California State University, Long Beach

Department of Mechanical and Aerospace Engineering

Final Design Project

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Course: MAE 490A - Computer-Aided Design/Computer-Aided Manufacturing

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Abstract

In typical indoor sports gyms, there are volleyball nets that are set up using poles that fit within sockets in the ground. These courts share the same game lines as badminton courts, but can't be used interchangeably due to the height of the volleyball net. The solution is to create a net pole that has the same strength as a volleyball pole while also being within the height of a standard badminton net. To fulfill these needs, the pole must have a height of 73 inches to fit within the socket depth of 12 inches and the regulation net height of 61 inches. The pole must also have a minimum factor of safety of 5 when a 100 lb-f is applied to the top of the pole, which is based on the maximum force a person can exert when pulling on the net. To analyze these forces, static load tests were performed with the 100 lb-f acting on the pulley, pin, and walls holding the pulley, where the force is applied in a counter-clockwise path to simulate the net being pulled around it. The mesh independence for the factor of safety was determined to be around 9 when utilizing 50,000 elements. The design passes the factor of safety requirement and is within standard height for badminton regulation nets.

Introduction

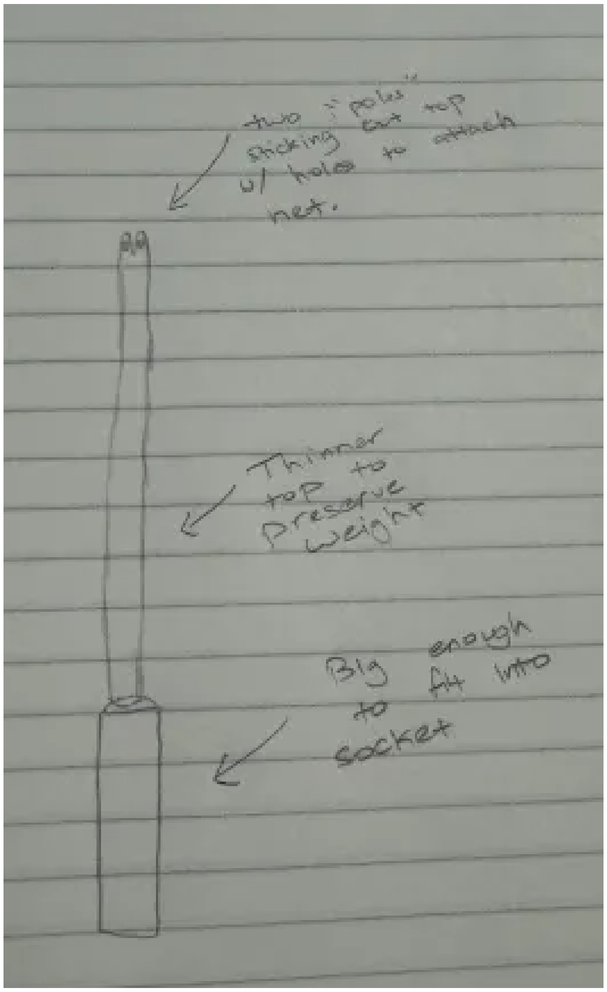
a. **Goal of the design. Explain the goal of the project. Are you trying to improve a product? Are you trying to analyze a critical part?**

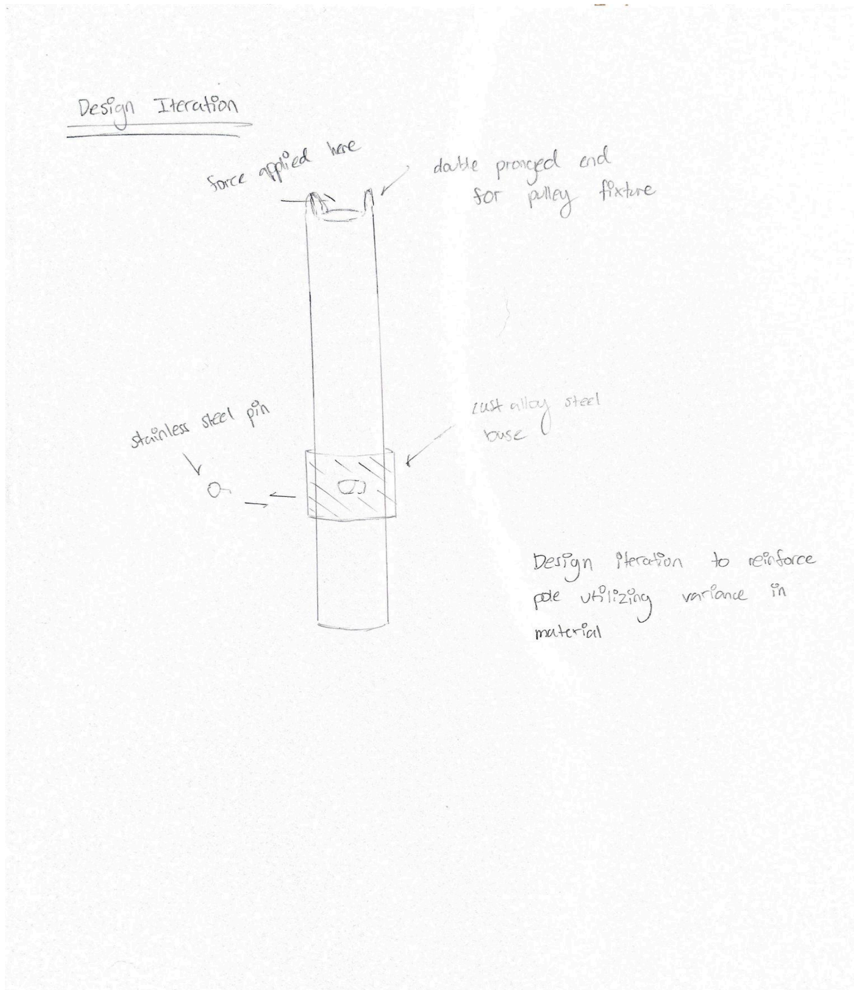
The goal of the design is to create a badminton pole that fits in the ground sockets used for indoor volleyball poles. The reason for this is that in typical gyms, volleyball and badminton courts generally share the same area, as their ground markings overlap. This means that players can play volleyball or badminton interchangeably on that court. However, volleyball nets are set up using two large poles with a net tied between them, which are supported by a socket in the ground of the gym to keep the poles fixed in place. Badminton courts don't have this and are mainly set up either by tying the net to opposite ends of the wall, or setting up plastic poles with no ground fixtures and tying a loose net in between. Another goal of this design is to redesign the part to be as cost-effective as possible through the use of cheaper materials and less material in places where there isn't a need for strength from the forces that the pole experiences.

b. **Design specifications and needs for the parts or assemblies that you are interested in.**

The specifications require the pole to have a bottom part that fits within the ground socket of the gym floor while also being strong enough at the top part for a tight net to be tied. The pole also has to be 5'1" for the net to meet height regulations. The pole must not exceed 35 lbs of weight so that it's easy to carry. The pole must also withstand 100 lb-f, which simulates the maximum amount of force a person can exert when pulling on the net. A moment force will also be applied to the top of the pole.

c. Rough sketches of the pole

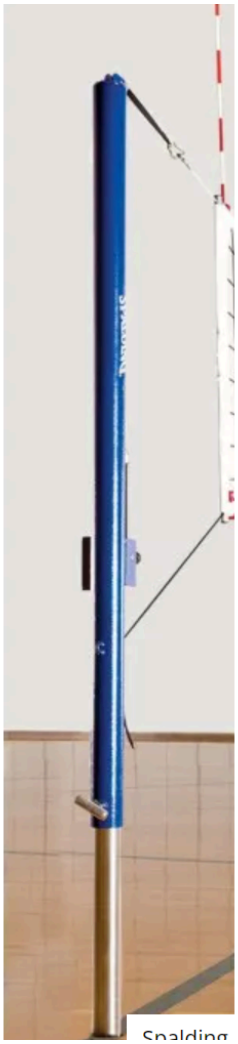




Conceptual designing of a Badminton pole where parameters of design concept utilize an area for stability towards the base of the pole and being able to maintain a grounded position. Design iterations also apply ideas of thickness to preserve the weight of the overall system as well as top segment design for pulley fixture application. Testing ideas of variation of materials in concept design as well as a separated base mechanism connected by a pin.

d. If you are redesigning a part: Pictures of a real existing part that you are redesigning (similar product in the market)

Based on volleyball gym poles

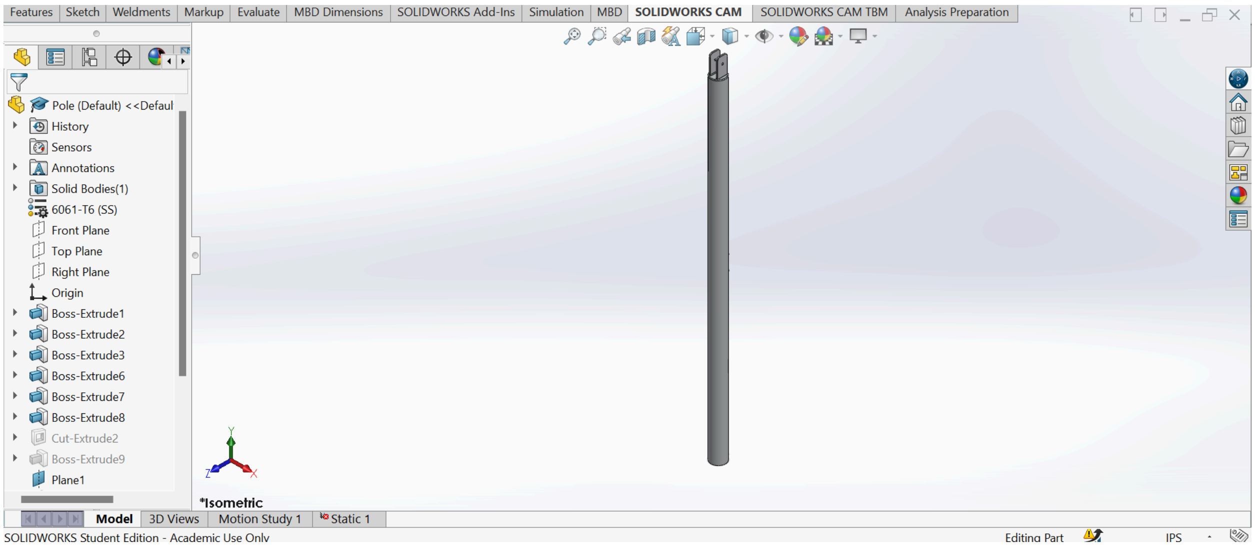


The Body

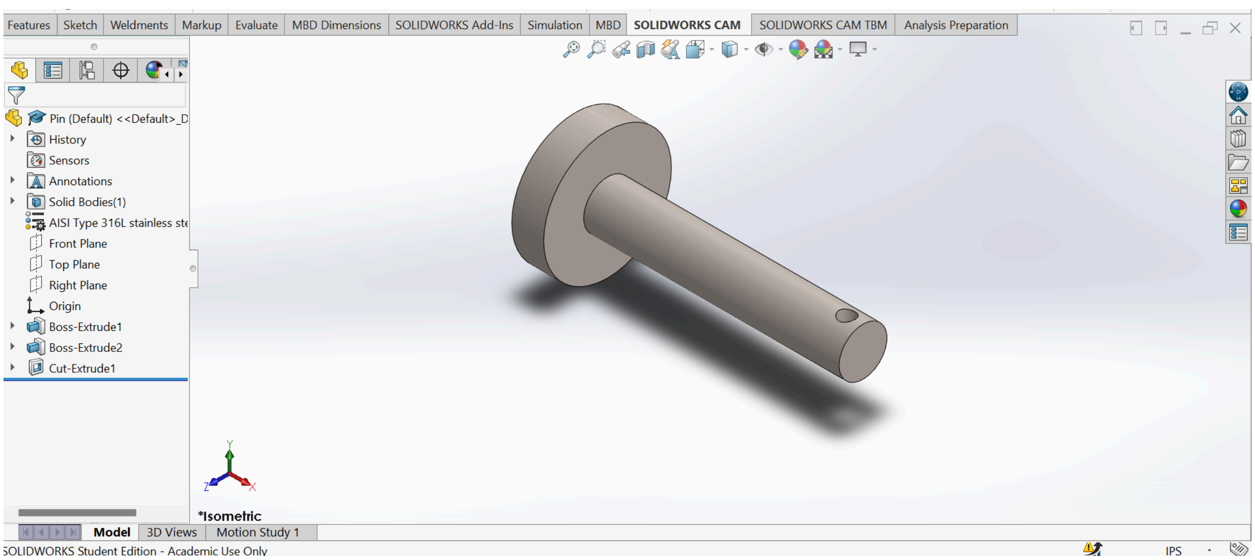
a. **3D design of the parts in SW or NX (The design should be as detailed as possible. Mention the challenges (if any) that you encountered in your design and how you**

overcame those challenges. For example, you wanted to design the outer surface of a computer mouse

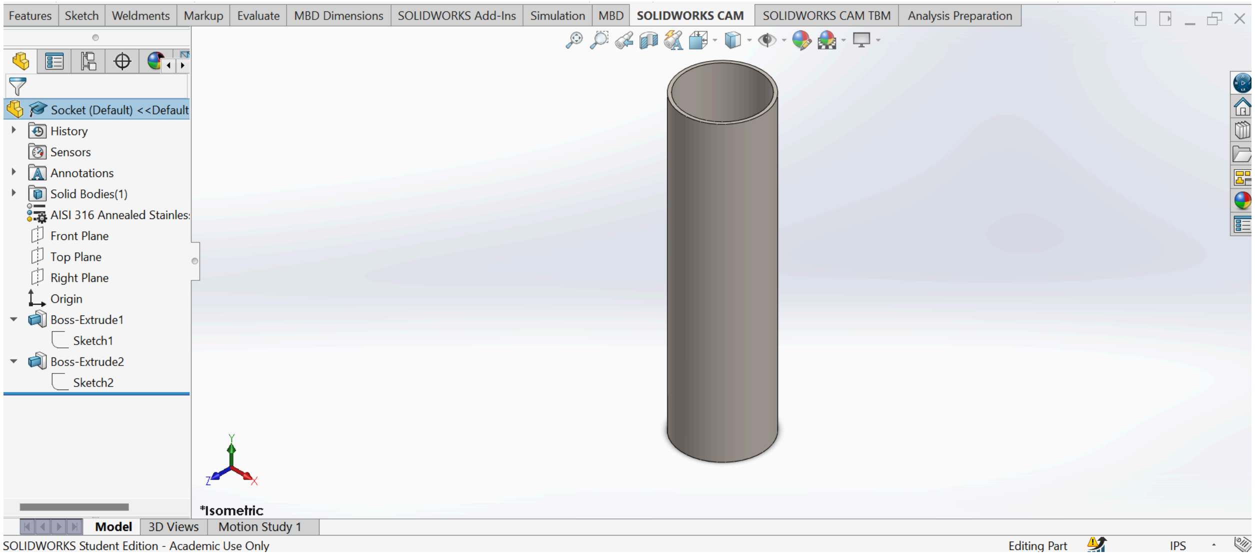
Pole



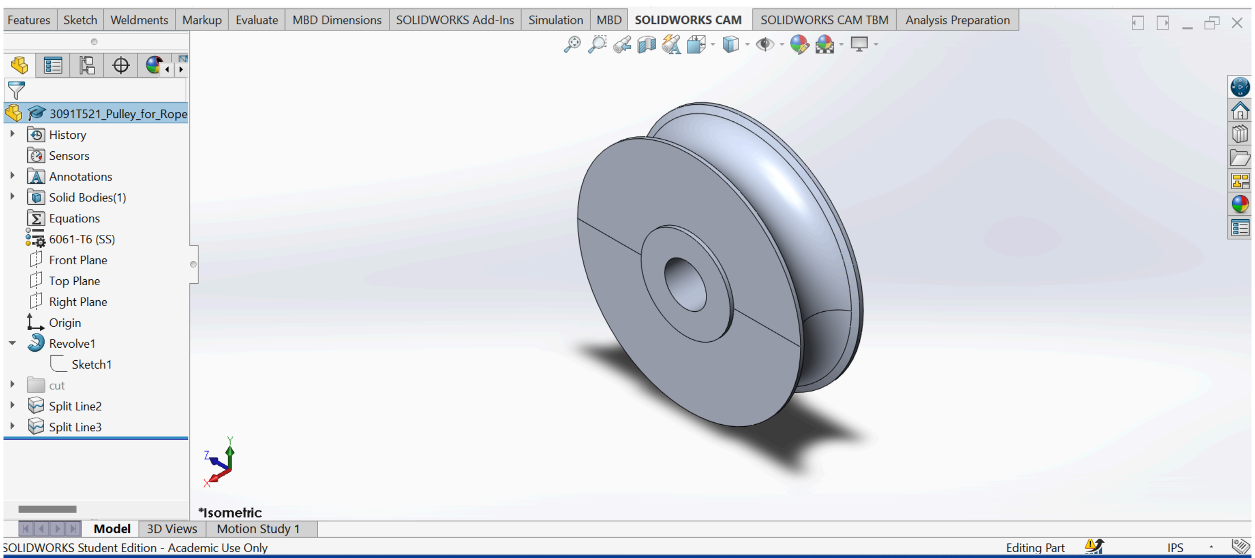
Pin



Socket



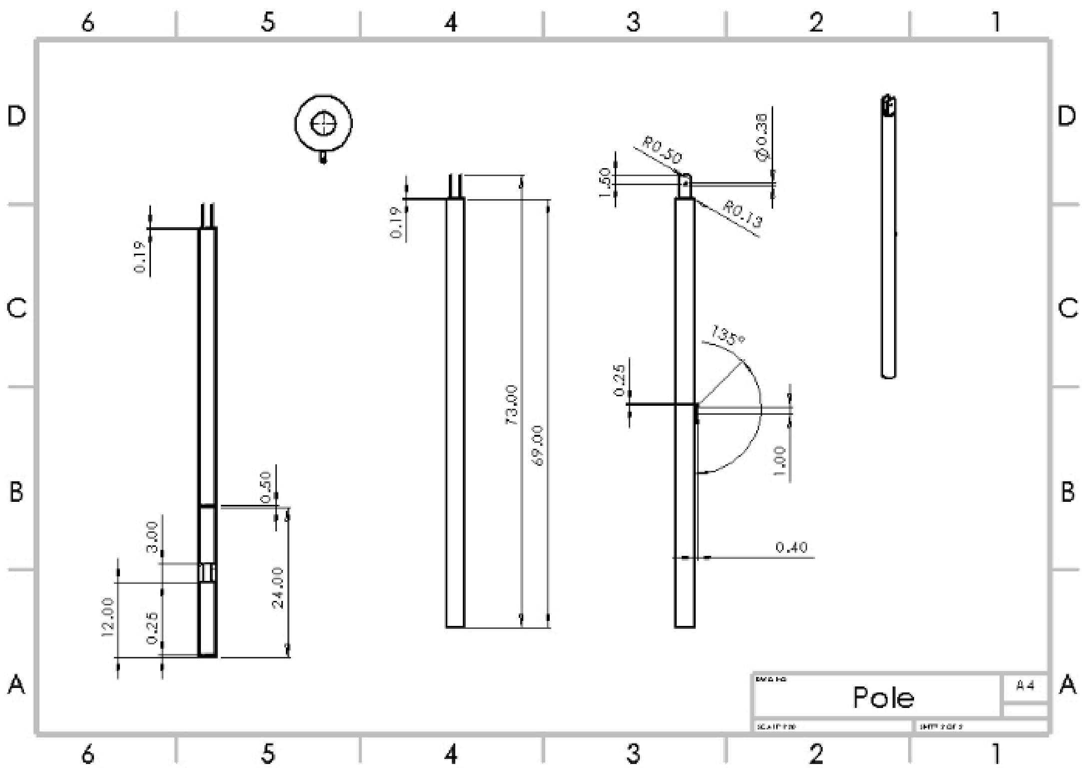
Pulley



b. 3D design of the assembly in SW (Exploded view)

<u>Final Design</u>

c. 2D engineering drawings of the parts and assemblies (All necessary dimensions and tolerances if needed)



Units applied for the final design are in inches with these listed designated design features as follows:

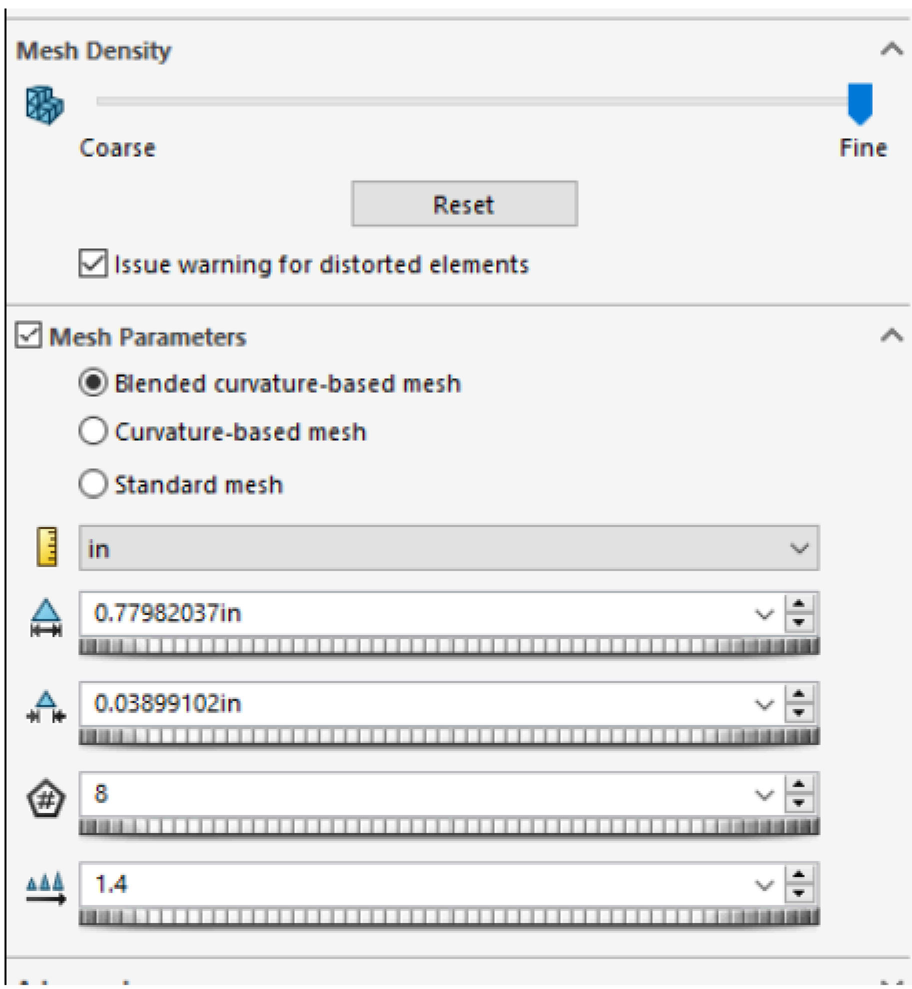
- Height of overall system: 73.00 in
- Height of system pole: 69.00 in
- Width of system pole: 0.40 in

d. **Any simulations and explanation (CFD, Stress analysis, Drop Test)**
<u>Final Design Static Test</u>

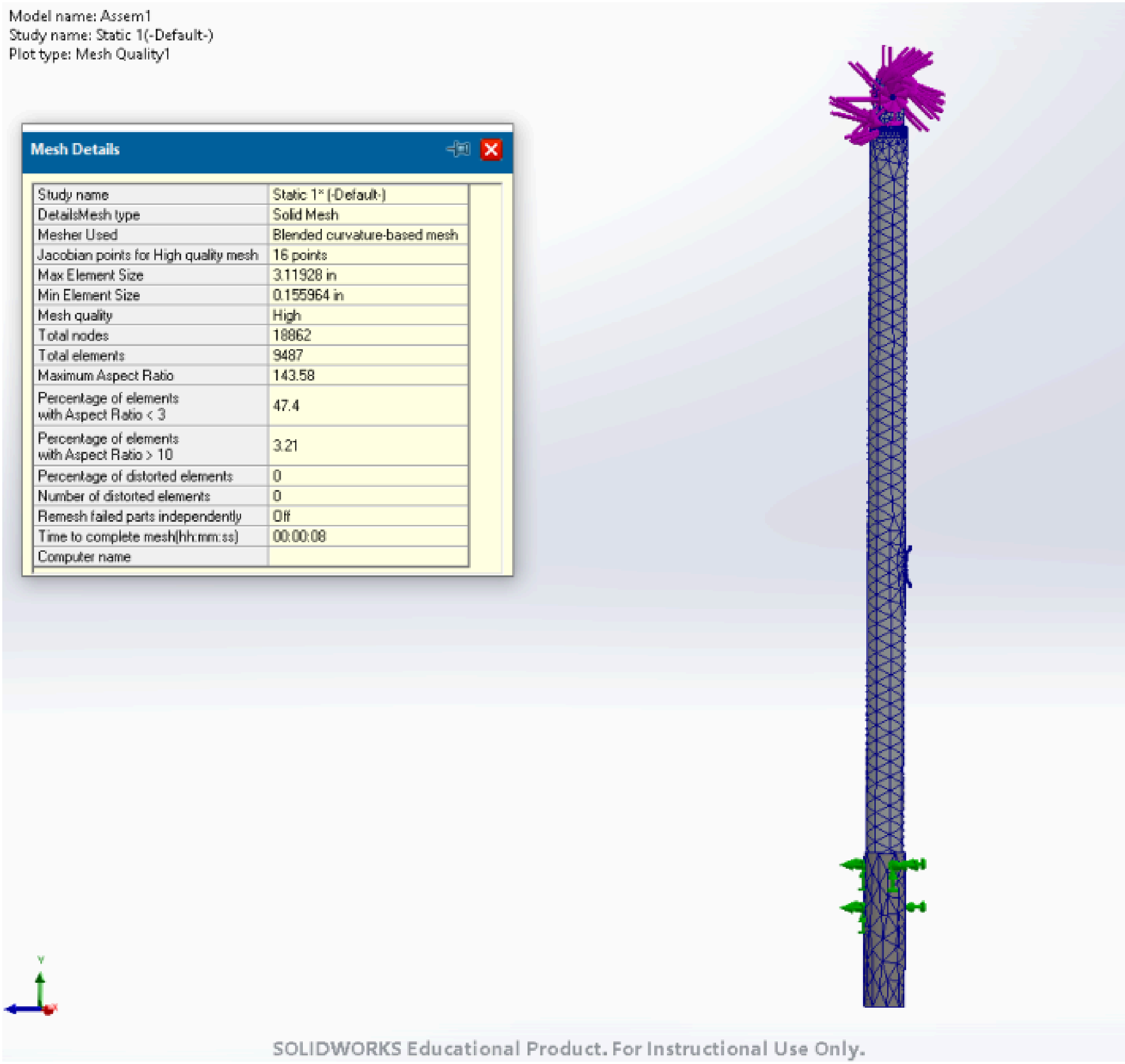
Final Design Parameters

The design parameters utilized for the static stress test analysis are as follows:

- Mesh Density: High
- Mesh Parameters: Blended curvature-based mesh
- External Force: 100lb-F
- Material: 6061-T6 Al

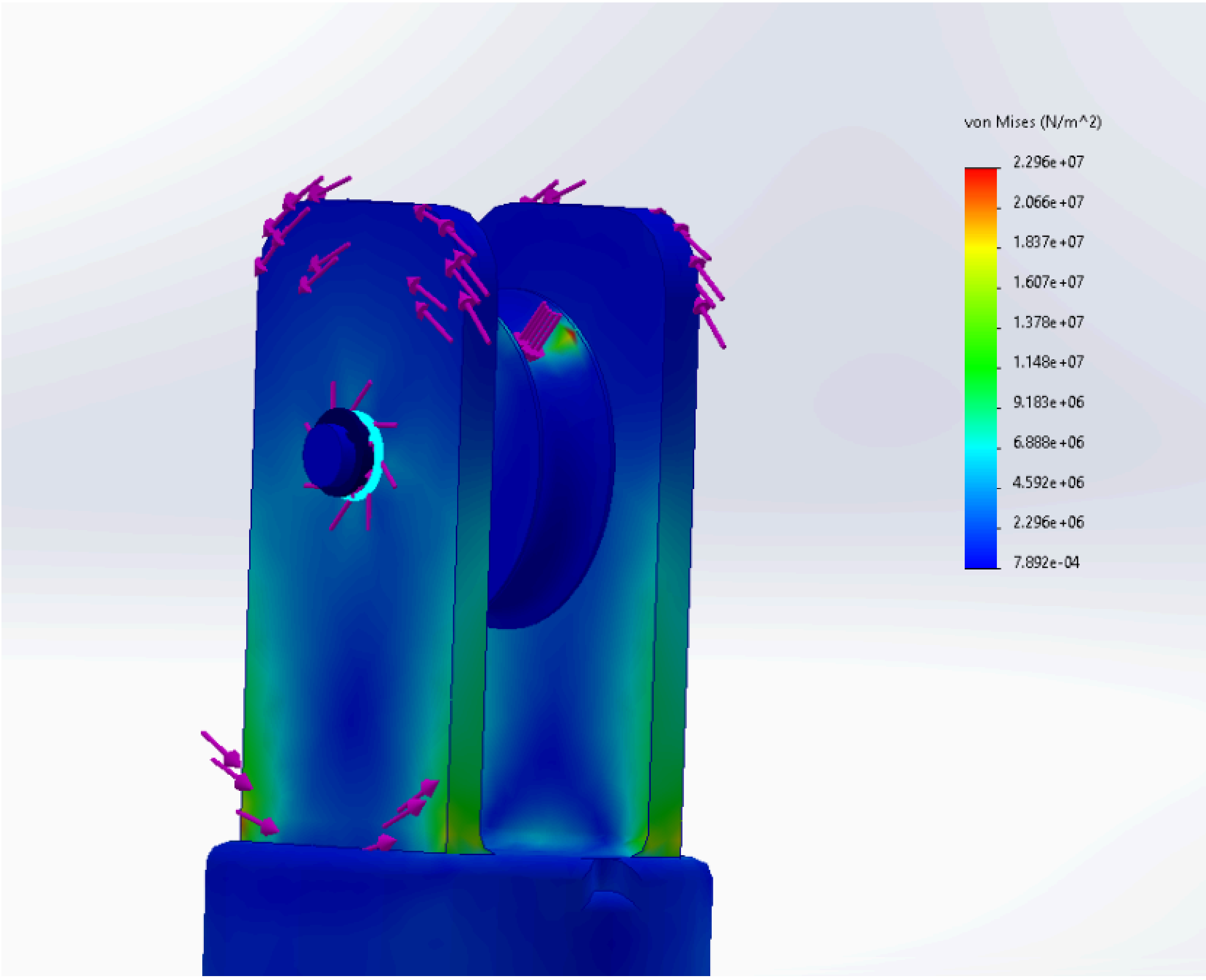


Final Design Mesh Details



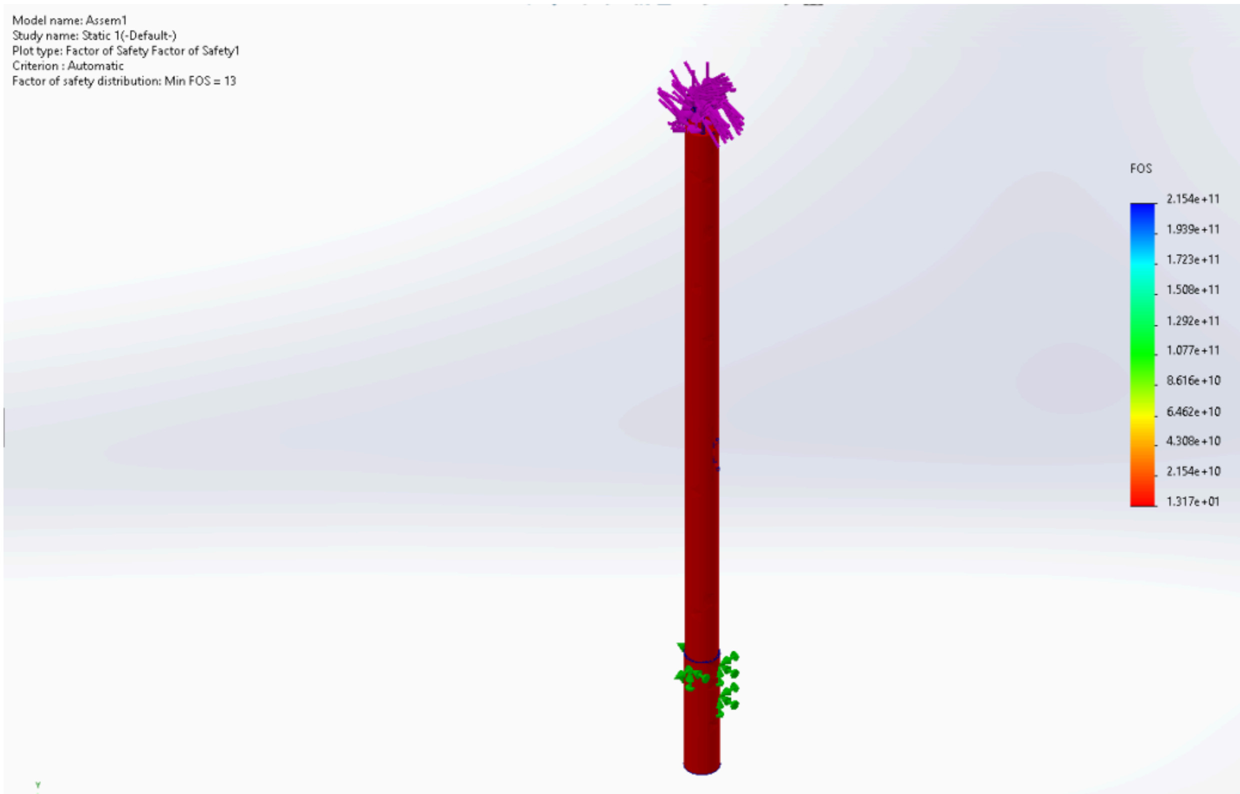
This static stress test analysis focuses on the external forces acting on the top section of the badminton pole design. Utilizing a blended curvature-based mesh allows for a higher amount of element and node application in comparison to standard-based mesh. Breaking down some mesh details, the quality is high, applying 18862 nodes and 9487 elements. These characteristics indicate a high amount of analytical input into the software to assess how the external forces act on this particular system. Like in previous simulations, the fixture is located at the bottom of the pole. The pole will be stuck into the ground socket and not able to move, hence why the pole is fixed at this position.

Final Design Deformation Analysis



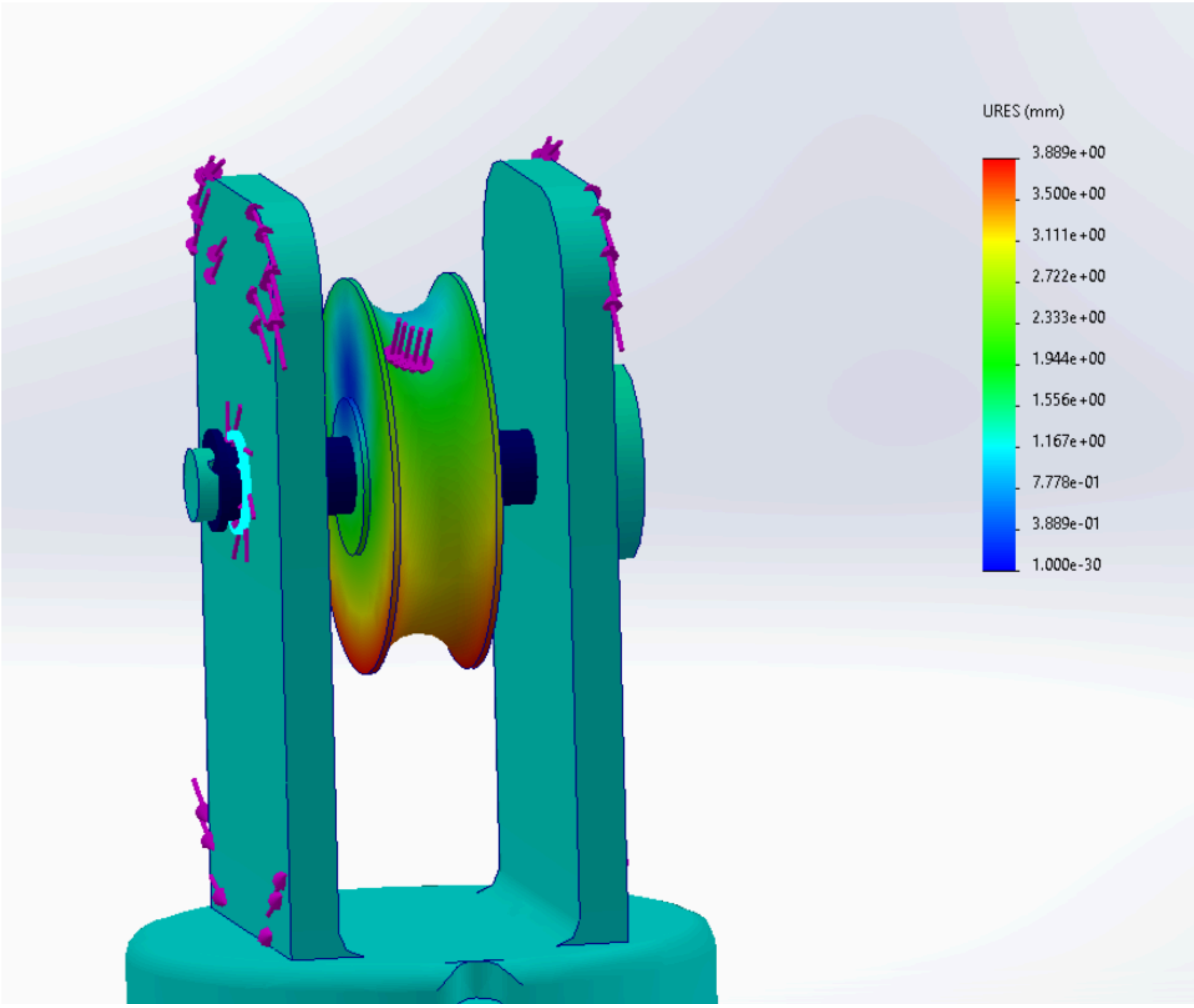
Taking a closer look at the top of the pole where the pulley is located shows us how the static forces are distributed. With how the static forces are being distributed you can see the areas in which analysis of deformation stresses are occurring with the Von Mises scale. The von Mises scale represents the occurrence of tensile, compression, and shear stresses enacting on the system. Based on the static force distribution of the von Mises scale it demonstrates that counterclockwise external forces applied in the specified areas do not cause deformation to the structure in that the scaling of von Mises of the applied area stays relatively low.

Final Design FOS Analysis



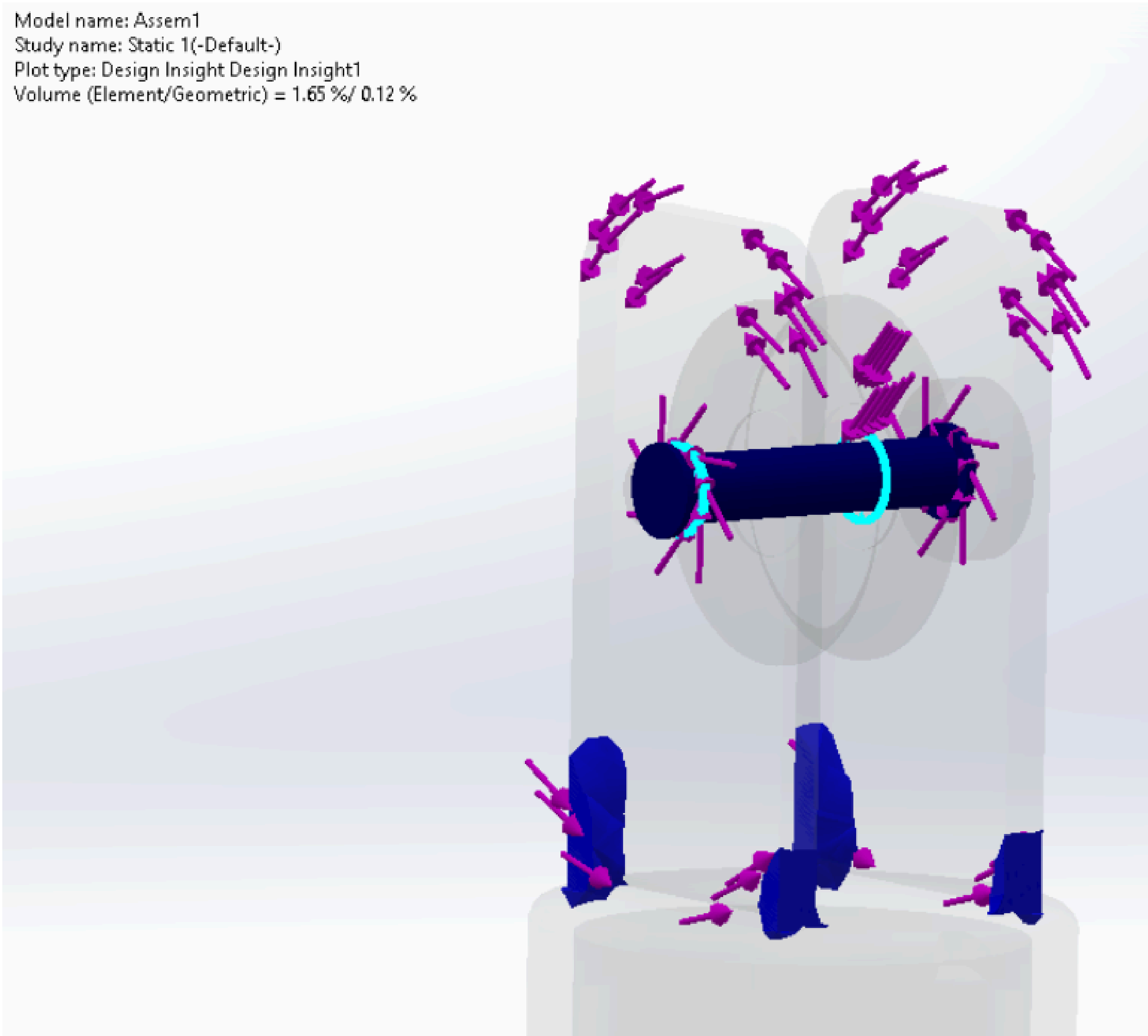
The minimum factor of safety for the applied system was 13 in that the factor of safety represents the load-carrying capacity that the design can withstand. The design specifications require a factor of safety greater than five, meaning that this pole passes the specifications set in place. However, this simulation was done using a coarse mesh. To ensure the factor of safety received isn't dependent on the mesh size used, more simulations were run with finer mesh sizes.

Final Design URES Analysis



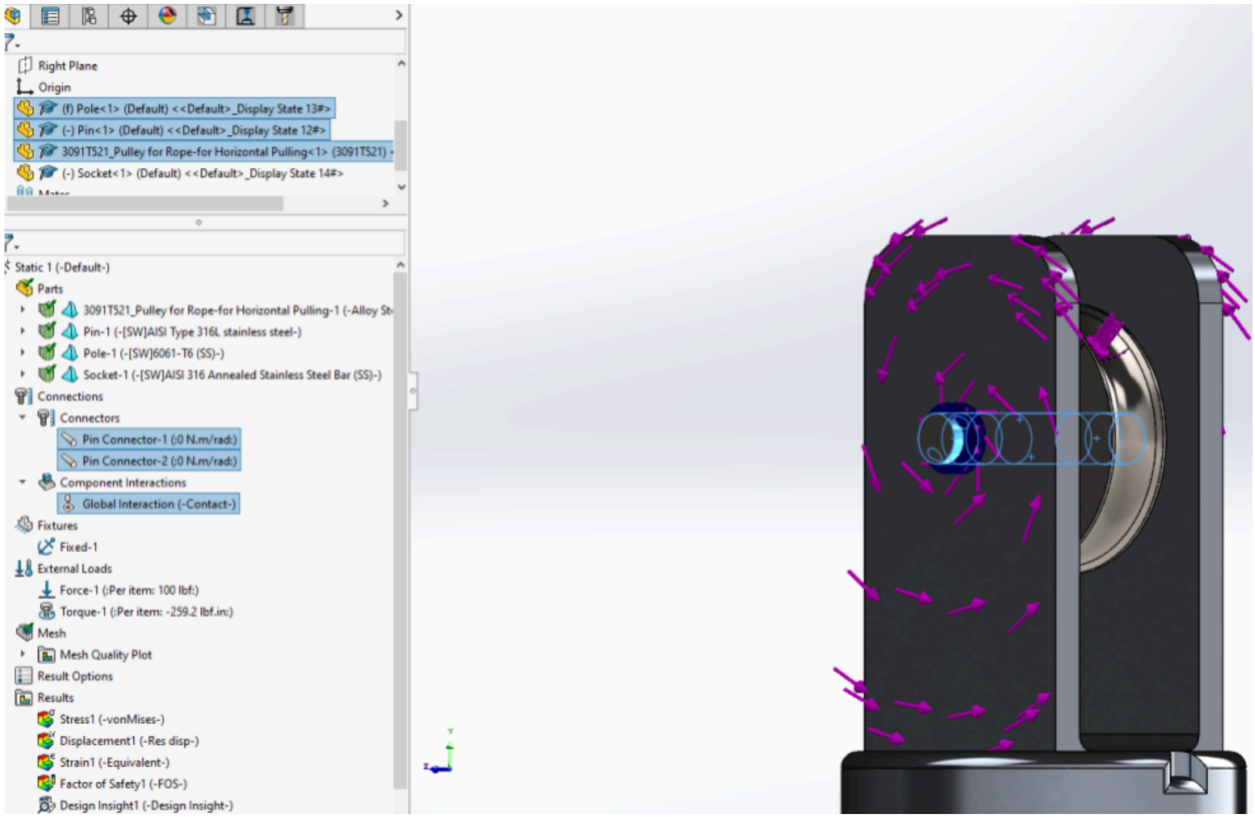
The URES analysis represents the motion direction in the specified system and how this motion displacement occurs. Based on the URES scaling it shows an applied external force motion in the counterclockwise direction and also demonstrates a higher amount of displacement enacting on the pulley of the system in comparison to the base of the structure surrounding it. Although more displacement occurs towards the pulley it does not exceed the URES standard for the overall integrity of the system.

Final Design Interaction Analysis



Utilizing Design Insight demonstrates the load path that is occurring in the specified system. The arrows demonstrating the applied external force motion occurring on the system make direct interactions with the edges and center base of the pulley. This demonstrates that most of the load occurring during analysis is applied within these specific regions.

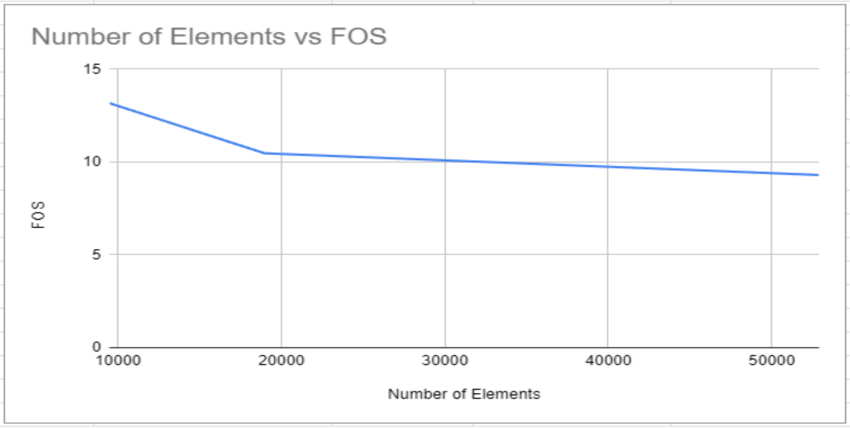
Final Design Contact Set Analysis



Because of the pins and pulley used, a global contact interaction was used for the simulation. The sides holding the pin in place were also defined as the two “Pin Connector” to ensure that the forces would be simulated along the top part of the pole. There were more than two contact points so setting the interaction as globally bonded would’ve produced inaccurate results.

Design #3.8 Analysis

Design #3.8				
Max Size Element (in)	Number of Elements	FOS	Max Stress (N/m^2)	Max Deformation (mm)
3.12	9487	13.17	22960000	3.889
0.77982	18972	10.47	26260000	1.895
0.35	52884	9.3	29540000	224.5



Two more simulations were completed to ensure the pole met the design specifications required. The first test included only 9,487 elements and produced a factor of safety of 13.7. The number of elements was doubled for the second simulation and provided a factor of safety of 10.47. The final simulation, utilizing 52,884 elements, yielded a factor of safety of 9.3. The pole is expected to meet our design specifications regardless of mesh size, given the anticipated convergence of the factor of safety around 9.

e. **Any CAM (bonus)**
   N/A

Conclusion

In conclusion, the design of a badminton pole tailored to fit within volleyball sockets while meeting the height and strength requirements set at the beginning of the report was reached. The final product can withstand 100lb-f with a factor of safety greater than 5.

The static tests performed initially yielded a factor of safety of 13.7. After running the simulation with higher amounts of elements, the factor of safety converged to 9. Even when accounting for mesh independence, the pole's factor of safety exceeded 5, the minimum factor of safety needed to call the design a success.

Additionally, the deformation and URES analyses displayed minimal structural deformation and acceptable motion displacement.