. The catapult system gained the bulk of the points for the robot throughout the competition. The falling wooden arms, which was the second system, was very effective in dismissing the outer two bowling pins (hecklers) completely out of the robot's zone. Of the four runs, the wooden arms deployed quickly, and consistently every time dismissing a total of six out of eight heckler pins. The last system, the rotating swing arms connected to the falling wooden arms, worked well throughout the competition as well. During all four runs, the arms protected foreign objects from entering the robot's zone protecting the remaining pin from falling down. The arms also collected the festival pins on the outer boundaries of the zone. Although the arms only collected an average of one block through all the runs, they collected three festival pins in the final run. By far, the most successful aspect of the three systems was seen in speed at which they completed their tasks. All three systems deployed almost immediately and completed their function in under three seconds.

Before the contest, the possible points of each subsystem was summed to provide an idea of the maximum attainable points. The telescopic slide with catapult was expected to gain a maximum of 50 points in every round. The maximum points the falling arms could attain was 20 points. The swinging arms could pull in four festival blocks attaining 40 points.

A few design shortfalls were discovered after analyzing the performance of the robot during the competition. One main performance issue was seen in the falling wooden arms. The arms, while meant to dismiss the hecklers forward, did not do so every time. This variation in performance may have been due to improper alignment of the robot during the setup. During a couple of the runs, the misaligned impact caused the pins to ricochet within the zone, and also change the position of the festival pins, further disrupting the performance of the swinging arms. The telescopic slide had a minor alignment issue as well. During one run, the slide was misaligned causing it to bump the middle pin (crowd), and knock it down. Also, during one run, the slide and catapult did not get the lego men (band) into the desired middle stage. This may have

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design process
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accuracy
we not have?

been due to a couple of factors. The slides, consisting of 3 main sliding sections, would need to deploy from largest slide to smallest. If this did not occur, the weight of the slide was distributed too evenly and lessened the momentum from the falling slides. This in turn caused the catapult to slow its rotation and the men would fall straight down instead of down and forward into the main stage. The rotating swing arms had a few issues causing performance problems. The arms, which achieved movement through the potential energy of a falling weight, proved to be too weak to consistently pull in all the festival pins into the zone. This problem could be rectified by a heavier falling weight that would transfer more potential energy into the arms.

VI. Conclusions

The final design to compete in the Festival International de Louisiane was chosen for its quick deployment and simple design. It fulfilled the customer requirements in size and task completion, while being powered by one motor and the force of gravity. The utilization of a house of quality, specification sheet, and function tree highlighted the importance of reliable coding and sturdy materials. Placing 1st in two rounds showed the overall design was effective, however the placement of 3rd and 4th showed the design lacked some of the flexibility needed to function on the changing course. The robot placed 8th overall in the final competition.

VII. References

- [1] Vaughan, Joshua. Festival International de Louisiane Stage Layout. Digital image. *C.R.A.W.Lab*. N.p., n.d. Web. 1 May 2016.
- [2] Vaughan, Joshua. *Festival International De Louisiane Judges' Scoring*. Digital image. *C.R.A.W.Lab*. N.p., n.d. Web. 1 May 2016.
- [3] Vaughan, Joshua. *Festival International De Louisiane Final Contest*. Digital image. *C.R.A.W.Lab*. N.p., n.d. Web. 2 May 2016.

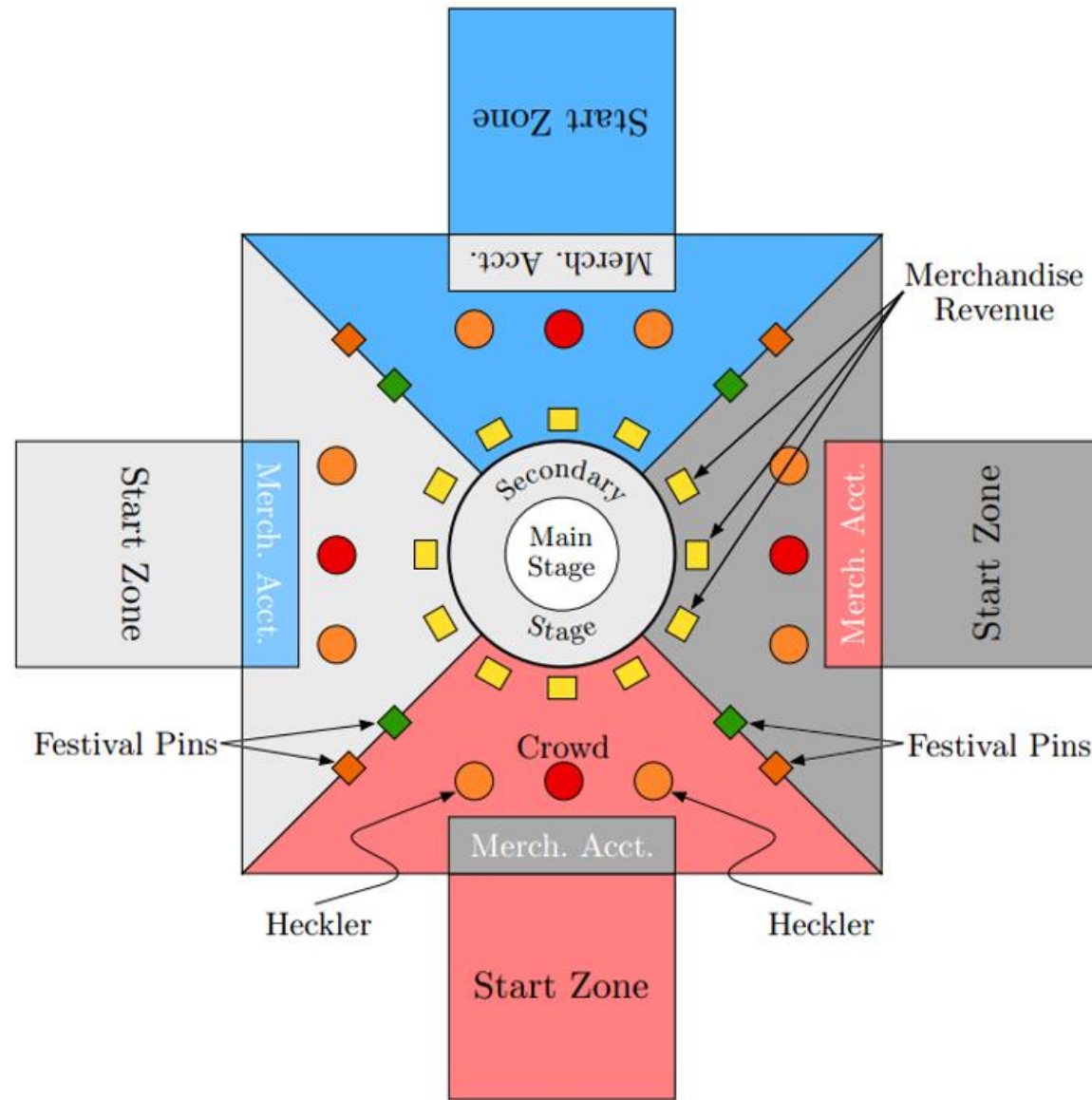


Figure 1: Festival International de Louisiane [source]

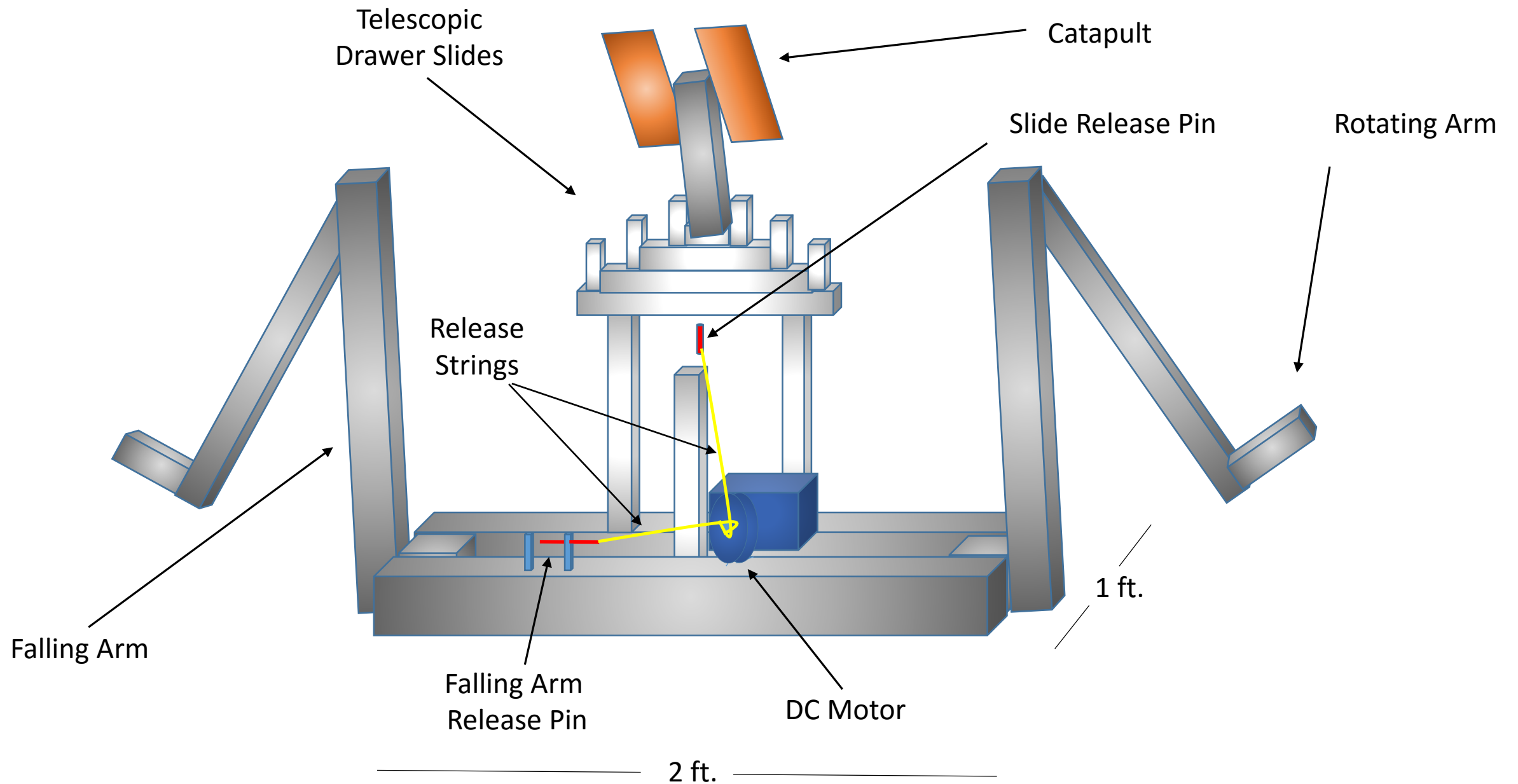
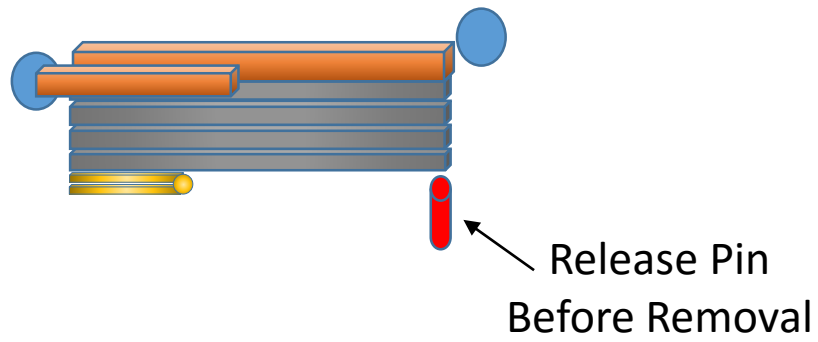


Figure 2 : *Caption*

**Position One
Fully Contracted**



**Position Two
Fully Extended**

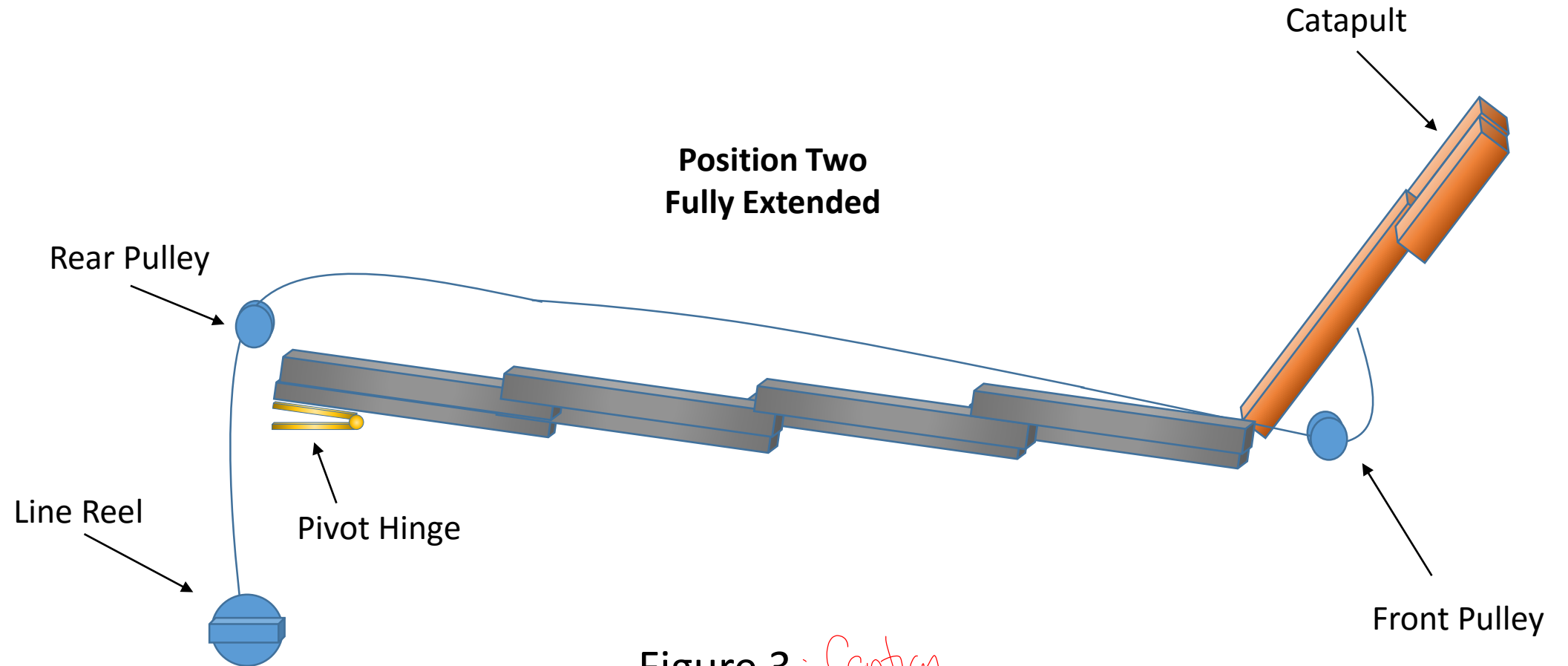


Figure 3 : *Caption*

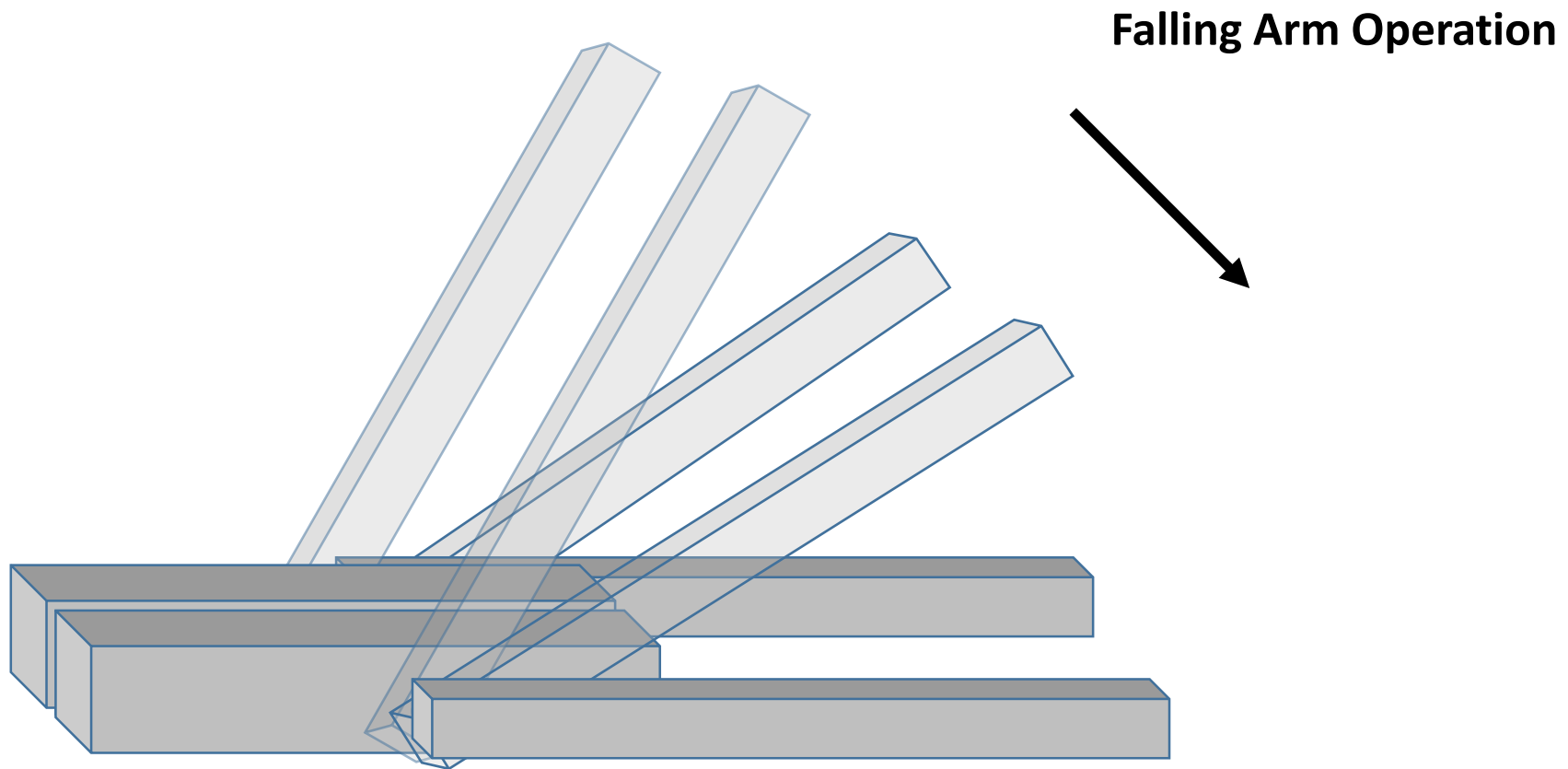


Figure 4 : *caption*

Swing Arm Operation

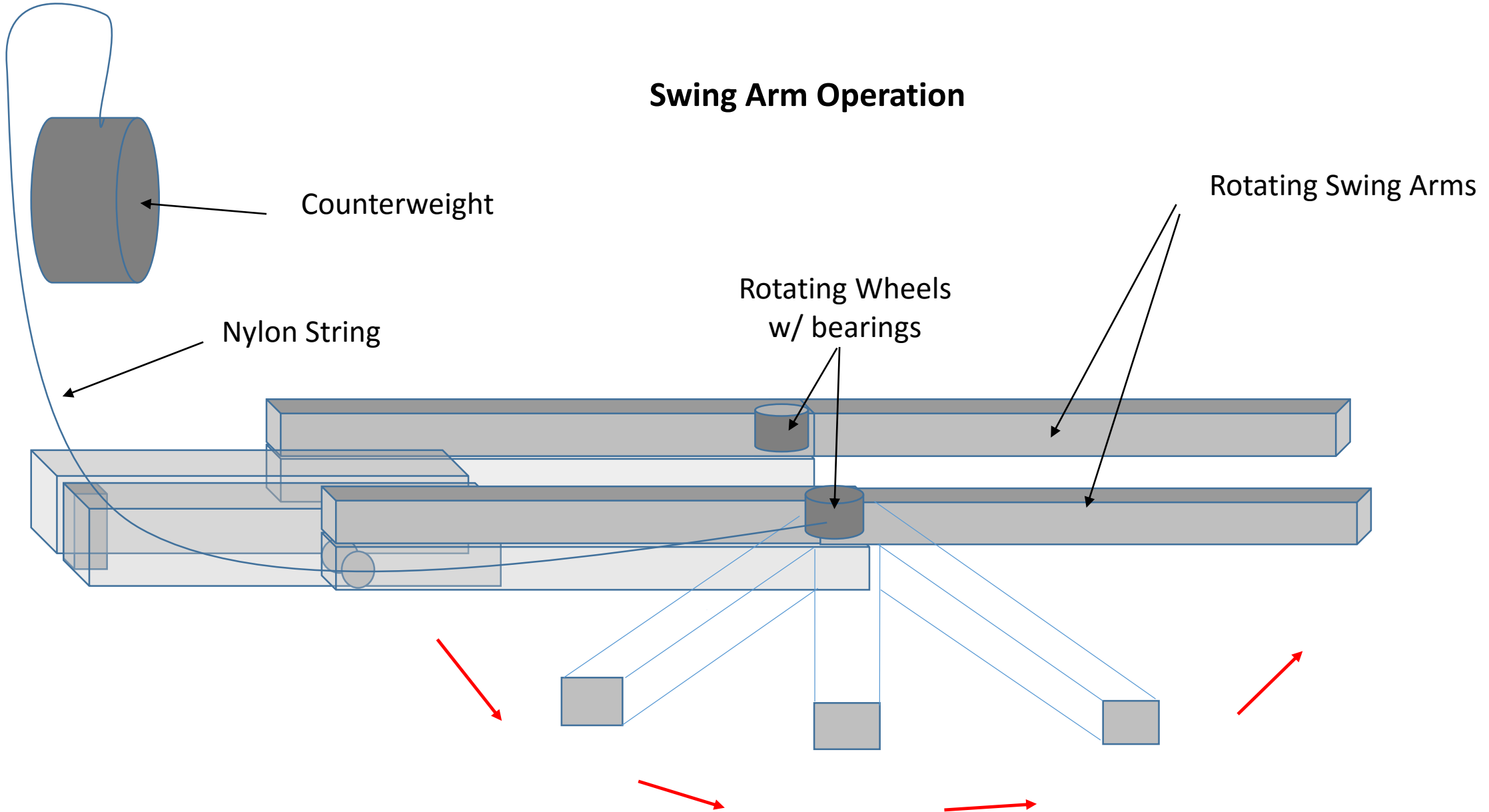


Figure 5 : *Caption*

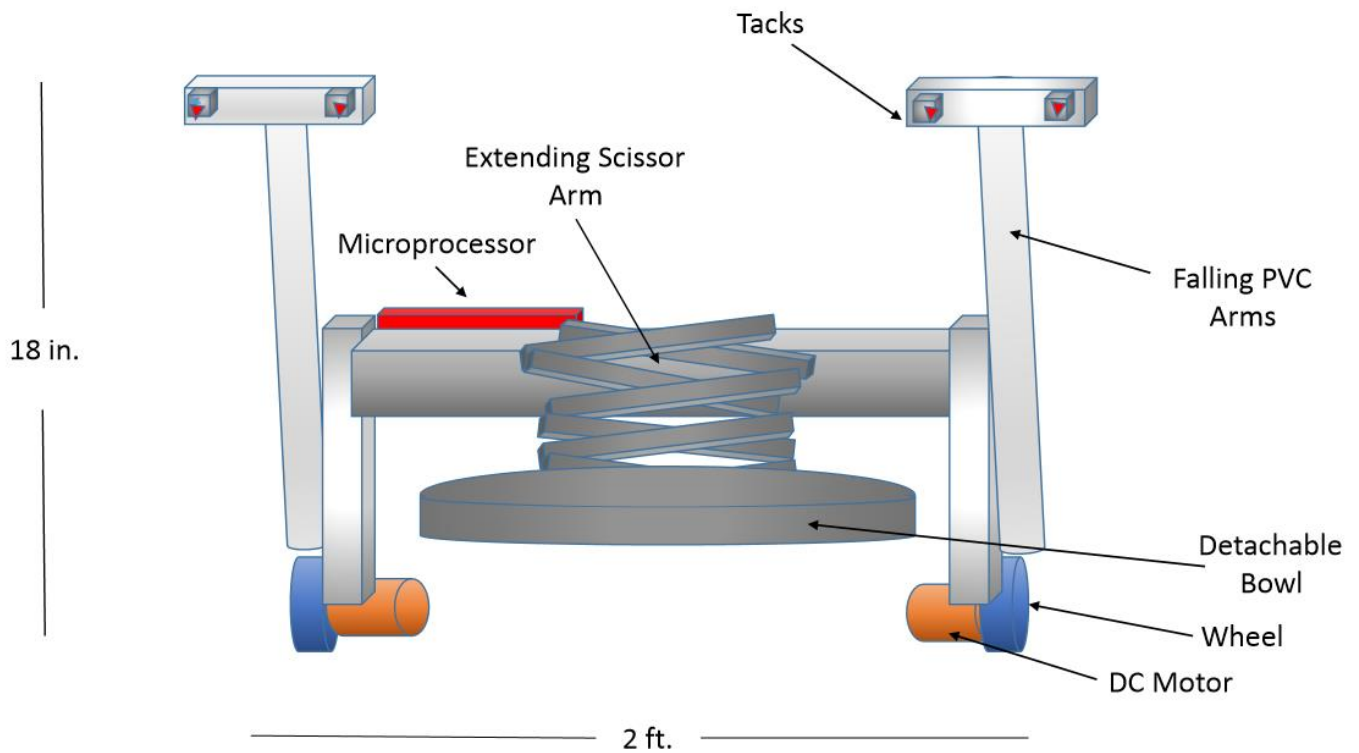


Figure 6: Alternate Design One

Good

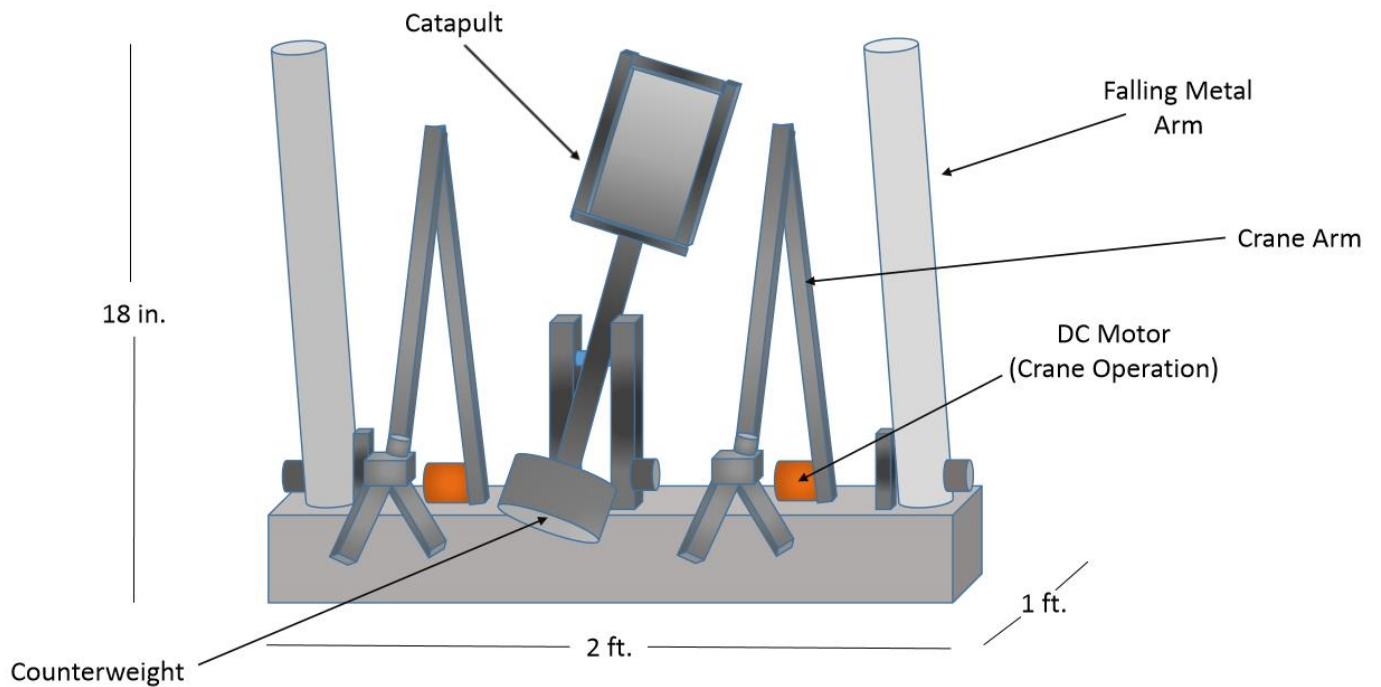


Figure 7: Alternate Design Two

Figure 8: Function Tree

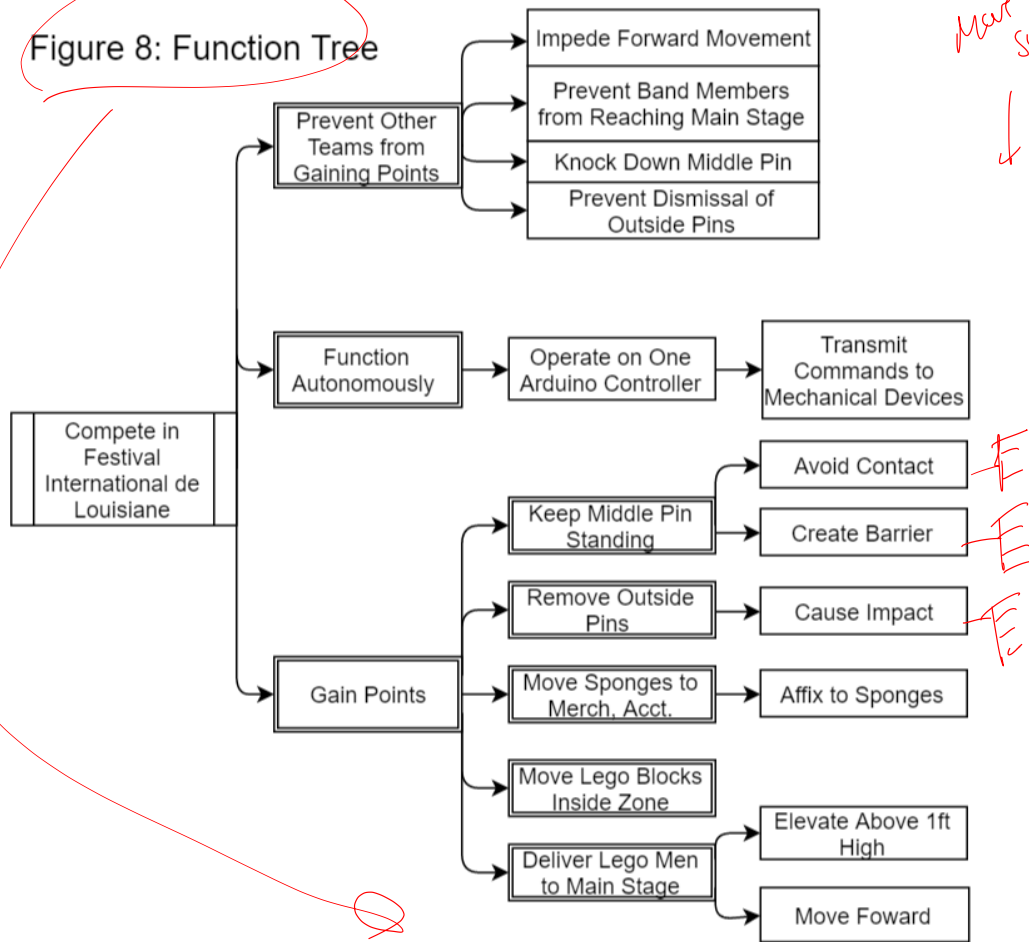






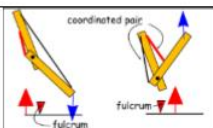









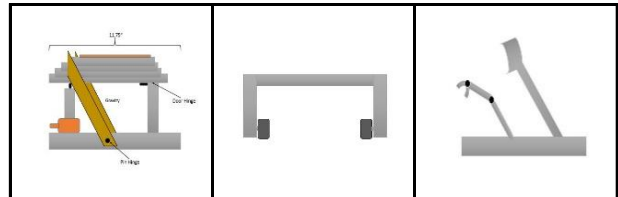
Figure 9: Morph Chart

Function	Idea 1	Idea 2	Idea 3
knock down hecklers			
move sponges to merch. acc.			
move Lego blocks in zone			
move Lego men to main stage			
interfere with other teams			

Should be low level subfuns.

Table

Figure 10: Evaluation Matrix



Cost less than \$100	9	10	9	10
Less than 1x2 footprint	9	10	7	7
Less than 18 in. tall	9	10	8	10
Completely automated after activation	9	10	10	10
Inactive until triggered	9	10	10	10
Sense closed circuit	9	10	10	10
Keep middle pin standing	7	7	5	6
Knock outside pins out of zone	7	8	7	8
Movement fully stops after task complete	9	10	10	10
Moves sponges into merchandise account	5	5	7	8
Run fully in less than 30 seconds	8	10	9	7
No interference during runs	9	10	10	10
Place band members into main stage	8	8	9	7
Move toy blocks into team zone	7	7	0	7
Reusable	9	10	10	10
Absolute Total		1133	1019	896
Relative Weight		0.3717	0.3343	0.2939

match antenna to
HbQ

Figure 11: Final Bracket [3]

Match 1

Trial Time	6:15 PM
Black	7
Gold	5
Red	4
Blue	2

Match 2

Trial Time	6:23 PM
Black	12
Gold	10
Red	6
Blue	11

Match 3

Trial Time	6:31 PM
Black	8
Gold	3
Red	1
Blue	14

Match 4

Trial Time	6:39 PM
Black	15
Gold	TA
Red	13
Blue	9

Match 5

Trial Time	7:03 PM
Black	5
Gold	10
Red	14
Blue	15

Match 7

Trial Time	7:35 PM
Black	5
Gold	9
Red	14
Blue	3

Match 6

Trial Time	7:11 PM
Black	2
Gold	12
Red	3
Blue	9

Final Match

Trial Time	7:59 PM
Black	5
Gold	15
Red	14
Blue	9

Loser's Bracket 1

Trial Time	6:47 PM
Black	7
Gold	11
Red	4
Blue	6

Loser's Bracket 2

Trial Time	6:55 PM
Black	8
Gold	13
Red	1
Blue	TA

Loser's Bracket 3

Trial Time	7:19 PM
Black	6
Gold	10
Red	8
Blue	15

Loser's Bracket 4

Trial Time	7:27 PM
Black	7
Gold	2
Red	1
Blue	12

Loser's Bracket 5

Trial Time	7:43 PM
Black	15
Gold	12
Red	6
Blue	1

Loser's Bracket 6

Trial Time	7:51 PM
Black	15
Gold	9
Red	1
Blue	3

Final Ranking

Rank	Team
1	14
2	15
3	5
4	9
5	3
6	1
7	6
8	12
9	8
9	7
11	10
11	2
13	4
13	12
13	13

Table 1: Cost Analysis

Cost Analysis		Total Cost: \$47.94
Material	Cost	
Wood: 96" 2"x6"	\$1.80	
Wood: 1ft. 1"x4"	\$1.50	
Plywood 2x2 ft.	\$3.46	
Box of wood screws	\$4.55	
Three 1ft. Drawer Slides	\$10.50	
Vex Robotics Kit	\$21.00	
Nylon String	\$1.10	
Fishing Line	\$1.25	
3 Cotter Pins	\$0.10	
Packing Tape	\$0.50	
L Brackets	\$0.75	
Eyelet Screws	\$0.10	
One Nail	\$0.05	
Two sets of 5 inch bolts w/nuts	\$1.28	

QFD: House of Quality

Project: Festival International de Louisiane
Revision:
Date: 4/30/2016

Table 2: House of Quality

Correlations	
Positive	+
Negative	-
No Correlation	

Relationships	
Strong	●
Moderate	○
Weak	▽

Direction of Improvement	
Maximize	▲
Target	◇
Minimize	▼

					Column #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
					Direction of Improvement	◇	◇	◇	◇	◇	▲	▼	▼	▼	▼	◇	▼				
Row #	Weight Chart	Relative Weight	Customer Importance	Maximum Relationship	Functional Requirements Customer Requirements (Explicit and Implicit)	Height of Robot	Total Footprint of Robot	Operational Reach	Electrical activation	Weight of Materials Used	Speed of Run	# of Motors	Amount of power supplied	Set-up Time	# of Moving Parts	# of Detachable Parts	Cost to Manufacture	Color			
1	<div></div>	7%	9	9	Cost less than \$100					▼		○			●		●	▽			
2	<div></div>	7%	9	9	Total Volume <= (1x2 ft. base by 18in. Height	●	●								▽	▽	○				
3	<div></div>	2%	3	3	Safe for observers(limit unnecessary force)			○								○					
4	<div></div>	7%	9	3	Completeley automated after activation				○			▼	○		▽	▽					
5	<div></div>	7%	9	9	Inactive until triggered				●					▽							
6	<div></div>	7%	9	9	Activate process from trigger provided				●				▼	▽							
7	<div></div>	5%	6	3	Keep middle pin standing			○		▽					▽						
8	<div></div>	6%	7	9	Knock outside pins out of zone			●	○	●					▽						
9	<div></div>	7%	9	9	Movement fully stops after task completion				●		▼				▽						
10	<div></div>	4%	5	9	Moves sponges into Merch. Acct.			●	○	▽											
11	<div></div>	6%	7	9	Complete Tasks in 30 seconds or less				●		●			●	▽		●	▽			
12	<div></div>	7%	9	9	Block competitors from scoring			●					▽		▽	●	▽				
13	<div></div>	6%	8	9	Place band members into main stage			●	▽	▽					▽	○					
14	<div></div>	4%	5	9	Move toy blocks into team zone			●	○												
15	<div></div>	6%	8	9	Reusable					▽				●	○		○				
16	<div></div>	7%	9	9	Operate using one Arduino Circuit Board				●		○		○	○			○				
17	<div></div>	3%	4	9	Aesthetically Pleasing	▽	▽										▽	●			
Target						18 inches	1x2 ft.	3.2ft	one switch	less than 30 lbs	14-30sec	2 motors or less	12V	4 min	5	1	< \$100	Red			
Max Relationship						9	9	9	9	9	9	3	3	9	9	9	9	9			
Technical Importance Rating						68	68	266.4	378.4	79.2	72	36	57.6	144	135.2	105.6	137.6	36			
Relative Weight						4%	4%	17%	24%	5%	5%	2%	4%	9%	9%	7%	9%	2%			

OK

Table 3: Specification Sheet

Spec Sheet		Final Contest	Issued: 4/5/16	
Page 1 of 1				
Changes	D/W	Requirements	Resp.	Source
		Electrical		
5-Apr	D	have power before run	team 12	customer
5-Apr	D	sense closed circuit	team 12	customer
5-Apr	D	run motors	team 12	customer
5-Apr	D	stop completely when finished run	team 12	customer
6-Apr	W	run fully off of one power source	team 12	team 12
		Tasks to Complete		
5-Apr	D	knock outside pins out of zone (8" away)	team 12	customer
5-Apr	D	keep middle pin standing (8" away)	team 12	customer
5-Apr	D	reach sponges (~2.4' away)	team 12	customer
5-Apr	D	affix to sponges	team 12	customer
5-Apr	D	move sponges to 2' by 6" 'Merch. Acct.'	team 12	customer
5-Apr	D	hold 'band members'	team 12	customer
5-Apr	D	move band members to 'main stage' (~2.8' away)	team 12	customer
5-Apr	D	reach lego blocks	team 12	customer
5-Apr	D	move blocks into zone	team 12	customer
		Logistics		
5-Apr	D	run fully in less than 30 sec	team 12	customer
6-Apr	W	set-up takes less than 3 min	team 12	team 12
5-Apr	W	less than 2 min of maintenance in between	team 12	team 12
5-Apr	D	height less than 18"	team 12	customer
5-Apr	D	footprint less than 1 ft x 2 ft	team 12	customer
6-Apr	W	reusable	team 12	team 12
		Materials		
7-Apr	D	use only one arduino controller	team 12	customer
5-Apr	D	extra materials cost less than \$100	team 12	customer
5-Apr	D	use only servo motors and DC motor	team 12	customer
5-Apr	D	no stored potential energy (except. gravity)	team 12	customer

OK

Table 4: Judges' Scoring [2]

Festival International de Louisiane Judges' Scoring

MCHE201: Intro. to Engineering Design – Spring 2016

Team	Ingenuity	Aesthetics	Presentation	Total
1	7.50	7.50	7.42	7.47
2	7.04	6.50	7.29	6.94
3	8.23	8.00	8.59	8.27
4	7.33	7.79	7.83	7.65
5	7.70	7.05	8.20	7.65
6	8.18	7.86	8.36	8.14
7	7.63	7.08	7.67	7.46
8	8.00	7.46	7.83	7.76
9	7.55	8.00	8.00	7.85
10	7.50	6.67	7.29	7.15
11	8.10	7.50	8.00	7.87
12	7.45	8.00	8.00	7.82
13	7.50	7.83	7.39	7.57
14	8.23	8.18	8.91	8.44
15	8.63	8.33	8.54	8.50