The EZ-Auto Tee

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ABSTRACT

The newly designed EZ Auto Tee Automatic Golf Ball Setter is guaranteed to improve any golf game. Golfing is a game that requires the up most concentration as well as practice. I have designed a system that is completely autonomous to the user, keeping corrected stances and body positioning while swinging. This is necessary in order to maximize practice sessions and improve your golf game. Included within this report are current market models, both manual and automatic, leading into the conceptual designs and fabrication for the EZ Auto Tee System. This system was designed solely on customer requirements and feedback in order to achieve the perfect, most beneficial system. With a more improved golf game and less time wasted replacing the golf ball each time; users should increasingly see a 35%-40% improvement of their game.

INTRODUCTION

PROBLEM STATEMENT

Golf is a sport that requires the upmost concentration as well as very specific form. There are over 8,100 stand-alone driving ranges in the United States that give golfers a chance to practice this deceptive art (1). From amateurs to professionals, avid golfers spend countless hours at these driving ranges trying to perfect their game. One of the most important methods of perfecting that golf game begins with the proper stance. If one possesses the proper stance, a smooth, uniform swing will soon follow. However, when at the driving range it is quite difficult to maintain that proper stance once it is established because after every swing the golfer must move, bend down, and replace the ball on the tee or mat therefore altering any proper or comfortable foot placement from the previous swing as well as adding more time at the range. With the EZ Auto-Tee moving from that new found stance can be completely eliminated!

With the electrically powered EZ Auto-Tee, the golfer will never have to bend down and replace a ball again. Once the golf balls are loaded into the integrated hopper the system has been initialized. With the built in button, the user will use their club to hit the button, the arm will lower and replace the golf ball whenever they are ready. Once the ball has been replace, the motion sensor inside the cup will initiate the retraction sequence of the arm back into the enclosure. This means no more moving of your feet, no more bending over and decreasing your time at the driving range by up to twelve minutes. "While trying to improve a person's swing, consistent foot positioning and stance is the most crucial part. Stepping away and bending down to replace the ball resets the entire positioning, and then we are back to square one of finding that sweet spot (2)." Not only will this system help amateur golfers, but will also benefit instructors by minimizing time without having to correct and re-correct stance and position issues. EZ Auto-tee will make lessons more efficient and ultimately less expensive.

CURRENT AUTOMATIC GOLF BALL SETTERS

POWERED SYSTEMS

Creating systems that are powered by alternative sources was one method the "Tee-it" company bases their products on. Based upon available research and information the Tee-it air powered tee setter is designed to automatically replace the golf ball after the previous ball has been hit within a given 1.50 seconds (3). This system is a high priced system that can be portable or mounted in various locations. This system comes equipped with an air tank and carrying bag that must be filled and maintained while using the system**.** The Tee-it system can hold up to 100 ball capacity with the option for a portable add-on storage container. One advantage of this system is that is provides two available tee heights as some golfers prefer a higher 2 inch tee height to help correct a swing (3). There is not an abundance of information available on this product without purchasing their information booklet, so specifications were quite limited. The only safety concerns revolving around this product is the separation from range mat to the supplied air tank. This could result in kinked or busted lines and pose as a walking hazard for some.

Figure 1 - Tee-it Mobile Automatic Tee Setter

Many aspects will be considered in the design of the EZ Auto-tee as well as some will be avoided. Since this system is considered a "mobile" system; however it contains an air tank that must be carried around with system and enclosure. Any product that will be used by the public should be visually appealing to satisfy all users. Finally, although this product is mobile, most homeowner do not own enough land or property space to be hitting golf balls 50 yards away, let alone 300 yards drives.

Figure 2 - Automated Ball

Some systems utilize the ball dispenser (Figure 2) located directly in front of the golfer which will operate for two golf mats, one on each side of the dispenser but with their individual agitators. Each mat is supplied 500 range balls before the system needs to be re-loaded which can be done by the key-locked doors located on the side of the dispenser. There is a modified version of this dispenser located in Japan that is actually buried beneath the golfer. Internal components are re-arranged to perform vertically with a constant replenishment of golf balls. Being that this is a high priced system, the overall visual appeal and functionality is seemingly more complex unless it is mounted underground as it is in Japan. The design aspect and usage would be good to reference for various design proposals, but using multiple sources for functioning (electric and air) reduces the energy efficiency of the system.

The Eagle Try Auto Tee-up system is a second example of a pneumatically powered system that also is electrically powered. Once the ball has been hit from the tee, an agitator is activated which will use air power to place the next ball in line onto the steel reinforced rubber tee (4). Figure 3 shows the disk agitator which is used to replace the ball on the tee once it is triggered by the sensor. The tee has a variable height ranging from 0mm to 60mm to adapt to specific club usage or user preference. When triggered, the ball drops from the within the separated 1,000 ball storage setup onto a dampening spring (for noise reduction) which will then be blown onto the lowered tee by a high blast of air. The Eagle Try system has a tee-up cycle time ranging between 3.1 and 5.2 seconds depending on specified tee height. With this available system, golfers can hit up to 40% more balls within the same amount of time spent at a self-service driving range. (4). The entirety of this system is fully enclosed to ensure that safety is not a concern.

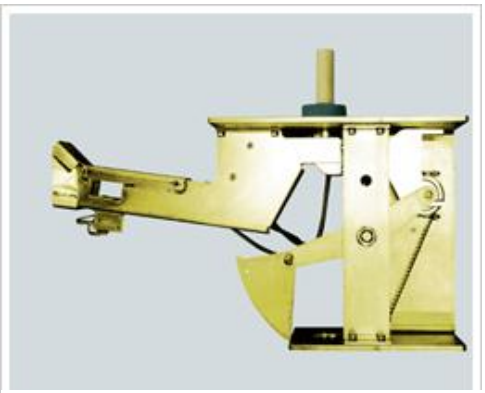

Figure 3 - Auto Tee-up Machine

MANUAL SYSTEMS

The next system is not automatic by any means, but does perform a similar functionality and does inhibit some simple, yet effective design characteristics. This product requires no electricity and no other source of power. The Golf Ball Setter (Figure 4) is a 12 inch high by 9 ¾ in wide portable ball setter able to be used for chipping, putting or driving (5). The compact size of this system allows user to transport it with them if they need to expand on the open area for improving their golf game. The 35 capacity ball storage provides enough shots for a quick practice without breaking the back. The Golf Ball Setters design allows the golfer to use their golf club to manually lower the retractable arm. Once the arm is lowered slightly below the 90° range, the next ball in line follows the track and arm to the placement cup at the end. Provided that the unit and arm are placed exactly in line with the tee (or desired location) the ball with arrive and place on that location. Although not powered automatically, this design still allows golfers to keep their present footing/stance and minimize the amount of bending over and discomfort all for the lower price of $36.00 (5).

Figure 4 - The Golf Ball Setter

The concept here is straight to the point yet very effective. There are no necessary safety concerns except maybe for smaller children, but even then there does not seem to be any immediate dangers. The simplicity of this system will be taken into consideration for proposed design concepts.

Throughout the research many available design options became available for consideration for the EZ Auto-tee. Many of these proposed ideas stem from various sources for power and control motion while minimizing the amount of safety concerns. Whether the concept is fully automatic or manually operated, each system prevented the golfer from having to move and re-position themselves after each swing. However, the bottom line comes down to cost effectiveness and relative location for practicing a sport that requires such an open area to perform safely in. All product designs will be evaluated and considered for proposed design variations for the EZ Auto-tee.

*For more detailed information on researched products, please see Appendix A.

CUSTOMER REQUIREMENTS

CUSTOMER SURVEY

The survey was distributed to a total of thirty golfers who have played the game avidly and to owners of various driving ranges around Southwest Ohio. This way the information received from the survey would be an accurate representation of what consumers are looking for in a product. The survey consisted of ten categories representing proposed customer features. The purpose of the survey was to conclude which of these categories the golfers would deem most important in an automatic golf ball setter. Next the customers will rate those same ten requirements against their experience (if any) with other automatic golf ball setters as well as life expectancy and potential costs of the product. Of the thirty total surveys handed out, only 24 were recovered.

CUSTOMER SURVEY ANALYSIS

From the 24 surveys, accurate representations of customer features will be considered for the preliminary designs of the EZ Auto-tee. Each customer feature was selected to design a product based on importance of what they would consider crucial for an automatic golf ball setter. The table below shows the average ranking of customer importance derived from the survey results. These results are in order from greatest importance beginning at the top down to least important at the bottom.

Survey Results	
Customer Feature	Customer's Importance
Weather Resistance	4.79
Quiet Operation	4.67
Reliability/Durability	4.63
Speed of Operation	4.46
Ease of Operation	4.29
System Safety	4.13
Ease of Installation	4.00
Low Maintenance	3.87
Ease of Assembly	3.50
Energy Efficiency	2.29

Table 1- Survey Results, Customer Importance

From these results the most important feature the customers selected for an automatic golf ball setter is the weather resistance. This does make complete sense because golf is played in inclement weather condition as long as there is no lightening. Even when the driving ranges are not being used in periods of bad weather, the system still has to be able to be protected against the elements. Following closely behind is quiet operation and reliability/durability. The game of golf is one that requires precise concentration and any distraction can be detrimental to a crucial shot. Therefore the system must operate quietly and without distracting the customers.

A designer's multiplier was added to the customer importance rankings. This multiplier was used to increase the importance of certain customer features if the designer was in disagreement with its current value. The table below shows the customer importance with the addition of the designer's multiplier.

Survey Results		
Customer Feature	Customer's Importance	Designers Multiplier
Weather Resistance	4.79	1.1
Quiet Operation	4.67	1.2
Reliability/Durability	4.63	1.3
Speed of Operation	4.46	1.2
Ease of Operation	4.29	1.2
System Safety	4.13	1.1
Ease of Installation	4.00	1.0
Low Maintenance	3.87	1.1
Ease of Assembly	3.50	1.0
Energy Efficiency	2.29	1.0

Table 2 - Customer's Importance with Design Multiplier

The designer was in agreement with a majority of the importance ratings. Quiet operation, weather resistance, Speed of operation, and Reliability/Durability all received a designer's multiplier greater than one because they were deemed more important than what the survey concluded. Quiet operation and speed of operation were given the largest multiplier of 1.2 due to the concern that golfers may be distracted or lose concentration if the products operation is too loud. Weather resistance, ease of maintenance, safety all received multipliers of 1.1 to respectively to illustrate their importance.

As previously mentioned, the survey also asked consumers about their satisfaction with their current application/trials of automatic golf ball setters. As before, they rated each customer feature from highest importance to lowest depending on how satisfied they were with their current product. The table below shows the average ranking of the customer's current satisfaction from the survey results.

Customer Feature	Customer Satifaction
System Safety	2.96
Ease of Operation	2.88
Quiet Operation	2.63
Reliability/Durability	2.50
Speed of Operation	2.33
Weather Resistance	0.79
Low Maintenance	0.75
Ease of Installation	0.54
Ease of Assembly	0.50
Energy Efficiency	0.29

Table 3 - Customer Satisfaction

Table 3 will help guide the designer by showing what the customers specifically liked from actual personal experience. Many of these features were ranked lower than one because they were variables that an average customer could not evaluate or predict.

In order to increase customer satisfaction, the designer will incorporate a "planned satisfaction" rating or a goal set to achieve for future proposals for the EZ Auto-tee. The table below shows what the designer anticipates what the customer satisfaction should be for the new EZ Auto-tee compared to the current satisfaction of similar models.

Customer Feature	Customer Satifaction	Planned Satisfaction
System Safety	2.96	3.50
Ease of Operation	2.88	3.50
Quiet Operation	2.63	4.00
Reliability/Durability	2.50	4.70
Speed of Operation	2.33	4.00
Weather Resistance	0.79	3.50
Low Maintenance	0.75	4.00
Ease of Installation	0.54	2.50
Ease of Assembly	0.50	1.50
Energy Efficiency	0.29	1.25

Table 4 - Planned Satisfaction

From this analysis, a relative weight was given to each feature to help gauge the attention each feature would require. This percentage will help the designer weigh out which of the customer features would need the work, or consideration when designing an automatic golf ball setter.

Customer Feature	Relative Weight
Weather Resistance	18%
Ease of Operation	17%
Quiet Operation	15%
Speed of Operation	12%
Reliability/Durability	10%
Low Maintenance	7%
Ease of Installation	6%
Ease of Assembly	6%
System Safety	4%
Energy Efficiency	3%

Table 5 - Relative Weight

From the table above weather resistance, low maintenance, and energy efficiency are to be considered the top most important features to be considered in the design of the EZ Auto-tee.

*For more detailed information on the customer survey and features, please see Appendix B.

DESIGN SPECIFICATION

PRODUCT OBJECTIVES

The following is a list of product objectives and how they will be obtained or measured to ensure that the goal of the project is properly met. The product objectives will focus on an automatic golf tee setter to be used without the need for human intervention once the balls have been loaded.

Weather Resistance (18%)

1. Fully enclosed system will be tested for water resistance.
2. All hinges and access door will be water tested.
3. Small drain will be located in base for potential leakage.

Ease of Operation (17%)

1. Load balls into integrated hopper.
2. Once balls have been loaded, system runs with push of a button.
3. Next ball available at leisure of golfer.

Quiet Operation (15%)

1. Product will use quiet electric motor will be chosen by lower decibel level output to prevent disrupting the concentration of golfer

Speed of Operation (12%)

1. Next ball to be set within 3.0 seconds of activation.
2. Sensor initiates ball arm retracting once ball has crossed sensor plane.

Reliability/Durability (10%)

1. System will be designed and tested for weather resistance.
2. Materials will be selected after mathematical analysis to perform under enclosed and high or low temperature conditions.
3. Outdoor paints and lubricants will be used to increase life moving parts per desired facility location and owner request.
4. Sensors will be fully encased to protect from dust, dirt and debris.
5. Small drain will be located under tee hole for potential water diversion.

Low Maintenance (7%)

1. Enclosure with flush mounted handle for easy access cover.
2. All moving parts coated in waterproof lubricant.
3. Motion sensor/laser will have scratch resistant lenses.
4. Small drain will be located under tee hole for potential water diversion.
5. Can be maintained with periodic inspection and lubrication.

Ease of Installation (6%)

1. Pre-assembled system will be secured to ground with provided hardware per mounting location.
2. Flush mount handles will make transporting for one to two people easy.

3. Pre-wrapped cables will come with wall and ceiling install brackets.
4. Can be assembled with everyday use tools.
5. Product can be moved and manipulated and installed by one person.

Ease of Assembly (6%)

1. System will be fully enclosed with flush mounted handle for access cover.
2. Product will use standard "off the shelf parts" tested for the EZ Auto-Tee.
3. Can be assembled with provided, low cost parts.

System Safety (4%)

1. System will be fully enclosed with flush mounted handle for access cover.
2. System will have an automatic malfunction shut-off.
3. System will be equipped with manual safety shut-off switch.

Energy Efficiency (3%)

1. Linked power to main control.
2. Driving motor will use no more than standard 115 volts for minimum power consumption.

* To view only the product objectives, please see Appendix D.

In order to meet the specific customer requirements, the designer has selected several key Engineering Characteristics or EC's. Using the QFD or Quality Function Deployment, each characteristic was rated as to how it would affect the individual features. These ratings were analyzed and the EC's were given an associated weighted value. This value was used to rank the EC's according to their importance in the design process. Table 6 shows each Engineering Characteristic along with their corresponding weight percentage.

Engineering Characteristic (EC)	Relative Weight (%)
Leak-proof enclosure	20%
Actuation Method	19%
Standard parts/equipment	11%
Physical size/weight	9%
Wear resistant material	9%
Tee load refresh time	9%
Quick connect wiring	9%
Access Panel	7%
Manufacturability	4%
Load Conditions	2%

Table 6 - QFD Relative Weights

*To see the QFD in its entirety, please see Appendix C.

DESIGN

DESIGN ALTERNATIVES

Design concept number one utilizes a mechanism that is located completely below the golfer within the driving range mat. This design makes the thickness of the driving range mat nine inches high off the ground, creating a nuisance step. The hopper will be mounted in front of the golfer onto the dividing wall between each range. Once the golf balls are loaded and have made their way into the range mat, a battery powered mechanism will load each ball on to the tee. The tee also will use a battery powered actuator to raise and lower it each time the ball is hit off of the tee. Installed within the tee itself would be a photo/motion sensor that will indicate when the ball has been hit off the tee and immediately begin to retract the tee into the enclosure, load the next ball, and then raise the tee back into position to be hit again. This system requires the enclosure to remain at its current location, therefore making the systems portability capabilities at zero. This system is certainly more complex, and definitely more expensive.

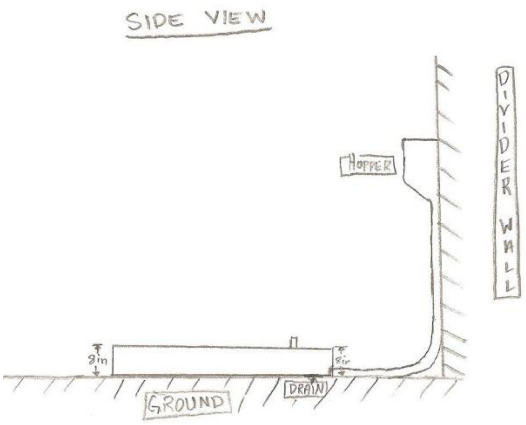

Figure 5 - Design Concept #1

This next concept takes a much simpler approach. It eliminates the expensive drive components to a completely manual system that will utilize the golfer's discretion at when they want the next ball. This includes an enclosure that is located against the wall in front of the golfer. There is a hopper mounted on to the top of the enclosure were one will put the golf balls into. From there they will travel down an internal tube leading to an arm. Once the golfer wants his next ball, he will then hook his club around hooks mounted to the outer edge of the arm and pull downward. The next ball in line will follow the track arm downward and place directly on to the tee. The golfer will then remove his cub and let go of the arm, and the arm will retract back into the enclosure. Now this system is completely manual, but is able to be used will all standard driving range mats, and could be portable if desired. The overall concept is different, but is indeed very simple.

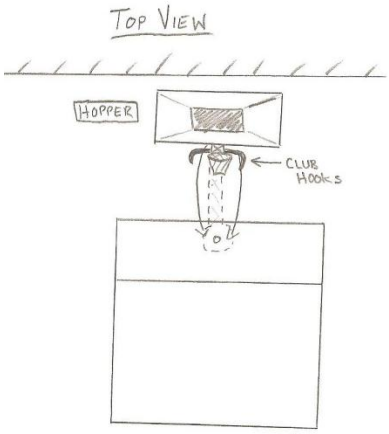

Figure 6 - Design Concept #2

The third and final design concept is a collaboration of both the above, concept number one and concept number two. This concept will still utilize the standard driving range mats, or can also be moved to any location that inhibits sufficient amount of space for driving range activity. It utilizes the same style of enclosure as concept number two along with the

top mounted hopper, and still remains located in front of the golfer approximately 12 inches from the tee location. Now the main difference here is that this system uses a mechanical mechanism and arm that is actuated by the golfer and ran off of a standard 110 volt power outlet. Along with the hose and track located inside the enclosure, there is also a small motor, battery and gearing that will raise and lower the arm once the golfer hits a button that will be mounted on either side of the enclosure. Again, the arm will lower, releasing the next ball in line down the track and placing it promptly onto the tee. At the end of the arm is a tapered cup, and mounted midway in the sidewall of the cup is a photo sensor that will recognize once the ball has passed that plane, and begin the retracting of the arm back into the enclosure. This system allows the golfer to receive the next ball entirely at his discretion with only the push of a button. The rest is done completely autonomously. As for the mobility aspect, a smaller laser will be mounted on the top front face of the enclosure. This small laser will be directed at the precise location on the ground where the tee should be to ensure direct placement of the ball. This eliminates measuring, and makes setup anywhere simple as long as a standard 110 volt outlet is accessible.

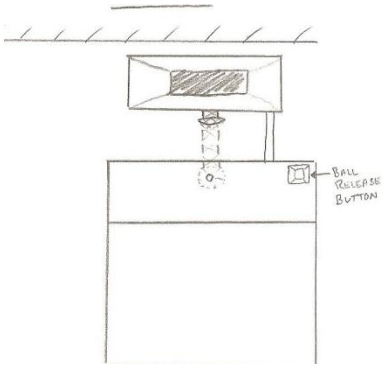

Figure 7 - Design Concept #3

* To view each design concept drawings in full, please see Appendix E.

CONCEPT SELECTION

The selected design concept was chosen by a weighted decision matrix. This method uses specific criteria determined to be most important to the design and overall usage of the system. Each criteria listed was also assigned a weighted value between 0.00 and 0.25 depending on it relative importance in that category. From there each design concept was rated 1 through 4 (1 being bad, 4 being good) comparatively to the criteria to each individual concept.

DESIGN CONCEPT SELECTION - EZ AUTO TEE									
		Design Concept Number							
Criteria	**Weight**	1	1b	2	2b	3	3b	4	4b
Cost	**0.25**	2	0.50	1	0.25	4	1.00	3	0.75
Weight	**0.20**	2	0.40	2	0.40	3	0.60	3	0.60
Size	**0.15**	4	0.60	2	0.30	3	0.45	3	0.45
Reliability	**0.20**	2	0.40	2	0.40	3	0.60	3	0.60
Efficiency	**0.05**	2	0.10	4	0.20	3	0.15	3	0.15
Interfacing	**0.15**	2	0.30	2	0.30	2	0.30	4	0.60
Total			2.30		1.85		3.10		3.15

Figure 8- Design Concept Selection Matrix

From the above (Figure 8) design concept number 4 was chosen due to its higher numerical rating factor of 3.15. This selection was made partially due to the decrease of user interfacing, but allowing enough to ensure that the golfer can decide if and when he/she would like the next ball to be loaded. All other weighted criteria were also higher ranked in this model as it has decreased in cost and weight while slightly being able to increase the overall reliability and efficiency. In this concept, the EZ Auto-Tee will effectively satisfy all range of customers and consumers to fit their needs.

DESIGN DRAWINGS

The Following are 3-D design drawings that the EZ Auto-Tee will be based off of for the initial manufacturing process. These drawings are a tool from which the final product should be closely based upon with the exception of minor changes if, and where necessary. All solid models were created using SolidWorks 2010 modeling software.

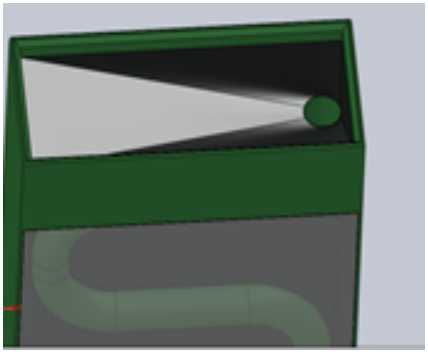

Figure 9 - Top View of Enclosure

Figure 9 shows the top section of the enclosure. This section has a built in hopper to which the user will pour the golf balls to load the system. All golf balls will funnel down the preceding two inch diameter tube to be loaded for the next placement.

The following is a section view of the lower portion of the enclosure. As seen in Figure 10, the system will be active by the small push button mounted on the lower side of the enclosure. The rectangular box is the waterproof box containing the motor and its relative mounting position. The motor assembly will be mounted three inches above ground level to avoid any leaking and potentially standing water and dirt that may enter the enclosure.

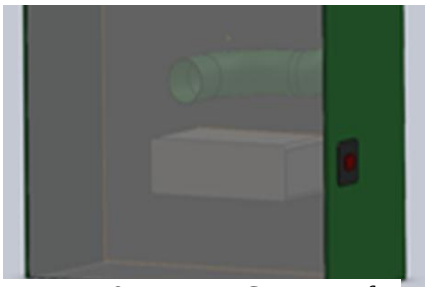

Figure 10 - Lower Section of Enclosure.

Figure 11 shows the solid model for the arm and guide cup. The diameter of the arm in this model is two inches which is slightly larger than the diameter of the golf ball (1.68”). The arm length is designed at 15.6 inches. This length with place the tee location at 7.5 inches from the front base of the enclosure. At the end of the arm is a guide that will stop the balls forward motion and guide the ball directly to the top of the tee. The arm will have a timed delay in order for the guide to properly seat the golf ball onto the top of the tee.

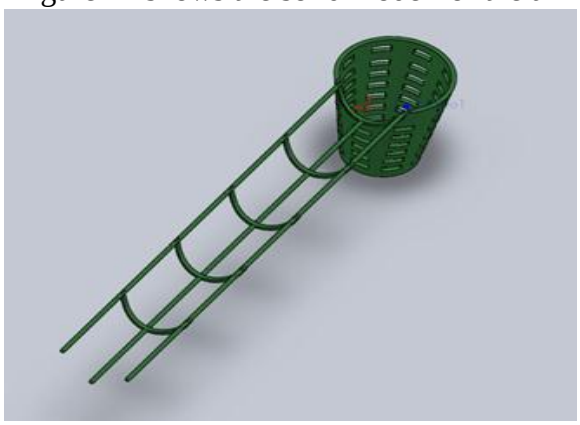

Figure 11 - Automatic Arm Model

LOADING CONDITIONS AND COMPONENTS

COMPONENTS AND DESIGN ANALYSIS

The standard diameter of a golf ball is 1.680 inches, weighing in at 1.620 ounces (0.03875 lbs.). This is totaling out that 0.831 lbs. pulling against the very end of the arm. Most lightweight aluminum will be able to withstand a one pound load at a maximum of one foot from the point of attachment. The additional weight of the cup in this context is negligible due to the fact that once the ball enters the cup the ball is in free fall. Therefore, adding no additional weight simultaneously to the arm or cup itself.

The motor being selected is a Black and Decker 7.2 volt DC motor operating at maximum of 2780 RPM that is capable of applying nearly 19 lbs. of force. Being that the maximum amount of force with the weight of the arm included could top out at nearly 4.3 lbs. there is no concern for undermining the factor of safety. The motor itself uses 7.2 volt battery system that is connected to a rectifier allowing it to be powered or simply charged on a standard 110 volt outlet while able to run a variable speed setting. The motor will be driving a series of gears connected to a six inch drive shaft that will be driving the arm forward and backward. This motor that was selected had to have a forward and reverse gearing in order to be able to retract the arm via mechanical means and not manual effort. The gearing for this motor was included with the motor; however it needed to be re-geared in order to slow the rotational speed of the motor. This was done by

Figure 13 - Black and Decker 7.2v DC Motor

Figure 12 - 1.5" Upgraded gearing

using the gearing from a 24.4 volt-high torque motor. The driving gear was nearly 2.5 times larger therefore drastically reducing the speed. This seemed to be the best route due to its rpm capabilities, variability of the speed range, as well as available output force. With that being said, purchasing an already plenty capable motor is the most cost effective route, on the manufacturing end and the consumer end. This was a simple approach towards reducing the rpm's to reaching the desired setting. This larger gearing will prove to be one of many approaches to reducing the overall rotational speed of the entire system.

ELECTRICAL

The purpose of The EZ Auto-Tee is to remain completely autonomous with the absolute minimum amount of user interfacing, while still allowing the user to be in control. What is meant by this is that once the user empties a maximum of fifty seven golf balls into the hopper of the EZ Auto-Tee, the system is ready to run at their leisure. In order to make this happen, a series of relay wiring, diode isolation and resistance had to be incorporated in order to actuate all motors and gears. In this system, the DC motor will only be operation when a pressure switch (N/O) is engaged and held at the normally closed position. Once the switch is released, the motor stops. In addition, a switch must be activated in order for the motor to receive a reverse signal which once again, the pressure switch must be applied for motor operation. In order for this series of events to occur completely autonomously, it took nine relays, six diodes, three resistors(1,000 ohms), one variable speed resistor(potentiometer) and one capacitor(10k μF). The accumulation of these components will activate the system with the push of a button to run continuously until the ball has been placed onto the tee and the arm has retracted back to the starting position. The DC motor and DC wiring schematic was chosen also in part due to its ability to resist weather. DC electronics can operate normally when wet without creating any form of short within the system. However, when fully submerged for any amount of time, they will quickly corrode and fail. The EZ Auto Tee is designed to be fully operational under all normal weather conditions.

Figure 14 - 12v DC Relays (SPDT)

FABRICATION AND ASSEMBLY

ENCLOSURE/HOPPER

The enclosure for the EZ Auto Tee is made of lightweight sixteenth inch steel that has been painted to prevent rust and corrosion. The enclosures dimensions are 24.5'x 14.25"x 18" which is slightly larger than what I originally had needed. One of the main issues in the customer requirements was to ensure this system was not too loud. In order to achieve this, the interior walls are lined with eighth inch thick sound deadening tar mats. These mats prevent any material from rattling while keeping noise reverberating inside the enclosure. While the addition of the sound deadening slightly increased the overall weight of the enclosure, the benefit of it greatly outweighed the additional weight, which also meets customer satisfaction requirements. In addition, an oversized locked door has been added to the rear of the enclosure. This was added for ease of access to the entire system (motor, electrical wiring, drive shaft, etc.) for any type of cleaning and maintenance that may be required.

Figure 15 - Integrated Golf Ball Hopper

In order to ensure ease of golf ball adding and holding; a large hopper has been flush mounted within the top section of the enclosure. The dimensions of the hopper are 15.5" x 11.25" with a tapered three inch storage leading to a two inch diameter tube that will direct the golfs balls to the loading position of the arm. The hopper is made of lightweight aluminum to be able to withstand the rapid placement and applied weight of the golf balls being dumped in. The hopper also has sound deadening added to the sides and underside to minimize any addition noise created in the process. The main purpose of this hopper is to make it easier for users to literally dump in a larger amount of golf balls to prevent them from having to keep adding golfs balls through their practice session. The golf balls are funneled through the hopper to the two inch tube where they will be stored until continuously cycled through one by one each time the arm drops the previous ball onto the tee. In total, the hopper and the placement tube can hold a maximum of 57 golf balls. This is three golfs balls short of a standard "medium bucket" at most driving ranges. Prior to the addition of the golf balls, the overall weight of the EZ Auto Tee is just 31 pounds. This is due partly to the slightly larger enclosure than anticipated. However, even at 31 pounds the system is still portable, and use of the supplied casters is recommended.

ELECTRICAL

This specific DC motor operates solely on the continuous applied pressure to a finely tuned pressure switch wired directly to the motor from a 7.2 volt battery. The design for the EZ Auto Tee is to be completely autonomous, while at the users' discretion. In order to achieve this, a series of nine relay assemblies (SPDT) had to be wired into the motor. Each relay is activated by the previous relay, or by a pin switch. The first three relays are activated by the activation push button (N/O pin Switch). As the arm reaches its lowest point, it strikes a second pin switch. This pin switch creates a one second delay for the ball to settle before the next two relays activate the reverse of the motor. The final relay is wired to a 10k µF capacitor. This capacitor stores charge long enough for the arm to fully retract to its starting position before it runs out and the final relays shuts the system off. Each relay has a maximum rating of 14 volts. Within this wiring system are six diodes. These diodes are wired in series with the main power, and the reverse sequence in order to prevent the back feed of current into the previous relay assembly. The entire system can be battery operated or can be plugged directly in using the provided 110 volt AC plug with built in rectifier. Once all nine relays have been added to the system, it required a minimum of 6.8 volts of power to operate the motor and all of its counterparts.

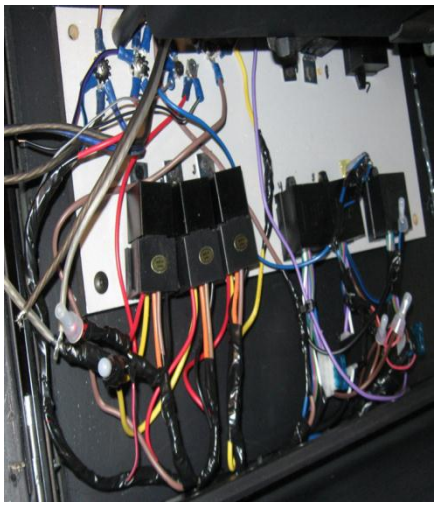

Figure 16 - Electrical Wiring for full automatic operation

AUTOMATIC ARM

The automatic arm will be controlled by the motor and essentially guiding and "placing" the ball onto the tee. This arm is made of 1.5 inch PVC tubing that is cut in vertically. Being that the diameter of a golf ball is larger than the 1.5 inch diameter arm, the inner edge is sanded down to a 45 degree angle. This is done to ensure the stability of the all while rolling down the arm. Since the diameter is slightly smaller, it will hold the ball in place and reduce all wiggling or bouncing which would occur using a two inch diameter arm. Since there will be no "wiggle room" as the ball is proceeding down the track, it maximizes a smoother transition from track to tee with a more steady placement with the help of the placement guide at the end of the arm. The guide ring at the end of the arm is a ¼ inch slab cut off the end of a two inch diameter piece of PVC. The two attached points are also cut to a 45 degree angle to be melted onto the end of the arm. This small rings main purpose is simply to stop the golf balls forward momentum and guide it directly onto the tee. This smaller ring is used rather than a larger tapered cup to minimize the chance that the end of the cup will knock the ball off of the tee once the arm begins to retract.

Figure 17 - Automatic Arm and Guide Ring

In order for the arm to retract back to its original position, there is a small pin switch mounted on the enclosure at the stopping point for the arm. When the arm reaches its lowest most point, this pin switch is activated shutting off the forward motor, and activating the reverse motor. This pin switch is a simple normally closed push button switch that activates when pushed one time.

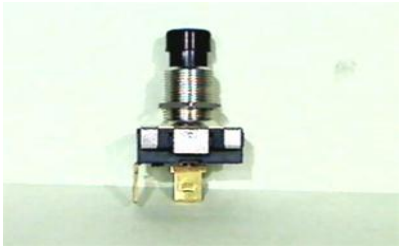

Figure 18 - Pin Switch, located at lower stop point under automatic arm

MOTOR ASSEMBLY

The DC motor and the 7.2 volt battery system is assembled inside of a water tight box. The motor needed to be slowed from its original 2780 RPM, in order to achieve this gearing from a higher torque motor (2.5x the original) is replacing the drive gear reducing the RPM around 38%. Also wired in series between the battery and the motor is a variable speed resistor. This potentiometer will allow for control of resistance to the motor therefore decreasing the overall rotational speed. This box is mounted three inched above ground level to prevent any water or debris from entering the motor and the gearing. The box is mounted to two steel "L" brackets as well as to the inner side wall of the enclosure. This dual mounting approach will ensure that the motor and drive shaft assembly does not twist or move during operation. Two small ¼ inch holes are on the reverse side of the box allowed for the wiring to the battery and motor. The drive shaft exits the box on the right side and connects directly to the arm.

TESTING

METHODS AND RESULTS

Most of the testing for the EZ Auto Tee was performed during fabrication of the individual components. Upon reviewing specifications and comparing the gearing of the two motors, it was concluded that they would mesh. The gears were inserted into the system and ran multiple times consecutively to endure proper fitment and meshing.

The electrical system for the EZ Auto Tee is the next most important component. This required a series of checks and power test during production to ensure there would be no overload or back feeding into the system. The addition of multiple diodes and resistors were placed in series with most of the activation relays to avoid any malfunction.

EZ AUTO-TEE			
Customer Test Results per 10 cycles			
	# Missed Tee	# Jammed	Other/Comments
1	X, √	√, √	Arm is too fast
2	√, √	√, √	Arm is too fast
3	√, X	√, √	easy to use, arm too fast
4	X, √	X, √	Arm is too fast
5	X, X	√, √	Arm is too fast
6	X, X	√, √	Arm is too fast
7	X, √	√, √	Arm is too fast
8	√, √	√, X	easy to use, arm too fast
9	X, X	√, √	Arm is too fast
10	√, X	√, √	Arm is too fast

Table 7 - Testing Results for two users, 10 cycles each

Table 7 above is the result of a series test with two different users at different times. Each user loaded 10 golf balls into the system and ran continuously through. This table was created to get an accurate idea of the final product as compared to the initial design requirements. We can conclude that they speed of the motor/arm assembly is too fast for ideal operation. This was also noticed during initial testing of the motor and was reduced using a series of resistance with the motor. However, the speed of the motor still proved to be too fast for the application. The motor/arm assembly is working properly and accurately with the tee, but the excessive speed of the arm does not allow enough time for the golf ball to settle on the tee. During customer testing, only 42% of the golf balls remained on the tee while the remaining were either dropped off of the arm or knocked back off the tee due to the abrupt speed of the system. Jamming was not a true concern, only two of twenty were reported jammed, but again this is entirely due to the excessive speed of the motor.

PROJECT MANAGEMENT

SCHEDULE

In order to maintain steady work progress, a schedule was created dating from November through early June for the completion of initial and final reports. Table 7, found below is a condensed version showing only the main portions of project. This schedule will act as a guide to help navigate and keep the designer on track with a proposed project completion date and record all variances.

Keith Mazuk - EZ Auto-Tee	12/6 - 12/12	12/13 - 12/19	12/20 - 12/26	12/27 - 1/02	1/03 - 1/09	1/10 - 1/16	1/17 - 1/23	1/24 - 1/30	1/31 - 2/06	2/07 - 2/13	2/14 - 2/20	2/21 - 2/27	2/28 - 3/06	3/07 - 3/13	3/14 - 3/20	3/21 - 3/27	3/28 - 4/03	4/04 - 4/10	4/11 - 4/17	4/18 - 4/25	4/25 - 5/01	5/02 - 5/08	5/09 - 5/15	5/16 - 5/22	5/23 - 5/29	5/30 - 6/05
Task																										
Proof of Design		14																								
Preliminary "EZ Auto-Tee Design"									2																	
Finalized Design									5																	
Order Materials									6	12																
Fabrication															17	21										
Assembly																		6	13							
Testnig																					28					
Modifications																						8	14			
Final Testing																							15			
Advisor Demo																								20		
Faculty Demo																								20		
Spring Presentation																									27	
Final Report Due																										3

Table 8 - Condensed Work Schedule. (Yellow Highlight is proposed, red is actual)

Due to a lack financial presence, the parts for the EZ Auto Tee were not ordered on time. The parts were finally ordered nearly a week later than scheduled. Once the parts arrived, fabrication was nearly five to seven days behind throughout the entire process. Since most of the testing for the EZ Auto-Tee was completed throughout the fabrication process, so final testing did take the planned amount of time. This allowed an on time completion.

*To view the entire projected work schedule, please see Appendix F.

BUDGET

One of the primary focuses of the designer was the preliminary cost estimations for the project. A preliminary budget was created by researching the many proposed parts that would be specific to the EZ Auto-tee. These costs are only projected amounts as the actual cost will vary some, but will be within a small deviance from these projected amounts. Table 9 on the following page shows the tentative budget with the projected cost for parts and materials necessary.

Budget		
Components	Projected Cost	**Actual Cost**
Motor	$ 160.00	$ 30.00
Enclosure	$ 350.00	$ 40.00
Hardware	$ 110.00	$ 60.00
Wiring	$ 195.00	$ -
Sensor	$ 90.00	$ 20.00
Hopper	$ 27.00	$ 10.00
Mat	$ 325.00	$ -
Fittings	$ 33.00	$ 18.00
Labor		
Install Labor	Free	-
Misc. Parts	$ 25.00	$ 15.00
Total	$ 1,315.00	$ 193.00

Table 9 - Projected Budget – Actual Expenditures

Due to lack of financial resources, the budget had to quickly be reduced as much as possible. This partly came into play once the first ordered motor was received and did not operate at all out of the box. From there many other parts were spare parts and wiring except for specific pieces. Overall I was able to save nearly $1,100 through the course of the project.

*A complete budget will be maintained with actual costs located in Appendix G.

CONCLUSION

There are many varying opinions and methods to perfecting someone's golf game. But if you ask any instructor out there, they will tell you first and foremost to correct ones stance and positioning is the key beginning to a better game. The overall concept behind the EZ Auto-Tee is minimize as much as possible, if not reduce having to move from your current position to replace the ball after every time you hit. In this method, you can keep your current stance, and make the possible slight adjustments where and if necessary from there, instead of starting all over with a new stance after every hit.

During the process of designing the EZ Auto-tee, many varying ideas have come up and grabbed my attention, many of them revolving around the complexity of the mechanisms and the potential mobility of the system. Due to these new concepts, some of my initial designs did change. For example instead of having the complete system located under the golfer, it is not enclosed in front of the golfer utilizing the standard 110 volt outlet instead of pneumatics. This is a large cost saving change for the system. Another change for the mobility aspect was reducing the size of the enclosure and constructing it of lightweight steel to make it easy to carry. Ultimately, the new design and the selection of components have reduced the overall cost by nearly 80%. Upon completion of the EZ Auto-Tee system, we will be able to improve the users' golf game in a much quicker manner, which ultimately is the goal for all golfers. The motor was also change due to a defective original motor. The DC motor was chosen due to its ability to resist the elements better, as well is the inexpensive cost.

As concluded from Table 7 on page 22, the failure 58% failure rate is dependent solely on the excessive speed of the motor. However, even with the excessive speed of the system, 42% of the golf balls still remain on the tee. Unfortunately due to financial obligations and time constraints, the speed of the system remains slightly faster than desired. When considering the complexity of the wiring that is involved with the EZ Auto Tee, a direct replacement of the motor with a slower is not feasible. A complete overhaul of the wiring schematic would be needed in order to directly correlate with the output rating of the new motor to once again avoid any feedback or overpowering the motor and relays. One the speed is controlled; this is a system that would be a great benefit to any golfer. Many people have expressed their interest in the system and its unique capabilities. However, this is a manufactured prototype of the EZ Auto tee, speed and size discrepancies will be corrected under the correct financial background.

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APPENDIX A – RESEARCH

http://www.teeit.com/TEE_IT_MODELS.htm 11/29/2010 **Auto Golf Tee, Mobile automatic golf tee.** teeit.com

No more bending over to tee another ball.

TEE IT automatic golf systems tee a new ball for you.

Just hit and another ball is brought to the turf, ready for the user to hit.

In automatic mode, systems can tee a ball every 1.5 seconds, allowing the user more time to practice.

TEE IT units are based on a design that has been thoroughly tested in a commercial environment.

Using this as starting point, units are designed to be especially pleasing to the eye, yet built to last.

With TEE IT, a golfer will use a bucket of balls up to 3 times faster.

Very High Cost
Does not require electricity
Up to 2" tee height
Internal storage up to 400 balls
Pneumatically powered
Mobile design
Replaces ball every 1.5 seconds

http://www.brandsonsale.com/sf-001310.html
11/30/2010
Automatic Golf Ball Tee Setter

This golf ball setter dispenser automatically tees a golf ball perfectly every time.

Allowing golfers to practice chipping, driving, or putting on grass or mats without changing their stance to set the ball.

To operate you simply lower the arm with your club and the device places the next ball onto the tee.

Measures roughly 12 high x 5 1/2 wide x 9 3/4 long

Low Cost: $39.99
Holds up to 35 golf balls at a time
No electricity or battery is required
Saves your back, arm returns automatically
Works for both left and right handed players

Interview with potential customer, Dec. 02, 2010
Donn Petit, Avid Golfer, 825 Merry John East, Miamisburg, OH, 45342.
Part-time instructor.
Has driving range just behind his home.
Has to constantly re-correct golfers stance and form.
Lower back problems for 9 years.
Extra time spent loading tees and adjusting tee height.
Would enjoy having golfers feet remain stationary.
Same tee height every time.
Hopefully quiet system to avoid breaking concentration.

http://www.eagletry.com/english/product/product01.htm
11/30/2010

Eagle-try Auto Tee

Auto Tee-up Machine

Rubber tee moves up and down without steps with height ranging from 0 to 60mm to accommodate varying size of the golf club

Special Feature

Steel-reinforced rubber tee protects itself from bending, falling off and wearing of the tee.

Tee-up cycle time: 3.1~ 5.2 sec. depending on tee height

Machine height : 256mm

When a ball is hit from the tee, the ball-sensor activates the agitating motor to air-blow another ball to the tee.

Very High Cost
Storing capacity : 1,000 balls (500balls per hitting area)
Ball sending method : air-blow
Ball agitating method : Disk agitation
Noise reduction (falling ball) : Buffer spring
Very Large for use

http://www.teego.com/tcpersonal.html
11/30/2010

Tee-Go Automatic Teeing machine

One-touch triggering— Teego is easily triggered by a simple tap on the ball release trigger with the golf club.

Natural surface compatible— Teego can be used on natural grass surfaces with its specially designed tee holder (patent pending).

Quick-load ball magazine—Quick load ball magazine makes reloading Teego a snap.

Large capacity—Teego holds 150 golf balls, 75 in the ball magazine and 75 in the reserve container.

Portable—Teego is light-weight, very portable and can be taken with you to the range.

Durable—Teego is made of durable impact and heat resistant plastic.

Quicker and more efficient practice sessions.

Less strain on the lower back since there is no need to bend over and tee up golf balls or retrieve them from a basket.

Low cost: $140.00
Personal use only
Holds up to 150 balls
Plastic design
No electricity needed
Portable

http://www.vending.com/Vending_Machines/Soda__Drink_Vending_Machines/12_Selections/
12/2/2010

'Refresh' Automatic Soda Dispenser

For cold sodas and fruit juices, bottled waters and iced teas, sports drinks, energy drinks and more. This soda drink vending machine offers them all. The 12 selection dispenses a variety of both canned and bottled beverage packages and has the largest capacity in its class. Features including a lighted product display, eye catching back lighted graphics, and easy to use customer purchase area makes the 12 Selection a powerful tool in beverage vending and customer satisfaction.

Height: 72" (183cm)

Width: 42" (106 cm)

Depth: 33 1/2" (85 cm)

Electrical: 115 VAC, 7.2 Amps (230 VAC, 3.75 Amps)

Refrigeration: 1/3 HP (115 VAC); R134a

Closed System

Cost: up to $1,000
Dispenses 322 bottles or 728 cans
12 varying choices
Large design
High power consumption
Stationary
Very heavy

APPENDIX B – CUSTOMER SURVEY

EZ Auto-Tee

I am currently a senior at the University of Cincinnati studying Mechanical Engineering Technology. The purpose of this project is to design an Automatic golf Ball setter for driving ranges. This is done to help golfers keep their stance and form without moving and bending over to replace the ball while minimizing time spent at the range. Please take a few moments to answer the following questions. Thank you for your time!

How important is each feature to you for the design of an Automatic Golf Ball Setter?

Please circle the appropriate answer. 1 = low importance 5 = high importance

System Safety	1 **(0)**	2 **(0)**	3 **(5)**	4 **(11)**	5 **(8)**	N/A	Ave=4.13
Reliability/Durability	1 **(0)**	2 **(0)**	3 **(0)**	4 **(9)**	5 **(15)**	N/A	Ave=4.63
Energy Efficiency	1 **(3)**	2 **(13)**	3 **(6)**	4 **(2)**	5 **(0)**	N/A	Ave=2.29
Ease of Operation	1 **(0)**	2 **(0)**	3 **(5)**	4 **(7)**	5 **(12)**	N/A	Ave=4.29
Speed of Operation	1 **(0)**	2 **(1)**	3 **(1)**	4 **(8)**	5 **(14)**	N/A	Ave=4.46
Weather Resistance	1 **(0)**	2 **(0)**	3 **(1)**	4 **(3)**	5 **(20)**	N/A	Ave=4.79
Quiet Operation	1 **(0)**	2 **(0)**	3 **(2)**	4 **(4)**	5 **(18)**	N/A	Ave=4.67
Ease of Assembly	1 **(1)**	2 **(2)**	3 **(8)**	4 **(10)**	5 **(3)**	N/A	Ave=3.50
Ease of Installation	1 **(1)**	2 **(1)**	3 **(4)**	4 **(9)**	5 **(9)**	N/A	Ave=4.00
Low Maintenance	1 **(0)**	2 **(0)**	3 **(11)**	4 **(5)**	5 **(8)**	N/A	Ave=3.87

How satisfied are you with current applications/trials of Automatic Golf Ball Setters?

Please circle the appropriate answer. 1 = very Unsatisfied 5 = very satisfied

System Safety	1 **(0)**	2 **(0)**	3 **(1)**	4 **(2)**	5 **(12)**	N/A **(9)**	Ave=2.96
Reliability/Durability	1 **(0)**	2 **(0)**	3 **(1)**	4 **(13)**	5 **(1)**	N/A **(9)**	Ave=2.50
Energy Efficiency	1 **(0)**	2 **(0)**	3 **(1)**	4 **(1)**	5 **(0)**	N/A **(22)**	Ave=0.29
Ease of Operation	1 **(0)**	2 **(0)**	3 **(2)**	4 **(2)**	5 **(11)**	N/A **(9)**	Ave=2.88
Speed of Operation	1 **(0)**	2 **(0)**	3 **(7)**	4 **(5)**	5 **(3)**	N/A **(9)**	Ave=2.33
Weather Resistance	1 **(0)**	2 **(0)**	3 **(2)**	4 **(2)**	5 **(1)**	N/A **(19)**	Ave=0.79
Quiet Operation	1 **(0)**	2 **(0)**	3 **(2)**	4 **(8)**	5 **(5)**	N/A **(9)**	Ave=2.63
Ease of Assembly	1 **(0)**	2 **(0)**	3 **(1)**	4 **(1)**	5 **(1)**	N/A **(21)**	Ave=0.50
Ease of Installation	1 **(0)**	2 **(0)**	3 **(0)**	4 **(2)**	5 **(1)**	N/A **(21)**	Ave=0.54

Low Maintenance 1 **(0)** 2 **(0)** 3 **(0)** 4 **(2)** 5 **(2)** N/A **(20)** Ave=0.75

How much would you be willing to spend on this system?

$500- $1,000(11) $1,000-$1,500(8) $1,500-$2,000(4) $2,000-$2,500(1) Ave=$1,395

What would you require the life expectancy to be for this system?

2-5 yrs. (3) 5-7 yrs. (12) 7-10 yrs. (7) 10 (+) yrs. (2) Ave=8.71 yrs.

APPENDIX C - QFD

Keith Mazuk EZ Auto-Tee 9 = Strong 3 = Moderate 1 = Weak	Physcal Size/Weight	Standard Parts/Equipment	Access Panel	Wear Resistant Material	Leak-Proof Enclosure	Quick Connect Wiring	Tee Load refresh Time	Manufacturability	Actuation method	Load Conditions	Customer importance	Designer's Multiplier	Current Satisfaction	Planned Satisfaction	Improvement ratio	Modified Importance	Relative weight	Relative weight %
System Safety		1	3						9	1	4.13	1.1	2.96	3.50	1.2	5.4	0.04	4%
Reliability/Durability	3	9		9	9	3		1	3	3	4.63	1.1	2.50	4.70	1.9	9.6	0.07	7%
Energy Efficiency		3				3	3		9		2.29	1.0	0.29	2.50	8.6	19.7	0.15	15%
Ease of Operation					1		9		9	3	4.29	1.0	2.88	3.50	1.2	5.2	0.04	4%
Speed of Operation	1						9		9		4.46	1.2	2.33	4.00	1.7	9.2	0.07	7%
Weather Resistance		1		3	9	3					4.79	1.1	0.79	3.50	4.4	23.3	0.18	18%
Quiet Operation				1			3		9		4.67	1.2	2.63	4.00	1.5	8.5	0.06	6%
Ease of Assembly	3	3	9					3			3.50	1.0	0.50	1.50	3.0	10.5	0.08	8%
Ease of Installation	9	3	3			3					4.00	1.0	0.54	2.50	4.6	18.5	0.14	14%
Low Maintenance		1		3	9			3	1		3.87	1.1	0.75	4.00	5.3	22.7	0.17	17%
Abs. importance	1.78	2.14	1.25	1.75	3.81	1.61	1.62	0.82	3.65	0.37	18.8					132.7		
Rel. importance	0.09	0.11	0.07	0.09	0.20	0.09	0.09	0.04	0.19	0.02								

APPENDIX D – PRODUCT OBJECTIVES

EZ Auto-Tee

The following is a list of product objectives and how they will be obtained or measured to ensure that the goal of the project is properly met. The product objectives will focus on an automatic golf tee setter to be used without the need for human intervention once the balls have been loaded.

Weather Resistance (18%)

4. Fully enclosed system will be tested for water resistance.
5. All hinges and access door will be water tested.
6. Small drain will be located in base for potential leakage.

Ease of Operation (17%)

4. Load balls into integrated hopper.
5. Once balls have been loaded, system runs with push of a button.
6. Next ball available at leisure of golfer.

Quiet Operation (15%)

2. Product will use quiet electric motor will be chosen by lower decibel level output to prevent disrupting the concentration of golfer

Speed of Operation (12%)

3. Next ball to be set within 3.0 seconds of activation.
4. Sensor initiates ball arm retracting once ball has crossed sensor plane.

Reliability/Durability (10%)

6. System will be designed and tested for weather resistance.
7. Materials will be selected after mathematical analysis to perform under enclosed and high or low temperature conditions.
8. Outdoor paints and lubricants will be used to increase life moving parts per desired facility location and owner request.
9. Sensors will be fully encased to protect from dust, dirt and debris.
10. Small drain will be located under tee hole for potential water diversion.

Low Maintenance (7%)

6. Enclosure with flush mounted handle for easy access cover.
7. All moving parts coated in waterproof lubricant.
8. Motion sensor/laser will have scratch resistant lenses.
9. Small drain will be located under tee hole for potential water diversion.
10. Can be maintained with periodic inspection and lubrication.

Ease of Installation (6%)

6. Pre-assembled system will be secured to ground with provided hardware per mounting location.
7. Flush mount handles will make transporting for one to two people easy.
8. Pre-wrapped cables will come with wall and ceiling install brackets.
9. Can be assembled with everyday use tools.
10. Product can be moved and manipulated and installed by one person.

Ease of Assembly (6%)

4. System will be fully enclosed with flush mounted handle for access cover.
5. Product will use standard “off the shelf parts” tested for the EZ Auto-Tee.
6. Can be assembled with provided, low cost parts.

System Safety (4%)

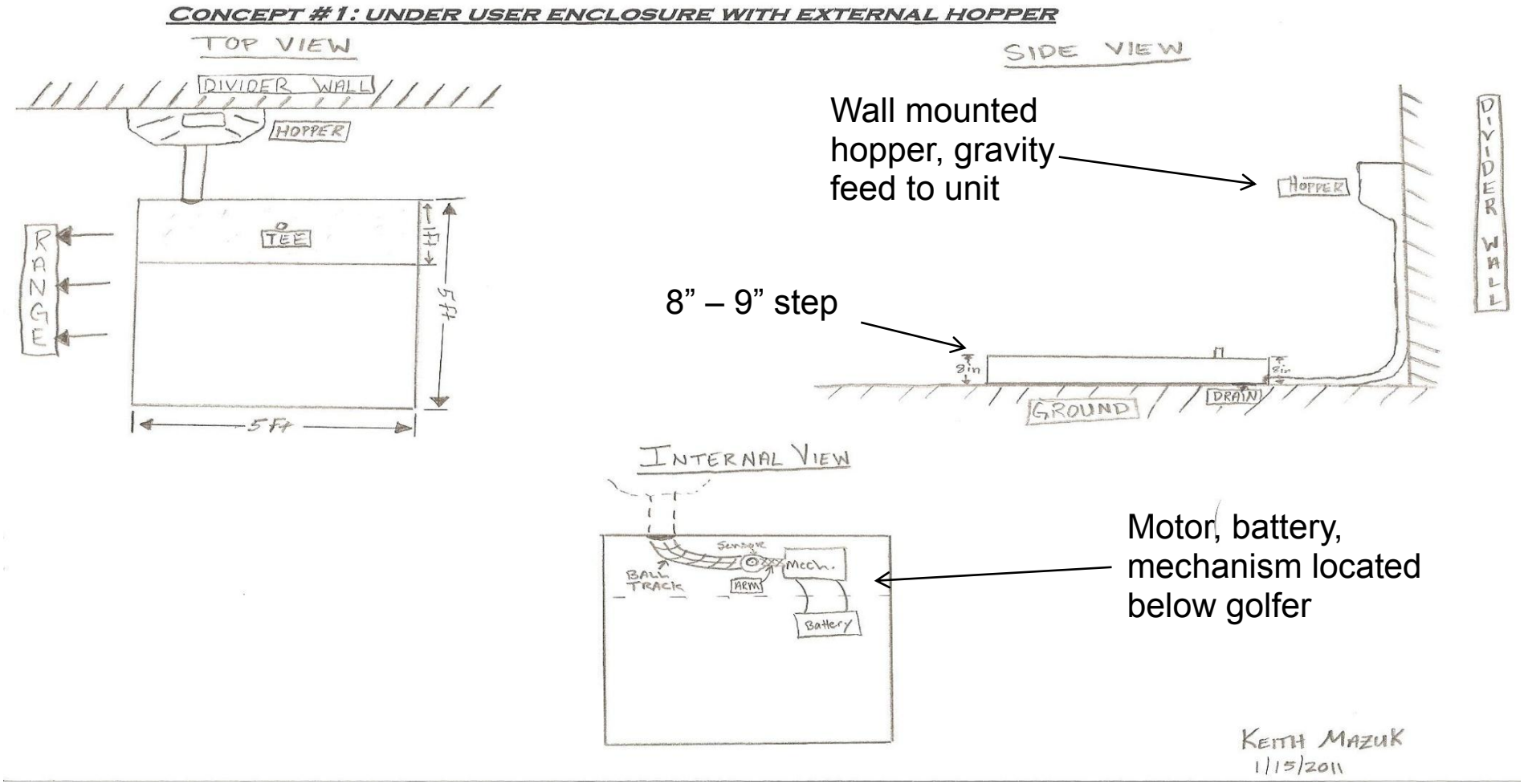
4. System will be fully enclosed with flush mounted handle for access cover.
5. System will have an automatic malfunction shut-off.
6. System will be equipped with manual safety shut-off switch.

Energy Efficiency (3%)

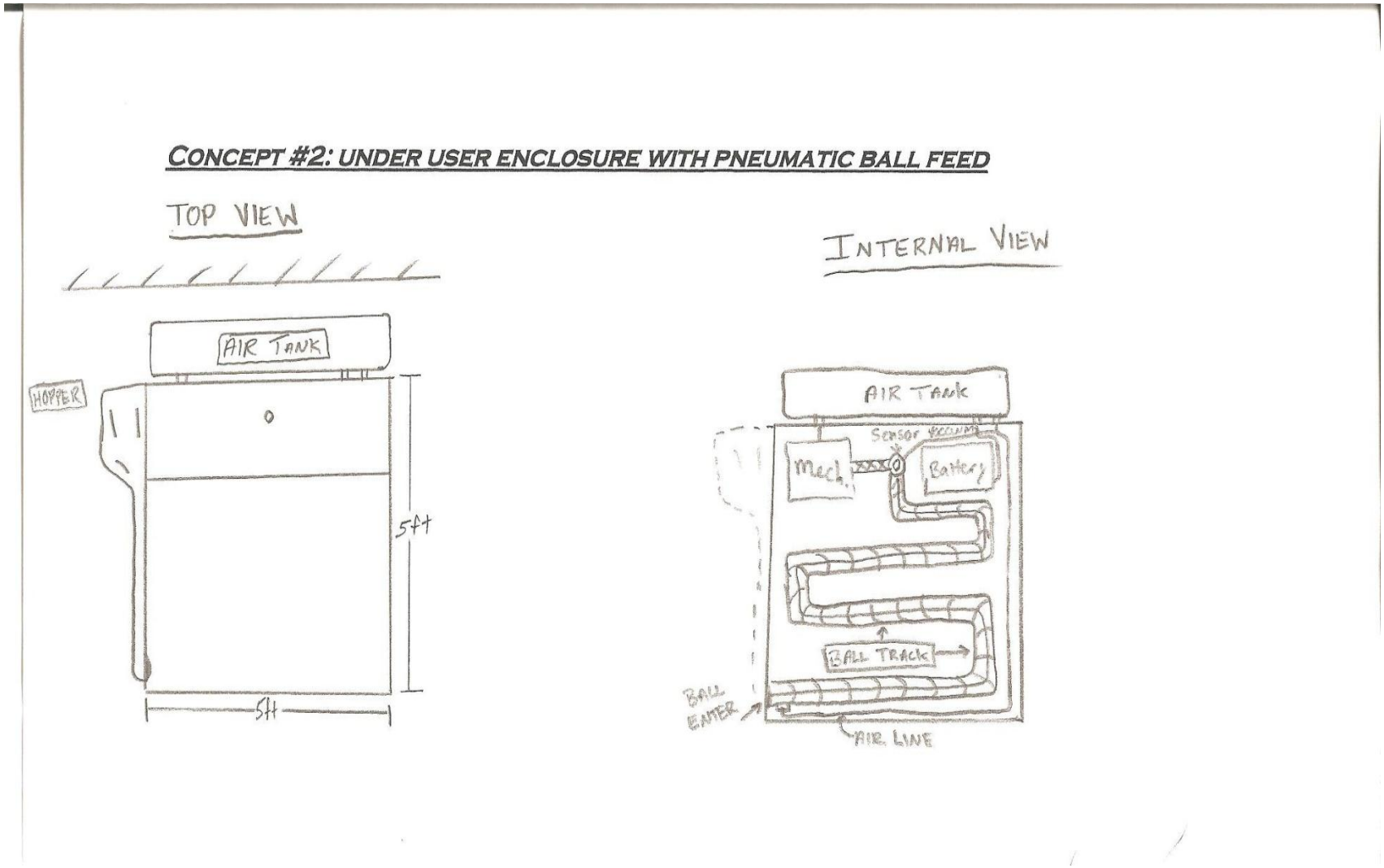
3. Linked power to main control. No more than 115 volts.

APPENDIX E – DESIGN ALTERNATIVES

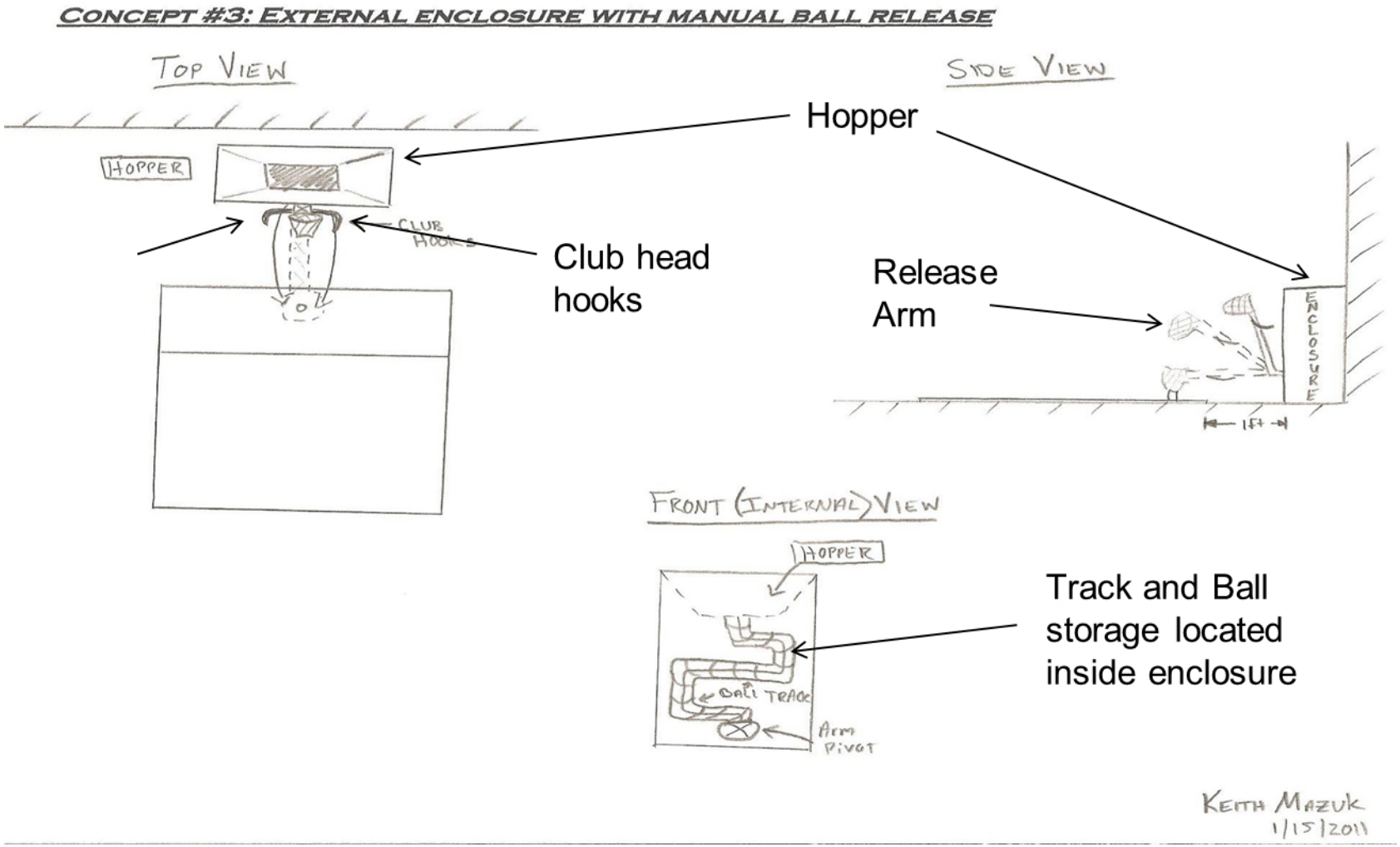
DESIGN CONCEPT #1



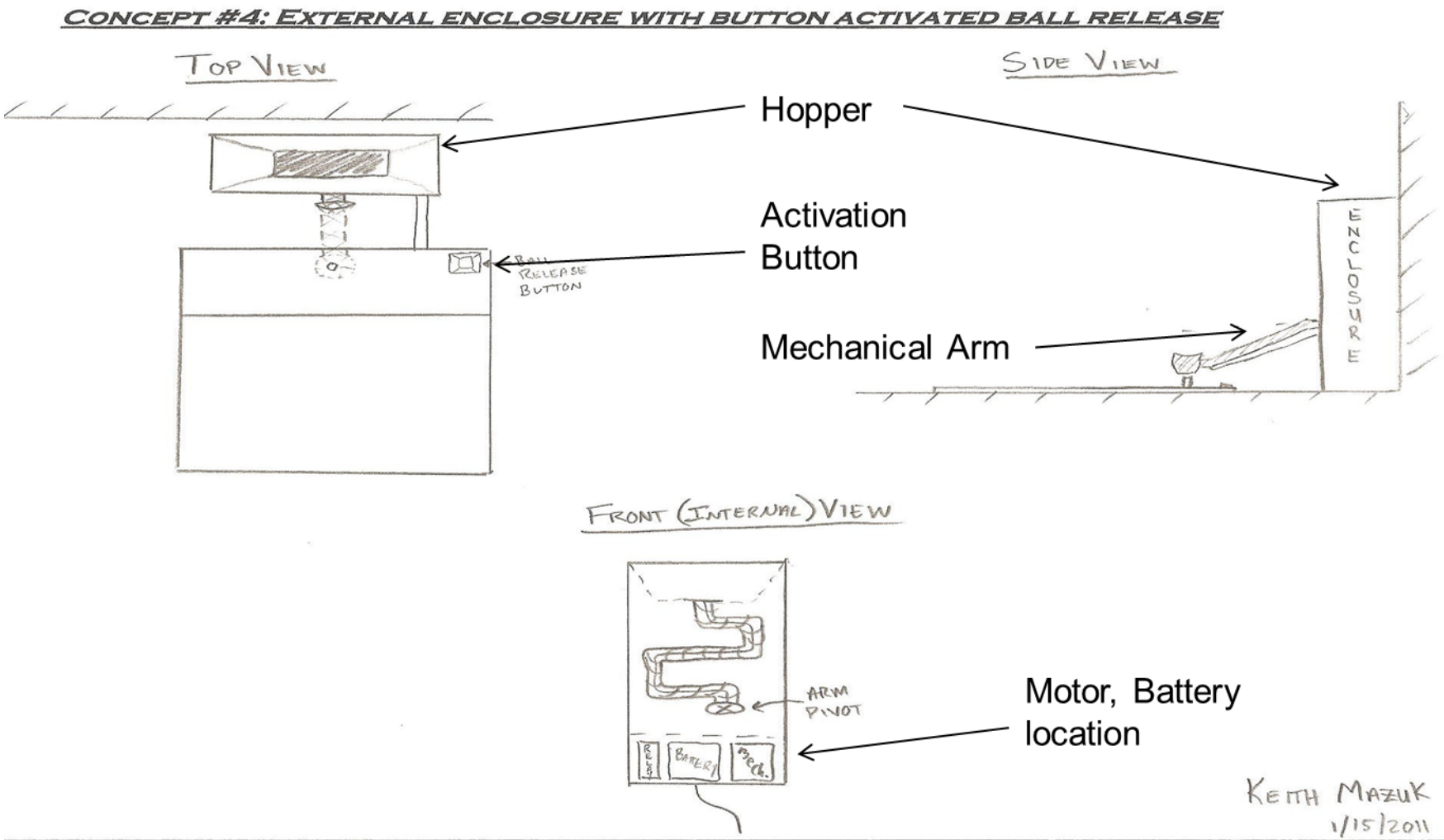
DESIGN CONCEPT #2



DESIGN CONCEPT #3



DESIGN CONCEPT #4



APPENDIX F – SCHEDULE

Keith Mazuk EZ Auto-Tee	11/21 - 11/15	11/28 - 11/22	12/5 - 11/29	12/12 - 12/6	12/19 - 12/13	12/26 - 12/20	1/2 - 12/27	1/9 - 1/3	1/16 - 1/10	1/23 - 1/17	1/30 - 1/24	2/6 - 1/31	2/13 - 2/7	2/20 - 2/14	2/27 - 2/21	3/6 - 2/28	3/13 - 3/7	3/20 - 3/14	3/27 - 3/21	4/3 - 3/28	4/10 - 4/4	4/17 - 4/11	4/24 - 4/18	5/1 - 4/25	5/8 - 5/2	5/15 - 5/9	5/22 - 5/16	5/29 - 5/23	6/5 - 5/30	6/12 - 6/6
DATE (BEGINNING EVERY WEDNESDAY)																														
TASK																														
Research			29																											
Customer Features			29																											
Survey			1																											
Product Objectives			5																											
QFD				8																										
Schedule				8																										
Budget				9																										
Appendices				9																										
First Draft Report				10																										
Autumn Report Due				10																										
Proof of Design					15																									
Concept Sketches								5																						
Best Concept Selection									12																					
System Requirement Calculations										19																				
Preliminary EZ Auto-Tee Design										19																				
Motor/Mechanisms/Sensor											26																			
											27																			
Enclosure/Cover/Hopper/Drain												2																		
												3																		
Design Freeze												4																		
Final EZ Auto-Tee Design												4																		
												6																		
EZ Auto-Tee BOM												5																		
Oral Design Presentation																4														
Winter Design Report																	7													
Order Necessary Materials															23															
Component Fabrication																		16												
																		17												
Assembly																					6									
																					13									
Product Testing																							20							
																								28						
Modifications																									8					
																										14				
Final Testing																										14				
																										15				
Advisor Demonstration																												20		
Faculty Demonstration																												20		
Final Project Presentations																												27		
Final Report Due																													3	

APPENDIX G – BUDGET

Budget					
Components	**Projected Cost**	**Description**	**Quantity**	**Unit Cost**	**Actual Cost**
Motor	$ 160.00	Black and Decker DC motor	1	$ 30.00	$ 30.00
Enclosure	$ 350.00	1/16 " steel w/rust proff paint	1	$ 40.00	$ 40.00
Hardware	$ 110.00	Hinges, Strut, Bolts,screw		$ -	$ 60.00
Wiring	$ 195.00	Surplus		$ -	$ -
Sensor	$ 90.00	Pin Switches	2	$ 10.00	$ 20.00
Hopper	$ 27.00	Aluminum tray w/ sound dead.	1	$ 10.00	$ 10.00
Mat	$ 325.00	Donated by Dick's Golf center	1	$ -	$ -
Fittings	$ 33.00	PVC	3	$ 6.00	$ 18.00
Labor					
Install Labor	Free		-	-	-
Misc. Parts	$ 25.00	screws, glue			$ 15.00
Total	$ 1,315.00				$ 193.00

APPENDIX H – WIRE SCHEMATIC