RUTGERS
School of Engineering

Mechanical and Aerospace Engineering
650:467 Design and Manufacturing I

CRITICAL DESIGN REPORT

for

S.I.D.
(Swing Improvement Device)

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EXECUTIVE SUMMARY

In a world where athletes are looking for every opportunity to improve their performance, swing mechanics are a key focus when it comes to baseball. Determining what swing path and trajectory yields the highest bat speed and the highest probability of contacting the ball, with the most efficiency, was the focus of our research. Our findings supported that an elastic swing that is led with a heavy forward step and shoulder rotation, followed by hand and wrist rotation, with a very slightly upward angled swing is what will lead to the most batting success. Our definition of batting success, the vision and goal of this project, is to be able to consistently have the most efficient and easily adjustable swing that will cause the batter to hit the ball in a "line drive" fashion. From our research, we have determined that the most successful line drive hits result from a swing that induced a 60+ mile per hour exit velocity of the ball at an angle ranging from 10 to 25 degrees upward from the horizontal plane. With this goal in mind, we designed a mechanical device that allows the batter to connect it to his/her own bat, that will give him/her instantaneous feedback on various aspects of his/her swing. The conceptualization of the swing feedback is reliant upon the mathematical and physical properties of centripetal acceleration.

STATEMENT OF THE PROBLEM

The market for sports training equipment is very large and continually growing. The sporting goods market is reported to have reached $49 billion in sales in the US alone, according to ibisworld.com. In addition to this, studies show that youth participation in baseball is increasing steadily, up 18.1 percent from 2015 to 2016 alone. This information clearly shows that there is demand for sports training equipment, specifically baseball training equipment. Our design provides a simple solution for a common problem in many youth players' swings. Many developing players tend to swing "too long" and lead with the barrel of the bat, rather than their hands and the butt of the bat. This practice leads to slower swings and less power in swings. In addition to this, it makes it harder for the batter to make consistent contact with the ball, which could be very frustrating and disheartening for young players trying to learn the game. S.I.D. is designed to help train the batter to develop better swing habits and improve their hitting game. Our design provides instant feedback to the batter on the timing of their swing while taking batting practice. There are a few products on the market that aim to accomplish the same result as S.I.D., most notably the Speed Hitter, which shares similar concepts to our design. The problem with the Speed Hitter and the other products on the market is that they don't allow for the player to use a bat that they are comfortable with or hit an actual ball with it. That is where S.I.D. stands above the other products. S.I.D. provides the batter with exceptional swing training while allowing them to use their bat of preference, most comfortable to them. Our product is designed to fit on any bat without altering the bat's balance and provide instant feedback to the batter on their swing. The designers of S.I.D. agreed that it is imperative for the batter to be able to see where the ball lands while using the product so they can recognize it in games and make adjustments accordingly. Our design, S.I.D., stands to improve the swings of youth batters while providing them with the luxury of being comfortable with their own bat.

DESIGN OBJECTIVES

(1) Enforce the "shine the light" technique to prevent casting
(2) Provide instant feedback of the moment at which bat velocity peaks
(3) Provide a set of metric which which the batter can use to track progress.
    (i) time between contact and highest bat velocity
    (ii) max velocity and acceleration of bat
    (iii) batting angle at contact

DESIGN PROCESS

We began our approach to this project by defining what the batter's goal is, which we consider to predominantly be hitting home runs, but also line drives. We researched famous techniques and tips used by professional baseball players and came up with the criteria that is crucial for successful batting for any given player and bat: having the maximum possible hitting velocity, maintaining a launch angle of between 15 and 25 degrees, and following the swing path that gives the highest chance of hitting the ball. We started to brainstorm ideas for devices that would conquer all of these tasks by first looking at what was on the market and evaluating their strengths and weaknesses in accomplishing the goals mentioned.

In assessing the market for baseball swing solutions, we came across three devices that most closely matched our own goals: The Speed Hitter, Louisville Slugger Instructo Batting Tee, and Zepp Baseball Tracking System. Although there are a lot similar variations of these products out there, these three can be considered the most popular and represent the main concepts that current devices help on. Yet, all of them had their strengths and pitfalls.

The Speed Hitter (Appendix D, Figure 1) is a device that that consists of a sliding baseball attached to a rod with a handle, which one can use to practice their swing with. It gives instant feedback of the moment you fully extend the bat, which can be used to prevent "casting," or basically snapping the bat and extending too early. The instant feedback is useful because the player can immediately change their swing until they consistently don't cast, but the drawback is that it doesn't feel like a real bat because of the moving weight of the ball and you cannot hit an actual ball with the bat while practicing.

The next device we analyzed was the Louisville Slugger Ultra Instructo Batting Tee (Appendix D, Figure 2) which consists of a curved bar around the hitting area which prevent the player from casting, chopping, or undercutting by forcing them to swing through the area inside the bar. While this makes sense, it only helps to a certain limit, because a player can still cast slightly and get away with swinging at wrong angles and still manage to get the bat through the area. It also is not the best for kids of all sizes, because based on each players arm lengths, height, etc it would not only need to be adjusted accordingly in height, which can get complicated, but also in wide and size, which is not one of its features.

Lastly, we looked at the Zepp Baseball Tracking System (Appendix D, Figure 3), a complicated device that attached to the butt of a bat and uses complicated algorithms to acquire knowledge about swing path, angle of attack, velocity, and much more. While this is very useful for players to know, it is more intuitive to coaches, as youth baseball players would find these metrics complicated to decipher. Furthermore, with this device, there is no instant feedback, so a player does not know what they are doing wrong until after practice, when they would connect their phones to the device via Bluetooth and use their app to retrieve all the information. Even after seeing this information, it becomes hard to pinpoint what is wrong and its cause. Thus, although this product is nice to track

your performance numbers, it does not force you to improve your swing and would be too complicated for youth players to be able to use.

Analyzing these other devices helped solidify what functions we wanted our product to perform. From here, we decided to make a bat that would be similar to the speed hitter, but instead of having a ball moving along the bat, there would be magnetic contacts inside a real bat. A moving magnetic contact would move inside the barrel and at the extension of the swing, would hit a receptor magnetic contact, thus finishing an electrical circuit that would sound a buzzer or give some type of auditory, visual, or tactical feedback of our choice. This solved the problem of not being able to practice with a real bat that could actually hit a ball simultaneously, but it still meant that we would have to make bats of all different weights and sizes to accommodate different aged players. It also meant that we would have cut open the bat to install these components, which might compromise the integrity of the bat's performance and durability over time. Another pitfall we saw was that players would not be able to practice and get comfortable with the bat that they would play with in actual games, which is crucial, especially for players of a young age.

To tackle these problems, we started to think of ways to make this an external device that one could attach to their own bat, an idea that would reduce the cost of making the device and allow the user to be more comfortable using the device. After brainstorming a few possible ideas, we came up with a design that accomplished the following goals: (1) give instant feedback of the time of extension (to prevent casting), (2) allow the player to hit a baseball while using the device, (3) allow the player to use their own bat of preference, (4) enforce the shine the light technique, and (5) give concise data that directly correlates to batting efficiency to make it easier for the user to track progress. In the next section, we discuss the features of our final design in more detail.

FINAL DESIGN

The main aspect of S.I.D. involves a metal bell in a tube that leads to a small bell. when the bat is swung, the ball moves towards the bell and when the ball hits the bell, it notifies the batter that that is the instant the bat should be making contact with the ball. Based on when the batter hears the bell, they can tell how early or late their swing is and adjust it accordingly. This concept of using the angular acceleration of the swing and relating it to an object moving linearly up the bat is similar to the Speed Hitter, referenced earlier, but our design harnesses that concept while allowing the batter to actually hit a ball at the same time. As seen in Appendix B, we will be using 0.5" vinyl tubing and a bicycle bell for the apparatus. The length of the tube will be determined so that the ball hits the bell precisely when the bat should be making contact with the ball. The tube, ball and bell will all be attached to a compression sleeve that will be tight enough to fit on any bat. One problem that could arise is the compression sleeve could start to slip off the bat after many swings and contact with the ball. To prevent this, as seen in Appendix B, friction tape will be sewn on to the ends of the sleeve to keep it from moving. In order to give the batter a good idea of if their coming through the zone leading with their hands, a laser will be placed on the butt of the bat with a receiver located in front of the bateer by where the pitcher would be. When the batter swings, the laser on the butt of the bat will trigger the receiver and notify the batter that they led with their hands. We are considering a diode laser to accomplish this, but we must do some more research and testing before we solidify the design for it. In order to notify that the batter's swing is level, we are also considering placing a laser in the top of the bat with 3 receivers stacked on top of eachother. Ideally, the center receiver will be triggered, but the other receivers will trigger if the batters swing angled up or down. These laser designs are late additions to our product that still need more research before it is added to the final design.

ENGINEERING ANALYSIS OF FINAL DESIGN

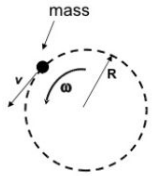
This project's success is heavily reliant on angular momentum and acceleration since the bat is taking a circular path before making contact with the tee or a real life baseball. Equations that will you be used are as follows but not limited to

Rotational relationship

$$L = I\omega$$

$$L = mR^2\omega$$

In the case for a mass moving in a circle.



Translational relationship

$$L = p \otimes r, \quad \theta = 90$$

$$L = mvR \quad v = R\omega$$

$$L = mR^2\omega$$

In both cases the angular momentum is the same.

$$F_r = \frac{mv^2}{r}$$

These equations cover most of the angular momentum equations that will be used and centripetal force. They will be in differential form and have to be integrated since the bat will not have a constant acceleration as it is moving through the swing path.

CONCLUSION

As previously stated there will be a bell that notifies the batter if they are swinging correctly or not since one of the aspects of this product that separates it from others on the market is its ability to provide instant feedback.

The first prototype still needs to be built in the spring semester and testing will follow. The first step will be to make the initial model and set up the entire configuration of the product and start using it as it was designed. The product will be tested in January and constant improvements will be made so that multiple bats and set ups can be tested. All of the engineering drawings have been made for the actual bat but will need to be made for the tee and whole apparatus.

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Appendix A1. PROJECT MANAGEMENT

This project began with rigorous research of different baseball swing mechanics and techniques. Research was conducted on other products in the market, as well as many of the common drills that are used to improve batting skills. The various swing techniques were studied and analyzed in conjunction with the lessons from the drills until the most efficient path was derived. Putting these concepts together, a list of all of the objectives of the project was put together, and an initial design was drawn up. After this design was analyzed, several more designs were created, and the best features of each design were compiled to ultimately create our finalized design. Hand drawings of the designs were transformed into CAD models to allow for further analysis of the project.

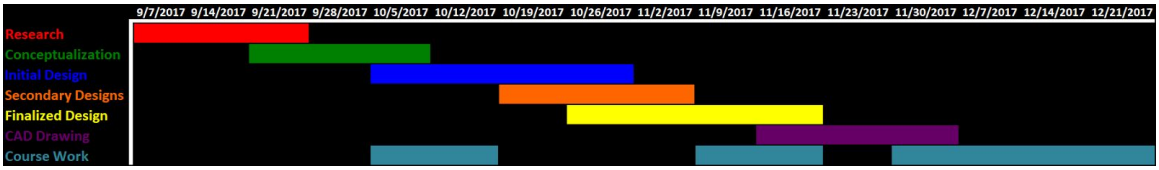


Figure 1: Gantt chart visualization of the work progression for the Fall semester

Going into next semester, the parts that we order will be manufactured into the current design, and then will be tested for functionality. This process will be iterative, and will require a lot of back and forth manufacturing and testing. The product will be analyzed along the way for improvements and weaknesses. The problems that are foreseen are related to impact based errors, which will hopefully be resolved by testing different parts for durability. The project and report will be completed and ready for presentation come April 28, 2018 (Rutgers Day).

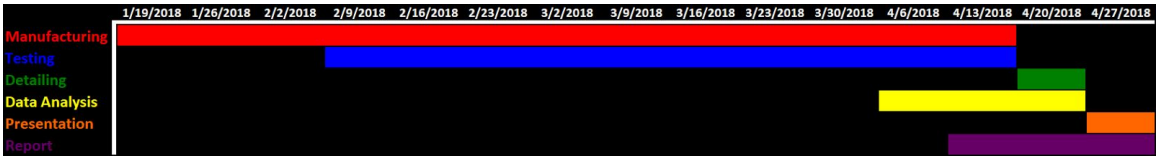
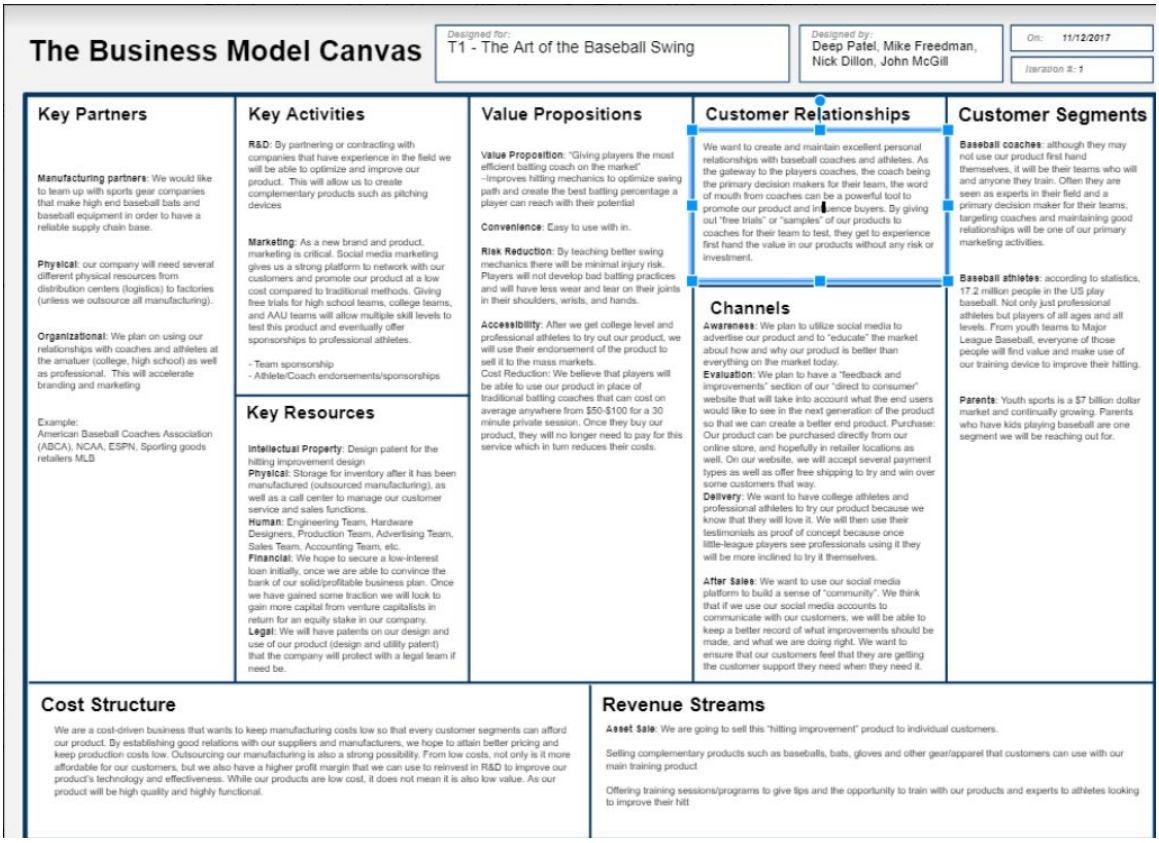


Figure 2: Gantt chart visualization of the expected work progression for the Spring semester

Appendix A2. BUSINESS MODEL CANVAS



The Business Model Canvas

Designed for: T1 - The Art of the Baseball Swing

Designed by: Deep Patel, Mike Freedman, Nick Dillon, John McGill

On: 11/12/2017

Iteration #: 1

Key Partners

Manufacturing partners: We would like to team up with sports gear companies that make high end baseball bats and baseball equipment in order to have a reliable supply chain base.

Physical: our company will need several different physical resources from distribution centers (logistics) to factories (unless we outsource all manufacturing).

Organizational: We plan on using our relationships with coaches and athletes at the amatuer (college, high school) as well as professional. This will accelerate branding and marketing

Example:
American Baseball Coaches Association (ABCA), NCAA, ESPN, Sporting goods retailers MLB

Key Activities

R&D: By partnering or contracting with companies that have experience in the field we will be able to optimize and improve our product. This will allow us to create complementary products such as pitching devices

Marketing: As a new brand and product, marketing is critical. Social media marketing gives us a strong platform to network with our customers and promote our product at a low cost compared to traditional methods. Giving free trials for high school teams, college teams, and AAU teams will allow multiple skill levels to test this product and eventually offer sponsorships to professional athletes.

- Team sponsorship
- Athlete/Coach endorsements/sponsorships

Key Resources

Intellectual Property: Design patent for the hitting improvement design
Physical: Storage for inventory after it has been manufactured (outsourced manufacturing), as well as a call center to manage our customer service and sales functions.
Human: Engineering Team, Hardware Designers, Production Team, Advertising Team, Sales Team, Accounting Team, etc.
Financial: We hope to secure a low-interest loan initially, once we are able to convince the bank of our solid/profitable business plan. Once we have gained some traction we will look to gain more capital from venture capitalists in return for an equity stake in our company.
Legal: We will have patents on our design and use of our product (design and utility patent) that the company will protect with a legal team if need be.

Value Propositions

Value Proposition: "Giving players the most efficient batting coach on the market"
-Improves hitting mechanics to optimize swing path and create the best batting percentage a player can reach with their potential

Convenience: Easy to use with in.

Risk Reduction: By teaching better swing mechanics there will be minimal injury risk. Players will not develop bad batting practices and will have less wear and tear on their joints in their shoulders, wrists, and hands.

Accessibility: After we get college level and professional athletes to try out our product, we will use their endorsement of the product to sell it to the mass markets.
Cost Reduction: We believe that players will be able to use our product in place of traditional batting coaches that can cost on average anywhere from $50-$100 for a 30 minute private session. Once they buy our product, they will no longer need to pay for this service which in turn reduces their costs.

Customer Relationships

We want to create and maintain excellent personal relationships with baseball coaches and athletes. As the gateway to the players coaches, the coach being the primary decision makers for their team, the word of mouth from coaches can be a powerful tool to promote our product and influence buyers. By giving out "free trials" or "samples" of our products to coaches for their team to test, they get to experience first hand the value in our products without any risk or investment.

Channels

Awareness: We plan to utilize social media to advertise our product and to "educate" the market about how and why our product is better than everything on the market today.
Evaluation: We plan to have a "feedback and improvements" section of our "direct to consumer" website that will take into account what the end users would like to see in the next generation of the product so that we can create a better end product. Purchase: Our product can be purchased directly from our online store, and hopefully in retailer locations as well. On our website, we will accept several payment types as well as offer free shipping to try and win over some customers that way.
Delivery: We want to have college athletes and professional athletes to try our product because we know that they will love it. We will then use their testimonials as proof of concept because once little-league players see professionals using it they will be more inclined to try it themselves.

After Sales: We want to use our social media platform to build a sense of "community". We think that if we use our social media accounts to communicate with our customers, we will be able to keep a better record of what improvements should be made, and what we are doing right. We want to ensure that our customers feel that they are getting the customer support they need when they need it.

Customer Segments

Baseball coaches: although they may not use our product first hand themselves, it will be their teams who will and anyone they train. Often they are seen as experts in their field and a primary decision maker for their teams, targeting coaches and maintaining good relationships will be one of our primary marketing activities.

Baseball athletes: according to statistics, 17.2 million people in the US play baseball. Not only just professional athletes but players of all ages and all levels. From youth teams to Major League Baseball, everyone of those people will find value and make use of our training device to improve their hitting.

Parents: Youth sports is a $7 billion dollar market and continually growing. Parents who have kids playing baseball are one segment we will be reaching out for.

Cost Structure

We are a cost-driven business that wants to keep manufacturing costs low so that every customer segments can afford our product. By establishing good relations with our suppliers and manufacturers, we hope to attain better pricing and keep production costs low. Outsourcing our manufacturing is also a strong possibility. From low costs, not only is it more affordable for our customers, but we also have a higher profit margin that we can use to reinvest in R&D to improve our product's technology and effectiveness. While our products are low cost, it does not mean it is also low value. As our product will be high quality and highly functional.

Revenue Streams

Asset Sale: We are going to sell this "hitting improvement" product to individual customers.

Selling complementary products such as baseballs, bats, gloves and other gear/apparel that customers can use with our main training product

Offering training sessions/programs to give tips and the opportunity to train with our products and experts to athletes looking to improve their hitt

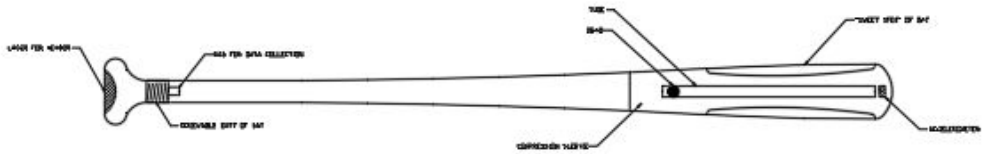
Appendix B. PARTS LIST/BUDGET

A priority for this project was to maintain a low budget, as this is a product that is intended to be mass produced and affordable. During the initial design process, the group defined all of the functioning parts that would be needed, despite which design was ultimately chosen to move forward with. Table 1 shows all of the parts that will be necessary for initial manufacturing, which comes to a total of $65.62. Once the iterative process of manufacturing and testing begins, it is probable that different parts will be needed, and the final list of items will change.

Table 1: Requested items and funds for initial design.

Item	**Supplier**	**Catalog No#**	**Quantity**	**Unit Price**	Total
Fishing Line (.2 mm)	Amazon	US-SA-AJD-22904	1	$4.62	$4.62
Bicycle Bell	Amazon	AL168	1	$1.52	$1.52
Compression Sleeve	Amazon	B01N257L2V	1	$11.99	$11.99
Friction Tape	Amazon	840178015433	1	$4.82	$4.82
Louisville Slugger Baseball Bat	Amazon	WTLW3AMIXB1632	1	$29.95	$29.95
Vinyl Tubing (0.5” ID)	Amazon	LPpvc050-010ft	1	$12.72	$12.72
				Total	$65.62

Appendix C. DRAWINGS



Appendix D. MARKET COMPETITION

Figure 1. Speed Hitter

Figure 2. Louisville Slugger Batting Tee

Figure 3. Zepp Baseball Tracking System