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Mechanical and Computer Engineering Student

Northeastern University, 2020

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About Me

I am a 5th year mechanical and computer engineering student at Northeastern University in Boston, USA. My interest in bio-inspired design led me to pursue mechanical engineering to create technologies that borrow from mechanisms found in the world around us. I started the computer engineering curriculum to improve my software and hardware skills and become a more rounded engineer better equipped for the design of robotic systems that can improve society’s quality of life.

I have been playing the violin since the age of 5 and love to play in my free time as well as go to orchestral performances. I also like to draw and have included some of my work in this portfolio.

Being Puerto Rican, I was raised with Spanish. In addition, I have taken interest in the Japanese language. This has prompted me to make language partners and explore different perspectives from a culture very different from my own.

Summary of Work Experience

At iRobot, being my first co-op experience, I had the freedom to work with the projects that I was interested in. I was introduced to machining, rapid prototyping, and testing. I was able to take training courses with machinists, electrical technicians, and work closely with industrial rapid prototyping equipment as well as create various testing fixtures .

I had much more independence and responsibility at my second position at Amazon Robotics as a hardware engineering co-op. I frequently created and pushed ECOs design changes and standards (ISO and AGMA) switches for parts, assemblies, and drawings. In addition to testing, fixture design, and assembly.

My third co-op at TechShare in Tokyo, Japan, in addition to technical design for robotic arm (uFactory and Dobot platforms) end-effectors and demo parts, I went to 4 major robotics exhibitions in Japan and exhibited and explained our developed systems in both English and Japanese. This experience pushed me far from my comfort zone to an area of marketing and business in a foreign language.

Pneumatically Actuated Gripper (iRobot, 2017)

From left to right: Modular version of gripper, first print of palm with two fingers, early finger prototype

Overview:

During my first co-op as a systems test engineering co-op at iRobot, I had access to industrial 3D printers such as Objet, Fortus, MarkForged, and HP platforms and I had to take advantage of the resources in the limited time. Being very interested in soft robotics, and having produced actuators by silicone molding, I explored the feasibility of printing a soft robotic actuator with an Objet printer with variable stiffness material printing.

Purpose:

- To experiment with the feasibility of manufacturing a soft robotic component with a Objet 3D printer
- Exercise practical CAD modeling skills
- Go through general procedures when designing with industrial 3D printers

Challenges:

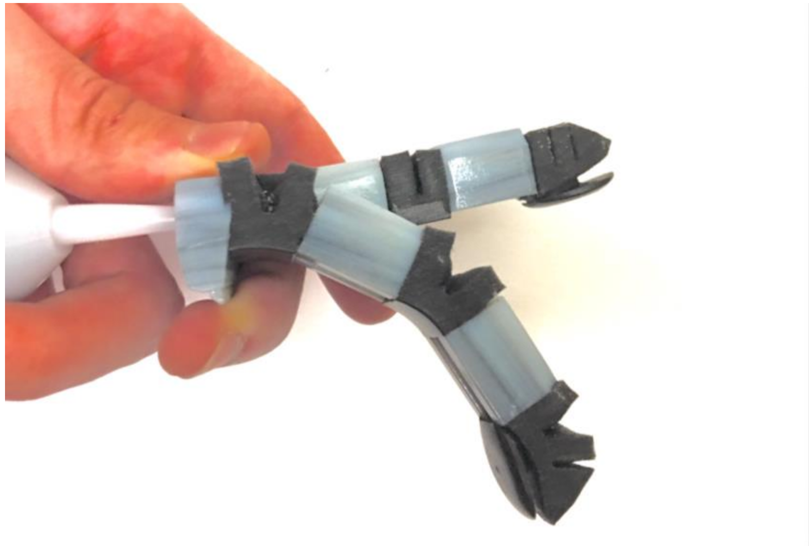
- Printer tolerances required some iteration and testing to understand better
- Interface between solid and flexible material needed to be substantial in area for secure adhesion
- Air pocket number, depth, and height had to be experimentally optimized
- Elastic modulus of the flexible material had to be experimentally optimized

Outcome:

- Small samples with different elastic moduli were printed to verify their strength and flexibility
- Finger modules were printed individually to verify the tolerances of the printers and the effectiveness of the fingers
- Contact surface area and configuration was altered to create resistant and durable seals between the two materials and parts
- Parts of the gripper were printed in a modular form for individual testing, and the number of air pockets, their depth, and height were verified and changed accordingly (palm, fingers, etc.)

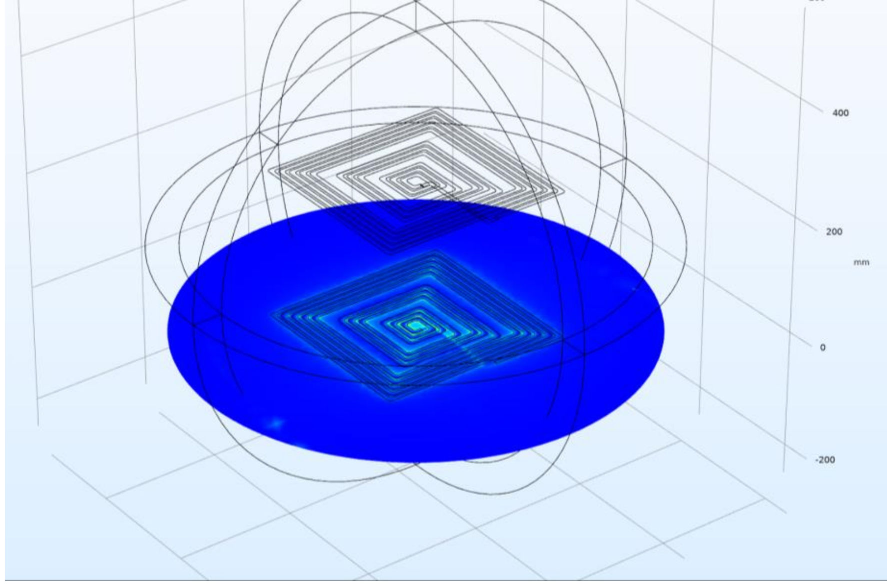
Skills Learned:

- Developed skills to work with industrial 3D printers (Objet variable stiffness printer): Printing assemblies, tolerances, and durability expectation
- Applied PneuNets (essential design concept in soft robotics) in a gripper design



Two finger module with unactuated finger in back and syringe actuated finger in front

Magnetic Resonance Drone Charging Simulation (Capstone project, 2020)



Overview:

With drone technology advancing quickly, drone applications continue to grow. Being one of the major limiting factors, flight time should be extended so drones can continue their mission without traditional charging interruptions, where drones would abandon the mission and have to land to charge. My capstone project group aimed to solve this by providing long distance wireless charging through magnetic resonance technology. Although the project was cut short by the Covid-19 pandemic, we made significant progress in arranging the schematics, simulations, and developing drone attachment designs. My role in the project was to complete the coil simulation and optimization.

Purpose:

- Use a multiphysics simulation software (Comsol) to simulate magnetic resonance power transfer between a transmitter and receiver coil
- Optimize coil design for long distance power transfer and use these optimized parameters to manufacture coil

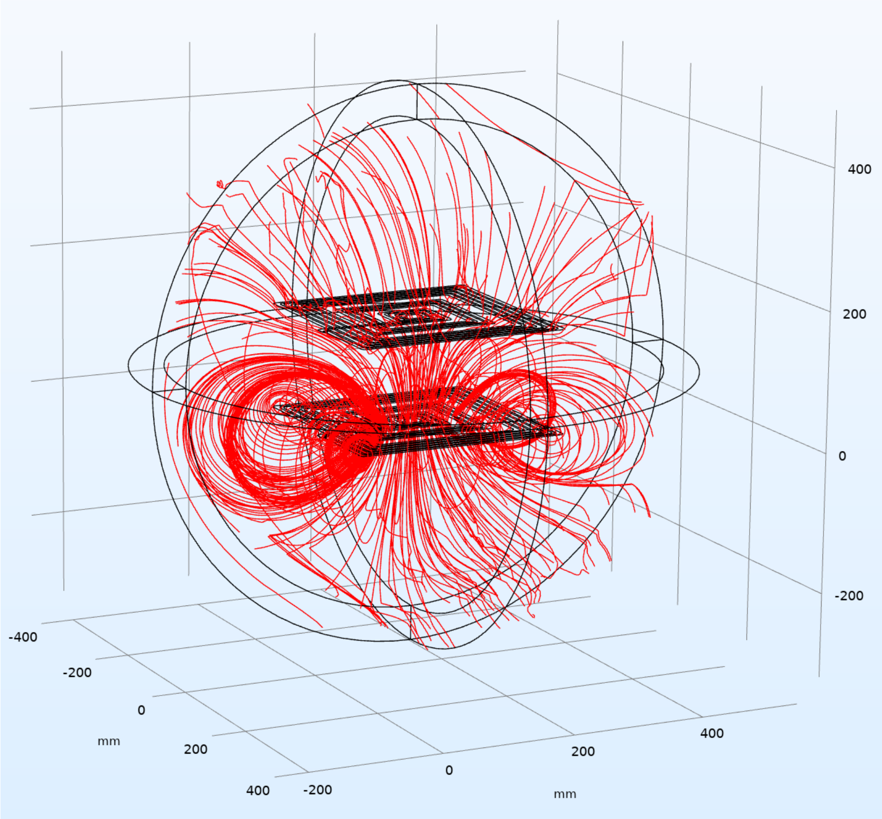
Challenges:

- Learn a new software and debug simulation and provide results within deadlines
- Create a simulation that would provide accurate results, but use assumptions that were valid

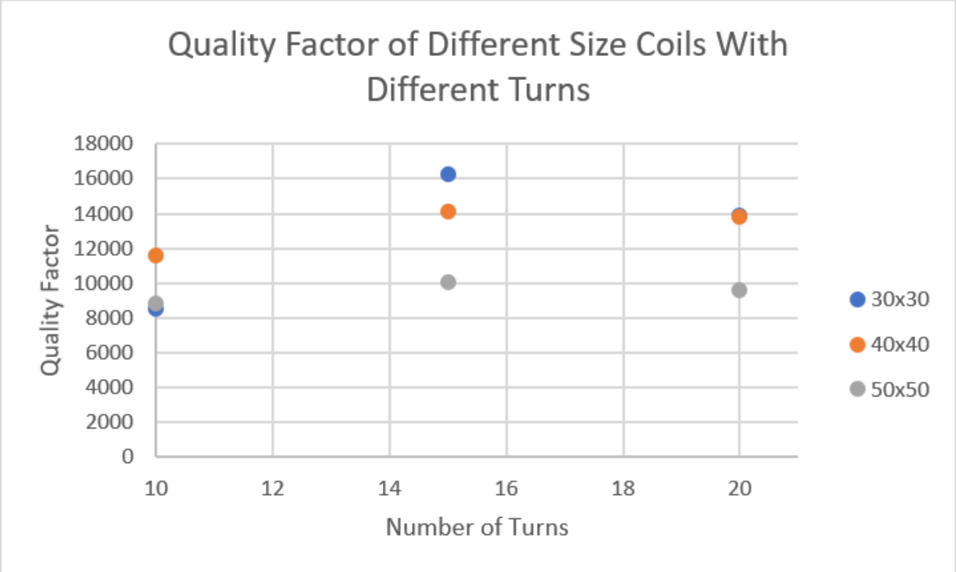
Figures from top to bottom:

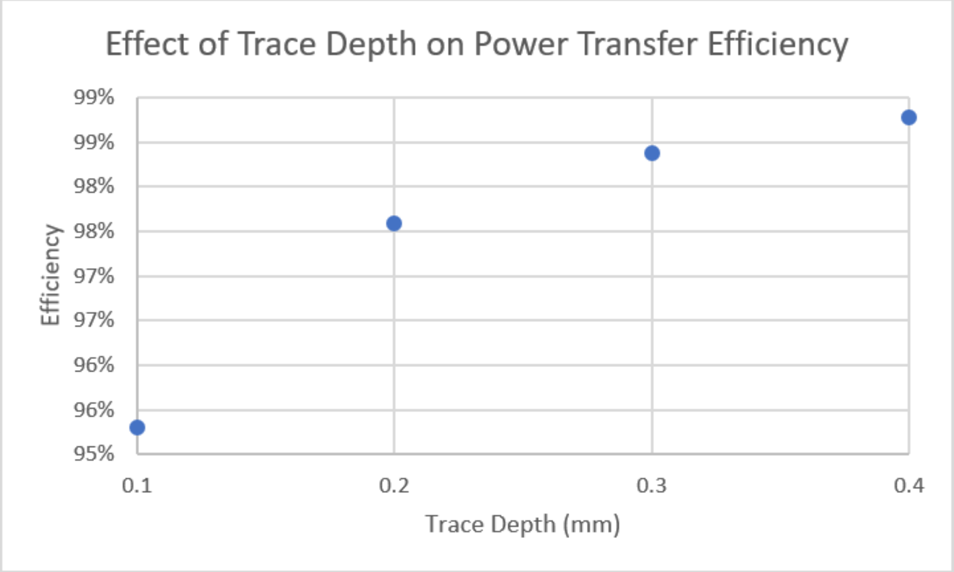
Transmitter and receiver coil with magnetic flux streamlines

Transmitter and receiver coil with magnetic flux density normal to coil plotted



Magnetic Resonance Drone Charging Simulation (Capstone project, 2020)





Process:

- Coil modeled as a perfect conducting surface
- Air sphere modeled encompassing the two coils and infinite boundary conditions on the outer surface of the air sphere
- Virtual circuits attached to inputs and outputs of coils
- Single coil simulations to optimize coil quality factor using coil size and coil turns as variable parameters (top figure)
- Two coil simulations to optimize power transfer efficiency using trace thickness as variable parameter in parametric sweep (bottom figure)

Magnetic Resonance Drone Charging Simulation (Capstone project, 2020)

Outcome:

- 31.4 x 31.4 cm (30 + 2*trace width) coil with 11 turns as optimal
- Achieves over 40% efficiency at 30 cm between coils

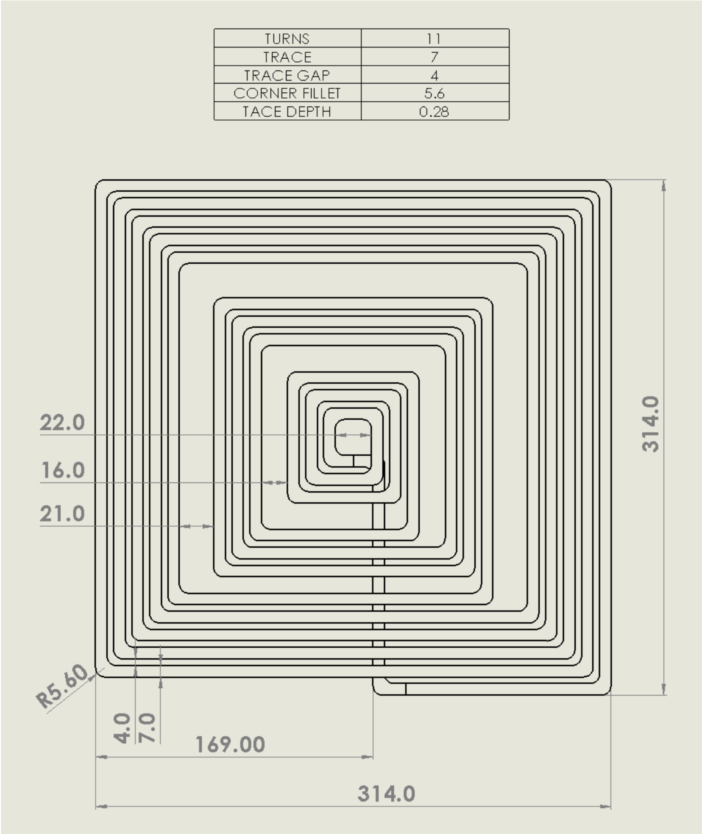
Skills learned:

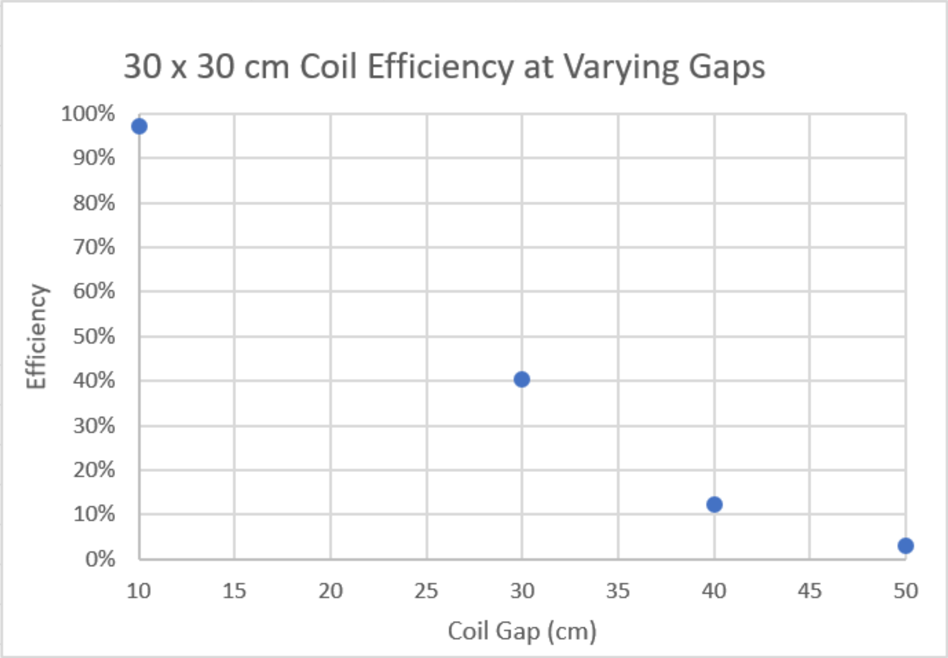
- Comsol simulation techniques
- Magnetic resonance and coil concepts

Figures from left to right:

Final coil design drawing

Final coil efficiency at different gaps between transmitter and receiver coils





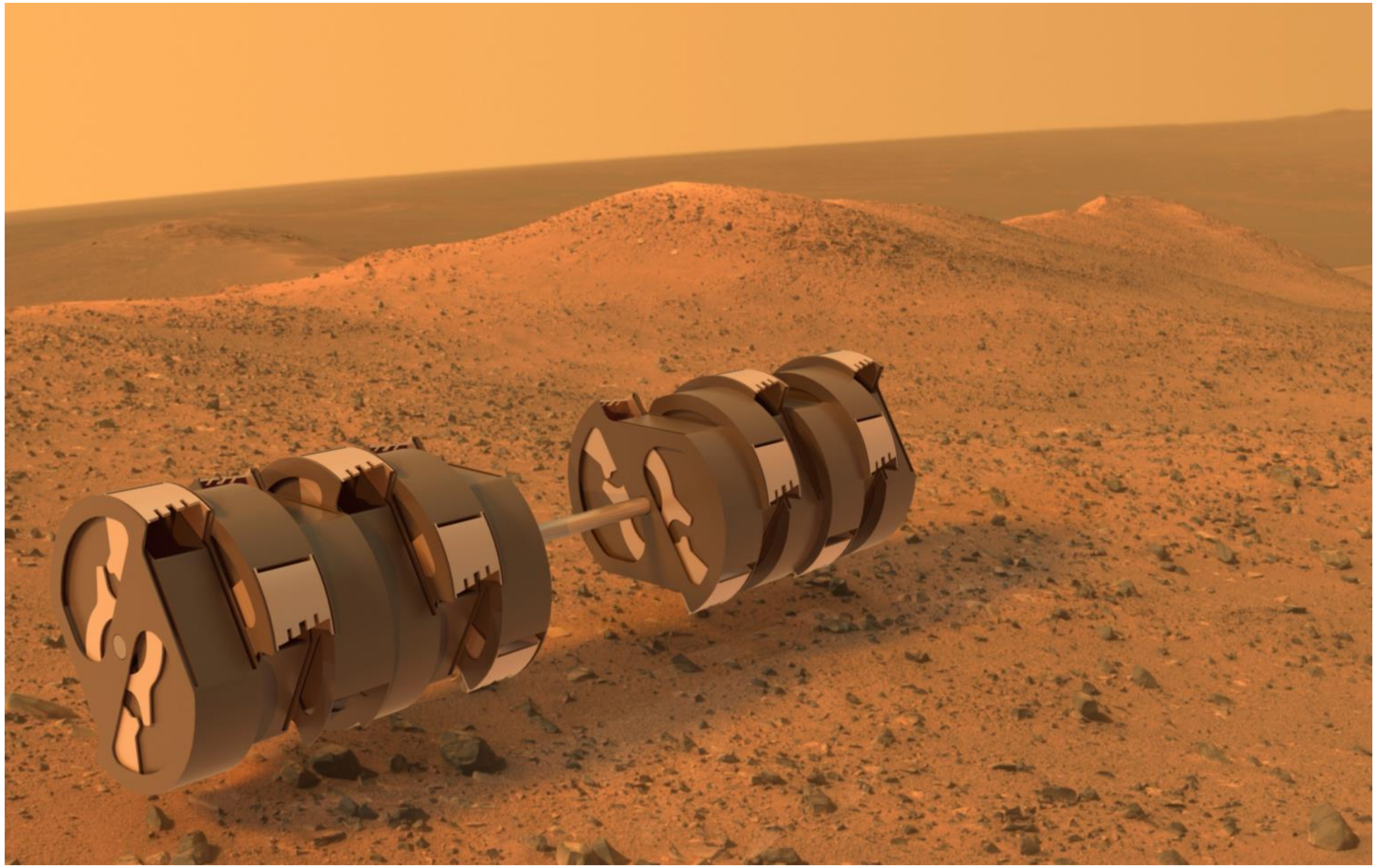
NASA Mars Regolith Excavator Design (2020)

Overview:

Looking for things to do during quarantine, I found a NASA design challenge hosted by GrabCad. The light-weight excavator vehicle under development facilitates the transport of the vehicle through space, but also limits the downward force required by traditional excavation techniques. The challenge consisted of improving the excavator/regolith storage drum for their vehicle to use.

Purpose:

- Practice designing under set parameters and expected outcomes
- Get exposure to the design techniques used at NASA
- Practice CAD design and simulation
- Practice SolidWorks rendering and presentation



SolidWorks PhotoView 360 render of my drum excavator design set in Mars background and lighting

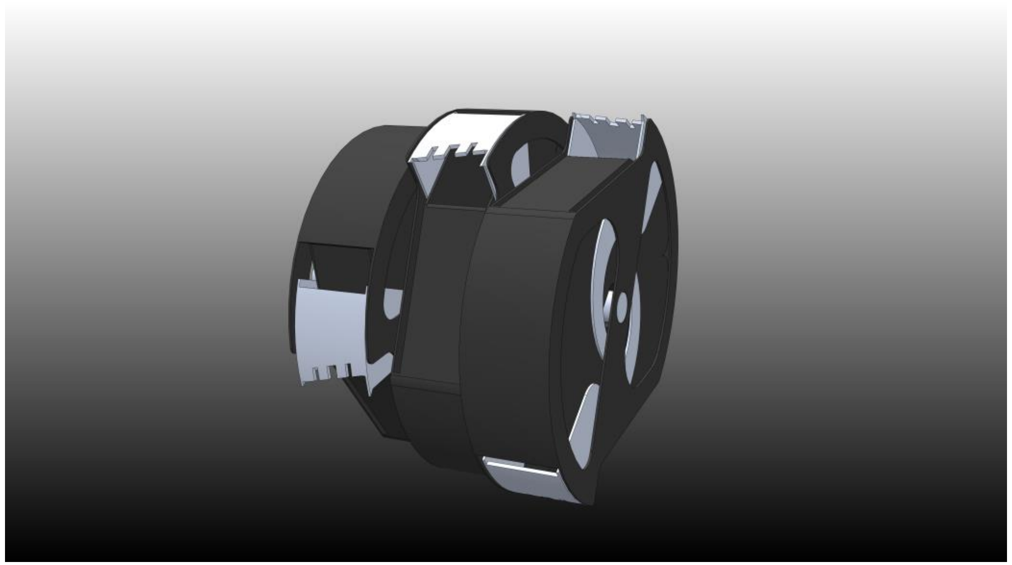
NASA Mars Regolith Excavator Design (2020)

Design Outcomes:

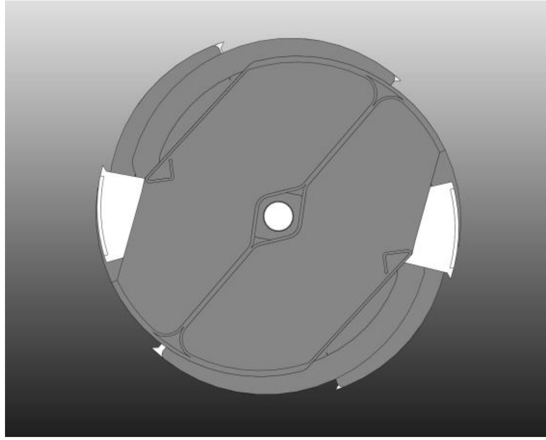
- Spring loaded shovels are set by contact with the ground and triggered when counter force is insufficient
- One drum made of three modules and one module is equipped with two counteracting shovels that will trigger at the same time, allowing for some cancelation of forces and decreasing net force on the mechanism
- Spring loaded shovels work with gravity and the rotation of the drum to provide more momentum
- Designed to be as light as possible and maximize regolith collection
- Sheet metal design

Things to consider:

- Springs will loose elasticity over time – because this excavator is to be used shortly before people arrive, parts should fail only after people can replace and maintain them
- Further sand proofing will be required to prevent the moving parts getting jammed



Motion simulation of one drum excavator with spring loaded shovels



Section view of the inner regolith collectors

SolidWorks Modeling and Rendering

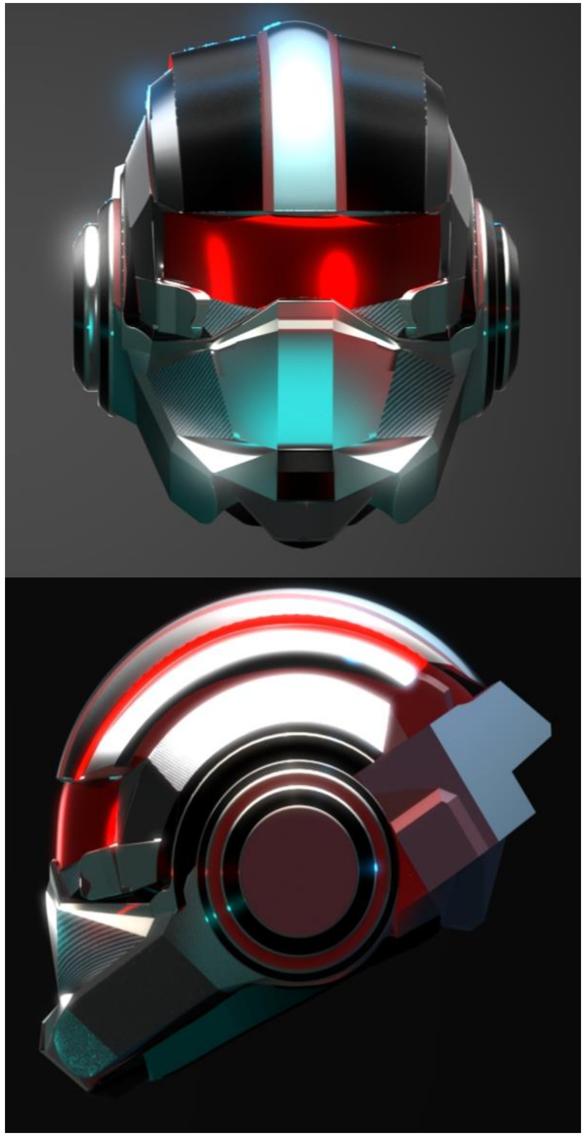
Overview:
Being well versed in CAD software and rendering is important to me as I pursue a career in robotics and design. This is why I have earned my CSWA certification and continue to practice CAD modelling and rendering with interesting objects.

Purpose:
- To practice learned skills and learn new skills through modeling complex objects
- To learn more about how to create a good render
- Create a good representation of my CAD technique

Outcome:
- Modeled a Pentel Graphgear 2000 pencil in Solidworks by creating each individual part and mating them together to exercise good assembly practices
- Learned about SolidWorks surface modeling and applied it to create a sci-fi helmet
- Researched PhotoView 360 and used it to create a render with adjusted lighting and material assignments

Skills Demonstrated and Learned:
- Extrusion and surface modeling of complex geometry
- Working with assemblies
- Assigning materials, lights, and effects to create a finished rendered piece fit for presentation.

From top to bottom: CAD model of Pentel Graphgear 2000 and reference pencil



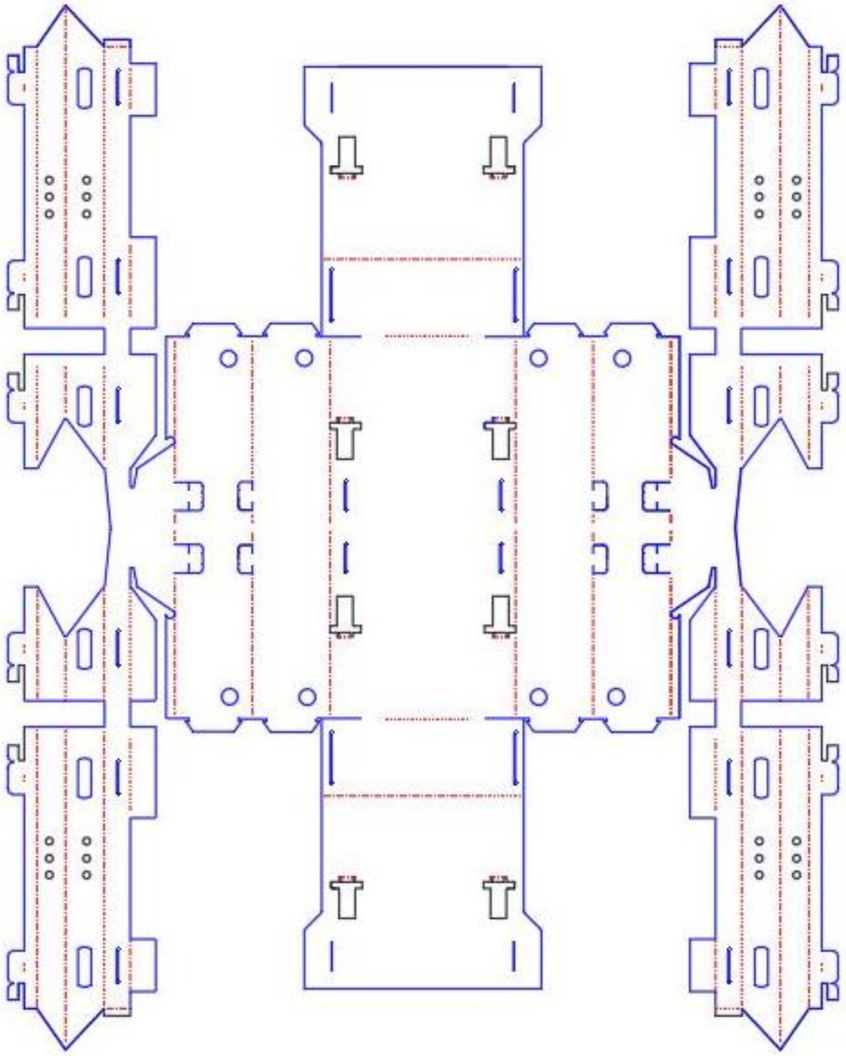
Different views of surface modeled sci-fi helmet

Folded Arduino PET Walker (2017)

One of my projects, assisting in robotics research at Northeastern University, was to modify the design of the foldable body of a robotic walker to be used in a high school AP physics. Folding robots are a popular research subject because of their space saving designs and self folding potential.

The foldable body is one piece of laser cut 0.01 in PET sheet that was modified using AutoCAD. To make folding easier there are perforations along the fold lines, which are marked by red in the image. The design was modified to feature four legs and fit a mounted Arduino Uno, which drives the four linear DC motors.

Future options for the design of the walker include modifying the design so that it can fold, in addition to the walker, a gripper. This will present the adaptability of folding robotics and how the same template can possibly fold into multiple structures depending on the situation.



Cutting template for four-legged walker drawn in AutoCAD

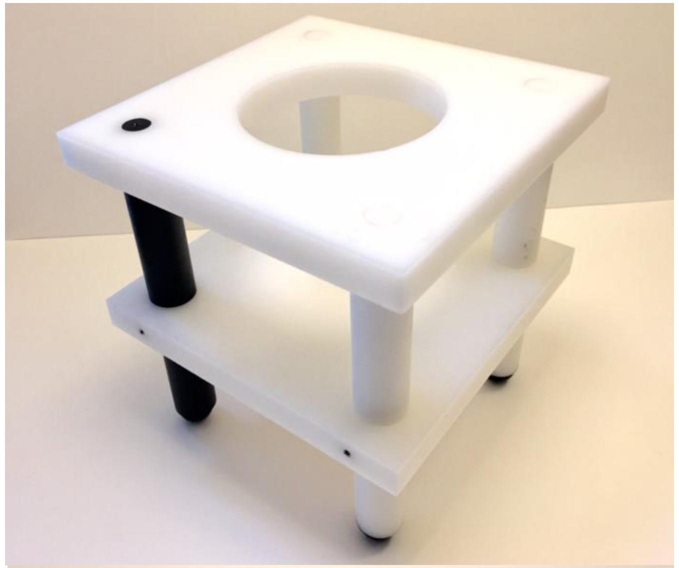
iRobot Machine Shop Course Project (iRobot, 2017)

Overview:

During my six month Co-op at iRobot as a Systems Test Engineer Intern, I was able to take part in two of the company's weekly machine shop courses offered to the company employees. The more in depth course culminated in a final project that consisted of the table-like cupholder shown in the images.

Outcome:

- Material: black and white Delrin
- Slip fits – lower platform and legs
- Press fit – top platform and legs
- Set screws – lower platform
- Equipment used:
  - Hybrid CNC Mill – platform profile programming, squaring, and facing
  - Lathe – turning legs
  - Table mounted digital gauge – tolerance checking

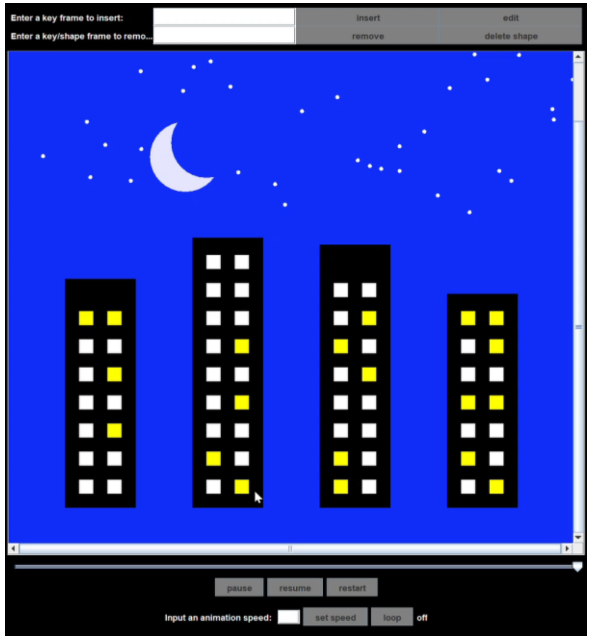


Animation Interpreter/Player (2020)

Overview:
Worked with a partner to design a program in Java that interprets a text file that defines shapes, motions, size changes, and color changes. The program uses MVC design pattern to interpret the animation file (model), control the display of the shapes (controller), and display the animation in one of three views: visual (to the right), SVG animation format, and a simplified text format.

Purpose:
- To independently design an object-oriented design that can effectively interpret and display animations of various shapes
- Practice working with other programmers to develop a solution

Outcome:
- Designed a program that successfully interprets the formatted text animation files and displays them based on the arguments inputted
- From the visual GUI:
    - Shapes can be edited and deleted
    - Movements can be added and edited
    - Animation speed can be set
    - Functional scrubber
    - Loop option
    - Basic navigation buttons
- Easily extended code
- Object oriented programming

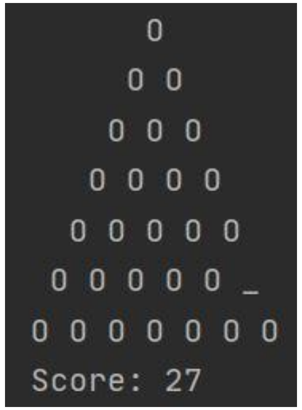


GUI demonstration

Text file input

GUI representation

Peg Solitaire Game (2020)



Triangular board with size set to 7 and the empty space set to 5, 5

Overview:

Developed a peg solitaire game that can be played through terminal. Based on the arguments to the main class, the board can be set to the default, European, or Triangle styles of the board and the empty space can be set to any valid position.

Purpose:

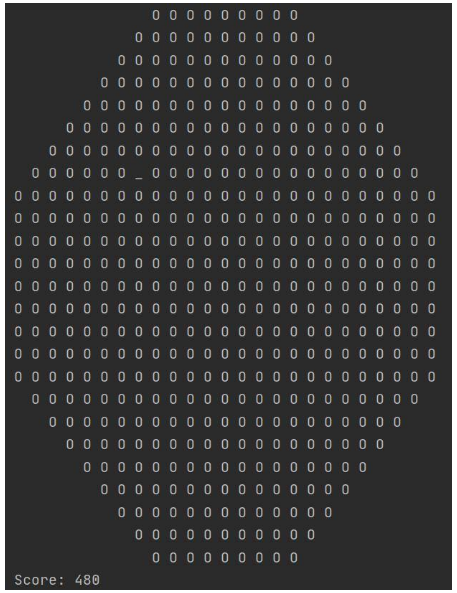
- Use object-oriented programming to develop a peg solitaire game that reuses code for different modes of play
- Implementation of decorator pattern

Outcome:

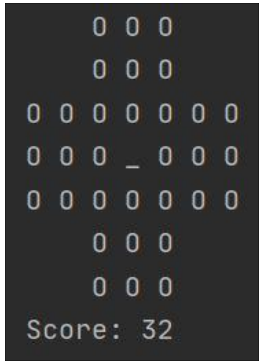
- Each board is a different class
- The board type, empty space position, and size can be set by the user
- Each marble is defined by a enum that can either be in play, taken, or out of bounds
- Code that is reused is in an abstract board class
- Error messages displayed when invalid inputs are entered

Skills Demonstrated and Learned:

- Object oriented programming
- Efficient and robust code implementation
- Developing a program that can be easily extended
- Extensive testing of program

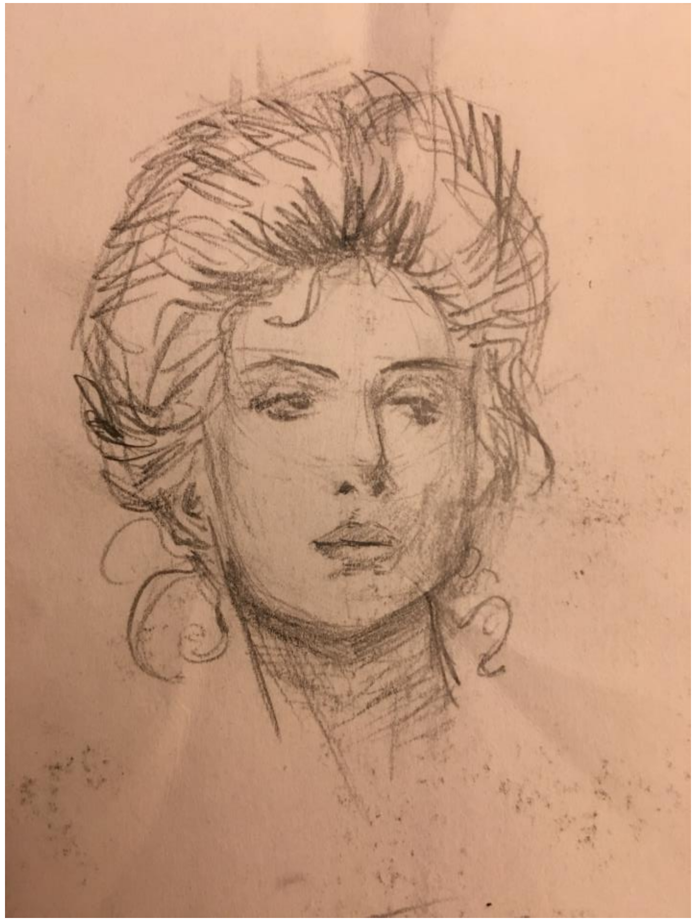


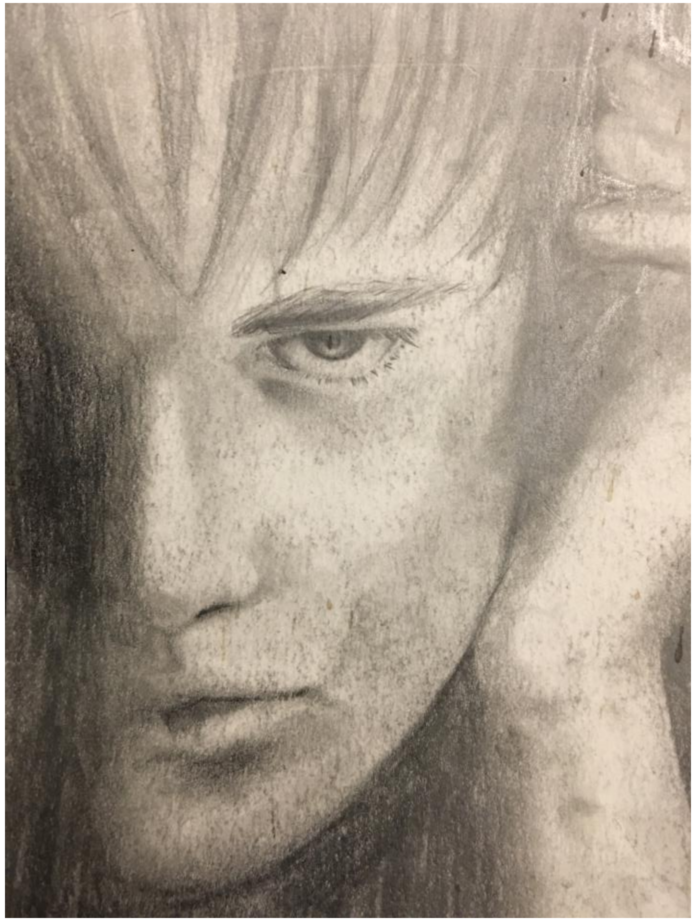
European board with size set to 9 and the empty space set to 7, 7



Default board with default size and empty space settings

Drawing Interest





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Marcos Rodriguez Website

Thank you!