

PING PONG BALL LAUNCHER

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PING PONG BALL LAUNCHING SYSTEM

ABSTRACT

Ping pong ball launching devices can be used in methods of practicing when a human opponent isn't available to return volley. Currently there are few systems on the market but due to the expensive and design of the systems, purchasing one of these systems may not be in a ping pong player's best interest. The purpose of this project was to design an improved and cost efficient ping pong ball launcher. The ping pong ball launcher created was an innovative design that used variable speed controlled motors to disperse balls onto a launching track then launch the balls as well. The designer will demonstrate the functionality of their novel, cost efficient ping pong launcher and how to raise the awareness to customers in selecting the more cost effective option.

ACKNOWLEDGEMENTS

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INTRODUCTION

BACKGROUND

The game of ping pong is a multiple person sport but when it comes to practicing, it is usually completed solo. Practicing shots and serving methods are possible but without another person to volley, serves cannot be returned which can affect practice. The systems that are currently available on the market cost more than an actual ping-pong table itself and are missing some essential features to enhance practicing methods. I plan to design an affordable ping pong ball launcher which will launch ping pong balls across the table(a distance of about 1 meter) so that the balls can be returned as in an actual game, thus enhancing solo practice. In addition to the design of this system, a new feature will be added to enhance a player's precision which comparable systems don't have. Ping pong players of all ages will be capable of using the system. The system will be designed to cost less than and comparable systems and the components of the system will be environment friendly.

PING PONG BALL LAUNCHER COMPARISON

ROBO-PONG 2050, ROBO-PONG 2040, BUTTERFLY SMARTPONG ROBOT AND TTMATIC 505B PING PONG ROBOT

Ping Pong Ball Launcher Comparison			
	Robo-Pong 2050	Robo-Pong 2040	Butterfly Smartpong Robot
Table Attachment	Yes	Yes	Yes
Programmable	No	No	No
Continuous Feed	Yes	Yes	Yes
Adjustable Height	Yes	Yes	No
Jam Resistance	Yes	Yes	Yes
Cost	\$ 799.00	\$ 499.00	\$ 1,799.00

Table 1- Ping-pong Ball Launcher Comparison

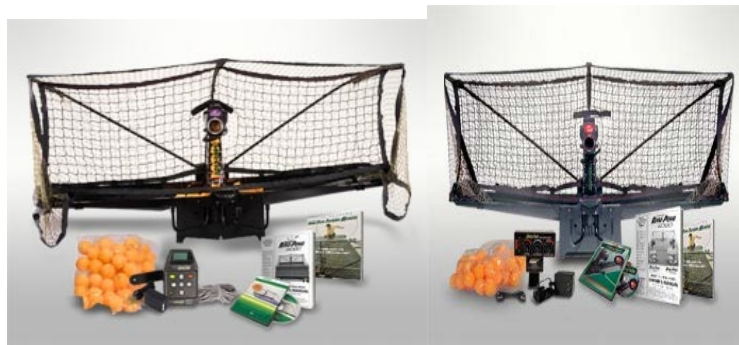


Figure 1- Robo-Pong 2050

Figure 2- Robo-Pong 2040



Figure 3- Butterfly Smartpong Robot

Ping-pong ball launcher systems are devices which are used to accurately launch ping-pong balls from the device to desired areas of a ping pong table so that a player can return the ball. The table and figures above compare three different types of ping-pong ball launchers based on some of the important features which are necessary in launching systems and areas of customer concern. Figure 1 is the Robo-Pong 2050 (1), Figure 2 is the Robo-Pong 2040 (2) and Figure 3 is the Butterfly Smartpong Robot (3). Starting from the beginning of this table, it is clear to see that each of these systems are ping pong ball launchers which are attached to one side of the ping

pong table, while the human player is located on the opposite side. One of the disadvantages of having the system attached to the table is that the system cannot be maneuvered from one location to another. Also, if the ping pong table is positioned in an area where there is not an even amount of space on each side, it could be difficult to complete practicing methods to the best ability. The system which seems to be mostly affected by maneuverability due to the table attachment would be Figure 1 2 3, due to the fact that each system is mounted on the end of the table.

Based on the reviews of the different systems, one of the main features which can distinguish the production of a launcher system would be the continuous feed feature. This feature is the control of how the ball is feed into the launching mechanisms and the rate at which the balls repeat this process into the system. Each of the launching systems in the figures has a continuous feed rate feature build into its system. Usually, the higher the feed rate of a system, the faster the system can retrieve and launch a ping pong ball. A feature which comes into play based on this continuous feed rate would be the jamming resistance. This is the resistance of multiple balls getting jammed into one area which stops the launcher from dispersing the balls properly. The jamming resistance is the basis on which a launcher system can perform the functional task properly; therefore it is vital to have some sort of design implemented into the launcher system. In figure 1 and 2, the Robo-pong robots have a feeding system where the ping pong balls fall into a narrow base which allows the balls to roll by means of gravity. The balls then roll into a vertical fixture which holds and moves the balls vertically into the position to be launched. Figure 3 is based upon the same concept as in figure 1 and 2. There is a slight disadvantage to this concept due to the fact that there is no type of mechanism which securely fastens the ping pong balls into the device which moves to the launcher; therefore a ball has the possibility of falling from the holding fixture.

One of the more important areas when selecting a launcher system would be the affordability of the overall launcher system based upon its need. For people who play ping pong as a recreational sport, spending several hundred dollars on a launching system would not be the most sensible option. Also, with the average cost of a ping pong table around \$550.00, spending an additional amount in that range for an additive which complements the playability of the ping pong table may not be the most cost efficient option as well. The average price of the systems in figure 1, 2 and 3 come out to be \$1032.33. Ideally, for a person purchasing a complete system at a price around \$550.00, it isn't likely that this person generously spend twice that amount on an addition to the system. The least expensive system is Figure 2 Robot-pong 2040 which is priced at \$499.00 and the most expensive is Figure 3 Butterfly Smartpong Robot which is priced at \$1799.00. The expense of these systems is an area in which customers will show a great deal of concern.

TTMATIC 505B PING PONG ROBOT

Ping Pong Ball Launcher Comparison	
	Ttmatic 505B Ping Pong Robot
Table Attachment	No
Programmable	Yes
Continuous Feed	Yes
Adjustable Height	Yes
Jam Resistance	Yes
Cost	\$ 3,699.00

Table 2- Ping-pong Ball Launcher Comparison



Figure 4- TTmatic 505B Ping-Pong Robot

The type of system in Figure 4 is a ping pong ball launching system which is not a table attachment style launcher as compared to those in the previous Figure 1, 2 and 3. The TTmatic 505B Ping-Pong robot rests on a wheel base which creates more options for maneuverability. Although this system is fixed to a wheel base, it posts one of the initial disadvantages similar to each of the launching systems in the previous figures. The TTmatic system takes up the entire area of one side of the ping-pong table. The wheel base will allow the system to be moved but if there is a restriction on space where there ping-pong table is located this can present a problem. One of the features which the Static 505B system has which the other systems don't would be the feature to program the spin of the balls launched as well as the speed on the balls launched. Figure 4 shows the control panel with the different functional options used for controlling speed, launching selection, distance and ball placement. The use of this style of technology is not only intelligent but sophisticated as well, but this type of technology will directly affect the overall total price of the system. Comparing the price of the TTmatic 505B with the systems in Figure 1, 2 and 3, the TTmatic is cost almost more than double the cost of the most expensive system in Figure 3 which is listed at \$1799.00. The TTmatic starting price is \$3699.00, which seems to be a very expensive addition to a ping-pong table which average cost is within the \$550.00 range. For professional players who compete in tournaments for cash prizes, this system would be a good option, but for players who play ping pong as recreation, this

system would more than likely not fit the budget.

COMPARISON SUMMARY

GENERAL INFORMATION

The four ping pong ball launching systems discussed in the comparison information all present features which separate each system from one another and it becomes clear which system is considered to be the better option and why. The vertical ping pong ball launcher design concept will not only focus on the important features which are discussed in this comparison, but also the features which are overlooked which also have the possibly of gaining the customers attention.

CUSTOMER FEEBACK, FEATURES AND OBJECTIVES

CUSTOMER IMPORTANCE AND DESIGN MULTIPLIER

Customer Importance and Design Multiplier		
Feature	Rating of Importance	Design Multiplier
Safety	5.0	1.08
Cost	4.8	1.10
Ease of Use	3.8	1.05
Jam Resistance	3.8	1.08
Accuracy	3.6	1.09
Assembly Ease	3.6	1.12
Appearance	3.5	1.02
Durability	3.5	1.09
Maneuverability	3.0	1.08
Noise	3.0	1.02

Table 3- Customer Importance and Design Multiplier

Table 3 displays the Customer Importance and the Designer Multiplier. The Customer Importance comes directly from the Customer survey and in this area customers rate features based on which features has the most importance. The safety of the ping pong launching system was the most important feature and this is understandable because when working with a mechanical system which presents different types of potential hazards, the most important aspect is the process being completed safely. Some of the other top rated featured based on the customer importance were the jam resistance, ease of use and the cost of the system. Some of the features which the customers felt weren't as important were the maneuverability of the system, the noise and the system's appearance. After reviewing the level of importance for each feature, the design multiplier then comes into the situation. The design multiplier indicates a possible percentage of the improvement in the rating of importance for each feature. The designer multiplier is determined by the designer based on how important and feasible the importance of the certain feature would be. For example, the feature with one of the highest design multiplier's would be the maneuverability. From the designer's standpoint it is clear to see that this feature was not one that the customer viewed as being one of the most important. But it should be kept in mind that the space surrounding a ping pong table may not be equal on both sides; therefore a player could become comfortable being on one side's as compared to the other. With the system having a maneuverable feature, this takes in account the limitations of space and can increase the movement and location of the system. One of the most important feature's in line which had the second highest designer multiplier was the cost of the system. Usually the more total features and more capabilities of the system, the higher the overall cost of the system. This system will potentially incorporate similar features of the comparable systems, but the means of use and design of this system will result in costing less than the comparable systems. The remaining design multiplier factors were determined on a similar basis by evaluating the importance of the feature and the feasibility for room of improvement for each

feature.

PLANNED SATISFACTION, CURRENT SATISFACTION AND IMPROVEMENT RATIO

	Current Satisfaction
Feature	Rating of Importance
Safety	1.0
Cost	1.0
Ease of Use	1.0
Jam Resistance	1.0
Accuracy	1.0
Assembly Ease	1.0
Appearance	1.0
Durability	1.0
Maneuverability	1.0
Noise	1.0

Table 4- Current Satisfaction

Listed in the table above are ratings for the current satisfaction. The current satisfaction is a rating of how the customer currently is satisfied with each feature of the system. The current satisfaction ratings are all listed as 1's due to the fact that all the customers that were surveyed did not currently have a ping pong ball launching system. Therefore the current satisfaction values were all listed as 1's ensure that the QFD data would be accurate. They were no stand out features based upon the current satisfaction, but with the help of the customer review information decisions were made on which features would have the higher ratings of planned satisfaction as compared to others.

The customer reviews placed a heavy emphasis on important feature which customers gave a good amount of feedback. The features were the affordability of the system, proper use of the system and assembly of the launcher. Several customers stated that in the case of recreational sport, spending a larger sum of money on an addition to a system isn't always a feasible option. In the case for the proper use of the system, many customers stated that a younger age group of players would be using the system so the difficult of the controls of the launcher system is an area which has a high level of importance. Due to the fact that a younger age group of players will be using the system, the launcher needs to be designed in ways that younger adults could know how to assembly and well as fix minor problems of the launcher system. These reviews of comparable systems allowed the designer to use the information on features of the other launcher systems to help establish guidelines for new design of the ping pong ball launching system.

Modified Importance	
Feature	Importance Rating
Safety	5.4
Cost	5.3
Assembly Ease	4.3
Jam Resistance	4.3
Ease of Use	4
Maneuverability	3.9
Accuracy	3.9
Durability	3.7
Appearance	3.7
Noise	3.1

Table 5- Modified Importance

The modified importance signifies the level of importance which is weighed on each of the customer features. This calculation involves the customer satisfaction, design multiplier and the improvement ratio. Based on the feedback of the customer satisfaction, the designer is able to select which features are most important and also which features are most attainable for improvement of the design. Then based the feasibility of the design for each feature would be, the designer implements the most suitable design multiplier which will produce a certain level of planned satisfaction which the designer believes in attainable. Multiplying these three factors; current satisfaction, design multiplier and improvement ratio will produce the modified importance. Looking at the modified importance from a designer's standpoint; over the analysis of the previous figures the noise feature was not one of the features which customers believed needed to be altered; therefore this features modified importance level was low. On the other hand throughout this analysis and from the previous figures, cost turns out to be a feature which displays a high level of importance for the customers and the designer; therefore the cost will be taken into account highly as compared to any feature and will result in the highest modified importance.

ENGINEERING CHARACTERISTICS

Engineering Characteristic	
Characteristic	Rating
Structure of Design	4.62
Specified Components	4.36
Material Selection	3.63
Assembly	3.32
User Friendliness	2.78
Efficiency	2.45
Weight	1.91
Size	1.67
Affordability	1.64
Guarding/Warning Labels	1.26
Tool Selection	1.00

Table 6- Engineering Characteristics

Table 6 lists the engineering characteristics which are used to give a detailed explanation of the aspects that will be incorporated into each of the customer features. Structure of design holds the highest rating because the means in which the launching system is designed is the most critical aspect to the success of the system. The specified component of the system is the next leading engineering characteristic. The launching system requires specific components based on calculations to achieve the desired launching goals of the system; therefore it is very important the correct components are used in the system to provide the most accurate results. The tool selection of the system is one of the engineering characteristics which suffer the biggest disadvantage. Due to the fact that the system will be designed to use common household tools to perform repairs on the system, a wide variety of tools will not be needed for this launching system. The same process is completed for each of the engineering characteristics on the same basis.

PRODUCT FEATURES AND OBJECTIVES

The product objectives which are developed come directly from the list of customer features that are determined in the customer surveys. Engineering characteristics are then used as a cross-reference with the customer features to identify the areas where there is strong, moderate or no correlation. Below the listed features are the objectives that will be used to incorporate this feature in the designing process.

- **Safety: 13%**
 - Guards will cover the component which launches the ping-pong balls
 - Every part would be screwed/bolted to the frame using lock washer and crown bolt to ensure no loose components within the device
 - Warning labels will be placed on areas of the system which could be hazardous
- **Cost: 13%**
 - The system will not exceed more than an additional 25% of the desired average price based on the survey results (\$242.00, with 20% \$325.40)
- **Jam Resistance: 11%**
 - The diameter of the track which the ping-pong balls flow thru will have a 10 – 30 millimeter clearance
 - A wheel/holder device will be a component on the ball track which slows the speed rate at which the balls are dispersed
 - The open-ended launching area will give the ping-pong ball open space to launch and help avoid any jamming thru a tunnel
 - Rubber wheel which is attached to shaft of the motor will propel the ping-pong ball
- **Ease of Use: 10%**
 - There will be four components or less which have be turn to the “ON” position for proper use
 - Photographic instructions will show the steps to take to properly use the system
- **Assembly Ease: 10%**
 - 6 or less components will have to be up together in order for the system to function
 - Step-by-step photographic instructions will explain how to assembly the system and how to properly use the system
 - Assembly of the system will only require common tools (flat-head/Phillips head screw drivers)
- **Accuracy: 10%**
 - The system will have a rotation base so that the ball can be launched to different areas of the ping-pong table

- The angle of trajectory will be designed to be launched over a regulation 6-inch table tennis net
- Balls will be launched from the launcher with a vertical spin motion similar to a basic serve as a human player
- **Maneuverability: 9%**
 - Wheel base on the system will allow the system to move horizontally across the table
 - System will not exceed 100lbs all pieces included
- **Durability: 9%**
 - Material used will be able to withstand household temperature conditions
 - All components within frame will be securely fastened by air nails or bolts with lock washers
 - The material MDF will be used for the frame. This material can withstand high loads and is designer friendly
- **Appearance: 8%**
 - Motor will be mounted to the base of the frame
 - The top and front portion of the system will be covered with ¼" sheet acrylic so that user cannot see inside the system
 - All components will be enclosed except for the hopper and side targeting device
 - System will be painted black to be comparable to similar systems
- **Noise: 7%**
 - Decibel level of the system will be in the range of 60 to 70dB

CONCEPT GENERATION AND SELECTION

TABLE ATTACHMENT DESIGN

The first concept shown in Figure 6 will be referred to as the Table attachment design concept. This system follows the style of the launching systems which are attached to on one end of the table. The base of this launching system will be designed with a wheel attachment structure which allows the system to move horizontally along one end of the table. The ping pong balls will be held and launched by means of a hopper and a swivel track system. The ball will leave the hopper, travel along the swivel track throughout the system, hit the launching wheel then be launched from the system. On the back upper frame of the system there will be a netting attachment which ping pong balls can be directly aimed towards by the player returning the ball in the netting area.

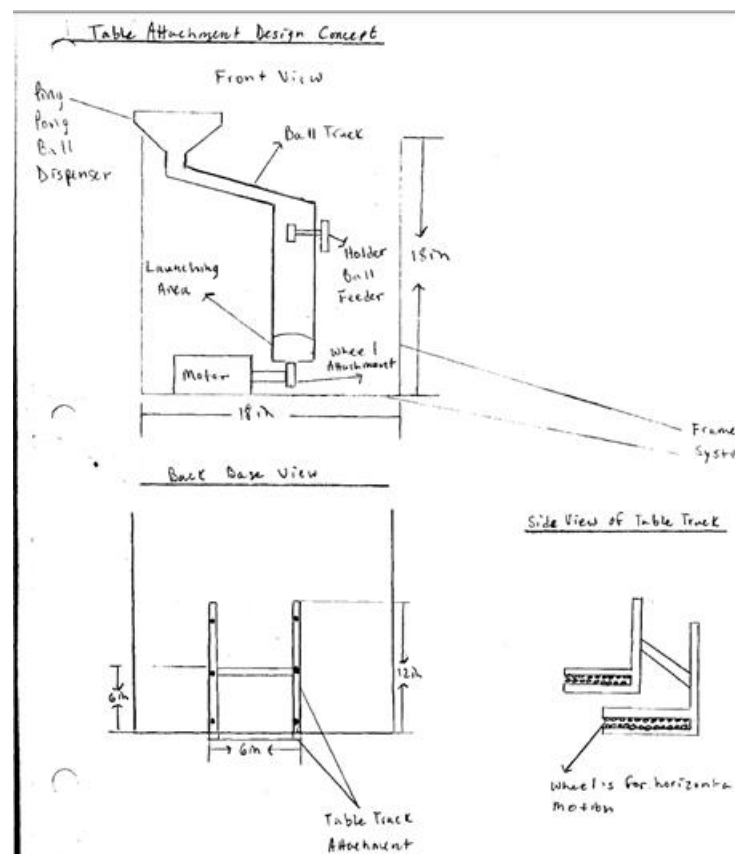


Figure 6- Table Attachment Design

VERTICAL BALL LAUNCHER DESIGN

This concept shown in Figure 7 will be referred to as the Vertical ball launcher design concept. This system differs from the style of the table attachment concept due to the fact that this system will be designed with a vertical wheel base. This base will allow the system to be maneuvered from one area of the ping pong table to another. The ping pong ball will be dispersed from a hopper by means of a continuous feeding ball motor. The ball will travel along a vertically sloped tracking system which leads to the launching motor wheel. Once the ping pong ball hits the launching wheel the ball will be launched. This launcher will be designed with a rotational netting system attached to the back of the frame of the launcher to increase a players returning precision as well as catch the ping pong balls which are dispersed from the system.

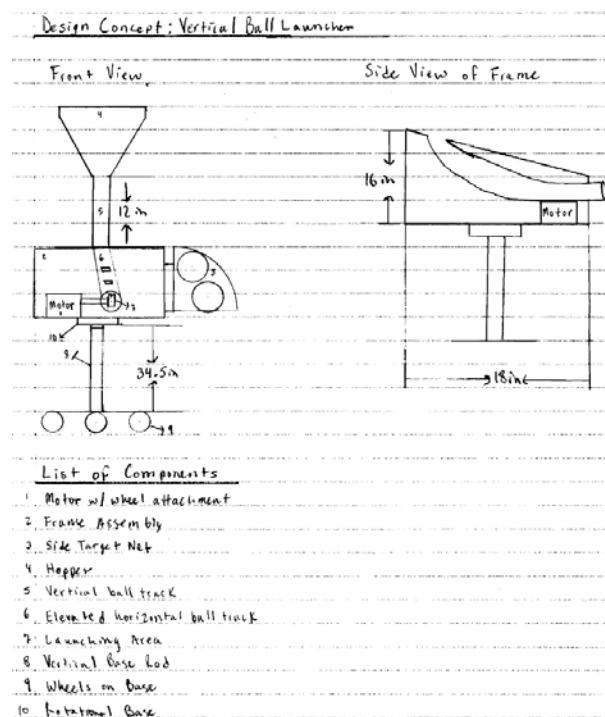


Figure 7- Vertical Ball Launcher Design

WEIGHTED DECISION MATRIX

The two design concepts were evaluated by the means of a weighted decision matrix using a ten-point scale. The scale ranges from zero being inaccurate to nine being an excellent selection. Weighted factors from the ten criteria shown in this table were adjustable from the QFD to total to a value of 1.00. The rating from each area is multiplied by the weighted factor then added together to produce the total rating for each concept. The Vertical Ball Launcher Concept is the design with the highest rating; therefore this concept will be the launching system which will be produced.

Design Criterion	Table Attachment Design Concept			Vertical Ball Launcher Design Concept		
	Raw Score	Weighted	Weighted Score	Raw Score	Weighted	Weighted Score
	(1-10)	(1-5)		(1-10)	(1-5)	
Safety	7.00	0.13	0.91	8.00	0.13	1.04
Jam Resistance	7.00	0.11	0.77	7.00	0.11	0.77
Cost	6.00	0.13	0.78	8.00	0.13	1.04
Appearance	8.00	0.08	0.64	7.00	0.08	0.56
Durability	8.00	0.09	0.72	8.00	0.09	0.72
Noise	6.00	0.08	0.48	7.00	0.08	0.56
Ease of Use	8.00	0.10	0.80	8.00	0.10	0.80
Accuracy	7.00	0.10	0.70	8.00	0.10	0.80
Assembly Ease	6.00	0.11	0.66	7.00	0.11	0.77
Maneuverability	9.00	0.09	0.81	8.00	0.09	0.72
Totals	72.00	1.0	7.27	76.00	1.0	7.78

Table 7: Weighted Decision Matrix

CALCULATIONS

CALCULATING THE WHEEL VELOCITY AND THE SPEED WHICH BALL LEAVES THE WHEEL

In the design of this launching system, the ping pong ball is basically a projectile which needs to be launched at a certain angle and travel a certain distance to obtain the required specifications. The equation listed below displays the variables which are used to solve for the initial wheel velocity.

Maximum Distance, $R = 9\text{ft}$

Launchin Angle $\theta = 10^\circ$

Gravity, $G = 32.2 \text{ ft/s}^2$

Wheel Diameter, $D_w = 1.5\text{in}$

Wheel Circumference, $D_c = 4.7124\text{in}$

$V_0 = \text{Initial Velocity}$

$$V_0 = \frac{R \times G}{(\sin[2\theta])^{1/2}}$$

$$V_0 = \frac{9 \times 32.2}{(\sin[2 \times 10])^{1/2}}$$

$$V_0 = 4.9553 \text{ ft/s}$$

$$V_0 = 59.4636 \text{ in/s}$$

$$V_0 = 63.093 \text{ RPM}$$

The speed at which the ball leaves the wheel

Motor specifications are an important area when designing the launching device. Based on the weight of a ping pong ball, the friction force, the total force and torque on the motor; a specific motor can be selected which best fits the calculated information

Motor Requirements

$$\text{RPM} = 63.093 \text{ rev/min}$$

Force to compress wheel = $(0.125\text{in}) \times (63.093)$

$$F_c = 7.887\text{lb}_f$$

Coefficient of Friction, $u = 0.3$

Friction Force

$$f = u \times F_c$$

$$f = (0.3) \times (7.887) = 2.365\text{lb}_f$$

Total force

$$F_t = F_c + f$$

$$F_t = (7.887) + (2.365)$$

$$F_t = 10.252\text{lb}_f$$

Torque on the Motor

$$T = Ft \times d$$

$$T = (10.252) \times (1.5)$$

$$T = 15.378$$

Weight of the Wheel, $W = 0.75\text{lbs}$

Mass of Wheel, $M = 0.01554\text{slugs}$

Energy, $E = 15.378\text{lbft}$

$$E = \frac{W \times (V_1^2 - V_2^2)}{2g}$$

$$V_1 = V_2 + \frac{\sqrt{E2g}}{W}$$

$$V_1 = \frac{\sqrt{(1.283) \times (2) \times (32.2)}}{0.75} + 4.9953$$

$$V_1 = 17.0751 \text{ ft/s}$$

$$V_1 = 204.90 \text{ in/s}$$

$$V_1 = 3.6234 \text{ RPS}$$

$$V_1 = 217.41 \text{ RPM}$$

The last velocity listed is the initial required revolutions per minute to launch the ping pong ball.

Angular Velocity

$$V_1 \text{ rads} = \frac{(217.41 \times 2\pi)}{60}$$

$$V_1 \text{ rads} = 22.767 \text{ rad/s}$$

$$a = 0.37945 \text{ rad/s}^2$$

Torque on the Motor

$$T = J_o \times a$$

$$J_o = 0.5 \times M_{r2}$$

$$I_o = 0.0012406 \frac{\text{slugs}}{\text{ft}^2}$$

$$T = 0.00047081 \frac{\text{slugs}}{\text{ft}^2} \frac{1}{\text{sec}^2}$$

$$Hp = T \times RPM$$

$$Hp = (0.00047081) \times (217.41)$$

$$Hp = 0.10236$$

$$\text{Safety Factor} = 1.25$$

$$Hp = 0.12795$$

This is the minimum horsepower required to launch the ping pong ball 9 feet.

$$\text{Pin Diameter } 1 - 4$$

$$\text{Force, } F = 20\text{lbs}$$

$$\text{Yield Stress of Material} = 13053\text{psi}$$

$$\text{Stress} = \frac{F}{a}$$

$$a = 0.00153\text{in}^2$$

$$a = \frac{\pi d^2}{4}$$

$$d = 0.0249\text{in}$$

$$\text{Safety Factor} = 4$$

$$d = 0.0996\text{in}$$

This is the minimum diameter for the pins used to attach the upper frame to the base of the system.

THE ASSEMBLY DESIGN DETAILS

The components of the assembly will be designed to perform in a recreational environment; most commonly home basements and gymnasiums. Figure 8 and 9 displays the overall final design of the ping pong ball launcher system upon completion of the design. The following Figures will displays components of the system which are vital to the creation of this system.

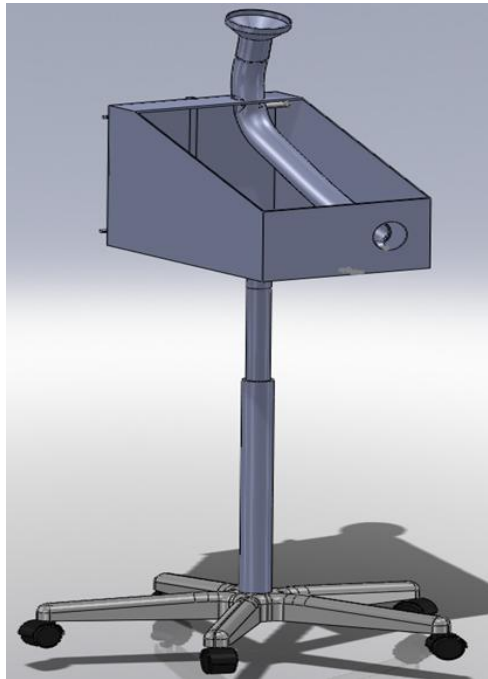


Figure 8- Ping Pong Ball Launcher (Front View)

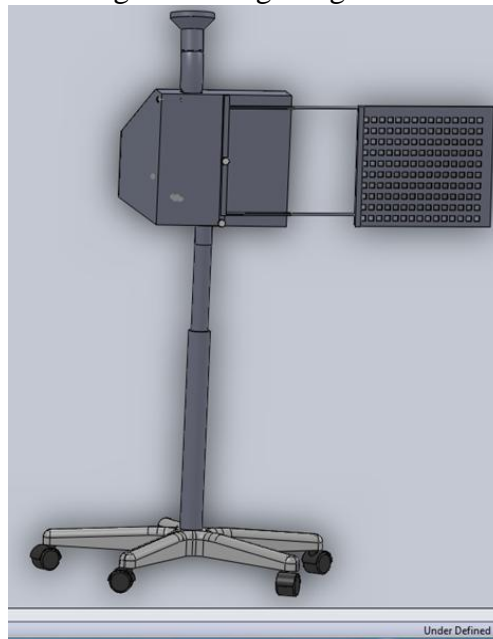


Figure 9- Ping Pong Ball Launcher (Back View)

Figure 10 is the design of the small ball feeding motor which will be used for the continuous feed feature. The motor will turn the small shaft as the balls are dispersed from the hopper. The propeller will hold the ping pong balls and turn the balls onto the vertical track of the system. The motor will be attached to the right wall of the upper frame and a speed variable control will allow the system speed of the motor to be controlled.

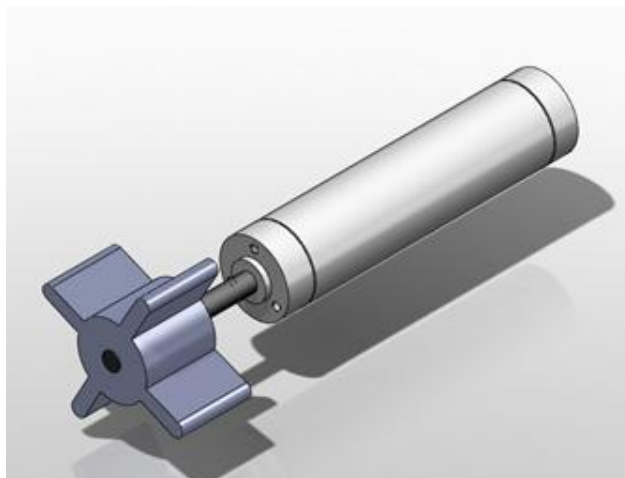


Figure 10- Continuous Feed Ball Propeller and Motor

Figure 11 shows the design of the large motor w/mount which will be used to propel the ping pong balls located at the end of the vertical track. A 1 1/4" diameter wheel attachment will be attached to the shaft of the motor to enable rotation of the wheel. One a ping pong ball is at the end of the vertical track, the ball will be launched once it makes contact with the motor's wheel.

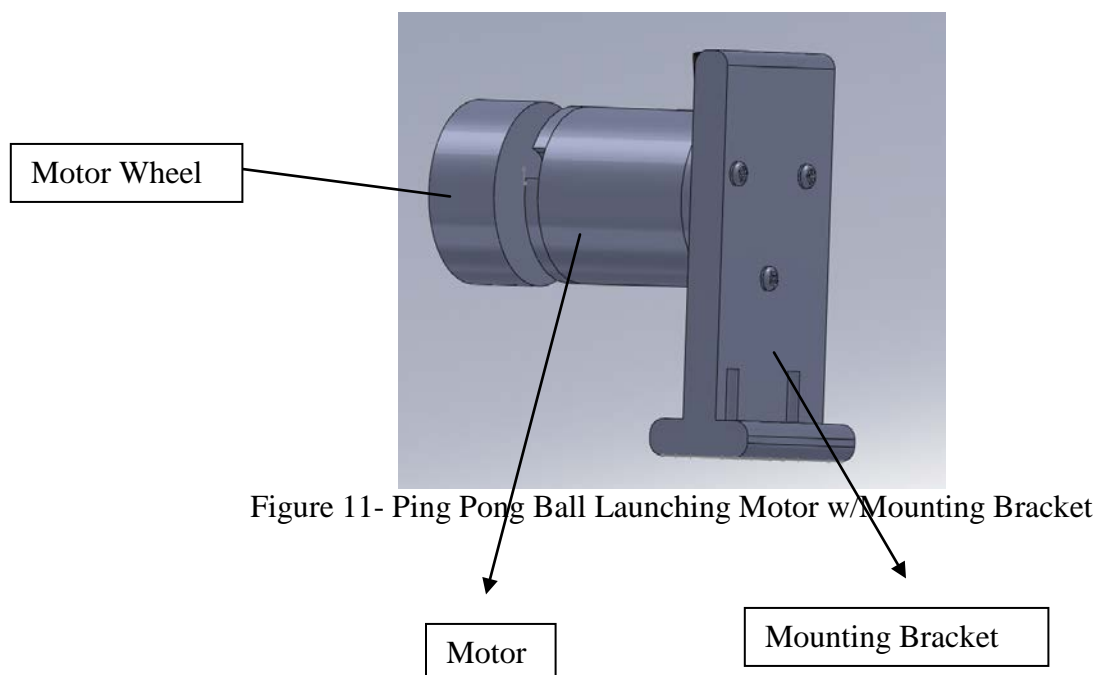


Figure 11- Ping Pong Ball Launching Motor w/Mounting Bracket

Figure 12 shows the design of the vertical track system. The ping pong balls will travel from the hopper to the track and will be launched from the bottom opening of the track system. The upper hole on this vertical track system is designed for the small motor and the continuous ball feeding feature. The tracking will be designed to cover a total of 18 inches in length.



Figure 12- Vertical Track System

Figure 13 displays the design of the rotation netting attachment with connection rods. The rotation netting system will be mounted to the back of the frame of the system. The attachment rods slide into the rotation fixture on the back of the frame which allows a 144 squared inch range of netting on the desired side for shot selecting and ping pong ball retrieval.

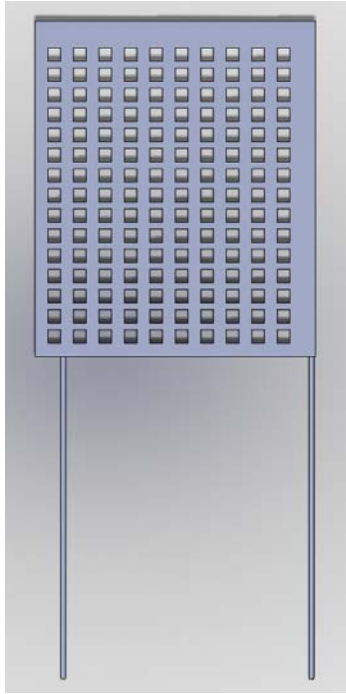


Figure 13- Netting System with Rotation Attachment Rods

Figure 14 displays the design of the upper frame of the system with all components enclosed or mounted to the system.

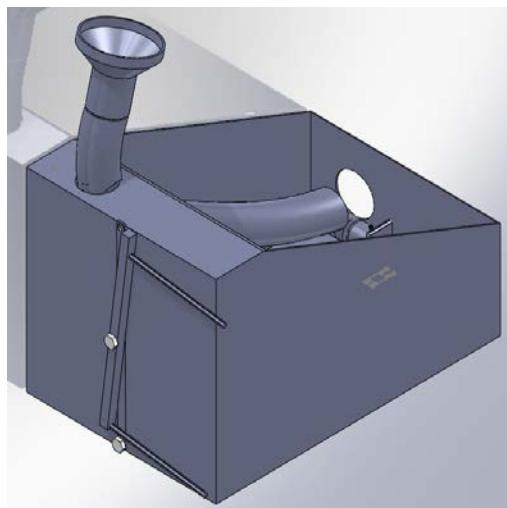


Figure 14- Upper Ping Pong Ball Launcher Frame

Figure 15 displays the design of the attachment rod with wheel base and the circular fixture

which will mount the upper launcher frame to the base of this system. The attachment rod has an adjustable height feature which can raise or lower the height of the system. Wheel base allows the system to be moved from one location of the ping pong table to another with no difficulty.



Figure 15- Attachment Rod with Wheel Base

BUDGET AND SCHEDULE

BUDGET

Material/Component/Labor	Forcasted Amount	Actual Amount	Donation
AC Induction Motor	\$95.00	\$95.00	
AC Synchronous Motor	\$125.00	\$125.00	
Ping Pong Balls	\$25.00	\$25.00	Y
4'x4' MDF Sheet	\$15.00	\$15.00	Y
2'x2' Acrylic Sheet	\$22.00	\$22.00	Y
5ft PVC piping	\$25.00	\$38.00	
Knex Wheel	\$2.00	\$2.00	Y
Ball Hopper	\$8.00	\$8.00	
Netting	\$5.00	\$5.00	Y
5 2" Diameter Twin Wheels	\$15.00	\$15.00	Y
Nylon chair base	\$22.00	\$22.00	Y
Base rod	\$20.00	\$20.00	Y
Screws/Bolts	\$17.20	\$17.20	
Ball Propeller	\$15.00	\$15.00	
2 110vac outlets	\$25.00	\$25.00	
Total	\$436.20	\$291.00	

Table 8- Budget

Table 8 displayed the total expected amount for the design of this system. When the components are purchased, an actual cost will be generated and compared to the expected cost of this ping pong ball launcher system.

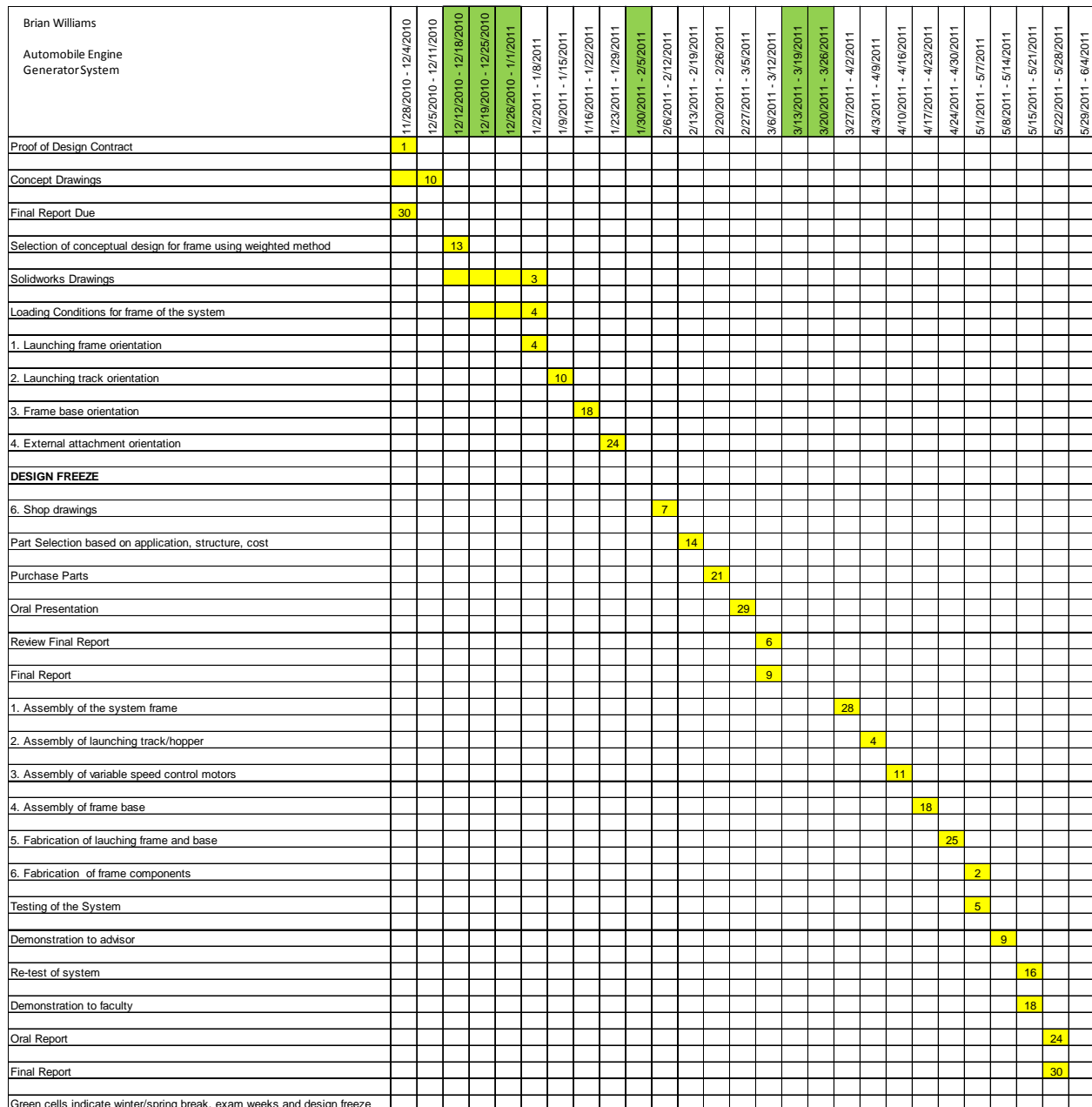
SCHEDULE

Figure 5- Schedule

The project timeline covers 27 weeks and ends June 9, 2008 with the presentation of the final report.

FABRICATION

For the designing process of the ping pong ball launcher certain components required fabrication in order to function properly within the system. The different methods of fabrication include welding, grinding, sandblasting, thread tapping and sawing.



Figure 16- Motor w/Variable Speed Control

The motor shown above is the component which is used to launch the ping pong balls. Guarding on each side of the motor needed to be removed to ensure the wheel attachment can be placed on the shaft. In addition to removing the guarding the based base of the motor required drilling to create mounting holes.



Figure 17- Fabricated Motor w/Variable Speed Control

The figure above displays the motor after the required fabrication is completed. Each of the

guarding areas of the system was cut off but use on an angle grinder to allow area for the ball feeding track. A wheel attachment was bolted on the left portion of the shaft which launches balls from the system.



Figure 18 – Acrylic Sheet

The figure above displays ¼” acrylic sheet which is used for guard of the interior components of the launcher system which includes the ball track, two motors and wiring cords. The acrylic sheet is clear and see-through on both sides when the brown protecting cover is removed.



Figure 19 – Sandblasted acrylic sheet

The figure above displays the acrylic sheet after the sandblasting process. Sandblasting uses fine sand to clean the surface while adding a frosty type coating. This coating allows the components of the launching system to not be exposed to the users and protected from scratches on the surface.



Figure 20 – Sandblasted frame piece

The figure above displays the largest attachment piece that is sandblasted. In total three piece of the acrylic sheet were sandblast, the launcher motor covering, the piece in this figure and the piece which holds the ball hopper and variable speed controller.



Figure 21- Ball Feeder motor Attachment

Figure 21 displays the ball feeder motor with the motor mount attachment and sleeve. The four legs of the frame were MIG welded to the base attachment and the sleeve. The MIG welding process uses welding wire and inert shielding gas. This specific welding process was used due to the fact that it is the most adaptable welding process as compared to TIG and stick welding. Also the welds didn't require specific precision as does the TIG welding process. 1/2" thru holes are on the base of the system so the attachment can be bolted to the frame of the launcher.



Figure 22- Netting Attachment

Figure 22 displays the netting attachment which bolts on the back of the launcher frame. Two round stock pieces of steel were MIG welded to a bar stock piece. The netting cage attaches to the round stock by two hollow PVC rods which slide onto the round stock.



Figure 23 – Edges of the launcher frame

Figure 23 displays two bounded edges of the launcher frame. The edges of the frame were cut at a 45 degree angle by means of a table saw. This angled cut allowed for a better appearance of the system and also less difficult means of mounting as compared to mount two squared corners. The base of the system consisted on four angled edges, two sides pieces consisted of two angled edges and the back piece of the frame consists of three angled edges.

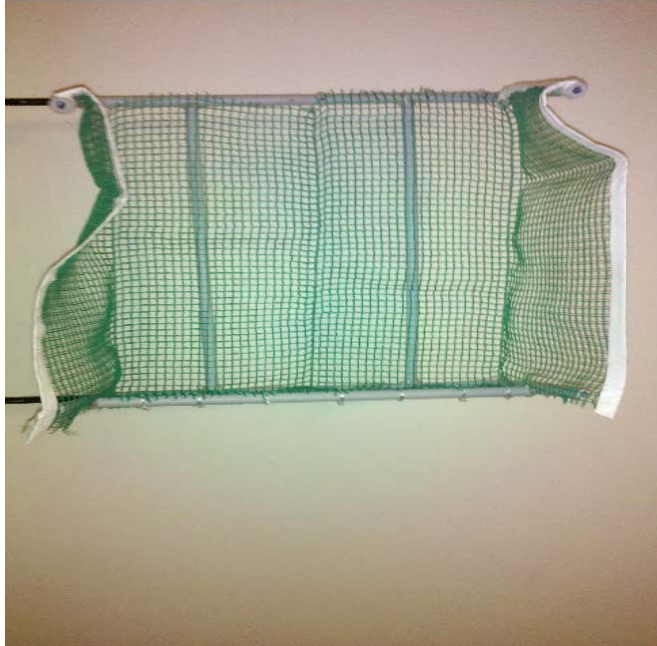


Figure 24 – Netting Cage Attachment

Figure 24 displays the netting cage which attaches to the back of the launcher frame. The net used for this cage was a standard ping pong table 5-foot net. The net was cut into four sections and sewed to the dimensions to design a 1 foot by 1 foot cage.

TESTING

For the design of the ping pong ball launcher, testing was completed to analyze the systems current performance, and then try to make adequate adjustments in the specific areas needed. The areas of testing which were vital to the success of the launcher consisted of maximum launching distance, accuracy, repeatability and ease of use. After completing the testing, the necessary changes were implemented to the system.

MAXIMUM LAUNCHING DISTANCE

With the design of a launching system, one of the most important features is the maximum launching range of the system. The ping pong ball launcher motor was set at range of rpm and the launching distance at each rpm was recorded in table 9.

Maximum Launching Distance	
Launching RPM's	Total Distance(ft)
400	6.5
500	8
600	9.5
700	12
Total length of table: 9ft	
Total distance includes 1ft displacement	

Table 9 – Maximum Launching Distance

As listed in table 9, the ball launching motor was set at 4 different rpm levels and total distance of the launched ball was recorded. The launcher was displaced one foot from the actual ping pong table as shown in figure 25.



Figure 25 – Launcher Displacement for Ping pong table

The total vertical length of the standard ping pong table is 9 feet; therefore the net is located at 4.5 feet. With the 1 foot displacement, at 400 rpms the launched ball proved to be able to cover half of the ping pong table and reach over the net. Gradually as the rpms increase the maximum launching distance of the system increased as well. At 700 rpms the ping pong ball was launched at a distance of 12 feet which surpassed the length of the table. This allows the displacement to be increased if necessary and the launched balls prove to still cover the required minimum launching distance of 4.5 feet to clear the net.

ACCURACY

Testing for accuracy consisted of a three ball series being placed into the hopper and launched to analyze the landing location of each ball. The main goal of this test was to ensure the balls were launched over the 5 inch net and hit any location on the opposing side. Initially the orientation of the launching wheel and the ball track were flush with one another. This allowed the ping pong balls to be launched that specific area every time but this wasn't the goal. In the game of ping pong the objective is to cover as many areas of the ping pong table as possible in order to force your opponent to stretch throughout the entire table and the initial orientation didn't meet this standard. By altering the orientation of the ball track and launcher wheel, balls were then launched at different locations of the ping pong table.

REPEATABILITY

Testing for repeatability was completed to ensure there was no jamming of the balls in the hopper and along the track. This test consisted of a 6 ball series in the hopper and the goal was to ensure that each ball was properly dispersed from the hopper, successfully moved onto the track by the ball feeding propeller and then be launched. There were little to no problems with this testing due to the fact that the lower diameter for the hopper could fit two standard ping pong balls at once. The ball propeller stopped each ball and the variable speed controlled the motor which propelled the balls onto the track.

EASE OF USE

Testing for ease of use was completed to ensure that each user would understand the basic instructions of the system to ensure that all users could properly use the launcher system. The user was given a set of photographic instructions to follow and test the ease of the ability to use the system. Photographic instructions are listed below:

Basic Instructions

1. Carefully adjust the height of the system using the knob on the base attachment rod



2. Plug launcher motor and speed control motor into wall outlets
3. Power on ball launching motor by turn knob inside circular cut out



4. Set ball launching motor speed around 500 RPM's for about 25 to 30 seconds
5. Power on speed controller



6. Place ping pong balls in ball hopper



7. Slowly turn on speed controller knob so that ping pong balls can be released to the track
8. Adjust ball launching motor speed higher/lower if the ball launching distance is too short or to long



A total of six users ranging from ages 12 to 65 years were tested then asked to complete a rating sheet on how well each user was able to adapt to the system using the basic photographic instructions.

Results from Photographic Instructions						
	1	2	3	4	5	Avg. Rating
Ease of Use				2	4	4.67
Ease of Instructions				1	5	4.83
Adaptability				2	4	4.67
Overall Experience				1	5	4.83

Table 10 – Results from Photographic Instructions

Table 10 shows the results from the rating sheet of the basic instructions given to the user. On the left of the table are the areas which were rating and to the far right are the average rating for the desired area. Based on these results the users rarely faced any obstacles following in instructions and correctly allowing the ping pong ball launcher to function properly.

DESIGN CONSIDERATIONS

The designing of the ping pong ball launcher was completed successfully. There were few areas of the system that saw design alterations and also a few after areas in which more advanced ideas could be implemented into the system. The main alteration of the system was the change in the initial orientation of the launching track with the launching wheel. In the initial design of the system, in wheel and the track was positioned in-line with one another. This allowed for the balls were launched a consistent location on the ping pong table for each ball launched. The disadvantage to this is that in real play versus an opponent shots returned to all areas of the table so that the challenger would have to work across the entire table to score points.

With this in mind the orientation of the wheel was moved to the offset position. The balls which are now hit the launching wheel in different locations which causes the balls to be launched in different locations on the ping pong table. As a result practicing methods would be similar to an actual opponent volleying in different locations on the table as if an actual game being played.

The final design alternation with the ping pong ball launcher was the based on the system. The original design the system had a wheel based as shown in figure 25.

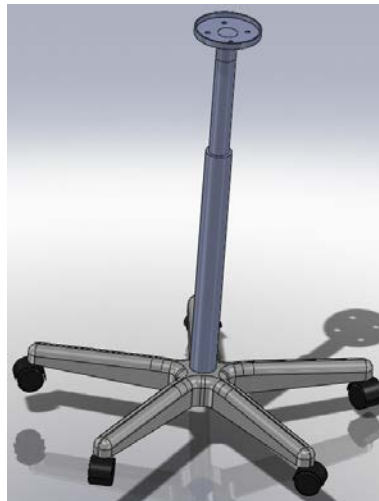


Figure 26 – Wheel Base

One of the areas overlooked was the response of vibration. While testing the system vibration caused the system to move slightly in the opposing direction due to the fact that the floor was a bit unbalanced. Not all floors in different locations would be the same, therefore to prevent the system from slight movement while running a new base was implemented.

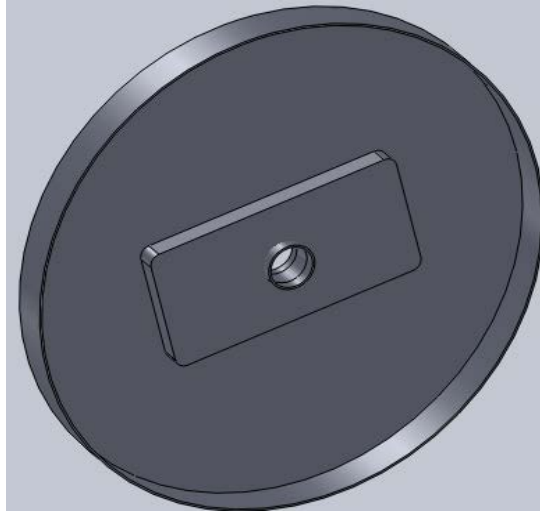


Figure 27 – Circular weighted base

Figure 26 displays the circular weighted base that was implemented into the design of the ping pong ball launcher. Without the wheels on the base, the cause of slight movement is now altered and no longer a concern.

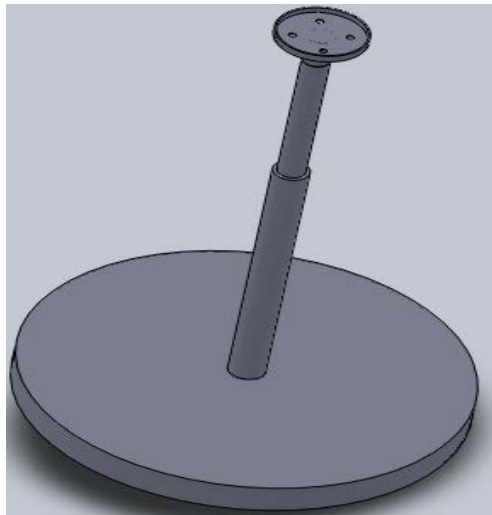


Figure 28 – Circular base with attachment rod

Figure 27 displays the circular base with the attachment rod which securely fastens to the launcher frame.

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1. Newgy Robo-Pong. *The New Revolution in Table Tennis*. [Online] Newgy Industries, Inc., 2009. [Cited: January 12, 2011.] <http://www.newgy.com/p-185-robo-pong-2050.aspx>.
2. Newgy Robo-Pong. *The New Revolution in Table Tennis*. [Online] Newgy Industries, Inc., 2009. [Cited: January 15, 2011.] <http://www.newgy.com/c-5-robots.aspx>.
3. Hayneedle. *Table Tennis Zone*. [Online] Hayneedle, Inc., 2007. [Cited: January 18, 2011.] <http://www.tabletenniszone.com/table-tennis-equipment/table-tennis-robots/butterflysmartpongrobot.cfm?TID=MKC071&source=gaffiliates&subid=k232999&affnam=Formula%20Shopping&kwid=Primary>.
4. Table Tennis DB. *Equipment Reviews, Ratings Everything*. [Online] PPGEAR, 2008. [Cited: January 18, 2011.] <http://www.tabletennisdb.com/robot/ttmatic-505-b.html>.

APPENDIX A- RESEARCH

Interview with Ping Pong Hobbyist, February 18, 2011

Amelia Williams, Ping Pong Player, 13814 Carter House Way.

- The sports of ping pong is growing as a widely known recreational sports
- Self ping pong ball launcher were not a piece of technology used several years ago in the sport of ping pong
- A system which is easy to use would be the best option for customers
- The cost of a launching system should not exceed the cost of a ping pong table with racquets and balls



Revolutionary digital technology means easy, precise regulation of ball speed, wait time, and landing location. Normal Mode gives you simple manual control over each function while in Drill Mode; you can run any of the 64 drills stored on the controller. Use PC Mode to create and save drills using a simple interface, and then run those drills direct from your PC. Setup Mode makes it easy to calibrate motors to a set standard and select your desired language. Intelligent design also allows selection of favored hand so drills run correctly for right-handers and left-handers alike. You can even tell your Robo-Pong 2050 to throw balls for 5 minutes, and it will automatically calculate how many balls will be thrown in that time.

- Ball Thrower
- Recycling Net System
- Side Net Extenders
- Rubber Tips Packet
- Full Size Digital

Expensive accessory for the sportsman's hobby

- Large scaled system
- Non-maneuverable
- No vertical/horizontal axial movement throughout ping-pong table
- Lengthy Installation
- on-adjustable
- Limited Flexibility

<http://www.newgy.com/p-185-robo-pong-2050.aspx>1/17/2010
Robo-Pong 2050

Control Box <ul style="list-style-type: none"> Transformer Connector Cable 48 Orange 40mm Robo-Balls Price: \$799.99 	
--	--



If you're ready for serious training, then Robo-Pong 2040 is for you. The 2040 robot does everything the Robo-Pong 1040 does, plus it comes with the Recycling Net System.

Recycling Net captures your returns and recycles the balls for non-stop action! Plug in optional Pong-Master for a fun target game to hone your accuracy and consistency or use it as a timer for your drills.


Package Includes:

- Ball Thrower
- Recycling Net System

- imited Flexibility
- engthy Installation
- he system doesn’t move horizontally/vertically throughout the ping-pong table
- ifficult to maneuver
- xpensive component for hobby

<http://www.newgy.com/c-5-robots.aspx> 1/17/2011
Robo-Pong 2040

<ul style="list-style-type: none"> • Side Net Extenders • Rubber Tips Packet • Full Size Control Box • Transformer • Connector Cable • 48 Orange 40mm Robo-Balls • Training Book 	
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	<p>http://www.tabletenniszone.com/table-tennis-equipment/table-tennis-robots/butterflysmartpong-robot.cfm?TID=MKC071&source=gaffiliates&subid=k232999&affnam=Formula%20Shopping&kwid=Primary 1/18/2011</p> <p>BUTTERFLY SMARTPONG ROBOT</p>	<ul style="list-style-type: none">• The system costs more than the table tennis equipment its-self• Non-mauve able• System cover the entire portion of the table• Needs an adult to complete the installation• No aiming target to improve accuracy• System produces different style of shots but remains one position on the table
<ul style="list-style-type: none">• Programmed patterns and manual modes• Customizable memory cycle up to 9 shots• Can produce topspin, under spin, and sidespin• Includes 100 balls that recycle for continuous play• Infrared remote and instructional DV• Measures 12L x 60W x 34H inches<ul style="list-style-type: none">• Price: \$1799.99 with a 28% discount		



<http://www.tabletennisdb.com/robot/ttmatic-505-b.html>

1/18/2011

TTMATIC 505 B PING PONG ROBOT

- Very expensive system
- Performing maintenance on the system would be difficult
- Difficult Installation process
- System would be too difficult for players of all ages to understand how to use properly
- No precision targeting with large netting
- Not affordable

A new dimension in robot training. The complete know-how of over thirty years of table tennis robot production goes into the building of this top machine.

The new five-channel digital control computer and the specially developed double head system offer training possibilities that will fill every table tennis professional with enthusiasm.

The two rotating heads make it possible to play completely different strokes in succession. For example, head A can produce backspin and head B can produce topspin. These basics can be adjusted individually using the electronic control. The system can produce short sequences of from one to thirty-six balls or can operate continuously until you stop it manually. The digital control computer has five channels. Each channel is controlled by five knobs that let you set the following independent attributes: head A or head B, speed, left/right position, number of balls until change to next channel, ball rate. A rotary switch lets you select a single channel or a channel chain. So, you can practice single strokes as well as complete ball sequences. In addition, the random mode produces balls from all five channels.

Features:

- Robot has its own stand
- Remote Control
- Power Spin Technology
- Up to 100 balls a minute
- Profi B netting
- Programmable attributes

APPENDIX B- CUSTOMER SURVEY

PING-PONG BALL LAUNCHER

This ping-pong ball launcher consists of affordable components achieved to produce an affordable system for ping-pong players of all ages to use.

How important is each feature to you for the design of the ping pong ball launcher?

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

Safety	1	2	3	4	5(6)	N/A AVG. 5.0
Jam Resistance	1	2	3(1)	4(5)	5	N/A AVG. 3.8
Cost	1	2	3	4(1)	5(5)	N/A AVG. 4.8
Appearance	1	2	3(3)	4(3)	5	N/A AVG. 3.5
Durability	1	2	3(3)	4(3)	5	N/A AVG. 3.5
Noise	1	2(1)	3(4)	4(1)	5	N/A AVG. 3.0
Ease of Use	1	2	3(1)	4(5)	5	N/A AVG. 3.8
Accuracy	1	2	3(2)	4(4)	5	N/A AVG. 3.6
Assembly Ease	1	2	3(2)	4(4)	5	N/A AVG. 3.6
Maneuverability	1	2(1)	3(4)	4(1)	5	N/A AVG. 3.0

How satisfied are you with your home ping-pong ball launcher?

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

Safety	1	2	3	4	5	N/A(6)
Jam Resistance	1	2	3	4	5	N/A(6)
Cost	1	2	3	4	5	N/A(6)
Appearance	1	2	3	4	5	N/A(6)
Durability	1	2	3	4	5	N/A(6)
Noise	1	2	3	4	5	N/A(6)
Ease of Use	1	2	3	4	5	N/A(6)
Accuracy	1	2	3	4	5	N/A(6)
Assembly Ease	1	2	3	4	5	N/A(6)
Maneuverability	1	2	3	4	5	N/A(6)

How much would you be willing to pay for this ping-pong ball launcher? \$100-\$250 (4), \$250-\$500 (2), \$500-\$750, \$750-\$1000, \$1000-\$1250, \$1250-\$1500, \$1500-\$1750, \$1750-\$2000

Average Desired Cost: \$241.68

Thank you for your time.

APPENDIX C- PRODUCT OBJECTIVES

Product Objectives

This list of objectives serves as the criteria which the design of the ping-pong ball launcher system will follow. Each bullet is an example of one of the features and followed by the bullets are the different ways to prove that this feature is incorporated into the design of the ping-pong ball launcher properly.

- Safety
 - Guards will cover the component which launches the ping-pong balls
 - Every part would be screwed/bolted to the frame using lock washer and crown bolt to ensure no loose components within the device
 - Warning labels will be placed on areas of the system which could be hazardous
- Jam Resistance
 - The diameter of the track which the ping-pong balls flow thru will have a 10 – 30 millimeter clearance
 - A wheel/holder device will be a component on the ball track which slows the speed rate at which the balls are dispersed
 - The open-ended launching area will give the ping-pong ball open space to launch and help avoid any jamming thru a tunnel
 - Rubber wheel which is attached to shaft of the motor will propel the ping-pong ball
- Cost
 - The system will not exceed more than an additional 20% of the desired average price based on the survey results (\$242.00, with 20% \$290.40)
- Appearance
 - Motor will be mounted to the base of the frame
 - The top and front portion of the system will be covered with ¼” sheet plastic so that user can see inside the system
 - All components will be enclosed except for the hopper and side targeting device
 - System will be painted black to be comparable to similar systems
- Durability
 - Material used will be able to withstand household temperature conditions
 - All components within frame will be securely fastened by air nails or bolts with lock washers
 - The material MDF will be used for the frame. This material can withstand high loads and is designer friendly
- Noise

- Decibel level of the system will be in the range of 60 to 70dB
- Ease of Use
 - There will be four components or less which have to be turned to the “ON” position for proper use
 - Photographic instructions will show the steps to take to properly use the system
- Accuracy
 - The system will have a rotation base so that the ball can be launched to different areas of the ping-pong table
 - The angle of trajectory will be designed to be launched over a regulation 6-inch table tennis net
 - Balls will be launched from the launcher with a vertical spin motion similar to a basic serve as a human player
- Assembly Ease
 - 6 or less components will have to be put together in order for the system to function
 - Step-by-step photographic instructions will explain how to assemble the system and how to properly use the system
 - Assembly of the system will only require common tools (flat-head/Phillips head screw drivers)
- Maneuverability
 - Wheel base on the system will allow the system to move horizontally across the table
 - System will not exceed 100lbs all pieces included

APPENDIX D- QFD

Brian Williams Ping Pong Ball Launcher 9 = Strong 3 = Moderate 1 = Weak	Guarding/Warning Labels	Size	Structure of Design	Affordability	Assembly	Material Selection	Weight	Efficiency	Tool Selection	User Friendliness	Specified Components	Customer importance	Designer's Multiplier	Modified Importance	Relative weight	Relative weight %
Safety	9		3	1	3		3		3	3		5.0	1.08	5.4	0.13	13%
Jam Resistance			3			3		9		3	3	4.0	1.08	4.3	0.11	11%
Cost			3	9		9					9	4.8	1.10	5.3	0.13	13%
Appearance		3	9	1	9	3	1	1		3	3	3.2	1.02	3.3	0.08	8%
Durability		3	3	3	9	9	3	3			9	3.4	1.09	3.7	0.09	9%
Noise	1		3		3	3				1	9	3.0	1.02	3.1	0.07	7%
Ease of Use			3		3	3		3	3	9	3	3.8	1.05	4.0	0.10	10%
Accuracy			9		3			9		3	3	3.6	1.09	3.9	0.10	10%
Assembly Ease		3	3		3	3	3		3	3	3	3.8	1.12	4.3	0.10	10%
Maneuverability		9	9		3	3	9			3	3	3.6	1.08	3.9	0.09	9%
Abs. importance	1.26	1.67	4.62	1.64	3.32	3.63	1.91	2.45	1.00	2.78	4.36	28.6		41.1	1.0	
Rel. importance	0.04	0.06	0.16	0.06	0.12	0.13	0.07	0.09	0.03	0.10	0.15	1.00				

APPENDIX E – BUDGET

PRELIMINARY BUDGET FOR PING-PONG BALL LAUNCHER

Material/Component/Labor	Forcasted Amount	Actual Amount	Donation
AC Induction Motor w/ Speed Control	\$170.00	\$210.00	
AC Variable Speed Control w/Motor	\$125.00	\$75.00	
Ping Pong Balls	\$10.00	\$10.00	Y
4'x4' MDF Sheet	\$15.00	\$15.00	Y
2'x2' Acrylic Sheet	\$22.00	\$22.00	Y
5ft PVC piping	\$25.00	\$38.00	
Knex Rubber Wheels	\$2.00	\$10.50	
Ball Hopper	\$8.00	\$3.50	
Netting	\$5.00	\$5.00	Y
5 2" Diameter Twin Wheels	\$15.00	\$15.00	Y
Circular nylon weighted base	\$12.00	\$12.00	Y
Base rod	\$10.00	\$10.00	Y
Screws/Bolts	\$17.20	\$17.20	Y
Ball Propeller	\$15.00	\$15.00	Y
1 110v power cord	\$25.00	\$15.00	
Steel Bar/Round Stock	\$15.00	\$15.00	Y
Total	\$491.20	\$367.00	

APPENDIX F - SCHEDULE

Brian Williams Automobile Engine Generator System	11/28/2010 - 12/4/2010	12/5/2010 - 12/11/2010	12/12/2010 - 12/18/2010	12/19/2010 - 12/25/2010	12/26/2010 - 1/1/2011	1/2/2011 - 1/8/2011	1/9/2011 - 1/15/2011	1/16/2011 - 1/22/2011	1/23/2011 - 1/29/2011	1/30/2011 - 2/5/2011
Proof of Design Contract	1									
Concept Drawings		10								
Final Report Due	30									
Selection of conceptual design for frame using weighted method			13							
Solidworks Drawings						3				
Loading Conditions for frame of the system						4				
1. Launching frame orientation						4				
2. Launching track orientation							10			
3. Frame base orientation								18		
4. External attachment orientation									24	
DESIGN FREEZE										

