# Festival International de Louisiane: Design Performance

MCHE 201: Introduction to Engineering Design

Spring 2016

Team [redacted]

[redacted]
Department of Mechanical Engineering
University of Louisiana at Lafayette
Lafayette, LA 70504
[redacted]@louisiana.edu

[redacted]
Department of Mechanical Engineering
University of Louisiana at Lafayette
Lafayette, LA 70504
[redacted]@louisiana.edu

[redacted]
Department of Mechanical Engineering
University of Louisiana at Lafayette
Lafayette, LA 70504
[redacted]@louisiana.edu

Submitted to:
Dr. Joshua Vaughan
May 3, 2016

## Abstract

The following report contains information regarding the performance of the design selected to compete in the Festival International de Louisiane competition. It also discusses how the design was picked. R2-STRING2, the chosen design, was created after a methodical design process. This process was aided by the use of a house of quality, function tree, specification sheet, and evaluation matrix. These tools identified the customers' requirements and analyzed how well R2-STRING2, as well as the alternative designs, satisfied those requirements. It was determined that R2-STRING2 was the best candidate to compete after undergoing this process. After competing in the Festival International de Louisiane, R2-STRING2 placed ninth overall by competing in three rounds. R2-STRING2's performance was assessed and the mistakes made during the design process were identified and analyzed. Several improvements to the design stage were proposed based on these mistakes.

## Section 1 – Introduction

The purpose of this report is to discuss the performance of the robot design selected to compete in the Festival International de Louisiane robotics competition. This competition, held every semester in Dr. Joshua Vaughan's MCHE 201 class, is a robotics project with a theme. This semester's theme is based on Lafayette's annual Festival International. The competition track can be found in Figure 1. The competition requires each team to build a robot that performs various tasks. For this competition, the main tasks are to Make it to the Main Stage, Keep the Crowd Rocking, Dismiss the Hecklers, Collect Merchandise Revenue, and Collect the Festival Pins. Each task is worth a different number of points, and the higher the point value, the more rewarding the task. Every heckler (plastic bowling pin) in a team's zone results in a 10-point deduction. If the crowd (plastic bowling pin) is upright at the end of the round, 20 points are awarded. For each piece of merchandise revenue (sponge) deposited completely in the merchandise account, 10 points are awarded, for a maximum of 30 points. Every festival pin (toy block) completely in a team's zone nets 10 points for the team. Getting band members (Lego men) to the main stage results in 10 points per band member, for a maximum of 50 points. If the band members are in the secondary stage, the team is awarded 5 points per band member, for a maximum of 25 points. These point values determine the overall importance for each task.

The final design is discussed in detail in Section 2. Problem understanding tools, including a house of quality, function tree, and specification sheet, are analyzed in Section 3. The concept evaluation tools used, including evaluation matrices and a morphological chart, along with two alternative designs are discussed in Section 4. An evaluation of the overall performance of the robot in the Festival International de Louisiane competition can be found in Section 5. Lastly, the conclusion in Section 6 focuses on final statements and results of the Festival International de Louisiane competition.

## Section 2 - Final Design

The final design, named "R2-STRING2," meets the customer requirements through several built-in mechanisms. The robot consists of a wooden frame built out of pine stock. Throughout its operation, several strings are used to pull multiple pins. At the start of the competition, the first pin is pulled via the pin-pulling motor shown in Figure 2. This motion causes a heckler arm kicker to drop and knock forward the heckler arms shown in Figure 3. This effectively removes the hecklers from the team's zone. The falling motion of the heckler arm kicker pulls 2 strings that cause two festival pin arms to fall. Pulley systems allow for the festival pin arms to extend outward and rotate in order to collect the festival pins. After the festival pin arms have been deployed, an arm-rotating motor is powered to rotate the band member arm on the top of the robot, shown in Figure 4. This arm turns and extends with a container of band members on the end to deliver them to the main stage in the center of the track. Both of these motors are run through a single processor that is solely powered through an AC to DC converter connected to the track.

### Main Frame

The main frame of R2-STRING2 consists of a wooden pine frame with a 23- by 11-inch footprint and measures 17.75 inches in height shown in Figure 5. Based on the Janka

Hardness Scale for wood, pine was strong enough to meet the structural strength listed in the specification sheet, which can be found in Table 1. It is held together with screws and wood glue, and has several eye hooks to support the pulley systems in the design. The main frame also contains mounting points securing the RedBoard, pin-pulling motor, and arm-rotating motor in place. The main frame contains no wheels and therefore remains stationary within the start zone, where it is able to perform its four main tasks from.

## Heckler Arms

The heckler arms can be found on the front of R2-STRING2, as seen in Figure 6. Also made of pine, these 13-inch arms are held vertically in place by hinges on the bottom of the main frame that allow for both falling and rotational motion. Once the pin-pulling motor is activated, a heckler arm kicker, is released and displaces the heckler arms. The hinges are placed next to each other and angled outward, in line with each heckler, so that the heckler arms fall from the center of R2-STRING2 directly into the hecklers. Dismissing the hecklers at an angle from the center of R2-STRING2 allows the hecklers to move directly in between the festival pins and into the opponent's zone, leaving the festival pins undisturbed to be collected later. The arms also have a 45-degree cut on the end to dismiss the hecklers more effectively.

## Festival Pin Arms

R2-STRING2's festival pin arms, as seen in Figure 7, are 17-inch pine arms that have a drawer slide mounted on them. Strings are connected at the bottom of the festival pin arms to the heckler arm kicker, which pulls the festival pin arms just enough to cause them to begin to fall, as it strikes the heckler arms. By utilizing an eye-hook pulley system from the main frame to the festival pin arms, the drawer slides are telescopically pulled and extended outward as the festival pin arms fall. The festival pin arms are mounted on the bottom of the frame to wooden dowels that rotate inward due to another pulley system attached to hanging weights within the main frame. The application of the telescopic arm allows for R2-STRING2 to remain stationary in the start zone while also collecting all 4 festival pins adjacent to the team zone.

## Band Member Arm

The band member arm is mounted on the top of R2-STRING2. Similar to the festival pin arms, it also has a drawer slide mounted on it that telescopes out as it rotates toward the main stage. However, unlike the festival pin arms, the band member arm operates using electromechanical energy instead of gravity. This arm is directly mounted to the arm-rotating motor, which rotates the arm approximately 120 degrees from the starting position. The end of the drawer slide has a small cardboard box that holds the five band members (Lego figures) as they are moved toward the main stage, where they are held until the end of the round. As seen in Figure 4, the final length of the band member arm is 42.5 inches. This is much larger than the start zone limitations, and would not be possible without the use of telescopic components.

## Control System

R2-STRING2's central processing unit is located on the base of the frame. A RedBoard from the Sparkfun Inventor's Kit is programmed to operate at the push of a button. The

processor is powered by a 12-volt DC power supply. Once R2-STRING2 reads that the button has been pressed, the RedBoard is programmed to run the pin-pulling motor for 5 seconds. This is ample time to pull the first pin. After a 10 second delay, the RedBoard activates the arm-rotating motor to get the band members to the main stage. After this function, the RedBoard no longer performs any function until it has been reset.

## Section 3 - Problem Understanding

### Overview

In order to design and develop a robot capable of performing in the competition, a sufficient process of problem understanding regarding the customers and the task at hand must be completed. This involves an in-depth analysis of the customers' requirements, including those that they might not foresee themselves, as well as the engineering characteristics of the robot, including its specifications and functions. Several design tools are used to complete this process such as the house of quality, specification sheet, and function tree, all of which are discussed with respect to the final robot design in this section.

### House of Quality

A house of quality, shown in Table 2, was used to weigh the relationships and correlations between the customer requirements and engineering characteristics. The customers taken into account for this competition are the competition judges, the design team, and festival attendees. It shows if each characteristic should be maximized, minimized, or meet a targeted value. Each customer requirement also has an importance. Some of the requirements of highest importance are those with the dimensional restrictions and "Make it to the Main Stage." This was determined because of the potential point value for each task. The most important engineering characteristics are materials chosen and functional operation. These two characteristics greatly impact the performance of R2-STRING2 and its ability to participate in the Festival International.

### Specification Sheet

A specification sheet, shown in Table 1, builds on the house of quality and quantifies the engineering characteristics of R2-STRING2. Items listed here include setup time limit, volumetric constraints, and the strengths of various parts to ensure high success rate in the competition. The specification sheet provides a list of detailed features that the design must accomplish, as well as those that are ideal if possible. In addition, the specification sheet helps keep up to date when each characteristic was last edited as well as the source of each requirement and who is responsible for carrying it out. The responsibilities are divided between each of the three team members and Dr. Vaughan, while the sources come from either Dr. Vaughan or the design team as a whole. The specification sheet focuses heavily on the requirements that are wanted but not necessary, as those consist of over half of the requirements. These include items such as the structural strength of the main fame and forces produced by the electrical components.

### Function Tree

The function tree, displayed in Figure 8, lists the actions R2-STRING2 will have to perform breaks them into many sub-functions. For this competition, the main function is to

"Autonomously ensure successful Festival International de Louisiane." This is divided into each of the 5 main competition tasks, which are further divided into smaller sub-levels. These sub-functions do not contain any solutions as to how to complete each function -- only what basic things need to be done. The function tree focuses heavily on offensive, as well as defensive functions to accomplish during the competition. Some functions, such as Make it to the Main Stage and Keep the Crowd Rocking include the deployment of defensive measures once the respective task has been accomplished, in order to prevent opposing teams from completing their functions. Others, such as Dismissing the Hecklers and Collecting Festival Pins involve offensive approaches to maximize R2-STRING2's point value while crippling the opponents' point value.

## Section 4 - Concept Evaluation

### Overview

Once a proper problem understanding process has been completed, the process of concept evaluation can begin. In this stage, concepts and design ideas are created and reviewed according to the previously established goals and specifications. Several designs are considered and compared based on the pros and cons of each design and how well each one satisfies the customer requirements. This results in a final design decision based on quantifiable data rather than instinct. This process is aided through the use and analysis of design tools such as a morphological chart and an evaluation matrix, both of which are discussed in this section along with descriptions of two alternative designs.

### Alternative Design 1

The first of these alternative designs, shown in Figure 9, showcases an I-shaped pine chassis with wheels to move forward. This design successfully collects merchandise revenue, keeps the crowd rocking, and dismisses hecklers. This design utilizes both the driving and the pin-pulling motors as well as two arm-rotating servos.

#### Main Frame

The main frame of Alternative Design 1 is I-shaped and fits in a 16- by 12-inch base and measures 17 inches in height. Based on the Janka Hardness Scale for wood, pine was strong enough to meet the structural strength listed in the specification sheet, which can be found in Table 1. It is held together with screws and wood glue. The main frame also contains mounting points securing the RedBoard, pin-pulling motor, and driving motor in place.

#### Drive System

A drive axle runs through the back of the frame and is connected to the driving motor. This propels the robot forward toward the crowd pin. Moving forward also allows for the ability to easily collect the merchandise revenue and dismissing the hecklers.

#### Heckler Arms

The heckler arms, as seen in Figure 10, are originally held in the upright position by a pin. Once the robot has moved forward, the pin-pulling motor pulls the pin, which releases the heckler arms. This dismisses the hecklers backward out of all teams' zones.

### Merchandise Revenue Stakes

The merchandise revenue stakes, as seen in Figure 11, wooden rods with toothpicks. After driving closer to the crowd pin, the rods are allowed to rotate downward by a servo motor. In their downward motion, the stakes impale the merchandise revenue with the toothpicks. After, the servos are reversed to lift the merchandise revenue upward. The robot then drives backward to suspend the merchandise revenue over the merchandise account.

good

### Control System

The central processing unit of Alternative Design 1 is located on the base of the frame. A RedBoard from the Sparkfun Inventor's Kit is programmed to operate at the push of a button. The processor is powered by a 12-volt DC power supply. Once the robot reads that the button has been pressed, the RedBoard is programmed to run the driving motor for 2 seconds. This is the time required to approach the crowd pin. Immediately after this, the RedBoard begins to spin the pin-pulling motor to pull the pin and release the heckler arms. Next, the RedBoard stops running the pin-pulling motor and rotates the servos forward and then backward. Lastly, the RedBoard runs the driving motor backward for 2 seconds to return to the starting position. After this function, the RedBoard no longer performs any function until it has been reset.

## Alternative Design 2

The second alternative design, displayed in Figure 12, is a stationary frame that relies mostly on gravitational energy. The square base remains in the starting zone and has two DC motors pull two separate pins. The first pin is pulled by the large pin-pulling motor and releases the two heckler arms. A wooden dowel runs through the frame and into the swinging arms to ensure that they fall together. The second pin is pulled by the small pin-pulling motor and releases a falling weight attached to a catapult arm. The trebuchet is used to allow the band members to make it to the main stage.

### Main Frame

The main frame of Alternative Design 2, as seen in Figure 13, is a wooden frame that has a 12- by 17-inch base and reaches 16 inches in height in the folded position. Based on the Janka Hardness Scale for wood, pine was strong enough to meet the structural strength listed in the specification sheet, which can be found in Table 1. It is held together by screws and wood glue. The main frame also contains mounting points securing the RedBoard and small pin-pulling motor.

### Heckler Arms

good

The heckler arms are 17-inch pine stock and are on the sides of the main frame. In the folded position, the heckler arms are held by a pin located near the back of the main frame. Once the pin is pulled by the large pin-pulling motor, the heckler arms fall on the hecklers and dismiss them into other teams' zones. As seen in Figure 14, the arms have a 45-degree cut on the ends to propel them forward more effectively. A wooden dowel runs through the frame and into the swinging arms to ensure that they fall together.

### Band Member Catapult

Once the heckler arms have fallen, the small pin-pulling motor pulls the second pin. This releases the counterweight on the band member catapult. Before being ejected from the start zone, the band members are placed in a net so that only one object is being thrown and not five. This allows for less uncontrollable error during operation.

### Control System

The central processing unit of Alternative Design 2 is located on the base of the frame. A RedBoard from the Sparkfun Inventor's Kit is programmed to operate at the push of a button. The processor is powered by a 12-volt DC power supply. Once the robot reads that the button has been pressed, the RedBoard is programmed to run the large pin-pulling motor for 1 second to pull the first pin. Immediately after this, the RedBoard begins to spin the small pin-pulling motor to pull the pin and release the catapult. After this function, the RedBoard no longer performs any function until it has been reset.

## Evaluation Matrix

Two alternative designs were conceived and contrasted to the final design by using an evaluation matrix, which can be found in Table 3. The evaluation matrix quantifies how good each design is, and demonstrates that the chosen design earns the highest score because it is the best design.

From the data listed in Table 3 the R2-STRING2 is well-suited for Festival International de Louisiane because it is easy to set up and reliable. It also performs equally well to the other designs at the tasks that it does accomplish. R2-STRING2's weak points, however, are that it does not collect the merchandise revenue. Based on relative weight, this customer requirement is not as important as the other tasks. Overall, the final design boasts reliability and consistency at the expense of not collecting the merchandise revenue. This is an acceptable compromise based on the problem understanding analysis of the Festival International de Louisiane competition. Alternative Design 1 is the only design that attempts to collect the merchandise revenue, but at the sacrifice of reliability, making it to the main stage, collecting festival pins, and effectively dismissing the hecklers. It is also less aesthetic than R2-STRING2. When compared to the other two designs, Alternative Design 2 falls short because it is more difficult to set up and does not collect merchandise revenue or festival pins. It does, however, boast reliability, aesthetics, and safety.

## Final Design Selection

After analyzing the evaluation matrix and understanding what the design concepts' strengths are, a final design was selected for the competition. The final design suffers because of the speed of the pin-pulling motor. By the time the pin is pulled to release the heckler arm kicker, other teams may have already dismissed their hecklers into our zone or collected the festival pins from the sides. This delay could affect the robot's overall performance by knocking down the crowd pin or not being able to dismiss the hecklers. The robot also does not collect the merchandise revenue. This is because that function has been determined to be the most difficult to accomplish, least desirable in terms of point value, and would reduce the robot's overall reliability. With its current operation, R2-STRING2 consistently makes it to the main stage, and, depending on other teams' robots, dismisses the hecklers, keeps the crowd rocking, and collects the festival pins.

Alternative Design 1 is the only design considered that collects the merchandise revenue, however, lacks the ability to make it to the main stage or collect the festival pins. It also takes unnecessary risks by moving from the start zone, such as running into other teams' hecklers or getting caught on the power cables. For these reasons, and those demonstrated in the evaluation matrix, this alternative design was not chosen.

The drawbacks to Alternative Design 2 are that it does not collect the festival pins or the merchandise revenue. Despite omitting these two tasks, the robot consistently keeps the crowd rocking, dismisses the hecklers, and makes it to the main stage. Although reliable, this robot was not chosen because it does not earn enough points per round, as shown in the evaluation matrix.

## Section 5 - Design Performance Evaluation

### Final Competition Performance

In the Festival International de Louisiane competition, R2-STRING2 competed in a total of three rounds. It started the competition ranked second as a result of the previous qualifying competition, and therefore competed in the first round of the final competition against three of the lower-ranked robots. However, toward the end of the setup time, one of the festival pin arms was unbalanced, causing it to fall by itself and swing into the track. With not enough time left to set the arm again, R2-STRING2 was therefore disqualified for the first round due to a simple mistake, effectively losing the advantage of a high seeding and getting sent to the loser's bracket.

During the second round, R2-STRING2 was correctly set up and ready to perform during the allotted time. However, once the switch to the track was closed, R2-STRING2 did nothing for some unknown reason. The RedBoard was powered and connected correctly to the track and the switch leads, which should have begun the programmed procedure. The only possible issues that could be determined were that some wire or lead on the RedBoard was loose or not connected properly, or that powering the RedBoard from only one source caused a glitch with the code for the program to not run properly. These issues are not likely, however, due to the fact of the code being very short and simple and because R2-STRING2 performed just as it should have during test runs immediately before and after the second round. Despite not performing correctly and gaining zero points, two of the opposing robots ended the round with negative points, resulting in R2-STRING2 placing second and therefore still advancing in the competition to another round.

After getting deeper into the competition bracket, R2-STRING2 was then competing against more of the high ranking robots during the third round. Again, it was correctly set up in time and started with the close of the track switch. It successfully dismissed the left side heckler and collected the left side festival pins. However, the opponent on the right side was faster and dismissed their heckler into R2-STRING2 first while also blocking their right side heckler from leaving. That opponent was also able to collect the right side festival pins before R2-STRING2 was able to, and in that collection attempt, the right side heckler and the opponent's heckler were collected into the zone, which knocked over the crowd pin. Once those functions were complete, the band member arm rotated and reached the secondary stage, but before it could continue to the main stage, the arm was blocked from moving any further by the right side opponent's band member arm. R2-STRING2 worked much better than the previous two rounds, but only ended

with 25 points for third place, which prevented R2-STRING2 from advancing any further in the competition. By reaching this round of the competition, R2-STRING2 earned ninth place overall.

## Initial Design Process

After understanding the problem by analyzing the customer requirements and the necessary specifications, the design process began. The majority of the design process was focused on the importance of the customer requirements from the house of quality. This influenced how much energy should be invested toward fulfilling each customer requirement. Because of this, the majority of the design process was focused on making it to the main stage. Another sizeable amount of time was spent on thinking how all of the different elements of R2-STRING2 would come together. Every measurement was carefully thought out to ensure that different arms would not collide, the hanging weights had enough space to fall, and that the pulley systems would not interfere with each other. Because these considerations were made in the design stage, the building of R2-STRING2 was not difficult.

## Assumptions

The biggest mistake made in preparing for the Festival International de Louisiane competition was waiting for other robots to operate. It was assumed that extending the band member arm last would be beneficial, but this proved not the case. From the results of the competition, this was definitely an error. The time required to set up the robot was also more than expected due to the positioning required. Another mistake made was presuming all components of the design would work flawlessly every time. This was disproven in the first and second rounds of the competition. Collecting the festival pins seemed to do more harm than help because of the amount of hecklers collected with them. In some rounds, the pins were already in another zone when R2-STRING2's festival pin arms deployed, which caused them to collect nothing but hecklers. The assumption that the festival pins could only increase the overall score was incorrect.

One correct assumption was the priority of the competition tasks. This was proven correct by the majority of the other teams emphasizing the same tasks. During the week between qualifying round and the final competition, it was also correctly assumed that other teams' designs would change; however, the degree of these changes was not appropriately accounted for. R2-STRING2 was only slightly modified after the qualifying round. Other robots were completely redesigned after seeing the ideas of other teams.

## Design Process Analysis

Based on the results of the Festival International de Louisiane and the assumptions during the design process, it is apparent that some changes should have been made. The most apparent would be to have a quicker release mechanism attached to R2-STRING2's pin-pulling motor. This could have prevented other teams from interfering. Another change would be to decrease the setup time. In its current state, R2-STRING2 fails to operate properly if even one small detail is overlooked during the setup. By motorizing some functions that are currently operated by pulleys, the complexity and setup time would be drastically reduced. Lastly, too much energy was spent on making it to the main stage. It would have been better to reallocate this wasted energy toward protecting the crowd or improving the release mechanism of the pin-pulling motor.

## Section 6 – Conclusions

The Festival International de Louisiane provided an intense challenge. Three unique designs were conceptualized in order to satisfy the customers' requirements. By using an evaluation matrix, the pros and cons of each design were compared. A final design, R2-STRING2, was chosen to compete in the competition because the two alternatives either had too many drawbacks or were not as effective. After earning the second seed from the qualifying round, R2-STRING2 competed in three rounds of competition at the Festival International de Louisiane and earned ninth place.

After participating in the competition, it was apparent that some assumptions made in the design stage were incorrect. The assumption that hindered R2-STRING2's performance the most was waiting to extend the band member arm. Another critical mistake was not pulling the pin that released the heckler arm kicker fast enough. Based on these assumptions, several changes to the design process were proposed. Some of these changes include having a quicker release mechanism, decreasing setup time, and reallocating energy.

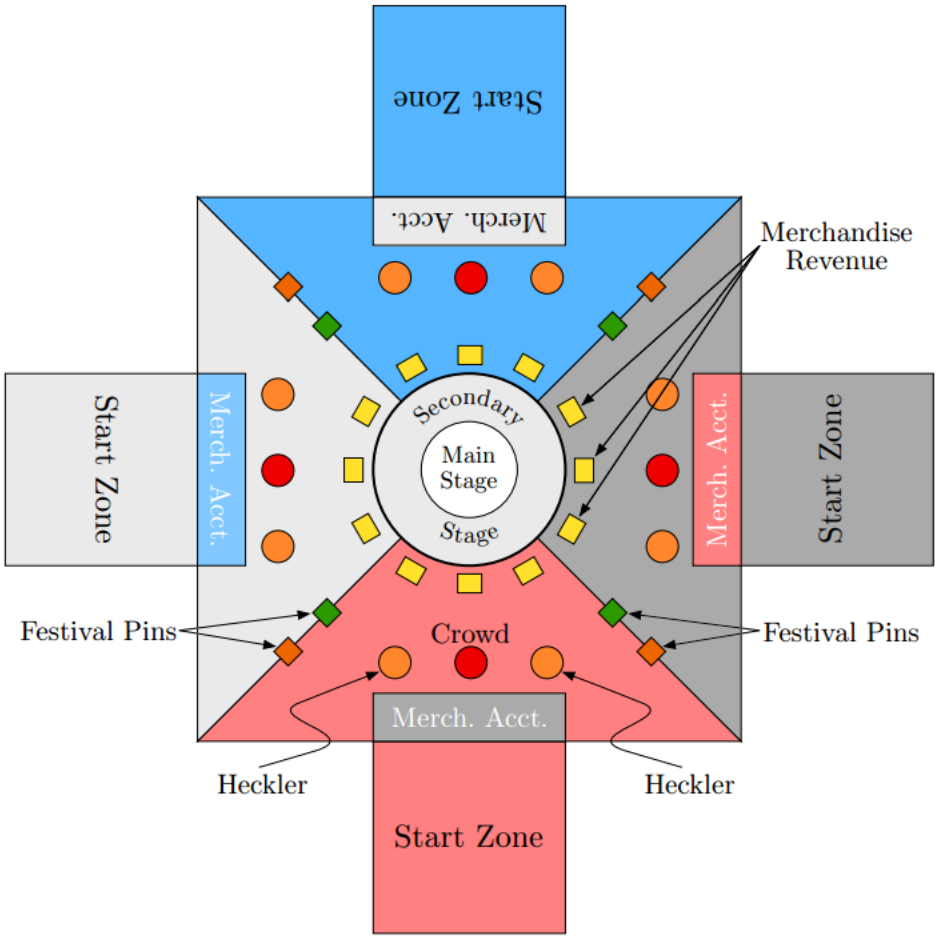



Figure 1 – Festival International de Louisiane Grounds [source]

Good for
at design

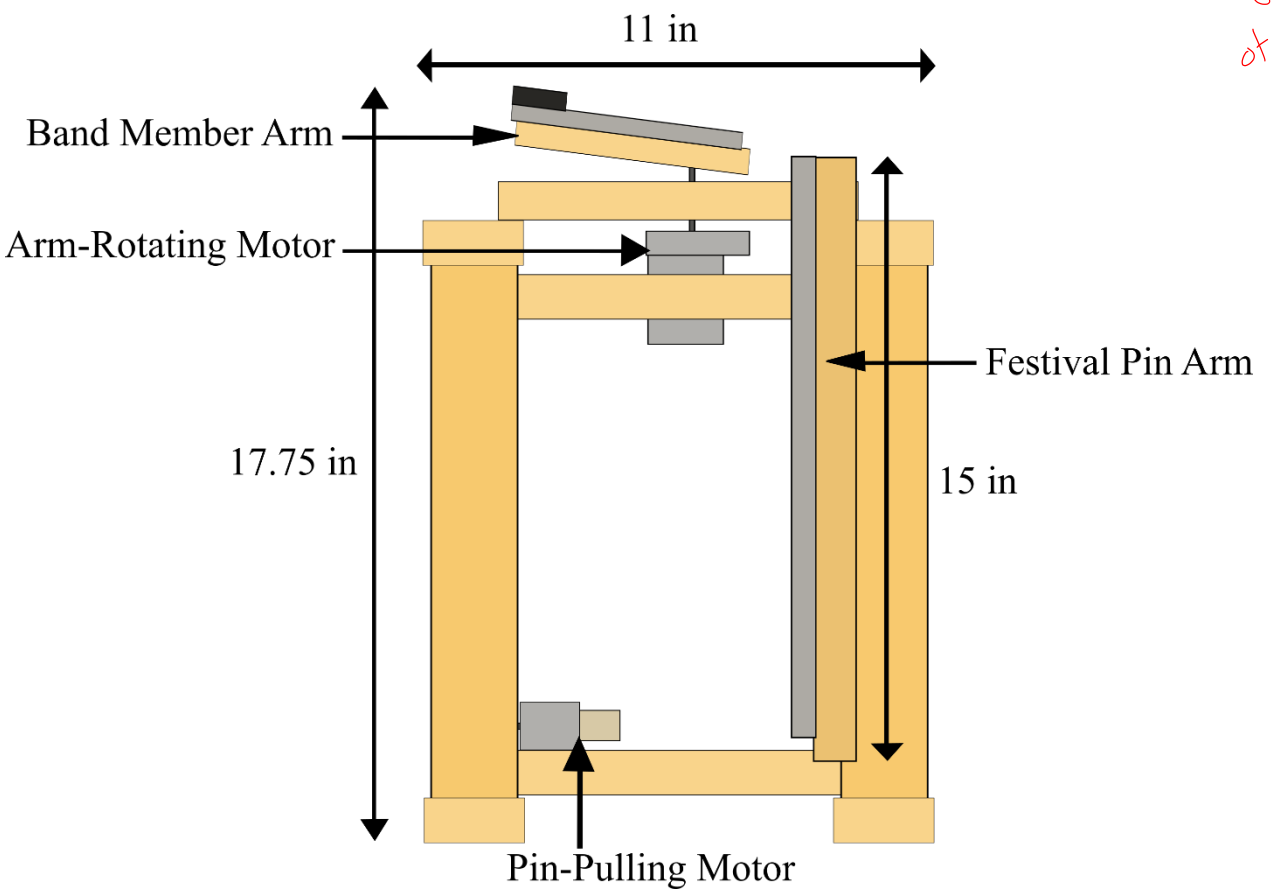



Figure 2 – R2-STRING2 Side View - Folded

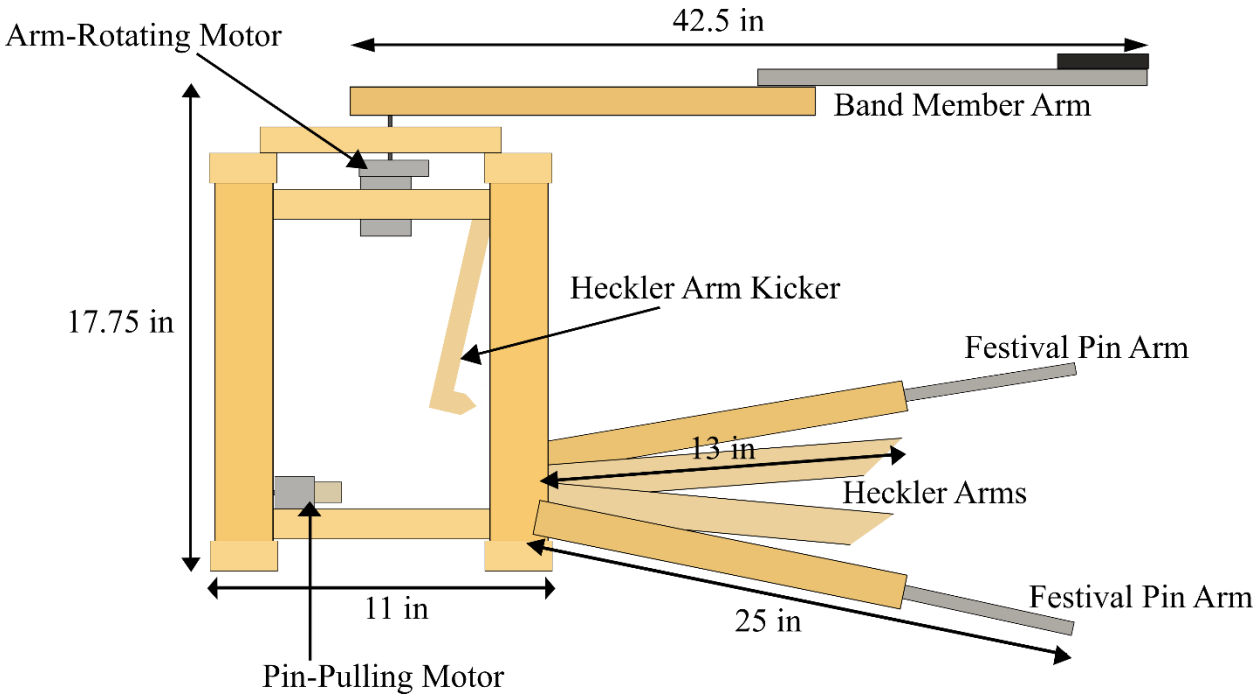



Figure 3 – R2-STRING2 Side View - Expanded

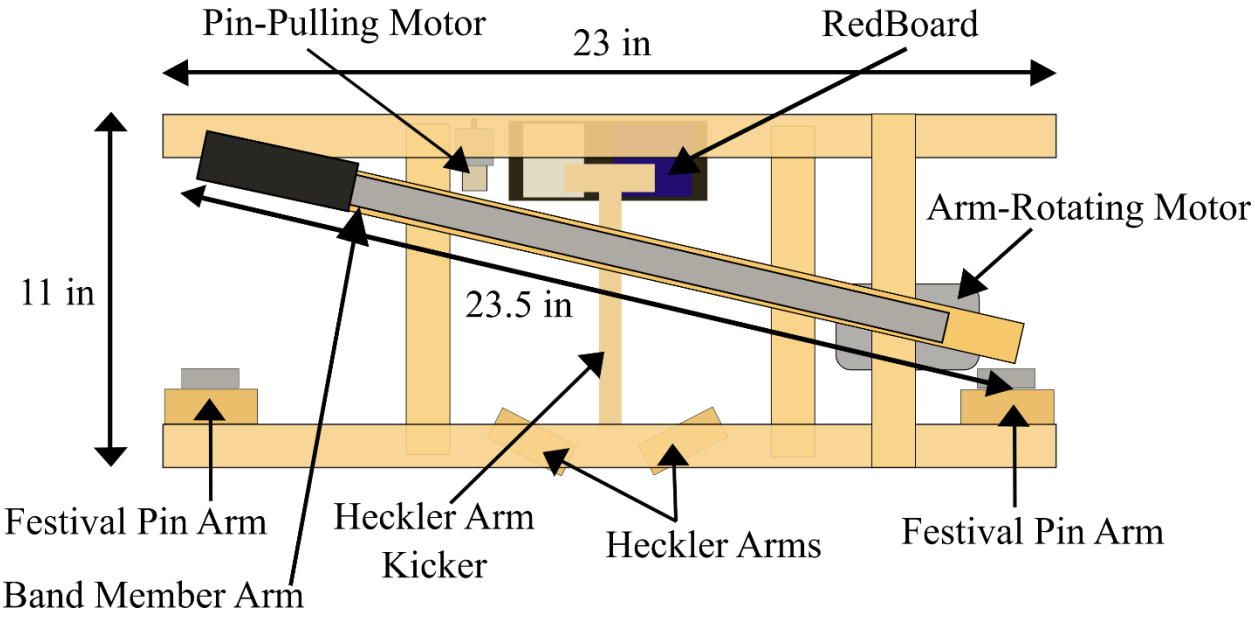



Figure 4 – R2-STRING2 Top View - Folded

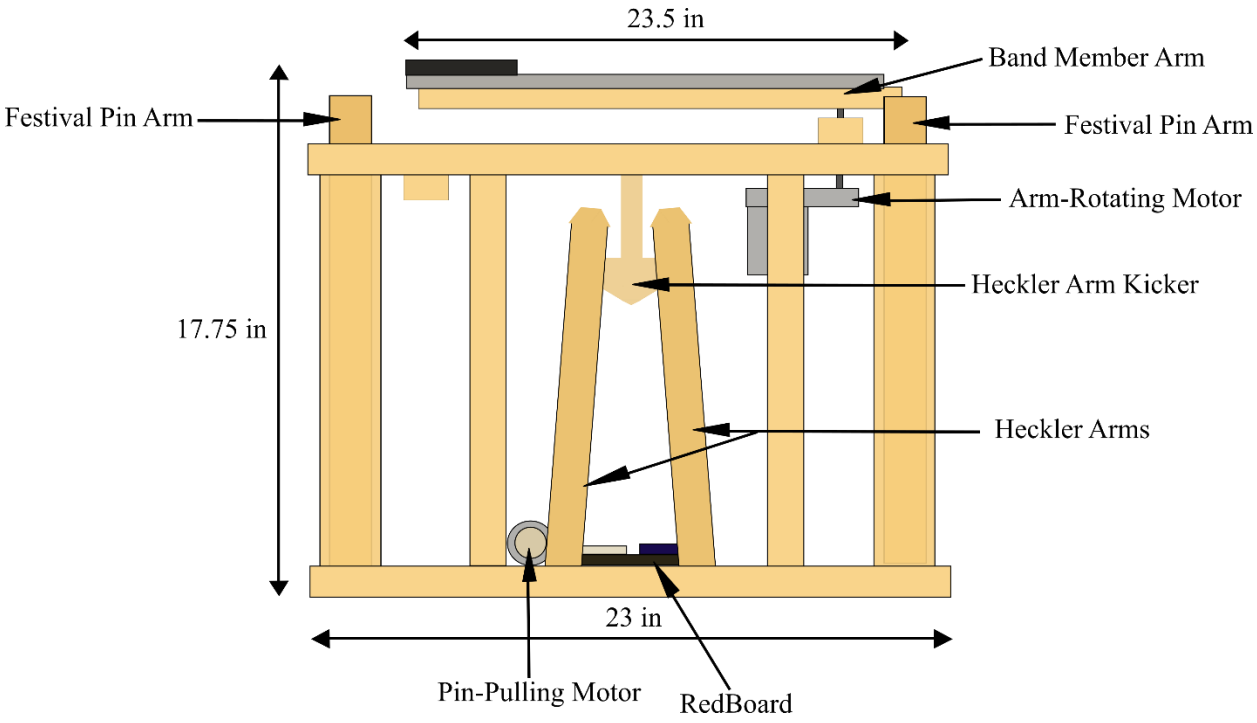



Figure 5 – R2-STRING2 Front View - Folded

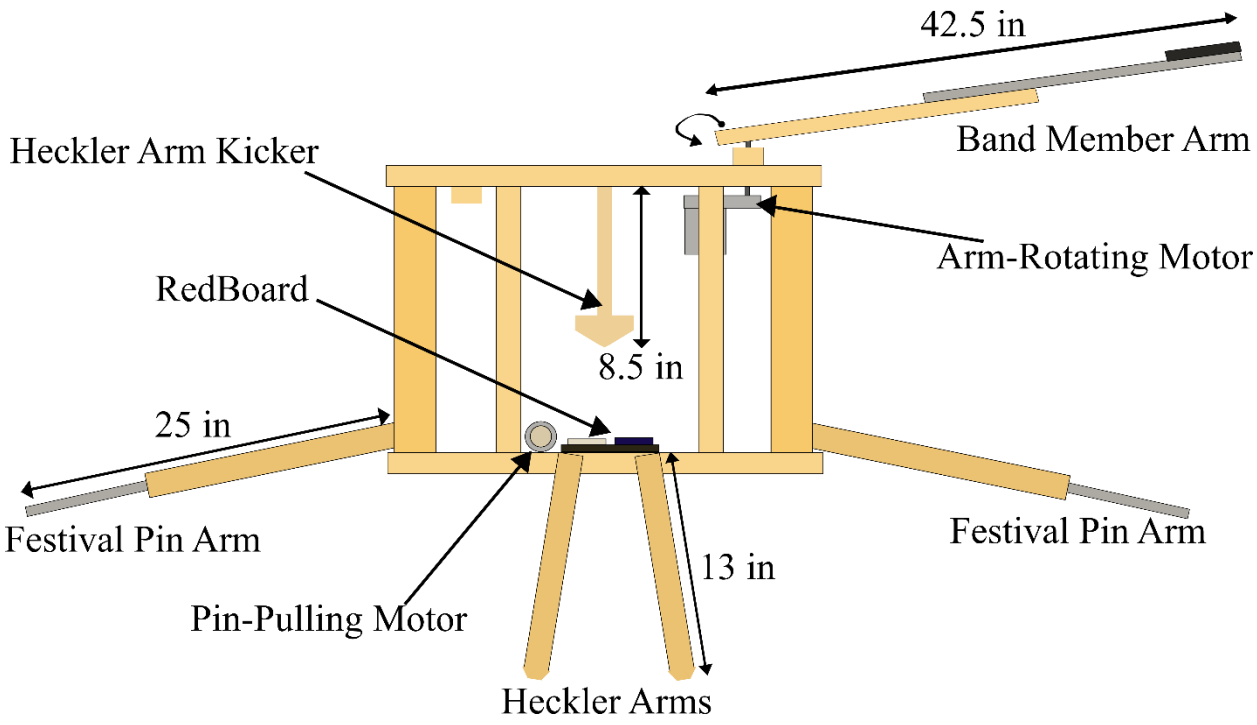



Figure 6 – R2-STRING2 Front View - Expanded

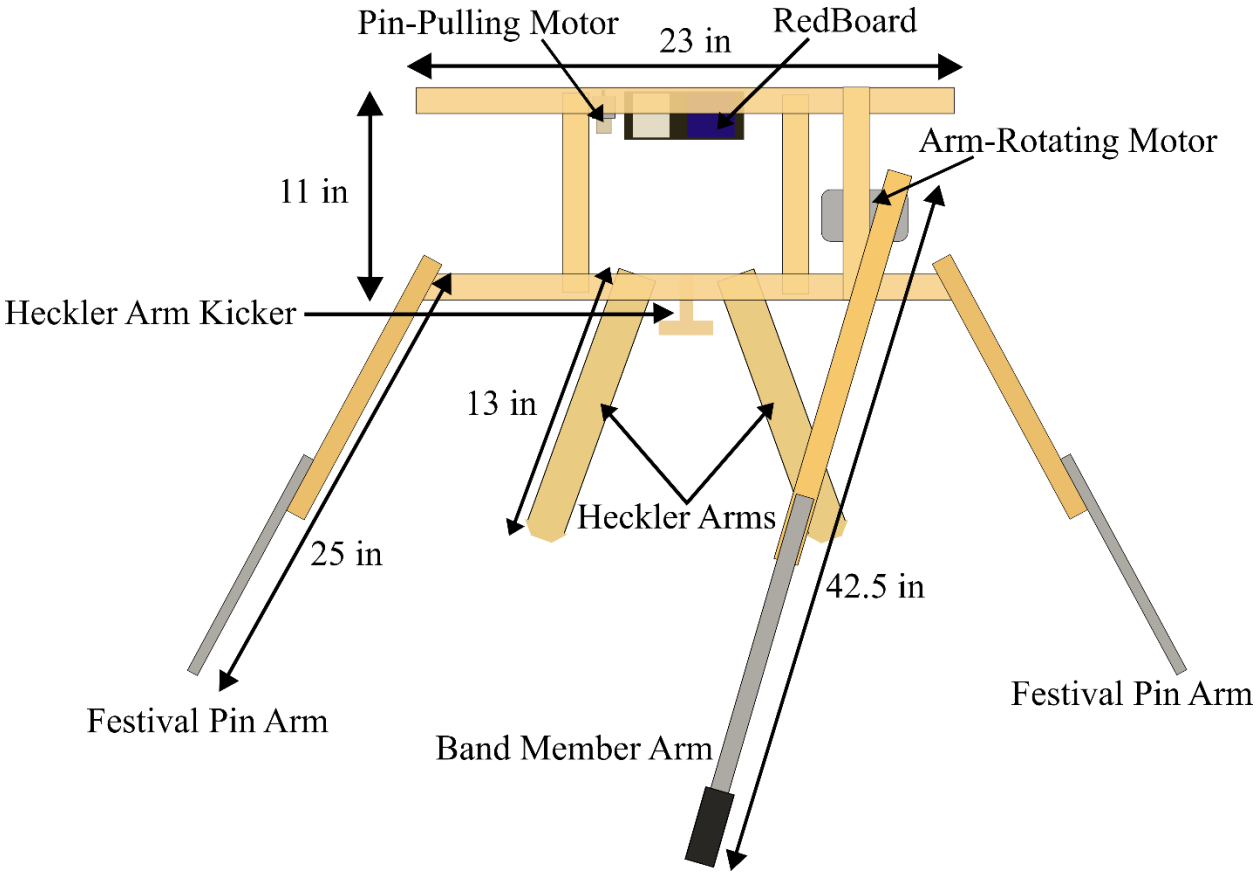



Figure 7 – R2-STRING2 Top View - Expanded

Table 1 – Festival International de Louisiane Specification Sheet

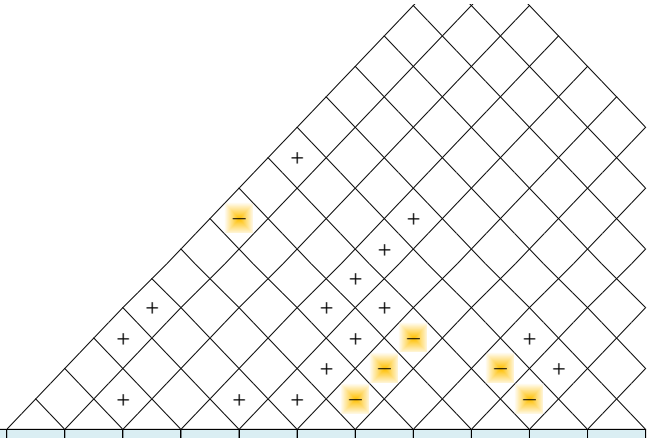
| For: Festival International de Louisiane Problem Understanding | | | Group 7<br>5/3/16 | |
|---|---|---|---|---|
| Date Changed | D/W | Requirements | Responsibility | Source |
| 3/30/16 | W | Structural strength of at least 20 pounds | Hunter Holland | Design Team |
| 3/30/16 | D | Setup time less than 4 minutes | Jacob Deshotels | Dr. Vaughan |
| 3/30/16 | D | Breakdown time less than 2.5 minutes | Jacob Deshotels | Dr. Vaughan |
| 4/5/16 | W | Material has 420-lbf Janka hardness | Benjamin Armentor | Design Team |
| 4/5/16 | D/W | Able to perform tasks autonomously | Benjamin Armentor | Design Team |
| 3/30/16 | D | Operating time of less than 30 seconds | Benjamin Armentor | Dr. Vaughan |
| 3/30/16 | W | Motor speed of at least 10 RPM | Dr. Vaughan | Design Team |
| 3/30/16 | W | Motor torque of at least 1.3 foot pounds | Dr. Vaughan | Design Team |
| 3/30/16 | W | Solenoid force of at least .3 pounds | Dr. Vaughan | Design Team |
| 3/30/16 | D | Initial device height of less than 18 in | Hunter Holland | Dr. Vaughan |
| 3/30/16 | D | Initial device footprint of 12 in x 24 in | Hunter Holland | Dr. Vaughan |
| 3/30/16 | W | Tensile strength of at least 7 pounds | Jacob Deshotels | Design Team |

# Table 2 – Festival International de Louisiane House of Quality

| Correlations | |
|---|---|
| Positive | + |
| Negative | – |
| No Correlation | |

| Relationships | |
|---|---|
| Strong | ● |
| Moderate | ○ |
| Weak | ▽ |

| Direction of Improvement | |
|---|---|
| Maximize | ▲ |
| Target | ◇ |
| Minimize | ▼ |



| Row # | Weight Chart | Relative Weight | Customer Importance | Maximum Relationship | Customer Requirements (Explicit and Implicit) \ Functional Requirements | Structural strength | Setup time | Breakdown time | Material selection | Functional operation | Operating time | Motor speed | Motor torque | Solenoid force | Initial device volume | Tensile strength |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| | | | | | Direction of Improvement | ▲ | ▼ | ▼ | ◇ | ◇ | ▼ | ▲ | ▲ | ▲ | ◇ | ▲ |
| 1 | \|\| | 6% | 9 | 9 | Fit in 12" x 24" footprint | ▽ | | | ● | ○ | | | | | ● | |
| 2 | \|\| | 6% | 9 | 9 | Less than 18" high | ▽ | | | ● | ▽ | | | | | ● | |
| 3 | \|\| | 6% | 9 | 9 | Must operate autonomously | | ○ | | ● | ● | ● | ○ | | | | |
| 4 | \|\| | 6% | 9 | 9 | Cost < $100 | ○ | | | ● | | | | | | | ▽ |
| 5 | \|\| | 4% | 7 | 9 | Complete tasks in < 30 sec. | | | | | ● | ● | ○ | | | | |
| 6 | \|\| | 6% | 9 | 9 | Powered from track | | | | | ● | | ● | ● | ● | | |
| 7 | \|\| | 6% | 9 | 9 | Cease functioning after 30 sec. | | | | | ○ | ● | ▽ | | | | |
| 8 | \|\| | 6% | 9 | 3 | Only use one circuit board | | | | ○ | ▽ | | | | | ▽ | |
| 9 | \| | 3% | 5 | 9 | Safe during operation | | | | ○ | ● | | | ▽ | | | |
| 10 | | 2% | 3 | 9 | Aesthetically appealing | | | | ● | | | | | | | |
| 11 | \|\| | 6% | 9 | 3 | May not be permanently bonded to track | ○ | ○ | ○ | ▽ | ▽ | | | | | ▽ | |
| 12 | \|\| | 6% | 9 | 9 | Relies on gravitational and electrical energy | ● | | | ● | ● | ● | ○ | ○ | ○ | ▽ | ● |
| 13 | \|\| | 6% | 9 | 9 | Limited to only two motors | | | | ● | ● | ○ | | | | ▽ | |
| 14 | \| | 4% | 6 | 9 | Easy setup | ▽ | ● | ● | ○ | | | | | | | |
| 15 | \| | 3% | 5 | 9 | Mobility | ● | ● | ● | ○ | | | | | | | |
| 16 | \|\| | 5% | 8 | 9 | Reliability | ● | | | ● | ● | | ▽ | ● | ● | | ○ |
| 17 | \|\| | 4% | 7 | 9 | Dismiss Hecklers | | | | ▽ | ● | ● | | | ▽ | | ● |
| 18 | \|\| | 5% | 8 | 9 | Collect festival pins | | | | ▽ | ● | ● | ○ | ● | ▽ | | ● |
| 19 | \|\| | 4% | 7 | 9 | Keep the crowd rocking | | | | | ● | | | | | | |
| 20 | \| | 3% | 5 | 9 | Collect merchandise | | | | ▽ | ● | ● | ▽ | | | | |
| 21 | \|\| | 6% | 9 | 9 | Make it to the main stage | | | | ▽ | ● | ● | ▽ | ● | | | ● |
| | | | | | Max Relationship | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| | | | | | Technical Importance Rating | 172.5 | 95.625 | 78.75 | 436.25 | 568.13 | 371.25 | 131.88 | 211.25 | 121.88 | 123.75 | 206.25 |
| | | | | | Relative Weight | 7% | 4% | 3% | 17% | 23% | 15% | 5% | 8% | 5% | 5% | 8% |

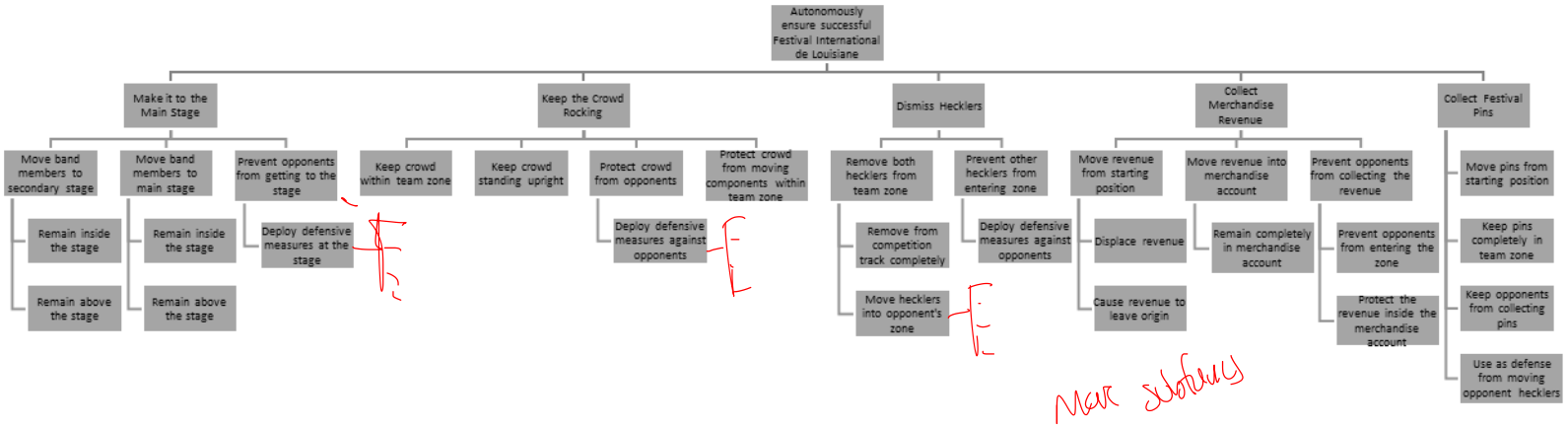



Figure 8 – Festival International de Louisiane Function Tree

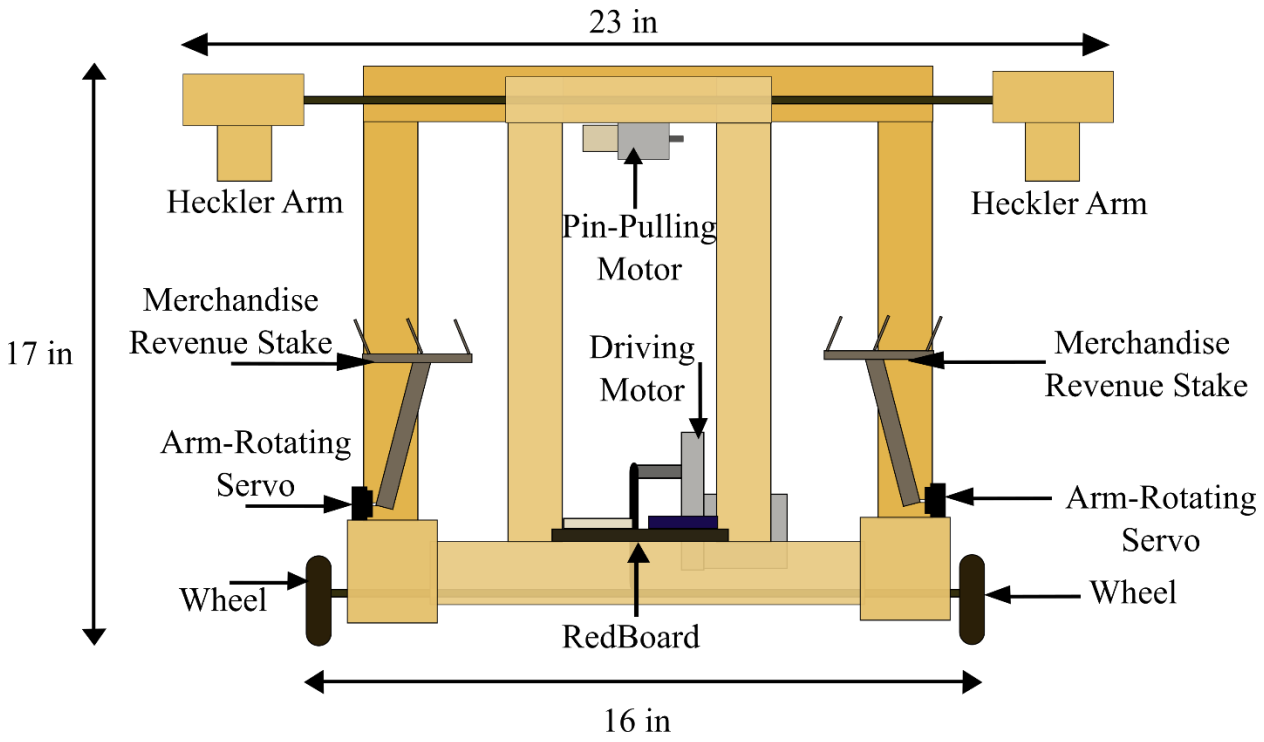



Figure 9 – Alternative Design 1 Front View - Folded

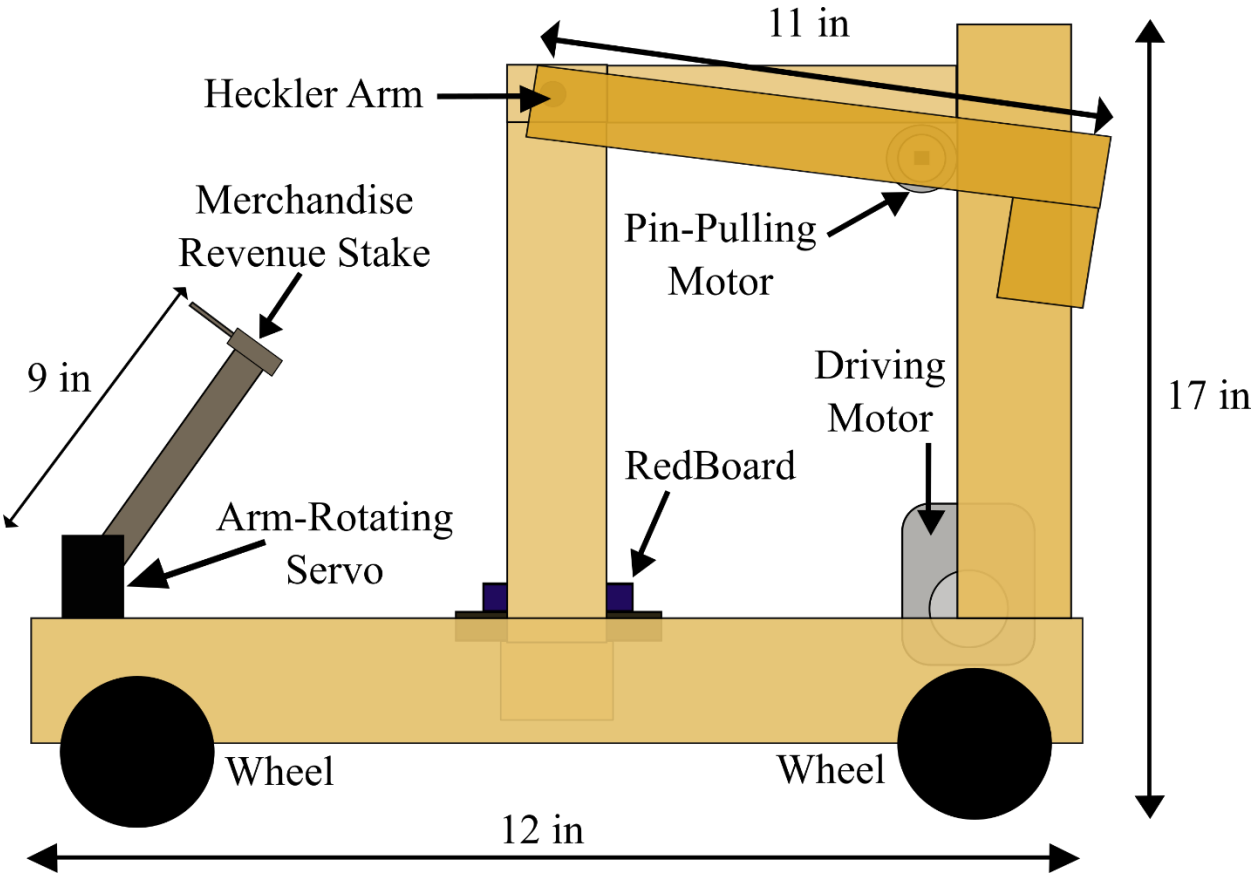



Figure 10 – Alternative Design 1 – Side View - Folded

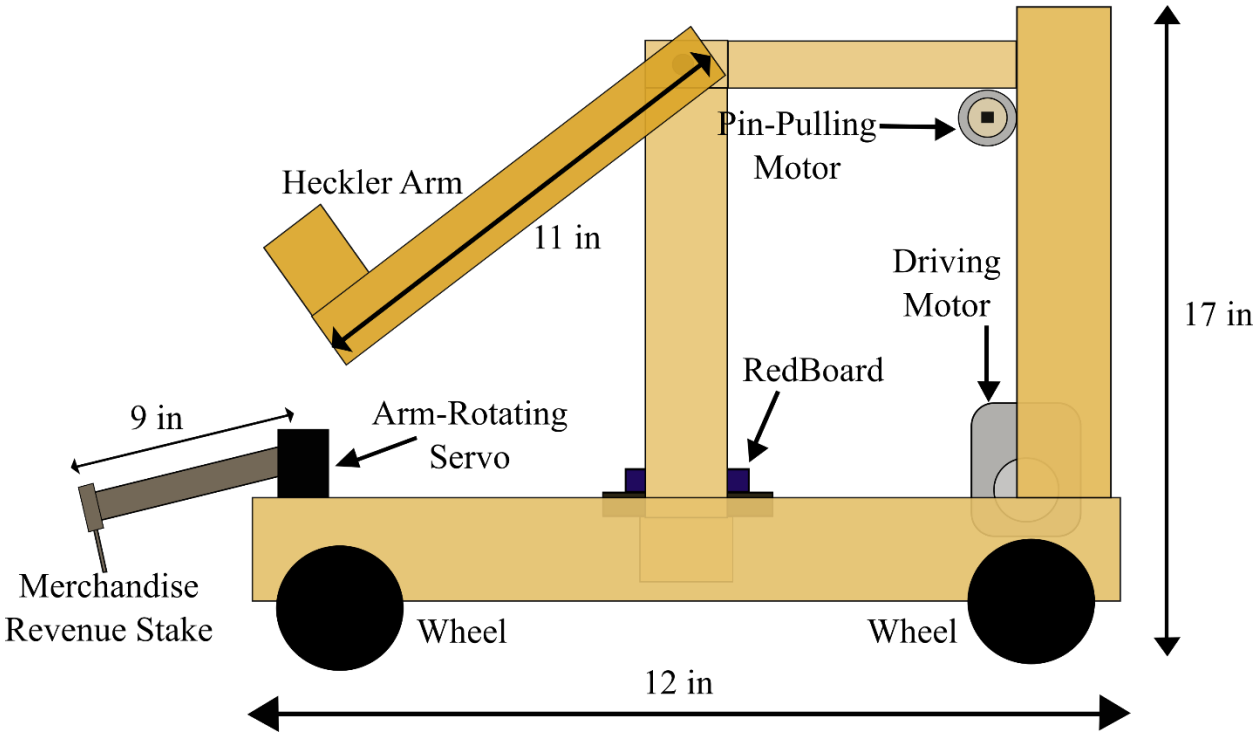



Figure 11 – Alternative Design 1 – Side View - Expanded

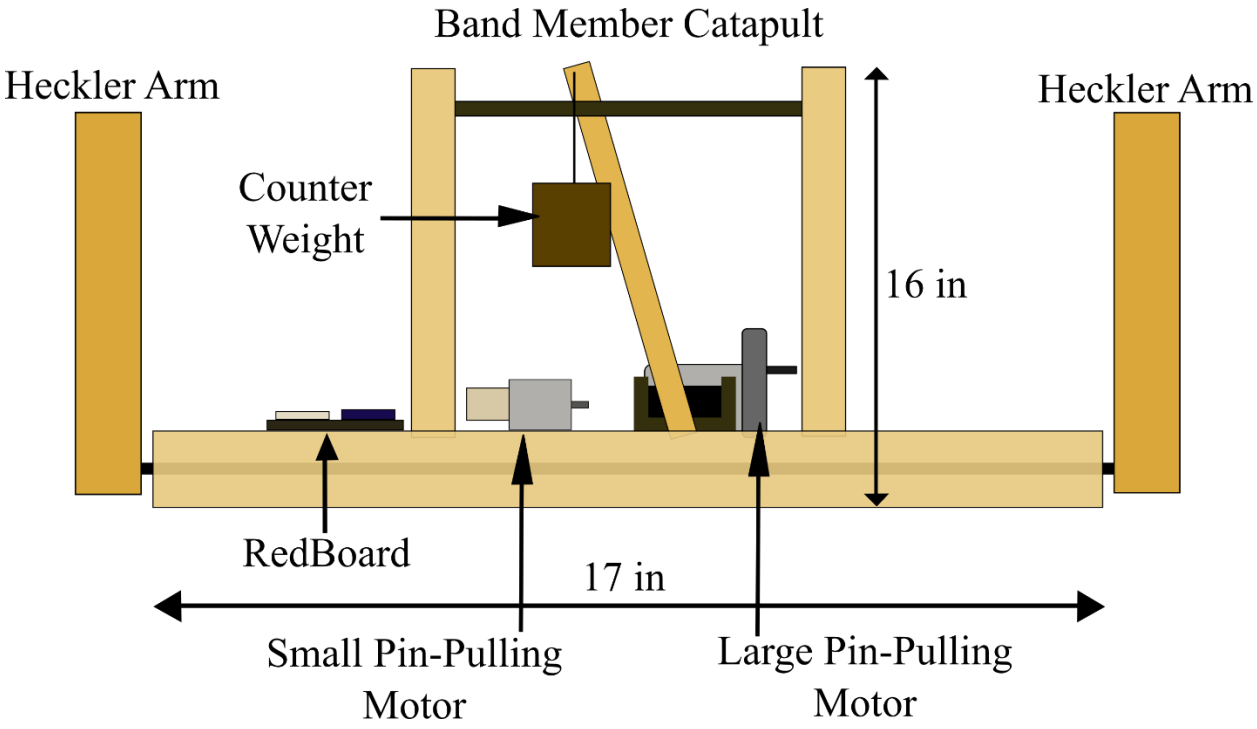



Figure 12 – Alternative Design 2 – Front View - Folded

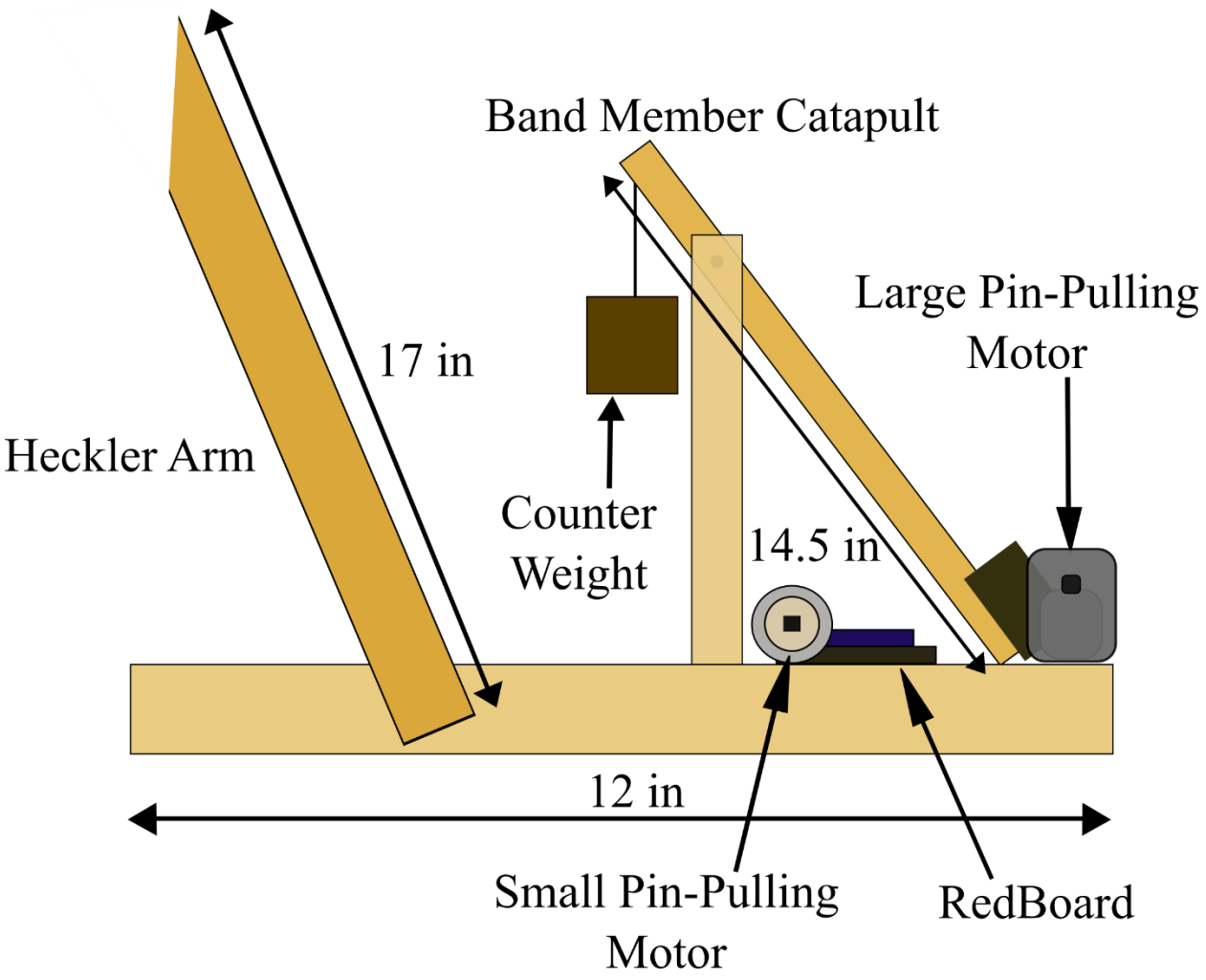



Figure 13 – Alternative Design 2 – Side View - Folded

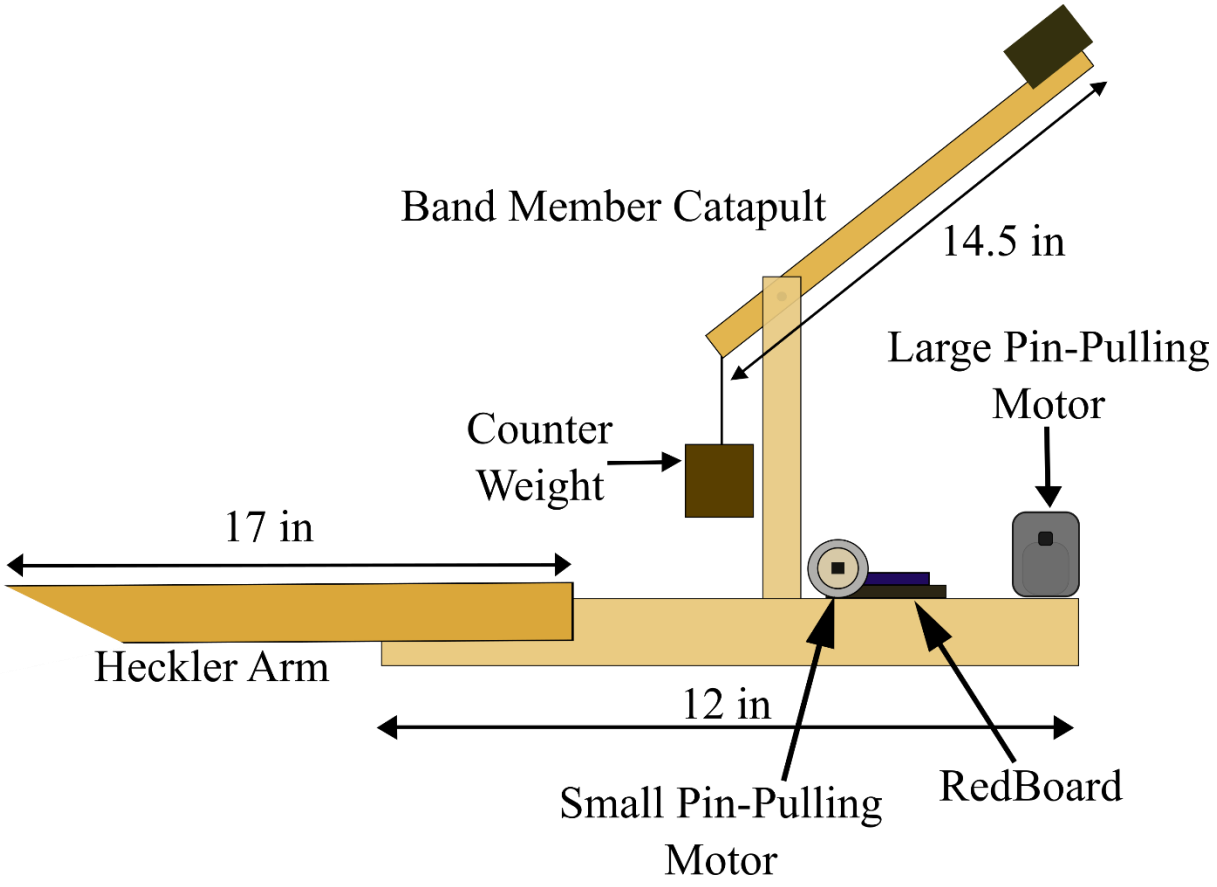



Figure 14 – Alternative Design 2 – Side View - Expanded

Table 3 – Evaluation Matrix

| **Customer Requirements** | Weight | Chosen Design | Alternative 1 | Alternative 2 |
|---|---|---|---|---|
| Less than 18" high | **9** | 9 | 9 | 9 |
| Must operate autonomously | **9** | 9 | 9 | 9 |
| Fit in 12" by 24" footprint | **9** | 9 | 9 | 9 |
| Cost < $100 | **9** | 9 | 9 | 9 |
| Complete tasks in < 30 seconds | **7** | 9 | 9 | 9 |
| Powered from track | **9** | 9 | 9 | 9 |
| Cease functioning after 30 seconds | **9** | 9 | 9 | 9 |
| Only use one circuitboard | **9** | 9 | 9 | 9 |
| Safe during operation | **5** | 6 | 6 | 8 |
| Aesthetically appealing | **3** | 8 | 5 | 9 |
| May not be permanently bound to track | **9** | 9 | 9 | 9 |
| Relies on gravitational and electromechanical energy | **9** | 9 | 9 | 9 |
| Limited to only two motors | **9** | 9 | 9 | 9 |
| Easy setup | **6** | 7 | 6 | 4 |
| Mobility | **5** | 3 | 5 | 4 |
| Reliability | **8** | 9 | 6 | 8 |
| Dismiss hecklers | **7** | 7 | 5 | 7 |
| Collect festival pins | **8** | 8 | 0 | 0 |
| Keep the crowd rocking | **7** | 6 | 6 | 6 |
| Collect merchandise revenue | **5** | 0 | 5 | 0 |
| Make it to the main stage | **9** | 7 | 0 | 7 |
| **Absolute Total** | | 1274 | 1129 | 1202 |
| **Relative Total** | | 0.885 | 0.784 | 0.835 |
| **Percent** | | 88.5 | 78.4 | 83.5 |

| Points | Meaning |
|---|---|
| 0 | Unsatisfactory |
| 1 | Weak |
| 2 | Tolerable |
| 3 | Adequate |
| 4 | Satisfactory |
| 5 | Good, but drawbacks |
| 6 | Good |
| 7 | Very Good |
| 8 | Exceeds Requirement |
| 9 | Ideal Solution |

Table 4 – Bill of Materials

| Bill of Materials | | | |
|---|---|---|---|
| Item | Quantity | Price | Total |
| Pine Wood | 273 inches | $0.06 | $15.02 |
| Wooden Dowel | 48 inches | $0.10 | $4.80 |
| 20 in Drawer Slide | 1 | $7.74 | $7.74 |
| 14 in Drawer Slide | 2 | $5.74 | $11.48 |
| Weight | 5 | $3.99 | $19.95 |
| Long Eyebolt | 2 | $1.13 | $2.26 |
| Small Eyebolt | 20 | $0.55 | $11.00 |
| Zinc screws | 100 | $0.13 | $13.00 |
| Zinc Washers | 50 | $0.12 | $6.00 |
| Small Hinge | 2 | $1.62 | $3.24 |
| Large Hinge | 1 | $2.82 | $2.82 |
| | | | |
| Total | | | $97.31 |

Works Cited

"Figure 1: Festival International de Louisiane." Vaughan, Joshua. "Full Contest Rules." *C.R.A.W.LAB* Spring (2016): 1. *MCHE 201: Introdction to Engineering Design*. PDF file.