ABOUT ME SECTION-----------------------------------

My name is Elijah Roberts! <br> <br>

                            I've just graduated with my master's degree in mechanical and aerospace engineering from Illinois Institute of Technology in Chicago. <br><br>

                            In this last academic year, I got the opportunity to co-author a research paper where I did stereological analysis on binder jet 3D printed stainless steel parts. I enjoyed being able to expand my skills into the world of material science and look forward to its publication! <br><br>

                            Some of my favorite skills include CAD, finite element analysis, stereological analysis, 3D printing, laser cutting and python for all your programming needs. <br><br>

                            I have a passion for designing and creating just about anything and would consider myself a maker at heart. Within my graduate education I specialized in CAD-CAM and love using my skills to create inventions to feed my 3D printing addiction. <br><br>

                            On any given day you can catch me rock climbing, playing board games and troubleshooting 3D printing projects! Check out the portfolio below to see what I've been working on <(˶ᵔ ᵕ ᵔ˶ )>

3D PRINTED CHESS SET-----------------------------------------

After getting my own personal 3D printer, this novelty chess set idea was the first major project I decided to undertake. <br> <br>

                            My vision for the chess set was for it to be portable with embedded storage for the pieces. This would prevent the pieces from needing to be kept in a separate compartment like most other portable chess sets I had researched. Additionally, I wanted it to be entirely 3D printed as an added constraint to test how far I could push the designs. <br> <br>

                            Having played my fair share of online chess, I thought why not simply have physical 2D tokens for the pieces that are stored in their starting positions. With this in mind set out to make the whole board fold up to store and transport the set like a pop-up book.

The tools I used for the CAD/CAM of this project are as follows: Autodesk Inventor for CAD, Inkscape to design the piece icons, Cura for slicing and my Ender 3 3D printer for part production. I started by designing the board squares and figuring out how I would make them fit together.

                        Since I would be using white and black PLA for the different square colors, they all needed to be individual parts. <br> <br>

                        Firstly, to join the squares together I thought a fun solution would be to use buckles. This would also allow for non-permanent joining of different board squares in case I wanted to change something or reprint a part. To achieve the folding function, I used double jointed hinges to allow

                        for a perfectly flat fold of the board on top of itself. Additionally, I added half circle cavities between some of the squares just below the top surface to allow for the insertion of small neodymium magnets. While the magnets are not 3D printed, it felt like the most elegant solution to prevent the board sections from swinging apart during transportation. The final functional element was making the storage cavities for the chess pieces. I originally designed the pieces to have circular bases but quickly changed them to square to maximize the space used. This allowed for better sized icons.

Playing off of the pop-up book inspiration I thought it would be unique if the pieces themselves folded out into 2.5D projections of the icons. With this in mind I designed a three-part mechanism that allowed for the piece icon to fold flat for storage and up during play. <br> <br>

The pieces consist of standard base and lever parts with a unique icon part. The lever arm rotates at the bottom of the base allowing for the sliding joints of the icon to flip the piece out into playing position.

Using a 3D printing layer height of 0.16mm the final prototype was constructed. The total part count for the completed board was 196 individually printed parts. Following standard chess square sizing, the board squares are 5cm wide. Each board square is 1cm thick. When unfolded this results in board dimensions of 40cm X 40cm X 1cm. When folded the dimensions are 20cm X 20cm X 4cm. The chess pieces assemblies are 3.74cm wide and 0.3cm thick. When unfolded into play position the pieces height from the board surface is ~3cm.

Telescoping Pole----------------------------------------------------------

In this project I worked in a team of four to develop a telescoping pole with

                            interchangeable heads for disk golf retrieval. My job was to develop the CAD model of the telescoping

                            arm for use in finite element analysis. <br> <br>

                            I knew that we would be adjusting the design based on the FEA results. With that in mind I wanted

                            a CAD model that allowed for easy and quick adjustment for iterative FEA testing. To achieve this, I designed

                            the whole assembly to be fully parameter driven. Major design variables are carried from the core pole section

                            to all five larger sections.

Using the parameter function in Autodesk Inventor, I developed the parts to be

                            interdependent and based off the parent core section. The most important of the design variables are the thickness

                            and length of the sections. <br> <br>

                            The full assembly is constructed of a core section that has a securing outward lip at the back and the threaded

                            mounting hole at the front. There are then four identical middle sections with both outward and inward facing lips

                            on respective ends. The final sixth end section only has an inward securing lip and a hollow back. A simple

                            plastic end cap is placed at the end to enclose the assembly. to allow for the adjustment of all sections

                            independently there are five clamps of appropriate size for each inner section to be secured when at desired length.

The parameter driven assembly allowed for extremely simple design adjustments.

                            The first two images above are of the assembly with the optimized thickness and length. For the design constraints,

                            we found 1/32in thickness was more than adequate. Total length collapsed is ~3ft and extended is ~14.5ft. <br> <br>

                            The third image shows how the assembly automatically adjusts to the wall thickness of the sections being changed from 1/32in to 5in.

WKH SINDy -------------------------------------------------

I used Python to program the Sparse Identification of Nonlinear Dynamics

                            (SINDy) algorithm to identify nonlinear differential equations from the Waleffe-Kim-Hamilton (WKH) model of

                            transition and sustained turbulence. The WKH model is defined by the following system of equations.

In the state vector 𝑥, 𝑢 is the amplitude of the spanwise modulation of

                            streamwise velocity, 𝑣 is the amplitude of streamwise rolls, 𝑤 is the amplitude of the inflection streak

                            instability and 𝑚 is the amplitude of the mean shear. These will be the fundamental variables monitored in

                            the analysis of the WHK model. In the A matrix, the constants 𝜆, 𝜇, 𝜈, 𝜎, correspond to positive viscous

                            decay rates. 𝑅𝑒 is the Reynolds number. 𝑄(𝑥) contains the constants 𝛾 and 𝛿 which are nonlinear interaction

                            coefficients of equal sign. <br> <br>

                            To recreate the WKH model from simulated experimental data the SINDy function will be used. This algorithm

                            will be of the form shown below.

Where Θ(𝑋) is a library of possible nonlinear functions and the columns of

                            matrix Ξ are the vectors of active coefficients. The determination of the coefficients should allow for

                            the reconstruction of the original dynamical system based solely off of the simulated experimental data. In

                            the above figure the SINDy algorithm is visualized for the Lorenz System for greater clarity.

Overall, the SINDy algorithm has been shown to successfully recreate the WKH

                            system with varying parameter sets and noise levels. For the scale of tests done over the course of this

                            project the SINDy function seems to be very robust and only had a meaningful error in one parameter set

                            under strange conditions. With further testing these results could be improved. More extensive testing

                            could be carried out using this code with extreme examples of the WKH system. The SINDy function results

                            may be improved with the use of a more efficient numerical derivative methods more geared toward use with

                            SINDy. I feel that the experimental system could be even further improved with the additional use of

                            traditional data methods such as smoothing and interpolation to clean up the noisier results.

UFarm -------------------------------------------------------------

This project sought to create a greenhouse to be constructed at the IIT

                            UFarm which could operate even during the coldest months of the year. The greenhouse would be constructed

                            using the funding provided to the UFarm from the Wagner Institute of Sustainable Energy Research. <br> <br>

                            I was tasked with developing the CAD model of the desired greenhouse and generating the bill of materials.

                            I also used to CAD model to develop a useful fluid simulation for general reference throughout the project.

Using Autodesk Inventor, I created the greenhouse assembly. First, I made the

                            relevant parts for the metal structure and then the door frame and tarp. I also used the rendering environment

                            within Inventor to generate the above image.

The following CAD materials were developed based on the current area available at the

                            UFarm site on IIT’s campus. The dimensions of the full structure are shown in the technical drawings above.

                            The parts of the assembly are also labeled for reference in the bill of materials.

Since this project did not have access to any experimental data, a simple

                            fluid simulation was carried out to understand the flow patterns of air within the greenhouse. This simulation

                            modeled a temperature difference between the interior and exterior of the greenhouse. The major point of fluid

                            flow is through the gaps of the door frame allowing heat leakage in that area. <br> <br>

                            Currently the UFarm Student Org has allotted roughly $5,000 of their budget to the

                            construction of the greenhouse. The overall funding of the UFarm is made possible by IIT and

                            WISER. Based on our CAD design and our own cost research the bill of materials shows an

                            estimated total cost of $4,722.90. These prices are estimated from similar parts found on

                            McMaster-Carr’s website. Alternatively, there are entire greenhouse kits available for purchase.

                            Of these kits a similar design was found at a cost of $2,465 on the web at Greenhouse Megastore.

                            It may be financially beneficial to consider the purchase of this kit to then retro fit the materials

                            to our specifications. As far as construction and labor is concerned, since this is a student lead

                            project the organizations members would provide physical labor. This means labor costs are

                            essentially zero. Also of note is that the site has on it the remains of the previous greenhouse.

                            These parts have been left in disrepair however so the possible cost savings from these materials

                            are tentative. With that in mind, current designs all fall under budget and are economically viable.

Home Beam Analysis ---------------------------------------------

A friend who was remodeling their home reached out with a structural question

                            for me to help them with. They wanted to move a stud ~1ft under a support beam in an interior first floor wall.

                            To help see if this would cause meaningful structural harm to the home I decided to model the problem using FEA.

Misc----------------------------------------------------------

Bedside Item Holder---------------------------

Currently I have a lofted bed with a metal frame that I sleep on. It is a great space saver, but the only issue is I don’t have a spot to put items like my glasses, phone and headphones. To help solve this problem I set out to design a 3D printable container that would attach to the side of my bed frame. <br> <br>

                            Given my bed frames construction I wanted to have the container attach by snapping to the circular poles of the side of the bed.

To make the snap on hinge I made some test prints with progressively smaller diameters until I got a satisfying connection. Because of the circular snap arm, the part had to be printed from its side up. This orientation required a draft top wall to allow for printing without the need for supports. In order to make sure the angle (46 degrees) and wall thickness would print well I printed a small triangular version of the large scale print.<br> <br>

                            With the tests complete and fine-tuned I was able to produce the final large scale product with a 20 hour print.

The final print came out pretty well but due to the size and thin walls there was some minor warping in the final product. This warping does not affect the usability of the final part, but I will be aware to use a slightly thicker wall when printing large scale parts without supports. The container has final dimensions of 8x3.2x7.4in. The wall thickness across the part is 1/32in and the part is printed in PLA.