## **Purdue ECE Senior Design Semester Report**

## **(Team Section)**

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| **Course Number and Title** | ECE 47700 *Digital Systems Senior Design Project* |
| **Semester / Year** | Spring 2023 |
| **Advisors** | Phil Walter |
| **Team Number** | 3 |
| **Project Title** | “Rigged” Card Shuffler |

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| Senior Design Students – Team Composition | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Utkarsh Priyam | CompE | Software (CV,Systems); Hardware (Soldering) | May 2023 |
| Brian Lee | CompE | Software, PCB Design, Mechanical | May 2023 |
| Zachary Williams | CompE | Software,Mechanical | May 2023 |
| Dan Gue | EE | Hardware | May 2023 |

**Project Description:** Provide a brief (2-3 page) technical description of the design project, as outlined below:

1. Provide a general description of the product to be delivered by this design project.

## Our “Rigged” Card Shuffler (RCS) is a device that allows a user to insert a 52-card deck of standard print size Bicycle brand playing cards and then provide user inputs via the on-board user interface (a set of directional buttons and an LCD screen). Then, depending on user inputs, the RCS will either output cards in a random order or in a controlled order as specified by the user. Potential user inputs will include options like where cards are in the resulting deal or which player is meant to win. Cards will be separated, reordered, and expelled in the desired order by a series of motors controlled by a STM32F091RCT6 microcontroller. Cards will be identified by an on-board Raspberry Pi by scanning cards with a camera, performing a computer vision identification process for each card, and then determining the ideal deal order according to the user's inputs. This process will be made as seamless as possible by a UART communication bus between the STM32F091RCT6 microcontroller and the Raspberry Pi.

1. What is the purpose of this product? For whom is it intended?

## The purpose of this product is to provide users for a more entertaining gaming experience. Also, if the user chooses a truly random shuffle, then our device will give users a quick and dependable shuffle versus traditional hand shuffling. In addition, having a quick way to perform a controlled shuffle of cards based on a user’s desired order can be useful as an educational tool to teach new players how to play different card games or highlight the dangers of gambling.

1. Describe how the engineering design process used to create your product was utilized in this project. Include how you were able to develop and conduct appropriate experiments, analyze, and interpret data, and use engineering judgment to draw conclusions related to the development of your product.

## The engineering design process was critical in the success of our project. Once we had our idea for the project we started prototyping the main components of our project. This included ensuring that we could spin a stepper motor utilizing a microcontroller and a stepper motor driver. We also tested out the image recognition software that we would use to identify the value and suit of each card in a deck.

## The way that our group went along with prototyping was by breaking down the task into smaller tasks and then checking that each task was working properly before moving on to the next step. This was essential not only in catching mistakes early on but also to deepen our understanding with the software and hardware that surrounded our project.

## From these prototypes we could confirm our interfacing and work on how the different parts of our project would communicate and be connected with each other. This allowed us to start creating our schematic for our PCB. The main challenge we had was figuring out how everything was going to be connected to our microcontroller and what pins were required for what. For example, our stepper motor was going to be controlled by the PWM output from the microcontroller. Not every pin from the microcontroller could provide this specific output so we had to make sure that we selected the right pin that could do it.

## Once we confirmed that our schematic was correct we started working on the PCB footprint and layout design while also starting to test communication between our different components. The main programming focus on this front was testing the communication between the microcontroller and the Raspberry Pi.

## After receiving the PCB and all of our other components we started assembly and final testing for our product. This came with problems that did not come up during prototyping. However, we were able to overcome these problems due to a deep understanding on how each part of our project worked. Overall, each component of our product was understood by at least someone on our team which led to the overall success of our product.

1. Describe the design constraints, and resulting specifications, incorporated into your product (list a minimum of 3).

## A critical design constraint that our product had is power. We have multiple devices that require different amounts of current and voltage. Because of this we constrained ourselves to wall power with an adaptor that converted the wall voltage to a 12 V DC output that will be used to power all electronics in our device.

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## It is also critical that temperature sensitive components such as the microcontroller, single-board computer, and LCD screen are not exposed to excessively high temperatures. Proper component spacing and heat management are therefore critical. For our PCB design we placed all the DC motors and components that would drive these components away from the microcontroller and other sensitive electronics. We did this because high voltage means high temperature and we wanted to decrease this voltage or temperature breaking our sensitive components. Especially within the context of an expected device up-time of several hours at a time.

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## The SPI channel uses 5 bits, while UART is a 2-bit bus. The DC motors, LEDs, and push buttons use 1-bit buses, while the stepper motors use 2-bit buses. Over UART, the SBC and microcontroller will send control acknowledgements back and forth, and they will also exchange key data for card identification and sorting, such as card identity and target card location. The speed that these signals can be sent over the receive and transmit lines will be a constraint as to how fast we can shuffle a deck efficiently.

1. Describe how each of the following factors influenced your design specifications and constraints.

## **Public Health, Safety, and Welfare:** The main safety concerns that we are aware of are the two stepper motors and two DC motors contained in our product. These motors have the potential to shake the device. However, we have them securely fastened to the box and have enough weight on the bottom of the box to prevent this from happening. The motors are also attached to parts that will be spinning quickly and could cause injury to the user. For this reason, we have decided to keep all the moving parts securely contained within the housing of the product out of reach of the user.

## **Global Factors:** While this product can be used globally, we do not have any multilingual support for the User Interface.

## **Cultural Factors:** The main cultural factor that our product might offend is that it encourages gambling. We have no intention for our product to be used for gambling and having a UI system that is attached to the shuffler should make it to avoid this kind of deceit.

## **Social Factors:** The social factor we had to consider is that the user would have a standard bicycle deck. In addition to this we have a very easy user interface that we believe will be understandable for all age groups.

## **Environmental Factors:** We tried to minimize our environmental impact as much as possible. Our housing that houses the components can be easily recycled since it is made of wood. Due to the size of the product and since we are only using a small number of parts, our product has a negative, but negligible, impact on the environment.

## **Economic Factors:** There is a very large range of prices for card shufflers on the market ranging anywhere from around $20 for a very low-end shuffler to somewhere close to $700 for a high-end card shuffler. Because the product is a gag item, we should attempt to stay near the middle of the road for card shufflers. Our goal is to keep the cost of the product somewhere below $350 to keep it cheaper than the high-end shufflers while allowing for more features. Currently we have not found any kind of direct competition for a gag Rigged Card Shuffler on the market.

1. Describe the appropriate engineering standards incorporated into the creation of your product.  
     
   Our design is relatively simple in terms of electrical circuits. The main focus our group would have been getting approval for our FCC. This included ensuring that we do not produce high amounts of electrical magnetic interference (EMI) and that our DC motors get verified since they fall into the category of incidental radiators since they have the potential to spark. We have safeguards in place for both. For EMI we are confident that we do not emit high levels of EMI due to everything being contained in a housing and that our motors and pi receive relatively low amounts of voltage. The low levels of voltage plus a protective diode also gives our team confidence that the DC motors wont spark and even if they do, it will not cause any physical harm to the user.
2. Describe the final status of your product.

Nearing the end of project completion, our project had several failures both mechanical and electrical that caused the project to not fulfill some of our original goals. About a day before the project was meant to be submitted, there was an accidental short that occurred that caused our 12-5V step down regulator to become non-functional. This was replaced with a Linear Drop-out regulator; however, the power dissipation may have exceeded what the LDO was rated for leading to further problems. About an hour before the final project demo, our LDO was heating up significantly, along with our stepper motors. This caused the 3D printed stepper motor mount to begin melting and warp into a shape that no longer allowed the stepper motor to function in its intended method. Because of both failures, the final state of the project included the LCD and button input menu system using SPI and external interrupts, The UART communication between the STM32 and Raspberry Pi was functional allowing us to both send and receive on both ends. The dispensing system is non-functional since the stepper motor is no longer in place and the card wheel is non-functional due to mounting issues. The computer vision system did not achieve the accuracy that we were hoping for, and this was likely due to the time constraint we faced when trying to take the ground truth images. Many of these problems could be fixed in another week or so, however, given the time that we have, these fixes are not possible.

1. Describe the makeup of your project team and how you were organized to establish goals, plan tasks, and meet the objectives of this project.

## The team consisted of four members, Zach Williams the team lead, Brian Lee the systems engineer, Dan Gue the electrical engineer, and Utkarsh Priyam the software engineer. Though everyone had these overarching titles, much of the project required each of us to assist each other in the areas that we were all confident in. During the start of the project much of the development was individual as it consisted of prototyping smaller parts of the product separately. These were separated between teammates based on their areas of expertise and confidence. This was roughly planned out and organized using the Atlassian toolkit. Using this software, we were able to track different tasks as well as our long-term goals. Initially all of our long-term goals were separated completely, however, as the project came closer to the end many of the long-term goals coincided. This meant that all of our long-term goals ultimately boiled down to the integration and final build of our project.

1. Did your project require the production of any written documentation other than this document (i.e., manuals, educational materials, etc.)? If so, describe the types, composition, and nature of the audiences for whom these materials were intended.

## Our course necessitated the creation of a user manual. This documentation was intended to be for an audience of end users and would provide basic operation instructions to ensure safe use and answer frequently asked questions. In addition, our team created professional documents, including legal analysis, reliability and safety analysis, and ethical and environmental analysis. These documents had an intended audience of the course staff, as well as any other engineers that wish to review our design to either assess the process or reproduce certain aspects.

1. Describe the types, composition, and nature of the audiences in attendance for the final oral design review. Discuss how you prepared for this audience.

## Our audience will be other teams and the professors from ECE 477. In preparation, we reviewed the entire design process and looked back over the design decisions that we made throughout the semester so that we are ready to answer any questions or concerns about the design. During our midterm design presentation, the focus was very heavy on the design considerations and PSSCs so we are expecting that the final presentation will be similar.

## **Purdue ECE Senior Design Semester Report**

## **(Individual Reflections Section)**

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| **Semester / Year** | Spring 2023 |
| **Advisors** | Phil Walter |
| **Team Number** | 3 |
| **Project Title** | “Rigged” Card Shuffler |

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| Senior Design Student Completing This Section | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Utkarsh Priyam | CompE | Software (CV,Systems); Hardware (Soldering) | May 2023 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## For this project, I worked primarily on the software for the Raspberry Pi, with contributions in the microcontroller’s software integration, soldering for the PCB, and mechanical design. In particular, for the RasPi I developed all of the logic for card recognition. For both software packages, I developed utility modules, including UART packet managers and translators, automated microcontroller GPIO pin management, and generalized initialization for various components including OPM timers and miscellaneous IO. I also worked on soldering and resoldering most of the PCB components as our product evolved, as we discovered broken or faulty connections, and as we fixed design flaws in our original electrical schematic. Lastly, I contributed to some parts of the mechanical design and prototyping, from positioning and lighting for the camera module to guard rails and relative positioning for the card ingest and processing mechanisms.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

## My software contributions to this project built on a lot of previous courses I took, such as ECE 20875 and ECE 26400 for my experience in Python and C, respectively. My work in ECE 36200 provided me with great experience in working with our chosen STM32 microcontroller, as well as in working with low-level embedded programming and assembly. ECE 40400 provided me with knowledge of networking systems and communication protocols, which I used in designing the UART packets and protocols we use in the project. Finally, my work in ECE 47300 gave me great insights into the tools and techniques I required to design and implement the entirety of the card recognition software. In particular, I leveraged my knowledge of first and second phase AI technologies to design a computer vision system that can accurately identify cards from images within the sharp timing constraints of our product’s operations. On the other hand, I used my knowledge of hardware design and soldering from ECE 20001, ECE 20007, and ECE 20002 to complete the tasks required for various design elements of the electrical components and PCB for this project.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## For this project, I had to explore state of the art designs and implementations for computer vision algorithms, as the ECE 47300 discussions were centered around generative image AI models. However, here we needed a classification and identification algorithm, which required additional precomputation and algorithmic design. I used my existing knowledge in CV technologies to filter online resources spanning external courses, library and wiki documentation sites, and prior experience in the field from internships and work opportunities to explore insights and implementation alternatives for our card recognition system. I filtered through the most applicable and simple design options, before studying them from an algorithmic point of view. I then used the collected knowledge to design a custom solution for our project that leverages the most relevant aspects of each reference solution I investigated. I also learned to solder both through-hole and surface mount components properly, and I discovered the importance and increased efficacy of liquid flux over pen-based applicators. I built my experience in and practiced soldering repeated on scrap and prototyping materials in order to raise my proficiency in soldering and repairing our PCB to a practical level. Finally, more abstractly, I learned a lot about mechanical design from observations of and contributions to our product’s overall assembly, packaging, and structure. I also learned a lot about collaborative design, problem solving, iterative testing, and rapid prototyping through practical experience as our team stepped through every phase of the design, implementation, and testing processes in the prototyping and development of our product.

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## Our ethical and professional responsibilities for this project spanned various scopes, from the end user to the larger community and the environment. However, as far as my responsibilities spanned for this project, the scope was far more limited since the aspects of this product that I developed were primarily internal software tools and libraries without user-facing interfaces. As a result, my primary responsibility was simply to ensure the accurate implementation of all the systems, in a manner that closely conforms to the agreed-upon specifications. Beyond software, I also worked on PCB soldering, for which I had to remain conscientious of user and environmental impacts for decisions such as electrical safety and substance selection. In particular, we went with lead-free solder and liquid flux, the latter of which was thoroughly rinsed off after every soldering session. We also carefully verified all components on the board to ensure both accurate and safe operation, especially in the context of electrical fire safety near the wall-power adapter interface and throughout the other sensitive components on the board.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

## This product does not have very many impacts economically, as it simply provides an alternative to existing card shuffling devices that already exist on the market. Environmentally, our design decisions such as material selection, product lifetime, and ease of repairability strongly influence the device’s impact. However, as mentioned prior, we primarily targeted renewable and eco-friendly options such as lead-free solder and compostable plastic in our construction, which significantly decreases our environmental impact. Societally and globally, on the other hand, our device has the potential to increase gambling, cheating, and other socially reprehensible or dangerous activities, alongside the fact that using such a device in official gambling settings like tournaments or casinos could even be illegal. As a result, our device would require extensive regulation and or clear identifying markers as a gag product in order to mitigate such impacts of the product post-sale. Finally, from a safety perspective, there are no major risks as the product is a single sealed system. However, there are a few risks, such as getting long hair caught by motors in the card ingest compartment or even electrical fires caused by components on the PCB. To protect against these impacts, the product would probably have to be shipped with safety manuals and labels or warnings for potential risks.

## **Purdue ECE Senior Design Semester Report**

## **(Individual Reflections Section)**

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| **Course Number and Title** | ECE 47700 *Digital Systems Senior Design Project* |
| **Semester / Year** | Spring 2023 |
| **Advisors** | Phil Walter |
| **Team Number** | 3 |
| **Project Title** | “Rigged” Card Shuffler |

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| Senior Design Student Completing This Section | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Brian Lee | CompE | Software, PCB Design, Mechanical | May 2023 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## The three main areas of my contributions to this design project were software design and development, PCB design, and mechanical design and assembly. On the topic of software development, I contributed to the embedded software on our microcontroller as well as the software on our single-board computer. For the microcontroller, my contributions mainly related to the UART communication, including enabling and setting the correct pins, configuring the desired UART settings, and providing the structure for the handling of received data, which was significantly built upon by Utkarsh. I also completed similar tasks for a beam break sensor and corresponding emitter. On the single-board computer, I performed the initial configuration process (opening the right ports, enabling serial communication, installing the proper libraries, etc.), writing the foundation for the UART communication on the Pi and the camera interfacing, and the general structure of our main code loop. Utkarsh also significantly contributed to building upon, revising, and integrating these portions. On the topic of the PCB I participated in a redesign of the board with Zachary, which included placing components, choosing trace widths based on expected current, and placing traces and vias to ensure all of our schematic connections were made. Lastly, I designed many of our mechanical components in CAD software, including the housing for our rotating card wheel, motor mounts, coupling mechanisms, rotating rollers, and various other parts, which were then 3D printed. I also played a key role in assembling these parts based on our overall mechanical design and troubleshooting mechanical issues as they arose.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

## Introductory classes like ECE 20001 and ECE 20002 provided us with the crucial fundamental electrical background to design, assemble, and debug our circuit, which included many concepts we learned in our core classes. These concepts included voltage dividers, decoupling capacitors, debouncing circuits, voltage regulators, etc. These topics were also covered in ECE 362 (Microprocessor Systems and Interfacing), which also provided essential knowledge about programming for and designing circuits for microprocessors and related systems. 362 also gave us the knowledge of various protocols such as SPI and UART, which were crucial to the integration of various systems in our project. In terms of programming, ECE 20875 (Python for Data Science) and 40862 (Software For Embedded Systems) provided us with very important Python programming experience, including for embedded systems in the case of 40862. ECE 264 (Advanced C Programming) and 368 (Data Structures) gave us important C programming experience as well as a strong background in data structures in the case of 368. Lastly, ECE 463 (Intro to Computer Communication Networking) and ECE 404 (Intro to Computer Security) provided us with the background of various communication protocols and packet styles, which allowed us to develop our own custom packet protocol for our UART communication.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## In order to complete this project, all of the members of our team had to learn new skills that we did not have before. For instance, I had never used CAD software before, but we had many mechanical parts that had to be designed. In order to learn how to use CAD software to model and design our parts, I started by watching tutorials for designing simple components. Once I understood the various tools at my disposal, I simply started designing the parts we needed for our device, and through the process of making these parts, I was able to gain a relatively high proficiency in CAD software over the course of this semester. For the process of learning how to design the PCB, the ECE 477 course staff were an incredibly useful resource. In particular, whenever I ran into issues or questions regarding PCB design, Joseph Bougher was able to guide me in the right direction, which considerably accelerated the rate at which I learned to use KiCAD.

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## There are a myriad of ethical and professional engineering responsibilities that applied to our engineering design experience. For instance, it was our responsibility to ensure that the materials used in our device were safe for the engineers working on it and for any potential consumers. This responsibility was reflected in our work when we discovered that a metal rod, we had been using for our axle was in fact a hazardous metal. It was then quickly handed off to ECE staff and replaced with a safe metal. It was also the responsibility of the team to ensure that the device we developed could not be used to harm others by its user. For example, because we produced a device capable of performing controlled shuffles, it was imperative that the device clearly indicated this capability such that it could not be used to defraud others in a gaming or gambling context.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

## The device we were prototyping has many potential impacts on the aforementioned contexts. For instance, the materials we chose have an impact on the environment because of the material type, the environmental cost of production, and the material lifespan. In this context, we had to make judgment calls about our material choices. For example, because PLA is compostable, it was more sustainable than other plastics options, and it was therefore chosen. Similarly, plywood allows for less desirable parts of a log to be used, and also has a comparatively longer lifespan than natural wood. As such, plywood was chosen for our device case over natural wood. In an economic context, it was important that the components and materials we chose result in a final product with a price point that could be affordable for the average consumer and is reasonable for its entertainment purposes. Societally, it was essential to guarantee that the device could not be used to defraud people, especially people who are already economically vulnerable. As such, it was essential that the fact that the device could perform controlled shuffles was very clearly indicated to all users. Lastly, from a global impact context, we had to consider what interface localization would allow the most users to interact with our device. In the end, because English is considered a modern lingua franca, our interface was implemented with English first.

## **Purdue ECE Senior Design Semester Report**

## **(Individual Reflections Section)**

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| **Advisors** | Phil Walter |
| **Team Number** | 3 |
| **Project Title** | “Rigged” Card Shuffler |

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| Senior Design Student Completing This Section | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Zachary Williams | CompE | Software,Mechanical | May 2023 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## My main contributions for the project were focused on embedded software, mechanical design, and PCB Design. In terms of the embedded software, I created the embedded software that allowed for a dynamic menu system. using SPI. This included correct spacing and dynamically updating the screen based on user input. I also created the external interrupt handling for push button inputs including using hardware debouncing and the falling edges of the input to take user input that would affect the LCD screen. Lastly, I implemented One Pulse Mode using timers for stepper motor control giving us accurate movement of the stepper motors down to the ability to send one single pulse and take a single step. In terms of the mechanical design, I designed and printed the Card Wheels which are used to hold the cards after dispensing from the starting deck and before depositing into the final deck, Stepper Motor mounts which are used to mount the stepper motors solidly to the walls of the housing, and the original card holder which was used to hold the starting deck that the cards would be dispensed from. Using Fusion360, I used the parts that Brian and I created to make an assembly that would show the rough layout of the internals to determine the necessary housing size. I also got the wood for our housing cut, assembled the housing, and mounted the majority of the parts onto the housing using the tools in the lab. In terms of the PCB design, I worked with Brian to redesign our PCB in order to fix the footprint sizes that were originally 0603 instead of 0805 as well as the stepper driver circuit design.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

## The most applicable classes that I would attribute my contributions to would be ECE 20007, ECE 362, ECE 368, and ECE 468. ECE 20007 gave me the original experience working with electronics and lab equipment that helped me in debugging my circuits while I was prototyping as well as during the final integration. ECE 362 provided me with the experience in embedded software development, specifically STM32 software development that made the development of the LCD, button inputs, and stepper motor control possible. ECE 368 gave me significant C development experience including advanced use of data structs and other methods for structuring both data as well as the code which allowed me to structure the code in a relatively neat and sensical manner. ECE 468 gave me the knowledge to understand consistent data transfer using acknowledgments that will be implemented in the final implementation of the project.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## My experience with CAD development prior to this class was extremely brief so I was forced to gain much more knowledge on things like implementing patterns in CAD drawings as well as constructing an assembly to model the layout of our project. In order to gain this new knowledge, I turned to the internet for tutorials as well as my roommates who are Mechanical Engineering seniors who were able to give me advice and help me if I was not sure how to proceed. Prior to this project, I had never delved very deeply into pulse width modulation or other alternate function outputs for STM timers, so it was necessary for me to relearn the knowledge about PWM as well as expand my knowledge in order to get the results that we needed for precise stepper motor movement. To do this, I referenced many of my previous labs as well as combing through the microcontroller datasheet in order to find the possible implementations that we could use for this.

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## One of the main responsibilities of an engineer is to ensure the safety and responsible use of our project. In order to do this, I determined that while our stepper and DC motors should not have the torque to injure our users, any part that could injure the user is safely contained within the housing where the user cannot access them. To ensure the responsible use of the product, it is made clear in multiple of our documents that the intended use of the project is for entertainment purposes only and is not to be used in a context for gambling or scamming others.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

## In terms of the impact that our product could have, there is not much that significantly impacts the societal and global contexts, however, we made specific choices in order to impact the economic and environmental contexts. In terms of economics, a large purpose of the product was to create an affordable middle ground between the $20 low quality shufflers and the $600-$700 very high quality shufflers. We used 3D printing and plywood in order to keep the construction costs as low as possible for the prototype. With further production development, the total cost of the product could be produced much cheaper than it was for us. In terms of the environmental contexts of the product, the 3D printing filament we chose was PLA as it is a very hardy material and is also compostable which would lead to a much less significant impact on the environment during production.

## **Purdue ECE Senior Design Semester Report**

## **(Individual Reflections Section)**

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| **Advisors** | Phil Walter |
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| **Project Title** | “Rigged” Card Shuffler |

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| Senior Design Student Completing This Section | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Dan Gue | EE | Hardware | Spring 2023 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## My personal contribution to this project was all hardware. I started by prototyping and becoming familiar with the stepper motor and the stepper motor driver. I first learned how the driver worked with a module and from there I understood how the driver chip itself worked. From here I started working on the schematic for the circuit and using this schematic I created a PCB design. After the PCB was ordered I worked on soldering different components onto the board. While I was soldering these components I debugged and ensured that all components on the board worked properly. From here I worked on debugging everything in general. This included the LCD screen, push buttons, stepper motors, and DC motors. Most recently, I worked on the user interface on the LCD screen and ensured that everything showed up in a uniform fashion.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

## The main thing I learned from this project is seeing what I learned in classes from a practical standpoint. Before this project, most of my time was spent learning about circuits in a classroom. Like in ECE20001 and ECE 20002 I understood what a capacitor did and the relationship with voltage to current but didn’t know what I would use the information for. Now, I understand that capacitors can be used to protect important components from voltage surges. The resistors can be used together and with voltage division I can control what the voltage will be. IN ECE 321 I learned more about power electronics, and it helped me understand potential problems that can come up. Being able to translate what I learned from the classroom into a practical setting gives me confidence that what I learned will be useful for my engineering career post college.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## Something new that I had to teach myself is how the specific stepper motor driver worked and how it would interact with our microcontroller. In classes before I was able to control a stepper motor using matlab and it was very software heavy. But for this project, I had to learn the functionality of the driver and what resistors, capacitors, and input signals I needed to surround the driver in in order for the stepper motor to work to our desire. I remember in previous classes that I had to look at the documentation in order to learn about the components, so I implemented these same skills. These skills mainly consisted of reading the fine print of the documentation in order to fully understand how the component worked and working closely with my team to ensure that I had the correct circuit that would lead to the motor working how we want it too. In addition to this I also had to teach myself how to do PCB design and soldering since this was never covered in classes before. Soldering was briefly touched on in one of my lab classes but I did not learn nearly enough to be confident in my abilities.

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## The ethical and professional responsibilities that we faced is ensuring that we did not cut corners during any part of our product. It is important that we stay honest and ensure that our product matches our documentation of the product. For me specifically this meant that the power supply is safely spread out to our components and to make sure that this power will not harm the user in any sort of way.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

## There is little significant that we have in terms of a social and global impact. For our project though our team made a conscious effort in terms of our economic and environmental impact. Our economic goal was to create a product between low quality shufflers and high end casino grade shufflers. We used cheaper parts such as 3D parts and plywood to keep cost low. For our environmental impact we chose to use PLA as it is sturdy so it would be reliable housing for our motors as well as compostable which leads to a significant decrease in the impact on the environment in comparison to other products.