



SCHOOL *of* ENGINEERING
& APPLIED SCIENCE

In a Pickle (Ball)

FINAL TECHNICAL REPORT

May 5, 2025

In a Pickle (Ball)

By: James Ford,
Conrad Jeon, Tyler Maglicmot, Adrian
Celaya-Hernandez, Vincent Agbeibor

Colin Sasthav, US Department of Energy

DRAFT REPORT:

Final Technical Report for the project *In a Pickle (Ball)*

Project:

Designing an intuitive, physical solution for testing a pickle ball paddle's inner structural integrity and assessing paddle gameplay worthiness.

Prepared for:

University of Virginia School of Engineering and Applied Sciences
Colin Sasthav

By:

Vincent Agbeibor

Adrian Celaya-Hernandez

James Ford

Conrad Jeon

Tyler Maglicmot

First Year Engineering Center

Instructor: Leyf Starling

Class section: 011

Group identifier: Group 3 – In a Pickle (ball)

University of Virginia

School of Engineering and Applied Sciences

Thornton Hall

351 McCormick Road

Charlottesville, VA 22904

Table of Contents

Executive Summary	1
1. Introduction	2
1.1 Client Problem.....	2
1.2 Objectives and Approach	2
1.3 Report Organization	3
2. Problem Definition and Background	4
2.1 Client Interview Summary and Customer Discovery.....	4
2.2 Literature Review.....	6
2.3 Problem Definition.....	11
2.4 Summary of sociotechnical considerations in problem	13
3. Initial Solution Ideation	16
3.1 Development of Multiple Designs	16
3.2 Design Decision Discussion	20
3.2.1 Decision Matrix	20
3.2.2 Sociotechnical Considerations in Selected Design	20
3.3 Detailed description of design.....	26
3.4 Initial Fabrication and Testing Plan	28
4. Testing Results, Analysis, and Design Iterations	32
4.1 Testing procedure.....	32
4.2 Testing results and analysis	33
4.3 Informed Design Revision.....	34
4.3.1 Justifications based on data.....	34
4.3.2 Design revisions.....	35
5. Summary of Final Solution	36
5.1 Description of detailed design.....	36
5.1.1 Detailed description of final design	36
5.2 Fabrication Workflow Schedule	38
5.3 Design Solution Addressing Customer Needs	39
6. Recommendations and Future Work	41
6.1 Recommendations	41
References.....	44
Appendix A:	46

TABLE OF CONTENTS

Appendix B:	47
-------------------	----

Executive Summary

The *In a Pickle (Ball)* project strove to create a viable solution to the pickleball paddle problem: how to determine the gameplay worthiness of a pickleball paddle by testing its interior structure? The idea the team chose to investigate and develop was a pressure gauge that would squeeze the paddle's sweet spot (center of the paddle, that is, the spot where players aim to strike the ball) a certain distance and measure the force of resistance in Pa. This value would then be displayed on a screen for the user to read and compare to a range of provided values. Through the repeated testing of a variety of paddles, the team was able to produce a table listing a range of values that corresponded to paddles in pristine, used and poor conditions. The final product was a handheld device that worked like a clamp; the user would squeeze the paddle and compare the presented pressure to a known healthy range of values. This device was able to differentiate healthy paddles from degraded ones. Going forward, the team hopes to continue to refine their design and leave their mark on America's fastest growing sport.

1. Introduction

1.1 Client Problem

With pickleball being one of the fastest growing sports in America, there is one major problem that players have. There is no existing way for players to tell how used their paddle has become over time, and this can result in wasted money. Because the inside structure of a pickleball paddle is not visible, the degradation takes place hidden from the outside, and the paddle will lose its spin and power without giving any clear sign. The client wanted a solution to this problem, whether in the form of a rule of thumb or a physical product that would allow the player to know when they should purchase a new paddle.

1.2 Objectives and Approach

To satisfy our client's requests, the approach we took to this problem was one that would create a real solution that would be able to provide players with the exact information which they needed. Our objective was to use the resources we had to build a solution that not only worked but also worked in the correct way.

There were two main approaches that we could have taken based on what our client asked of us. The first was to create a rule of thumb, and the second was to build a physical solution. After some discussion and deliberating, we decided to take on the project from the latter approach and build something that would directly provide a solution to the problem.

1.3 Report Organization

Each chapter of this report focuses on a different part of our planning, design and testing process. Chapter one introduces the report, chapter two introduces the problem and provides background information, chapter three looks at the design of our solution and initial steps, and chapter four is about the testing of our solution and looks at revision. Chapter five is about our official final design, what the process of getting to that design looked like, and how our design addressed the needs of its ideal customer. Chapter six is all about recommendations and future work, while chapter seven ends the report with our references. A list of appendices is the very last content of this report.

2. Problem Definition and Background

2.1 Client Interview Summary and Customer Discovery

Client Interview Summary

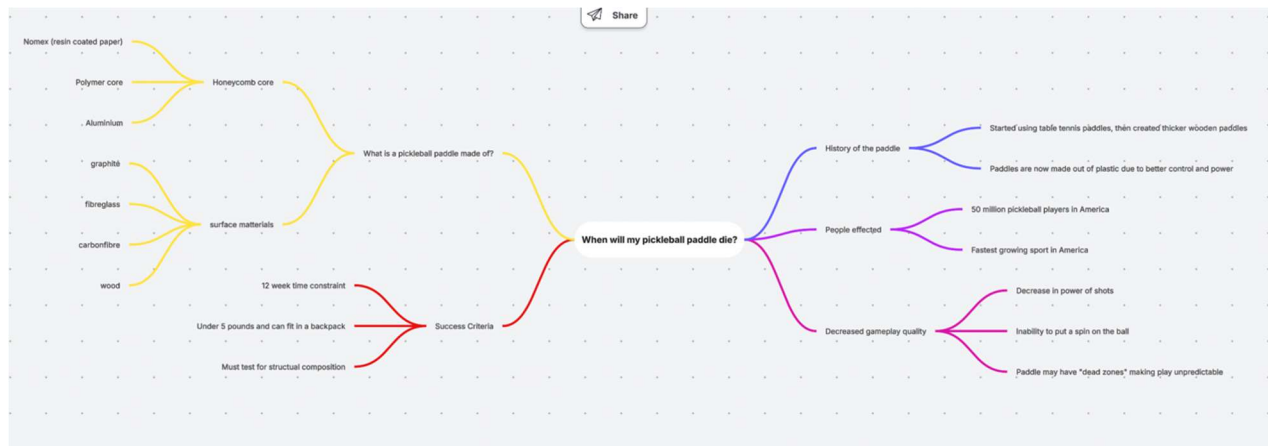
On 29 January 2025, the client, Colin Sasthav, was able to meet with a group of design teams to further discuss and answer questions they had about the product. Students slowly joined the zoom meeting scheduled for 4pm with plenty of questions prepared for the interview. Once the layout of how the meeting would work was explained to us by Professor Anne McAlister, she sat back and opened the floor to the client to give us a little background information on himself and the problem. The name of the client was Colin Sasthav, who is currently a hydropower engineer at the U.S. Department of Energy. He received his B.S. in biological engineering from the University of Ohio State and his PhD in energy science and engineering from the University of Tennessee, Knoxville. The client also enjoys playing tennis which leads into his connection and personal tie to the project/problem. Because he was a tennis player, he related to and enjoyed playing pickleball. He explained the rising growth in pickleball's popularity over the last few years and admitted that it had hooked him as well. After this introduction, the client gave a quick summary of the problem. He explained how pickleball paddles degrade over time, and that the while this is the same for similar sports such as tennis and badminton rackets, the key difference is that there is no way to tell how degraded a pickleball paddle really is. For rackets the structure is visible, making it obvious when the strings are wearing down. However, for a paddle, the structure is on the inside and hidden by the outer layer. The client then explained how the problem with this was that a paddle with just break or not perform the way it should while it is still being used, leading to a player having to buy or find a new paddle at an inconvenient time.

We were being tasked with finding a solution to this problem, by creating a product that will be able to tell when a paddle is degrading and how much it already has. After a little bit of silence, a barrage of questions came in at the client about various things such as what the dimensions of the product should be and who is the ideal customer. The rest of the meeting was the

Customer Discovery

The relationship between clients, customers, and users slightly overlaps for our product. To begin with, the user of this product is anyone who plays pickleball. More specifically, those who play pickleball at a higher level which will usually be within the 40-65 age range. These are the main people who will have use for a product that shows levels of degradation in a pickleball paddle because they are the main ones who will care enough to want to know when they need a new paddle, and the only ones who will be using a paddle to that point of degradation. Next, the main customers of this product will be the exact same as the users of the product. However, in addition to that, there will also be many pickleball companies and local retailers or stores that will also be customers of the product. Finally, the client discussed previously is Colin Sasthav, who works for DOE. This client is also both a customer and a user of the product. The client, customer, and user are all connected as the client is the customer and user, and the user is also the customer.

2.1.1 Model of problem



Link: https://lucid.app/lucidspark/01d33895-216a-4505-a173-ea06e92089f5/edit?viewport_loc=2842%2C-464%2C3078%2C1742%2C0_0&invitationId=inv_7e8bd201-7681-4bb4-97cfc7ba180edbW

2.2 Literature Review

Introduction

What started off as a backyard game to keep kids entertained, has now become the fastest growing sport in America (Ready to Play, 2025). In 1965, Joel Pritchard, Bill Bell, and Barney McCallum came up with the game of pickleball using elements of badminton and table tennis. As pickleball becomes more popular, so does the demand for high-quality equipment, particularly paddles. However, modern pickleball paddles often face issues such as frequent breakage, due to the materials that are used and the amount of usage. Many modern paddles are made with lightweight cores and composite faces that offer performance benefits but can be more prone to cracking or breaking under stress. To fix this problem, manufacturers have been working to improve paddle durability by experimenting with new materials that are stronger and stronger

and more durable (Pickleball, n.d.). The goal as a group is to create a solution that can test the durability of a pickleball paddle as well as identify any other problems the paddle might have.

History of the game/problem

To fully understand why this product is important, you first must need to have a decent understanding of the history. The first game was played on an old badminton court with a plastic ball and table tennis paddles. Joel Pritchard, Bill Bell, and their kids would volley the ball over the net using paddles. They realized that the plastic ball bounced well on the asphalt surface, so they lowered the net to the ground. Barney McCallum was introduced to the game the following weekend, and the three men created rules (*History Of The Game | USA Pickleball*, n.d.). This is when the sport of pickleball was born. As the sport became more popular, the equipment became more advanced. The table tennis paddles began to break consistently, so the men engineered their own wooden paddles that were larger and thicker (*A Brief History of the Pickleball Paddle*, 2021). The paddles that are used now are made of graphite, carbon fiber, wood, and fiber glass (*Why Pickleball Paddle Materials Matter and How to Choose*, n.d.). Even though the paddles are a lot better than table tennis paddles, players still experience problems with their paddles. One of the most common problems players experiences with their paddles is core degradation. It is very difficult to notice how degraded the core of the paddle is without breaking it open. Core degradation can cause the paddle to have soft spots and not be as powerful. This can also cause players to buy new paddles often. Our goal is to create a product that can identify how degraded the core of the paddle is without breaking it open.

Paddle structure

Once the history of the paddle is acknowledged, the structure of the paddle is the next important step of completely recognizing how the problem exists. A pickleball paddle has a sandwich-like structure. This structure involves an outer layer and an inner layer, the inner layer consisting of a honeycomb core. There are three main materials that the honeycomb structure can be made up of. The first of them being Nomex, this is a resin coated paper which is very firm. Because of how strong the material is, it is said to provide very good power, making it the paddle of choice for many single players (*Pickleball Paddle Construction* -, n.d.). Polymer cores (polypropylene), the most popular of the three materials is a softer material; it holds up well but requires a strong outer layer surface. Polymer cores sizes differ from manufacturer to manufacturer. Paddles with smaller cells are firmer and therefore create the most power. Larger shells are not as powerful but will have more control. Because they use less material and are not as strong, larger cell paddles will not last as long due to dead spots occurring sooner (*Why Pickleball Paddle Materials Matter and How to Choose*, n.d.). These are caused from the crushing of the honeycomb, resulting in debonding of the core from the face sheet. Finally, aluminum is the third of the three materials, this is the least popular option for players. As you would expect with aluminum it's lightweight and lacks power, this makes the paddle easier to control. Aluminum cores are most suited to beginners who are less concerned about power and more concerned about control. The power and control of paddles can also be determined by the thickness of the honeycomb structure. A 16mm thick paddle is 1.5x stiffer than a 13mm thick paddle, indicating an increase in core thickness of just 3mm results in a 50% increase in stiffness of the paddle. Thicker paddles are known as “control” paddles whereas the thinner paddles are considered “power” paddles (Science, 2022). This is because thicker cores have more shock

absorption, dampening the impact of the ball and making it easier for players to play with good precision (Bros, 2024). Pickleball-paddle outer layers come in many different forms, created from a variety of different materials, each designed to optimize a certain aspect of gameplay, sometimes at the cost of a different paddle characteristic. Modern surface materials include graphite, carbon fiber, fiberglass, wood, and hybrid (which combine characteristics of different materials). Graphite paddles are extremely lightweight, rigid, stiff and strong. Because of this strength, vibrations from impacts with the ball can be felt in the hand and arm of the user leading to faster fatigue. Carbon fiber shares many of the characteristics of the graphite paddle, however, carbon fiber is slightly softer than graphite because of its woven formation (whereas graphite is tightly packed carbon), meaning that the power of the paddle is slightly reduced. Because of this softer build, the user feels less shock when hitting the ball. Fiberglass coated paddles are less stiff, meaning the energy of a strike is not evenly spread across the paddle. For players, this means the paddle will have a smaller "sweet spot" where the paddle is able to maximize its power. Most surface layers are only a fraction of an inch thick; material scientists have created paddles that allow for reduced weight, allowing for more comfortable, prolonged gameplay (Corless, 2023). At the end of the day, it is up to the player to decide what material they prefer to play with, and what characteristics matter most to them. A few things to look out for that indicate it is time to change your paddle include an unusual "feel" of the paddle during game play, an unusual, sharper and louder sound when hitting the ball, and an uneven, rough surface to the touch. Points of interest showing that the surface is worn down include surface scratches, cracks, dents, breaks, and a worn-down look. (*Is Your Pickleball Paddle Dead? When to Replace Your Paddle* | Pickler, 2022, December 12.). These are indicators that point to a paddle that requires replacement.

Solutions

Currently, there are no existing solutions that would tell a user if their paddle has been degraded enough to the point that it should no longer be used. The general rule of thumb is once the paddle breaks or can obviously not perform the way that it needs to be, it is time to purchase a new one. This leads people to look for signs that their paddle can no longer be used the way in which they want. Among numerous common signs are a soft spot when hitting the ball, a bad grip on the paddle handle, not being able to give the ball proper spin, or the ball obtaining less speed after it is hit with the paddle and not traveling the same distance it did at first. (Townsend, 2022). Therefore, our solution is geared towards finding an efficient way to combine all these signs into one product that will tell the customer exactly when they need to purchase a new paddle. The cost for our product would not necessarily have to be cheap, but something that makes sense for what the product itself is. The size of the product would need to be able to fit inside of an average sized backpack, and able to be carried around easily. This would make the dimensions of the product between 18-20 inches in height, and 12-14 inches in width. The product being made would have to be used in under 5 minutes; however, we strive to make the product as rapid as possible. Since the product is targeting people who have money to spend and disposable income, we hope to gear this toward players within the 40-65 age range. (Foster, 2015). With that being said, the players are generally skilled and play regularly, typically having a skill level of 4 or higher. This scale ranges from 1 to 5.5, where 1 represents a beginner and 5.5 signifies an expert. ("How to Figure Out Your Pickleball Rating in 3 Steps," n.d.). However, there will also be players who play at a professional level. These players who play professionally with referees will have to get their paddles checked as there are USAPA regulations and rules.

The product will have to follow the rules and regulations of USAPA to make sure any and every one can use it. (*USA Pickleball*. (n.d.)).

Conclusion

Pickleball is the fastest growing sport in America, and its rapid growth has driven advancements in paddle technology, yet the challenge of determining when a paddle has degraded remains unresolved. From the history of the paddle to the intricate details of its inner structure, there are many factors involved in determining how degraded a paddle is and why it would need a replacement. As paddles wear down, their internal honeycomb structures weaken, leading to reduced power, spin, and control. These issues are often difficult to detect without physically breaking the paddle open.

To address this challenge our solution integrates key indicators of wear such as soft spots, reduced spin, and diminished power into a user-friendly device that can accurately assess paddle degradation. For widespread use, the product must be portable, efficient, and easy to use. Additionally, to ensure accessibility for players at all levels, from beginners to professionals, it must comply with USAPA regulations. By filling this gap in the sport, our product aims to help players make informed decisions about paddle replacement, ultimately saving time, money, and resources while improving overall gameplay.

2.3 Problem Definition

Pickleball is the fastest growing sport in North America (USA Pickleball. 2025, January 14). Available to people of all ages, the game is played with paddles on a court by two teams, either 1X1 or 2X2. Pickleball paddles (7-8.25 inches (17.78-20.96cm) wide and 15-16 inches (38.10-

40.64cm) long) are put together in a sandwich style with a honeycomb inner layer and a rigid outer layer. The outer layer is responsible for paddle characteristics such as ball spin, power, and speed. After prolonged use of a paddle, the inner structure and outer layer begin to degrade, decreasing gameplay quality. The health of a paddle (especially the inner layer) cannot be easily assessed without fundamentally altering the paddle. As of date, the current mentality has been focused on preventative measures rather than diagnosis of paddle health. (*Is Your Pickleball Paddle Dead? When to Replace Your Paddle* | Pickler, 2022, December 12.) Players have been counting how many hours they have used their paddle as a gauge of paddle "health." For example, after two months of consistently using the same paddle, players would simply assume it is time to get a new one. Some players choose to completely ignore replacing their paddles because of ignorance, lack of financial means, or considering themselves only recreational players not requiring top of the line equipment.

Ideally, a solution would allow a player to easily gauge health of a paddle within five minutes. The product will be designed with specific limitations to ensure convenience, efficiency, and practicality for users. This device would test for the structural composition and soundness of the inner layers and test the surface layer's resiliency and traction. There could be two different devices, one for the outer layer and one for the inner. These devices could be battery powered but ideally would not need to be connected to an outlet. Additionally, this device would be easily accessible to the public, not requiring a significant cost for acquisition.

One of the primary limitations is the ideal usage timeframe of five minutes referenced earlier. This means that setup, operation, and any necessary processing must be quick and straightforward, allowing users to achieve their desired results (users being able to assess the remaining durability of their paddles and determine when it's time for a replacement) without

unnecessary delays. Additionally, the product must be compact enough to fit inside a backpack, ensuring that it remains portable and easy to carry without becoming a burden. Furthermore, the product must perform its intended function accurately (preferably 90% accurate) and consistently, as users are unlikely to invest in something that is unreliable or produces inconsistent results. Affordability is also a major consideration as the product should be reasonably priced (under \$75) so that it remains accessible to a wide range of consumers. Ultimately, our goal is to create a product that is efficient, portable, cost-effective, and dependable.

2.4 Summary of sociotechnical considerations in problem

A device that can test, accurately and reliably, the health of a pickleball paddle should not be made without first considering the economic, societal, and environmental impacts it may have. Doing this ensures the device created will have a positive impact on humanity, avoiding any unnecessary strain on our world. To begin, the product should not be sold at an unreasonable price (under \$100 per unit). A pickleball paddle that is considered good can be purchased anywhere from \$75-\$100, so it would be reasonable that users are not paying more than this for a supplemental device for their paddle. This will also ensure the product sells without straining the pockets of consumers. This device raises few societal concerns because of its purely athletic purpose. Lastly, the device should be manufactured with environmentally friendly materials and methods by staff in working appropriate conditions.

Actors

Primary actors range from casual enthusiasts to professional pickleball players who rely on paddles for consistent gameplay and performance. Manufacturers and producers are also affected by paddle degradation as it determines how regularly they will sell paddles. Conceptual actors involve the governing bodies of pickleball, such as USA Pickleball (USAPA), which sets standards for paddle specifications and ensures fair play through equipment regulations. Social actors would include the wider community, coaches and clubs. These groups will drive demand for new innovations and products in pickleball. Finally natural actors in the form of heat, humidity and rain will contribute to paddle degradation. Understanding these interconnected influences is essential for designing an effective paddle testing solution that benefits both players and manufacturers.

Ethical considerations:

Developing a product to determine the remaining useful life of a pickleball paddle has important ethical implications. By providing players with a reliable method to assess a paddles performance, such a tool could prevent unreasonable disposal, reducing waste and conserving materials. Ethically, this promotes sustainability by discouraging unnecessary consumption while ensuring players do not unknowingly use degraded equipment that could interfere with performance. Manufacturers might not support this idea since it could mean people buy paddles less often, making it harder for them to sell more. However, being honest about paddle durability could build customer trust, improve a brand's reputation, and promote more responsible manufacturing. Ultimately, a reliable product benefits players by saving money, reducing

material waste, and promoting fairness in competitive play, ensuring that equipment performance remains consistent and predictable.

Universal Design

In the universal design portion of our engineering project, the goal is to create a solution that is accessible for anyone who plays pickleball, whether a beginner or a professional. Pickleball paddles are used by people of varying ages, physical abilities, and skill levels, so it is important to design a solution that is easy to use for everyone. The solution will allow users to determine the integrity of their paddle's core without breaking open the surface of the paddle. This allows players to know when to get a new paddle, which can save the user money. This solution aims to increase accessibility for everyone, regardless of experience or knowledge of the game, and to prevent the risk of using a degraded paddle that could affect performance or lead to injury.

3. Initial Solution Ideation

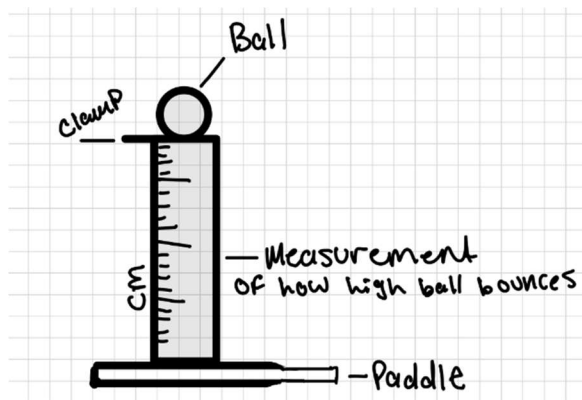
The following section will discuss how the team chose which design idea to pursue and will cover how the team began to develop their vision. The first part of this chapter will cover potential designs the team considered before uncovering in greater depth the planning stages of this project.

3.1 Development of Multiple Designs

Design Idea #1: Ball Drop through cylindrical tube

For this project, the group came up with five possible solutions to the presented problem: how to determine if a pickleball paddle is still game worthy. The first idea involved dropping a ball of a fixed mass from a constant height through a cylindrical tube and measuring how far up the ball would travel after rebounding of a paddle placed on the ground as seen below in figure 2. This would mimic the paddle hitting a pickleball ball. By measuring how high up the ball would travel, it would be possible to estimate the compression of the paddle and consequently determine the "health" of the paddle. However, the group decided against this design because of its complexity in the number of moving parts (having to secure the tube to the paddle, drop the ball, create a way to measure and record the heights of the rebounding balls).

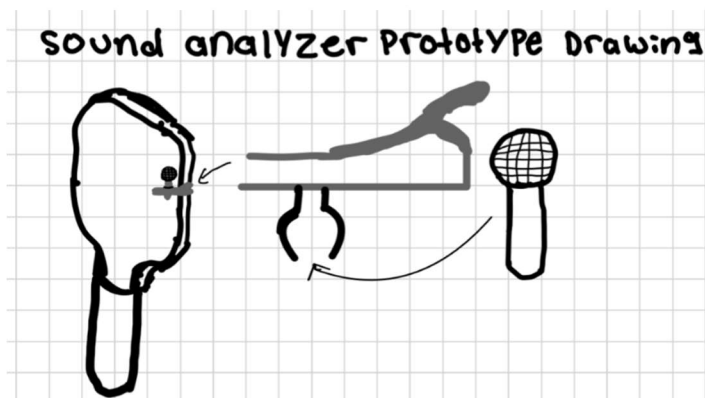
Figure 2: Design 1



Design Idea #2: Sound Analyzer

The team then considered measuring and quantifying the sound a paddle would make when striking a ball. The idea was that new paddles would be in good playing condition and would create a sound different from a degraded paddle when striking a pickleball. This idea, however, was also outvoted because of its potential complexity, such as the ability to transfer the pitch from the sound analyzer to the user's phone. Ultimately the lack of guarantee of success in the given timeframe of this project is why we did not go with this solution (1.5 months from design to product).

Figure 3: Design 2

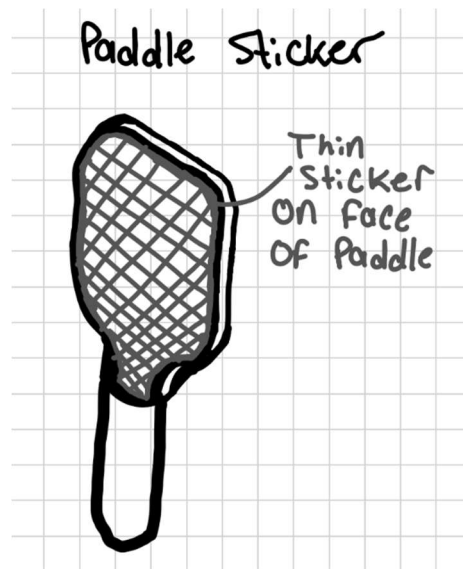


Design Idea #3: Sticker that erodes over time

Next, the team shifted focus on the surface of the paddle. One idea involved attaching a thin sticker onto the surface of the paddle that would have similar properties in terms of friction as the real surface of the paddle. Over time and use, the sticker would erode and "rub off" from the paddle indicating wear and tear. The sticker can be seen on the surface of the paddle in the figure below. This idea, too, was ditched because of considerations in professional pickleball

tournaments, and rules regulating what can and can't be put on paddles. This solution would limit the potential customer pool, making it a less desirable solution.

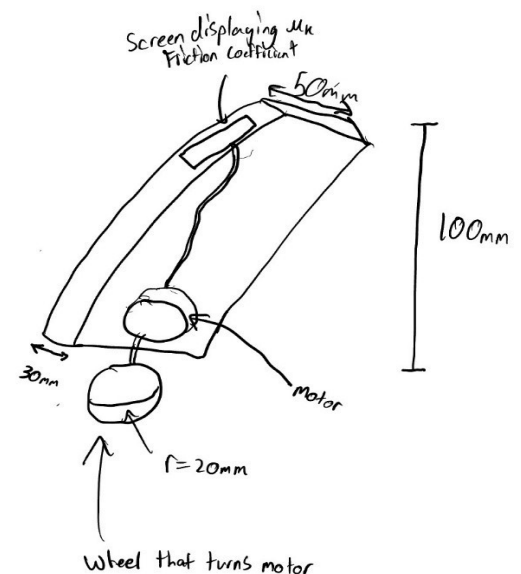
Figure 4: Design 3



Design Idea #4: Friction coefficient wheel

Another solution consisted of a wheel attached to an electric motor that when pressed against and rolled along a surface would calculate the friction coefficient of the paddle's surface, giving an indication of the paddle surface's "playability." This idea was agreed to be too complex and not guaranteed to solve the problem well.

Figure 5: Design 4

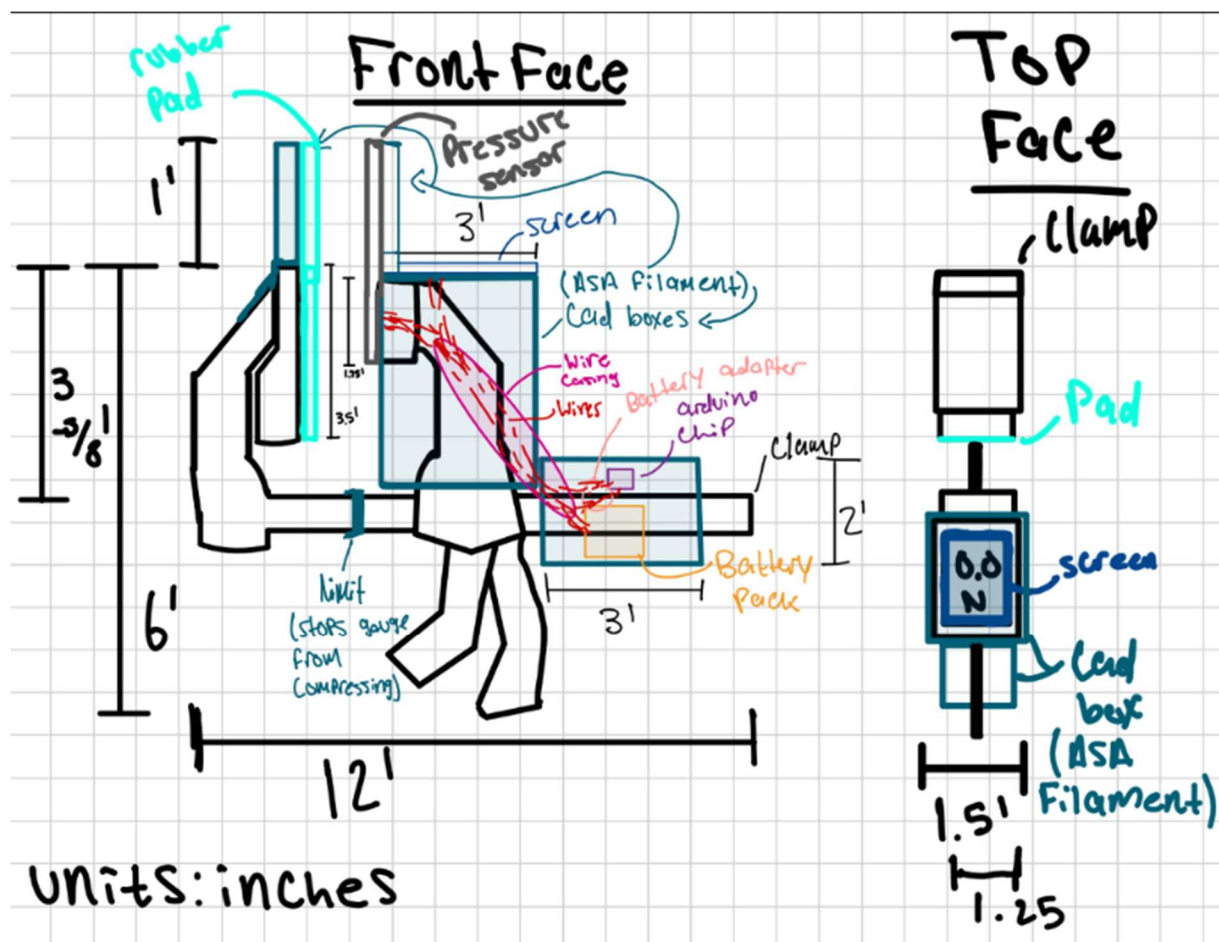


Design idea #5: Compression Gauge

This leads to the group's last, fifth and agreed upon idea. A pressure gauge that would measure the force of resistance by the paddle when clamped at different points on the paddle.

The group acknowledged that this would be a complex project to accomplish and that it would push our understanding of engineering principles to a new front. But the team also agreed that this project was doable and realistic; this project would teach us how to come up with solutions and learn on the fly, and in the end come up with the best solution we can.

Figure 6: Design 5



3.2 Design Decision Discussion

3.2.1 Decision Matrix

Decision Matrix

5=best 1=worst	cost	Development time / Testability	Complexity	Practicality/function	Feasibility	Total
Gauge	2	4	3	5	4	18
Friction	3	4	1	2	3	13
Sound	2	1	1	3	2	8
Ball Drop	5	4	4	1	2	16
sticker	4	3	3	2	2	14

- **Cost:** Affordability of materials and production
- **Development Time / Testability:** Time and ease required to build and test the concept.
- **Complexity:** Technical difficulty of building and implementing the solution.
- **Practicality / Function:** Usefulness and effectiveness in solving the problem.
- **Feasibility:** Realistic ability to build and test with available resources.

Each solution was scored on a scale of 1-5 (1 being the worst and 5 being the best) based on 5 different metrics listed above. The totals were tallied up with the best idea receiving the most points. The gauge had the highest score, supporting our choice to use it as our final solution.

3.2.2 Sociotechnical Considerations in Selected Design

Economic Sustainability

Currently, the proposed paddle gauge costs approximately \$150 per unit due to prototype testing, sourcing material in small quantities, and experimentation with different Arduino chips.

As a result, the initial sale price will position the gauge as a niche product for more dedicated

consumers. However, the long-term strategy is focused on achieving economic sustainability through scaling production, improving relationships with suppliers, and leveraging economies of scale. This will significantly reduce per-unit costs, making the product more affordable, accessible, and hence socially sustainable by broadening the market. Additionally, the product's high durability and long lifespan will lower replacement costs for users, providing long-term economic value.

Environmental Sustainability

Environmental sustainability was a key consideration in both material selection and design. This was important because our goal was to create a product that not only performs reliably but also minimizes its environmental impact throughout its lifecycle. By using high-quality, durable materials, the gauge is built for a long functional life, reducing the need for frequent replacements, and minimizing waste. The 3D-printed components are made from ASA filament, known for its strength, durability, and resistance to UV, weather, impact, and heat. Additionally, protective wire casing ensures water resistance, preventing damage if water enters the gauge. This focus on durability and protection helps extend the product's lifespan and reduces the number of devices ending up in landfills. Overall, our design prioritizes longevity over disposability, aligning with sustainable product lifecycle principles.

Social Sustainability

The paddle gauge promotes social sustainability by serving the needs of the growing pickleball community. By providing players with a reliable tool to assess paddle condition, the gauge helps extend paddle life, and improve performance. While early pricing limits

accessibility, our scaling plans aim to make the product more affordable and available to a wider range of players. The gauge supports inclusion and fairness, ensuring players at all levels can make informed equipment decisions helping to improve performance and save players money on unnecessary paddle purchases.

Ethical Considerations

While designing the pickleball paddle pressure gauge, our team was mindful of the ethical implications surrounding usability, safety, and accessibility. To prevent accidental injury or equipment damage, the clamp pads are intentionally designed not to fully close, eliminating the potential for “pinching” and protecting paddles from excessive force. This ensures the device can be safely used by individuals of all ages and backgrounds.

Our design approach is aimed at prioritising the needs for users, after speaking with players, and industry professionals, we identified reliability, ease of use, and affordability as core requirements. In response, we are aiming to engineer the gauge to deliver consistent, accurate feedback while remaining intuitive for users at any experience level. To further support accessibility, especially for older users who may have limited mobility, we plan to implement a reversible screen feature, allowing the display to be flipped for both left- and right-handed use. This small but thoughtful adjustment ensures the device can be operated comfortably without requiring the user to twist or reposition the gauge.

Universal design

In developing the engineering solution, the team placed a strong emphasis on the Principles of Universal Design to ensure that the product is functional, accessible, and user-friendly for a diverse population. After thorough evaluation, the principles we prioritized include Equitable Use, Simple and Intuitive Use, Perceptible Information, Tolerance for Error, and Size and Space for Approach and Use.

Equitable Use was a primary focus to ensure that individuals of varying skill levels and abilities can effectively utilize the solution. With the aim of minimizing any barriers to use by designing a straightforward mechanism that does not require specialized knowledge or training. Simple and Intuitive Use guided us in making the solution self-explanatory. To support this, the final design will feature a small, clear label with concise directions to facilitate ease of use for all individuals, regardless of experience.

Perceptible Information is addressed through clear visual labeling, ensuring that users can easily understand how to operate the device. Tolerance for Error is being carefully considered through repeated testing to identify and mitigate potential risks or misuse, enhancing overall safety and reliability. Based on client feedback, Size and Space for Approach and Use became a significant design driver. The client requested a portable solution that fits into a backpack, prompting us to prioritize a compact form factor without compromising functionality. While we strived to integrate all Universal Design principles, certain aspects, such as Flexibility in Use, proved challenging. Our solution is designed with a single mode of operation—squeezing a clamp mechanism. This limits flexibility but allows us to optimize the solution's performance

and simplicity. However, we acknowledge that this requirement may present challenges for users with low grip strength, a limitation we aim to mitigate as much as possible during prototyping.

Problem Framework

The design decisions made were guided by stakeholders involved in determining when a pickleball paddle should be replaced. We prioritized players who need a straightforward and dependable way to assess paddle degradation. By understanding how paddles break down, we could create a solution that aligns with real-world use cases. We prioritized sustainability as it played a crucial role in our approach, as we aimed to reduce unnecessary waste by helping players extend the lifespan of their paddles rather than discarding them prematurely. This required balancing material durability with affordability to create a tool that encourages responsible equipment maintenance. To achieve these goals, we carefully selected components that ensure both accuracy and ease of use. The design incorporates pressure sensors, Arduino microcontrollers, and 3D-printed components, making it both accessible and practical. Since players come from diverse backgrounds, we focused on making the tool intuitive and easy to operate without requiring technical expertise. This tool not only enhances their playing experience but also contributes to a more sustainable approach to equipment usage in pickleball.

Client input

During the client interview, we received very helpful feedback that has been incorporated into the design process to try and make a product that takes many things into consideration. The first thing that we used the feedback for is deciding where the force sensor will be put. A

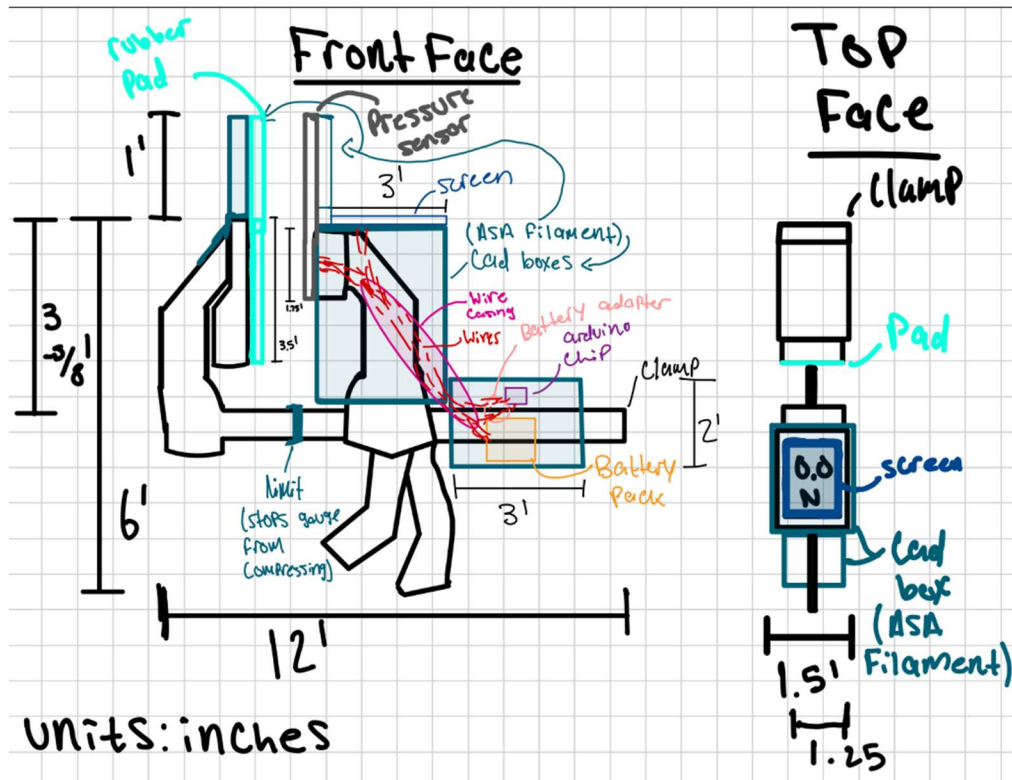
pickleball paddle has a wide area where the ball can be hit, so we must be specific on where we actually want to place the force sensor. The “sweet” spot, which is located around the direct center of the paddle would be the best spot to put our force sensor. This is the area where the ball is usually hit from and would be the best for analyzing whether the paddle is performing at the level that it should be. Additionally, the client asked how we would control the force that is applied to the clamp when using the gauge. Taking this into account was important because if the force was decided based from the individual pressing, the results would not be consistent. Instead, we decided to use a limit that would allow the clamp to be pressed to a certain point, at which it would stop and give a reading. This would be the same point every time someone wanted to use the product. Finally, the client told us to consider the conditions of when the sensor should be applied. The questions were if it would work consistently when it is raining and not raining as well as whether it would work consistently no matter the temperature, were things that we would need to consider in our design process. Weather could possibly change the readings of the paddle, so making sure the conditions are consistent when using the product is extremely important.

Conclusion

In conclusion, the use of high-quality materials ensures longevity for the gauge. In term this makes the product economically and environmentally sustainable. While the initial prices are high and may limit accessibility, this tradeoff was necessary to prioritize product reliability and longevity. As production scales, costs will decrease, making the gauge more affordable and accessible, and enhancing its economic and social sustainability over time.

3.3 Detailed description of design

Figure 7: Final Design



Materials and Final Design Description:

For the final design, we are using a commercially available clamp as the base. To modify it for our testing needs, we are attaching 3D-printed ASA plastic blocks to each side of the clamp. These blocks extend the jaw depth, allowing the pressure gauge to reach the center of the paddle.

One of the 3D-printed blocks holds a pressure sensor, while the opposite block is fitted with a rubber pad to evenly distribute the applied force and protect the paddle surface. The pressure sensor is wired to an Arduino chip, which is connected to a digital display. All wiring is enclosed in protective casing to improve durability and prevent wear. Additionally, the Arduino, battery, and wiring are housed inside 3D-printed ASA enclosures for protection and longevity.

How the User Will Use the Device:

To operate the device, the user places the paddle between the two 3D-printed blocks and applies pressure using the clamp. The design ensures that the applied pressure is consistent each time. As the paddle is compressed, it applies force to the pressure sensor. The force reading is then displayed on the screen in real time. The user can compare this reading to a known "healthy range" of values, established through testing of undamaged paddles. If the paddle's reading falls outside this range, it indicates core degradation predicting decreased paddle performance.

3.4 Initial Fabrication and Testing Plan

Gantt Chart

Gantt chart	3/19	3/24	3/26	3/31	4/02	4/07	4/09	4/11 (testing day)	4/14	4/16	4/21	4/23	4/26 (engineering expo)
Complete chapter 3 draft	XXX X												
Cading parts to design		XXX X	XXX X	XXX X									
CAD Parts for design		XXX X	XXX X										
3D print for design			XXX X	XXX X	XXX X								
Design wiring					XXX X	XXX X	XXX X						
Assembly of gauge					XXX X	XXX X	XXX X						
Testing								XXX X					
Make improvements to design									XXX X	XXX X	XXX X		
Retest design										XXX X			
Compose design slides									XXX X	XXX X			

INITIAL SOLUTION IDEATION

Prepare presentati on										XXX X	XXX X	XXX X	
Present													XXXX

Linear Responsibility Chart

Responsibility	Adrian	Vincent	Conrad	James	Tyler
Low fidelity	1	1	1	1	1
BOM	1	1	1	1	1
Chapter 3 description (Break down into parts)	1	1	1	1	1
Calendar	3	3	3	1	3
STS Sustainability Mindset and Framework	3	3	3	1	3
STS Problem Framework	1	3	3	3	3
Principles of Universal Design	3	3	3	3	1
Ethical Considerations	3	3	1	3	3
Client Information	3	1	3	3	3
CAD Design	1	2	2	2	2
Coding for sensor	2	2	1	3	3
Wiring for sensor to battery	3	3	1	2	2
Wiring for sensor to screen	3	1	2	2	2
Applying casing to wiring	2	2	3	1	1
Testing	1	1	1	1	1
Slides	2	1	2	2	1
presentation	1	1	1	1	1

Key:

1-Main priority

2-Help work on it

3-Help if needed

Testing plan:

Note:

- This test will ensure the paddle gauge can determine a paddle's condition.

Testing Procedure:

1. Take paddle and use the gauge to measure the force of resistance of paddle in the center of the paddle, i.e. "the sweet spot," the part of the paddle where players aim to hit the ball (about center of paddle).
2. Confirm that the measurements are within the range of acceptable values for the paddle tested. (new, used, needs to be replaced).

Note:

- To calibrate the device, the team will take measurements of brand-new paddles, used but in good condition paddles (donated by a local gym), and completely worn-out paddles (donated by a local gym). These readings will be analyzed, and an average range for each condition will be determined.
- To test the gauge, the person conducting the test will be given a paddle whose condition is unknown to said person. The person, using the gauge, will have to determine the condition of the paddle. This test will be conducted a total of 27 times, using 9 paddles (3 in great condition, 3 used, and 3 in poor condition) and each paddle will be tested 3 times to confirm readings.

4. Testing Results, Analysis, and Design Iterations

The following section will describe how the team tested the product to ensure that it performed as expected, any adjustments and updates the team made to the design, as well as review any unusual findings that came up during testing.

4.1 Testing procedure

The tests conducted proved to be successful. When a paddle is squeezed, depending on paddle health, different pressure readings are presented consistently. The group tested a total of eight different paddles of different health. Limited resources and time capped testing to eight different paddles. However, the group did have access to multiple paddles of the same make (Gonex) and model, of varying health. Healthy Gonex paddles showed pressure readings above 4.84 Pa, used Gonex paddles read values above 4.82 Pa, whereas used and worn-out paddles consistently presented values below 4.82 Pa. The group determined paddle health before testing, allowing said values to be assigned to the corresponding paddle condition. The paddle conditions were determined via the following methods. New (off the shelf) paddles were assumed to be in pristine condition because they were unused and recently manufactured meaning they have experienced no wear and tear. Degraded paddles were donated to the engineering class from a local gym which had explicitly stated that the paddles were in a "no good" condition. Used paddles were borrowed for testing from another local gym and from pickleball players who claimed that the paddles had been used and were in good condition. It was assumed that people who donated or lent us pickleball paddles were professionals who were making their claim backed in experience. Our tests confirmed our assumptions and the claims about donated/lent paddle health. Another important point to mention is that when testing paddles from different manufacturers, pressure readings vary depending on paddle health. For example, brand new paddles manufactured by Paddletek showed readings of 4.9 Pa, which is

higher than those for Gonex. Similarly, used Paddletek paddles showed readings of 4.84 Pa which is also the healthy value of Gonex paddles. This proves that readings are very paddle make and model specific, and that more testing is required to make a table with make and model specific values.

4.2 Testing results and analysis

The group tested paddles from three main groups: brand new, used but in playable condition, degraded and in need of replacement. The group understands that different companies will make paddles differently, making testing a paddle-specific task. As such, the group tested and made relevant tables to qualify paddle health based on paddles manufactured by the company Gonex (to provide a company and paddle specific table) and a separate set for a mix of paddles from different companies (to provide a general guideline for paddle health). The final data from the group's findings suggests that a healthy paddle will show a reading above 4.82, and paddles in need of replacement will show readings below that, however, these numbers were found to be very paddle specific as some degraded paddles from different manufacturers may show different readings. If given additional time, the group would have tested a wider variety of paddles than it had access to at the time and would have created a universal paddle-specific data table with pressure readings from good, medium, and poor health paddles. Additionally, the group would have been able to make a more universal table which would have made the final prototype more applicable to a wider audience by increasing the customer base. Another limitation of the paddle is the user handling aspect. The paddle gauge works by squeezing the paddle a certain distance, compressing a foam to prevent paddle damage, and reading the force of resistance as pressure; if the paddle is squeezed beyond the predetermined distance, then it is possible to achieve the same

pressure reading from any paddle. For this reason, it is important that potential users follow instructions accurately to achieve the best results. In conclusion, this product was able to succeed in its design goal of being able to reliably and repeatedly identify the health of a paddle and determine if it is in need to be replaced. This goal was based off the client's need: to be able to determine paddle health. By those means and purposes, both the client's need and personal group goals have been met by this product.

4.3 Informed Design Revision

4.3.1 Justifications based on data

Data driven design decisions: Testing results informed changes

Our group tested different brands of pickleball paddles with our newly designed and made product. After completing many trials, we realized that different brands of pickleball paddles will have different healthy values and ranges. This is due to pickleball paddle brands having different thicknesses and materials. We needed to find a pickleball paddle brand that had three different condition types: Brand new, slightly used, and heavily used. Luckily, we were able to test all three types of conditions for only one brand of pickleball paddle: Gonex. Our product can be used for any pickleball paddle brand and material, but our group only has a healthy value range for Gonex plastic paddles (a force of resistance above 4.82 Pa). Our client, Colin, wanted us to be able to create a product that can test any type of pickleball paddle, but told us that we should test plastic paddles as they are the most used paddles. To improve our product so that it can be used by everyone in the pickleball community, we would need to test and give the healthy values for many kinds of paddles, not just the Gonex paddle.

4.3.2 Design revisions

Design revision and implementation

During the manufacturing process, we made several key revisions to the design in response to practical challenges and our original design goals.

First, we initially planned to design and build our own clamp. However, early in Unit 2, we realized that manufacturing a functional clamp from scratch would be time-consuming and very difficult. We changed our approach and purchased a pre-made clamp and instead focused on 3D printing custom parts to attach to our components (screen, Arduino board, microchip, and battery). This change helped us meet our time constraints, but it introduced some new trade-offs: the clamp materials are not recyclable, which reduced our product's environmental sustainability, and it increased production costs, conflicting with our goal of keeping our product affordable.

Second, we changed the geometry of our 3D printed parts. The initial design was bulky and inefficient, using excessive filament and making the product less portable. By redesigning the parts to be more compact, we aligned better with our design criteria for portability and reduced material waste. However, smaller components were slightly harder to assemble and required more precise wiring, presenting new challenges in the building process. This meant having to reprint certain parts up to 3 times.

Overall, each design revision helped us move closer to a functional and user-friendly product, even if it introduced some new problems that we had to address.

5. Summary of Final Solution

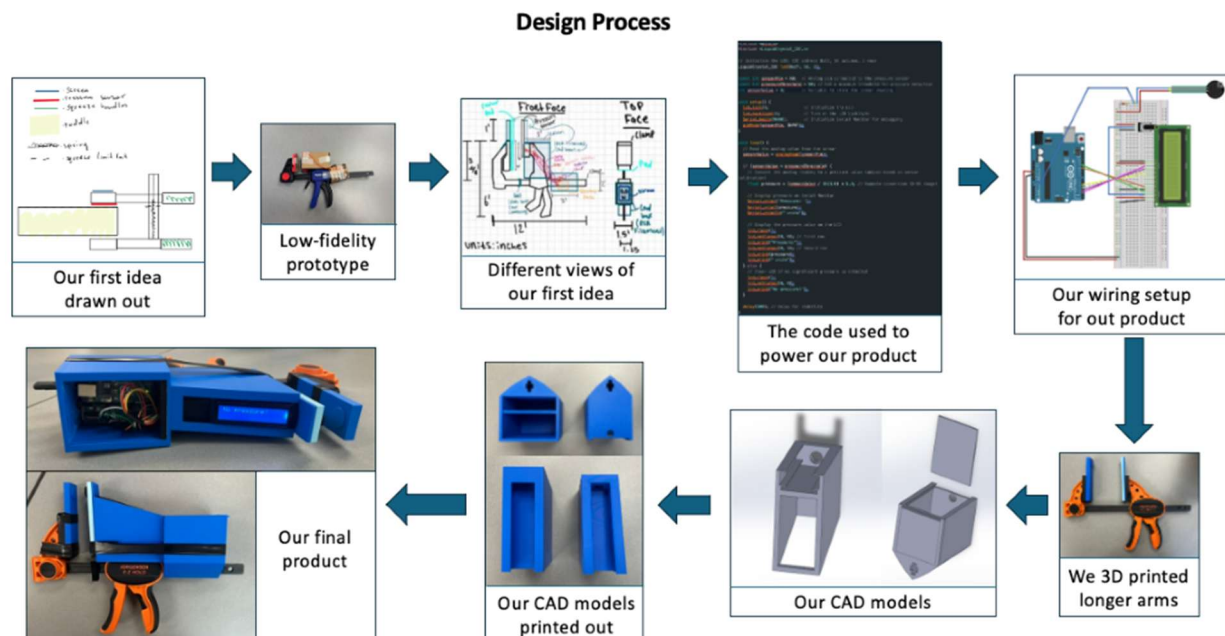
5.1 Description of detailed design

5.1.1 Detailed description of final design

Our final design allows users to determine the degradation of any pickleball paddle. Most pickleball paddles degrade over time due to constant use, weather, and other effects. There is no way to determine the degradation of the paddle without breaking open the surface of the paddle. Not knowing when the core of a pickleball paddle is degraded or not could cause players to not play as well in a match. This could also cause players to buy new paddles when they do not have to. Our team started brainstorming different ideas to fix this problem. We all agreed on designing and building a gauge that would test the pressure of the core of a pickleball paddle. We decided to use a bar clamp and add on 3D printed designs that hold the different components like an Arduino board, breadboard, pressure pad, wires, battery, and screen. We developed code that we uploaded onto the Arduino board so that our product would not have to be plugged into a computer while being used. We 3D printed four main parts: two arms to extend the pressure pad to the middle of the paddle and two pieces that house all the components. One of the pieces houses the breadboard, Arduino board, wires, and battery. The other piece displays the screen so that the user is able to read the value off the screen. The two arms allow the pressure pad to reach the center of the pickleball paddle. To use our product, the user places a pickleball paddle between the two arms so that the pressure sensor is lined up with the center of the pickleball paddle. Then, the user would close the clamp by squeezing the handle and wait about five seconds with the clamp pressed on the paddle. Then, a value will be displayed on the screen, and once read, the user can release the clamp by clicking the inside black section on the black handle and pulling the clamp apart. The value that is displayed on the screen is in units of Pascals. The

value will determine if you should get a new paddle or not. Our team was only able to come up with a healthy range for one brand of paddle because that is all we had available for us to test

Our planned design in Chapter 3 is very similar to our final design. There were only two main differences that our team mentioned in Chapter 3, but did not end up making. One thing we mentioned in Chapter 3 was creating an instruction label with steps on how to use the product. An instruction label would have been helpful to the user and demonstrate the universal design principles of equitable use and flexibility in use. In the future, all of us will make sure to include a similar component that follows those two universal design principles. Our team also mentioned that we would have a chart for different brands of paddles so that the user knows what value range their paddle should be within. We were only able to come up with healthy ranges for one brand because that was the only brand we had multiple paddles for in different conditions.



Fabrication workflow and schedule
Fabrication workflow and schedule

5.2 Fabrication Workflow Schedule

Gantt chart	3/19	3/24	3/26	3/31	4/02	4/07	4/09	4/11 (testing day)	4/14	4/16	4/21	4/23	4/26 (enginee ring expo)
Complete chapter 3 draft	XXXX												
Coding parts to design		XXXX	XXXX	XXXX									
CAD Parts for design		XXXX	XXXX										
3D print for design			XXXX	XXXX	XXXX								
Design wiring					XXXX	XXXX	XXXX						
Assembly of gauge					XXXX	XXXX	XXXX						
Testing								XXXX					
Make improvements to design									XXXX	XXXX	XXXX		
Retest design										XXXX			
Compose design slides									XXXX	XXXX			
Prepare presentation										XXXX	XXXX	XXXX	
Present													XXXX

Linear Responsibility Chart

Responsibility	Adrian	Vincent	Conrad	James	Tyler
Low fidelity	1	1	1	1	1
BOM	1	1	1	1	1
Chapter 3 description (Break down into parts)	1	1	1	1	1
Calendar	3	3	3	1	3
STS Sustainability Mindset and Framework	3	3	3	1	3
STS Problem Framework	1	3	3	3	3
Principles of Universal Design	3	3	3	3	1
Ethical Considerations	3	3	1	3	3
Client Information	3	1	3	3	3
CAD Design	1	3	3	2	3
Coding for sensor	2	2	1	3	3
Wiring for sensor to battery	3	3	1	2	2
Wiring for sensor to screen	3	1	2	2	2
Testing	1	1	1	1	1
Slides	2	1	2	2	1
presentation	1	1	1	1	1

Key:

1-Main priority

2-Help work on it

3-Help if needed

The primary differences between the Chapter 3 plan and the actual workflow, as seen in the Gantt chart and responsibility chart, reflect common challenges in executing our project such as shifting priorities, unexpected delays, and uneven task distribution. The Gantt chart shows that tasks like "Make improvements to design" and "3D print for design" extended longer than likely anticipated in Chapter 3, suggesting that either the complexity was underestimated or that technical or coordination issues occurred. Tasks like "Make improvements to design" and "Retest design" occurred later than ideal, indicating delays in earlier phases impacted later refinement and testing, as well as there being technical difficulties and problems with re-printing parts.

The linear responsibility chart helps explain why some of this happened. While responsibility was relatively well-distributed, all members were listed as backup or secondary help on many tasks, which may have led to role confusion or inefficiencies if not clearly managed. Additionally, in some cases, people who were supposed to help may not have been ready to jump in when needed. Overall, the charts illustrate that while planning was thorough in Chapter 3, real-world implementation required flexible adaptation and more focused collaboration to stay on track.

5.3 Design Solution Addressing Customer Needs

Reflect on the ability of your final product to address your customer needs, meet your constraints and objectives. Does it address all the needs? What is still outstanding?

Our final product effectively evaluates the paddle health of the Gonex paddle, successfully meeting our primary customer needs. However, it is not yet compatible with other paddle models without additional testing and calibration.

Ease of use was a central focus in our design. We incorporated a flappable screen to accommodate both right- and left-handed users, as well as a sliding mechanism for quick battery replacement. Based on our testing and user feedback, we believe the gauge to be intuitive and user-friendly. The gauge's compact size and light weight also align with the design constraints we established early in the project, ensuring portability and convenience.

One notable limitation is the 3D-printed casing material. While it keeps the device lightweight, it lacks the durability needed to withstand drops, potentially shortening the product's lifespan. Improving material strength is a key area for future development.

6. Recommendations and Future Work

This section goes over the team's closing thoughts about the project as well as noting what the team would have done differently if given the opportunity to start over.

6.1 Recommendations

While our team completed the paddle pressure gauge to the best of our ability within the project's time constraints, there remains significant room for refinement and development. As we continue pursuing a potential patent, we have identified several key areas for improvement that we could build upon.

One of the most impactful enhancements would be designing an accurate paddle limiter to control the gauge's maximum compression distance. Currently, we rely on a foam marker as a visual guide, which lacks precision and consistency. We plan on developing a mechanical stopper that can be adjusted based on paddle thickness, allowing the device to test a broader range of models. This stopper must be durable enough to withstand the full clamping force. A promising design could include a steel or metal component adjustable via a threaded cork-screw mechanism to ensure both strength and flexibility.

To improve durability, we suggest reinforcing the outer casing. Although we currently use ASA filament for its UV and impact resistance, switching to an even stronger filament or composite materials such as carbon fiber-infused filament—could reduce breakage risk if the gauge is dropped. However, this must be weighed against sustainability objectives. More industrial materials like aluminum or metal may improve strength but could increase environmental impact

and cost. Future iterations should explore an optimal balance between durability, sustainability, and affordability.

A substantial portion of the device's weight currently comes from the off-the-shelf clamp. As we push onwards in improving the clamp we will aim to design and manufacture a custom clamp tailored to the gauge's specific needs. A lighter, more ergonomic design would not only improve usability but lower production costs. This aligns with both our economic and social sustainability goals and could make the device more attractive to a broader consumer base.

If the product is scaled for commercial distribution, we will aim to establish stronger relationships with manufacturers and material suppliers. This would allow for bulk ordering, lower costs through economies of scale, and consistency in component quality. These relationships will be essential to achieving long-term affordability and sustainability—key goals in our original design philosophy.

The current prototype establishes a strong foundation, but continued iteration will be crucial in improving functionality, durability, and cost-efficiency. As we build on our work we plan to focus on mechanical precision, material performance, and production scalability. With thoughtful refinement, the paddle pressure gauge has the potential to become a widely adopted, sustainable tool for the pickleball community.

Appendix C

Refined framing of the problem and the technical solution

We can refine the way we phrase the problem from just trying to create a way to tell when users need to get a new paddle to:

Creating a cost-effective solution that can fit inside of a backpack and takes under five minutes to use. As the degradation usually happens inside at the honeycomb structure, the solution should target evaluating when the honeycomb structure is becoming weak and no longer able to be used by someone who has intermediate to expert skill as a pickleball player. The solution also must follow USAPA rules and regulations regarding pickleball.

References

A Brief History of the Pickleball Paddle. (2021, April 8). Baddle

Pickleball. <https://baddle.com/blogs/news/a-brief-history-of-the-pickleball-paddle>

Bros, A. P. (2024, November 14). *Pickleball Paddle Core Thickness: Best for Every Skill Level.*

<https://www.aussiepickleballbros.com/pickleball-paddles/pickleball-paddle-corethickness/>

Fairmat. (2023, October 11). *Manufacturer's guide to develop high-performance pickleball paddles.*

Fairmat. Retrieved February 7, 2025, from <https://www.fairmat.tech/blog/manufacturers-guide-to-develop-high-performancepickleballpaddles/#:~:text=Pickleball%20paddles%20have%20a%20layered,goals%2C%20and%20desired%20paddle%20characteristics.>

Foster, A. (2015). Consumer expenditures vary by age. *U.S. Bureau of Labor*

Statistics, 4(14). <https://www.bls.gov/opub/btn/volume-4/consumer-expenditures-varyby-age.htm>

History Of The Game | USA Pickleball. (n.d.). Retrieved February 10, 2025,

from <https://usapickleball.org/what-is-pickleball/history-of-the-game/>

How to Figure Out Your Pickleball Rating in 3 Steps. (n.d.). *Paddletek.* Retrieved February 10,

2025, from https://www.paddletek.com/blogs/news/pickleball-ratingsguide?srsId=AfmBOop36L_1-eWRFdamVFbxzRTKzpmduJB_cgoib497kl9prujHmOP

Official Pickleball Rulebook | USA Pickleball. (n.d.). Retrieved February 10, 2025,

from <https://usapickleball.org/what-is-pickleball/official-rules/>

- Pickleball Paddle Construction* -. (n.d.). Retrieved February 4, 2025, from <https://brickhousepaddles.com/pickleball-paddle-construction/>
- Pickleball, P. (n.d.). *Latest Innovation in Pickleball Paddles*. PBPRO Pickleball. Retrieved February 10, 2025, from <https://www.pbpropickleball.com/blogs/news/latest-innovation-in-pickleball-paddles>
- Ready to Play: Sports and fitness participation grows steadily*. (2025, February 5). Sports Business Journal. <https://www.sportsbusinessjournal.com/Articles/2024/06/03/sports-participation/>
- Science, P. (2022, October 5). Pickleball Paddle Materials. *Pickleball Science*. <https://pickleballscience.org/pickleball-paddle-materials/>
- Townsend, S. (2022, December 12). Is your pickleball paddle dead? When to replace your paddle. The Pickler. Retrieved February 10, 2025, from <https://thepickler.com/pickleball-blog/pickleballpaddledead/#:~:text=Does%20the%20surface%20area%20near%20the%20center%20of%20your%20paddle,pickleball%20paddle%20may%20be%20dead.>
- USA Pickleball. (2025, January 14). Pickleball annual growth report. USA Pickleball. Retrieved February 10, 2025, from <https://usapickleball.org/about-us/organizational-docs/pickleball-annual-growthreport/#:~:text=Media%20Attention:%20Pickleball%20continued%20to,the%20sport's%20growth%20and%20impact.>
- Why Pickleball Paddle Materials Matter and How to Choose*. (n.d.). Paddletek Pickleball, LLC. Retrieved February 10, 2025, from <https://www.paddletek.com/blogs/news/pickleball-paddlematerials>

Appendix A:

List of questions asked specifically by our group and the answers provided in interview.

Question: Who is the engineered solution used by? (Athletes, armature players, stores ensuring their stock is in good condition, factories conducting quality assurance tests, etc.)? Answer:

Someone at the Mid-level 4-5.5 level range, 40-65, disposable income

Question: Are there physical dimensional constraints to the project?

Answer: The project must be able to fit in and be carried by a backpack.

Question: What is the success criteria?

Answer: Being able to make the best product at the most efficient cost, the cheaper the better.

Question: What are the rules and regulations that we should consider in the design process?

Answer: They must be USAPA approved. Refs check paddles. Not doing anything to the paddle that

helps it go over the limit of power and spin.

Question: Are there any existing solutions, if so what's wrong with them?

Answer: There are only rules of thumb people use, but no concrete solution.

Appendix B:

Notes from interview

- The ideal users of our technology are 40–65-year-olds. They have money to spend and a disposable income. They also are used to buying new all the time.
- The dimensional constraints that were explained is that if there is a product, it has to be dimensioned to fit inside a backpack.
- The product would have to USAPA approved. If it is connected to the paddle the Refs would have to check it and it cannot enhance the paddles power and spin.
- The skill level should most likely be around the 4-5.5 skill level.
- It is preferred for the product to be able to be used within less than 5 minutes.
- Typically, people feel around the paddle to see if there are any dents or bumps on the paddle. However, there isn't anything that is concrete or consistent enough.
- The success criteria would be for the product to be consistent and successful as well as cost effective and cheap.
- The paddles lose their power and speed overtime. It is the honeycomb structure on the inside of the paddle that gets degraded when being used.