Northeastern University
College of Engineering

Cornerstone of Engineering I & II
Spring 2023 TF

Sustainable National Parks Exhibit

Relevant Graphic

SUBMITTED BY:

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Report Submitted: **4/11/23**

ABSTRACT

Abstract things

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PETER MOLZER

INTRODUCTION

PROBLEM STATEMENT

1.1

Create a museum exhibit that, above all, should educate users on how oil rigs and other natural resource mining in the national parks (a tangible perspective of all nature/wildlife) is terrible for the parks, and how removing these sources and replacing them with renewables is better. The exhibit should also teach that you should only create as much power as you need, where different sources of renewable power are needed based on the energy requirement.

The exhibit must fit on a 36” wide by 28” deep tabletop and must cost less than $100 excluding items already owned. It must be tailored to its target audience, children, who need the exhibit to be durable, safe to use, and easy to interact with. Users should come away knowing: the negatives of oil rigs and natural resource mining in nature, why renewables are better, cool facts about the national parks and their animals, and which renewables are suitable for different parks.

STAKEHOLDERS

Our design intends to meet the expectations of the client, who wishes to create a new travelling museum that is small enough to be transported to areas where the children are too distant from real museums. The client has delegated this task to a project manager, KSG, who has assigned eight teams to design, prototype, and construct exhibits for the travelling museum. The main users of the design, children, are interested in the quality and educational value that our exhibits aim to teach.

PERTINENT TOPICS IN ENGINEERING

SUSTAINABILITY AND RENEWABLE ENERGY

Sustainable energy generation comes from infinitely renewable natural sources from the earth itself, such as light from the sun, wind currents, and ocean tides. Energy created from these sources is less detrimental to the long-term wellbeing of our planet due to the lesser degree of pollution and destruction of the environment. This topic makes up the content which is taught by the final exhibit.

SCOPE

This report encompasses the process of creating a museum exhibit from the inception of its topic to the final construction and evaluation.

BACKGROUND

History of energy in national parks

In 2017, President Donald Trump issued an executive
1.2 order that would remove a number of policies protecting the national parks from the impacts of oil and gas drilling [1]. These removed policies set safety and environmental standards which protected over 40 national parks from encroaching drilling companies.

Research

Renewable energy at our national parks has many benefits to the experience of the parkgoer as well as the environment as a whole. For instance, renewable energy sources instead of natural gas and oil mining will preserve water quantity, dark night skies, natural soundscapes, geologic processes, as well as hydrologic processes [2]. Renewable energies such as solar power allow for remote locations, such as the Grand Canyon, to power ranger stations and visitor centers instead of importing the energy from far away, an impractical feat [3].

Oil and natural gas mining near natural parks can contaminate the soil, air, and water of the parks ecosystem, thereby harming its wildlife [4]. Habitats are wiped out, and the visitor experience can be ruined with evidence of drilling. These oil and gas companies often abandon mining sites, and fail to pay the park enough for the costs of its clean up [4].

Universal Design

Through our research, we found that interactive elements of an exhibit lead to far greater user engagement and learning. Interaction of the exhibit should be required in order for it to function, and the controls should be clearly marked and accessible to everybody. Writing is to be large and without serifs, and gameplay elements should not be catered to one gender or the other, such as strength [5]. Children, our clients for this project, are shown to engage better when there is a competitive aspect to the exhibit. The exhibit, however, should not be made too child-like, as it makes the science presented seem unauthentic and too disconnected from reality [6].

Report Justification

As time passes, oil and gas drilling companies will continue to pollute the air, water, and soil of our natural parks. This exhibit plays an active role in educating future policymakers and engineers about the importance of preserving our parks. This technical report may provide design and construction insight for future projects in sustainability in order to continue this important education to the next generation.

METHODOLOGY

Topic Selection

Each member of the team conducted preliminary research
1.3 into current sustainability topics and leading industry solutions to those problems. Some ideas, like demonstrating the cleanup of the oceans of trash, were ruled out because of the difficulty in constructing an exhibit that uses water. After taking into consideration the interest children might have in the topic and the ability for us to affectively teach it, we decided to pursue education of the dangers of natural resource drilling and the benefits of renewable energies in America's national parks.

Problem Definition

After deciding on a topic, we examined the contract and its requirements and constraints to create a problem statement that will guide the project's development. While the problem statement evolved through the development of the project, a general problem statement persisted:

> Create a museum exhibit that teaches and brings awareness to one area of sustainability. This exhibit has to be engaging to children, the main users of the exhibit, while also being informative. The exhibit must be inexpensive, use a handful of electronic components to improve immersion, and be fully operable and safe to use by a child.

Solution Generation

The overall design and concept of the exhibit required the use of ideation techniques that allowed us to home in on what parts of the exhibit we needed and what was just wanted. We started off with a fishbone diagram that laid out preliminary design aspects which we thought could be useful:

Figure 1: Fishbone Diagram

After using this diagram to come to an understanding of the design objectives and constraints, each team member hand-sketched a unique exhibit that contained the concepts for all of the user inputs and visual outputs. Using this method, our team of three ended up with a handful of potential concepts for our exhibit.

To decide which exhibit concept our team wishes to develop and construct, we used a Kepner-Tregoe decision matrix that assigns a numerical score to each design based on weightings of many categories, found in Appendix B. Ultimately, we decided on a simple to construct design that featured levers to select a type of renewable energy source that is most appropriate for a given landscape shown on a screen. This decision, however, would be overhauled later

Initial Model

Before building a model out of cardboard, we first created a Solidworks CAD drawing to use as reference for our measurements:

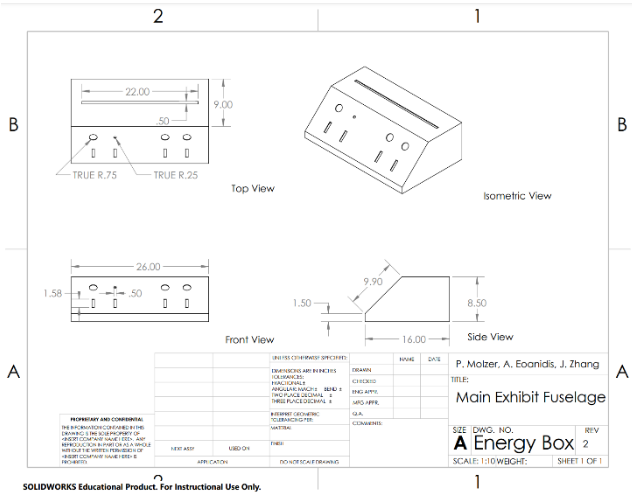

Figure 2: Early Model CAD Drawing

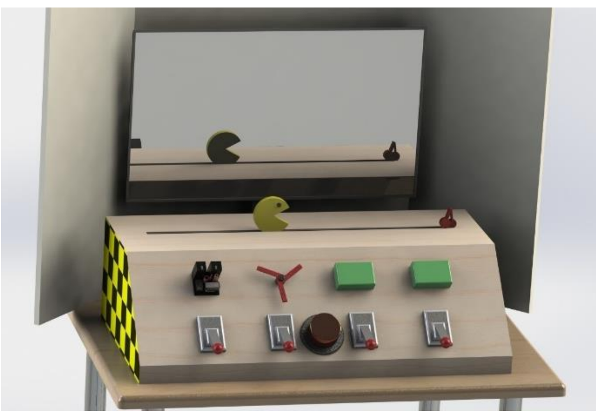

Figure 3: Solidworks Render of early exhibit design

As seen in Figure 2, The exhibit console takes the form of a box with a slant for the user interface. Cutouts are placed where the model power plants go, as well as cutouts for the wiring of the levers. The exhibit also features a Pacman character that slides along a slot, shown in Figure 3.

The project consists of a poster board, a monitor or laptop screen, and the actual exhibit console. The screen will inform the user when they should be moving the levers: Lift the lever for the proper energy type given a photo of a landscape. After they are satisfied with what levers they push, the program tells them to press the big button to “submit” the answer. The goal is to get the Pac man to get his food, the cherries, at which point the user “won”. The game then resets, and the user is prompted to push the button again.

Rapid Prototyping

Our team used the drawings for this preliminary exhibit to create a cheap, cardboard mock-up of what the exhibit would look like. The goal of this was to get a better sense of how large the exhibit will be and if there are any glaring issues with its construction that were missed during the design process.

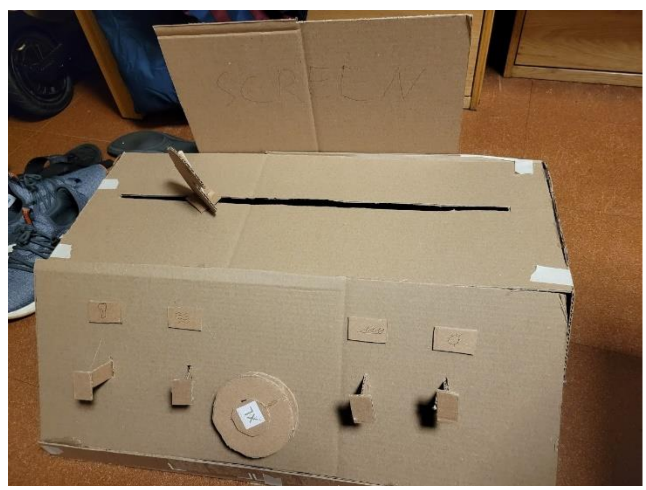

Figure 4: Cardboard mock-up of first exhibit design

Based on feedback gathered from peers after showcasing the exhibit, we determined that it needed a haircut, which is reflected in the smaller exterior dimensions of the new design.

Design Revision

This design, however, was ultimately changed based on initial feedback. Instead of levers, an RFID system would choose between three different power sources. The new design would be themed towards national parks, with the goal of kicking out oil and gas mining companies and implementing renewable sources of power to provide for ranger stations and visitor centers.

Figure 5: Final exhibit design CAD

The computer render in Figure 5 features a foldable laptop that is easy to transport and setup, which will act as the computer to run the code and as the monitor to display the MATLAB program. The new iteration makes use of a servo motor, a button, and an RFID reader for user input.

Proof of Concepts

Before construction of the final exhibit, our team tested each function of the exhibit in isolation to make sure that it was feasible to accomplish in the allocated time, as well as reliable for use in application.

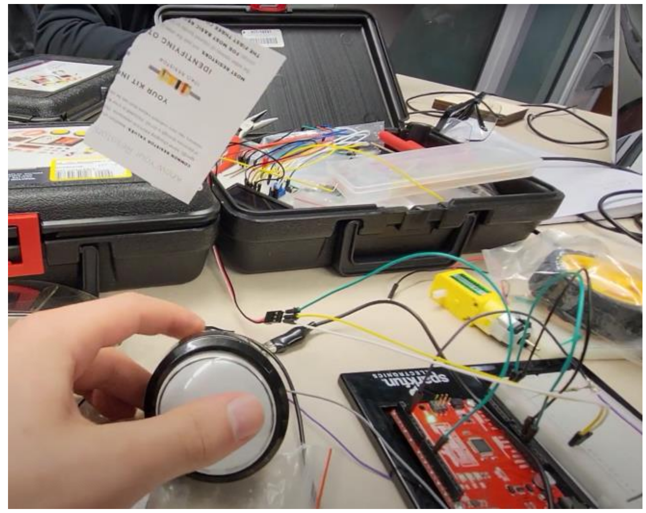

Figure 6: Proof of concept of servo motor and button

This first proof of concept, displayed in Figure 6, consists of a servo, and a button that lowers the image attached to the servo. Each time the button is pressed, the picture – eventually to become an oil rig – is lowered by about 30 degrees. Once the image gets to the bottom, the demo code will bring it back up. The concept was entirely successful and practical for our exhibit.

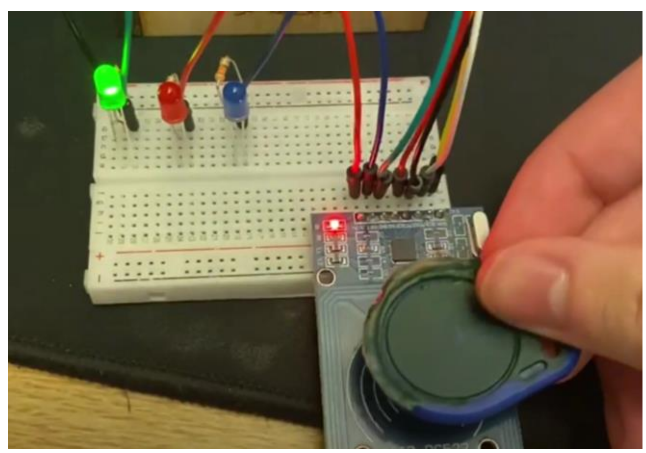

Figure 7: Proof of concept of RFID reader

The second proof of concept, shown here in Figure 7, demonstrates the use of an RFID reader that will be implemented into the exhibit. Each time a chip is read its UID tag is read and stored into a value. Each chip will represent a different type of energy source. The user will be asked a question which they will respond to by placing a block with each chip onto the RFID Reader. The code contains 3 if statements to recognize which answer was picked.

CONSTRUCTION

After finalizing the design and displaying that each function of the exhibit works in isolation, the team began work to build the chassis of the exhibit. After taking into consideration our budget, we decided to construct only the front console out of ¼” wood, and make the rest out of cardboard. This, in turn, allowed us to spend money elsewhere like in more 3D printing, and have the benefit of being lightweight and more portable, a minor design goal. A photolog of this construction process can be found in Appendix G.

EVALUATION

To evaluate the performance of the exhibit during the expo that it will be demonstrated in, we used a variety of data collection methods to capture the educational value, degree of fun, aesthetics, and engagement of our design. To test the educational value and aesthetic opinion of our users, we used a short quiz that could be filled out by one of our team members after a user is finished playing with the exhibit. The questions on this quiz included: What is something you learned? And “Do you think it looks cool?”. In addition to these two questions, a numerical estimate of how long an average user of the exhibit plays for is collected electronically within the Arduino program. The program times the duration of each interaction and outputs it to a database where the data is stored. After analysis of the data…

INDIVIDUAL CONTRIBUTION

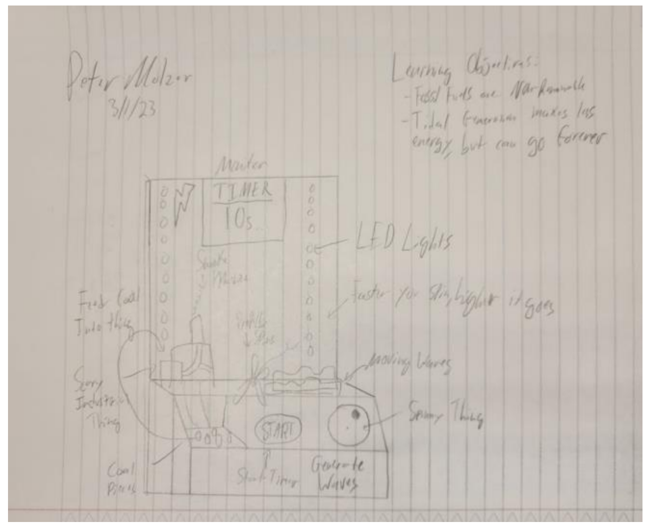

Figure 8: Peter's design contribution

This design, shown in Figure 8, would serve as a strong influence for what shape the main body of our exhibit would look like. While the final design did not have a dial or a big back-board, it s flat top and angled front panel made it to the final steps.

Early in the design process, after all team members contributed their ideas and a topic was selected, I curated the problem statement that would guide our project through the milestones.

In milestone 3, once the group had verbally agreed on a design, I drew up the design in Solidworks, deciding upon the exact measurements and shape of the exhibit. These designs can be seen in figure 2, 3, and 5.

I designed, wired, and tested the proof of concept seen in figure 6, alongside the coding.

```
#include <JC_Button.h>

#include <Servo.h>  // servo library
Button myBtn(2);       // define the button
Servo servo1;  // servo control object

int rigPos = 0;
void setup() {
  // put your setup code here, to run once:
  servo1.attach(10, 900, 2100);  //Connect the servo to pin 9
  Serial.begin(9600);
  myBtn.begin();               // initialize the button object
  servo1.write(0);    // Tell servo to go to 90 degrees

}

void loop() {
  int position;
  myBtn.read();               // read the button
  if (myBtn.wasReleased())    // if the button was released, change the LED state
  {
    lowerRig();
  }

}
void lowerRig() {
  servo1.write(rigPos);    // Tell servo to go to 90 degrees
  rigPos+=45;

  if(rigPos>135) {
    rigPos=0;
  }
}
```

Figure 9: Code for button and servo Proof of Concept

A portion of this code would be useful for the final scripts.

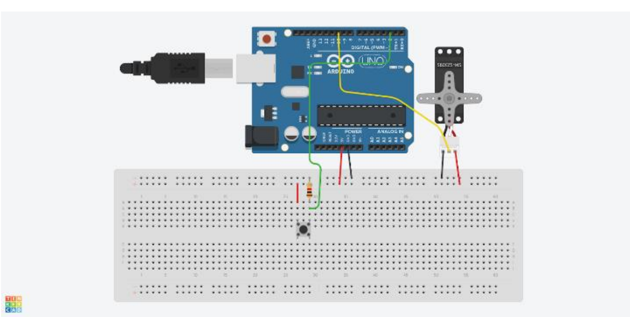

Figure 10: Wiring for button and servo proof of concept

This wiring diagram was used in the final wiring schemes that were used in the final exhibit.

JAMES ZHANG

INTRODUCTION

Problem Statement

1.4 Create and design an exhibit that will be educational, safe, and engaging. The exhibit will teach the children about the importance of renewable energy sources such as wind, hydroelectricity, solar, and geothermal energy. The exhibit must be within a budget of $100. It must also be able to be portable within a bag that KSG has given us. The exhibit will also teach children the effect of oil rigs on the environment and explain everything through animals so the children will be able to understand and follow along

Stakeholders

This project is meant to have its main users be children. The stakeholder of this exhibit is our professor, KSG, who has set expectations for our project. She expects it to be interactive, educational, and engaging for the children.

Pertinent Topics of Engineering

Our focus for this exhibit is to explain the benefits of renewable energy and what can be used to create renewable energy. Burning fossil fuels will not be sustainable in the future because of the limited resources available and it also leaves a large scar on the environment. Renewable energy provides a positive alternative by utilizing the Earth's natural wind, water, sunlight, and heat.

Scope

This report will be a presentation of the work done from the beginning steps of the exhibit to the final design. This includes software designs, wire diagrams, code, and more.

BACKGROUND

Background Information

1.5 There have been projects for renewable energy in national parks with the first being found to be in 1995 **[source].** The Grand Canyon was one of the first to be in the federal solar energy projects. Although the amount of energy produced was very small compared to the amount that can be produced now, the panels were displayed to millions of visitors and gave them an insight into renewable energy.

Research

If national parks could switch towards incorporating renewable energy sources onto their land, it would benefit the environment. For example, the usage of solar energy would help lower greenhouse gas emissions and also power remote off-grid sites in the park with minimal damage to the environment **[source].** Solar energy in national parks can reduce their energy demand as a whole with Yosemite's solar energy production expected to offset the park's total energy demand by 12%. Renewable energy will also result in a reduction in air and noise pollution. According to the National Park Service, air pollution affects visibility by creating a white or brown haze, which inhibits the visitor's ability to see colors and the textures of features in the park {**source).**

Justification

By creating this report and exhibit we hope to educate future engineers about the environmental problems that they will also have to face. We want to educate them about sustainability and how the national parks would benefit from it. The children also need to be aware of how burning fossil fuels will impact the parks as well as the children's own health. We need to give them a basis so that they can grow up thinking about new ways to address sustainability and renewable energy.

METHODOLOGY

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1.6

ANDREW EOANIDIS

INTRODUCTION

Problem Statement

1.7 Design and create a museum exhibit focused on educating users on the negative effects of oil drilling while promoting use of sustainable energy substitutes in national parks to protect wildlife. Additionally, the exhibit teaches users which sources of sustainable energy perform to their optimal capacity in varying environments as well as how these sources of energy function.

The exhibit constraints are that it must fit on a 36” wide by 28” long tabletop and must cost no more than $100 not counting previously owned items. It must be tailored to its target audience, children, who need the exhibit to be durable, safe to use, and easy to interact with. Takeaways from interaction with the exhibit include: the negatives effects of oil rigs and other natural resource drilling, why renewables are a better option for the environment, interesting facts about national parks, and how and where sustainable energy source’s function best.

Stakeholders

The creation of our exhibit aims to follow all the client’s requests. The client desires an interactive, yet educational museum exhibit that is easily transportable. The educational aspect of the museum exhibit must relate to the topic of sustainable engineering, educating users while also promoting the awareness of sustainable engineering. The exhibit must be built tough enough not only to withstand transportation between sites, but also to be regularly interacted with by children and remain functional.

Pertinent Topics of Engineering

The exhibit incorporates sustainable energy as the main educational aspect. Energy meets the criteria of being sustainable if it meets the needs of the present without compromising the future. This energy can be found anywhere on earth, specifically for our exhibit we will be teaching about geothermal, hydroelectric, and offshore wind energies. The ultimate goal of sustainable energy usage is to reduce pollution and environmental harm while providing clean energy that meets society’s needs.

Scope

The objective of this report is to outline the process of our museum exhibit on sustainable energy from its first steps to the final polished version.

BACKGROUND

Problem History

For over 100 years, the federal government administrations
1.8 have respected and protected the land on national parks through various policies. However, soon after President Trump’s inauguration, many policies were rescinded by interior secretary Ryan Zinke [1]. Some changes included the null and voidance of climate policies and studies, the destruction of animal’s habitats, and the systematic execution of some of these animals. The purpose of these actions is to ruin national parks to the point where the government can drill and exploit the sacred resources found there.

Research

Raising awareness to this pressing issue, along with educating users on sustainable energy provides a solution to the issue. Rather than destroy national parks simply to exploit them, sustainable energy offers can be implemented in these parks to provide energy, while also maintaining the natural beauty and history of these parks. The three proposed types of sustainable energy substitutes are hydroelectric power, geothermal power, and offshore wind power; each having its own place in national parks. Hydroelectric power functions off the difference between two bodies of water at different elevations. By harnessing the potential energy located in the higher body of water, when the water flows through a dam, the now kinetic energy of the water spins turbines, which in turn produces energy [2]. However, this process relies on the water cycle as it needs constant access to optimally function. Another type of sustainable energy we will incorporate is geothermal energy. There are multiple ways to harvest geothermal energy such as dry steam power plants, flash steam power plants, and binary cycle power plants. For our project we will be focusing primarily on flash steam power plants. These plants produce electricity through the pumping of extremely hot water into a low-pressure area where it is converted to steam and powers a turbine [3]. Finally, offshore wind power simply works through strategic placement of wind turbines off a coast where wind spins a turbine which causes DC power to be converted to AC electricity through a generator [4].

Technical Report Justification

The institution of policies that disregard the condition of natural parks paired with a rise in pollution and climate change, a positive agenda must be pushed. Through educating users on the upsides of sustainable energy along with the imminent downfall of national parks, the main objective is to influence future policy makers and government employees to advocate for change.

METHODOLOGY

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1.10 FINAL DESIGN

The chassis of the exhibit features a primarily cardboard construction, with a wooden front console. The console is slanted at a 45-degree angle towards the user, and the rest of the box encloses the electronics inside.

Figure 11: Annotated exhibit diagram

As seen in Figure 12, on the left side of the box near the bottom of the console is the arcade button assembly. The button is separated and attached to the chassis using a 3D printed gasket that is meant to withstand high impact loads from hard button presses. The button is lit up with an internal LED.

Above the button is a slot in the chassis for the Pop-up oil rig. The slot, with dimensions found in Appendix C, allows for a 3D printed oil rig model to swing up.

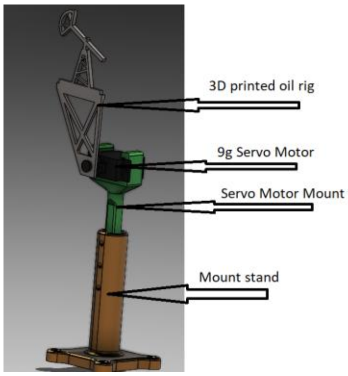

Figure 12: Servo mounting assembly

As seen in Figure 12, the oil rig and servo mounting assembly consists of three different parts. The mount stand attaches to the baseboard of the exhibit to the left of the oil rig slot in the chassis. The servo motor mount slides into the mount stand, where its height and rotation are set using screws.

A 3 by 3 inch square hole is cut into the front console on the lower right side of the exhibit. Beneath this hole is the RFID reader holder.

Figure 13: RFID reader stand

The stand shown in Figure 13 accommodates a rectangular RFID reader with a cutout at the top to allow wires to pass through. The holder at the top is slanted 45 degrees to match the inclination of the front console.

As shown in Figure 11, above the square hole is storage for the three game pieces. Each piece consists of a 3d printed base block and a small model of a renewable energy source adhered to it.

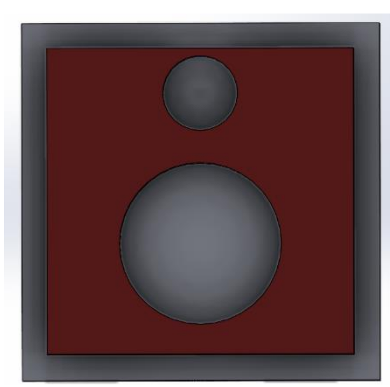

Figure 14: Underside of game piece

As shown in figure 14, each game piece features two circular indentations. The top smaller hole accommodates a magnet used to secure the piece to the front console, above the square hole, when not in use. The larger, lower hole accommodates the RFID tag.

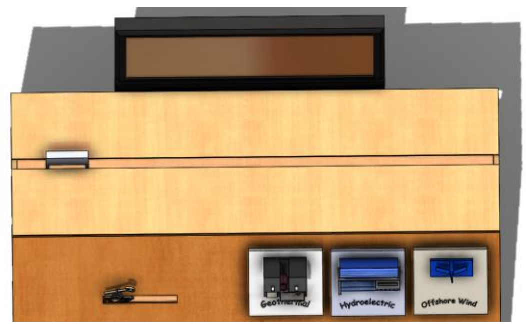

Figure 15: Top face of exhibit body

Seen in Figure 15, the top face of the exhibit is constructed with two boards, leaving a small gap in the middle. This gap provides the clearance necessary for a sliding progress bar, as annotated in Figure 11. The piece is slid along the top of the two boards using a loop of string that is driven by a hobby motor.

Behind the exhibit is a folding laptop whose monitor faces forwards. The laptop is connected to the electronics inside.

1.11 RESULTS

This section is for the results of testing you engaged in. Like the Final Design section, you are providing information for the reader and no analysis. You are setting up for your discussion where you can then argue or defend the output of your engineering design cycle using this information. For now, let the reader come to their own conclusions without referencing any design constraints or requirements. For instance, do not state “The prototype meets the size requirements.” but rather say “The prototype measures XX in by XX in by XX in.” They already know what the requirements are because they were laid out earlier in the report. This section is not for you to state that your prototype meets the design requirements but to rather put forth all data and let the reader make that determination.

Think about it from a trust stand point. If the reader fully trusted you, you could just say “It meets all the requirements” and move on. At this point, everyone who needs convincing does not trust you. Even if the client does, there are others who may need convincing down the line, especially if something goes wrong and someone has to look back over all your previous work. You need to just let the evidence speak for itself for now. When you get to the discussion section, then you use it to start making your case.

In this section you should:

- List how the final design performed during all evaluative methods and procedures
  - Excessive data should be summarized here with the raw data included in an appendix
- For any testing method or procedure applied to the final design described in the methodology section, provide the resulting data here.
  - You will likely have to reference those methods and procedures but you do not have to redescribe them in detail.
- Provide comparisons for reference if available and particularly if necessary for context
  - This can also be done in the discussion but you can provide it here. This is typically performances of other groups or other benchmarks but leave as facts only, not opinions. It is not “We performed better than other groups.” It is “We had this, they had that.” Let the reader make the comparison.

Common Issues:

- Forgetting the qualitative data
  - Your Observations from Exhibition Day, User Testing and other qualitative data are results and must be included.
- Too much or too little data
  - Primarily a qualitative data issues where you can’t present it all but you can provide exemplar data points. Provide a typical example or a positive and a negative interaction. Put the rest in an appendix.
  - You don’t need to include a table of all quantitative data here if it takes up multiple pages. That can be put in an appendix and summarized/referenced here.
- Re-describing collections methods in too much detail
  - They should already be described in methodology. You should mention them but this section is for learning the results. If the reader wanted to know the methods in detail they’re read the methodology.

PETER MOLZER

DISCUSSION/ANALYSIS

In the end, our exhibit failed/succeeded in providing an adequate education of the encroachment of oil and mining
1.12 companies on our natural parks and the harms of that, as well as educating the children on the usefulness of renewable energy sources at different national parks based on their geography. This was our primary goal, and all other goals met or failed only slightly impact the overall performance of our design.

From the results, we found that the “fun” components of the exhibit, namely the fast button pushing and moving bear, contributed greatly to the “fun” factor that the children received. Educationally, this engagement may have taken away from some children’s attention to the actual content of the exhibit, something that we wanted to avoid.

Engagement data taken from the Arduino logs tell us that…

In terms of durability, the design was good/bad…

Considering that no children got hurt in the operation of the exhibit, I conclude that it is very safe for use, in part because of the low voltages and weak motors that are featured in its mechanisms.

Concerning the constraints of the exhibit listed in the problem statement, our exhibit is much smaller than the maximum size. This is demonstrated by the fact that assembly does not require putting the exhibit together in any manner, as the whole design fits within the provided carrying bag. Its set-up is brisk which is optimal for a travelling museum. Because of its relatively cheap construction of wood and cardboard, it is lightweight and practical to carry around. The design itself does not come close to the $100 budget set for it, which can be found in Appendix I.

1.13 CONCLUSION

Our team designed and constructed a travelling museum exhibit that was used to educate children on national parks, oil drilling, and renewable energy. The design allowed the user to interact with moving features of the exhibit and influence the progression of the story.

Our final design met the goals set forth in the problem statement stated in the introduction. It succeeded in the education of children on the impacts of oil and gas drilling in our national parks, as well as the reasons that different renewable energy sources are used in different environments. The exhibit acted as a good medium for education through tactile feedback and a hint of competition.

I think that our exhibit is visually very basic but serves as a simple and straightforward device that is easy to interact with by users. While the team lacked creativity in this field, the educational value makes up for it. Most of the effort and thinking went into programming, where two Arduino's were interfaced to control the motors and button, while also transmitting data to the MATLAB program. Doing this was a very tedious but educational task, which may help in the future with circuit design.

1.14 RECOMMENDATIONS

The pulley system that moves the bear character across the exhibit should be made of a proper gear and rack system for increased durability and precision. As of now, the mechanism has very basic knowledge of where it is. Because of this, it is difficult to calculate the distance the carriage must travel to reach the end, and how much the program should increment the motor for each step. Our current solution with a simple DC motor and twine will eventually wear down from friction, and suffers from slippage. With a better design, the sliding bear will not need to rest on dowels that rub against the top surface, instead being supported from underneath.

In general, the wiring of the exhibit should not require the use of a breadboard, which creates more endpoints for loose connections. A revision of this exhibit would feature shorter wires and ones that are directly soldered to each component. In the current design, wires often become loose or fall out during transport.

The Arduino-to-Arduino connection system is rudimentary and prone to failure, as miscommunication is common. Instead of using sets of digital and analog pins to communicate, the system should make use of a serial connection to send strings of text that could contain more complex data.

Given enough time and a larger Arduino with more digital pins, the large arcade button could flash to indicate that the user should press it. In our design, the light is static and gives no user feedback.

The next stage of development for this exhibit would include a full-wooden exterior, which while heavier, will provide more structural stability. A very lightweight wood could be used to increase the rigidity of the currently floppy back and top panels.

LESSONS LEARNED

Contributions

1.15

Resources

Reflections on Learning

Reflections on Working in a Team

STUDENT NAME #2

DISCUSSION

Through peer-review, we found that the exciting parts of the exhibit were the button and the moving progress meter.
1.16 The button is showing that the oil rigs should disappear 1.17
which allows them to learn while having fun. The progress meter being exciting is good for our exhibit because then it 1.18
motivates children to get more correct answers.

(Results after Friday) 1.19

The constraints for this exhibit included the budget and the size. The exhibit easily fits into a bag and can be easily assembled. The cost of the total exhibit, according to the BOM, was not close to $100 so all constraints were met.

CONCLUSION

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RECOMENDATIONS

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LESSONS LEARNED

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STUDENT NAME #3

1.20 **DISCUSSION**

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CONCLUSION

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1.22 **RECOMENDATIONS**

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LESSONS LEARNED

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1.23

REFERENCES

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[2] "Renewable Energy and our National Parks - Renewable Energy (U.S. National Park Service)." https://www.nps.gov/subjects/renewableenergy/energyandparks.htm (accessed Apr. 08, 2023).

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[4] A. Goldstein, I. C. S. February 13, and 2023, "Fossil fuel drilling threatens air and wildlife in national parks, advocacy group finds," *Idaho Capital Sun*, Feb. 13, 2023. https://idahocapitalsun.com/2023/02/13/fossil-fuel-drilling-threatens-air-and-wildlife-in-national-parks-advocacy-group-finds/ (accessed Apr. 08, 2023).

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AUTHOR BIOGRAPHIES

Peter L. Molzer was born in Livingston, New Jersey, in 2004. He graduated from Livingston High School with high honor roll, and with membership of the French National Honors Society. He was accepted as an undergraduate in mechanical engineering at Northeastern University in 2022.

From 2013, he participated as a member of the Livingston Robotics Club as part of a sub-team, called the Spongebots. There, he gained experience in PCB design, CAD, and other robotic sensing devices. Before leaving to study in Massachusetts, his team created an autonomous robot that could play soccer in a 2v2 matchup. To construct such a machine, he gained proficiency in machine learning software that could, with the help of an homemade omni-directional camera, could evaluate the location of an orange ball from a circular picture. Though never tested because of external factors, his robot won the appraise of many mentors and peers.

Mr. Molzer is the member of the French National Honors Society, and senior member of the Livingston Robotics Club. He plays the guitar.

James R. Zhang was born in Albany, New York, in 2004. He graduated from Shaker High School in 2022 with merit roll and as a National Merit Scholar. He was accepted to Northeastern University as an undergraduate in Electrical Computer Engineering.

Throughout high school, he was a member of the robotics team in the coding and fabrication sub-teams. There, he learned how to create metal parts as well as code. He also took DDE which helped him learn how to sketch designs by hand and in AutoCAD. His team would go on to be Semi-Finalist in Darwin Division at Nationals and New York Tech Valley Regional Winner.

Mr. Zhang was a recipient of the National Merit Scholar for his placement on the PSAT as well as Scholar Athlete for keeping a good standing in both his classes and at swim competitions.

APPENDICES

Appendices are for supplemental material that supports the arguments and descriptions in the main body of the report. They are typically not included in the main body for a few common reasons:

1. Too much information. Typical for Data sets where you just need averages, common responses, trends or other summary information for discussion and the Data set can be put in the appendix to ensure availability for the reader.
2. More detailed reference. Typical for test procedures, survey questions, or interview protocols. You do not need to list out every item in those while describing the tests in the methodology but it needs to be included somewhere.
3. Limited interest but important historically. Sometimes, things happen during a design process that are important to document for greater context and understanding or it simply would be important information for future designs and for the organization in general. This could be a more detailed description of an earlier prototype or a procedure, particularly when an edge case occurs. This is not important for describing the final artifact and the analysis of it but it's useful to have it documented somewhere.
4. Contract requirements. Client contracts typically require certain information like logged hours or third party validated test records. These can be included in the appendix to ensure delivery of all contract requirements in one document or at least in as few as possible.

The following are the required appendices. You may include more if you believe them to be necessary. Each appendix should start on a new page.

APPENDIX A – TEAM CONTRACT

Intro

All members must abide by these rules to ensure a successful project.

Respect

Work is late when it is submitted past the due date. All members should communicate to ensure all parties are submitting work on time. Members should arrive to meetings no later than the specified time unless communicated beforehand. If a team member is not meeting these expectations, they will be reminded of their responsibilities internally within the group. If the member is persistently showing up late or not doing work even after being told to do so, the matter will be presented to the professor for them to handle.

Commitment

Members will be expected to meet at a time set by the group that best suits everybody's class schedule. Members should be expected to meet up to four times a week, for two hours a session. Questions can be posted to the group chat at any time and other members should answer them at their convenience. Quality work is expected of all members, and will be judged upon before submission. Members should peer review each other's work. If everybody agrees on the quality of a member's work, it is approved for the project. Should a member produce work that does not meet the quality expectation, they will be asked to amend the issue themselves or ask for help from others. Note that other members should not be expected to complete another member's work.

Transparency

Team decisions should take place during meetings, where compromises should be made to suit everybody's needs. A consensus occurs when all members are happy with a decision, not just the majority. All project material should be located in a shared folder, and resources are listed publicly for the rest of the group to use. Group members who feel excluded should address the issue to the others and the group will find a solution that makes the member feel more excluded.

Communication

Our primary way of communicating with each other will be through a WhatsApp group chat. We will make sure that if a member has a suggestion or question that the group as a whole will discuss it. Members are expected to provide feedback to other member's work. If there is a disagreement within the group everyone is expected to be respectful and keep an open mind. A member will not say someone is outright wrong, but try to correct their mistake. If both options are correct then each member discusses which they think is more efficient. Members of the group should not feel that they are more or less important than another member. Once a week there will be a group meeting for reflecting on strengths and issues within the group. Again, each member should be respectful and politely tell the group if they have a concern about its teamwork.

Justice

After the group receives a project, there will be a group meeting to determine how work should be evenly divided. Evenly does necessarily mean all members each get very similar tasks. For example, if a member has a strength that the others are lacking then that member will primarily be focusing and working on that strength. To prevent conflict each member will always voice their opinions on the work efficiency and environment of the group. If a group member receives information that they are unable to complete their part of a project by the decided completion date, other members must be respectful of what may have happened. The member that has the conflict must make it clear to the group what they are able and unable to do. If a member does not tell the group about their situation the other members will explain to them their importance to the group and that they have responsibilities within it. If the member continues to not abide by the group's rules then they will be reported to the professor.

Team Goals

<u>Team Goals:</u>

- Communicate effectively with one another so that nobody is left in the dark
- Effectively allocate work to suit the strengths and weaknesses of each member
- Be on time to every meeting and submit the project by the deadline
- Document progress as the project progresses to make sure everyone does the same amount of work with equity.

<u>James's Individual Goals:</u>

- Learn to code more efficiently
- Be more creative in problem solving

<u>Peter's Individual Goals:</u>

- Resolve bad CAD practices that I have learned over the years
- Get better at working in a team as opposed to an individual
- Effectively answer question to help others grow

Andrew's Individual Goals:

- Become better acquainted with coding software
- Organize my own responsibilities ahead of time
- Be the best teammate as possible

Team Roles

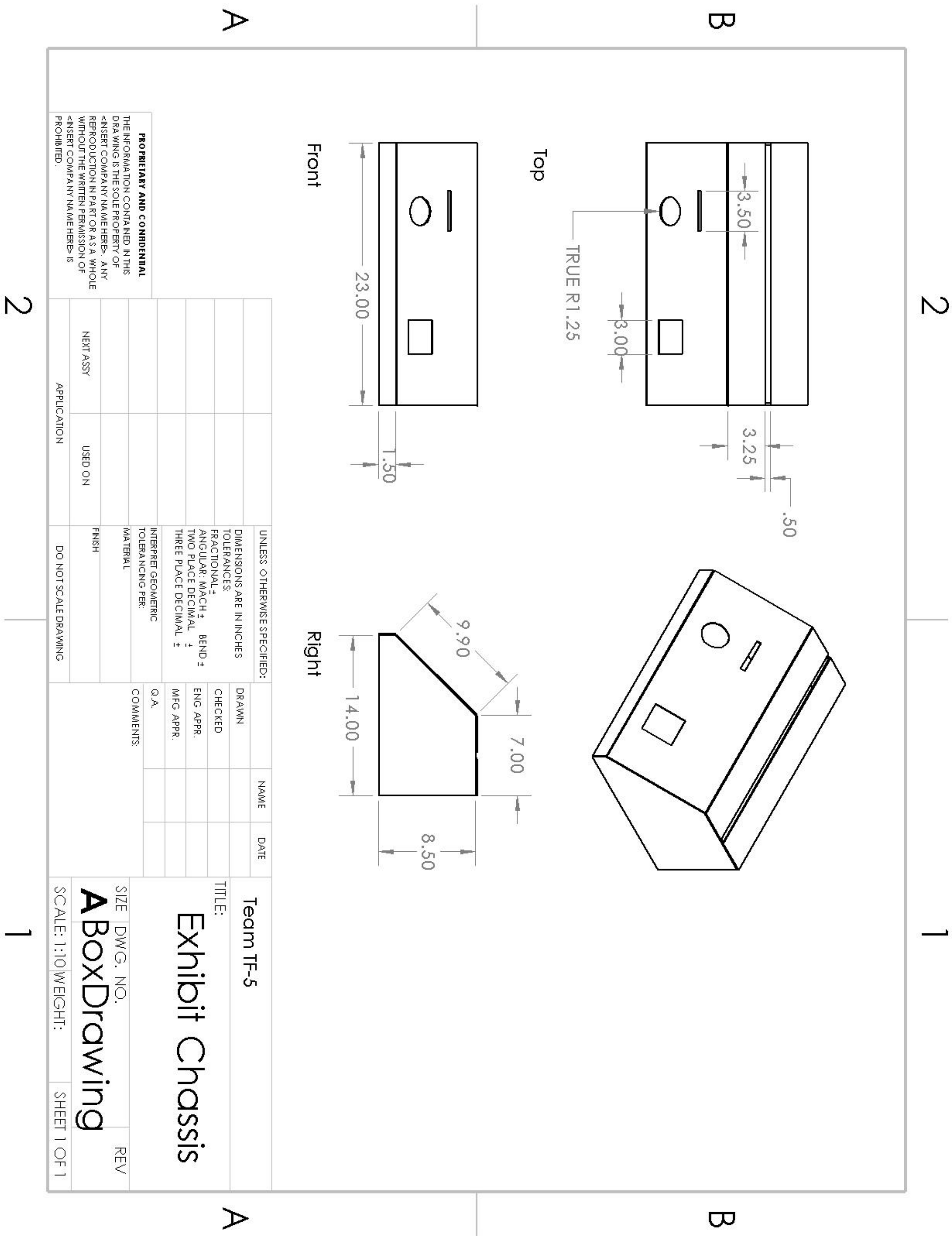
- Project Manager 1: Peter
- Project Manager 2: James
- Project Manager 3: Andrew

APPENDIX B - DESCISION ANALYSIS

Kepner-Tregoe Decision Matrix				
Musts	Weight	Hydroelectric Demonstration	Ocean Trash Cleanup	Tidal Energy Generation
Cost (<$100)	-			
Safe	-			
Transportable	-			
Wants				
Engaging	7		9	9
Competetive	6		9	7
Educational	10		5	9
Design difficulty	10		8	6
Fun to play	6		9	6
Appropriate	9		8	10
Interactive	6		10	9
Easy to Use	9		6	9
Builders' interest	4		5	9
Total		**0**	**507**	**552**

Our three design ideas were placed in a Kepner-Tregoe Decision Matrix that objectively decided for us what the best exhibit idea was. We determined that the exhibit must of course stay within the limits of the constraints, namely the budget and size. We ranked the "wants" based on what we valued most in our problem statement. Overall, the educational value and the ability for us to create the exhibit are the most important.

APPENDIX C - FINAL AUTOCAD/SOLIDWORKS DRAWINGS



APPENDIX D – PRODUCT TESTING RESULTS

** from Milestone #6 – any typos fixed and comments addressed.

APPENDIX E – CODE USED IN PROJECT

MOTOR, SERVO, RFID ARDUINO CODE

```
#include <MFRC522.h> //RFID
#include <SPI.h>
#include <SparkFun_TB6612.h>
#include <JC_Button.h> //Useful for getting button state
#include <Servo.h>  // servo library

#define AIN1 7
#define AIN2 8
#define PWMA 5
#define STBY 4
#define SRVO 3

#define gamePin A0
#define buttonPin A3
#define rfidPin 6
#define rfidPin2 A4
#define servoPin A1
#define resetPin A2

#define SS_PIN 10
#define RST_PIN 9
MFRC522 mfrc522(SS_PIN, RST_PIN);   // Create MFRC522 instance.

int uid; //Stored RFID UID
unsigned long OLDuid; //Past UID

int currentTag = 0; //Most recent tag

const int offsetA = 1;

Button myBtn(2);       // define the button
Servo servo1;  // servo control object

int rigPos = 145; //Raised Rig
bool isFinishedLowering = false;
int motorBuffer = 0; //Motor movement

bool buttonToggle = false; //Toggles the button on and off
int gamestate; //Recieved from the other arduino

Motor motor1 = Motor(AIN1, AIN2, PWMA, offsetA, STBY); //Init the motor
int motorIncrement; //Integer value of where the motor rig is

void setup() {
  servo1.attach(SRVO, 900, 2100);  //Connect the servo to pin
  Serial.begin(9600);
```

```
  myBtn.begin();              // initialize the button object
  servo1.write(0);    // Tell servo to go to 90 degrees

  SPI.begin();      // Initiate  SPI bus
  mfrc522.PCD_Init();   // Initiate MFRC522

  pinMode(servoPin,OUTPUT); //Config pins
  pinMode(resetPin,OUTPUT);
  pinMode(buttonPin,OUTPUT);
  pinMode(rfidPin,OUTPUT);
  pinMode(rfidPin2,OUTPUT);
  //gamestate input on A0
}

void loop() {
  gamestate = getGameState(); //Gets gamestate
  getGameState();

  if(gamestate==3) { //Gamestate 3: RFID tag reading
    Serial.println("start Gamestate 3");
    disableRig(); //Lowers rig
    myBtn.read(); //Retrieves button state

    while(!myBtn.wasReleased()) { //waits until the button is pressed to confirm
      myBtn.read();
      if(mfrc522.PICC_IsNewCardPresent()) { //Sets currentTag when new RFID tag is inserted
        uid = getID(); //Gets id of tag when present
        if(uid != 0){

          Serial.print("New Card detected, UID: "); Serial.println(uid);
          if (uid == 4908)  { //Checks UID
            Serial.println("IDLOWER1");
            currentTag = 1; //If its the tag, set the current tag variable
          }
          else if (uid == 17622)  { //ditto
            Serial.println("IDLOWER2");
            currentTag = 2;
          }
          else if (uid == 27416)  { //ditto
            Serial.println("IDLOWER3");
            currentTag=3;
          }
        } else {
          Serial.println("No new card");
          uid=0; //Loops again if no card is read
        }

      }
    }
    sendRFIDState(currentTag); //Sends which tag is read after button is pressed
    currentTag = 0;
```

```
    delay(300);
    sendRFIDState(currentTag); //Stops sending that tag, in case its wrong
    //digitalWrite(A5,LOW);
    //Serial.println("gamestate: 3");


  } else if (gamestate==2) { //Gamestate 2, where the program is instructed to lower the rig
    isFinishedLowering = false; //Keeps track if the rig is lowered yet
    unsigned long startTime = millis();
    Serial.println("resetting rig");
    resetRig(); //Raises the rig upright
    while((!isFinishedLowering)) { // &&&&(millis()<(startTime+12000))&&(getGameState()==2)
      myBtn.read();              // read the button
      if (myBtn.wasReleased())    // if the button was released, change the LED state
      {
        lowerRig(); //Lowers rig one incrament
        updateMotor(); //Moves motor a bit
      }
      if(rigPos<0) { //Once the rig is too low, it stops lowering
        isFinishedLowering = true;
        disableRig(); //resets rig downward
      }
      Serial.println("Sent servo state low");
      sendServoState(isFinishedLowering); //Pulses the servo pin such that the program is still running, LOW
      //Serial.println("gamestate: 2");

      updateMotor();
    }
    Serial.println("Sent servo state high");
    unsigned long initTime = millis();
    while(millis()<(initTime+500)) { //Sends the servo pin HIGH for 500ms
      sendServoState(true);
      Serial.println("SENDING HIGH");
    }
    sendServoState(false);
    //Serial.println("gamestate: 2");

  } else if (gamestate==1) { //Default state, sends button pin high if button is pressed
    if(rigPos!=0) { //Lowers rig if its not lowered
      disableRig();
    }
    updateButton();


    Serial.println("gamestate: 1");
  }
  updateButton(); //Updates button state
  updateMotor(); //Drives motor
}

void lowerRig() { //Lowers rig by one increment
```

```
  // Tell servo to go to 90 degrees
  Serial.println(rigPos);
  if(rigPos>(145-29*3)) { //Lower rig when above wood
    rigPos-=(29/2);
  } else {
    rigPos-=1000; //Completely lowers rig if its below the wood
  }
  servo1.write(rigPos);
  incrementMotor(); //Incraments motor when you lower the rig
}

void resetRig() { //Raises rig
  rigPos=145;
  servo1.write(rigPos);
}

void disableRig() { //Lowers rig
  rigPos = 0;
  servo1.write(rigPos);
}

bool updateMotor() {
  if(motorIncrement>0) { //Drives motor forward
    if(motorBuffer>0){
      motor1.drive(100);
      motorBuffer-=30;
      return true;
    } else if (motorBuffer<0){ //Drives backward if buffer is negative
      motor1.drive(-100);
      motorBuffer-=30;
      return true;
    } else { //Breaks if its zero
      motor1.brake();
      return false;
    }
  }
  return false;

  //Returns true is motor is active
}

/**
 * mfrc522.PICC_IsNewCardPresent() should be checked before
 * @return the card UID or 0 when an error occurred
 */
unsigned long getID(){ //https://stackoverflow.com/questions/32839396/how-to-get-the-uid-of-rfid-in-
arduino
  if ( ! mfrc522.PICC_ReadCardSerial()) { //Since a PICC placed get Serial and continue
    return 0;
  }
  unsigned long hex_num;
```

```
  hex_num =  mfrc522.uid.uidByte[0] << 24;
  hex_num += mfrc522.uid.uidByte[1] << 16;
  hex_num += mfrc522.uid.uidByte[2] <<  8;
  hex_num += mfrc522.uid.uidByte[3];
  mfrc522.PICC_HaltA(); // Stop reading
  return hex_num;
} //

int getGameState() { //Retrieves the gamestate based on pwm signal from other board
//Uses only one pin!
  unsigned long duration; //Tracks pulselength
  duration = pulseIn(gamePin,HIGH); //Gets pulselength
  Serial.print("Pulse duration: ");
  Serial.println(duration);

  if(duration<500) {  //Pulelength is low, i.e. low voltage from other board
    Serial.println("returning 1");
    return 1;
  } else if(duration < 900) { //Gamestate 2
    return 2;
  } else if(duration <1300) { //gamestate 3
    return 3;
  } else {
    return 4; //Gamestate 4, shoudn't happen though
  }
}

void updateButton() {
  myBtn.read();               // read the button
  if (myBtn.wasReleased())    // if the button was released, change the LED state
  {
    digitalWrite(buttonPin,HIGH); //If the button is pressed, send signal to other board
                              // Pulse as to not stop program for long
    digitalWrite(A5,HIGH);
    delay(120);
    digitalWrite(buttonPin,LOW);
    digitalWrite(A5,LOW);
  }
  digitalWrite(buttonPin,LOW); // end pulse

  if (myBtn.pressedFor(4000)) { //Checks for reset
    digitalWrite(resetPin,HIGH); //Sets reset pin high, which restarts matlab program
    delay(200);
    digitalWrite(resetPin,LOW);

  }

}
void sendRFIDState(int state) { //Sends combination of digital pins for for states
  if(state==0) { //RFID card is not found yet
    digitalWrite(rfidPin,LOW);
```

```
    digitalWrite(rfidPin2,LOW);
    Serial.println("sent RFID state 0");
  } else if(state==1) { //Card 1 is read
    digitalWrite(rfidPin,HIGH);
    digitalWrite(rfidPin2,LOW);
    Serial.println("sent RFID state 1");
  } else if(state==2) { //Card 2 is read
    digitalWrite(rfidPin,LOW);
    digitalWrite(rfidPin2,HIGH);
    Serial.println("sent RFID state 2");
  } else if(state==3) { //Card 3 is read
    digitalWrite(rfidPin,HIGH);
    digitalWrite(rfidPin2,HIGH);
    Serial.println("sent RFID state 3");
  }

  resetMotor();
}

void sendServoState(bool state) { //Sends signal to other arduino that its done
  if(state) {
    digitalWrite(servoPin,HIGH); //Servo is lowered
  } else {
    digitalWrite(servoPin,LOW);
  }
//  digitalWrite(servoPin,LOW);
}

void incrementMotor() { //Moves the motor one step
  motorIncrement+=1; // Adds one to position tracker
  motorBuffer+=300; //Adds 300 to motor buffer

}
void decrementMotor() { //Moves the motor one step back
  if(motorIncrement>0) {
    motorIncrement-=1; //Only decreases increment when its positive
  }
  motorBuffer-=300; //Decreases from motor buffe
}
void resetMotor() { //Resets motor to initial position. Called when program is restarted
  motorBuffer-=motorIncrement*300;
  motorIncrement=0; //resets position tracker
}
```

*****INSERT CODE FOR MATLAB HERE*****

APPENDIX F – WIRE DIAGRAMS FOR SPARKFUN BOARDS

*** Make it clear to what you are presenting – labels!

APPENDIX G – PHOTO LOG

CARDBOARD PROTOTYPE

Image 1: Raw Materials (Cardboard)

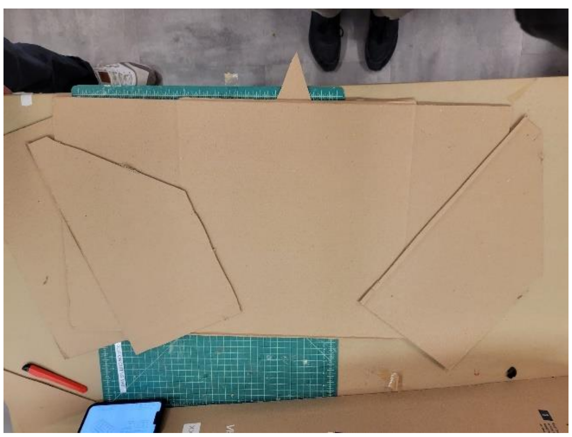


Image 2: Cutout of the walls and bottom panel

Image 3: Bottom, walls, top with slot, and front piece all attached

Panels are taped temporarily, then glued with hot glue. The patchwork cardboard to the left is evidence of shortening the whole model down from 30 inches wide to 26, in order to fit in the carrying bag better. Other than this, no other design changes were made.

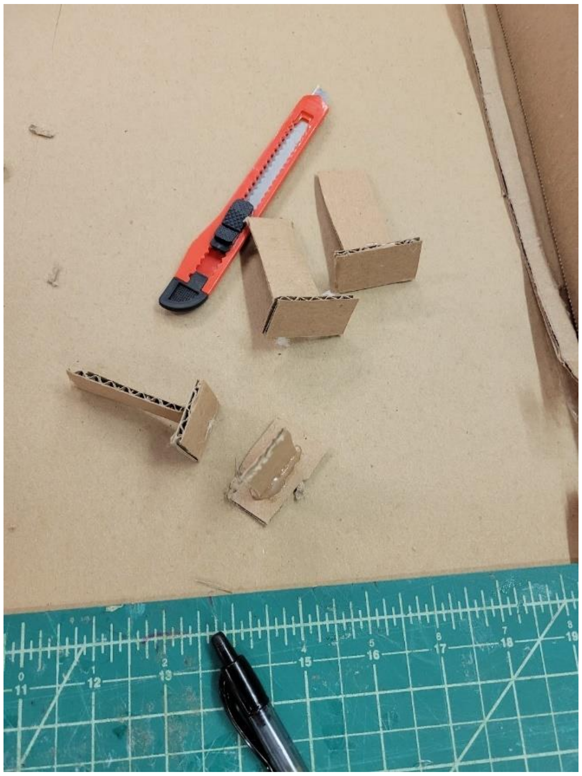


Image 4: “Levers” that slot into front panel

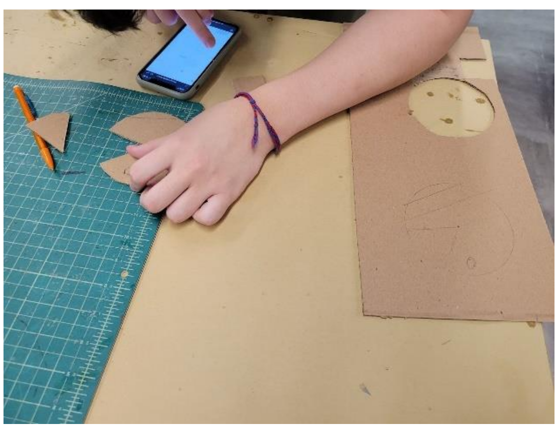


Image 5: Creation of Pacman piece

Image 6: Pacman on a stick. The stick extends far below the character into the machine, and serves the purpose of guiding Pacman along the slot as well as ballast to keep it upright.

Image 7: Start/Reset/Confirm button. The button is large and inviting, making it attractive for children. In the final

design this may light up when a press is needed.

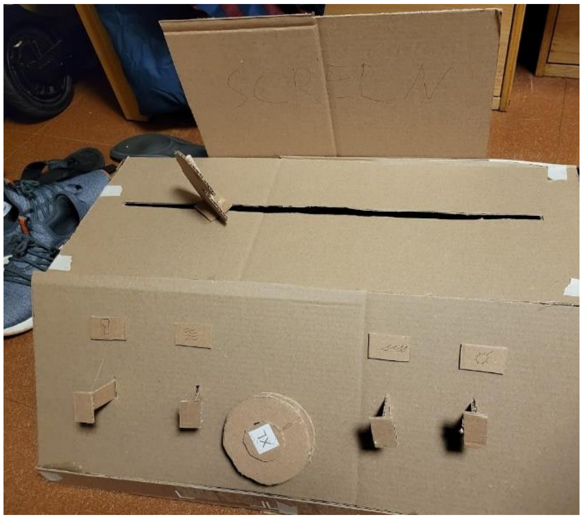


Image 8: View of the completed build. Above each lever, there is a placeholder piece for each of the animatronic models that will activate when the lever is activated.

FINAL DESIGN

Figure 1: Raw materials

Figure 2: Cutting out walls

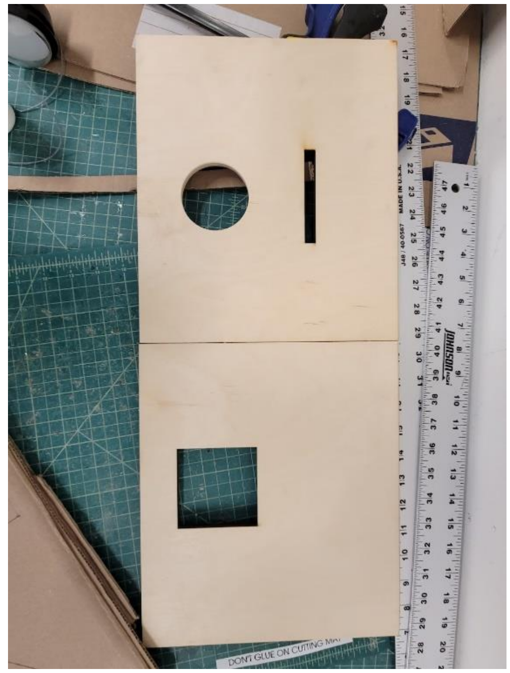


Figure 3: Laser Cut wood front console

Figure 4: Join between console boards

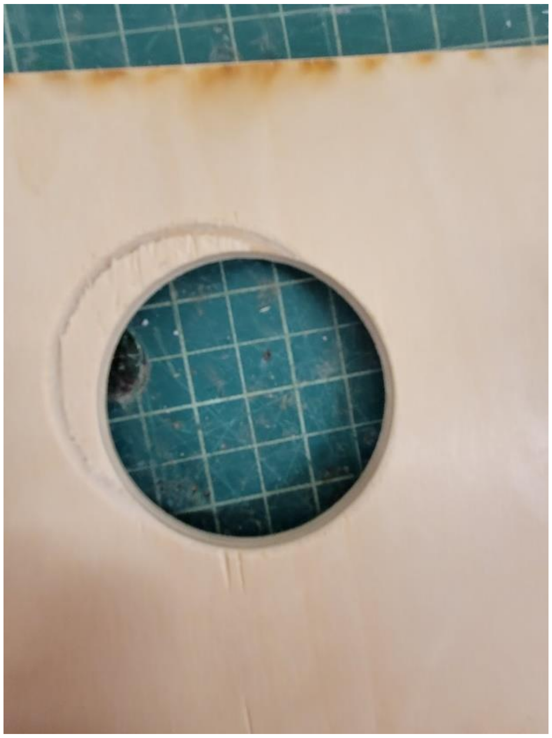


Figure 5: Failed and Successful enlarging of buttonhole

Figure 6: Assembled walls, front console, bottom

Figure 7: Finished build, temporary top

Electronic Implementation

Figure 1: wooden dowel as pulley

Figure 2: Trolley, temporary cardboard

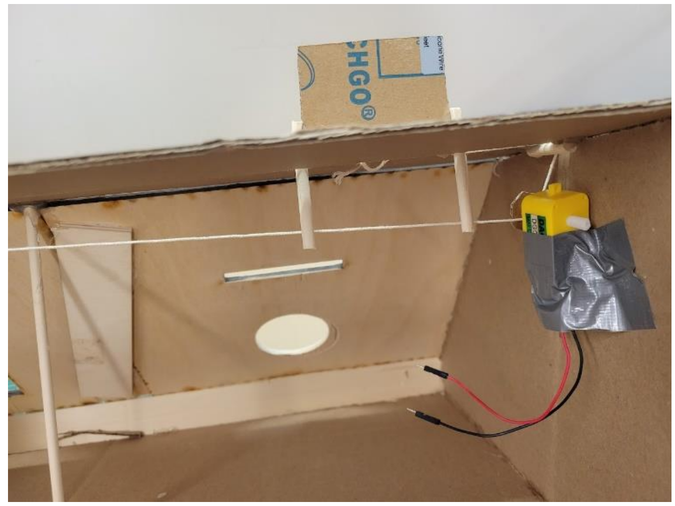


Figure 3: String and Motor attached

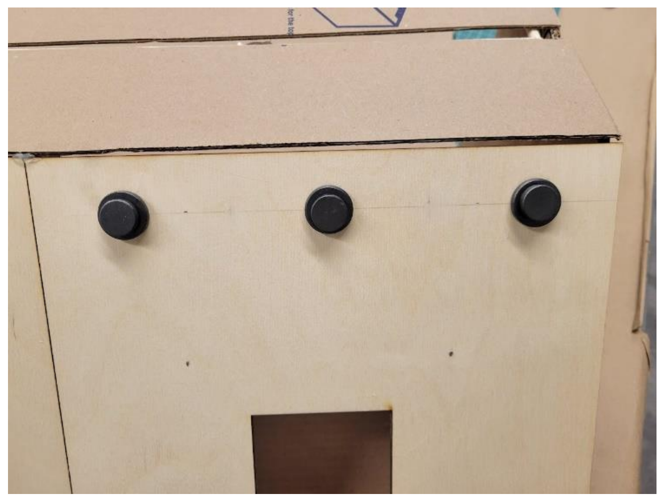


Figure 4: Magnets for storage of each block

Figure 5: assembly of 3d printed servo stand and oil rig part

Figure 6: Button and button gasket

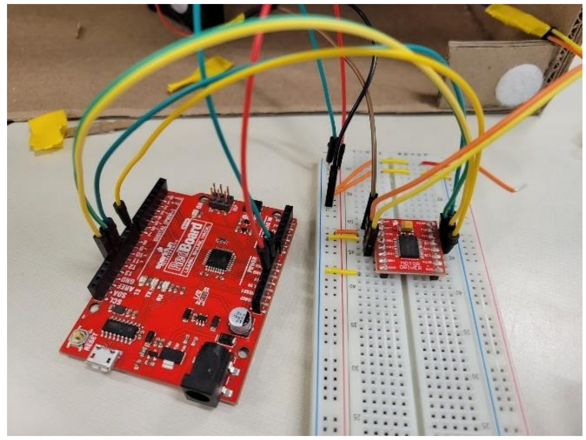


Figure 7: wiring of motor driver

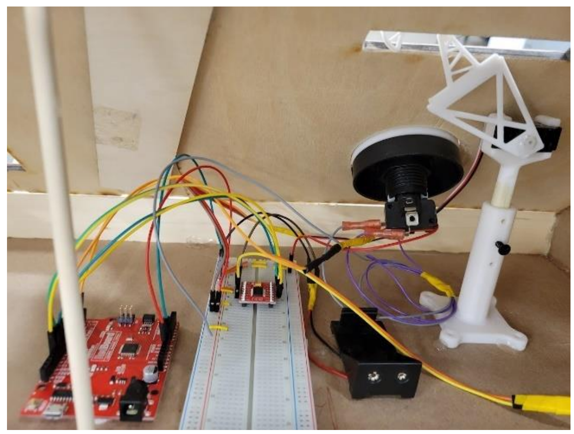


Figure 8: wiring of button, 9v battery, servo, and driver

APPENDIX H – FINAL GANTT CHART

**Updated to show the evolution of the entire project – 11 x 17 (z-fold)

APPENDIX I – FINAL BUDGET

Bill of Materials				
Items	Quantity	Source	Unit Cost	Total Cost
Sparkfun Components				
RedBoard Uno	1	Sparkfun Kit	$0	$0
10k ohm resistors	6	Sparkfun Kit	$0	$0
330 ohm resistors	4	Sparkfun Kit	$0	$0
Push buttons	5	Sparkfun Kit	$0	$0
LEDs	4	Sparkfun Kit	$0	$0
breadboard minis	2	Sparkfun Kit	$0	$0
Piezo speaker	1	Sparkfun Kit	$0	$0
Jumper wires	26	Sparkfun Kit	$0	$0
Tricolor LED	1	Sparkfun Kit	$0	$0
Dual motor	1	Sparkfun Kit	$0	$0
Potentiameter	1	Sparkfun Kit	$0	$0
Breadboard holders	2	Sparkfun Kit	$0	$0
RFID Sensor	1	FYELIC	$0	$0
RFID Tag	3	FYELIC	$0	$0
Tools/Items Needed for Project				
Box cutter	1	FYELIC	$0	$0
3d Printer	1	FYELIC	$0	$0
Super glue	1	FYELIC	$0	$0
Laser cutter	1	FYELIC	$0	$0
Velcro	8	FYELIC	$0	$0
Items Needed for Poster				
Laptop	1	Owned	$0	$0
Energy plant props (3d printed)	3	FYELIC	$0	$0
Progress monitor (3d printed)	1	FYELIC	$0	$0
Paint/Markers	1	Bought	$15	$15
Cardboard	3 20"x20"	Bought	$10	$30
Wood	2 12"x12"	Bought	$8	$16

Total Cost	**$61**

APPENDIX J – PROJECT HOURS LOG

P1 M1	Peter	Andrew	James	Milestone Total
Research	5	2.5	2	
Presentation Prep	1	0	0	
Memo Writing	4	0	0.5	
Gantt Chart	0.5	0	0	
Dunker Diagram	0.4	0	0	
Design Notebook	0.8	0	0	
Individual Total	11.7	2.5	2.5	16.7
P2 M2	Peter	Andrew	James	Milestone Total
Research	0	0.5	1	
Presentation Prep	0	0	5	
Memo Writing	1	0.5	2	
Gantt Chart	1	0	0	
Ideation	2	2	1	
Design Notebook	1	1.5	1.5	
Individual Total	5	4.5	10.5	20
P2 M3	Peter	Andrew	James	Milestone Total
Research	1	2	0.5	
Presentation Prep	0	3	0	
Memo Writing	3	2	0	
Gantt Chart	0.25	0	0	
Prototype Construction	3	3	1.5	
Design Notebook	1	1	0	
Individual Total	8.25	11	2	42.5
P2 M4	Peter	Andrew	James	Milestone Total
Research	0.5	0	1	
Presentation Prep	2	0	0	
Memo Writing	2	1	1	
Gantt Chart	0.5	0	0	
Exhibit Constrution	5	3	0	
Design Notebook	1	2	0	
Proof of Concept	1	0	2.5	
Individual Total	12	6	4.5	45
P2 M5	Peter	Andrew	James	Milestone Total
BOM	0.25	0.25	0	
Evaluation	0.5	0.5	0.5	
Memo Writing	2.5	0.5	0.5	
Gantt Chart	0.5	0	0	
Exhibit Constrution	8	0	3	
Design Notebook	1	0	1	
Individual Total	12.75	1.25	5	19
P2 M6	Peter	Andrew	James	Milestone Total

Individual Total	0	0	0	**0**
P2 M7	Peter	Andrew	James	**Milestone Total**
Indivial Report Section	10			
Appendicies	4			
Group Sections	2			
Individual Total	16	0	0	**16**
Project Total	**65.7**	**25.25**	**24.5**	**159.2**