LATE

Final Project, Design Performance Evaluation

Mech201: Introduction to Engineering Design

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Don't number title or abstract pages.

Start numbering with the page of the Introduction section.

Abstract:

Avoid. Basically 1st person.

This report goes over the design chosen by Team 2 for the RoboX competition. The RoboX competition requires a robot to autonomously navigate a playing field; deliver and retrieve items; avoid obstacles; and return to start zone. The final design prioritized the points that were the most valuable for the competition based off the HOQ and Spec Sheet. The problem understanding section uses the HOQ, Spec Sheet and Function Tree to conclude the most important requirements for the competition. The concept evaluation uses an evaluation matrix, alternate designs, and a morph chart to show the how the final design was developed. Lastly, the design performance evaluation section uses the result of the competition to draw conclusions about the final design and improvements that can be made.

Too general

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

Here, that would be a 1-2 sentence overview of the design and a summary of the competition results.

Why the extra space?

Section I: Introduction:

Avoid. Basically 1st person. Too team-centric.

This report is about the design, for the Robo X competition, made by design team 2. The competition is a challenge given to engineering students to design, build, and program a robot that can complete a series of tasks with the purpose of gaining as many points as possible. The tasks involved delivery, retrieval, and navigation. Team 2 had to evaluate which tasks were the most important to accomplish. Then create several designs and test porotypes before eventually choosing a final design, which would then undergo a more intense design process. The remainder of the report will include an overview of the final design in Section 1; a walk-through of the problem understanding process in Section 2; an evaluation of the other concepts and designs used in Section 3; a performance evaluation of the robot in Section 4; and conclusions about the design in Section 5.

What tasks? You need to explain the contest and engineering challenges to your reader.

Good

Section 1: Title

Reference the figure and make labels in it and this text

Team 2's final design was based on simplicity. It was decided that the design would only deliver 3 ping pong balls, retrieve 2 small beacons, and port and dock. It is driven forward with a contact wheel and uses two servo motors to open a door and lower a retriever arm for the beacons. The robot was driven by a contact wheel for approximately 4 seconds, then the code would wait a certain amount of time to open the servo to deliver the ping pong balls. The motor would then reverse for about .5 seconds, and then the servo connected to the retriever arm would rotate the arm to the ground. The robot would then drive backward for about 2-3 second, and then stop and rotate the retriever arm back up to deliver the small beacons to the data center.

Without explaining the contest above, your reader won't know what these tasks mean.

Label parts according to their function.

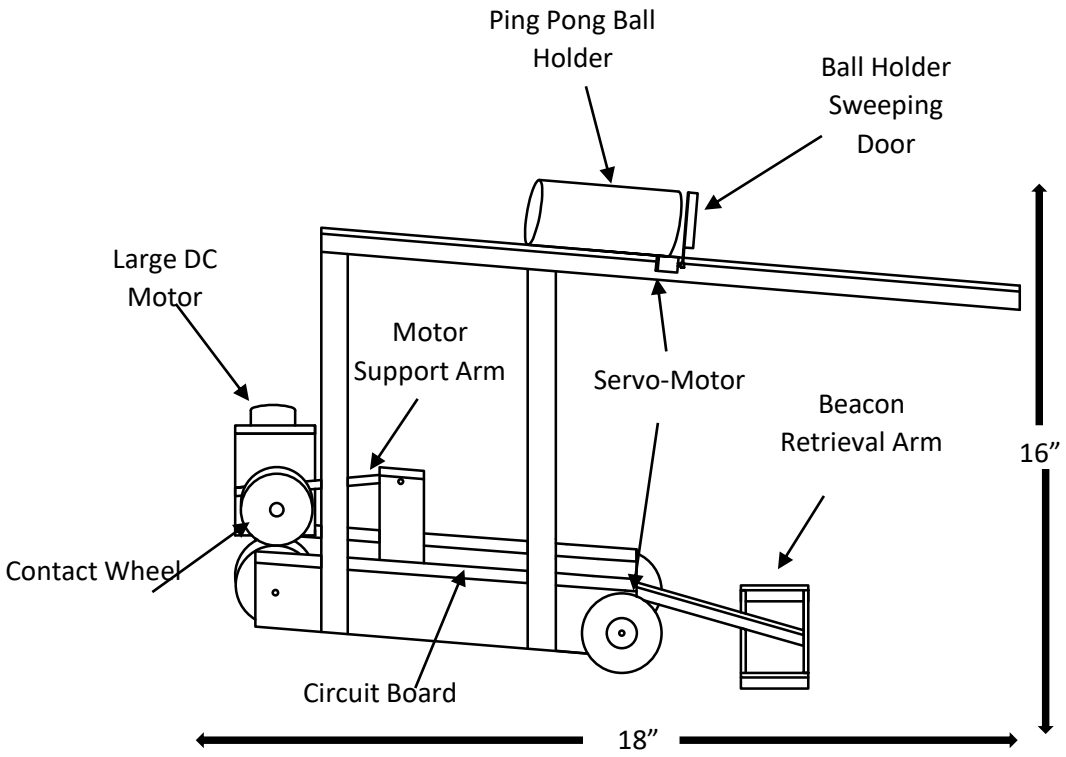


Figure #: Caption

Section 2: Section Title

~~For the RobotX competition, there are several aspects to understand before being capable of designing.~~ The competition presents a variety of obstacles including the rules of the competition, task hierarchy and conflicts, and budget assessment for materials. A specification list, shown in Table 1, was created to help define all requirements for the competition. The robot must not exceed 12” x 24” x 18” and must fit in a 2’ x 2’ start zone. For each run, the robot must return to the start zone in less than 30 seconds. The House of Quality tool correlates the customer requirements and engineering characteristics to form a better understanding of the functionality of the robot. Table 2 shows that the most important requirements to team 2 are autonomous operation, robot dimensions, detect and deliver, and beacon retrieving; as well as the least important requirements, which are aesthetically pleasing, robust to minor deviations, and to can operate on stage with three other teams. Team 2 also developed a function tree,

No need to highlight table numbers.

too team-centric

Avoid chronological, narrative construction

No need to highlight figure references.

which breaks down the main functions of the device. As seen in Figure 1, the main functions are motion, ping pong ball drop off, and tabasco bottle retrieval.

Table1: RobotX Specification List

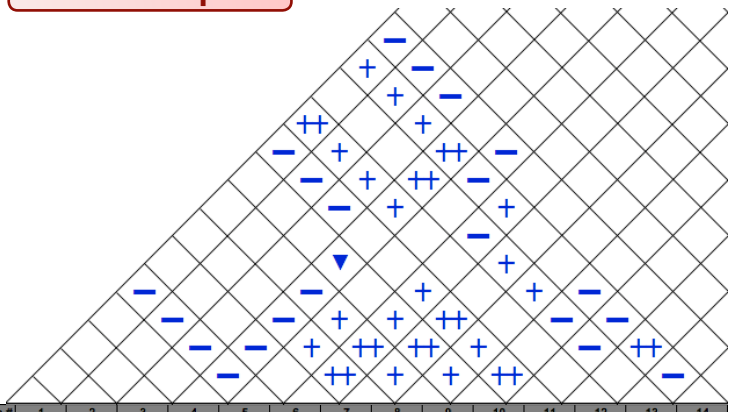
Final Project RobotX				ISSUED: 10/18/16 Page: 1 of 1
Changes	D/W	Requirements	Responsibility	Source
		Geometry		
	D	12" x 24" x18"	Design Team	Contest Rules
	W	10" x 22" x 16" >? <? <=?	Design Team	Design Team
	D	Must fit into a 2' x 2'	Design Team	Contest Rules
	W	Move approx. 22" to outside ring	Design Team	Design Team
	W	Move within approx. 13" between buoys	Design Team	Contest Rules
	D	No weight limit or restriction	Design Team	Contest Rules
		Operation		
	D	Operates <30 sec	Design Team	Contest Rules
	W	Collect 4 tabasco bottles (Small beacons)	Design Team	Contest Rules
	W	Collect 2 bowling pins (Large beacons)	Design Team	Contest Rules
	W	Return beacons to data center	Design Team	Contest Rules
	D	Keep buoys in place	Design Team	Contest Rules
	W	Device must return to start zone	Design Team	Contest Rules
	W	Deliver 3 ping pong balls to outer ring	Design Team	Contest Rules
	W	Deliver 3 ping pong balls to inner ring	Design Team	Contest Rules
		Time		
	D	Set up in 4 minutes or less	Design Team	Contest Rules
	D	Complete tasks in 30 seconds or less	Design Team	Contest Rules
		Kinematics		
	D	Autonomously navigate track	Design Team	Contest Rules
	W	Move forward, backward, left, and right	Design Team	Design Team
		Energy		
	D	One arduino red board	Design Team	Contest Rules
	D	One motor driver	Design Team	Contest Rules
	D	One large motor	Design Team	Contest Rules
	D	One small motor	Design Team	Contest Rules
		Signals		
	D	Activate from 1 pushbutton switch	Design Team	Contest Rules
	D	Use code from Design team	Design Team	Contest Rules
		Materials		
	W	Heavier materials for sturdy base	Design Team	Design Team
	W	Lightweight materials for extended parts	Design Team	Design Team
		Cost		
	D	Total cost less than $100	Design Team	Contest Rules
	W	Total cost less than $50	Design Team	Design Team

Expand

Why the extra space?

Table 2: RobotX House of Quality

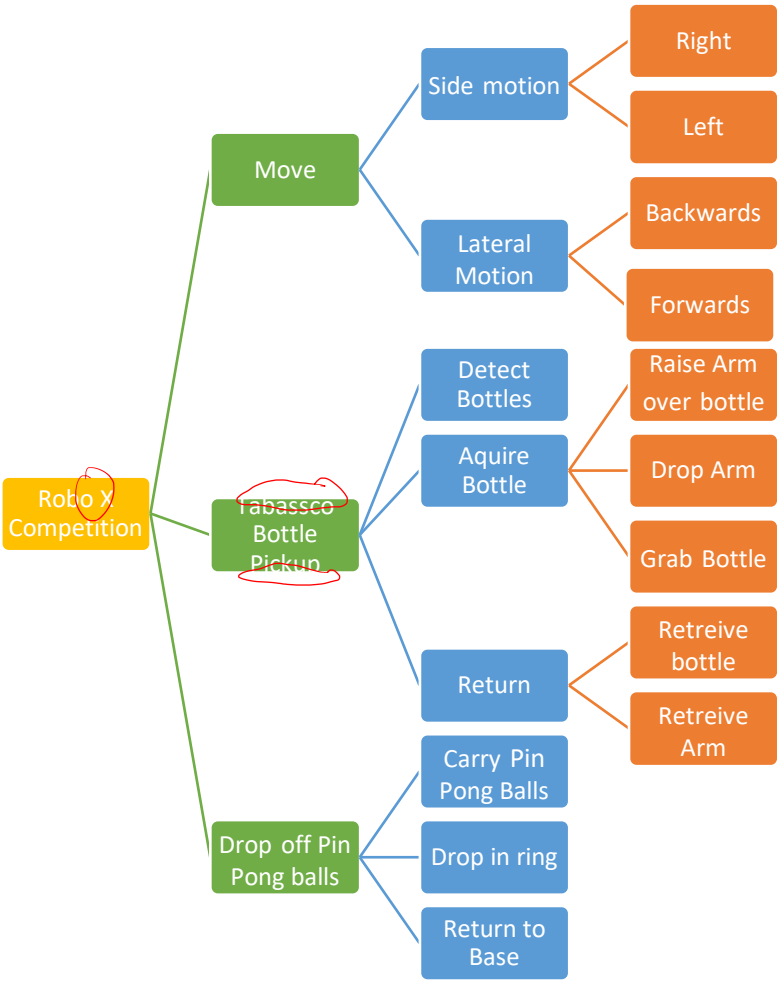
Table #: Caption



Column #				1	2	3	4	5	6	7	8	9	10	11	12	13	14
Direction of Improvement: Minimize (▼), Maximize (▲), or Target (x)				x	x	x	▲	▼	▼	▼	▼	▼	▼	x	▲	▲	▼
Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Demanded Quality (a.k.a. "Customer Requirements" or "Whats") \ Quality Characteristics (a.k.a. "Functional Requirements" or "Hows")	Length	Width	Height	Number of tasks complete	Cost of parts	Length of code	Number of motors	Number of sensors	Run time	Set-up time	Mechanical reach	Tasks completed by code	Tasks completed mechanically	Cost of aesthetic parts
1	9	4.9	4.0	Set up in 4 minutes	▲	▲	▲	O	▲		O	O		Θ	O		O	
2	9	6.1	5.0	Complete tasks within 30 seconds				Θ		O	O	O	Θ			O	O	
3	9	6.1	5.0	Under 18 inches in height			Θ		O					O	O		▲	
4	9	6.1	5.0	Under 12 inches in length	Θ				O					O	O		▲	
5	9	6.1	5.0	Under 24 inches in width		Θ			O					O	▲		▲	
6	3	3.7	3.0	Leave track undamaged				▲					O	▲		▲	▲	
7	3	4.9	4.0	Activate with start button				▲		O	▲	▲		O				
8	9	6.1	5.0	Operate Autonomously				O	O	Θ	O	O	▲	▲		O		
9	9	4.9	4.0	Total Cost less than $100	O	O	O		Θ		O	O			▲			Θ
10	9	4.9	4.0	Electrically powered				▲		O	Θ	Θ	Θ	O		O		
11	9	3.7	3.0	Repeatable functions				O		Θ			O			O		
11	9	3.7	3.0	Repeatable functions				O		Θ			O			O		
12	9	6.1	5.0	Score as many points as possible				Θ	▲	O	▲	▲	▲		O	Θ	Θ	
13	3	2.4	2.0	Robust to minor deviations				▲		O	O	O	O			O	O	
14	3	2.4	2.0	Operate on stage with 3 other teams				O		▲			▲	▲	O	▲	▲	
15	9	4.9	4.0	Leave 2 bouys unmoved						▲		Θ	▲			O	O	
16	9	4.9	4.0	Collect 4 small beacons (tabasco bottle)				Θ		O	▲	O	▲		O	Θ	O	
17	9	3.7	3.0	Collect 2 large beacons (bowling pin)				Θ		O	▲	O	▲		O	Θ	O	
18	9	6.1	5.0	Deliver 3 ping pong balls to center cylinder				Θ		O	▲	O	▲		O	Θ	O	
19	9	2.4	2.0	Aesthetically appealing					O									Θ
20	3	3.7	3.0	Safe during operation				▲	O				▲					
21	9	6.1	5.0	Return beacons to data center				Θ	O	O	O	O	O			O	O	
Target or Limit Value					Less than 12 inches	Less than 24 inches	Less than 18 inches	Max possible	Less than $100	As few lines as possible	1	1	Less than 30 seconds	Less than 4 minutes	Far enough to deliver ping pong balls	Maximum possible	Maximum possible	Less than $100
Difficulty (0=Easy to Accomplish, 10=Extremely Difficult)					2	2	2	8	3	7	5	5	6	4	3	7	7	3
Max Relationship Value in Column					9	9	9	9	9	9	9	9	9	9	3	9	9	9
Weight / Importance					74.4	74.4	74.4	367.1	164.6	230.5	161.0	234.1	184.1	140.2	131.7	295.1	196.3	65.9
Relative Weight					3.1	3.1	3.1	15.3	6.9	9.6	6.7	9.8	7.7	5.9	5.5	12.3	8.2	2.8

Of what?

Many?



These are "arm" solutions, not general functions.

Figure 1: RobotX Function Tree

Section 3: Section Title

Besides the final design that was presented in section II, there are two alternate RobotX designs created by team 2. As seen in Table 3, a Morph Chart was formed to assist in constructing these designs. This design tool presents solutions to the variety of functions RobotX is expected to perform. By combining different solutions, three distinctive designs were generated, the final design, and two alternate designs. The first alternate design shown in Figure 2 uses a pulley system attached to the DC motor and rear axle. The device carries the ping pong balls over in a basket and uses an extending arm to push the basket down and then release the ping pong balls into the center ring. Team 2 recognized that this design presented multiple build challenges and would interfere with the competition rules.

Save for evaluation discussion

Figure 3 shows that alternate design two has the DC motor directly spinning the rear wheel, and the ping pong balls resting on a rail at the end of the arm of the device. When the robot approaches the edge of the ring for ping pong ball drop off, the ring will push on a bar that will come up through the rail triggering the ping pong balls to fall into the center ring. Alternate design two also accounts for tabasco bottle retrieval. There are two moving arms attached by a bar that drops behind the tabasco bottles and drags them into the start zone. Team two recognized that by connecting the motor directly to the axel would create issues with balance and only allows one rear wheel. An evaluation matrix, was formed to numerically break down the functionality between all three designs. This design tool assists in comparing customer requirements of the 3 possible designs. Table 4 will show that as a result of the numerical conclusions, a final design was chosen.

Figure 2: Alternate Design 1

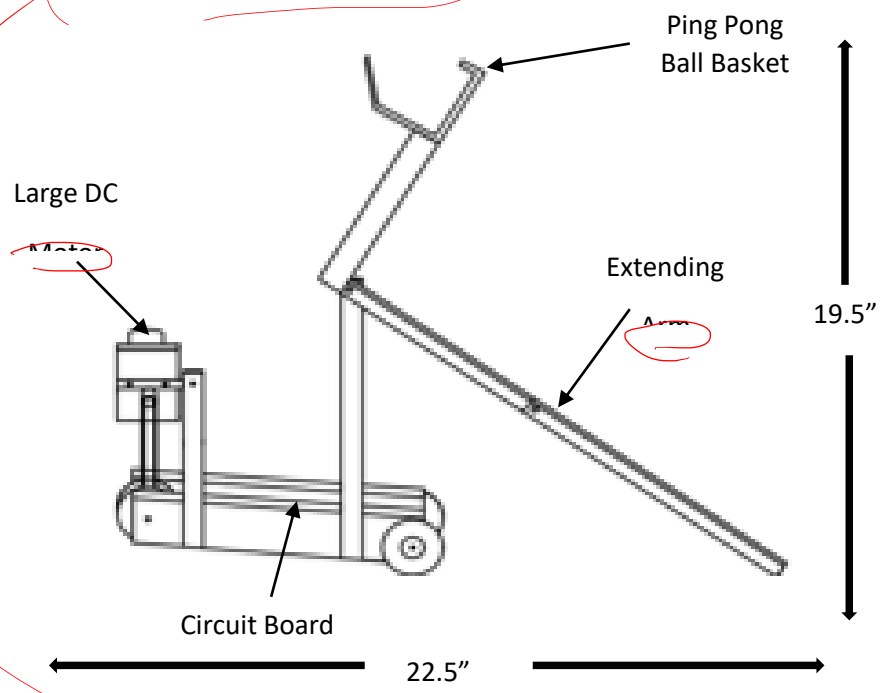


Figure #: Caption

Figure 3: Alternate Design 2

Why the extra space?

Label parts according to their function.

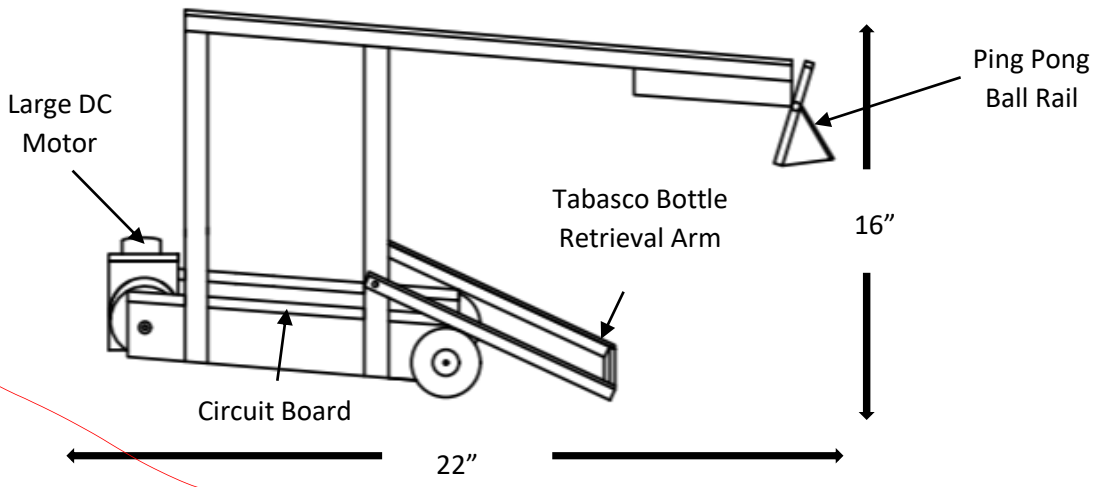
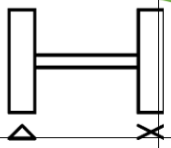
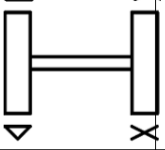
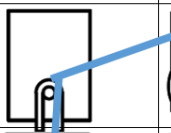
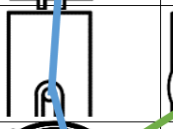
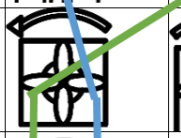
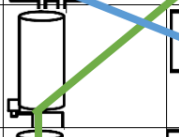
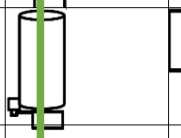


Figure #: Caption

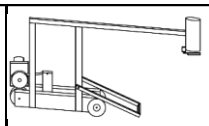
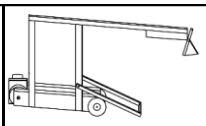
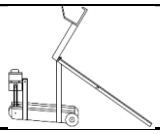
Move closer to reference in text

Table 3: RobotX Morph Chart

	Solutions		
Sub Functions	1	2	3
Go Right			
Go Left			
Go Forwards			
Go Backwards			
Raise Arm over Bottles			
Lower Arm			
Drag Bottles Back to Data Center			
Carry Ping Pong Balls			
Drop Balls in Ring			
Return to Start Zone	Motor Code Timing		

These are "arm" solutoins, not general sub-functions

Table 4: RobotX Evaluation Matrix

Customer Requirements These should match the HoQ			
Must fit within 12" x 24" x 18"	4	4	4
Operates less than 30 seconds	4	4	4
Move approximately 22" to the outside ring	4	4	4
Collect as many beacons as possible	3	2	1
Return beacons to data center	3	2	1
Do not disturb bouys	4	4	4
Set up in 2 minutes and 45 seconds	4	4	4
Autonomously navigate track	4	4	4
Move forward, backward, left, and right	4	4	4
Activated by a pushbutton switch	4	4	4
Cost less than $100	4	3	2
No weight limit or restriction	4	4	4
Device must return to start zone	4	4	4
Absolute Total	204	193	182
Relative Total	0.962	0.91	0.858

Section 4: Section Title

The Robot's performance merited it the semifinal rounds of the competition but lacked ability to win. The robot could gain dock, deliver all three ping pong balls to the center circle, and retrieve two Tabasco bottles to the date zone. In the first rounds the After the first three rounds the robot began to fail, not moving at all. The robot failed do to electrical issues with the wiring. The choice to have multiple different programs for the robot was useful for acquiring points but proved challenging when the computers ran slowly or if the code was not entirely accurate for the changing environment. No points were lost in going after only two Tabasco bottles. Avoiding completely entering the center ring prevent the robot from undergoing any damages or point loses do to other robots. Most assumptions made from the HOQ and Specs were correct. The only failures were equipment malfunctions. The equipment that failed was the required equipment and could not have been replace or improved during the contest. The second

incorrect assumption was that the competition field would be the same as the testing field. The playing field was not the same as it had been during the testing round because of the changed environment. To gain more points the design could have attempted to collect all four Tabasco bottles or the boiling pins. Ultimately these design choices still would have required too much time to build and program with too high of a risk of losing points. Overall the final design chosen was the best fit for the competition.

Section 5: Section Title

stay formal

Don't reference sections, figures, or tables in the conclusion.

This report goes over the final design by Team 2 in Section 1; the problem understanding in Section 2; the concept evaluation in Section 3; and the design performance evaluation in Section 4. The robot could complete all its assigned tasked and make it into the semifinal rounds until equipment failure. For the final design team 2 chose the best fitting applications to gain the most points. The problem understanding goes over how the HOQ and Specification list showed that the most important customer requires were to have a device that can dock, deliver ping pong balls, and retrieve Tabasco bottles. The concept evaluation shows the alternate designs that were used to develop the final design. The design performance evaluation reviews the results of the competition and concludes that design was a good choice for the competition but better equipment should have been used.

Too general.