Analysis and Design of Optimal Improvement Methods for Basketball Shooting Mechanics

by

Stephen Kaatz

A Report Submitted to the Faculty of the

Milwaukee School of Engineering

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Engineering

Milwaukee, Wisconsin

February 2021

Abstract

The purpose of this capstone project was to employ optimization tools and techniques to improve basketball jump shot mechanics, resulting in an increased basketball shooting percentage. The capstone project is being submitted to meet the requirements for the Milwaukee School of Engineering's (MSOE) Master of Science in Engineering (MSE) program. Six factors that affect basketball shooting ability have been identified in the literature, including shot release time, shot release angle, leg angle, vertical jump, rotational speed on the ball, and ball speed immediately upon release. A Design of Experiments (DOE) approach, featuring factor brainstorming, factor sorting, and a fishbone diagram, has been developed and implemented to examine the factors and the combination of factors that are statistically significant in increasing shot percentage. In this investigation, the author served as the lone study participant. This project employed the mobile artificial intelligence (AI) basketball feedback app, *Homecourt* (https://homecourt.ai), to record and track a large number of free throw line jump shots associated with the six factors. These collected data were then assessed in *Minitab* statistical analysis software. These data were employed to develop a *MATLAB*/*Simulink* model and simulation of the author's jump shot, which can be used to evaluate factor changes and determine statistical improvement for optimum factor values.

From the results of the analysis, it is seen that main factors - release angle, release speed, and backspin, as well as the combination factors, including release angle/vertical, leg angle/vertical, vertical/release speed, release time/vertical/backspin, and release angle/leg angle/backspin -- were found to be statistically significant in determining the corresponding response variable, the make percentage. There exist opportunities to improve the analysis of significant factors, including the evidence that the introduction of further study factors may add additional significant factors to determine make percentage. In addition, an increase in number of data points and the ability to track response variable as a continuous response variable would help with the accuracy and applicability of the data found in this experimentation and used within the simulation.

Acknowledgments

Obtaining my master's degree was a goal that would not have been possible without the assistance, guidance and support of many people in my life.

I would like to especially thank the Mechanical and Electrical Engineering Departments at MSOE for the constant assistance and support, and specifically Dr. Subha Kumpaty, Dr. Douglas Grabenstetter, and Professor Gary Shimek.

Table of Contents

List of Figures

List of Tables

Nomenclature

A – Surface Area – The frontal area affected by drag. Since the basketball is a sphere, the frontal area affected is the area of the outer diameter circle of the basketball.

C_D **– Coefficient of Drag**

D – Total Drag force

g – Local acceleration due to gravity

H – Vertical jump – The distance from the ground to the lowest part of the shooter at the apex of the shot.

LA – Leg angle – The largest angle off of the straight line of the shooter's knee as the shooter bends the knees to generate the jump from the ground.

t – Time

T – Release time – The time it takes from the shooting hand to begin moving forward to the moment the ball is no longer in contact with the shooter.

Vi – Initial Ball speed – The initial speed the ball is travelling at the moment after it is released by the shooter.

V –Ball speed – The speed the ball is travelling at any given time after it is released by the shooter.

w – Rotational speed on the ball – The speed of rotation of the ball the moment after the ball is released by the shooter.

θ – Release angle – The angle relative to the ground the ball travels at the moment the ball is released by the shooter.

∆x – Distance – The distance in vertical or horizonal plane traveled by a ball after release.

ρ **– Density of air**

Introduction

The process of improving one's ability to perform at any number of different sports is currently a nine billion-dollar (U.S.) industry in the United States [1]. Sports science is hitting great strides in designing equipment that can optimize in-game play and workouts to produce athletes who can perform at levels never seen in the past. Sports have become a huge facet of society and continue to grow day after day [1]. In particular, basketball is one of the fastest growing sports today [2]. The National Basketball Association (NBA) has become the fourth highest world sport league, valued as a nearly five-billion-dollar industry with some projections predicting it can overtake the other professional leagues in a matter of decades [3]. With basketball courts located in parks worldwide, the ability to play and practice this sport has never been easier. This growth and increased outreach have inspired high amounts of interest in the science community in helping these athletes to improve.

Basketball is a sport with many facets to master in order to improve one's ability to play and win. Athleticism, dribbling, playmaking, special awareness, rebounding, and defending are just a few of the skills to master to improve one's game. However, one of the most discussed and examined aspects of the game is shooting. The ability to shoot a ball from anywhere on the court and have the best percent chance of scoring a basket has inspired some of the biggest professional athletes in today's game. Because of this, the NBA has become increasingly focused on shooting ability and identifying shooting ability in the draft [4]. One of these biggest factors NBA scouts and general managers use to identify a prospect's ability to shoot is the player's free throw percentage [4]. A free throw shot is a rare time in the game when everything stops, providing a player with a chance to take an uncontested shot fifteen feet from the basket -- see Figure 1. This attempt is usually earned after the opposing team commits a foul or violation that results in one, two, or three attempts from the free throw line. The point earned or missed out on at the free throw line can drastically change the outcome of the game leading many players to develop routines and rituals to improve their free throw shot success [5].

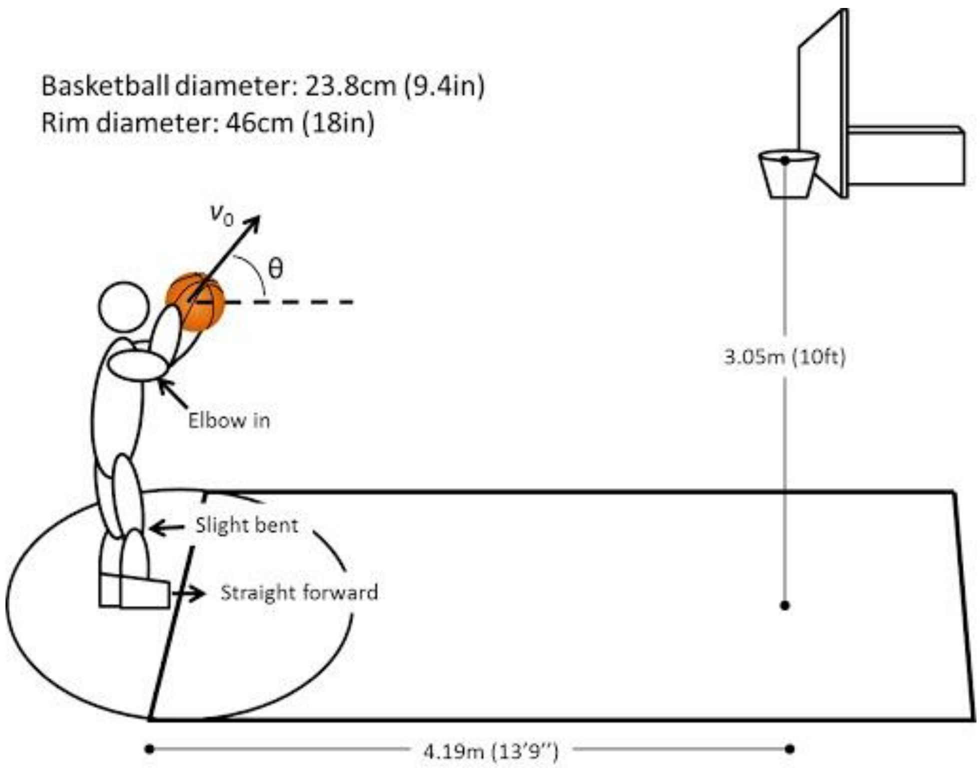

Figure 1: Visual Representation of Free Throw Line Shot [6].

There is a surplus of information on what people around the community believe should be the ideal shooting form to convert these shots at the highest percentage [7, 8]. Most of these sources analyze the best shooters in the game and try to implement their form as the ideal form for all aspiring players [7]. In the article "Shooting the J", Kelley investigates the basics for the ideal shooting form as it pertains to the leg base, square up, jump, elbow, hands, target site, and release [7]. Based on professional athletes, such as JJ

Redick, Kelley explored the basics of the ideal basketball shooting form. Kelley found that the ideal shooting mechanics based on professional athletes featured a strong launch from the legs, feet and shoulders facing the basket, a slow and controlled jump directly vertical or slightly towards the basket, an elbow tucked in but not jammed into the shooter's side, a ninety degree bend in the elbow before launch, only the tips of the fingers touching the ball, an offhand that is only used for stability, and a follow through featuring the ball rotating off the tips of the fingers, generating backspin and little to no side spin. Although the basics for this study are extremely beneficial, this approach is difficult for everyone to utilize as every player is different. Different player heights, release points, spin generations, and even hand size can all play a major role in affecting one's "ideal" shooting mechanics [9]. In addition, those with unconventional shooting mechanics would need to completely change their form in order to utilize the mechanics described as ideal. The ideal jump shot also changes based on the distance the shooter is from the basket [10]. Many players in the basketball community do not wish to completely change their form and spend years learning to implement the changes as muscle memory. An avid, but less skilled, basketball player may ask how they can learn the shooting mechanics of these professional players when they simply don't have the same physical attributes? Moreover, what if a player's personal attributes warrant different shooting mechanics? With the increased emphasis placed on players in the modern shooting heavy culture, these are among the questions several players ask themselves when training.

Justification of Project

In the basketball industry today, there is not enough analysis done on an individual's shooting mechanics until they achieve a professional talent level or near professional talent level. In addition, recreational players and/or those who never can make it at that level but still wish to improve have no real options to analyze their shooting mechanics outside of paying large amounts of money for services that are more focused on improving consistency and good behaviors while shooting. As a recreational basketball player, the author has a desire to improve his shot and to truly see if the "ideal" mechanics presented online are also the ideal mechanics for his personal shot. In addition, as a player who has not been traditionally coached in shooting mechanics, the author's shooting form may be different from players who have spent years and years perfecting their specific form. With a desire not to re-learn shooting mechanics over from near scratch, significantly improving the form currently used by the author seems to be the most effective option. Although this project is only applicable for the author's specific shooting mechanics, this idea can be implemented by any parent, coach, or player who wishes to do a similar analysis on their own shooting form. Everyone who shoots the basketball does so in a slightly different way. The approach in this capstone project provides those with an unconventional shooting form a template on how to map out their most effective and crucial areas of their shooting form and how to improve it over time without having to completely change their form.

Background

Growing up, the author had always loved the competition and complexity involved in the game of basketball. Every day that the author played, he learned small nuances and strategies that can play a major role in affecting the outcome of a game. As the author grew up playing this sport, he could see the evolution of the game both from a skill/age range and from the increased emphasis on shooting ability and spacing. No longer was the game focused on getting the ball as close to the basket as possible, as players were hitting shots from over thirty feet with ease at record clips. For reference, the average NBA team in the 1980 season attempted 2.77 three-point shots per game, but in 2014, the season average was 21.25 [11]. See Figure 2. In the latest 2019-2020 season, the average NBA team attempted 33.9 three-point shots a game [11]. It is evident in every level of basketball that shooting is increasingly a focal point of the game.

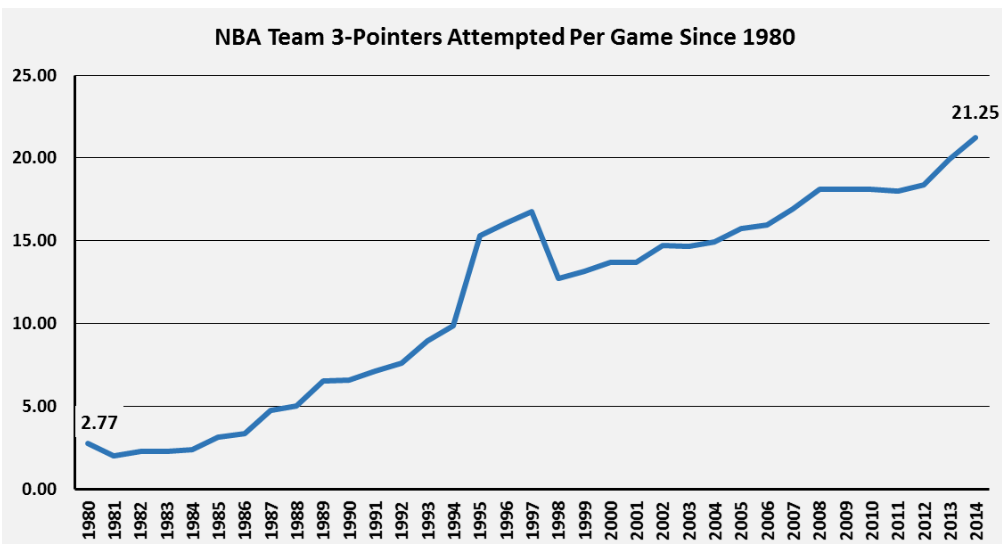

Figure 2: NBA Three-Point Shots Attempted per Game 1980-2014 [11].

With an increased emphasis on shooting ability and spacing, the sports science industry has increasingly investigated the ideal form and mechanics to produce the highest rate of success when shooting the ball. The problem with this approach is that it leaves behind a generation of players, like the author, who have spent years developing a jump shot that does not conform with this ideal model. For some, a complete rebuild of their form with years of additional practice has been possible, but what about those players who don't have the time to change their form? The process of completely overhauling one's shooting form can remove one's ability to make shots for several months at the minimum, while muscle memory begins to accept this new release. This leaves a group of players who are not able to take advantage of the constant output of research findings to improve their shot, as it may not apply to them directly. There are also many players who did not grow up going through youth programs and learning the specific shooting mechanics that conform to this ideal shooting approach. These players can only address small changes or general ideas in their shooting form to try to improve.

Going to play basketball, the author sees players with different forms and unconventional releases nearly every time on the court. During college, the author began to wonder how he could optimize his shooting form without having to completely change his form to meet the ideal professional standards. That is the basis for this capstone project. The research goal was to identify the most crucial aspects of the author's jump shot and to determine what areas of improvement can be made to become a better shooter. The same systematic approach can be used by others who similarly have a form that does not conform to the standard shooting practices utilized in the game today and taught in youth leagues.

At the heart of this project is the ability to isolate the factors that need improvement or greater consistency to help improve the relative probability of making a jump shot. There is not currently a marketable approach available to recreational players or players who have not been recognized as elite level talent. There are coaches and programs to help improve the dynamics of one’s jump shot, but they usually rely on mirroring the jump shot mechanics of professional players. This project provides anybody who is looking to improve and to determine the most crucial elements of their jump shot without being forced to change their mechanics to the point of rebuilding. From many academic sources, it is apparent that the largest amount of experimentation has been conducted into investigating the release angle at set distances for optimality [12].

Project Goals

This project provided a unique opportunity to utilize much of the academic curriculum experienced in the author’s graduate level courses, as well the chance to revisit important concepts from the author’s undergraduate physics courses. Basketball is a staple in the author’s daily life and this capstone project provided the opportunity to utilize the author’s extended education to achieve a more complete understanding of it. More specifically, this project helped to clarify the fundamental aspects of the author’s jump shot, isolate the components most critical to shot success, and allow the author to model his jump shot to see these factors and implement improvement goals to achieve growth.

The design and analysis of this project required a multidisciplinary approach to effectively isolate the factors most critical to shot success and to model the effective solution. The entire design of this experiment relied on principles in quality engineering. A formal Design of Experiment (DOE), factor sorting, fishbone diagram, and full factorial analysis were required to fully gather the required information. In addition, several concepts investigated in advanced mechanical systems, *Simulink* modelling, and advanced level physics and dynamics were implicated.

The goal of this project was to show a statistically significant difference in basketball shot success based on measured values of six project factors that were identified in a review of literature: release time, release angle, leg angle, vertical jump, rotational speed on the ball, and ball speed immediately upon release [12, 13, 14, 15]. In the basketball community, it is difficult to examine a jump shot and provide statistically supported suggestions for recreational players to improve. If this issue is ignored, players will continue to not utilize potentially more effective shooting mechanics and miss more basketball shots in games. This project utilized the Design of Experiments (DOE) methodology to evaluate the author's shooting mechanics to help improve future shot success. This capstone project investigation was intended to isolate the statistically significant factors relevant to the success of a free throw line jumper. In addition, an adjustable and statistically significant model was produced that will allow the adjustments of significant factors based on improvements in the future. The statistical model produced in this project was based on assumptions made and concluded through a Design of Experiment (DOE) process, based on a 95% probability null hypothesis. This procedure allowed the factors determined to be statistically significant with 95% certainty.

The primary goals of this project were to:

1. Produce a full factorial Design of Experiment (DOE) that complies with the standard requirements in quality engineering, accounting for biases and randomization to achieve more statistically significant results.
2. Run a full experimentation process to collect one thousand data points with respect to the parameters of this study.
3. Isolate the factors determined to be statistically significant with respect to the outcome of free throw line jump shot success based on the data collected.
4. Design and create a simulation model with *MATLAB*/*Simulink* that will correctly map out the data collected from the investigation.
5. Produce hypothetical results from the simulation model to track potential progress in areas of significance.

Review of Literature

In the academic community today, there has been extensive research into shooting mechanics with respect to jump shot accuracy. Specifically, much of the research has focused on the three main components of the jump shot: release height, release angle, and initial velocity of the ball upon release. An increase in distance from the basket produces a smaller ideal launch angle [12]. These findings from “The Relationship Between Basketball Shooting Kinematics, Distance and Playing Position”, by Stuart Miller and Roger Bartlett, determined an ideal release angle of around 52 to 55 degrees from the horizontal as a shorter distance tended to provide the advantage of a steep angle of entry into the basket, whereas the longest distance ideal release angle of 48 to 50 degrees was closer to those requiring the minimum possible release speed [12]. This is evident as a six-foot tall athlete shooting one foot from the rim will need a much higher release angle than the same athlete shooting from thirty feet away. It is also important to note that the higher the release angle of the shot, the larger the area of target is with regards to making the shot, as the basketball rim is parallel with the floor [13]. This is further complicated by the addition of spin on the ball. By adding back spin on the basketball during a jump shot, an increase occurs in the entry angle of the ball into the rim, which in turn increases the target area [13]. In addition, adding back spin to the ball can cause a softer bounce on the rim and backboard in several areas to help increase the overall area where a shot can go in [14]. These are the findings from "Biomechanics of the Basketball Jump Shot – Six Key Teaching Points" by Duane Knudson [14]. Knudson investigated the effect ball rotational speed has on shot success and determined that a vigorous vertical wrist flexion and pronation near release creates backspin that helps decrease the speed of the ball when the ball contacts the rim and increases shot success. These ideas are explored further in the book *Straight Shooter* by Bob J. Fisher [15], which investigates the physics of free-throw shooting.

According to Fisher [15], the ideal release angle for a six-foot tall player is about 51 degrees. Because the author is the subject for this capstone study, this value was investigated to see if a similar result could be verified. In the journal article "Biomechanical Analysis of the Jump Shot in Basketball", Struzik *et al*. [6] examined the biomechanics of basketball scoring. From this study, approximately 70 percent of the shots taken were characterized as a jump shot. This study also investigated the take-off time, mean power, peak power, relative mean power, jump height, maximum landing force, and impact ratio during this process. This study also examined the differences in shooting mechanics of the participating players, revealing unique shooting styles even at the same level of play. Struzik *et al*. [6] theorized that this state of affairs is largely due to the different length proportions between upper body segments.

Methods

The purpose of this project was to determine the relevant mechanics most crucial to affecting the desired outcome of making a jump shot and what steps in manipulating them can affect shooting percentage in the future. To accomplish this task, this capstone project featured a Design of Experiment (DOE) approach to measure six factors of the author's jump shot from the free throw line: release time, release angle, leg angle, vertical jump, rotational speed on the ball, and ball speed immediately upon release. These factors were selected for this analysis based on their ease of recording utilizing the Homecourt application and the estimated effect on the response variable, make percentage. Figure 3 displays the visual representations of the study factors used in this experimentation.

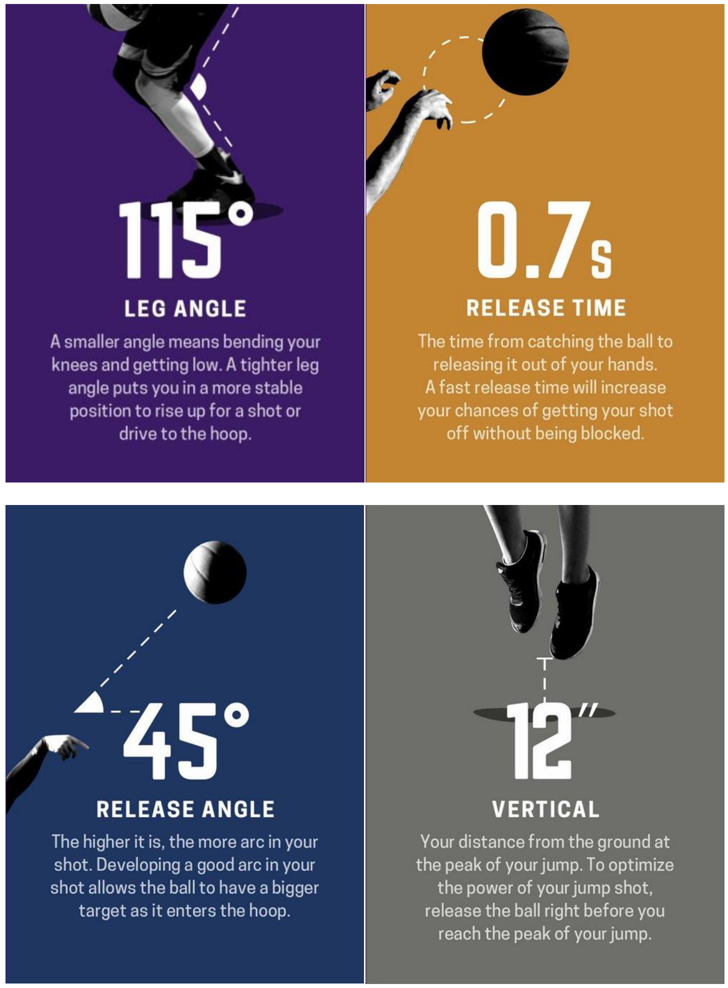

Figure 3: Study Factor Definitions [16].

This project took place on a regulation indoor basketball court with a stand to mount the video recording device in one single location. After setting up this experiment using factor sorting and a fishbone diagram to identify these six project factors and determine any noise factors, these six factors were video recorded over a collection of one thousand free throw line jump shots and then analyzed with software available in *Minitab*. The *Homecourt* application utilizes AI-powered assessment tools to provide real time feedback of the study factors along with determining whether the shot was made or missed, saving a video recording of each shot. Once the data for each shot were collected, the video recordings were saved in the application and available to review with the time between shots cut out for ease of analysis. The relevant information for each shot was then manually entered into Excel for analysis. The one thousand free throw line jump shots were taken over a two-month period in two hundred-shot increments every Saturday at the same time each week to account for any shots in which the video recording was unable to produce realistic values.

After values from the *Homecourt* application were collected and transferred to Excel, the study factors were broken down into three levels, consisting of low (-), medium (0), or high (+), based on the averages found for each factor. The number of levels for each factor was determined by analysis from the *Minitab* software. As the levels increased, the data lose resolution as the response variable becomes values of zero percent and one hundred percent with few shots for each configuration. Conversely, the decrease of level utilized explains less of the data collected and consequently produces a governing equation with less variance explained. After several trials with differing amounts of levels for each study factor, it was determined that three levels provided enough resolution without sacrificing on the amount of the variation that would be explained.

The next step was to convert the discrete response for the make/miss collected from the experimentation into a continuous make percentage value to allow utilization of the general linear model within the *Minitab* software. To do this, each configuration of the study factors, as broken down by the three levels, was isolated and a make percentage was determined for every configuration found. Within the *Minitab* software, it was possible to then determine which of these six factors, and combination of factors, are statistically significant in increasing the desired outcome of making the shot go through the basket. With this methodology, an analysis of the normality, distribution, and means/medians of all these factors to provide a more complete understanding of the author's jump shot was conducted utilizing a Ryan-Joiner normality test [17]. Because of the sensitivity of the Anderson-Darling normality test when analyzing a large sample size such as the data collected for this experiment [18], the Ryan-Joiner normality test was used [17]. In this investigation, the Ryan-Joiner normality test features high power when testing for normal distribution and higher precision in comparison to other normality tests. After the normality examination confirms a likely normal data distribution, a general linear model can be utilized to determine significance and a governing equation for how the study factors in this project and their combinations contribute to the make percentage of this free throw line author's jump shot. A general linear model or general multivariate regression model simply is a process of simultaneously writing several multiple linear regression models in the sense that it is not a separate statistical linear model.

The next step of the analysis was to create a model of these data to be able to statistically model the author's jump shot using *Simulink* and *MATLAB*. This final step allows the author to see how changes in any number of these factors can affect shot success. The model was developed using the distribution data for each study factor as expressed in the Ryan-Joiner normality tests as the input to the model using a normally distributed random number generator block. After recording the values for each study factor, the simulation then categorizes each study factor's value into the same three levels determined from the averages of the collected data in the experimentation. The next step of the simulation was to input the equation described from the general linear model to produce a percent chance that the shot will be made or missed with the given inputs for the study factors. Finally, the model then uses the percent chance of a made or missed basket from the input study factors to simulate whether the shot will be made or missed using a random number generator and track made and missed shots. This model has the ability to recreate a realistic simulation of the data collected using the analysis conducted through this project. In addition, the model allows for the editing of the study factors inputs to account for improvements in consistency and increases or decreases in the mean values.

The goal of this project was to show a statistically significant difference in basketball shot success based on measured values of the six project factors: release time, release angle, leg angle, vertical jump, rotational speed on the ball, and ball speed immediately upon release. In the basketball community, it is difficult to examine a jump shot and provide statistically supported suggestions for recreational players to improve. If this issue is ignored, players will continue to not utilize potentially more effective shooting mechanics and thus miss more basketball shots in games. This project employed the Design of Experiments (DOE) methodology to evaluate the author's shooting mechanics to help improve future shot success.

To conduct the investigation itself, there were several resources that were necessary. First, access to a standard indoor basketball court with outline markings for a free throw line and a standard men's basketball were required. In addition, access to the mobile application "Homecourt" provides the easiest way of tracking several of the key factors that were investigated in this project [https://homecourt.ai]. With the use of this app, access was required to a device to record video. Moreover, a set-up was needed to be devised to mount this device to be able to see the subject perform the free throw line jump shot. The analysis in this project required the use of *Minitab*. This software features the built-in capabilities to conduct the general linear model analysis necessary for this experiment. Lastly, access to *MATLAB* and *Simulink* was required to build the final model for this project. This model allowed the participant to see their current shooting ability and it provides an opportunity to see how changes in consistency or any of the statistically significant factors can affect the subject's shooting percentage.

Results and Discussion

In this experiment, one thousand of the author's free throw line jumpers were examined under six study factors: release time, release angle, leg angle, vertical, release speed, and backspin. For each shot, the value for each of these study factors, as well as if the shot was made (1) or missed (0), was recorded. Table A-1 in Appendix A shows the recorded numerical values of the data for each shot recorded under these conditions.

The data associated with the one thousand jump shots in this project show average values for release time, release angle, leg angle, vertical, release speed, and backspin of 1.5 seconds, 57.14 degrees, 131.99 degrees, 4.73 inches, 5.75 meters per second, and 2.45 rotations per second, respectively. These data produced a shooting percentage of 51%. Since the study factors are continuous as they are measured by each shot, the data can be broken down into levels for each factor. Each factor was broken down into three levels, low (-), medium (0), and high (+). Table 1 shows the numerical breakdown of the data to determine the levels within each factor.

Table 1: Breakdown of Ranges for Each Study Factor.

	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)
Low (-)	0-1.4	0-56	0-126	0-4	0-5.6	0-2.2
Medium (0)	1.5	57-59	127-131	5	5.7-5.8	2.3-2.6
High (+)	1.6+	60+	132+	6+	5.9+	2.7+

A review of Table 1 shows that a shot with a release time of between zero and 1.4 seconds would be categorized as a low (-) release time shot, while a shot with a release time of 1.6 seconds or more would be categorized in the high range. This breakdown allows the conversion of the continuous data collected by the experimentation to be discrete and acceptable within the constraints of a general linear model study.

The first portion of the data analysis was to conduct a probability plot for each study factor to examine normality and explore irregularities that may influence the validity of the results. Figure 4 displays the probability plot for the study variable of release time in seconds.

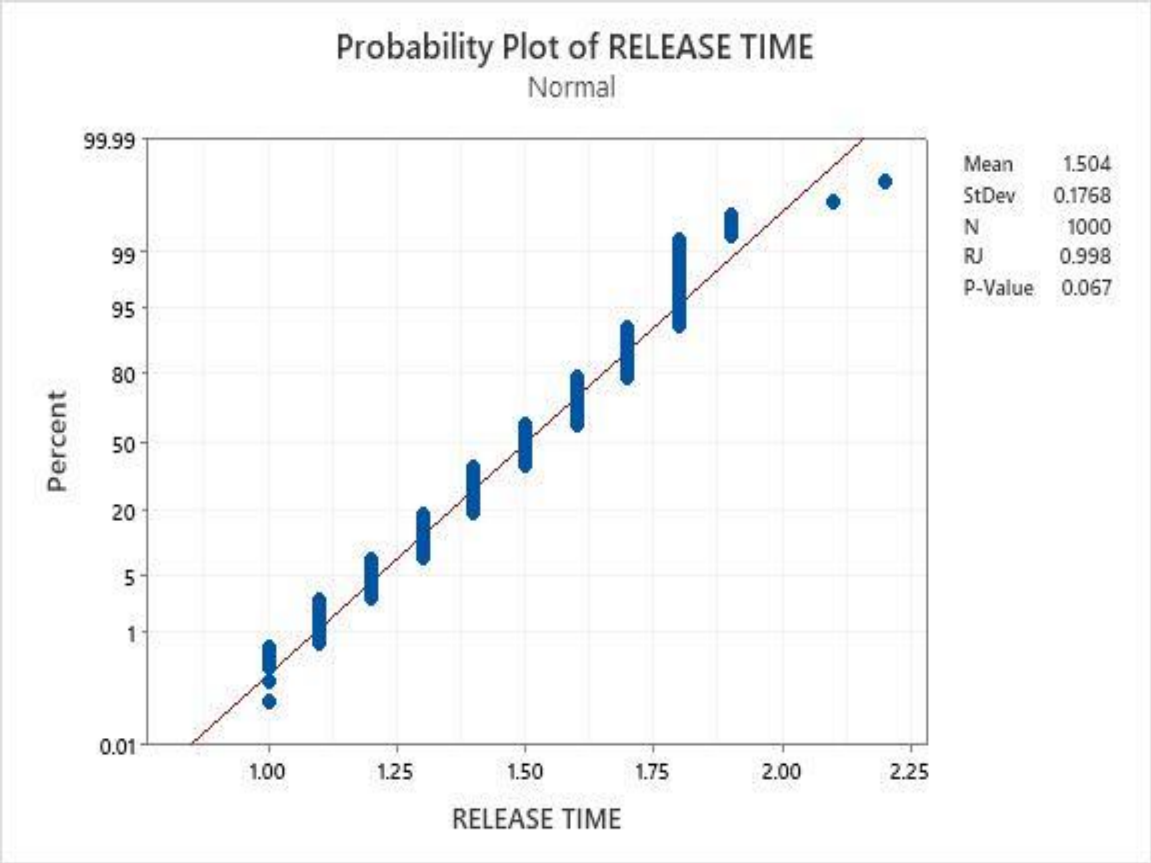

Figure 4: Probability Plot for Release Time (seconds).

Using a Ryan-Joiner Normality Test, the release time data collected can be reasonably assumed to be normally distributed with a P-Value of greater than 0.05. From this test, a mean and standard deviation for these data can be found as 1.504 seconds and 0.1768 seconds, respectively. The Ryan-Joiner statistic of the data collected can also be noted at 0.998. Since the Ryan-Joiner statistic is near a value of one and the P-Value is above 0.05, there is not enough evidence to conclude that the data collected for release time do not follow a normal distribution and therefore the data are likely normally distributed. Figure 5 displays the probability plot for the study variable of release angle in degrees.

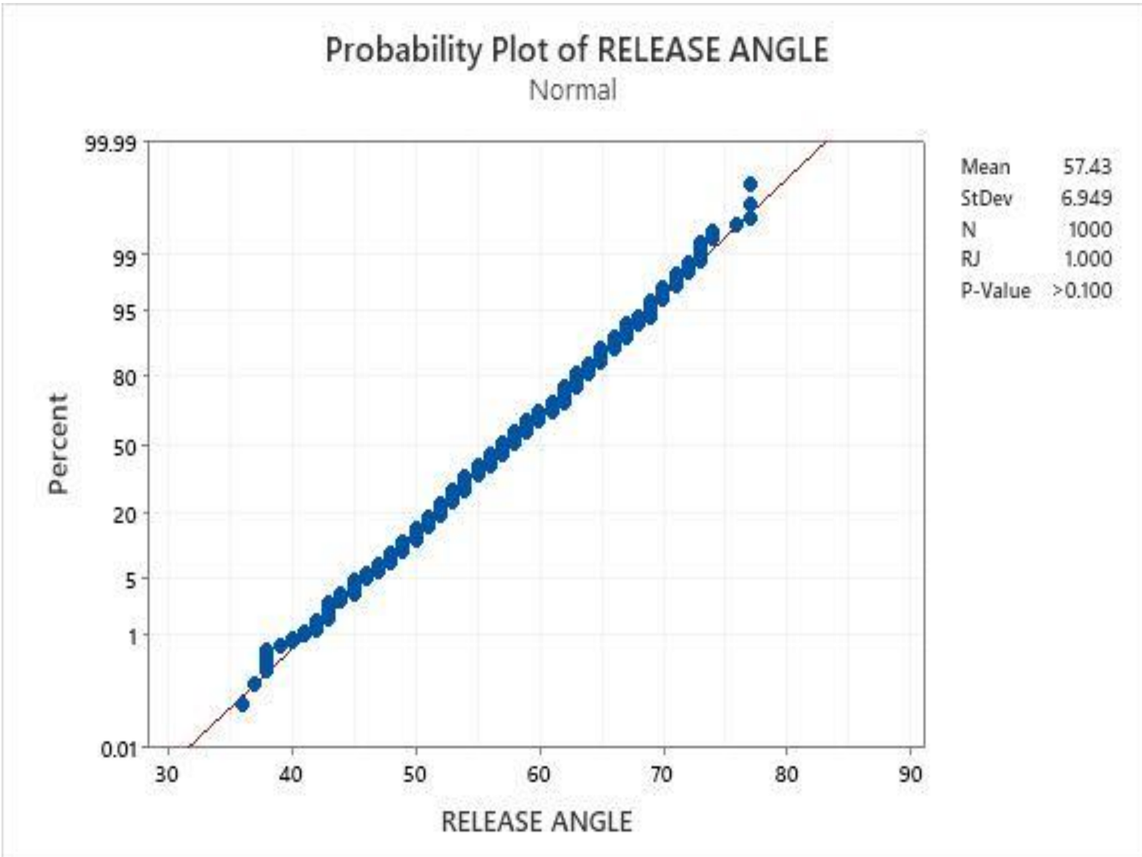

Figure 5: Probability Plot for Release Angle (degrees).

Using a Ryan-Joiner Normality Test, the release angle data collected can be reasonably assumed to be normally distributed with a P-Value of greater than 0.05. From this test, a mean and standard deviation for these data can be found as 57.43 degrees and 6.949 degrees, respectively. The Ryan-Joiner statistic of the data collected can also be noted at 1.000. Since the Ryan-Joiner statistic is a value of one and the P-Value is above

0.05, there is not enough evidence to conclude that the data collected for release angle do not follow a normal distribution and therefore the data are likely normally distributed. Figure 6 displays the probability plot for the study variable of leg angle in degrees.

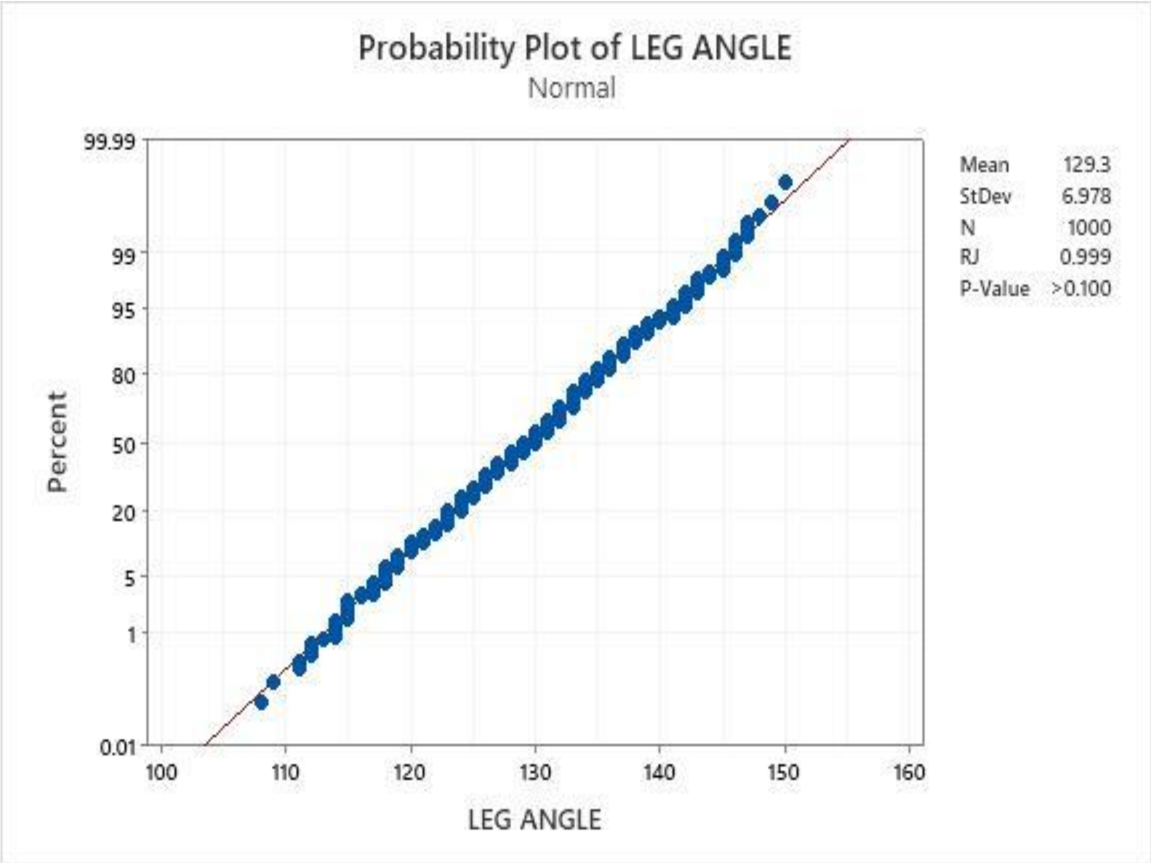

Figure 6: Probability Plot for Leg Angle (degrees).

Using a Ryan-Joiner Normality Test, the leg angle data collected can be reasonably assumed to be normally distributed with a P-Value of greater than 0.05. From this test, a mean and standard deviation for these data can be found as 129.3 degrees and 6.978 degrees, respectively. The Ryan-Joiner statistic of the data collected can also be noted at 0.999. Since the Ryan-Joiner statistic is near a value of one and the P-Value is above 0.05, there is not enough evidence to conclude that the data collected for leg angle do not follow a normal distribution and therefore the data are likely normally distributed. Figure 7 displays the probability plot for the study variable of vertical in inches.

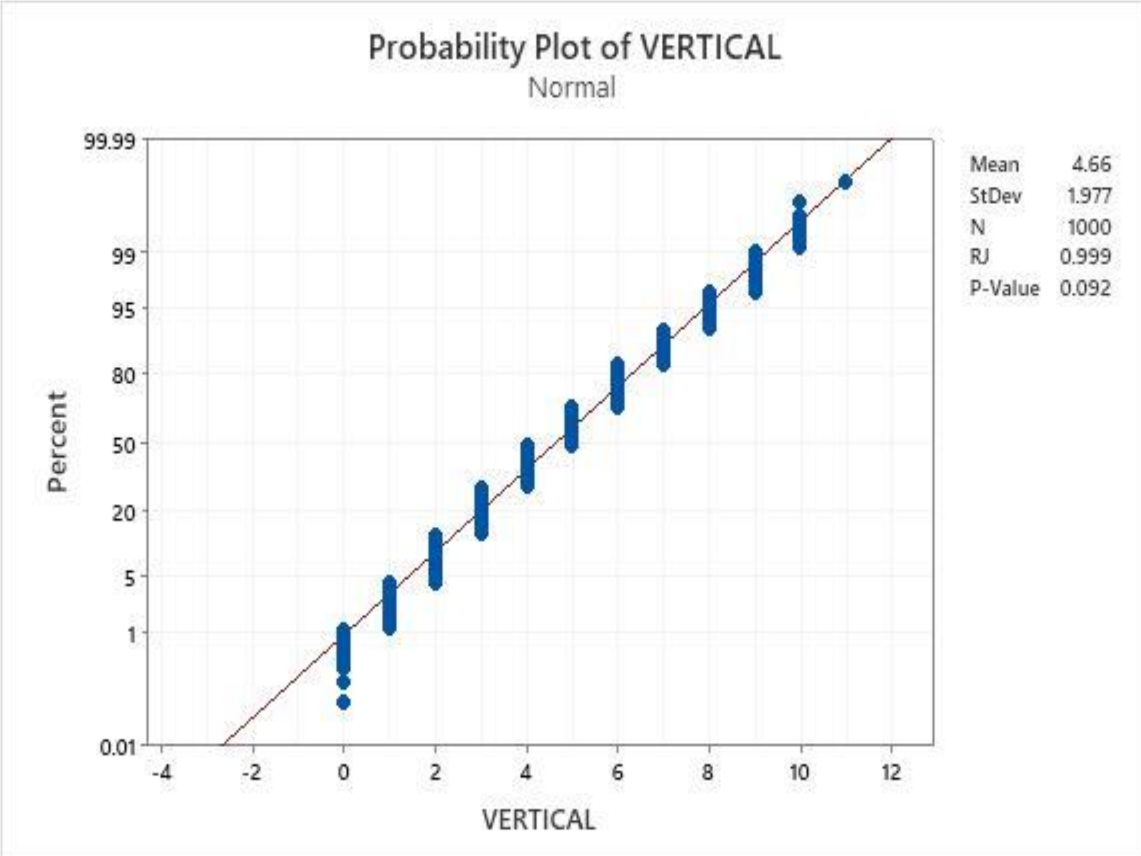

Figure 7: Probability Plot for Vertical (inches).

Using a Ryan-Joiner Normality Test, the vertical data collected can be reasonably assumed to be normally distributed with a P-Value of greater than 0.05. From this test, a mean and standard deviation for these data can be found as 4.66 inches and 1.977 inches, respectively. The Ryan-Joiner statistic of the data collected can also be noted at 0.999. Since the Ryan-Joiner statistic is near a value of one and the P-Value is above 0.05, there is not enough evidence to conclude that the data collected for vertical do not follow a normal distribution and therefore the data are likely normally distributed. Figure 8 displays the probability plot for the study variable of release speed in seconds.

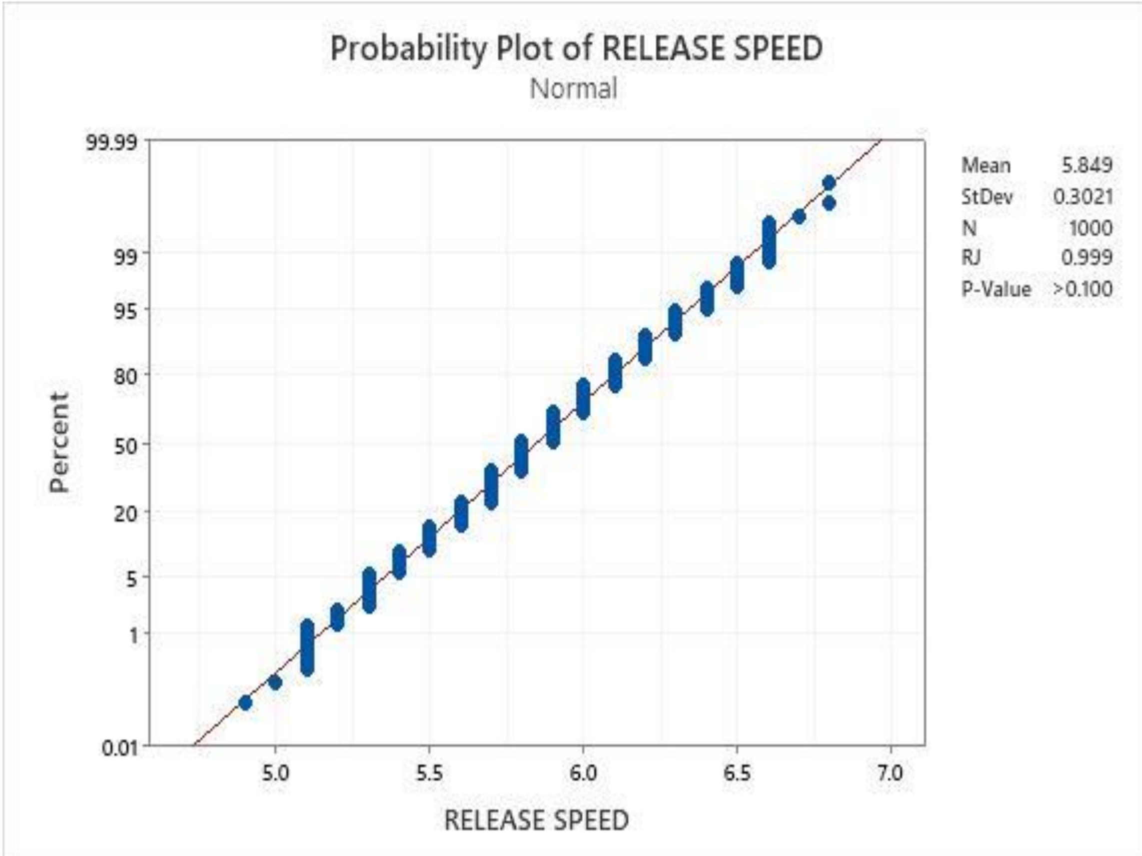

Figure 8: Probability Plot for Release Speed (meters/second).

Using a Ryan-Joiner Normality Test, the release speed data collected can be reasonably assumed to be normally distributed with a P-Value of greater than 0.05. From this test, a mean and standard deviation for these data can be found as 5.849 seconds and 0.3021 seconds, respectively. The Ryan-Joiner statistic of the data collected can also be noted at 0.999. Since the Ryan-Joiner statistic is near a value of one and the P-Value is above 0.05, there is not enough evidence to conclude that the data collected for release speed do not follow a normal distribution and therefore the data are likely normally distributed. Figure 9 displays the probability plot for the study variable of backspin in rotations per second.

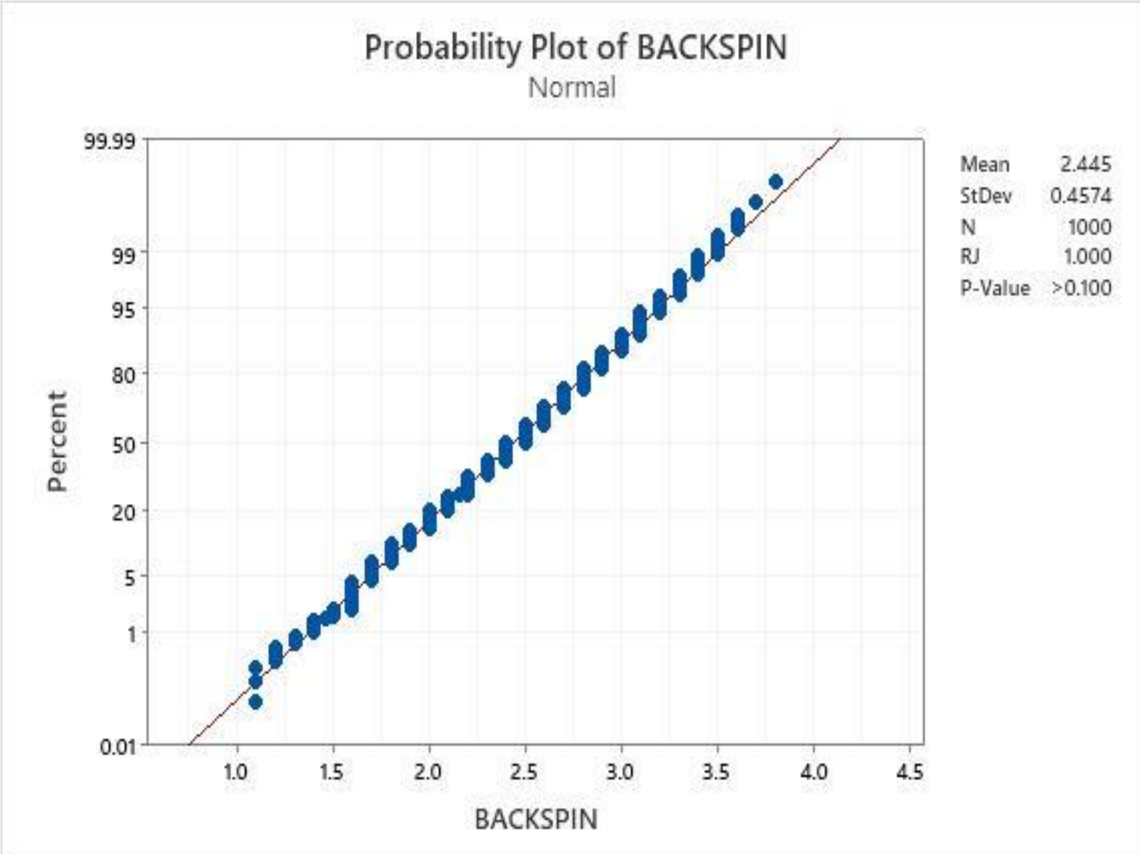

Figure 9: Probability Plot for Backspin (rotations/second).

Using a Ryan-Joiner Normality Test, the backspin data collected can be reasonably assumed to be normally distributed with a P-Value of greater than 0.05. From this test, a mean and standard deviation for these data can be found as 2.445 rotations per second and 0.4574 rotations per second, respectively. The Ryan-Joiner statistic of the data collected can also be noted at 1.000. Since the Ryan-Joiner statistic is a value of one and the P-Value is above 0.05, there is not enough evidence to conclude that the data collected for backspin do not follow a normal distribution and the data are likely normally distributed.

After each study factor's normality was validated with a Ryan-Joiner Normality Test, and examined for potential abnormalities that could affect the study, the study factors categorized into the low (-), medium (0), and high (+) values were examined under their corresponding make percentages. Using a general linear model in accordance with an alpha value of 0.05, the significant factors and interactions were identified, as shown in Table 2.

Table 2: Determination of Significant Factors and Interactions.

Source	P-Value
RELEASE TIME (s)	0.329
RELEASE ANGLE (deg)	0.008
LEG ANGLE (deg)	0.931
VERT (in)	0.904
RELEASE SPEED (s)	0.000
BACKSPIN (rot/s)	0.018
RELEASE TIME (s)*VERT (in)	0.618
RELEASE TIME (s)*BACKSPIN (rot/s)	0.480
RELEASE ANGLE (deg)*LEG ANGLE (deg)	0.577
RELEASE ANGLE (deg)*VERT (in)	0.000
RELEASE ANGLE (deg)*BACKSPIN (rot/s)	0.981
LEG ANGLE (deg)*VERT (in)	0.006
LEG ANGLE (deg)*BACKSPIN (rot/s)	0.472
VERT (in)*RELEASE SPEED (s)	0.000
VERT (in)*BACKSPIN (rot/s)	0.200
RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)	0.019
RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)	0.024
Error	
Total	

Using a general linear model, the results presented in Table 2 can be used to determine the significant factors and interactions playing a role in determining the response variable, make percentage. The general linear model used a backward elimination method to remove variables that were not considered to be statistically significant based on a P-Value of 0.05. Based on this experiment, release angle, release speed, and backspin, as well as the combination factors -- release angle/vertical, leg angle/vertical, vertical/release speed, release time/vertical/backspin, and release angle/leg angle/backspin -- were found to be statistically significant in determining the corresponding response variable, make percentage. Main factors that were not determined to be statistically significant by themselves but were found to be statistically significant as a combination factor were kept as they provided effects on the response variable.

The next step of this examination was to explore how well the study factors are associated with the response and determine whether the model may be missing higher order study factors that include the predictors in the model. An analysis of the variance of the significant study factors was performed, as shown in Table 3.

Table 3: Analysis of Variance for Significant Study Factor.

Source	DF	Adj SS	Adj MS	F-Value
RELEASE TIME (s)	2	0.2112	0.105576	1.12
RELEASE ANGLE (deg)	2	0.9365	0.468243	4.96
LEG ANGLE (deg)	2	0.0136	0.006785	0.07
VERT (in)	2	0.0190	0.009520	0.10
RELEASE SPEED (s)	2	1.5187	0.759325	8.04
BACKSPIN (rot/s)	2	0.7790	0.389491	4.12
RELEASE TIME (s)*VERT (in)	4	0.2509	0.062718	0.66
RELEASE TIME (s)*BACKSPIN (rot/s)	4	0.3306	0.082662	0.88
RELEASE ANGLE (deg)*LEG ANGLE (deg)	4	0.2732	0.068307	0.72
RELEASE ANGLE (deg)*VERT (in)	4	2.2364	0.559102	5.92
RELEASE ANGLE (deg)*BACKSPIN (rot/s)	4	0.0390	0.009744	0.10
LEG ANGLE (deg)*VERT (in)	4	1.3962	0.349053	3.70
LEG ANGLE (deg)*BACKSPIN (rot/s)	4	0.3357	0.083919	0.89
VERT (in)*RELEASE SPEED (s)	4	2.6568	0.664209	7.03
VERT (in)*BACKSPIN (rot/s)	4	0.5713	0.142815	1.51
RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)	8	1.7878	0.223473	2.37
RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)	8	1.7237	0.215464	2.28
Error	194	18.3258	0.094463	
Total	258	30.7735		

The data shown in Table 3 explore the variance of the significant factors. Since in this study, it was decided to examine the null hypothesis based on the P-Values obtained in Table 2 against the 0.05 alpha value instead of the F-Value, the F-Values are not compared to a null hypothesis for determination of significance. Both the P-Values and the F-Values can be used to determine significance and should be used in conjunction to understand the overall results, but in this study the P-Values are used to evaluate the probability the results could have occurred by chance and can be compared directly to the alpha value of 0.05. It is important to note the adjusted mean squares and the adjusted sum of squares, as these values represent the variance around the fitted values and the variance due to different sources within this model, respectively. These values are both utilized to calculate the corresponding P-Values displayed in Table 2 and the R^2 value.

The next step of the examination was to interpret the percentage of variance explained by the model. Within the general linear model, values for S, R^2, adjusted R^2, and predicted R^2 can be obtained. These values are shown in Table 4.

Table 4: Analysis of Percentage of Variation Explained by Model.

S	R-sq	R-sq(adj)	R-sq(pred)
0.307348	40.45%	20.80%	0.00%

The value for S in Table 4 represents how far the data values fall from the fitted values in the model. The value for S is a relatively low value of approximately 0.307, meaning the model does a fair job in explaining the data but more factors may be playing a role. The value for R^2 adjusted (R-sq(adj)) is a value for the percentage of the variation that is explained by the model while adjusting for large sample size and inflated factors. In this experiment, approximately twenty-one percent of the variation can be explained by this model. Based on the results presented in Table 4, it can be observed that the model is able to explain the data collected, but there is more that may be playing a part in determining the response variable, make percentage. In this case, the low percent of the variation in the data that can be explained was limited by the amount of factors that it was feasible and sensible to measure.

The final step of this examination was to examine the residuals using a four-in-one chart utilized in general linear models. This examination of residuals was necessary in order to identify indications of skewness and outliers, to verify normality of the residuals, and to verify random distribution and independence of the residuals found in experimentation. Shown in Figure 10 are the residual plots found in this experimentation.

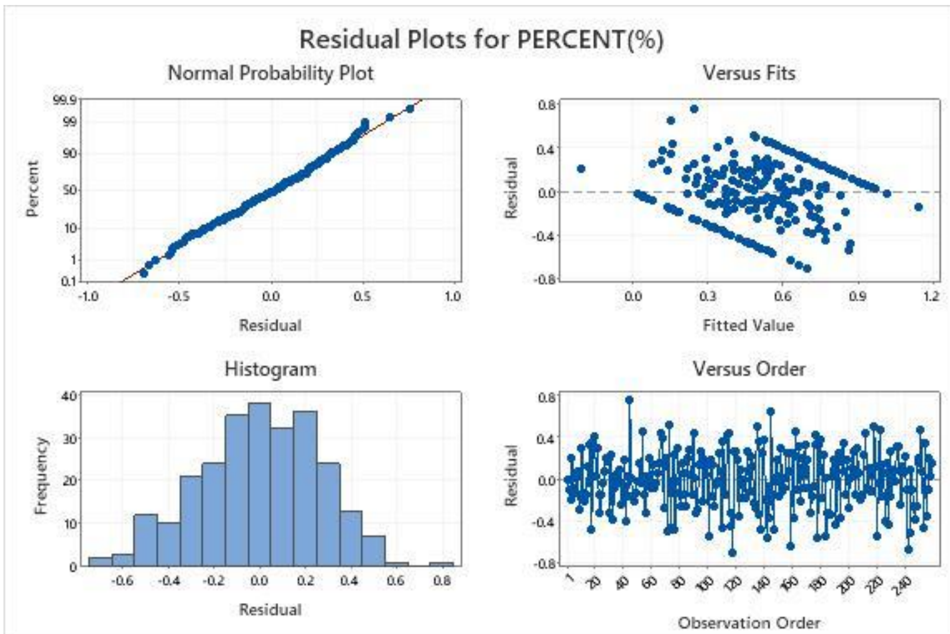

Figure 10: Residual Plots for Make Percentage.

Figure 10 first displays the normal probability plot of the data. The normal probability plot of the residuals is utilized to verify the assumption that the residuals are normally distributed. Based on this plot, the residuals follow the line very well and do not represent an S-curve, inverted S-curve, or downward curve that would imply a distribution with long tails, a distribution with short tails, or a right skewed distribution. There are a few points lying away from the plotted line, which could imply a distribution with outliers, although it appears that the residuals can be assumed to be normally distributed. The next plot displays the histogram of the residuals. This plot shows the distribution of the residuals for all the observations collected in this data set. The histogram appears to follow a normal bell curve and does not appear to have a long tail in either direction or a bar that is far away from the main group, which means it is unlikely that the residuals have skewness or an outlier to be aware of.

The third plot displays the versus fit of the residuals obtained in this experimentation. Ideally, this plot would appear as if points are randomly distributed on both sides of zero. In this experimentation, there appears to be a clear pattern, which could indicate a missing higher-order term or nonconstant variance. For this experiment, this can be attributed to the original discrete response that was converted to a continuous make percentage for this study. For this study, the assumption of randomly distributed residuals is made. The final plot in Figure 10 displays the versus order of the residual values. Ideally, this plot will show no clear trends or patterns and appear randomly distributed in the time order. The plot in Figure 10 for versus order does not appear to have any noticeable trends or patterns, meaning that the assumption of independent residuals can be justified.

The final step of this analysis was to examine the effects each of the significant factors and interaction factors have on the resulting response variable. Shown in Figure 11 is the main effect plot for the six study factors. Of these six study factors, it was determined in Table 2 that the release angle, release speed, and backspin were the only factors to be considered statistically significant in determining the make percentage of this author’s free throw line jump shot.

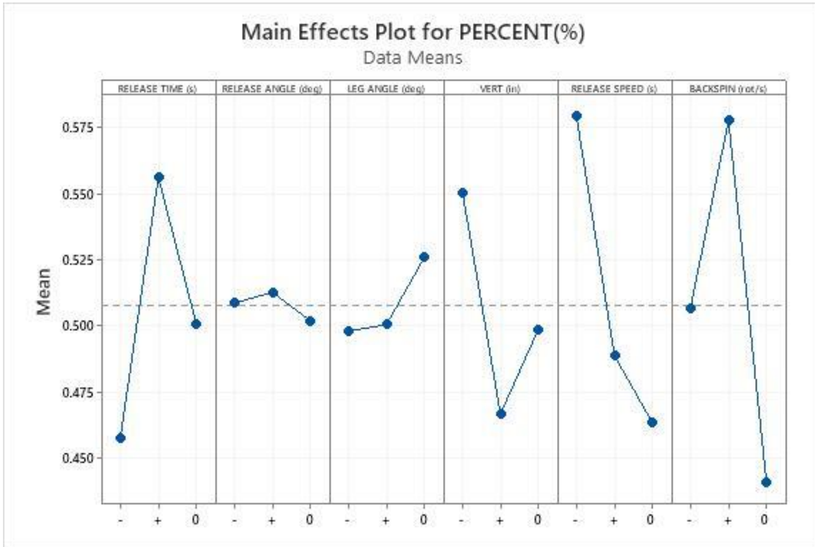

Figure 11: Main Effects Plot for Study Factors.

In Figure 11, the mean value for the response variable, make percentage, is compared across the three levels of each study factor. Of these six study factors, it was determined in Table 2 that the release angle, release speed, and backspin were the only factors to be considered statistically significant in determining the make percentage of this author's free throw line jump shot. It can be observed that the optimum values for the statistically significant study factors -- release angle, release speed, and backspin -- can be defined as high (+) for release angle, low (-) for release speed, and high (+) for backspin. This means that an ideal shot would utilize a release angle of 60 degrees or greater, a release speed of 5.6 seconds or less, and a backspin of 2.7 rotations per second or greater.

After looking at the main effects plot for this experimentation, it was determined that a detailed investigation into the statistically significant interaction plots was needed. Shown in Figure 12 is the interaction plot of the vertical and release angle on the response variable, make percentage.

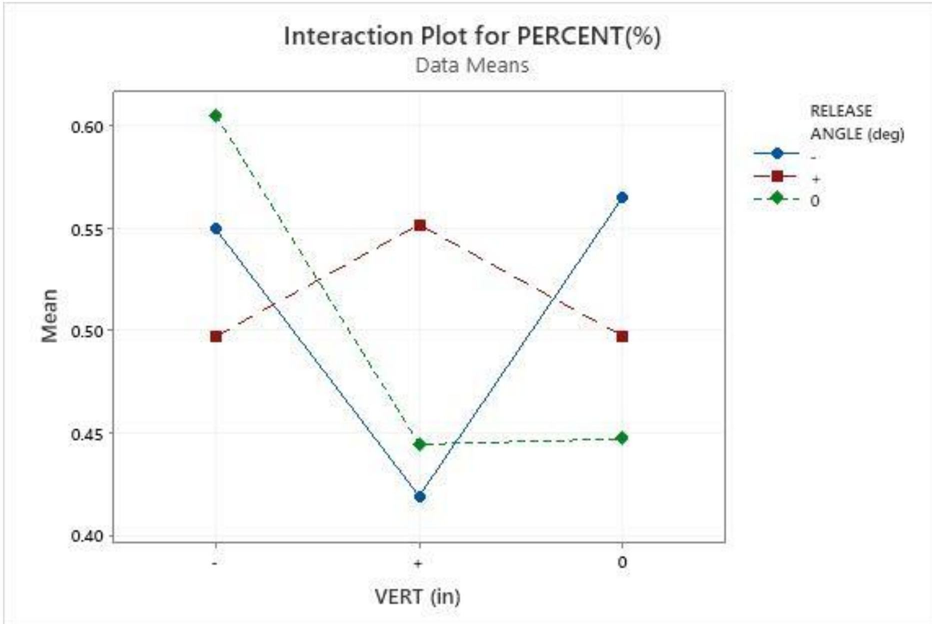

Figure 12: Interaction Plot for Release Angle and Vertical.

The plot in Figure 12 shows the effects of the three levels of release angle and vertical on make percentage when combined. It can be observed that with a maximum make percentage mean of over 60 percent and a minimum mean percentage of approximately 42 percent, these interactions play a major role in determining the make percentage of this author's free throw line jumper. The ideal shot based on this interaction plot would be a medium release angle between 57 and 59 degrees and a low vertical of four inches or less.

After looking at the interaction plot for release angle and vertical for this experimentation, an investigation into the leg angle and vertical interaction plot was undertaken next. Shown in Figure 13 is the interaction plot of the vertical and leg angle on the response variable, make percentage.

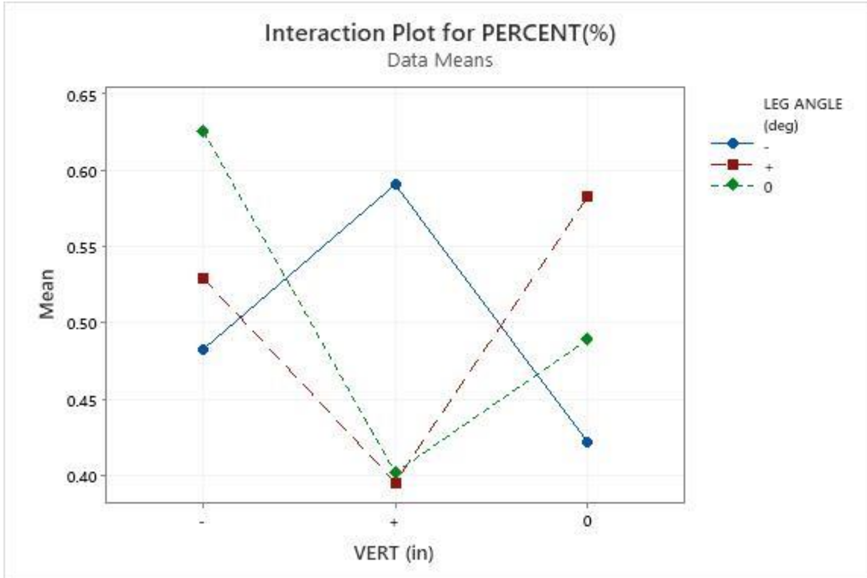

Figure 13: Interaction Plot for Leg Angle and Vertical.

The plot in Figure 13 shows the effects of the three levels of leg angle and vertical on make percentage when combined. It can be observed that with a maximum make percentage mean of approximately 63 percent and a minimum mean percentage of approximately 39 percent, these interactions play a major role in determining the make percentage of this author's free throw line jumper. The ideal shot based on this interaction plot would be a medium leg angle of between 127 and 131 degrees and a low vertical of four inches or less.

After looking at the interaction plot for leg angle and vertical for this experimentation, an investigation into the release speed and vertical interaction plot was conducted. Shown in Figure 14 is the interaction plot of the vertical and release speed on the response variable, make percentage.

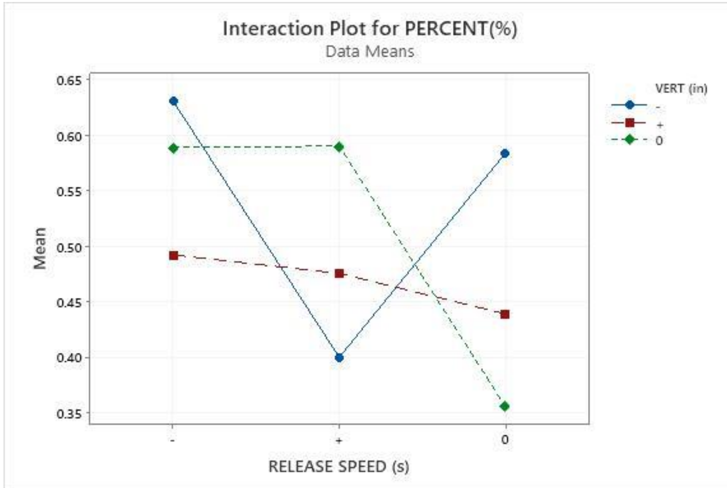

Figure 14: Interaction Plot for Release Speed and Vertical.

The plot in Figure 14 shows the effects of the three levels of release speed and vertical on make percentage when combined. It can be observed that with a maximum make percentage mean of approximately 63 percent and a minimum mean percentage of approximately 40 percent, these interactions play a major role in determining the make percentage of this author's free throw line jumper. The ideal shot based on this interaction plot would be a low release speed of 1.4 seconds or less and a low vertical of four inches or less.

After looking at the interaction plot for leg angle and vertical for this experimentation, an investigation into the statistically significant three-factor interaction factors was then undertaken. Shown in Figure 15 is the interaction plot of the release time, vertical, and backspin on the response variable, make percentage.

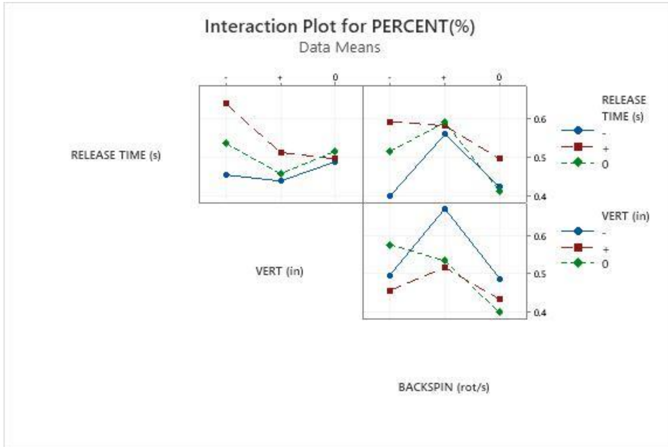

Figure 15: Interaction Plot for Release Time, Vertical, and Backspin.

The plot in Figure 15 shows the effects of the three levels of release time, vertical, and backspin on make percentage when combined. It can be observed that with a maximum make percentage mean of nearly 70 percent and a minimum mean percentage of approximately 40 percent, these interactions play a major role in determining the make percentage of this author’s free throw line jumper. The ideal shot based on this interaction plot would be a high backspin of 2.7 rotations per seconds or greater, a low vertical of four inches or less, and a high release time of 1.6 seconds or greater.

After looking at the interaction plot for release time, vertical, and backspin for this experimentation, an investigation into interaction of the study factors of release angle, leg angle, and backspin was conducted next. Shown in Figure 16 is the interaction plot of the release angle, leg angle, and backspin on the response variable, make percentage.

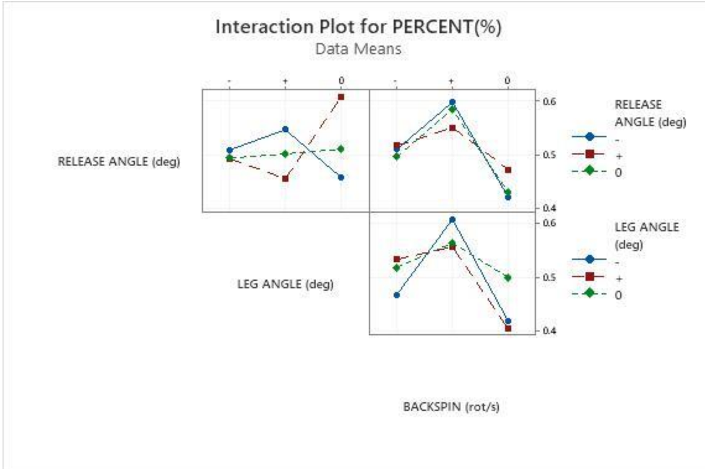

Figure 16: Interaction Plot for Release Angle, Leg Angle, and Backspin.

This plot shows the effects of the three levels of release angle, leg angle, and backspin on make percentage when combined. It can be observed that with a maximum make percentage mean of approximately 61 percent and a minimum mean percentage of approximately 40 percent, these interactions play a major role in determining the make percentage of this author’s free throw line jumper. The ideal shot based on this interaction plot would be a high backspin of 2.7 rotations per seconds or greater, a low leg angle of 126 degrees or less, and a low release angle of 56 degrees or less.

From the general linear model shown in Table 3, it was determined that release angle, release speed, and backspin, as well as the combination factors -- release angle/vertical, leg angle/vertical, vertical/release speed, release time/vertical/backspin, and release angle/leg angle/backspin -- were found to be statistically significant in determining the corresponding response variable, make percentage. Based on this conclusion, a general equation can be developed to estimate the make percentage, which is based in turn on the levels of the significant factors within this study. Shown in Table 5 is the estimation equation for make percentage as found by the general linear model.

Table 5: Equation for Make Percentage for Significant Factors and Interactions.

Response Variable		Equation
PERCENT(%)	=	0.4903 - 0.0432 RELEASE TIME (s)_- + 0.0332 RELEASE TIME (s)_+ + 0.0100 RELEASE TIME (s)_0 - 0.1847 RELEASE ANGLE (deg)_- + 0.1047 RELEASE ANGLE (deg)_+ + 0.0800 RELEASE ANGLE (deg)_0 - 0.0060 LEG ANGLE (deg)_- + 0.0104 LEG ANGLE (deg)_+ - 0.0044 LEG ANGLE (deg)_0 - 0.0098 VERT (in)_- + 0.0128 VERT (in)_+ - 0.0030 VERT (in)_0 + 0.2163 RELEASE SPEED (s)_- - 0.0959 RELEASE SPEED (s)_+ - 0.1204 RELEASE SPEED (s)_0 - 0.0224 BACKSPIN (rot/s)_- + 0.0779 BACKSPIN (rot/s)_+ - 0.0555 BACKSPIN (rot/s)_0 + 0.0155 RELEASE TIME (s)*VERT (in)_- - + 0.0286 RELEASE TIME (s)*VERT (in)_- + - 0.0441 RELEASE TIME (s)*VERT (in)_- 0 + 0.0343 RELEASE TIME (s)*VERT (in)_+ - - 0.0399 RELEASE TIME (s)*VERT (in)_+ + + 0.0057 RELEASE TIME (s)*VERT (in)_+ 0 - 0.0498 RELEASE TIME (s)*VERT (in)_0 - + 0.0114 RELEASE TIME (s)*VERT (in)_0 + + 0.0384 RELEASE TIME (s)*VERT (in)_0 0 - 0.0488 RELEASE TIME (s)*BACKSPIN (rot/s)_- - - 0.0030 RELEASE TIME (s)*BACKSPIN (rot/s)_- + + 0.0518 RELEASE TIME (s)*BACKSPIN (rot/s)_- 0 + 0.0258 RELEASE TIME (s)*BACKSPIN (rot/s)_+ - - 0.0325 RELEASE TIME (s)*BACKSPIN (rot/s)_+ + + 0.0068 RELEASE TIME (s)*BACKSPIN (rot/s)_+ 0 + 0.0231 RELEASE TIME (s)*BACKSPIN (rot/s)_0 - + 0.0355 RELEASE TIME (s)*BACKSPIN (rot/s)_0 + - 0.0586 RELEASE TIME (s)*BACKSPIN (rot/s)_0 0 + 0.0238 RELEASE ANGLE (deg)*LEG ANGLE (deg)_- - + 0.0346 RELEASE ANGLE (deg)*LEG ANGLE (deg)_- + - 0.0584 RELEASE ANGLE (deg)*LEG ANGLE (deg)_- 0 - 0.0005 RELEASE ANGLE (deg)*LEG ANGLE (deg)_+ - - 0.0521 RELEASE ANGLE (deg)*LEG ANGLE (deg)_+ + + 0.0526 RELEASE ANGLE (deg)*LEG ANGLE (deg)_+ 0 - 0.0233 RELEASE ANGLE (deg)*LEG ANGLE (deg)_0 - + 0.0176 RELEASE ANGLE (deg)*LEG ANGLE (deg)_0 + + 0.0057 RELEASE ANGLE (deg)*LEG ANGLE (deg)_0 0 - 0.0408 RELEASE ANGLE (deg)*VERT (in)_- - - 0.3136 RELEASE ANGLE (deg)*VERT (in)_- + + 0.3544 RELEASE ANGLE (deg)*VERT (in)_- 0 + 0.1006 RELEASE ANGLE (deg)*VERT (in)_+ - + 0.2820 RELEASE ANGLE (deg)*VERT (in)_+ + - 0.3826 RELEASE ANGLE (deg)*VERT (in)_+ 0 - 0.0598 RELEASE ANGLE (deg)*VERT (in)_0 - + 0.0316 RELEASE ANGLE (deg)*VERT (in)_0 + + 0.0282 RELEASE ANGLE (deg)*VERT (in)_0 0 - 0.0188 RELEASE ANGLE (deg)*BACKSPIN (rot/s)_- - + 0.0085 RELEASE ANGLE (deg)*BACKSPIN (rot/s)_- + + 0.0103 RELEASE ANGLE (deg)*BACKSPIN (rot/s)_- 0 + 0.0017 RELEASE ANGLE (deg)*BACKSPIN (rot/s)_+ - - 0.0107 RELEASE ANGLE (deg)*BACKSPIN (rot/s)_+ + + 0.0090 RELEASE ANGLE (deg)*BACKSPIN (rot/s)_+ 0 + 0.0171 RELEASE ANGLE (deg)*BACKSPIN (rot/s)_0 - + 0.0022 RELEASE ANGLE (deg)*BACKSPIN (rot/s)_0 + - 0.0193 RELEASE ANGLE (deg)*BACKSPIN (rot/s)_0 0 - 0.0738 LEG ANGLE (deg)*VERT (in)_- - + 0.1387 LEG ANGLE (deg)*VERT (in)_- + - 0.0648 LEG ANGLE (deg)*VERT (in)_- 0 + 0.0032 LEG ANGLE (deg)*VERT (in)_+ - - 0.0713 LEG ANGLE (deg)*VERT (in)_+ + + 0.0682 LEG ANGLE (deg)*VERT (in)_+ 0 + 0.0707 LEG ANGLE (deg)*VERT (in)_0 - - 0.0673 LEG ANGLE (deg)*VERT (in)_0 + - 0.0033 LEG ANGLE (deg)*VERT (in)_0 0 - 0.0120 LEG ANGLE (deg)*BACKSPIN (rot/s)_- - + 0.0308 LEG ANGLE (deg)*BACKSPIN (rot/s)_- + - 0.0188 LEG ANGLE (deg)*BACKSPIN (rot/s)_- 0 + 0.0465 LEG ANGLE (deg)*BACKSPIN (rot/s)_+ - + 0.0024 LEG ANGLE (deg)*BACKSPIN (rot/s)_+ + - 0.0488 LEG ANGLE (deg)*BACKSPIN (rot/s)_+ 0 - 0.0345 LEG ANGLE (deg)*BACKSPIN (rot/s)_0 - - 0.0331 LEG ANGLE (deg)*BACKSPIN (rot/s)_0 + + 0.0677 LEG ANGLE (deg)*BACKSPIN (rot/s)_0 0 + 0.0695 VERT (in)*RELEASE SPEED (s)_- - - 0.1837 VERT (in)*RELEASE SPEED (s)_- + + 0.1142 VERT (in)*RELEASE SPEED (s)_- 0 + 0.2370 VERT (in)*RELEASE SPEED (s)_+ - - 0.2463 VERT (in)*RELEASE SPEED (s)_+

Table 5: Equation for Make Percentage For Significant Factors and Interactions (continued).

Response Variable		Equation Continued
PERCENT(%)	=	+ + 0.0093 VERT (in)*RELEASE SPEED (s)_+ 0 - 0.3066 VERT (in)*RELEASE SPEED (s)_0 - + 0.4300 VERT (in)*RELEASE SPEED (s)_0 + - 0.1234 VERT (in)*RELEASE SPEED (s)_0 0 - 0.0565 VERT (in)*BACKSPIN (rot/s)_- - + 0.0629 VERT (in)*BACKSPIN (rot/s)_- + - 0.0065 VERT (in)*BACKSPIN (rot/s)_- 0 - 0.0184 VERT (in)*BACKSPIN (rot/s)_+ - - 0.0381 VERT (in)*BACKSPIN (rot/s)_+ + + 0.0565 VERT (in)*BACKSPIN (rot/s)_+ 0 + 0.0749 VERT (in)*BACKSPIN (rot/s)_0 - - 0.0248 VERT (in)*BACKSPIN (rot/s)_0 + - 0.0501 VERT (in)*BACKSPIN (rot/s)_0 0 + 0.0480 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_- - - + 0.0618 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_- - + - 0.1098 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_- - 0 - 0.0549 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_- + - + 0.0123 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_- + + + 0.0426 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_- + 0 + 0.0069 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_- 0 - - 0.0741 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_- 0 + + 0.0672 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_- 0 0 + 0.1447 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_+ - - - 0.0972 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_+ - + - 0.0474 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_+ - 0 - 0.0501 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_+ + - + 0.0000 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_+ + + + 0.0501 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_+ + 0 - 0.0945 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_+ 0 - + 0.0972 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_+ 0 + - 0.0027 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_+ 0 0 - 0.1926 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_0 - - + 0.0355 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_0 - + + 0.1572 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_0 - 0 + 0.1050 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_0 + - - 0.0124 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_0 + + - 0.0927 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_0 + 0 + 0.0876 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_0 0 - - 0.0231 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_0 0 + - 0.0645 RELEASE TIME (s)*VERT (in)*BACKSPIN (rot/s)_0 0 0 + 0.0527 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_- - - - 0.0730 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_- - + + 0.0203 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_- - 0 + 0.0408 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_- + - + 0.0587 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_- + + - 0.0995 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_- + 0 - 0.0936 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_- 0 - + 0.0143 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_- 0 + + 0.0792 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_- 0 0 + 0.0954 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_+ - - + 0.0341 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_+ - + - 0.1295 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_+ - 0 - 0.0458 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_+ + - + 0.0145 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_+ + + + 0.0314 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_+ + 0 - 0.0495 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_+ 0 - - 0.0486 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_+ 0 + + 0.0981 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_+ 0 0 - 0.1481 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_0 - - + 0.0389 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_0 - + + 0.1091 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_0 - 0 + 0.0050 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_0 + - - 0.0732 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_0 + + + 0.0682 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_0 + 0 + 0.1431 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_0 0 – + 0.0342 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_0 0 + - 0.1773 RELEASE ANGLE (deg)*LEG ANGLE (deg)*BACKSPIN (rot/s)_0 0 0

Utilizing the equation for the response variable, an estimation of the make percentage can be obtained based on the values for the six study factors of this experimentation. This equation allows for the estimation of the percent chance of this author making a free throw line jump shot based on the relative levels of the six study factors and their corresponding interactions. This equation provides an ideal value for each study factor for the maximum shot success based on the data provided and can be implemented into the model.

The next step of this project was to create a model of the data collected in this experimentation. The model utilizes the data collected for each study factor, the breakdown into identical levels as stated in Table 1, and the equation for make percentage as found by identifying the significant factors and interactions shown in Table 5. Figure 17 shows the top-level view of this model created within *Simulink*.

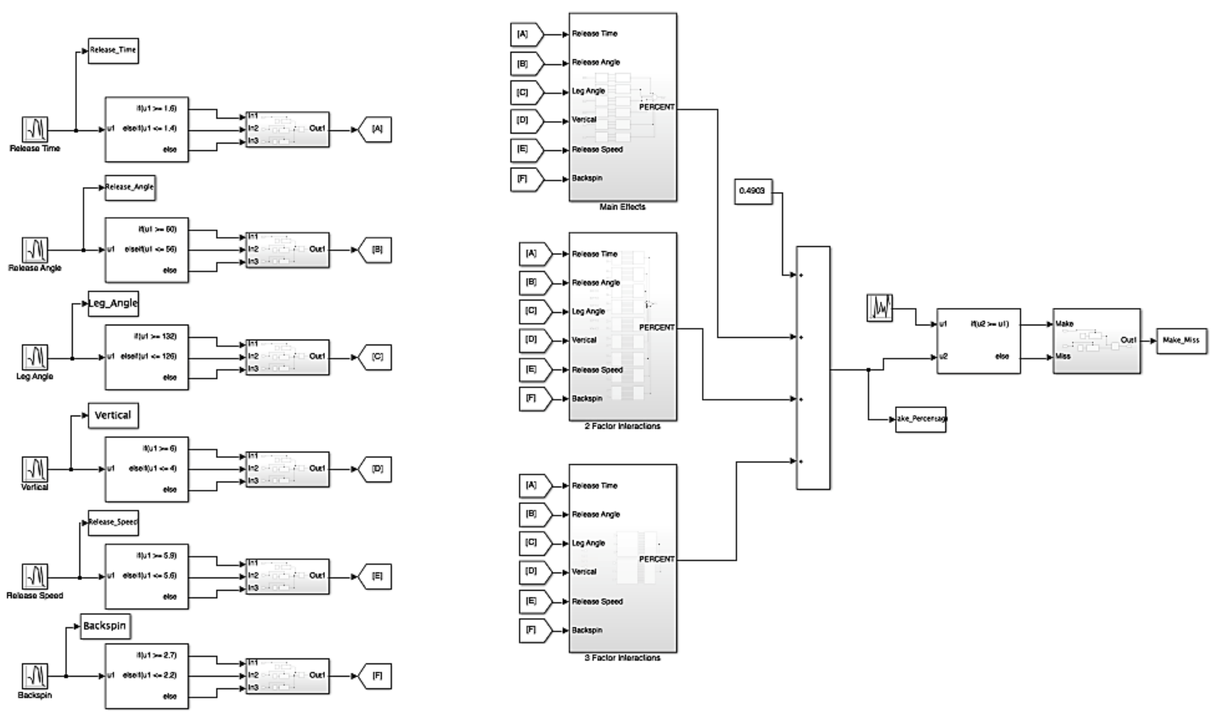

Figure 17: Top-Level View of Simulation Model.

Figure 17 shows the top-level view of the working model for this experiment to simulate this author's real free throw line jump shot and the chance of making or missing the shot based on the levels for each study factor. The input to this model are the collected values for the six study factors: shot release time, shot release angle, leg angle, vertical jump, rotational speed on the ball, and ball speed immediately upon release. Using an Ryan-Joiner Normality Test, the summary report information for each study factor, as shown in Figures 4 through 9, is utilized to input these data to accurately represent the collected values for each of the study factors. This is achieved with a normally distributed random number generator block with the values for standard deviation and mean as found. These values are then collected and recorded by the program and run through a block to determine which of the three levels each study factor is in: low (-), medium (0), or high (+), as shown in Table 1. Figure 18 shows the subsystem used to calculate the corresponding level for the study factor of release time.

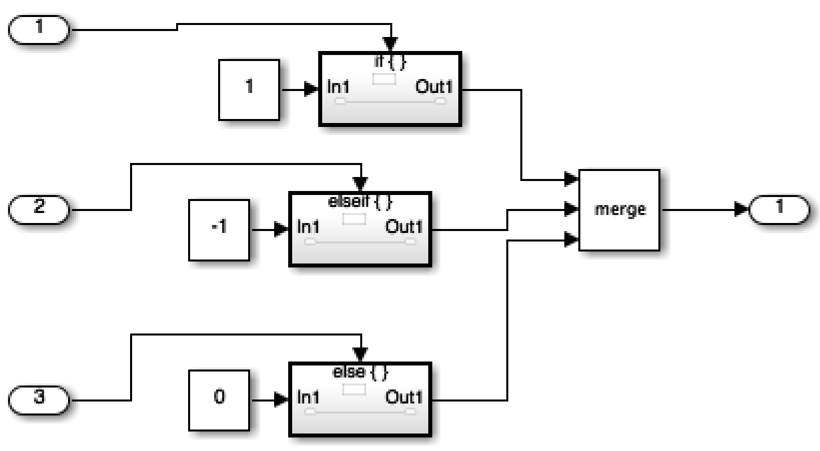

Figure 18: Expanded View of Level Determination for Release Time.

After the study factor, release time in this case, is determined to be low (-), medium (0), or high (+) based on the values shown in Table 1, the value is assigned a value. In this case, the high value, low value, and medium value are given a value of 1, -1, and 0, respectively. These values are then controlled with a merge block to keep whichever value was determined based on the original normally distributed random number generated for the given study factor. The same subsystem is used for each study factor to determine the level of each study factor. The levels for each study factor then are input into the main effects and interaction subsystems. Shown in Figure 19 is the main effects subsystem.

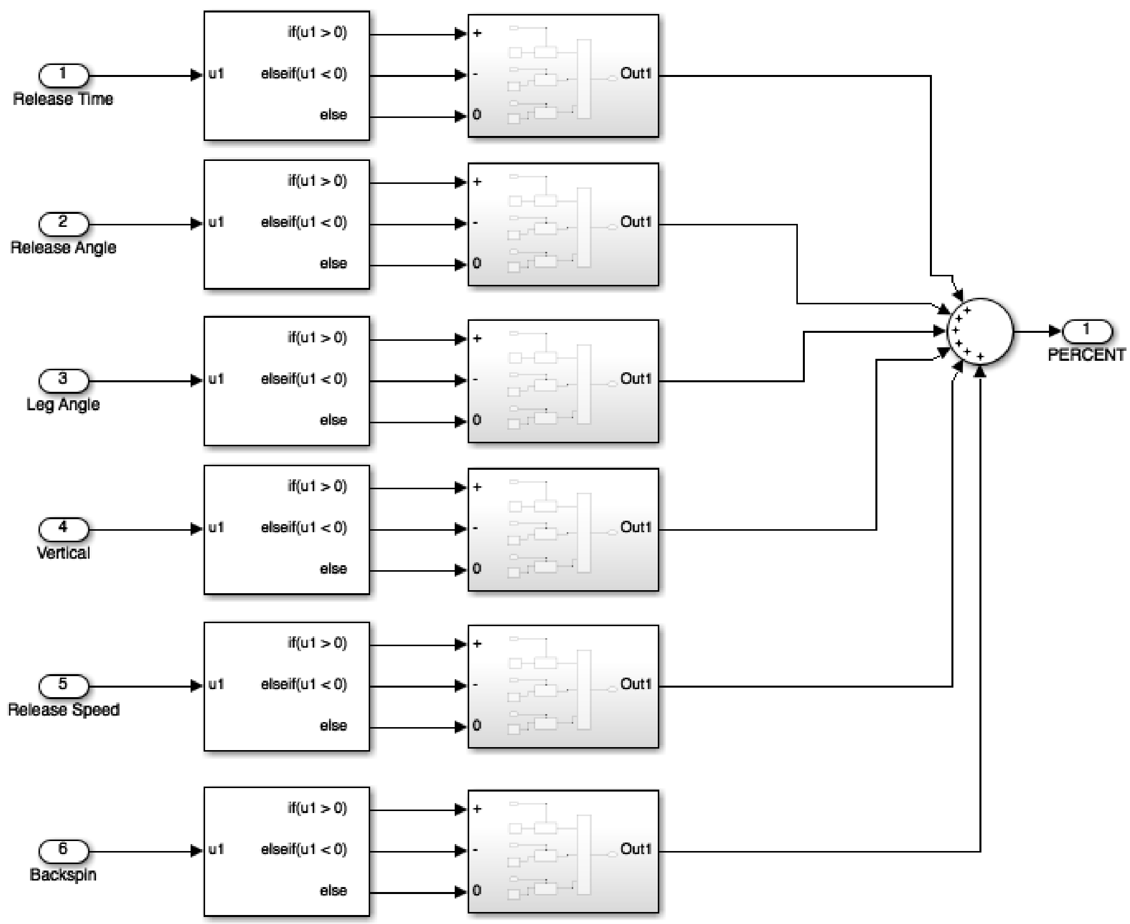

Figure 19: Expanded View of Main Effects on Make Percent Calculation.

Figure 19 shows how the input of each level of the study factors is used to calculate the effect of the make percentage. The input to this subsystem is the 1, -1, or 0 level value determined for each study factor. Each of these values are then separated by the level to be fed into the calculation subsystem. In this model, the block determines if the study variable is high, low, or medium, and inputs the corresponding value to the calculation subsystem. After the level for each study factor is determined and run through the calculation subsystem to determine the effects of the make percentage, all the effects are summed and outputted from the subsystem as the main effects subsystem effect of make percentage. The calculation for the effect on make percentage of the release time level is shown in Figure 20.

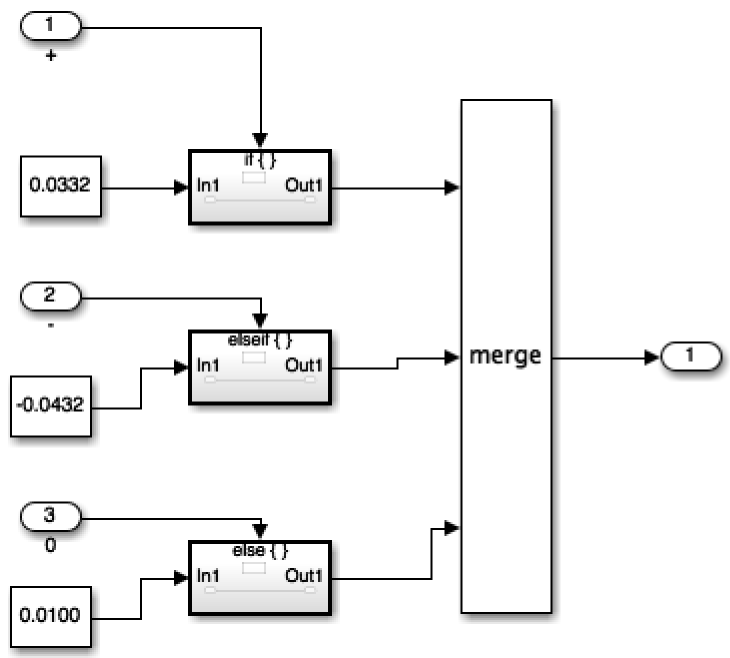

Figure 20: Expanded View of Effect on Make Percent Calculation for Release Time Level.

Figure 20 shows effects of the release time level on the make percentage. Utilizing the information in Table 5, the effects for make percentage based on the level of the release time can be observed as an increase of 0.0332 for a high release time level, a decrease of 0.0432 for a low release time level, and an increase of 0.01 for a medium release time level. Since the input to this subsystem is separated by a conditional block to determine the level, only one of these boxes will affect the make percentage as they are merged together. The same subsystem is used for each study factor to determine the level of each study factor.

The next step in this model is to find the effects of make percentage of the study factor levels for the two-factor interactions, as shown in Figure 21.

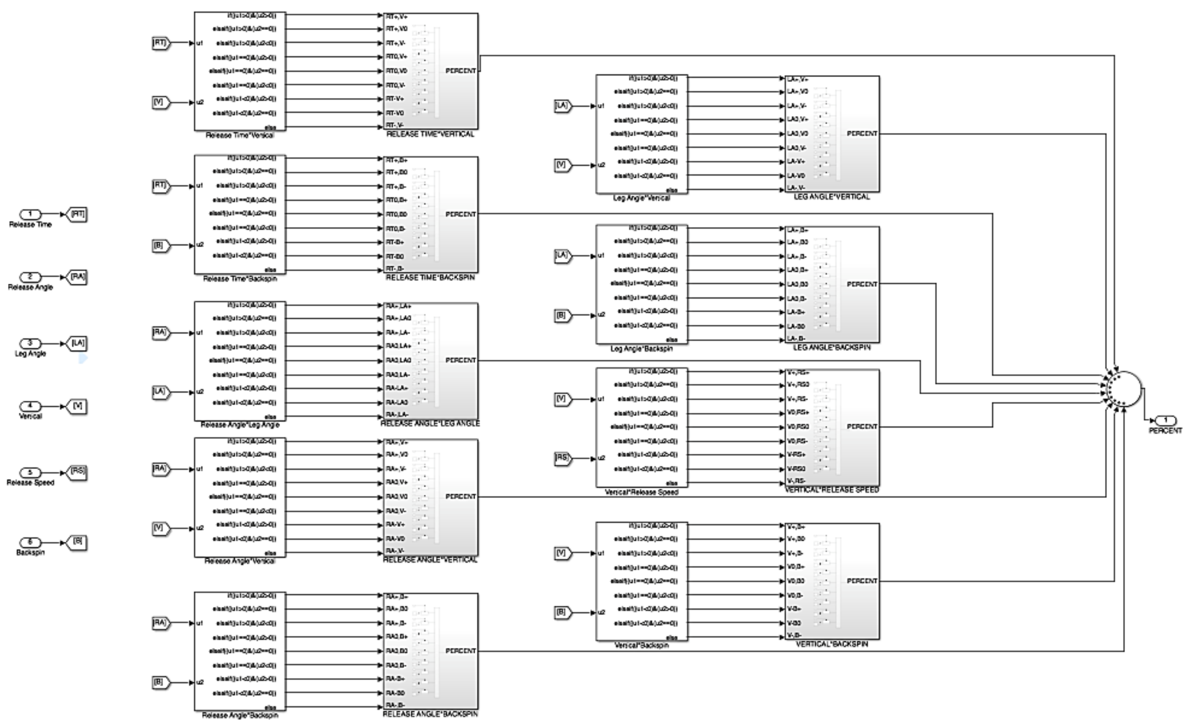

Figure 21: Expanded View of Two-Factor Interactions on Make Percent Calculation.

Figure 21 shows the calculation done to determine the corresponding effects of the make percentage by two-factor interactions as deemed significant in Table 5. From this equation, it was determined that eight interactions were needed to determine the effects on the make percentage – release time/vertical, release time/backspin, release angle/leg angle, release angle/vertical, release angle/backspin, leg angle/vertical, leg angle/backspin, vertical/release speed, and vertical/backspin. The values for each set of two factors is fed into a block to determine which of the nine possible combinations of levels was found. After the combination of level is found, the effect on the make percentage based on Table 5 is determined for each two-factor interaction and summed as the total effect on the make percentage from the two-factor interactions. Shown in Figure 22 is the effect on make percentage calculation for release time/vertical.

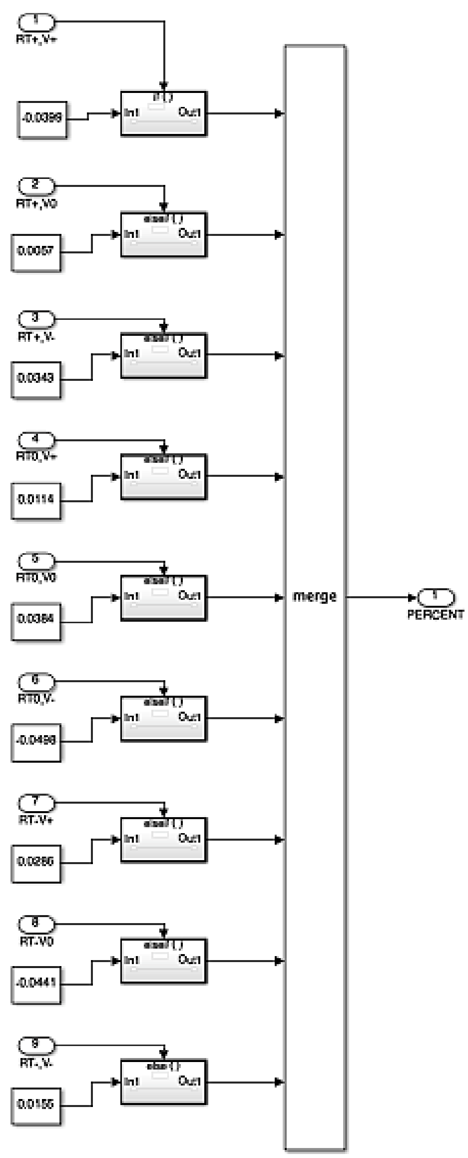

Figure 22: Effect on Make Percent Calculation for Release Time/Vertical Levels.

Figure 22 displays how the combination of levels for release time and vertical are used in conjunction with the equation in Table 5 to determine the effect on make percentage. For each of the nine possible level combinations for release time and vertical, an effect on the make percentage can be added or subtracted from the make percentage. For example, the level combination of a high (+) release time and a high (+) vertical can be associated with a decrease in the make percentage of 0.0399. This is the case for the other eight level combinations. After the level combination is found and the corresponding effect on the make percentage is calculated, the subsystem outputs this effect to be added with each of the other two-factor interactions that were determined to be statistically significant.

The final step to find the effect on make percentage in this model is to find the effects of make percentage of the study factor levels for the three-factor interactions as shown in Figure 23.

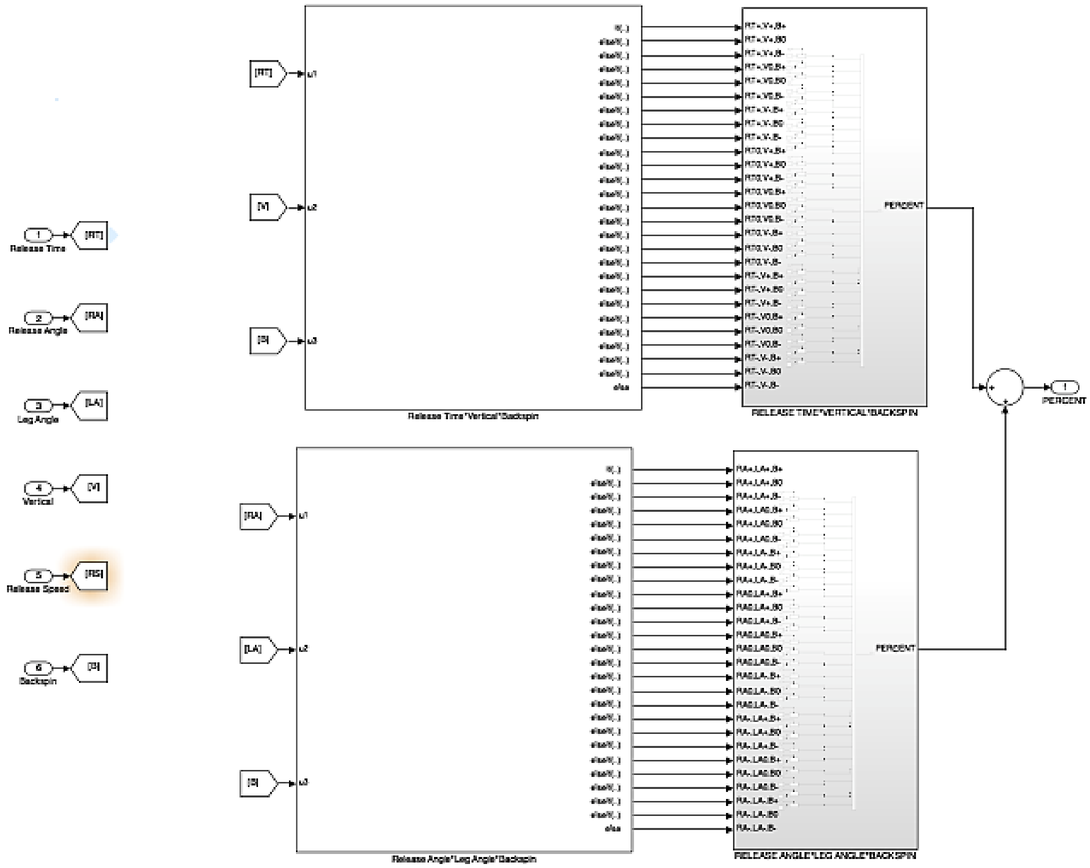

Figure 23: Expanded View of Three-Factor Interactions on Make Percent Calculation.

Figure 23 shows the implementation of the equation in Table 5 for the statistically significant three-factor interactions as determined by the general linear model. In this model, release speed is brought into the subsystem as an input, even though it was not determined to be statistically significant, for ease in the case that further research deems this study factor to have a statistical significance in a three-factor interaction. In this subsystem, there were two three-factor interactions determined to be statistically significant, including release time/vertical/backspin and release angle/leg angle/backspin. In each case, the 27 total level combinations for the three input study factors were determined and separated. This allowed for the 27 combinations for each three-factor interaction to be input into the effect of make percentage calculation, shown in Figure 24.

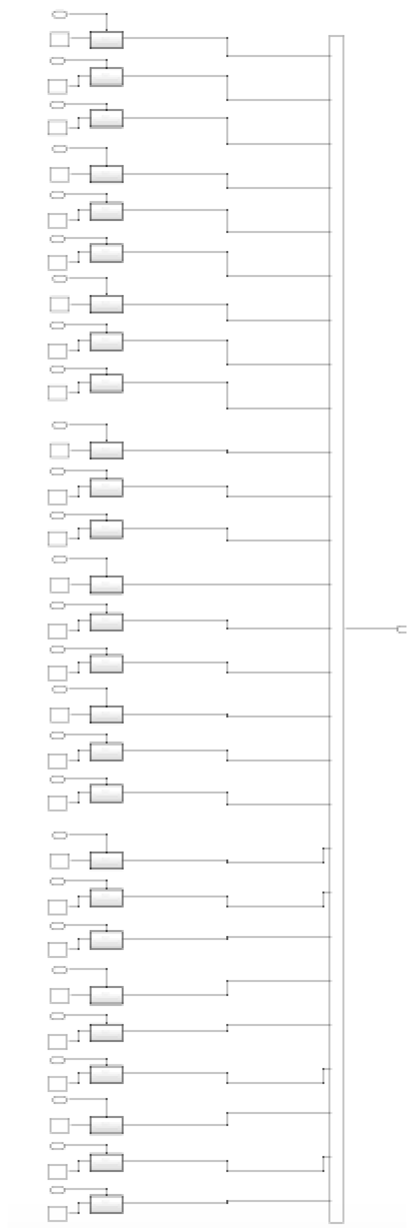

Figure 24: Effect on Make Percent Calculation for Release Time/Vertical/Backspin Levels (Values Not Shown).

Figure 24 shows the outline for the calculation for the effect on make percentage of the three-factor interaction of release time/vertical/backspin. Since there are 27 level combinations, it is difficult to display the values, but they follow a similar structure as the effects on make percentage for two-factor interactions shown in Figure 21. In this subsystem, after the level combination is found, the corresponding effect on the make percentage, according to the governing equation found in Table 5, is output and added together to find the combined effects of the three factor interaction levels on the make percentage.

After the effects on make percentage for the main effects, two-factor interactions, and three-factor interactions are found and added to the base value of 0.4903, as found in Table 5, the total make percentage is tabulated. The model then goes one step further to use this make percentage and a random number generator to simulate if this shot is made or missed and collects the data. By adding in this last step, the model allows the collection and simulation of realistic data based on this author's free throw line jump shot, assuming the validity of this equation. Shown in Figure 25 is the subsystem used to give the value of 1 for a make or 0 for a miss, similar to the real data collected in Table A-1.

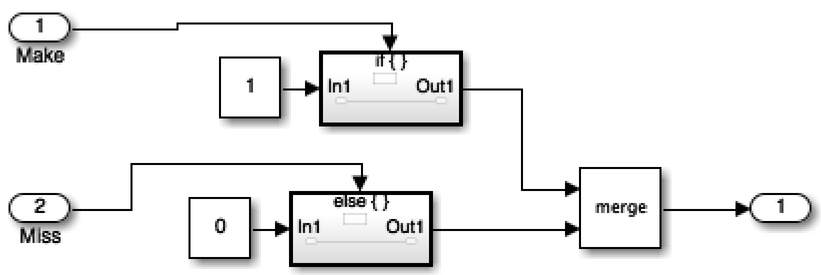

Figure 25: Make/Miss Determination Based on Make Percent Calculation.

Figure 25 shows the calculation done to assign a value of 1 for a made shot and a value of 0 for a missed shot. Input into this subsystem is a determination of whether the given combination of normally distributed random number generators for each study factor, as based on the real-world collection, resulted in a made or missed shot. To do this, a uniform random number generator block was utilized to compare to the make percentage to find if the shot was made or missed. With a higher make percentage, the chance of a make is higher as it leaves more room for the random number generator to output a number under this value. Once the shot is determined to be made or missed, this subsystem assigns it a value of 1 for a make and a value of 0 for a miss. This value for make/miss is then output from the subsystem and tabulated.

This simulation generates new values for each of the study factors each second and can be run for as many replications as needed. Since the simulation produces results identical in format to the results collected in testing, the data can produce additional data with a couple of assumptions as explored in the conclusion and recommendations section of this report. This procedure allows for quick collection of realistic data and the ability for simulations with improvements in select areas of the author's jump shot, including changes to the means and improvements or declines in variance of select study factors.

In order to test the validity of this model, a replicated experiment of the one thousand jump shots was conducted using this model. To verify the simulated results with the recorded results, a two-proportions test was conducted to examine if a statistically significant difference can be found between the two data sets. Shown in Figure 26 are results from the two-proportions test comparing the results collected from the recorded data and the simulated results from the model created from this project.

Descriptive Statistics

Sample	N	Event	Sample p
Sample 1	1000	510	0.510000
Sample 2	1000	485	0.485000

Estimation for Difference

Difference	95% CI for Difference
0.025	(-0.018812, 0.068812)

CI based on normal approximation

Test

Null hypothesis	H_0: $p_1 - p_2 = 0$
Alternative hypothesis	H_1: $p_1 - p_2 \neq 0$

Method	Z-Value	P-Value
Normal approximation	1.12	0.263
Fisher's exact		0.283

Figure 26: Two-Proportions Test Comparing Simulated and Recorded Results.

Figure 26 shows the results of the two-proportions test comparing the recorded results shown in Table A-1 and the results simulated using the Simulink model, which was created based on the input variables shown in Figures 4 through 9 and the governing equation for make percentage based on these values shown in Table 5. From a simulation of one thousand jump shots to replicate the recorded data, the simulation model recorded 485 made jump shots while the data collected in Table A-1 recorded 510 made jump shots. In Figure 26, the recorded results are listed as Sample 1 and the simulated results from the model are listed as Sample 2. From this test, a P-Value greater than 0.05 means that there is not enough evidence indicating that a difference between the two proportions exists. With the results of this test, it is reasonable to assume the simulation model can represent the recorded data from this experiment.

Conclusion and Recommendations

The purpose of this experiment was to determine the statistically significant study factors and interactions responsible for increasing the shooting percentage of this author's free throw line jump shot. In the entirety of this experimentation, all study factors were found to be normally distributed based on an alpha value of 0.05 utilizing an Ryan-Joiner normality test, and the residuals were determined to meet the necessary requirements for normality and independence necessary for utilizing a general linear model approach. It is important to note that from the investigation into this data set, it is likely there are more factors and levels that may play a role in determining the make percentages with respect to the data set. From the general linear model shown in Table 3, it was determined that release angle, release speed, and backspin, as well as the combination factors -- release angle/vertical, leg angle/vertical, vertical/release speed, release time/vertical/backspin, and release angle/leg angle/backspin -- were found to be statistically significant in determining the corresponding response variable, make percentage. From the general linear model examination, an equation was generated with the capabilities to estimate the percent chance of this author making a free throw line jump shot based on the relative levels of the six study factors and their corresponding interactions.

It is important to note that this equation can just be used as an estimation, as it was determined that more factors and/or levels likely play a role in determining the shot success percentage examined in this experiment and the addition of a larger sample size would aid in increasing the confidence in the final results. Because the equation only explains approximately 20% of the variation found in the data, the simulation cannot be relied on to produce realistic results. The model, however, provides the ability to simulate the author's jump shot to as much accuracy as the experimentation has allowed with the ability to add in additional details or corrections when more data and information are found. In addition, the model assumes any combination of study factors input into the system are possible independent of other study factor values, although this may not be entirely accurate. In reality, there likely exists a correlation of high and low levels for each study factor depending on other values. For example, it is likely that a low vertical level will result in a high release speed to compensate for a low release height. In addition, a low leg angle typically would result in a higher vertical as the body would likely generate more force to propel the shooter into the air. Because of these limitations, the simulation can only be used as a rough estimation of the data collected but does provide the capability to be updated with an increase in data and understanding of the factors that go into this author's jump shot.

From the mindset of a basketball player, many of the correlations of study factors and interactions follow techniques commonly taught in basketball. With the information collected in this project, there are insights that can be used to improve the shooting consistency of this author's free throw line jump shot. In the main factors found to be statistically significant, it was expected that the release angle and release speed would play a major role in the make percentage based on common approaches to teaching jump shots. From this project, both study factors were determined to be statistically significant. The finding that backspin was determined to be statistically significant also can be understood. The backspin generated on a ball during a jump shot both increases the entry angle into the basket, thus increasing the size of the target, and decreases the bounce on the rim from counteracting the motion of the ball, resulting in a softer bounce. This can be observed in the findings of the project, as a higher backspin value was determined to be most likely to result in a made basket.

In addition, a lot can be understood by looking at the interactions found to be statistically significant in determining the make percentage. As Table 3 indicates, release angle/vertical, leg angle/vertical, vertical/release speed, release time/vertical/backspin, and release angle/leg angle/backspin were all found to be statistically significant. Several of these interactions make sense from a basketball perspective. The interaction of release angle/vertical is a combination of factors that often have a correlation. When a basketball player has a lower vertical on their jump shot, they will likely compensate and have a larger release angle on their shot to make sure the ball has enough height to reach over the rim. Similarly, the interaction of leg angle/vertical are an example of two factors that should have a direct relationship, as a smaller leg angle likely produces more upward force, leading to a higher vertical jump. This relationship can also be found in the interaction between vertical and release speed. With a higher vertical jump, less power is needed to propel the ball towards the rim, as the release point is higher. These findings can also be taken from the statistically significant three-factor interactions.

There are several insights found in this project that can be applied to improve the make percentage of this author’s free throw line jump shot. It can be observed from the information presented in Figure 11 that the optimum values for the statistically significant study factors -- release angle, release speed, and backspin -- can be defined as high (+) for release angle, low (-) for release speed, and high (+) for backspin. This means that an ideal shot would utilize a release angle of 60 degrees or greater, a release speed of 5.6 seconds or less, and a backspin of 2.7 rotations per second or greater. Although the accuracy of the numbers found may not be exact due to the low percent of variation explained by the model, it can be observed that a shot with a high release angle, low release speed, and high amount of backspin would likely improve the author’s chances of making the jump shot. From this information, the author should work to increase the average release angle and backspin generated while decreasing the average release speed on their free throw line jump shots. This makes sense from a basketball standpoint as a higher release angle increases the target size of the basket by increasing the entry angle, and a lower release speed and higher backspin will likely decrease the bounce of the ball on the rim, creating a higher likelihood that the shot will go in if it makes contact with the rim.

To increase the validity and accuracy of these results, further experimentation is needed. The addition of a much larger sample size will assist in creating a more accurate percentage to be used in each combination of levels. Furthermore, the change from a discrete data set collection to a continuous data set would further add to the validity of the results. In this experimentation, the levels for each data were collected by observation, leading to different combinations of study factor levels having different amounts of data under each subsequent combination. Adding additional data will allow for a higher resolution in each data set. A different form of the response variable -- for example, utilizing the distance away a jump shot is to be categorized as successful -- would also help alleviate this issue. The final recommendation for further experimentation is to collect these data over a longer time to account for improvements in shooting form and/or consistency made while continuous collection of data is occurring that may not have been present in the early stages of data collection. These improvements would also help improve the validity of the simulation model. Since a basketball jump shot is a dynamic process, it would also be beneficial to add into the simulation model correlations between the generation of the study factors in this investigation, because many factors may affect others, as a basketball player will likely compensate in one or more study factors for extremes in other factors. One example of this would be if a player has a lower vertical jump, it is likely that the player will try to compensate for this lower release point with a higher release speed.

References

[1] O'Conner, Claire. April 2020. Sports Coaching in the U.S. U.S, Industry (NAICS) Report 61102. [Internet, WWW, Database]. Available: IBISWorld Database; Address: http://www.ibisworld.com

[2] Surdam, David G. 2014. *The Rise of the National Basketball Association*.University of Illinois Press. [Internet, WWW, Ebook]. Available: EBSCO Academic eBook Database; Address: http://www.proquest.com/

[3] Jaura, Rohan. February 2020. Sports Franchises in the U.S. U.S, Industry (NAICS) Report 71121A. [Internet, WWW, Database]. Available: IBISWorld Database; Address: http://www.ibisworld.com

[4] Keshri, Suraj. 2019. *Essays in Basketball Analytics.* Ph.D. Diss., Columbia University. [Internet,www,Database]. Available: Proquest Dissertations and Theses Database; Address: http://www.proquest.com/

[5] Southard, Dan *et al*. 1989. "Ritual and Free-Throw Shooting in Basketball." *Journal of Sports Sciences*, Vol. 7, No. 2, pp. 163–173. Address: http://doi.org/10.1080/02640418908729834

[6] Struzik, Artur *et al*. 2014."Biomechanical Analysis of the Jump Shot in Basketball." *Journal of Human Kinetics*, vol. 42, no. 1, pp. 73–79. http://doi.org/10.2478/hukin-2014-0062

[7] Kelley, B G. December 2003. "Shooting the J*"*, *Coach and Athletic Director*; Vol. 73, No. 5, 24-26. [Internet, WWW, Database]. Available: Proquest; Address: http://www.proquest.com

[8] Okubo, Hiroki, and Mont Hubbard. 2010. "Identification of Basketball Parameters for a Simulation Model." *Procedia Engineering*, Vol. 2, No. 2, pp. 3281–3286. Address: http://doi.org/10.1016/j.proeng.2010.04.145

[9] Okubo, Hiroki, and Mont Hubbard. 2016. "Comparison of Shooting Arm Motions in Basketball." *Procedia Engineering*, Vol. 147, 2016, pp. 133–138. Address: http://doi.org/10.1016/j.proeng.2016.06.202

[10] Miller, Stuart, and Roger M. Bartlett. 1993. "The Effects of Increased Shooting Distance in the Basketball Jump Shot." *Journal of Sports Sciences*, Vol. 11, No. 4, pp. 285–293. Address: http://doi.org/10.1080/02640419308729998

[11] "NBA Shooting By the Numbers (1980-Today)." 12 February 2014. *Best Tickets Blog*, [Internet, WWW, Blog]. Address: http://www.besttickets.com/blog/nba-shooting/.

[12] Miller, Stuart, and Roger Bartlett. 1993. “The Relationship between Basketball Shooting Kinematics, Distance and Playing Position.” *Journal of Sports Sciences*, Vol. 14, No. 3, pp. 243–253. Address: http://doi.org/10.1080/02640419608727708

[13] Tran, Chau M., and Larry M. Silverberg. 2000. “Optimal Release Conditions for the Free Throw in Men's Basketball.” *Journal of Sports Sciences*, Vol. 26, No. 11, pp. 1147–1155. Address: http://doi.org/10.1080/02640410802004948

[14] Knudson, Duane. 1993. “Biomechanics of the Basketball Jump Shot—Six Key Teaching Points.” *Journal of Physical Education, Recreation & Dance*, Vol. 64, No. 2, pp. 67–73. Address: http://doi.org/10.1080/07303084.1993.10606710

[15] Fisher, Bob J. 2018. *Straight Shooter: A Game-Changing New Approach to Basketball Shooting*. Telemachus Press.

[16] The Nex Inc. “Shot Science” 2017. *Homecourt*. 2017-2020. Address: https://www.homecourt.ai/home-as-of-june-19-2019.

[17] Minitab Blog Editor. 10 October 2013. “Anderson-Darling, Ryan-Joiner, or Kolmogorov-Smirnov: Which Normality Test is the Best?” [Internet, WWW]. Address: https://blog.minitab.com/en/the-statistical-mentor/anderson-darling-ryan-joiner-or-kolmogorov-smirnov-which-normality-test-is-the-best

[18] Philip Rowe. 2016. *Essential Statistics for the Pharmaceutical Sciences*, Second Edition. Wiley. [See Section 4.6 Appendix: Power, sample size and the problem of attempting to test for a normal distribution]. [Internet, WWW, E-Book]. Available: Proquest Academic E-Book Central Database; Address: https://www.proquest.com/

Bibliography

Montgomery, Douglas C. 2020. *Design and Analysis of Experiments*. Wiley.

Appendix A: Jump Shot Data for Six Study Factors

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots.

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
1	1.4	49	117	7	5.5	2.4	1
2	1.5	52	121	5	5.5	2.5	1
3	1.4	52	126	5	5.5	2.7	0
4	1.2	50	129	2	5.5	2	1
5	1.2	50	124	4	5.5	1.4	0
6	1.5	46	121	7	5.5	2.5	0
7	1.3	53	156	5	5.6	2.6	1
8	1.6	55	123	4	5.6	2.9	1
9	1.8	54	122	4	5.6	2.3	0
10	1.5	53	121	2	5.6	2.3	1
11	1.3	51	119	5	5.5	2.1	1
12	1.3	53	131	1	5.6	2.1	0
13	1.4	52	127	1	5.5	2.5	1
14	1.3	57	129	2	5.7	1.8	0
15	1.5	53	123	7	5.6	2.3	0
16	1.6	51	144	4	5.5	2.7	1
17	1.5	50	123	7	5.5	2.6	0
18	1.4	51	118	7	5.5	2	1
19	1.6	50	128	4	5.5	1.9	0
20	1.7	53	121	4	5.6	2.8	1
21	1.5	55	125	1	5.6	2.2	0
22	1.2	54	124	9	5.6	2.5	1
23	1.4	53	123	7	5.6	2.5	1
24	1.5	50	122	1	5.5	2.9	1
25	1.8	48	122	5	5.5	3.1	0
26	1.1	52	124	1	5.5	2.7	0
27	1.5	53	115	1	5.6	3.1	1
28	1.5	52	116	1	5.5	2.3	0
29	1.6	56	122	2	5.7	3.6	1
30	1.8	54	121	2	5.6	2.4	1
31	1.4	51	127	4	5.5	2.8	1
32	1.6	53	128	1	5.6	3.6	0
33	1.6	55	125	5	5.6	1.8	0
34	1.8	56	124	1	5.7	2	1
35	1.4	53	130	2	5.6	2.8	1
36	1.6	51	132	6	5.5	2.2	1
37	1.8	53	125	6	5.6	2.8	1
38	1.4	53	141	9	5.6	3.1	1
39	1.6	51	129	7	5.5	2.2	0
40	1.8	55	132	7	5.6	2.9	1
41	1.4	48	135	9	5.5	2.4	0
42	1	56	133	1	5.7	2	1
43	1.6	55	132	2	5.6	1.7	0
44	1.8	49	131	2	5.5	2.5	1
45	1.5	52	131	6	5.5	3.1	0
46	1.7	48	134	5	5.5	2.6	1
47	1.6	45	167	4	5.5	2.3	0
48	1.4	51	128	1	5.5	2.7	1
49	1.5	53	126	5	5.6	2	0
50	1.7	60	128	3	5.9	2.2	1
51	1.4	51	135	4	5.5	3.5	1
52	1.2	54	136	1	5.6	2.6	0
53	1.3	54	136	1	5.6	2.6	0
54	1.7	43	123	2	5.5	2.8	1
55	1.6	32	149	6	5.8	2.9	0
56	1.7	45	129	1	5.5	2.8	1
57	1.8	36	159	2	5.6	2.1	1
58	1.4	53	128	1	5.6	2.5	1
59	1.7	43	158	1	5.5	2.7	0

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots (continued).

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
60	1.5	43	126	5	5.5	2.2	0
61	1.4	48	132	6	5.5	1.7	1
62	1.2	50	137	1	5.5	2.1	1
63	1.2	45	132	8	5.5	3	0
64	1.5	79	127	6	5.4	2.6	0
65	1.3	44	133	6	5.5	2.4	1
66	1.6	52	129	7	5.5	2.3	1
67	1.6	38	136	4	5.5	2.7	0
68	1.3	51	141	1	5.5	2.8	1
69	1.5	55	129	9	5.6	2.7	1
70	1.7	41	148	4	5.5	1.8	1
71	1.8	47	138	5	5.5	2.9	1
72	1.4	47	125	5	5.5	2.4	0
73	1.5	40	126	9	5.5	2.7	1
74	1.6	45	152	4	5.5	2.2	1
75	1.8	45	137	7	5.5	1.6	0
76	1.2	54	132	4	5.6	1.7	1
77	1.2	44	132	7	5.5	2.3	0
78	1.6	38	128	1	5.5	2.2	0
79	1.7	46	128	7	5.5	3.5	0
80	1.5	46	131	6	5.5	3.1	1
81	1.3	49	127	7	5.5	2	0
82	1.7	46	122	4	5.5	2.6	1
83	1.3	52	127	7	5.5	2.5	1
84	1.6	48	129	1	5.5	1.8	0
85	1.7	40	130	9	5.5	2.6	0
86	1.6	38	127	6	5.5	2.9	1
87	1.4	47	125	5	5.5	2.5	1
88	1.2	47	134	9	5.5	1.3	1
89	1.3	49	134	5	5.5	2.8	1
90	1.4	47	130	2	5.5	3.2	0
91	1.7	52	132	5	5.5	1.5	1
92	1.5	46	125	4	5.5	2.7	0
93	1.4	51	133	2	5.5	2.4	1
94	1.6	35	127	5	5.6	2.6	0
95	1.4	63	127	5	6.1	2.8	1
96	1.5	44	133	5	5.5	3	0
97	1.2	47	125	7	5.5	2.6	1
98	1.7	49	132	7	5.5	2.8	1
99	1.5	50	132	8	5.5	3	0
100	1.7	51	131	2	5.5	1.7	0
101	1.6	45	124	5	5.5	2.6	1
102	1.3	52	125	4	5.5	2.6	0
103	1.3	46	124	6	5.5	2.3	0
104	1.4	44	123	6	5.5	2.8	0
105	1.3	49	145	8	5.5	2.4	0
106	1.5	47	127	6	5.5	2.8	1
107	1.6	54	144	1	5.6	2.1	0
108	1.5	52	134	5	5.5	2.6	1
109	1.4	51	125	6	5.5	2.1	1
110	1.6	51	125	5	5.5	2.6	0
111	1.7	52	124	10	5.5	2.4	1
112	1.5	55	126	2	5.6	3	0
113	1.2	54	142	6	5.6	3	1
114	1.4	53	122	5	5.6	2	0
115	1.6	54	125	2	5.6	2.5	1
116	1.2	52	126	5	5.5	2.3	0
117	1.3	51	125	5	5.5	2.6	0
118	1.7	48	120	4	5.5	3	1
119	1.4	51	126	6	5.5	2.6	0
120	1.8	53	128	5	5.6	2.7	1
121	1.6	53	125	5	5.6	3.1	0

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots (continued).

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
122	1.5	57	128	1	5.7	3	1
123	1.3	52	133	6	5.5	3	1
124	1.6	51	126	5	5.5	2.4	0
125	1.7	50	125	5	5.5	2.8	1
126	1.3	55	127	2	5.6	3.1	0
127	1.2	48	142	1	5.5	2.5	1
128	1.5	43	157	5	5.5	2.8	1
129	1.2	41	148	1	5.5	1.7	0
130	1.5	52	136	7	5.5	2.4	0
131	1.8	48	130	1	5.5	2.8	1
132	1.2	47	132	2	5.5	2.8	1
133	1.4	54	130	2	5.6	1.9	1
134	1.6	42	129	4	5.5	2.2	1
135	1.5	51	124	1	5.5	3.3	0
136	1.4	54	140	9	5.6	1.9	0
137	1.4	57	127	4	5.7	2.6	0
138	1.4	38	147	1	5.5	2.8	1
139	1.4	38	128	7	5.5	2	0
140	1.7	43	127	2	5.5	3	0
141	1.5	58	124	6	5.8	3.1	1
142	1.4	44	124	9	5.5	1.2	0
143	1.6	44	149	1	5.5	3.1	1
144	1.6	47	134	1	5.5	3.2	1
145	1.3	44	135	1	5.5	2.4	1
146	1.3	46	124	9	5.5	2	1
147	1.4	42	133	4	5.5	1.6	0
148	1.6	43	152	1	5.5	2.2	0
149	1.4	60	129	3	5.9	1.7	1
150	1.4	43	130	4	5.5	2.3	1
151	1.5	46	130	2	5.5	3	1
152	1.3	48	128	1	5.5	1.1	1
153	1.7	48	156	6	5.5	2.4	0
154	1.4	43	132	6	5.5	2.2	1
155	1.8	47	129	4	5.5	2.1	0
156	1.5	61	132	1	5.9	2.1	0
157	1.3	38	124	10	5.5	1.5	0
158	1.3	48	125	1	5.5	2	0
159	1.6	55	124	2	5.6	1.4	1
160	1.6	41	126	4	5.5	3.1	0
161	1.4	33	133	6	5.7	2.6	1
162	1.6	42	153	9	5.5	1.8	1
163	1.5	46	144	8	5.5	2.4	0
164	1.4	35	138	1	5.6	2.6	0
165	1.4	39	131	1	5.5	2.7	1
166	1.6	42	128	1	5.5	2.7	1
167	1.5	43	121	5	5.5	1.7	1
168	1.6	39	126	2	5.5	2.4	1
169	1.6	46	125	6	5.5	2	1
170	1.7	47	129	5	5.5	3.1	0
171	1.4	43	134	2	5.5	1.8	0
172	1.8	51	148	4	5.5	3.4	1
173	1.5	50	125	7	5.5	1.8	1
174	1.7	47	135	5	5.5	1.6	0
175	1.8	48	142	1	5.5	2.9	1
176	1.6	65	124	6	6.2	3.4	1
177	1.7	57	122	6	5.7	2.3	1
178	1.6	68	133	6	6.6	2.5	1
179	1.7	65	128	6	6.2	2.8	0
180	1.2	64	126	5	6.2	2.8	0
181	1.6	65	126	6	6.2	2.2	1
182	1.3	63	129	6	6.1	2.9	0
183	1.5	65	129	6	6.2	2.5	1

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots (continued).

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
184	1.5	66	123	4	6.3	1.1	1
186	1.6	68	127	5	6.6	2.8	0
187	1.7	63	129	6	6.1	2.2	0
188	1.3	65	128	5	6.2	3.3	1
189	1.6	62	125	5	6.0	2.6	1
190	1.4	63	127	6	6.1	3.2	1
191	1.8	63	128	4	6.1	1.9	1
192	1.8	61	130	1	5.9	2.2	1
193	1.6	66	130	5	6.3	2.7	0
194	1.5	62	131	1	6.0	2.6	0
195	1.2	63	124	6	6.1	2.1	0
196	1.3	62	124	6	6.0	2.8	1
197	1.6	65	120	5	6.2	3.4	0
198	1.1	64	126	6	6.2	2.4	1
199	1.7	63	132	4	6.1	3.5	0
200	1.2	66	146	1	6.3	2.7	1
201	1.6	65	126	5	6.2	2.2	0
202	1.3	64	123	4	6.2	1.8	1
203	1.8	67	119	7	6.4	2.3	1
204	1.6	67	130	5	6.4	3.2	1
205	1.4	64	124	7	6.2	2.6	1
206	1.3	65	136	2	6.2	2.5	1
207	1.4	67	125	2	6.4	2.8	1
208	1.6	63	141	4	6.1	3	1
209	1.3	65	129	6	6.2	1.8	1
210	1.5	65	129	6	6.2	1.8	1
211	1.4	65	122	6	6.2	2.3	1
212	1.5	63	131	5	6.1	2.4	0
213	1.4	67	139	4	6.4	2.1	0
214	1.6	63	129	7	6.1	2.7	1
215	1.4	60	129	9	5.9	2.3	0
216	1.4	61	122	6	5.9	2.4	0
217	1.5	67	125	6	6.4	3.1	1
218	1.4	66	121	5	6.3	1.4	0
219	1.3	64	156	1	6.2	2.4	1
220	1.4	63	122	6	6.1	2.6	1
221	1.5	64	127	2	6.2	1.8	0
222	1.6	63	130	5	6.1	2.8	1
223	1.5	66	122	6	6.3	2.5	0
224	1.4	64	128	5	6.2	1.8	0
225	1.3	62	124	6	6.0	2.2	1
226	1.3	64	134	6	6.2	2.5	1
227	1.6	68	130	4	6.6	3	0
228	1.4	65	127	7	6.2	1.6	1
229	1.8	65	121	5	6.2	2	0
230	1.7	64	126	6	6.2	2.4	0
231	1.9	65	128	5	6.2	3.1	1
232	1.6	66	127	7	6.3	2	0
233	1.4	65	123	5	6.2	2	1
234	1.8	65	127	5	6.2	2.6	1
235	1.3	67	125	4	6.4	2	0
236	1.5	68	136	4	6.6	2.6	0
237	1.4	65	132	7	6.2	1.9	0
238	1.7	65	131	5	6.2	1.9	1
239	1.6	65	124	4	6.2	2.2	0
240	1.4	60	123	6	5.9	1.8	0
241	1.5	63	122	6	6.1	2.3	0
242	1.8	70	129	6	6.8	3	1
243	1.4	67	122	7	6.4	1.8	1
244	1.6	64	123	6	6.2	2.5	0
245	1.8	64	124	7	6.2	3.1	1
246	1.4	66	124	6	6.3	2.5	1

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots (continued).

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
247	1.6	66	151	5	6.3	3.1	0
248	1.3	62	134	5	6.0	2.6	1
249	1.3	65	123	6	6.2	2.2	1
250	1.7	64	134	6	6.2	2.3	1
251	1.6	66	135	6	6.3	2.6	0
252	1.3	67	125	6	6.4	2.7	1
253	1.8	64	117	7	6.2	2.6	1
254	1.8	62	130	10	6.0	2.8	0
255	1.8	68	124	6	6.6	2.3	1
256	1.5	65	126	5	6.2	2.4	1
257	1.4	63	125	5	6.1	2.8	0
258	1.8	67	126	5	6.4	2.2	0
259	1.5	61	129	6	5.9	2.6	1
260	1.5	67	145	4	6.4	2.5	0
261	1.7	69	129	10	6.7	2.4	0
262	1.4	65	126	6	6.2	2.8	1
263	1.5	63	127	4	6.1	2.6	1
264	1.4	63	124	6	6.1	2.5	0
265	1.6	64	132	7	6.2	1.9	0
266	1.6	67	119	9	6.4	1.8	0
267	1.7	65	135	6	6.2	2.7	1
268	1.4	64	122	7	6.2	2.5	1
269	1.5	66	123	7	6.3	2.2	0
270	1.7	67	127	6	6.4	2.8	1
271	1.4	66	134	7	6.3	2.2	0
272	1.2	65	122	6	6.2	2.2	1
273	1.4	66	123	5	6.3	2.7	1
274	1.4	66	127	5	6.3	2.6	0
275	1.6	66	124	7	6.3	2.6	1
276	1.5	64	128	6	6.2	1.9	1
277	1.4	64	130	6	6.2	3	1
278	1.4	68	123	4	6.6	2.3	0
279	1.7	65	132	5	6.2	1.8	1
280	1.6	67	128	5	6.4	2.8	1
281	1.6	65	124	2	6.2	2.9	0
282	1.4	67	135	6	6.4	2.5	1
283	1.4	65	138	5	6.2	2.1	0
284	1.5	63	133	9	6.1	3.1	0
285	1.4	68	130	6	6.6	2.8	0
286	1.9	66	122	6	6.3	3.2	0
287	1.7	65	132	5	6.2	2.6	1
288	1.4	67	124	7	6.4	1.9	1
289	1.8	66	129	6	6.3	2.5	1
290	1.5	62	127	9	6.0	2	1
291	1.4	65	132	6	6.2	2	1
292	1.5	66	127	5	6.3	2.6	1
293	1.6	67	136	7	6.4	3.6	1
294	1.3	65	130	5	6.2	2.6	0
295	1.4	66	125	9	6.3	2.7	1
296	1.6	68	132	6	6.6	2.7	0
297	1.2	62	132	5	6.0	2.2	0
298	1.4	62	122	6	6.0	2.3	0
299	1.6	66	126	6	6.3	2.4	0
300	1.3	66	124	5	6.3	2.2	1
301	1.4	67	123	6	6.4	2.9	1
302	1.6	69	137	2	6.7	2	1
303	1.6	66	128	2	6.3	2.7	0
304	1.4	66	119	6	6.3	2.5	0
305	1.4	66	138	6	6.3	2.6	1
306	1.2	64	127	5	6.2	2.1	0
307	1.5	68	129	5	6.6	2.3	0
308	1.6	65	129	7	6.2	2.2	1

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots (continued).

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
309	1.3	69	126	6	6.7	2.6	0
310	1.8	65	125	5	6.2	2.6	0
311	1.4	64	122	5	6.2	2.4	1
312	1.5	65	135	4	6.2	2.4	0
313	1.4	67	120	7	6.4	2.4	1
314	1.4	67	134	7	6.4	2	0
315	1.7	66	127	6	6.3	2.4	1
316	1.7	67	132	7	6.4	2.2	0
317	1.7	68	140	5	6.6	1.9	0
318	1.6	65	140	2	6.2	3.1	1
319	1.8	65	121	6	6.2	2.7	1
320	1.4	60	133	6	5.9	2	0
321	1.6	65	141	6	6.2	2.2	1
322	1.7	65	130	6	6.2	2	0
323	1.5	65	117	6	6.2	2.2	0
324	1.7	64	123	7	6.2	2.1	1
325	1.4	64	135	7	6.2	3.3	0
326	1.5	65	126	5	6.2	1.9	0
327	1.4	65	129	4	6.2	2.8	1
328	1.6	63	126	6	6.1	2	1
329	1.3	62	120	10	6.0	2.6	0
330	1.5	65	113	7	6.2	3.4	1
331	1.6	61	118	9	5.9	2.6	0
332	1.5	61	124	6	5.9	2.9	1
333	1.4	64	126	9	6.2	0	0
334	1.3	67	124	5	6.4	2.6	0
335	1.1	63	121	5	6.1	2	0
336	1.4	62	123	6	6.0	1.8	1
337	1.2	63	123	4	6.1	2.7	1
338	1.7	62	125	5	6.0	2.2	1
339	1.3	65	123	2	6.2	2.7	1
340	1.3	63	124	5	6.1	1.7	0
341	1.7	64	118	2	6.2	2.7	1
342	1.6	62	118	2	6.0	2.6	0
343	1.1	66	112	2	6.3	2.1	1
344	1.2	65	120	4	6.2	1.6	0
345	1.3	61	116	4	5.9	3.7	0
346	1.4	61	113	7	5.9	2.6	0
347	1.1	65	117	1	6.2	1.8	0
348	1.4	62	122	7	6.0	2.4	1
349	1.6	62	115	2	6.0	2.3	0
350	1.6	61	124	9	5.9	3.4	1
351	1.6	57	128	5	5.7	3	0
352	1.5	56	130	2	5.7	3.2	1
353	1.6	59	128	7	5.8	1.8	0
354	1.3	62	130	1	6.0	1.7	1
355	1	59	128	1	5.8	2.6	1
356	1.5	59	135	4	5.8	2.6	0
357	1.3	57	133	4	5.7	2.7	0
358	1.6	54	124	6	5.6	1.9	0
359	1.1	59	131	4	5.8	2.7	1
360	1.6	58	130	1	5.8	2.8	0
361	1.2	62	135	1	6.0	2.5	0
362	1.5	59	124	5	5.8	2.6	0
363	1.6	60	137	5	5.9	1.8	1
364	1.3	58	128	1	5.8	2.9	1
365	1.2	58	127	4	5.8	2.8	1
366	1.8	58	129	2	5.8	2.9	0
367	1.9	54	130	5	5.6	2.2	0
368	1.2	56	129	1	5.7	2.3	0
369	1.3	57	134	2	5.7	2.5	0
370	1.4	58	132	7	5.8	1.3	1

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots (continued).

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
371	1.5	58	139	1	5.8	2.8	1
372	1.3	58	136	2	5.8	2.4	0
373	1.4	58	125	5	5.8	2.8	0
374	1.7	58	126	4	5.8	2.4	0
375	1.3	60	131	1	5.9	2.3	0
376	1.4	60	131	1	5.9	2.2	1
377	1.5	57	130	1	5.7	2.4	0
378	1.4	59	125	4	5.8	2.9	0
379	1.7	58	132	2	5.8	3.1	1
380	1.5	58	132	4	5.8	2.4	1
381	1.3	60	133	4	5.9	2	1
382	1.2	60	132	5	5.9	2.8	1
383	1.4	57	129	4	5.7	2.4	0
384	1.8	59	123	5	5.8	1.8	0
385	1.8	62	129	5	6.0	2.1	0
386	1.3	56	131	2	5.7	3.4	1
387	1.6	60	134	5	5.9	2.4	1
388	1.3	58	119	1	5.8	2.2	0
389	1.1	60	131	2	5.9	2.9	0
390	1.3	58	135	2	5.8	2.3	0
391	1.6	58	128	6	5.8	2.9	1
392	1.2	61	129	1	5.9	2.2	0
393	1.1	60	127	1	5.9	2	1
394	1.1	62	131	1	6.0	3.8	1
395	1.3	59	144	4	5.8	2.6	0
396	1.7	59	132	1	5.8	1.7	1
397	1.3	58	136	1	5.8	3.2	1
398	1.4	61	124	4	5.9	2.2	0
399	1.7	62	130	4	6.0	2	0
400	1.1	58	127	1	5.8	2.5	0
401	1.3	60	131	4	5.9	2.1	1
402	1.3	60	137	1	5.9	1.9	1
403	1.4	62	130	1	6.0	1.3	0
404	1.5	57	124	6	5.7	2.7	0
405	1.4	57	126	5	5.7	2.6	1
406	1.4	58	128	7	5.8	1.8	0
407	1.5	55	129	5	5.6	2.3	1
408	1.3	61	135	2	5.9	2.4	0
409	1.4	61	129	1	5.9	2.3	1
410	1.6	59	131	2	5.8	1.8	0
411	1.5	60	120	6	5.9	2.6	0
412	1.6	57	128	1	5.7	2.7	1
413	1.1	59	134	1	5.8	2.9	1
414	1.2	59	128	4	5.8	2.1	0
415	1.7	62	132	1	6.0	2.2	1
416	1.1	56	127	1	5.7	2.7	0
417	1.6	59	125	6	5.8	2.7	0
418	1.2	58	132	4	5.8	2	0
419	1.5	59	128	4	5.8	2.3	1
420	1.5	58	132	4	5.8	2.4	1
421	1.4	60	130	2	5.9	2.1	1
422	1.5	55	125	4	5.6	2.3	1
423	1.5	55	130	2	5.6	2.3	1
424	1.7	60	137	4	5.9	2.7	0
425	1.6	58	129	4	5.8	2.4	0
426	1.6	61	134	4	5.9	1.4	0
427	1.4	55	123	4	5.6	2.8	0
428	1.8	59	127	2	5.8	2.8	1
429	1.6	62	130	2	6.0	1.7	0
430	1.8	61	126	5	5.9	3.4	1
431	1.3	57	128	5	5.7	2	1
432	1.5	60	131	4	5.9	2	1

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots (continued).

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
433	1.4	56	135	5	5.7	2	1
434	1.2	59	131	5	5.8	2.2	0
435	1.4	60	137	5	5.9	2.5	0
436	1.5	58	126	5	5.8	2.2	0
437	1.4	58	133	5	5.8	2.8	1
438	1.3	63	130	4	6.1	2.1	1
439	1.5	61	137	4	5.9	1.4	1
440	1.7	56	130	4	5.7	2.6	1
441	1.5	60	134	4	5.9	3.1	1
442	1.6	59	132	5	5.8	2.5	0
443	1.7	58	130	5	5.8	2.7	1
444	1.5	59	131	4	5.8	2.7	0
445	1.6	59	132	5	5.8	2.7	1
446	1.7	59	136	4	5.8	2.2	1
447	1.5	60	139	2	5.9	1.8	0
448	1.4	59	132	5	5.8	3.1	0
449	1.5	58	127	5	5.8	3	0
450	1.2	60	131	5	5.9	1.8	1
451	1.4	60	135	2	5.9	3.3	0
452	1.5	58	132	4	5.8	2.4	0
453	1.7	55	120	5	5.6	1.6	1
454	1.5	61	134	6	5.9	2.5	1
455	1.7	58	126	6	5.8	2.6	1
456	1.5	58	128	5	5.8	2.2	1
457	1.6	60	130	4	5.9	2.1	1
458	1.6	63	138	4	6.1	2.4	0
459	1.8	57	131	4	5.7	3	0
460	1.9	56	131	1	5.7	3.2	1
461	1.7	57	141	4	5.7	2	0
462	1.5	58	128	2	5.8	2.5	1
463	1.6	61	122	5	5.9	3.1	1
464	1.7	60	126	5	5.9	2.4	1
465	1.5	61	130	2	5.9	3	1
466	1.4	61	134	5	5.9	2	0
467	1.6	58	129	5	5.8	2.2	1
468	1	59	128	4	5.8	2.7	0
469	1.6	57	136	4	5.7	2.6	1
470	1.5	59	126	7	5.8	1.8	1
471	1.7	60	130	5	5.9	1.6	1
472	1.5	56	135	2	5.7	2	0
473	1.7	57	129	4	5.7	1.9	0
474	1.6	57	133	4	5.7	1.7	1
475	1.5	57	125	4	5.7	2.4	0
476	1.7	60	130	5	5.9	1.8	1
477	1.4	60	128	4	5.9	2.3	0
478	1.4	59	132	4	5.8	2.5	0
479	1.6	57	124	4	5.7	2	1
480	1.5	60	133	4	5.9	2.9	0
481	1.7	57	128	4	5.7	1.5	1
482	1.6	58	130	4	5.8	2.5	0
483	1.7	59	136	4	5.8	2.7	1
484	1.7	59	129	5	5.8	2.3	0
485	1.5	57	134	5	5.7	3.1	1
486	1.7	59	128	5	5.8	2.8	1
487	1.8	58	126	4	5.8	2.1	1
488	1.7	62	129	5	6.0	2.5	0
489	1.6	56	124	4	5.7	1.6	0
490	1.6	56	127	5	5.7	2.5	1
491	1.5	57	126	4	5.7	3.1	1
492	1.3	59	134	5	5.8	2.4	1
493	1.5	57	127	4	5.7	2.1	0
494	1.8	57	132	4	5.7	3.5	1

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots (continued).

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
495	1.6	57	129	5	5.7	2.1	1
496	1.5	60	126	5	5.9	2	1
497	1.6	59	124	5	5.8	2.9	0
498	1.1	59	130	4	5.8	2.6	1
499	1.6	57	131	4	5.7	2.9	1
500	1.5	58	129	5	5.8	2.5	0
501	1.3	60	129	5	5.9	2.5	0
502	1.5	58	132	6	5.8	2.2	1
503	1.8	57	128	5	5.7	2.2	0
504	1.7	59	127	5	5.8	2.2	1
505	1.7	60	133	5	5.9	1.7	0
506	1.5	57	137	6	5.7	2.6	0
507	1.7	57	133	5	5.7	2.5	1
508	1.8	56	134	5	5.7	2.4	1
509	1.7	54	130	5	5.6	2.5	0
510	1.6	58	136	6	5.8	2.1	1
511	1.5	55	132	5	5.6	2.7	0
512	1.3	55	124	4	5.6	3.2	1
513	1.5	57	129	5	5.7	2.2	0
514	1.8	55	125	6	5.6	2.1	0
515	1.6	60	130	5	5.9	3	1
516	1.8	60	127	4	5.9	2.6	1
517	1.5	58	131	5	5.8	3.2	0
518	1.7	58	132	5	5.8	2.8	0
519	1.6	60	129	5	5.9	2.2	1
520	1.6	55	139	5	5.6	3.2	0
521	1.3	60	135	5	5.9	2.3	0
522	1.7	58	130	5	5.8	1.9	0
523	1.6	59	128	4	5.8	2	1
524	1.2	59	131	4	5.8	1.9	1
525	1.5	60	132	4	5.9	2.4	0
526	1.7	57	131	6	5.7	2.2	0
527	1.5	58	126	5	5.8	2.2	0
528	1.6	59	132	5	5.8	2.5	0
529	1.6	60	128	6	5.9	2.4	0
530	1.6	54	128	5	5.6	2.3	1
531	1.6	60	130	5	5.9	2.1	1
532	1.6	58	127	5	5.8	2.2	0
533	1.7	60	127	6	5.9	3.2	0
534	1.5	59	123	4	5.8	2.8	1
535	1.5	63	126	5	6.1	2.2	0
536	1.4	55	129	5	5.6	2	1
537	1.7	55	127	4	5.6	2.8	1
538	1.4	59	138	5	5.8	2.2	0
539	1.7	61	128	5	5.9	2.2	0
540	1.6	56	131	6	5.7	3.1	1
541	1.6	60	132	5	5.9	2.4	0
542	1.7	59	130	5	5.8	2.1	1
543	1.5	60	131	6	5.9	3.1	1
544	1.5	58	135	6	5.8	1.7	1
545	1.4	59	138	4	5.8	2.4	0
546	1.5	61	134	5	5.9	2.5	0
547	1.6	58	129	5	5.8	2.6	1
548	1.5	56	125	6	5.7	2.4	1
549	1.6	58	131	5	5.8	1.46	1
550	1.5	55	121	6	5.6	2.9	1
551	1.6	55	130	5	5.6	2.3	1
552	1.5	56	129	6	5.7	2	1
553	1.4	57	132	5	5.7	2.6	0
554	1.5	60	142	5	5.9	2.4	0
555	1.6	56	136	6	5.7	2.7	0
556	1.4	59	129	4	5.8	2.7	0

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots (continued).

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
557	1.8	59	133	5	5.8	3	0
558	1.5	59	134	5	5.8	2.1	1
559	1.6	58	134	6	5.8	2.3	0
560	1.7	58	131	4	5.8	2.3	1
561	1.4	57	134	4	5.7	3.3	0
562	1.7	60	130	6	5.9	3	1
563	1.4	58	130	5	5.8	2.7	0
564	1.5	56	130	5	5.7	2.6	0
565	1.5	57	131	5	5.7	2.7	0
566	1.6	62	127	4	6.0	2.1	1
567	1.5	59	131	6	5.8	3.3	1
568	1.5	58	131	5	5.8	2.8	1
569	1.7	61	130	4	5.9	2.8	0
570	1.5	60	134	5	5.9	2.2	1
571	1.6	62	131	5	6.0	2.6	0
572	1.7	61	131	5	5.9	2.1	0
573	1.5	58	135	5	5.8	3	1
574	1.6	60	136	5	5.9	2.7	0
575	1.9	60	136	6	5.9	2.4	0
576	1.7	57	132	4	5.7	2.6	1
577	1.7	59	134	5	5.8	2.7	0
578	1.2	58	133	6	5.8	2.6	1
579	1.1	57	126	5	5.7	2.7	1
580	1.5	60	128	6	5.9	2.8	0
581	1.6	61	133	5	5.9	2.2	0
582	1.6	57	132	5	5.7	2.4	1
583	1.4	57	127	5	5.7	2.9	0
584	1.6	59	134	7	5.8	2.5	1
585	1.6	59	134	5	5.8	2.3	1
586	1.6	56	134	5	5.7	2.4	1
587	1.8	58	134	5	5.8	2.9	1
588	1.6	58	125	5	5.8	2.9	1
589	1.5	53	136	5	5.6	2.7	0
590	1.5	59	129	4	5.8	3.3	0
591	1.6	59	130	6	5.8	1.9	1
592	1.7	58	136	5	5.8	2.4	0
593	1.8	60	135	5	5.9	2.1	1
594	1.4	63	135	4	6.1	2.7	0
595	1.7	58	127	6	5.8	1.6	0
596	1.8	54	127	6	5.6	2.2	1
597	1.7	59	132	6	5.8	2.4	1
598	1.6	57	131	5	5.7	2.4	1
599	1.6	60	126	2	5.9	1.6	1
600	1.1	59	132	5	5.8	2.8	0
601	1.6	58	126	5	5.8	2.1	1
602	1.5	57	130	6	5.7	2.7	0
603	1.5	57	129	6	5.7	3.3	1
604	1.3	56	131	5	5.7	2.6	0
605	1.3	59	126	5	5.8	2.6	0
606	1.5	58	126	5	5.8	2	1
607	1.6	60	128	5	5.9	2.4	1
608	1.4	56	123	4	5.7	1.6	0
609	1.6	58	127	6	5.8	3.1	0
610	1.4	60	124	5	5.9	3.4	1
611	1.8	60	128	6	5.9	2.7	0
612	1.7	59	125	5	5.8	1.9	0
613	1.5	56	119	4	5.7	2.3	1
614	1.6	59	131	5	5.8	1.9	1
615	1.7	59	141	5	5.8	2.2	0
616	1.5	61	129	6	5.9	2.7	1
617	1.7	57	125	7	5.7	3.2	1
618	1.8	56	126	6	5.7	1.6	0

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots (continued).

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
619	1.7	61	129	5	5.9	2.7	0
620	1.7	58	131	5	5.8	2.3	1
621	1.3	59	132	7	5.8	1.7	0
622	1.7	61	136	6	5.9	1.7	0
623	1.3	55	132	5	5.6	2	1
624	1.7	61	129	5	5.9	1.1	0
625	1.5	61	125	4	5.9	3	0
626	1.6	58	128	5	5.8	2.4	0
627	1.6	63	132	6	6.1	2.8	0
628	1.7	61	125	6	5.9	2.6	1
629	1.7	60	126	4	5.9	2.8	1
630	1.6	61	127	5	5.9	3	0
631	1.7	58	126	5	5.8	2.4	0
632	1.8	60	131	6	5.9	2.2	1
633	1.4	56	129	6	5.7	2.1	1
634	1.8	58	127	5	5.8	2.5	0
635	1.4	55	127	5	5.6	1.7	1
636	1.4	57	129	6	5.7	2.6	0
637	1.4	60	128	4	5.9	2.1	1
638	1.8	59	129	6	5.8	2.5	0
639	1.7	59	130	5	5.8	2.8	0
640	1.5	58	1218	4	5.8	1.8	0
641	1.4	64	124	5	6.2	1.9	1
642	1.6	62	127	6	6.0	3.3	1
643	1.5	60	118	5	5.9	3.2	0
644	1.4	57	124	5	5.7	2.1	0
645	1.3	58	122	7	5.8	2.7	0
646	1.5	58	130	5	5.8	2.2	1
647	1.5	59	124	5	5.8	1.9	0
648	1.5	57	129	4	5.7	1.6	1
649	1.4	59	125	5	5.8	2.4	0
650	1.3	57	136	2	5.7	2.7	1
651	1.6	61	127	6	5.9	2	0
652	1.1	57	124	5	5.7	2.9	0
653	1.5	60	130	5	5.9	3	0
654	1.7	60	128	6	5.9	2.8	1
655	1.6	59	126	4	5.8	2.5	1
656	1.5	56	131	6	5.7	2.5	0
657	1.7	59	124	5	5.8	3.2	0
658	1.5	60	127	7	5.9	3.1	0
659	1.4	56	134	7	5.7	2.2	0
660	1.6	58	122	6	5.8	2.7	1
661	1.8	59	127	6	5.8	2.5	0
662	1.4	58	127	6	5.8	1.8	1
663	1.6	56	124	7	5.7	2.8	0
664	1.2	61	126	5	5.9	2.4	0
665	1.6	58	125	5	5.8	3	1
666	1.5	54	124	2	5.6	3.1	1
667	1.7	57	127	4	5.7	2.9	0
668	1.5	60	130	5	5.9	3	1
669	1.4	59	123	5	5.8	3.5	1
670	1.6	61	132	5	5.9	2.6	1
671	1.5	61	135	5	5.9	3.4	0
672	1.8	59	124	7	5.8	1.7	0
673	1.4	57	124	5	5.7	3.3	0
674	1.6	56	133	7	5.7	2.9	0
675	1.7	54	134	6	5.6	2.5	0
676	1.5	63	124	6	6.1	2.9	1
677	1.5	64	125	5	6.2	2.4	1
678	1.4	55	132	7	5.6	2.9	1
679	1.5	59	131	6	5.8	2.4	0
680	1.7	61	130	4	5.9	2.1	0

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots (continued).

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
681	1.8	56	125	4	5.7	2	0
682	1.7	61	140	6	5.9	2.2	1
683	1.4	58	124	6	5.8	2.2	0
684	1.6	59	132	6	5.8	2.1	0
685	1.6	60	132	6	5.9	1.7	0
686	1.7	58	136	5	5.8	2.7	0
687	1.3	60	128	5	5.9	2.4	1
688	1.5	60	129	6	5.9	2.5	1
689	1.8	62	125	6	6.0	2.4	0
690	1.6	56	135	6	5.7	2	1
691	1.7	62	131	6	6.0	2.8	0
692	1.7	58	127	5	5.8	1.9	1
693	1.6	58	133	6	5.8	2.5	0
694	1.6	60	129	5	5.9	2.7	0
695	1.7	57	125	6	5.7	1.9	1
696	1.7	58	134	7	5.8	2.7	0
697	1.5	59	130	5	5.8	2	0
698	1.5	59	132	6	5.8	3.1	0
699	1.6	60	131	4	5.9	1.8	1
700	1.8	59	130	6	5.8	2	1
701	1.7	61	130	5	5.9	2.5	0
702	1.5	62	124	5	6.0	2.3	0
703	1.6	56	131	5	5.7	3.1	0
704	1.4	58	129	6	5.8	1.9	0
705	1.3	57	130	7	5.7	3.1	1
706	1.6	63	125	6	6.1	2.8	0
707	1.5	64	122	7	6.2	2.5	1
708	1.3	61	132	2	5.9	2.6	0
709	1.4	61	128	6	5.9	2.6	0
710	1.5	62	128	5	6.0	2.7	1
711	1.4	59	124	8	5.8	2.7	1
712	1.5	62	124	8	6.0	2.5	1
713	1.6	62	129	4	6.0	2.5	0
714	1.3	59	124	7	5.8	3.2	0
715	1.8	62	124	7	6.0	2.2	1
716	1.5	58	129	4	5.8	2.3	1
717	1.4	61	122	7	5.9	2.9	0
718	1.7	62	125	7	6.0	1.9	1
719	1.6	65	131	6	6.2	3.1	1
720	1.3	63	123	8	6.1	1.8	0
721	1.7	62	130	6	6.0	2.8	1
722	1.4	59	125	7	5.8	2.4	1
723	1.7	48	134	7	5.5	2.3	1
724	1.5	47	128	2	5.5	2.8	0
725	1.7	48	127	4	5.5	3.3	1
726	1.6	49	131	5	5.5	2	1
727	1.7	50	135	4	5.5	2	1
728	1.5	48	125	5	5.5	2.6	0
729	1.5	47	125	6	5.5	1.7	0
730	1.5	49	126	6	5.5	2.8	0
731	1.8	50	123	5	5.5	2.5	0
732	1.6	51	124	4	5.5	2.9	1
733	1.4	49	127	6	5.5	1.9	1
734	1.8	49	129	5	5.5	2.4	1
735	1.7	52	134	6	5.5	1.9	0
736	1.5	49	131	7	5.5	2	0
737	1.4	47	124	6	5.5	2.5	1
738	1.6	51	136	6	5.5	2.3	1
739	1.6	56	130	5	5.7	2.8	0
740	1.6	54	125	5	5.6	2.2	0
741	1.5	55	125	5	5.6	2.2	1
742	1.6	52	130	5	5.5	2.3	1

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots (continued).

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
743	1.4	53	130	4	5.6	3.2	0
744	1.6	55	134	4	5.6	2.6	0
745	1.5	50	134	6	5.5	2.1	1
746	1.1	53	126	4	5.6	2.5	0
747	1.4	52	134	4	5.5	2.5	0
748	1.6	54	126	2	5.6	2.9	0
749	1.3	54	125	5	5.6	2.6	1
750	1.4	55	125	5	5.6	1.8	1
751	1.3	53	131	4	5.6	2.5	0
752	1.4	54	129	5	5.6	2.5	0
753	1.5	52	129	5	5.5	2.4	0
754	1.7	58	125	2	5.8	2.2	0
755	1.7	52	128	4	5.5	2.2	0
756	1.4	56	124	5	5.7	3.1	1
757	1.4	60	125	5	5.9	2.6	1
758	1.6	54	124	4	5.6	2.5	0
759	1.8	52	121	4	5.5	2	1
760	1.4	54	129	5	5.6	2.3	0
761	1.4	52	124	6	5.5	2.3	1
762	1.3	56	124	6	5.7	2.3	0
763	1.7	56	126	4	5.7	2.7	1
764	1	52	137	2	5.5	2.2	0
765	1.4	57	132	2	5.7	2.3	0
766	1.6	57	124	6	5.7	2.8	1
767	1.1	55	134	2	5.6	2.1	0
768	1.2	55	140	4	5.6	1.7	1
769	1.4	56	128	5	5.7	2.3	0
770	1.6	55	127	4	5.6	1.6	0
771	1.5	53	124	5	5.6	2.8	1
772	1.4	55	120	6	5.6	2.3	1
773	1.3	55	132	4	5.6	2.9	0
774	1.5	54	125	6	5.6	2.16	1
775	1.3	55	122	4	5.6	3.3	0
776	1.4	53	124	5	5.6	2	1
777	1.6	55	129	5	5.6	2.1	0
778	1.7	53	132	5	5.6	2.6	0
779	1.5	57	129	5	5.7	2.9	1
780	1	57	133	2	5.7	2.1	0
781	1.7	52	114	5	5.5	2.5	0
782	1.3	52	125	6	5.5	2.9	1
783	1.2	56	132	5	5.7	2.7	1
784	1.3	55	128	4	5.6	2.4	1
785	1.7	55	135	5	5.6	2.6	1
786	1.4	55	124	2	5.6	2	0
787	1.6	55	133	4	5.6	1.7	0
788	1.5	57	133	4	5.7	3	1
789	1.1	56	124	2	5.7	2.6	0
790	1.4	52	123	5	5.5	1.6	1
791	1.3	53	125	4	5.6	2.2	1
792	1.7	50	133	2	5.5	3	0
793	1.3	50	126	5	5.5	2.9	0
794	1.5	57	123	4	5.7	2.9	1
795	1.6	56	120	5	5.7	2.7	0
796	1.3	53	123	5	5.6	2.4	0
797	1.4	53	123	4	5.6	1.9	0
798	1.4	55	134	5	5.6	3	0
799	1.4	54	122	6	5.6	2.7	1
800	1.3	57	131	2	5.7	3	1
801	1.6	55	121	4	5.6	1.9	1
802	1.5	56	129	4	5.7	2.1	0
803	1.3	56	131	4	5.7	1.6	0
804	1.5	56	128	4	5.7	2.4	1

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots (continued).

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
805	1.6	54	131	5	5.6	2.1	0
806	1.5	55	134	5	5.6	2.7	1
807	1.7	56	130	4	5.7	2.2	1
808	1.5	54	129	6	5.6	2.3	0
809	1.4	55	122	5	5.6	2.5	1
810	1.4	58	129	6	5.8	1.9	1
811	1.7	53	126	5	5.6	2.5	0
812	1.4	56	133	5	5.7	1.8	1
813	1.4	53	129	5	5.6	2.2	1
814	1.2	56	128	5	5.7	2.5	1
815	1.7	57	130	6	5.7	2.5	0
816	1.3	57	130	6	5.7	3.3	0
817	1.3	56	135	4	5.7	2.6	0
818	1.3	54	122	6	5.6	3.1	0
819	1.6	53	124	5	5.6	1.5	0
820	1.4	56	128	6	5.7	2.4	0
821	1.2	53	132	2	5.6	2	1
822	1.1	56	124	1	5.7	2.7	1
823	1.4	54	125	6	5.6	3	1
824	1.4	56	132	4	5.7	2.2	1
825	1.6	56	130	5	5.7	2.1	1
826	1.2	56	138	4	5.7	2	1
827	1.5	57	129	6	5.7	2.4	0
828	1.4	54	130	4	5.6	2.9	1
829	1.2	54	137	2	5.6	2.8	1
830	1.3	56	130	2	5.7	2.5	0
831	1.3	55	124	6	5.6	2	0
832	1.5	53	127	5	5.6	2.4	1
833	1.8	56	129	5	5.7	2.5	0
834	1.5	54	125	4	5.6	2.1	0
835	1.4	56	124	5	5.7	2.2	0
836	1.6	56	128	6	5.7	2.8	0
837	1.5	56	141	2	5.7	2.9	1
838	1.4	56	127	4	5.7	1.7	1
839	1.2	56	131	4	5.7	2.6	0
840	1.5	53	134	2	5.6	1.9	0
841	1.5	53	137	4	5.6	2.9	1
842	1.4	55	136	4	5.6	1.6	1
843	1.5	54	130	6	5.6	2.1	0
844	1.4	56	130	6	5.7	2.6	0
845	1.5	53	128	5	5.6	1.6	1
846	1.7	59	132	2	5.8	2.8	0
847	1.3	56	129	4	5.7	2.7	0
848	1.4	58	130	5	5.8	2.3	0
849	1.6	57	129	4	5.7	2.8	1
850	1.5	55	129	5	5.6	2.3	1
851	1.4	57	134	2	5.7	1.9	0
852	1.3	57	127	4	5.7	2.7	1
853	1.3	55	130	6	5.6	2.2	0
854	1.8	54	132	4	5.6	2.8	0
855	1.7	56	128	5	5.7	2.7	0
856	1.6	59	140	6	5.8	2.5	1
857	1.1	58	134	2	5.8	1.6	0
858	1.8	56	137	4	5.7	2.5	0
859	1.6	56	122	5	5.7	2.8	1
860	1.6	56	129	5	5.7	2.5	1
861	1.4	56	128	1	5.7	2.6	1
862	1.4	54	135	2	5.6	3.1	1
863	1.3	55	127	5	5.6	2.8	0
864	1.3	54	137	5	5.6	3	1
865	1.5	55	128	4	5.6	2.5	1
866	1.7	60	134	2	5.9	2.2	1

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots (continued).

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
867	1.3	58	142	5	5.8	2.4	1
868	1.6	53	136	4	5.6	2.1	1
869	1.5	56	126	5	5.7	2.1	0
870	1.5	57	129	5	5.7	1.6	1
871	1.6	59	128	5	5.8	2.5	1
872	1.5	57	129	2	5.7	2.6	1
873	1.3	57	125	5	5.7	3.1	1
874	1.4	55	122	5	5.6	2.1	0
875	1.8	58	134	2	5.8	2.4	1
876	1.3	58	126	4	5.8	3.1	1
877	1	51	133	4	5.5	2.2	0
878	1.5	53	125	5	5.6	1.7	1
879	1.3	56	126	5	5.7	2.5	1
880	1.5	53	126	5	5.6	2.7	1
881	1.6	54	129	5	5.6	2.3	1
882	1.5	55	136	5	5.6	2.2	0
883	1.6	54	132	4	5.6	2.8	1
884	1.3	53	126	5	5.6	2.3	0
885	1.6	55	129	5	5.6	2.9	1
886	1.6	55	124	5	5.6	3.5	0
887	1.5	58	125	4	5.8	3.2	1
888	1.5	54	128	4	5.6	3.1	0
889	1.7	51	135	5	5.5	2.8	1
890	1.6	52	129	5	5.5	2.2	0
891	1.6	45	138	4	5.5	2.5	1
892	1.4	53	134	5	5.6	2.7	0
893	1.5	52	133	5	5.5	2.7	0
894	1.5	57	131	5	5.7	2.2	1
895	1.6	53	135	5	5.6	2.3	1
896	1.4	51	131	5	5.5	2.3	0
897	1.5	60	130	6	5.9	3.1	1
898	1.2	60	138	1	5.9	3.1	0
899	1.4	61	125	7	5.9	2.2	1
900	1.5	61	128	7	5.9	2.2	1
901	1.8	64	134	1	6.2	2.4	1
902	1.5	62	135	5	6.0	2.7	1
903	1.8	59	138	1	5.8	1.2	1
904	1.4	62	137	5	6.0	2.7	0
905	1.5	61	126	5	5.9	1.9	1
906	1.4	59	128	4	5.8	2.5	0
907	1.3	63	125	5	6.1	2.6	0
908	1.6	58	125	6	5.8	2.2	1
909	1.5	59	131	1	5.8	1.4	0
910	1.6	60	128	5	5.9	2.5	1
911	1.2	61	133	1	5.9	2.2	0
912	1.5	60	128	1	5.9	2.3	1
913	1.6	60	124	5	5.9	2.1	1
914	1.3	62	131	1	6.0	2.8	0
915	1.5	61	125	4	5.9	2.6	0
916	1.8	61	135	2	5.9	2.4	1
917	1.3	59	132	4	5.8	1.6	0
918	1.6	59	132	6	5.8	2.4	1
919	1.4	63	136	2	6.1	2.3	0
920	1.2	59	125	4	5.8	2.3	0
921	1.4	58	130	6	5.8	2.5	0
922	1.3	63	131	5	6.1	2.7	0
923	1.6	65	133	1	6.2	2.3	0
924	1.5	61	125	6	5.9	2.1	0
925	1.7	58	131	5	5.8	3	1
926	1.4	62	125	5	6.0	3	1
927	1.5	61	132	6	5.9	2.8	1
928	1.6	57	132	4	5.7	2.1	1

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots (continued).

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
929	1.3	66	131	5	6.3	2.6	1
930	1.2	61	131	4	5.9	2.5	0
931	1.7	61	132	4	5.9	1.9	1
932	1.8	58	132	4	5.8	2	0
933	1.9	61	132	5	5.9	1.6	0
934	1.7	63	132	4	6.1	2.6	0
935	1.6	60	132	6	5.9	2.9	1
936	1.8	60	126	4	5.9	2.4	0
937	1.8	64	125	4	6.2	3	0
938	1.4	61	128	6	5.9	2.3	1
939	1.5	55	125	7	5.6	2.9	1
940	1.7	61	131	6	5.9	3.3	1
941	1.7	61	126	5	5.9	2.5	0
942	1.6	60	131	6	5.9	2.4	1
943	1.4	62	125	5	6.0	2.9	0
944	1.4	58	129	5	5.8	3.2	0
945	1.4	60	136	5	5.9	2.9	1
946	1.3	60	128	6	5.9	2.9	1
947	1.5	59	128	5	5.8	2.9	0
948	1.5	59	127	7	5.8	2.8	1
949	1.7	63	134	5	6.1	2.1	0
950	1.6	59	131	5	5.8	1.8	0
951	1.5	59	128	4	5.8	2.4	0
952	1.6	61	139	5	5.9	3.3	0
953	1.5	59	127	2	5.8	2.2	1
954	1.6	61	128	5	5.9	2.1	1
955	1.7	59	133	5	5.8	2.9	0
956	1.8	58	124	4	5.8	1.8	1
957	1.3	60	136	2	5.9	2.5	1
958	1.3	58	129	5	5.8	2.5	0
959	1.2	58	128	4	5.8	1.9	0
960	1.8	56	127	5	5.7	1.9	1
961	1.4	61	127	4	5.9	2.4	1
962	1.5	61	139	5	5.9	1.7	0
963	1.4	61	130	2	5.9	2.8	1
964	1.5	61	132	7	5.9	2.4	0
965	1.3	58	128	6	5.8	1.8	1
966	1.4	61	133	1	5.9	2	0
967	1.5	59	128	6	5.8	2.5	0
968	1.7	63	144	5	6.1	1.9	1
969	1.6	62	126	4	6.0	2.5	0
970	1.3	59	124	5	5.8	2.7	0
971	1.6	62	131	6	6.0	2.9	1
972	1.5	61	131	5	5.9	2.1	1
973	1.4	62	133	5	6.0	2.4	1
974	1.4	62	126	5	6.0	2.4	1
975	1.3	60	132	4	5.9	2.6	1
976	1.7	61	132	6	5.9	2.9	1
977	1.5	60	126	5	5.9	3.4	1
978	1.7	62	132	4	6.0	2.6	0
979	1.4	59	127	5	5.8	2.8	0
980	1.8	59	135	6	5.8	2.1	1
981	1.7	60	129	4	5.9	3	1
982	1.5	58	131	5	5.8	1.6	1
983	1.2	58	137	2	5.8	2.6	0
984	1.7	57	134	2	5.7	2.3	1
985	1.4	56	134	6	5.7	2.2	0
986	1.6	59	127	4	5.8	2.4	0
987	1.4	60	136	5	5.9	3	0
988	1.5	56	128	5	5.7	2.2	1
989	1.2	56	132	4	5.7	2.3	0
990	1.4	59	131	4	5.8	2.3	1

Table A-1: Capstone Project Jump Shot Data for Six Study Factors - 1000 Shots (continued).

Shot #	Release Time (s)	Release Angle (deg)	Leg Angle (deg)	Vertical (in)	Release Speed (s)	Backspin (rot/s)	Make/Miss
991	1.6	60	129	2	5.9	2.2	1
992	1.4	56	128	4	5.7	2.5	0
993	1.7	58	128	6	5.8	1.7	1
994	1.5	58	130	5	5.8	2.7	1
995	1.3	56	126	4	5.7	1.9	1
996	1.3	58	127	7	5.8	1.6	1
997	1.4	60	133	2	5.9	2.5	1
998	1.4	59	127	5	5.8	2.1	1
999	1.8	59	129	6	5.8	2.6	1
1000	1.6	60	133	4	5.9	3.2	1
Average	**1.50**	**57.14**	**131.99**	**4.73**	**5.75**	**2.45**	**0.51**

Engineering

Capstone Report Approval Form

Master of Science in Engineering – MSE

Milwaukee School of Engineering

This capstone report, titled “Analysis and Design of Optimal Improvement Methods for Basketball Shooting Mechanics,” submitted by the student Stephen Kaatz, has been approved by the following committee:

Faculty Advisor: ________________________________ Date: ___________________

Dr. Subha Kumpaty, Ph.D.

Faculty Member: ________________________________ Date: ___________________

Dr. Douglas Grabenstetter, Ph.D.

Faculty Member: ________________________________ Date: ___________________

Professor Gary Shimek, M.L.I.S.