Dynamic Mask Stand

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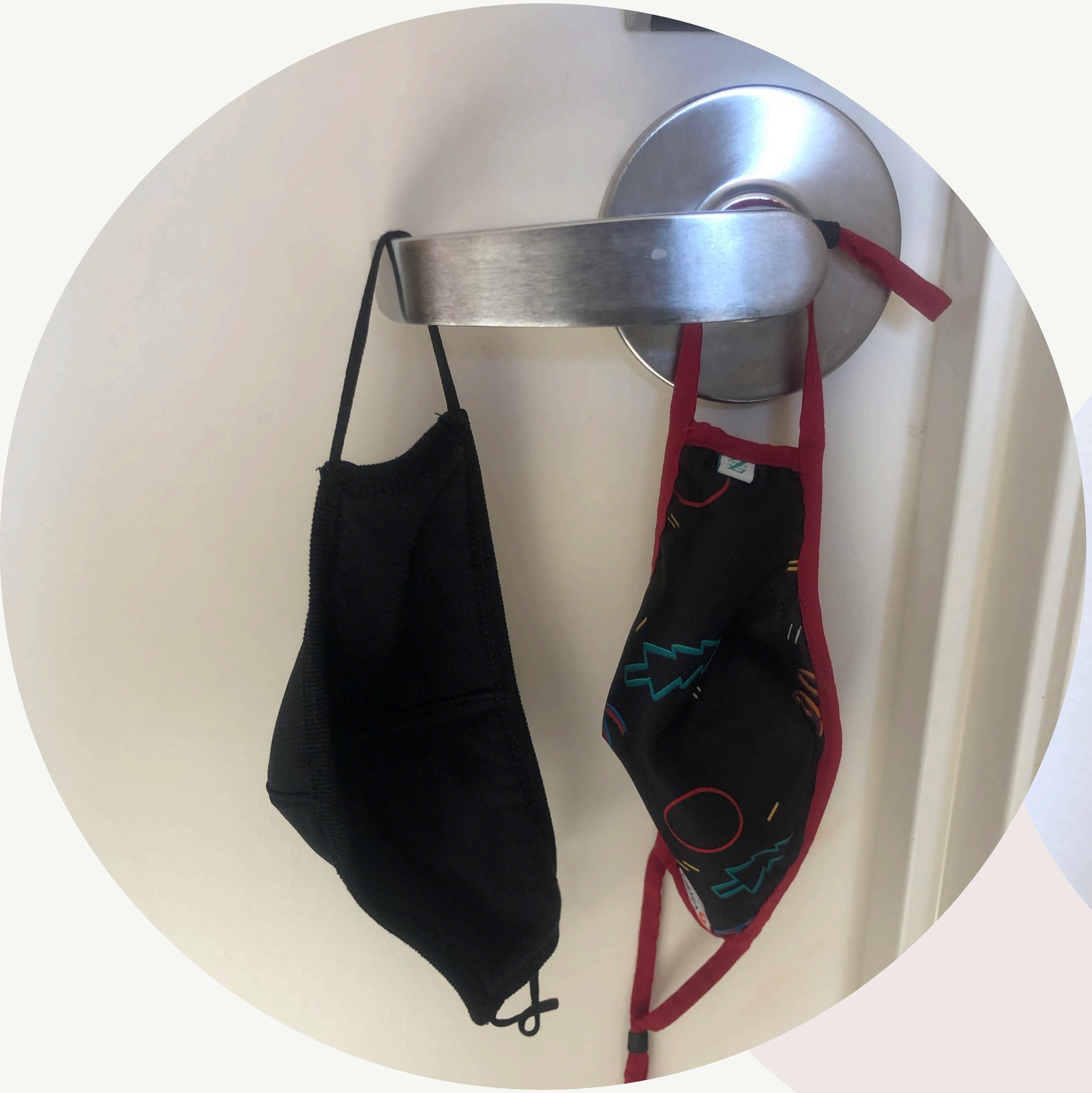
ME 127
Winter 2021

I never know where to hang my reusable face masks...

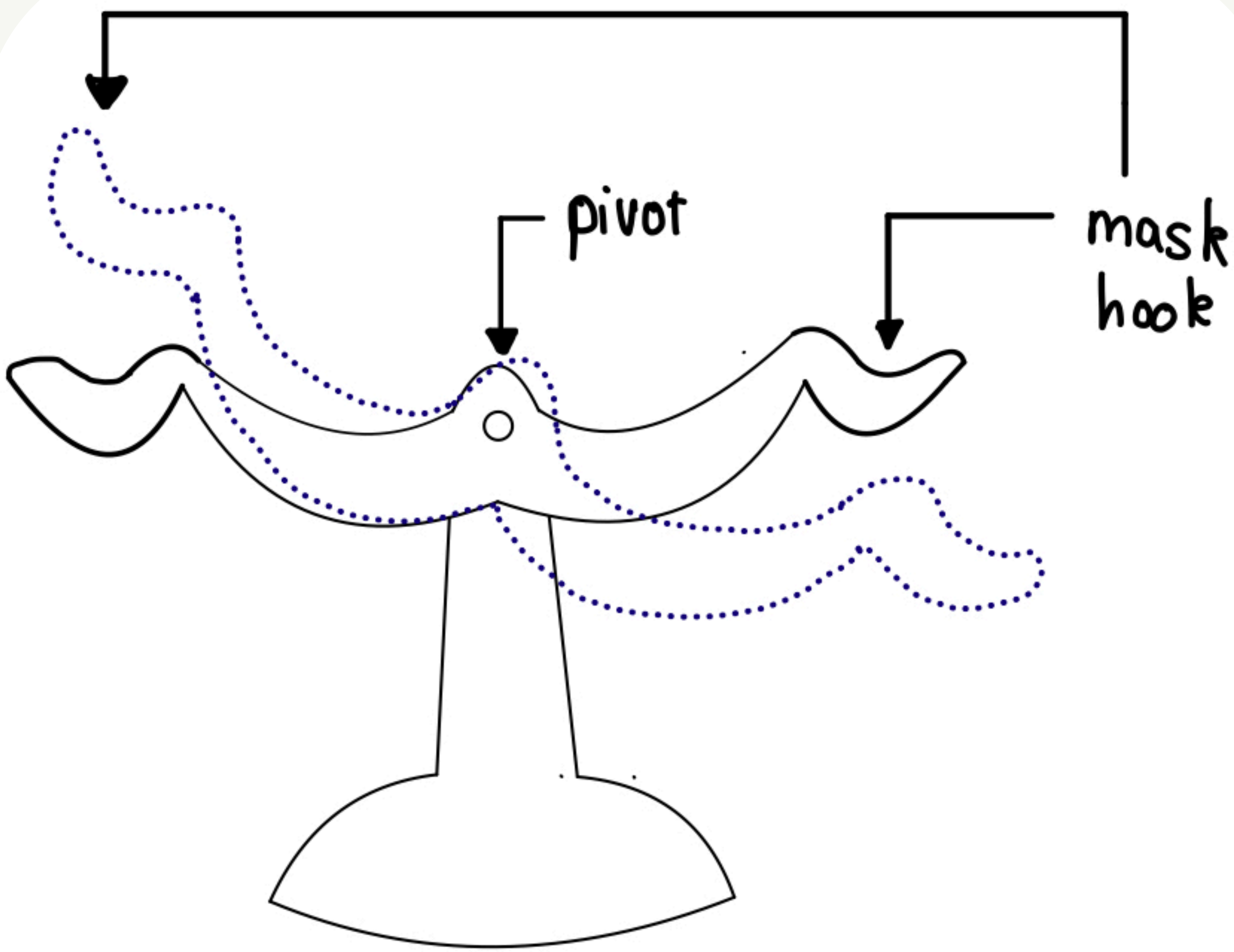
Need Finding



So they usually end up on door handles

I wanted to design and fabricate a stand for my reusable masks...

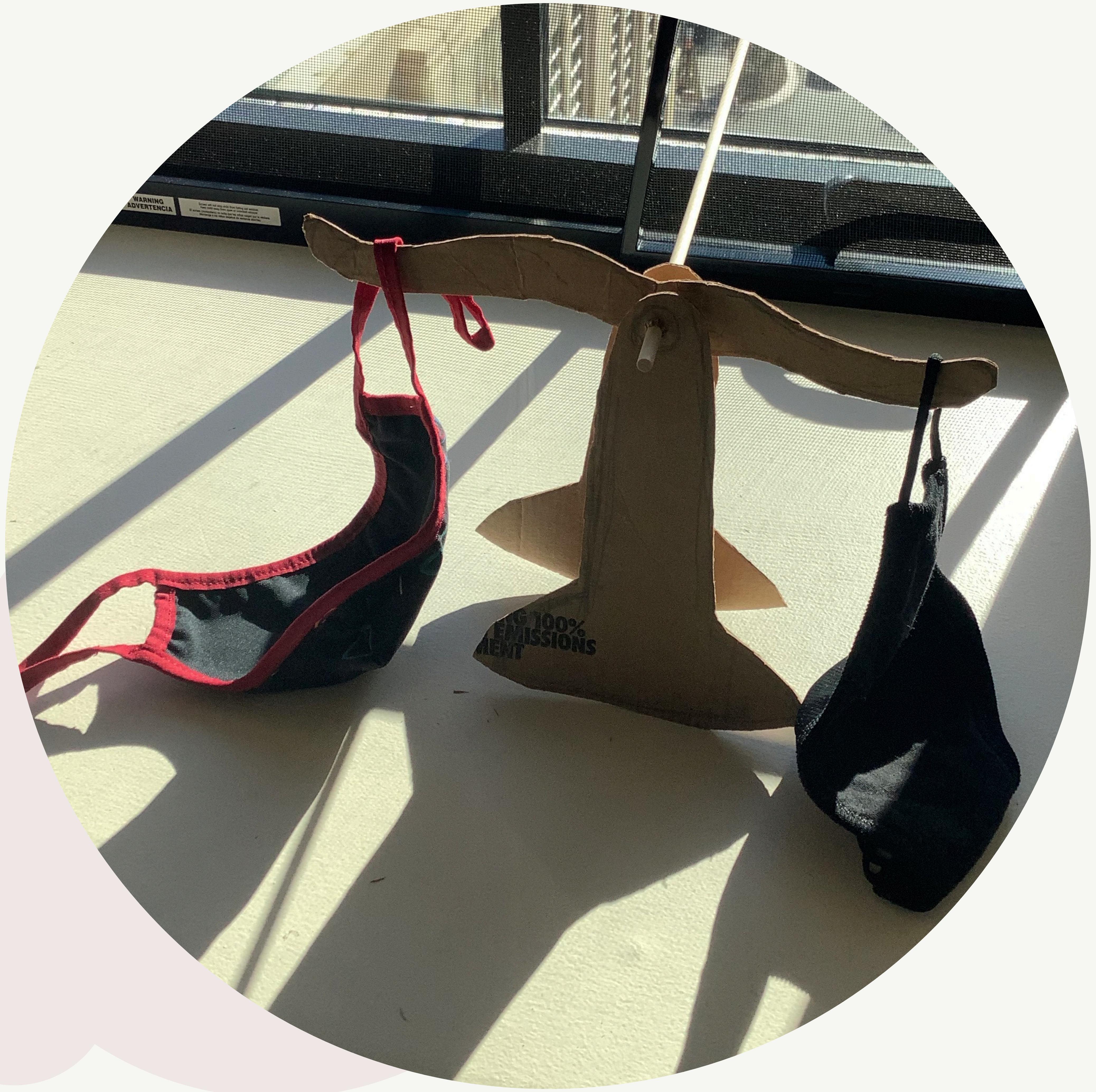
Ideating



I wanted to have a mask stand that had a bit of personality

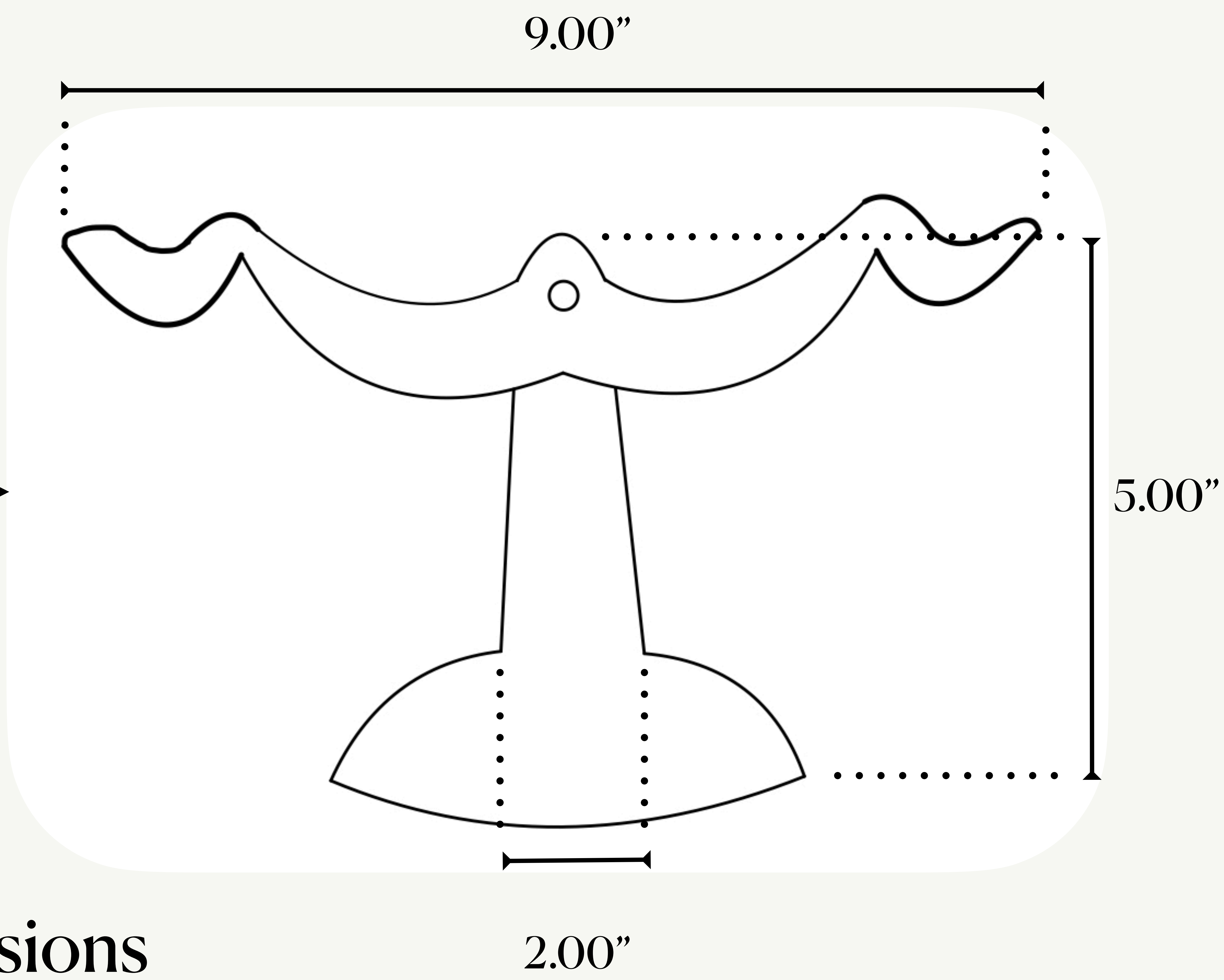
Making it **dynamic** and **rotating** about a **fixed point**

Prototyping



I made a quick prototype to get dimensions

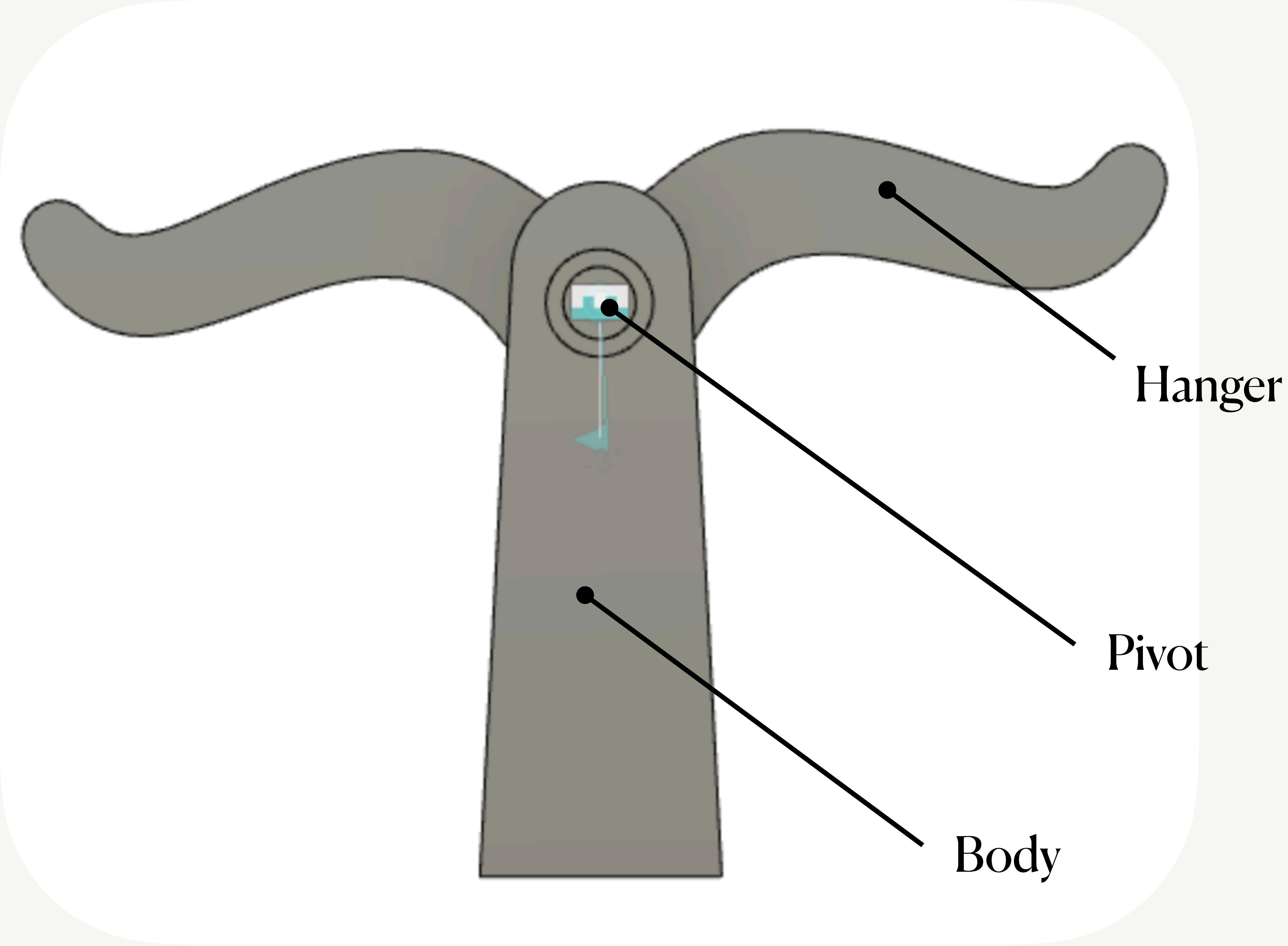
Prototyping



I picked initial dimensions based of my lofi prototype

Then I made a CAD model...

CAD



Dynamic mask stand components

Instead of focusing on the assembly base, chose to focus on the **rotational joint**

CAD

Front and side profiles of dynamic mask stand assembly

Made an assembly with **clearance** between the mask hander and sides of stand to design for **3D printing as an assembly**

But I still wanted to get a better understanding of how different loading types would impact my design...

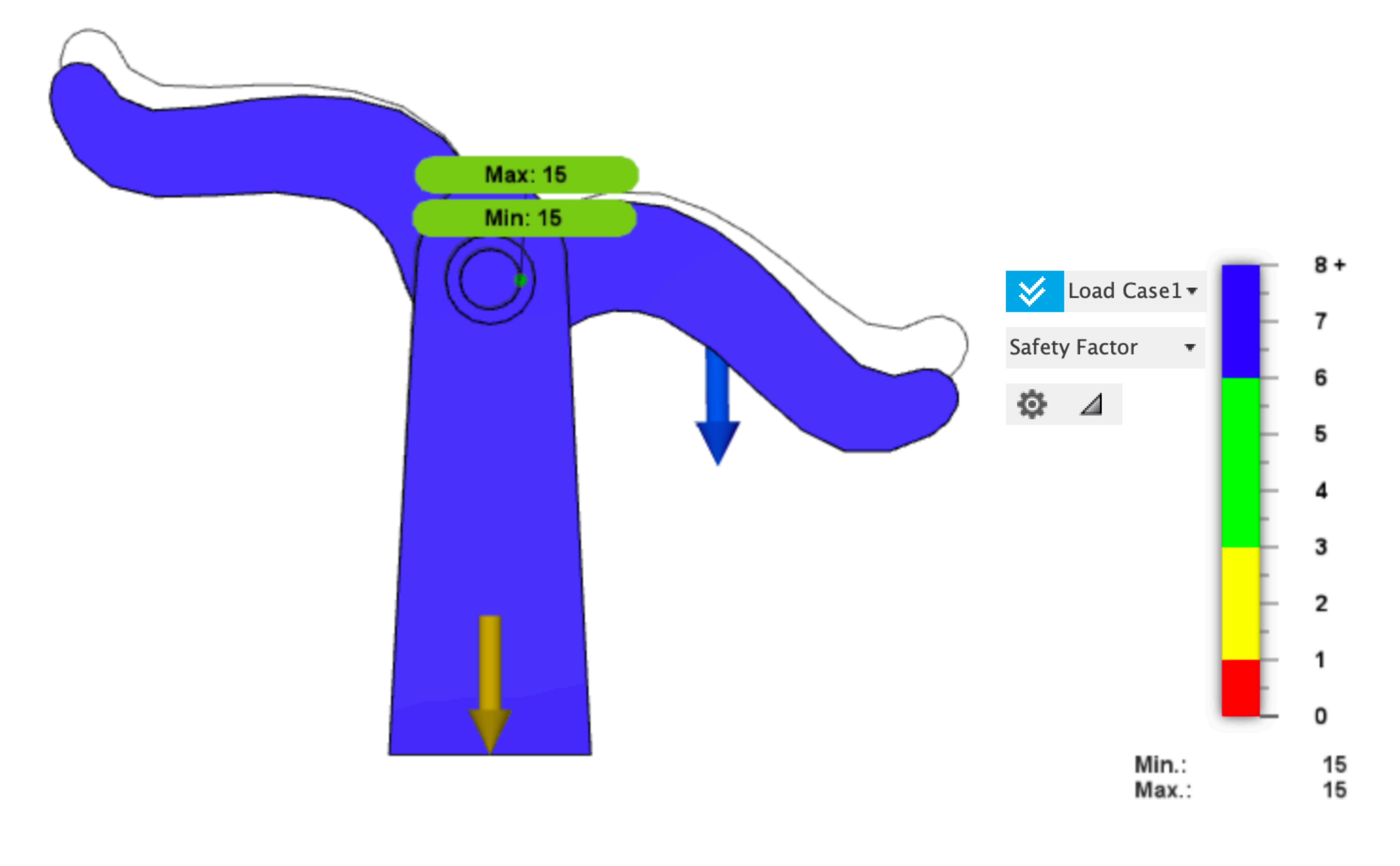
Simulation Prep

I measured a single mask 3 different times to find a mass of **13.67g**

Then ran static studies...

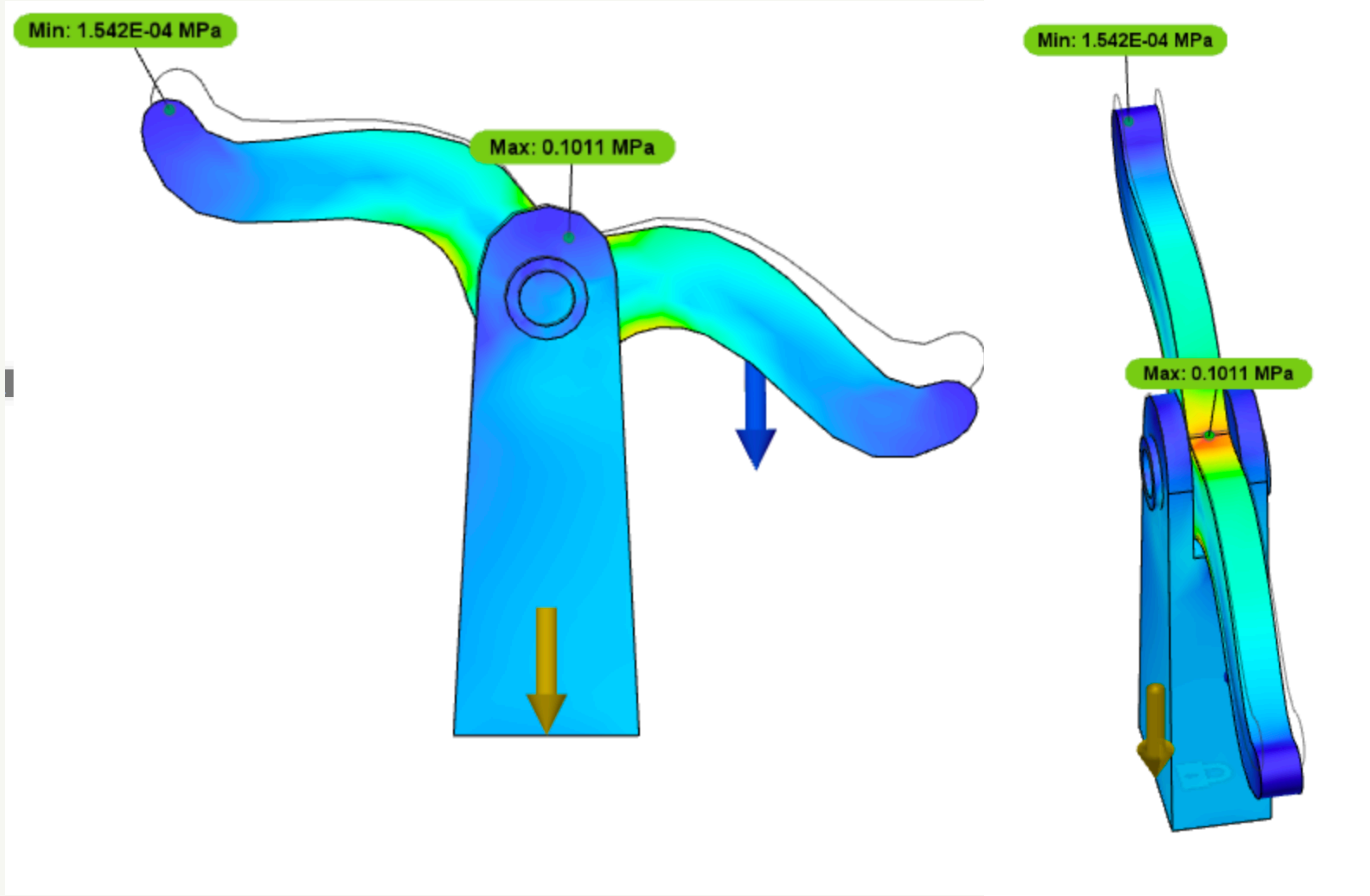
In the case of asymmetric loading...

Simulation - Asymmetric loading



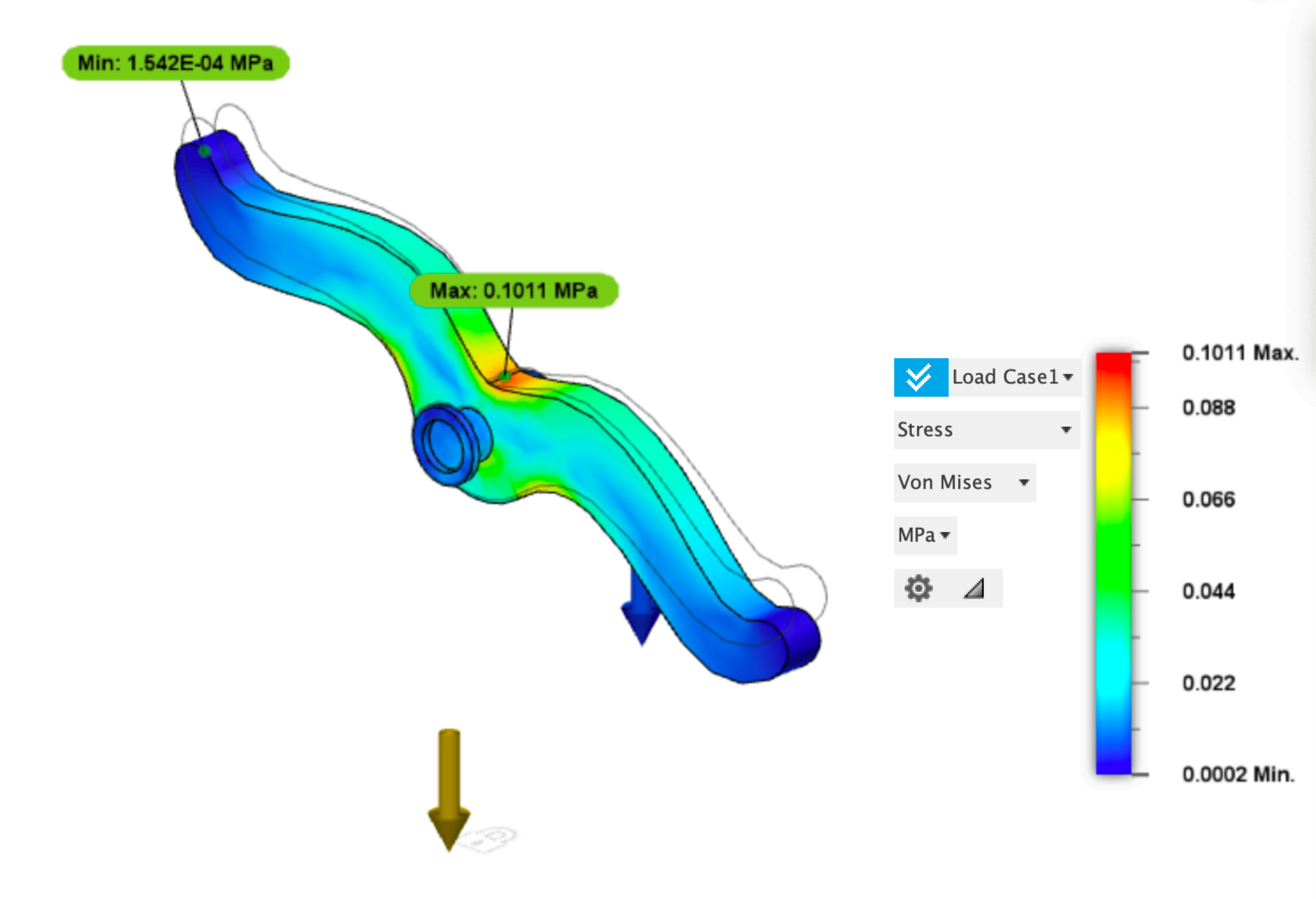
I have a high FoS since my stand is not intended to carry any large loads

Simulation - Asymmetric loading



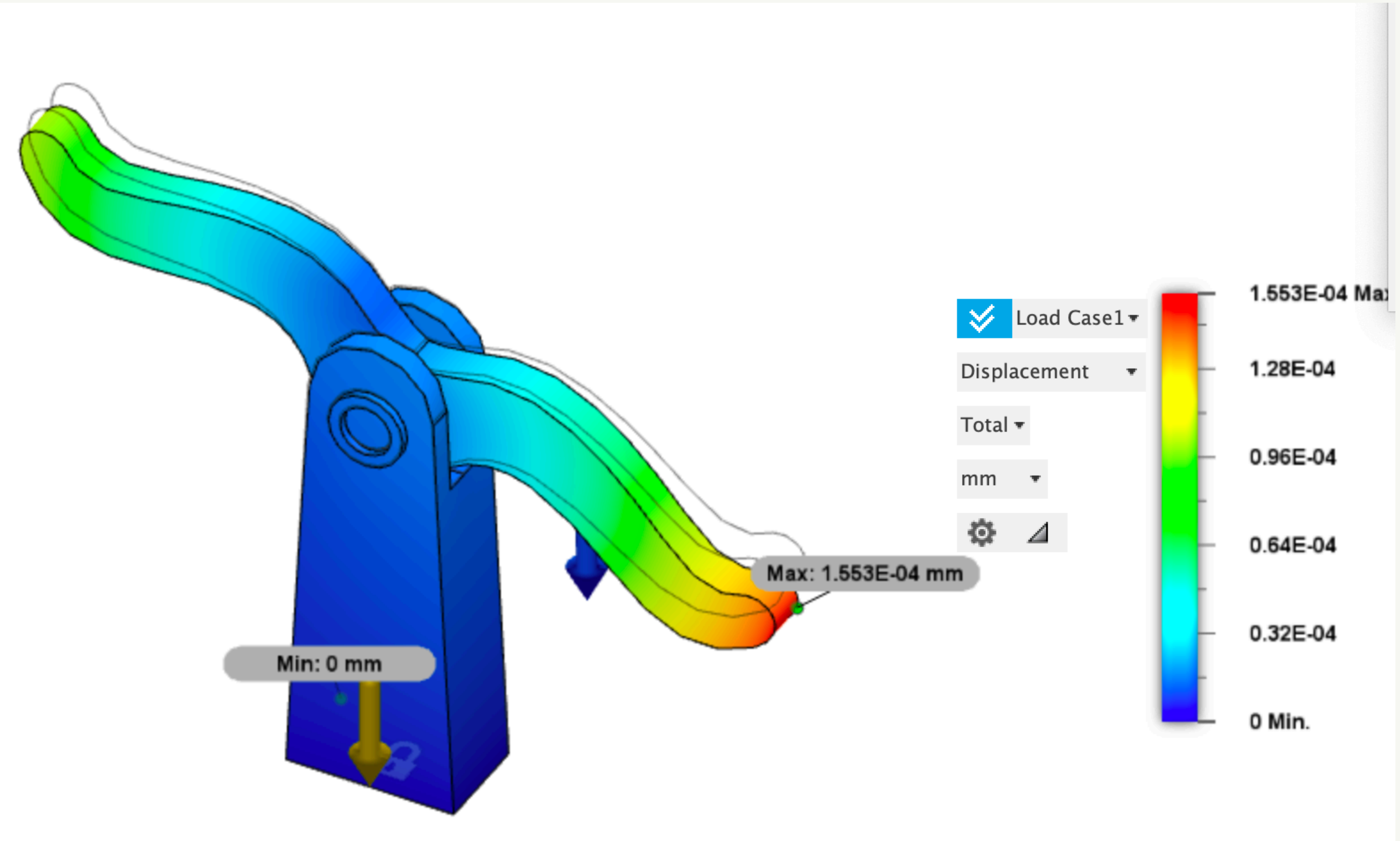
I focused on where the **largest stress concentrations** would be in the case of **asymmetric loading, with a maximum of 0.1011 MPa**

Simulation - Asymmetric loading



The **largest stress concentrations** would be at the **sharp corners** in the case of **asymmetric loading**

Simulation - Asymmetric loading

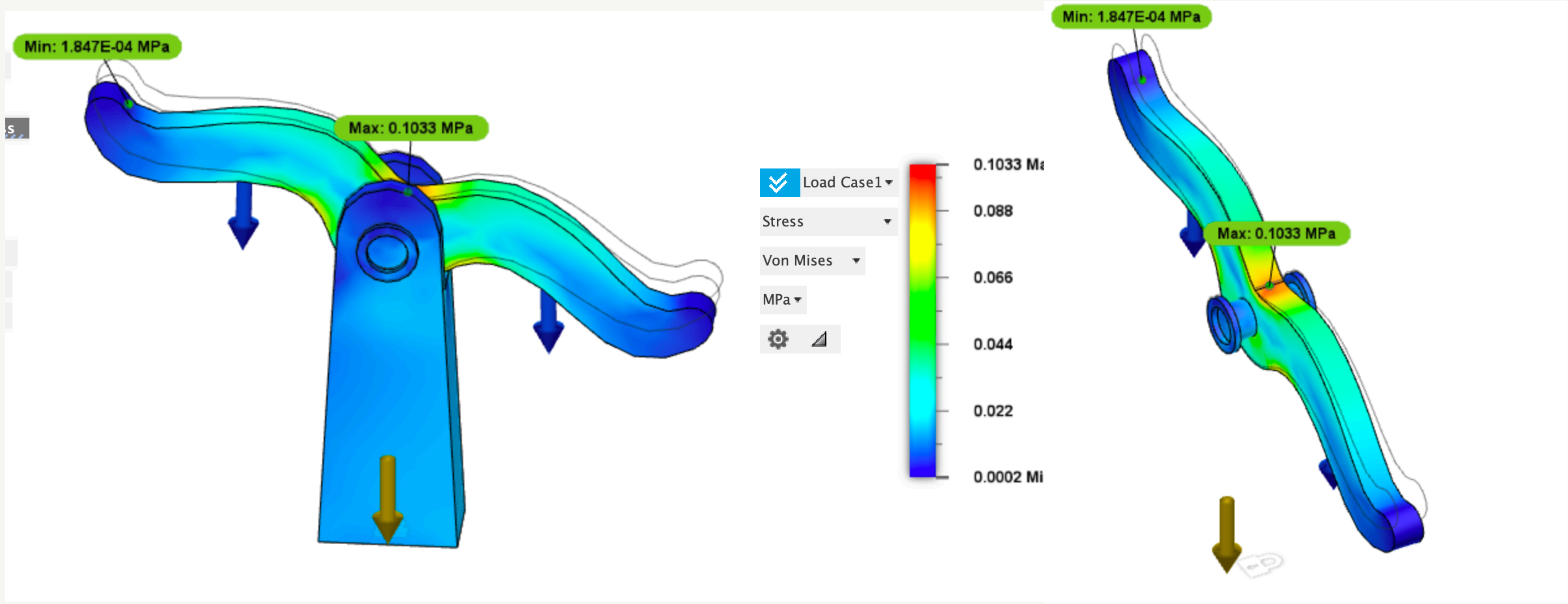


Since my mask hooks are cantilevered, I also did a **deflection analysis**

Although the deflection would be so minuscule

And in the case of symmetric loading...

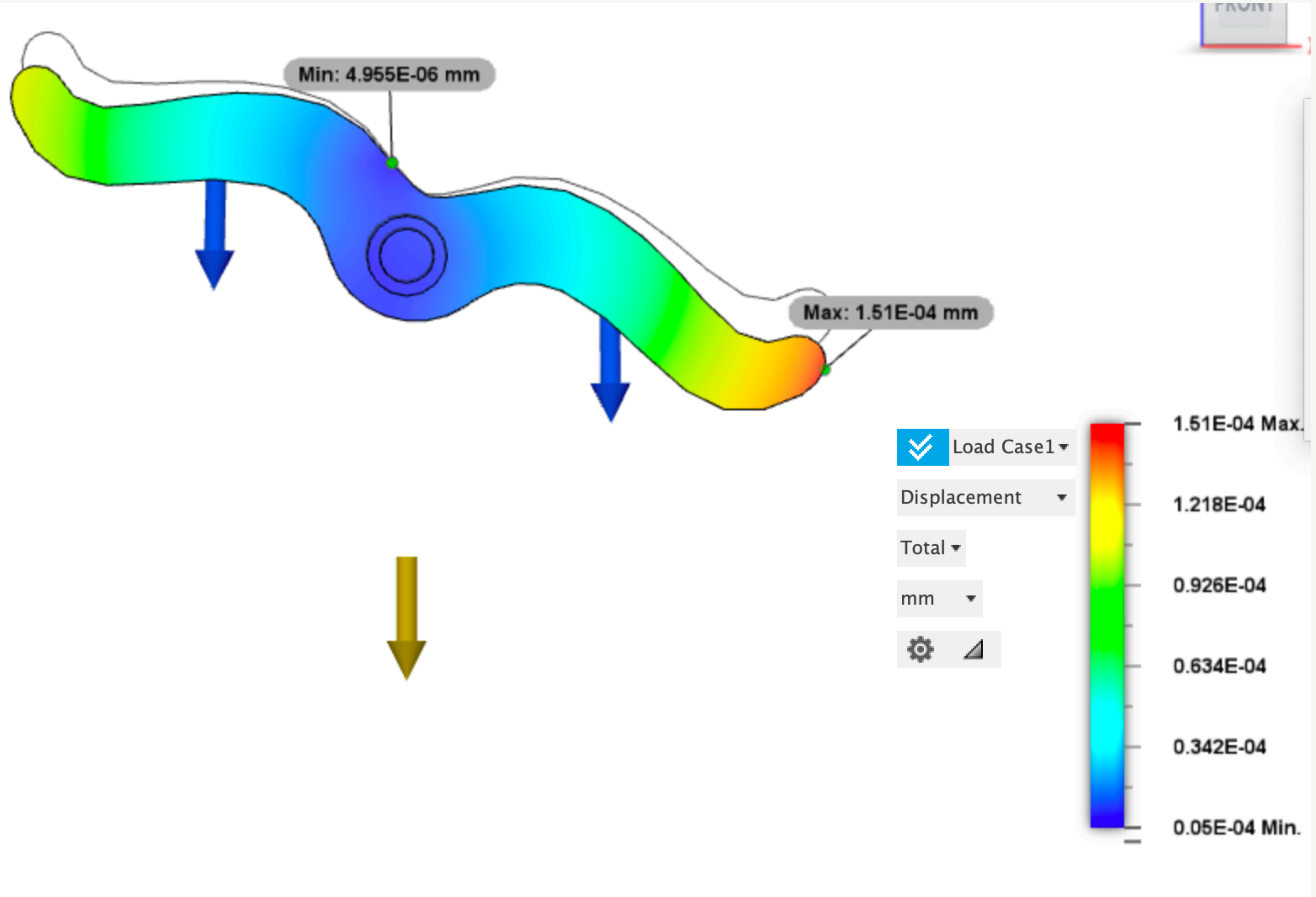
Simulation - Symmetric loading



For symmetric loading, the FoS is the same

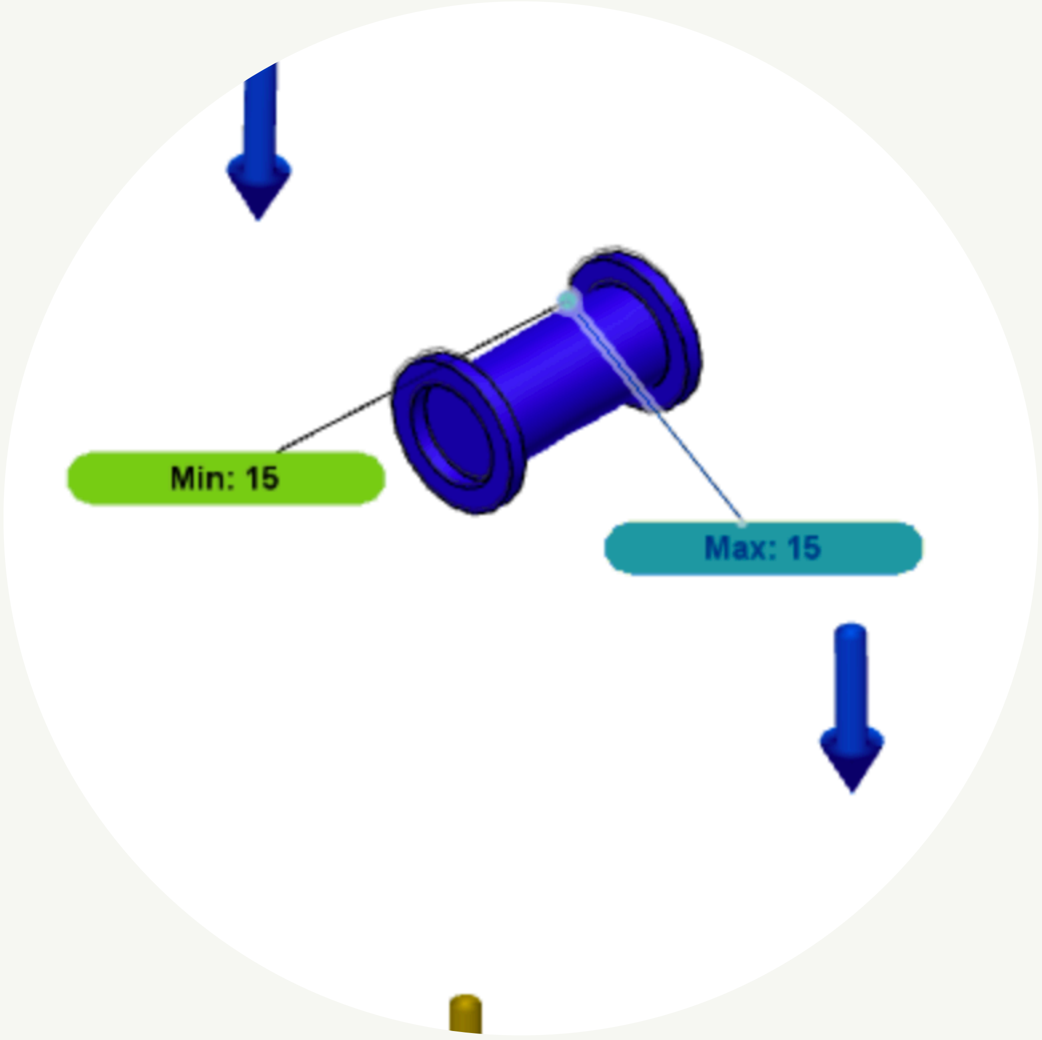
However, the **maximum stress** would be larger than in the asymmetric case at **0.1033 MPa**

Simulation - Symmetric loading

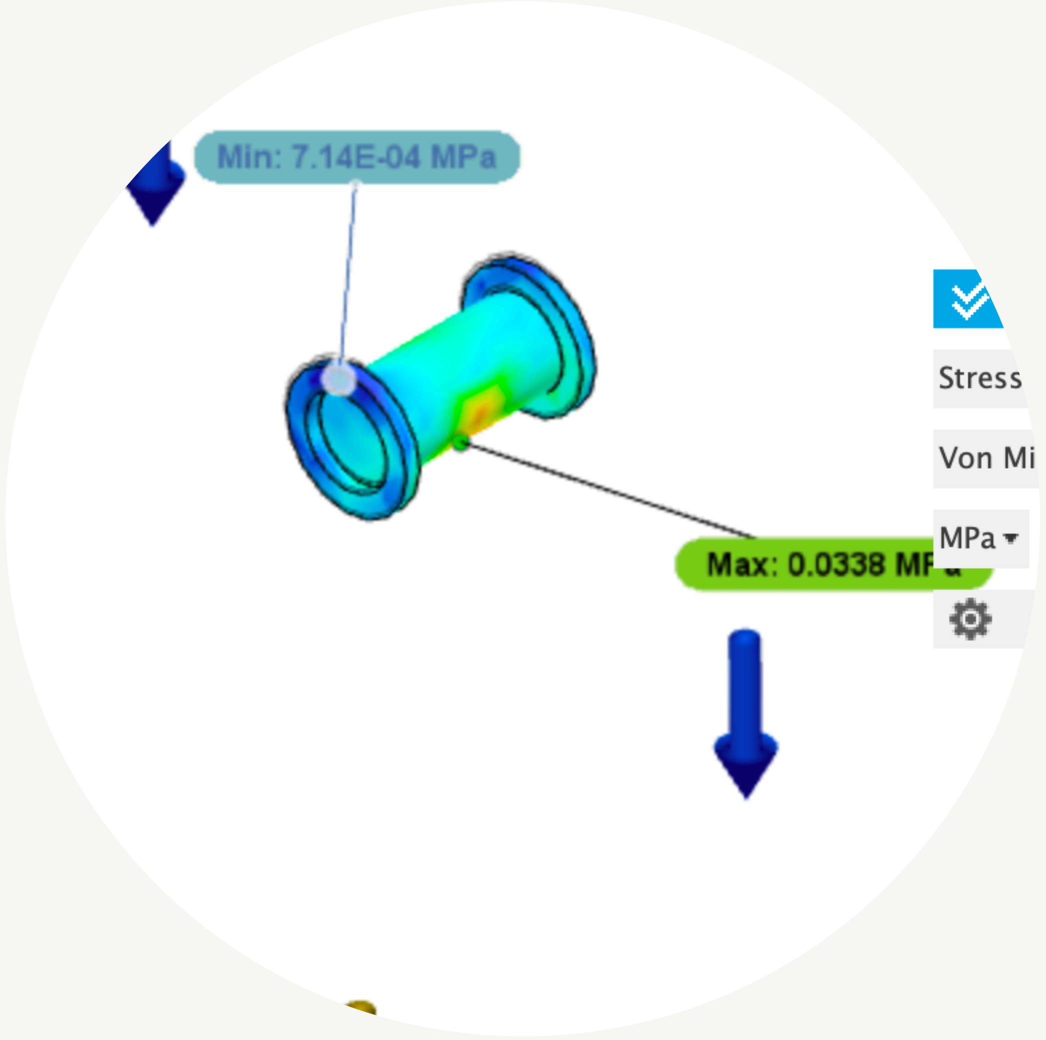


While the deflection would still be minuscule

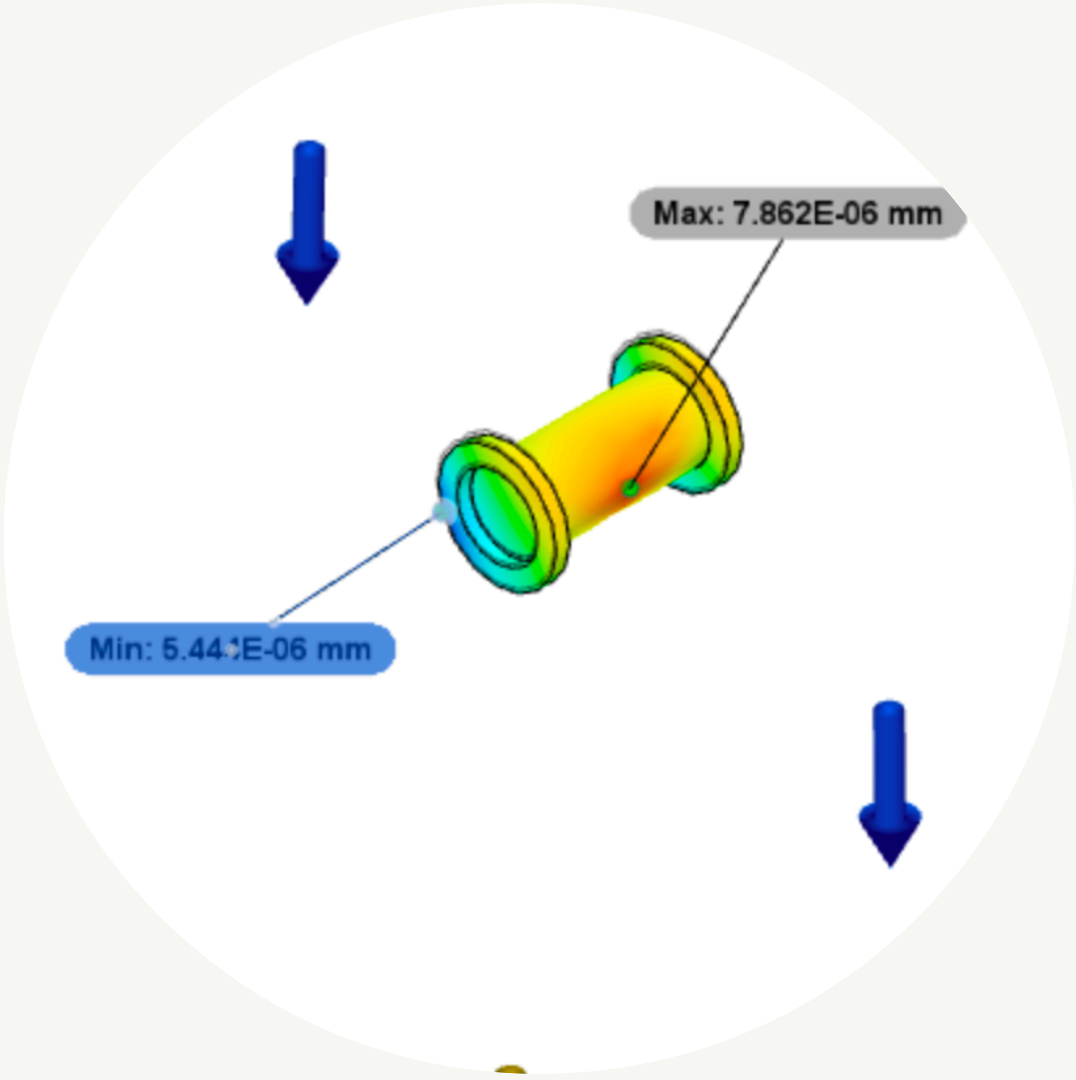
Simulation - Symmetric loading



FoS



Stress



Deflection

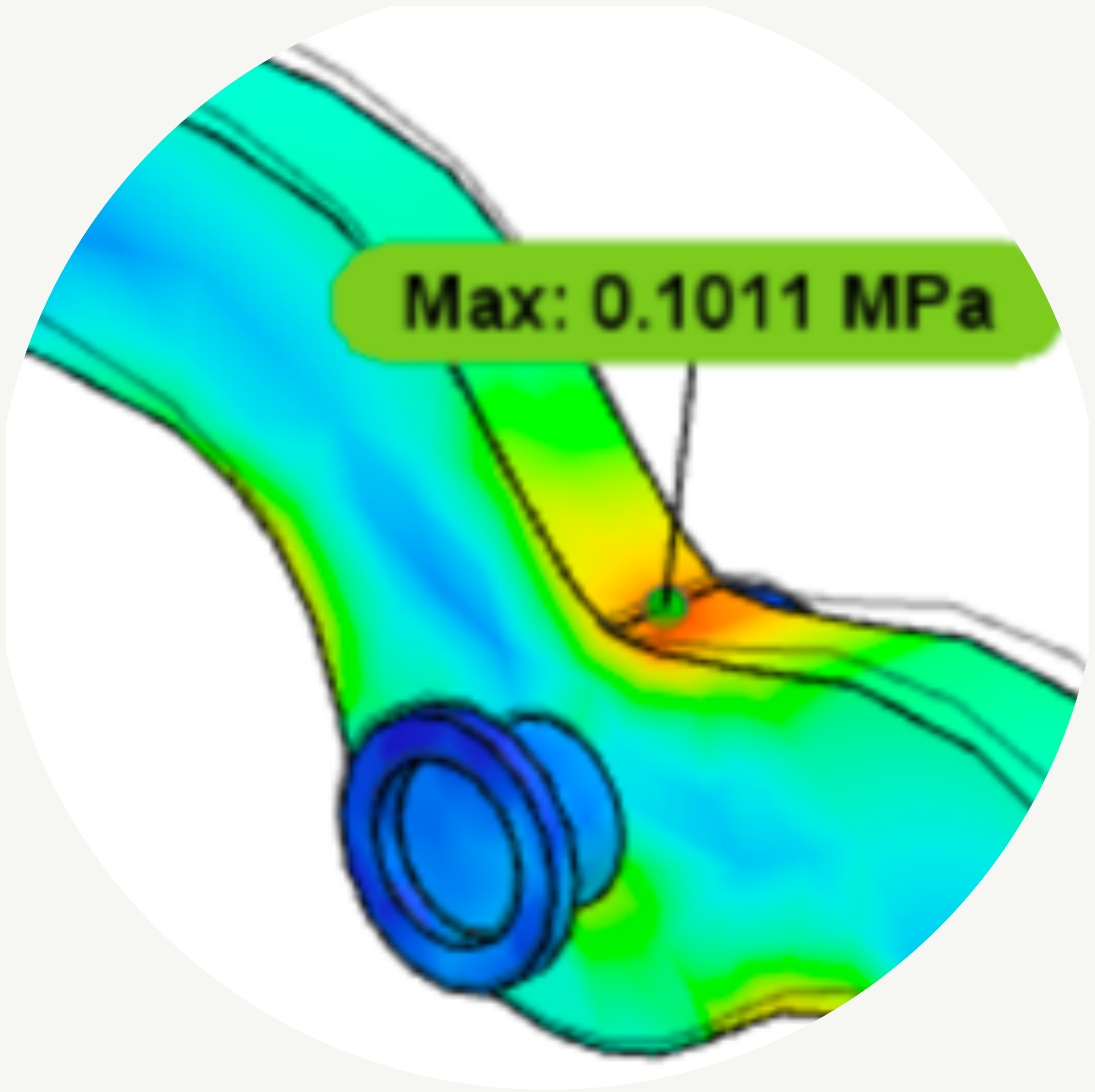
I also looked at just the pivot...

Since pivot is cantilevered, a **shorter length** would help avoid failure modes, such as **deflection**

I had some key take aways from these studies…

Take aways

Based off my CAD models and simulation analysis, these are the changes I want to implement for my final design:



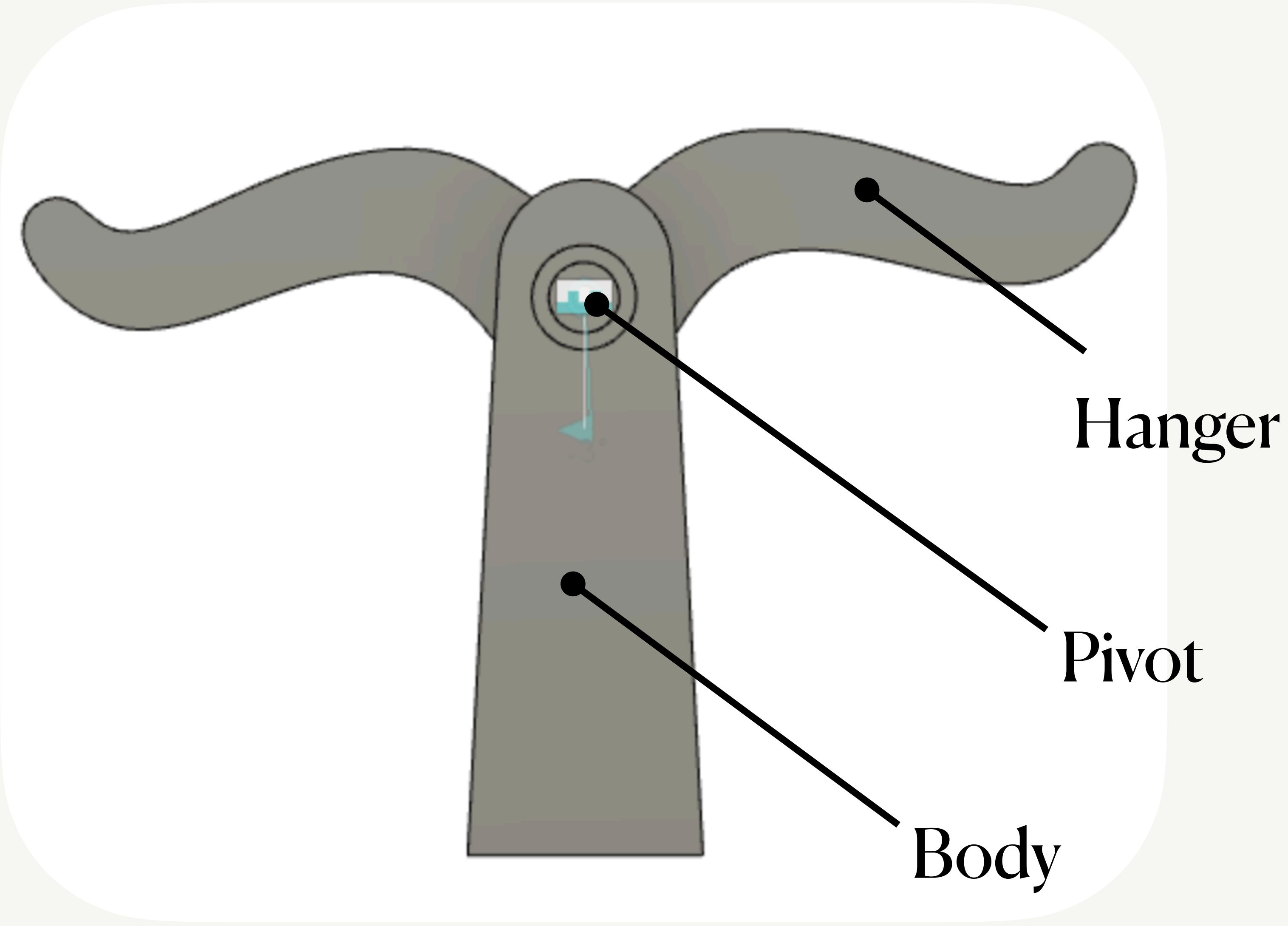
Minimize points of high stress by adding fillets

Ensure enough clearance between the mask hanger to rotate smoothly

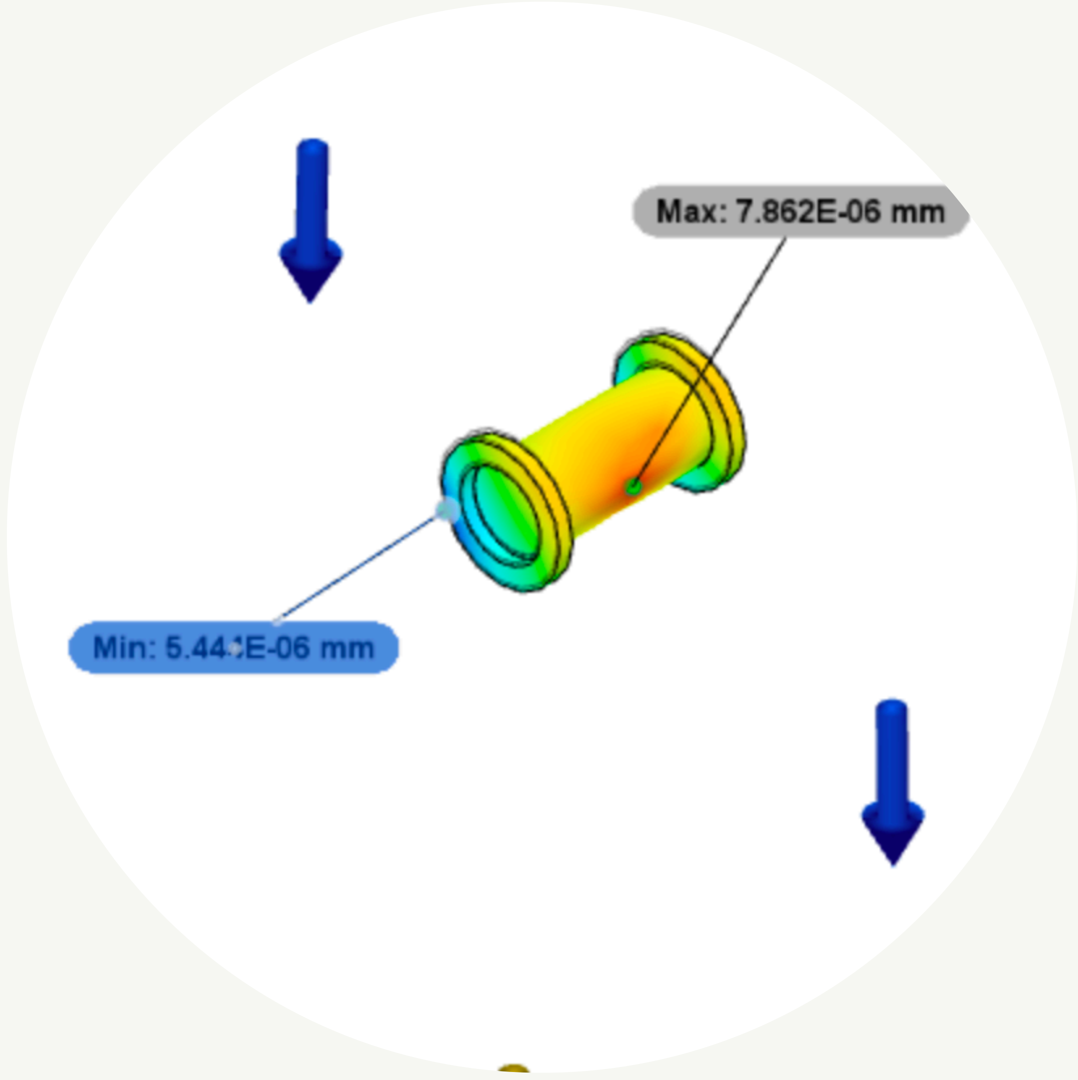
Add stop to limit mask hook movement

Take aways

Based off my CAD models and simulation analysis, these are the changes I want to implement for my final design:



Reduce number of assembly components

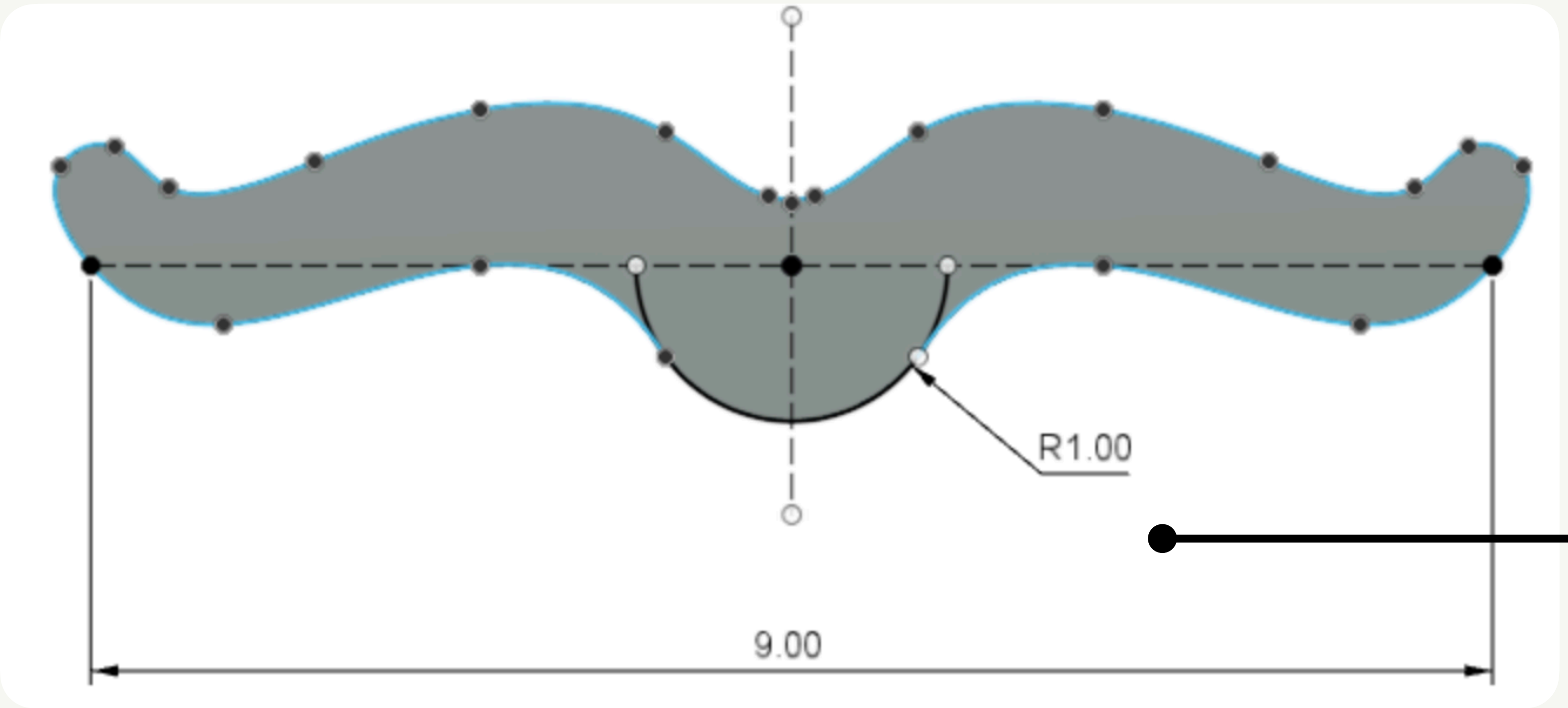


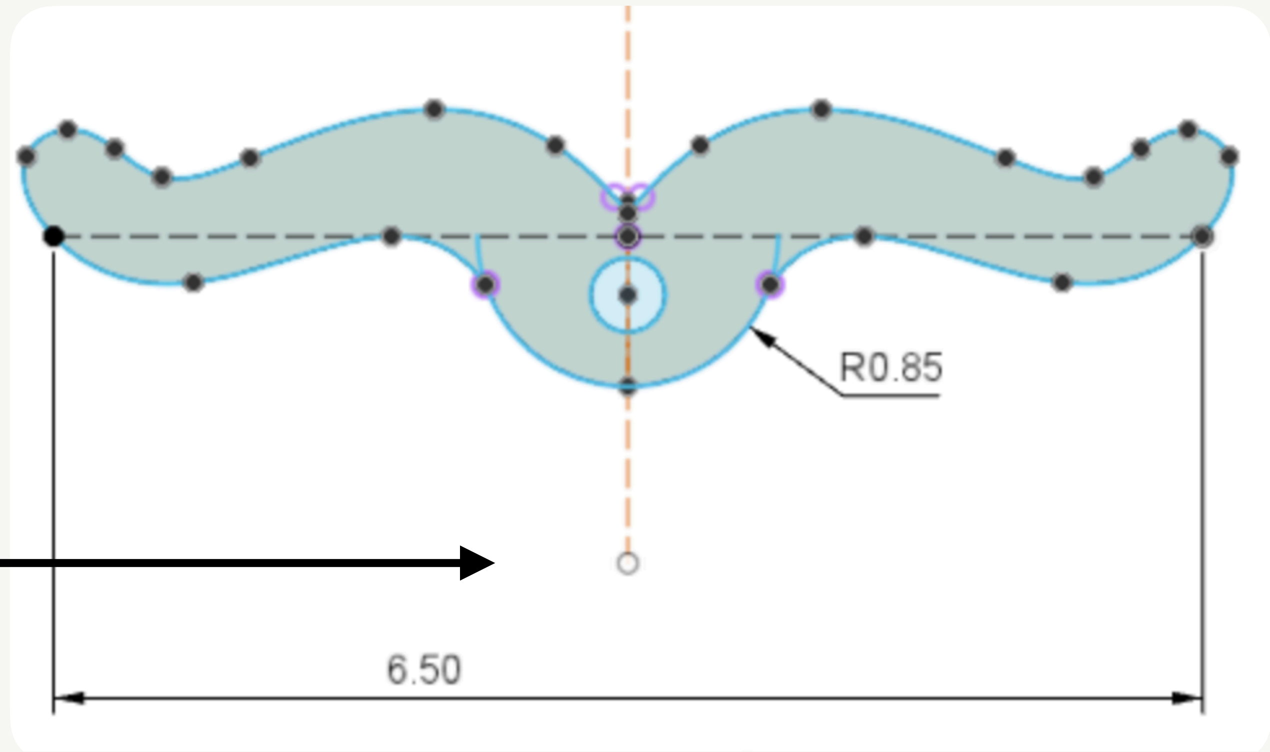
Minimize failure modes of pivot by shortening

Based on these takeaways, I iterated upon my design

Iterations

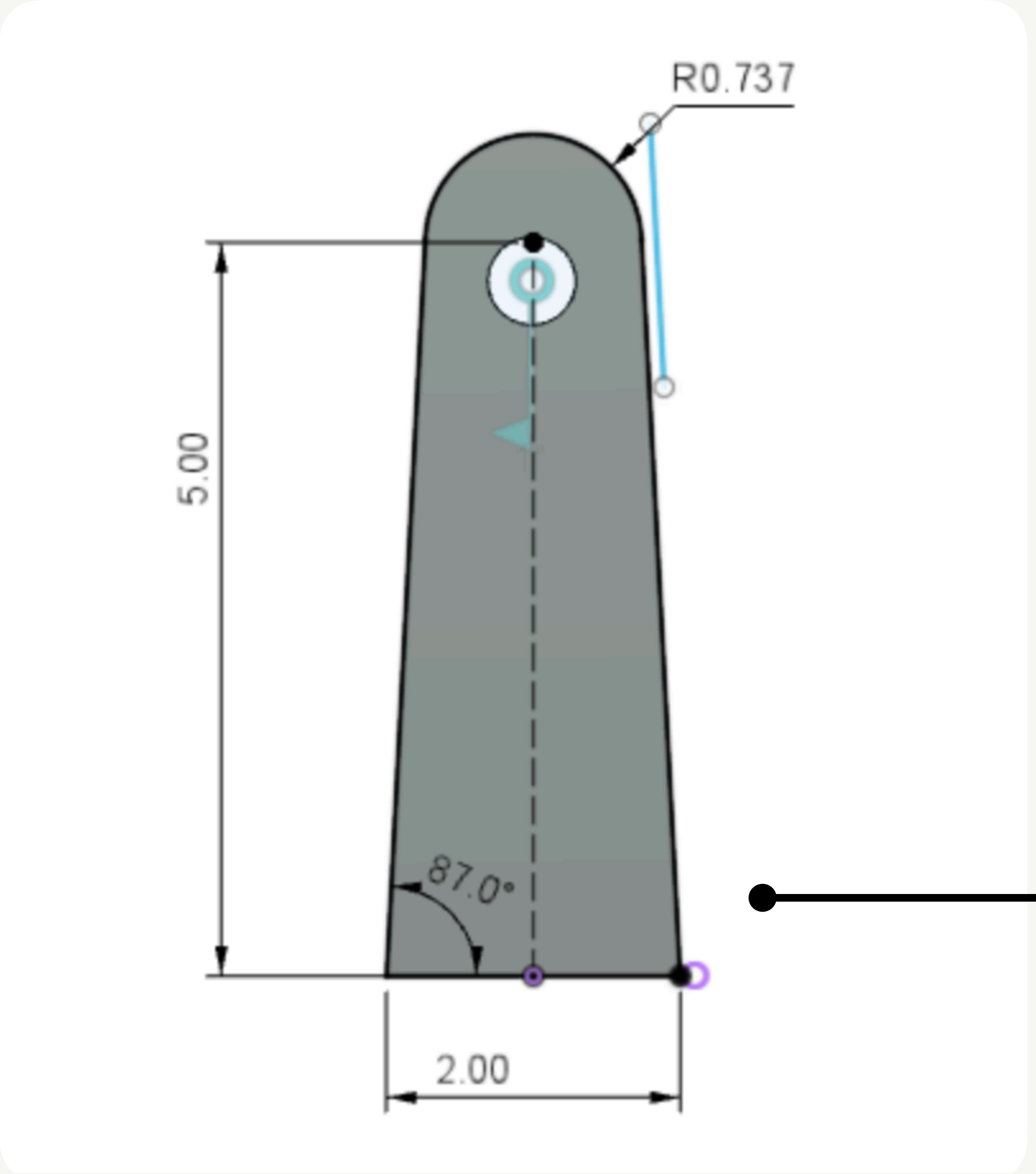
Initial Hanger sketch



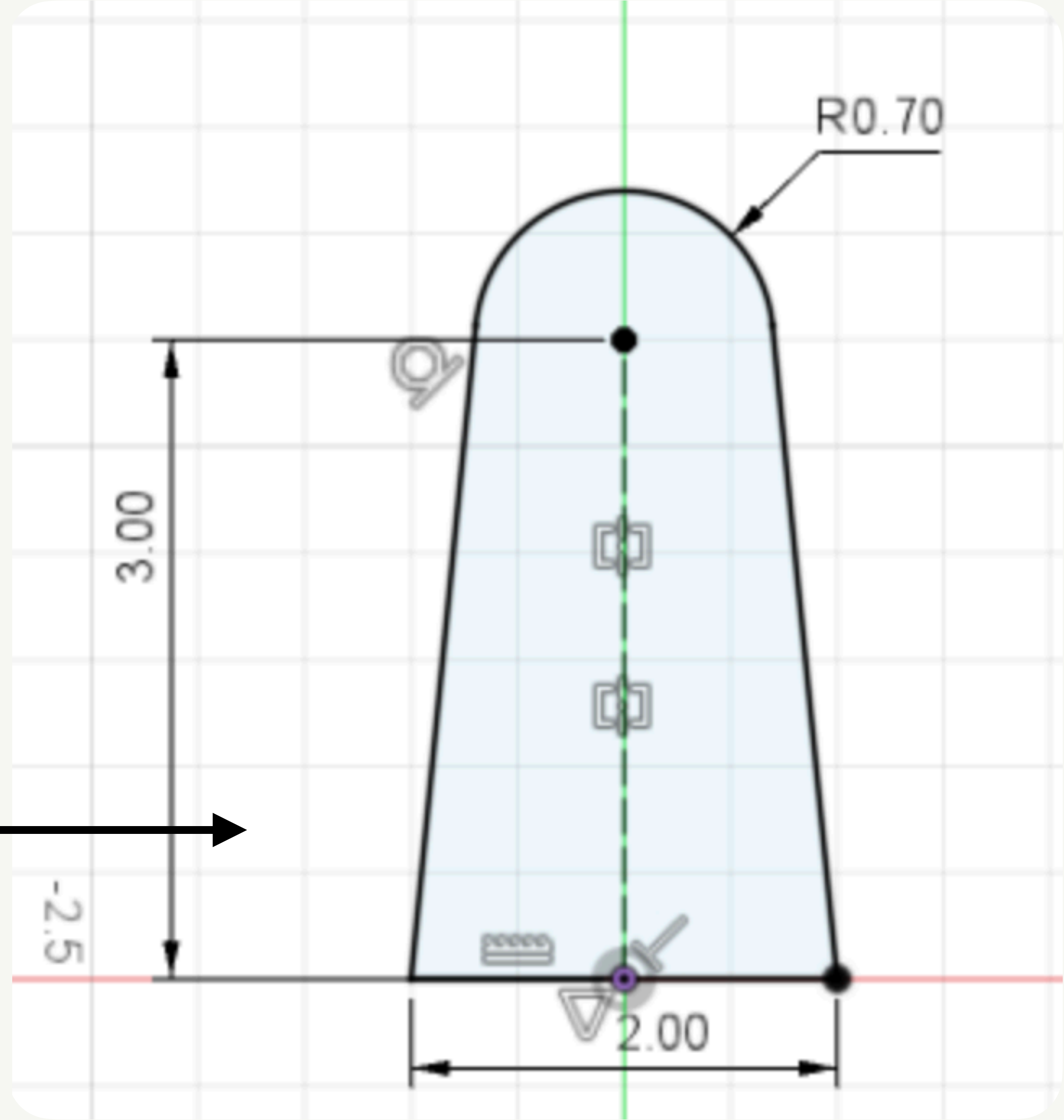


Final Hanger sketch

Initial Stand body sketch

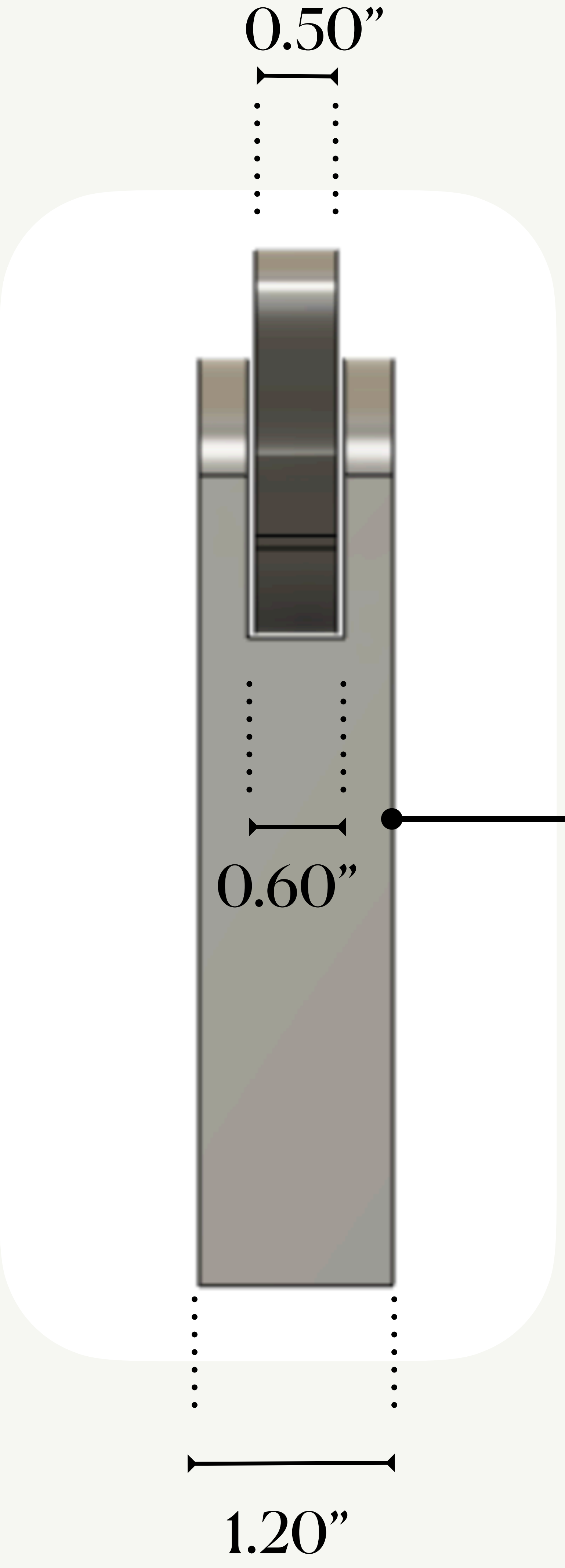


Initial model was **as large** as printer bed, so **scaled down**



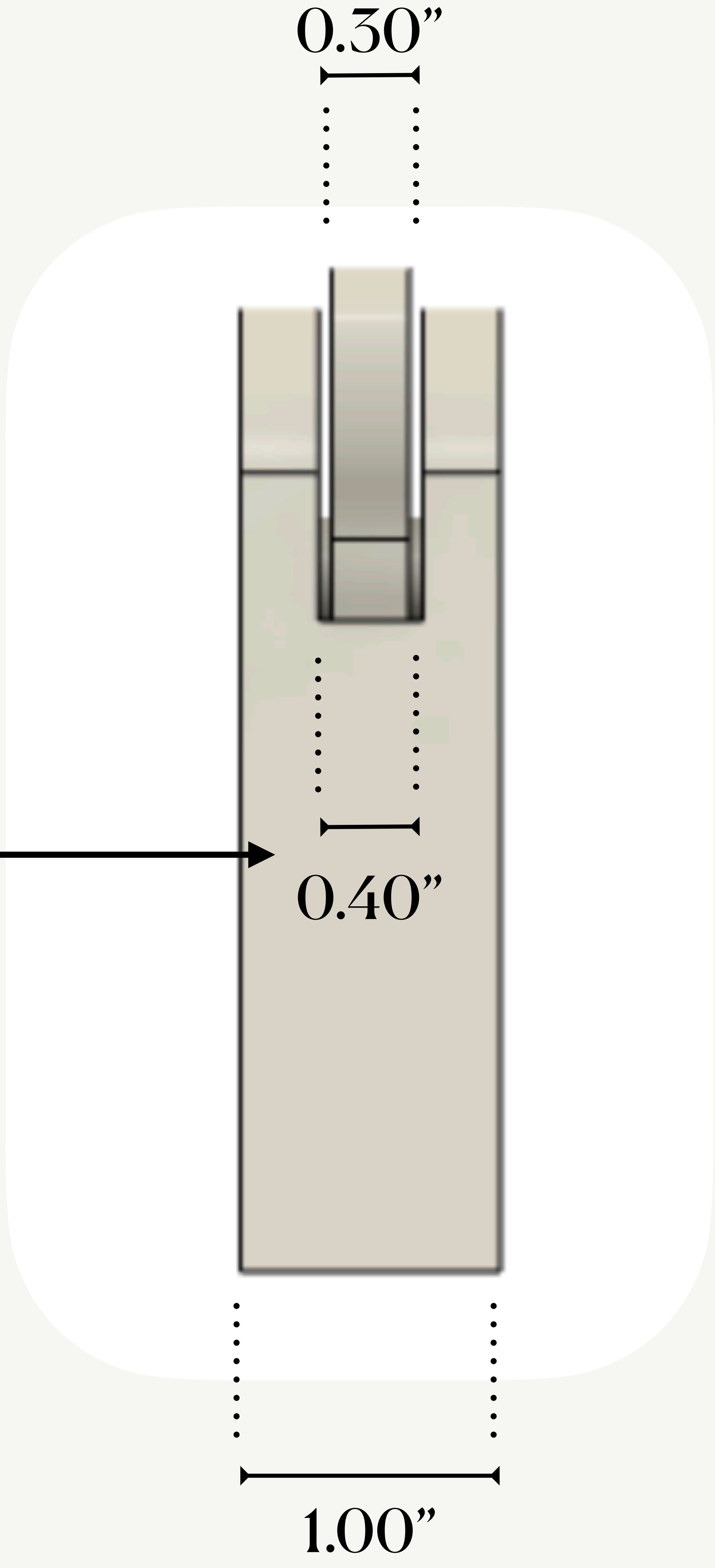
Final Stand body sketch

Iterations



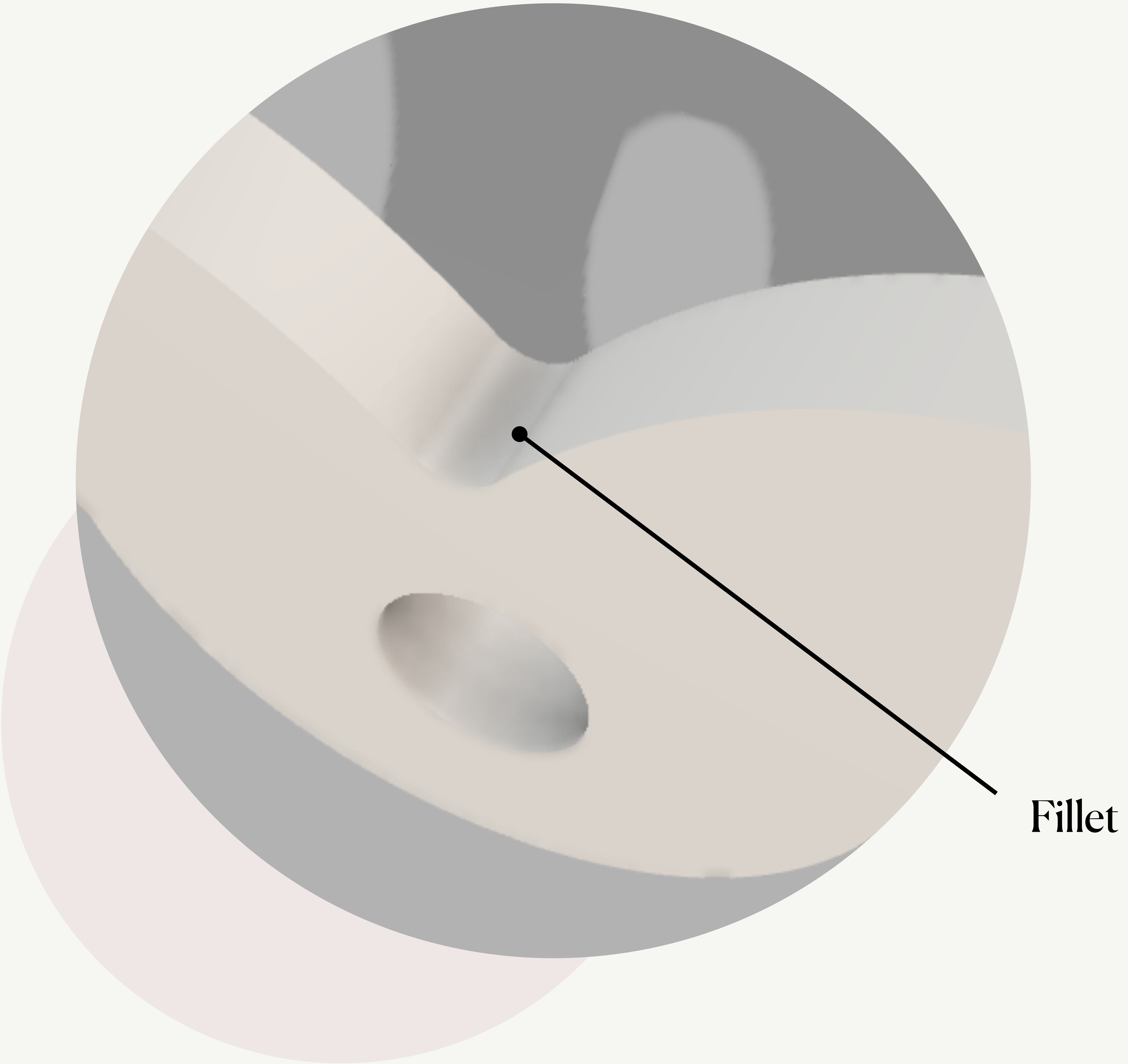
Initial assembly side profile

Scaling down the **pivot length** from 0.60” to 0.30” to **minimize deflection**



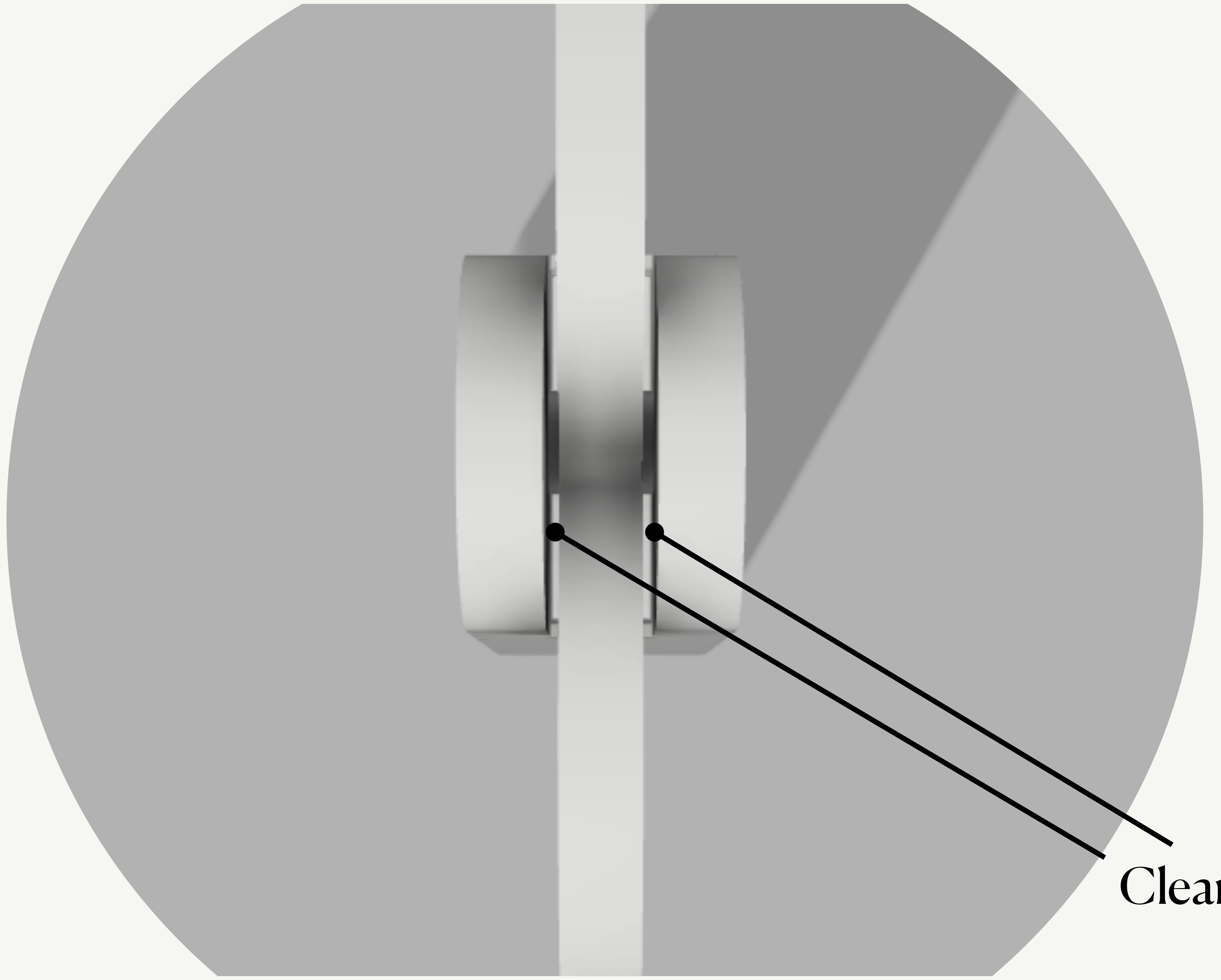
Final assembly side profile

Iterations



To **minimize points** of **high stress**, I added **fillets** to the mask hanger

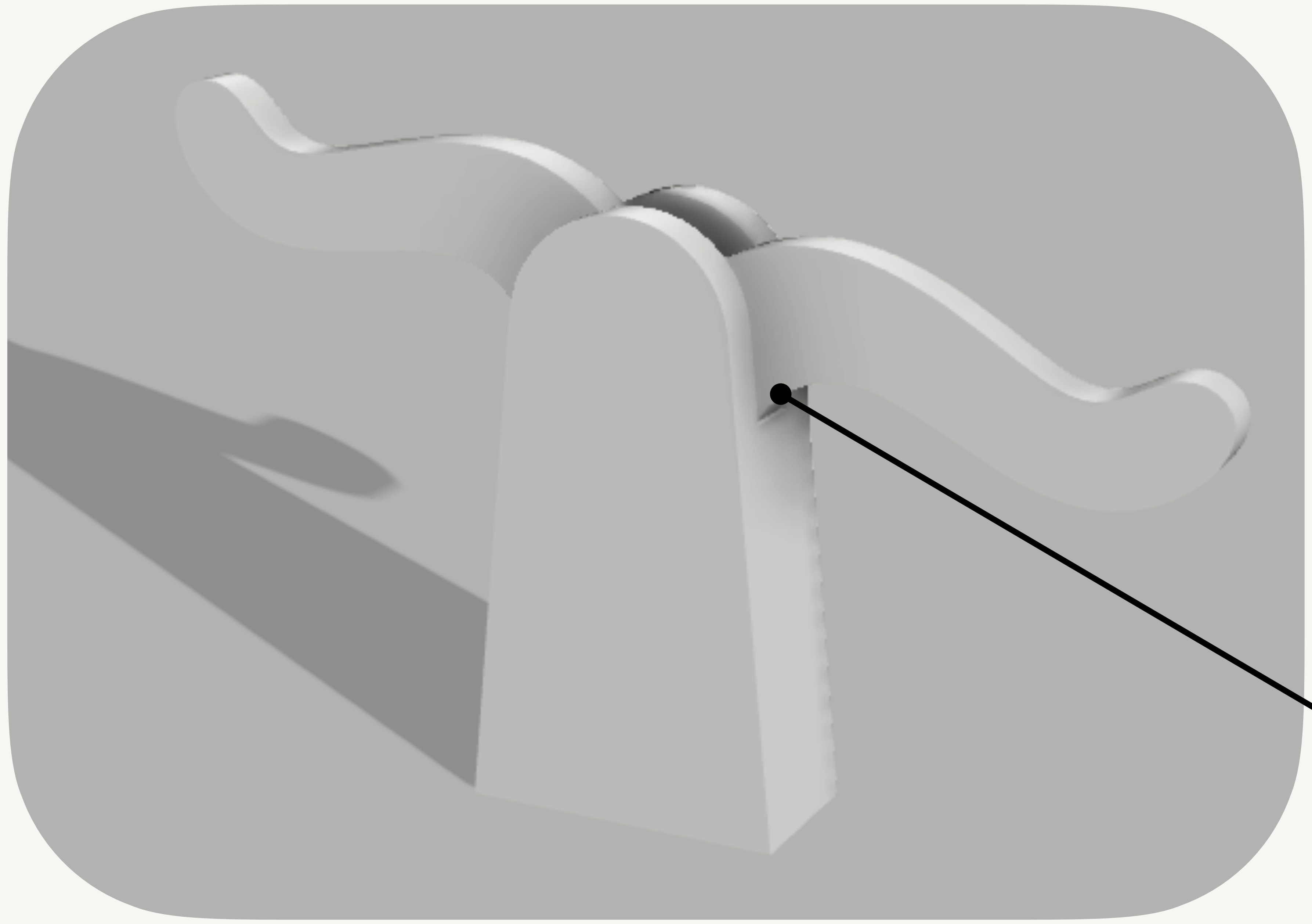
Iterations

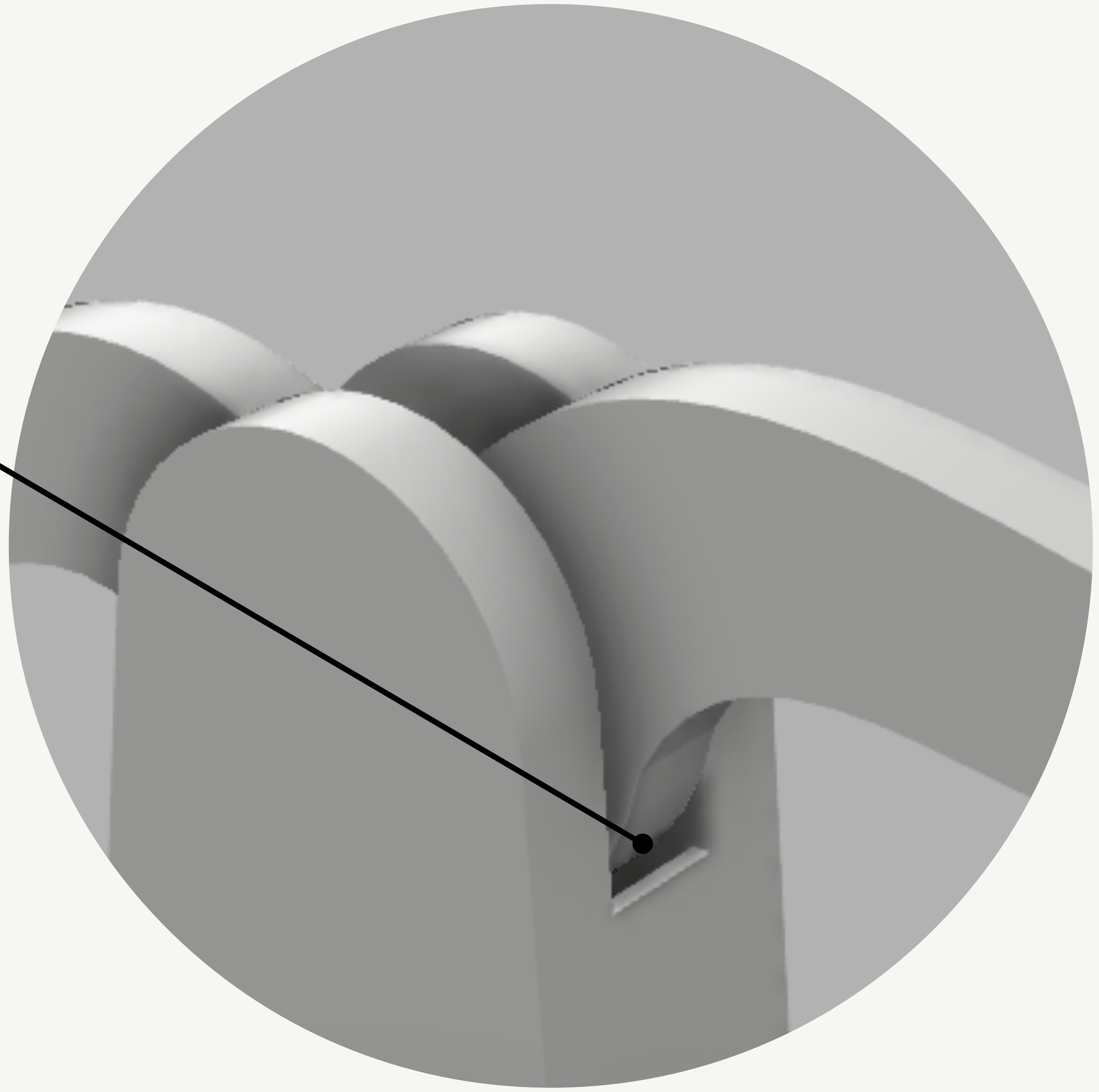


Top view of the clearance between the mask hanger and body

To ensure mask hanger to rotates smoothly, clearance of **0.05in** on **each side** of mask hanger

Iterations

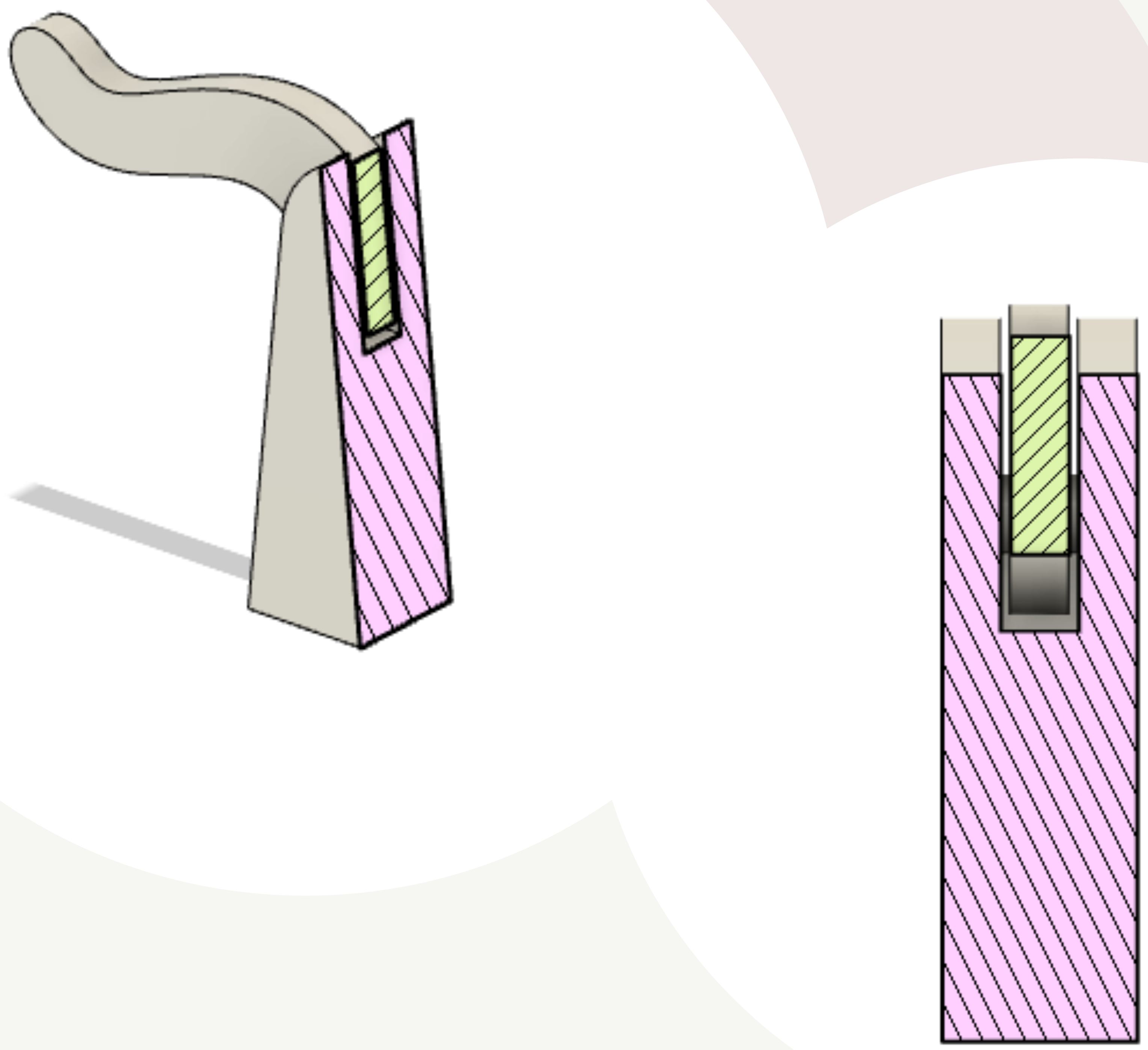




Adding my stop to limit mask hook movement (**11**° in each direction)

Close up view of stop to limit the movement, enabling only slight movement

Iterations

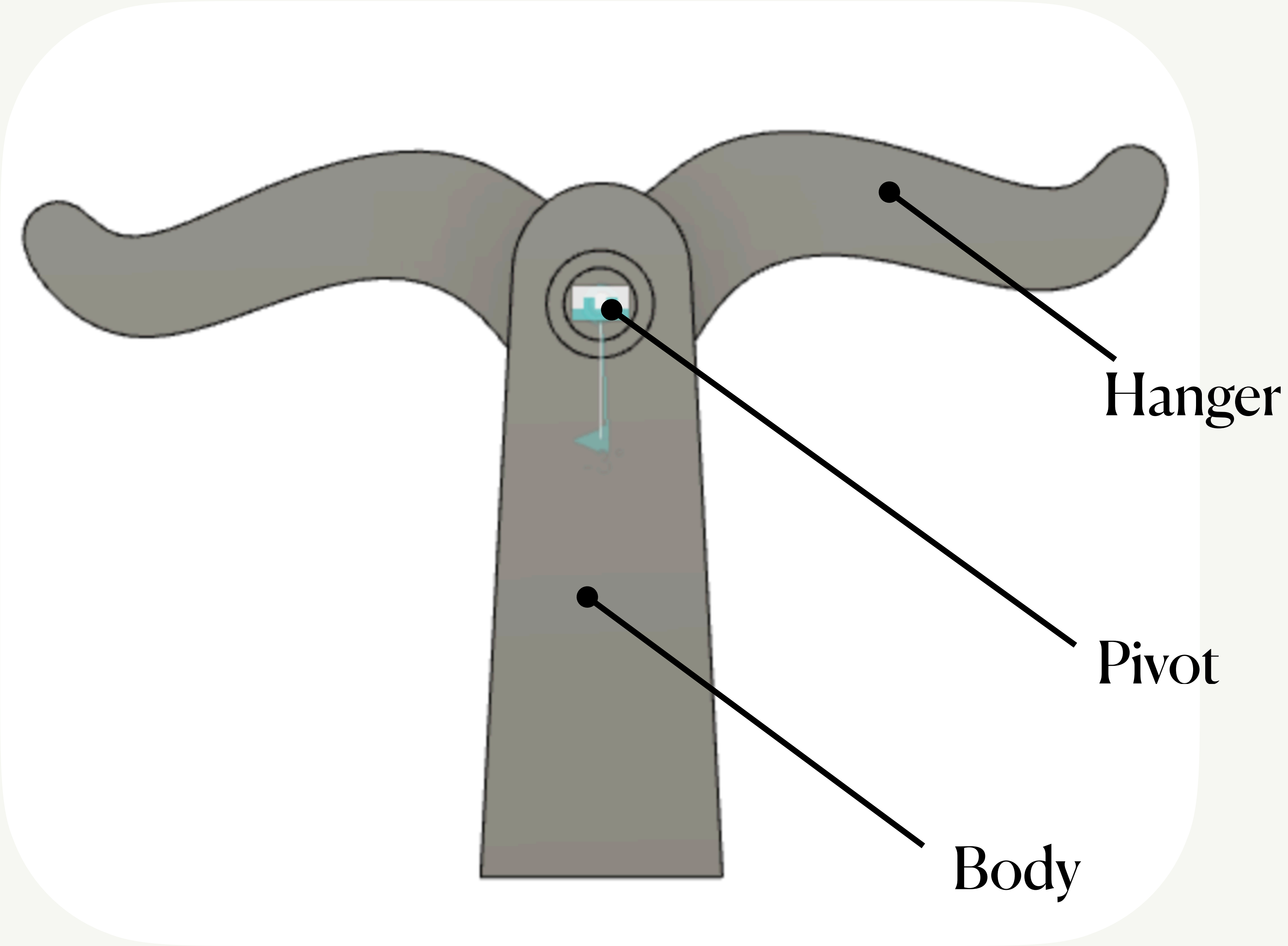


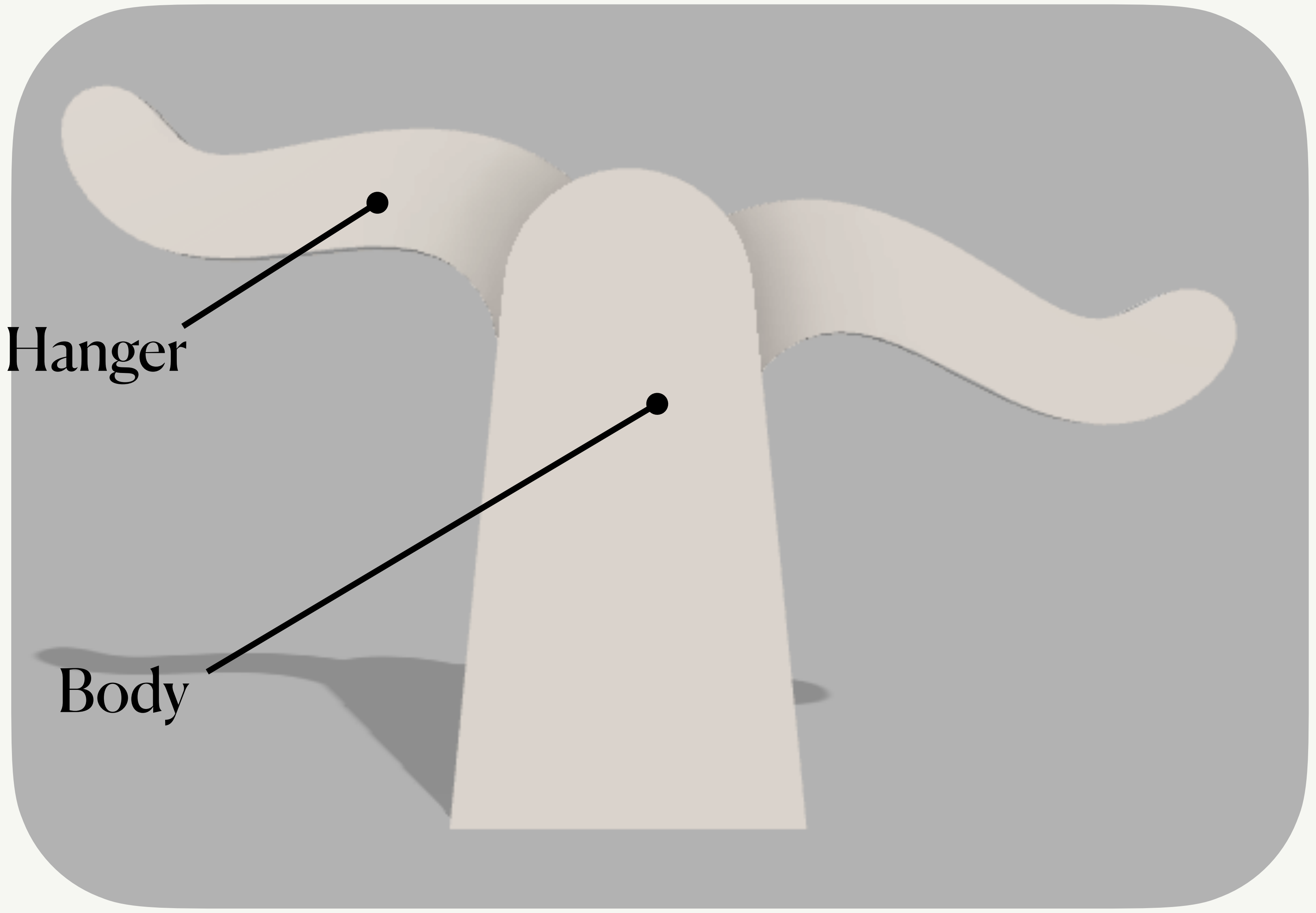
Section analysis of mask hanger and body

Adding my stop to limit mask hook movement...

but also left **internal clearance** to ensure there would be **no interference**

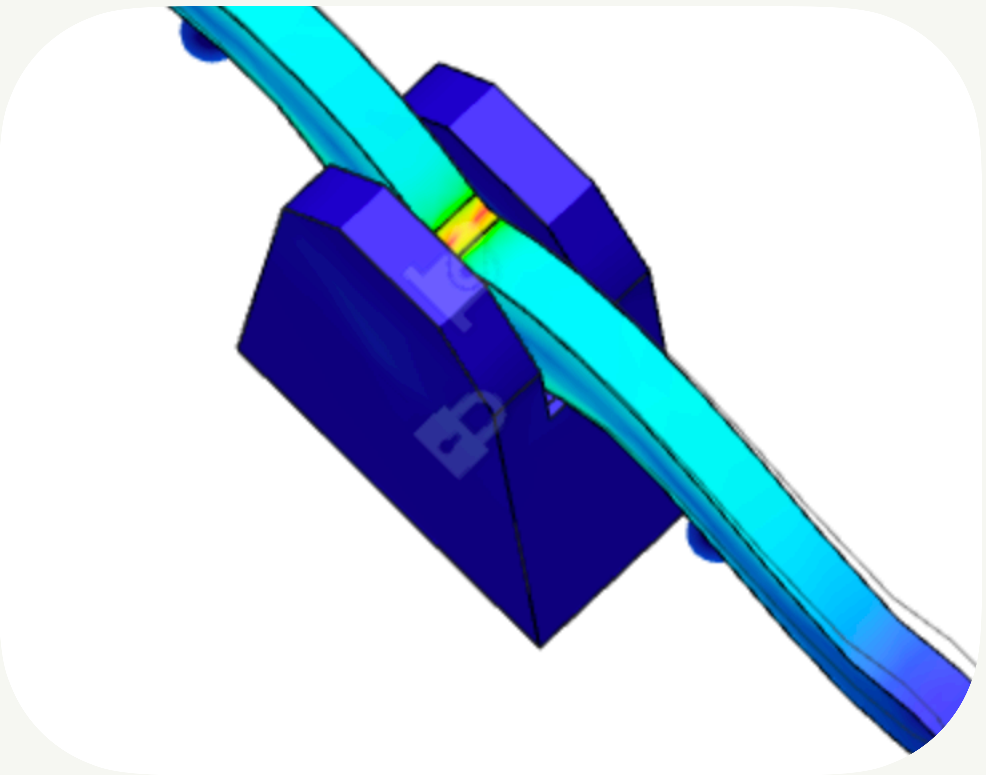
Iterations



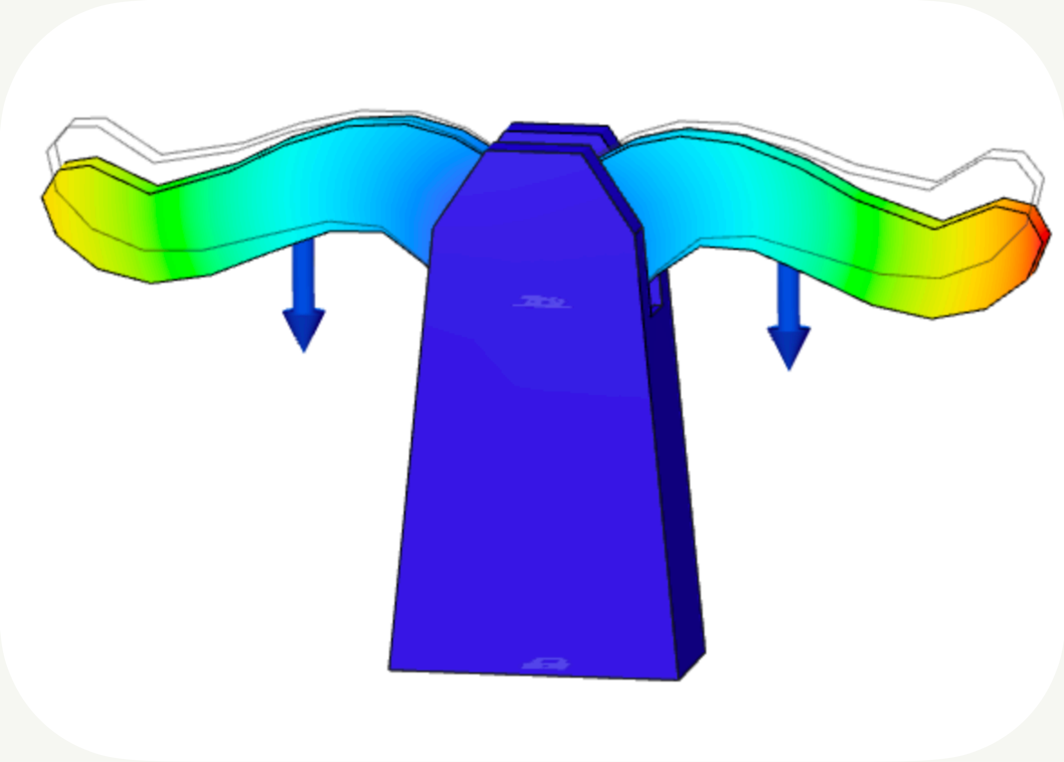


Reduced number of components from **three** to **two**

Iterations - Simulation



Stress
Max = **0.01216MPa**
(vs **0.1033 MPa** of previous design)



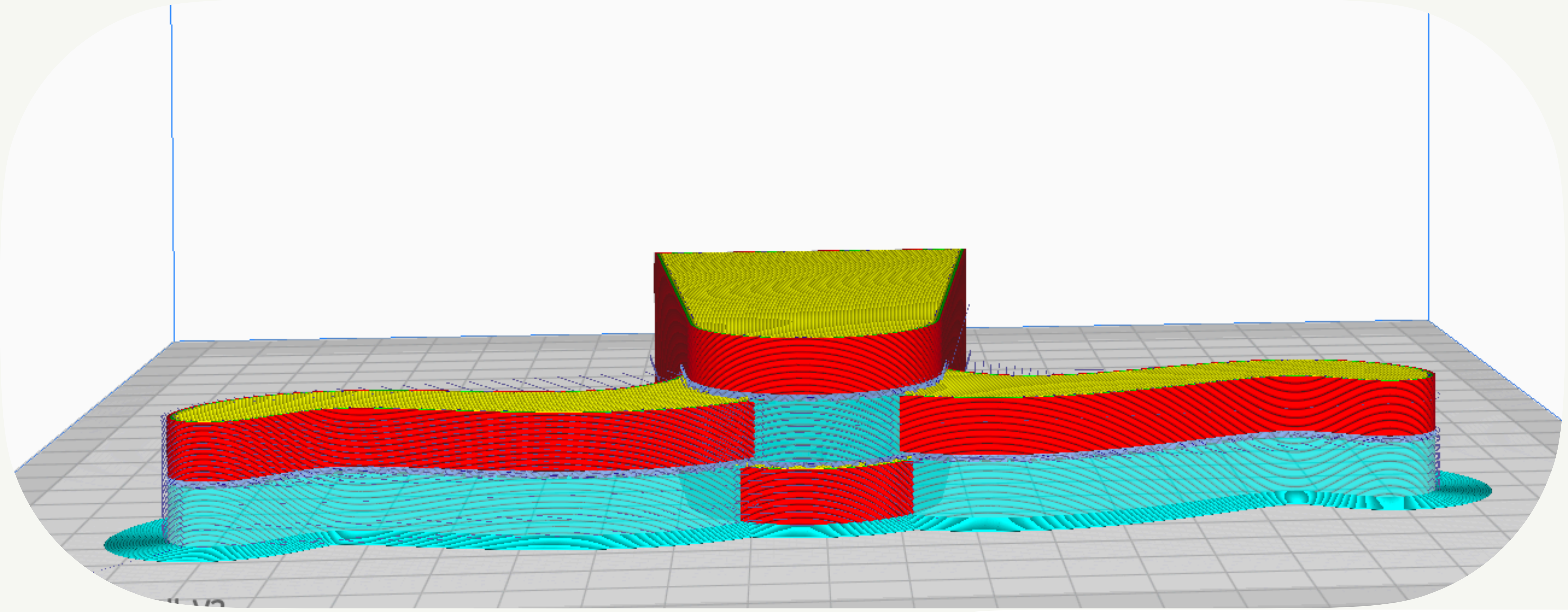
Deflection
Max = **7.366*10^-6mm**
(vs **1.51* 10^-4mm** of previous design)

Changes in geometric parameters impacted performance in symmetric loading case...

By reducing **maximum stress** (~9x) and **deflection** (~100 x)

To fabricate my assembly…

Preparation - First Attempt

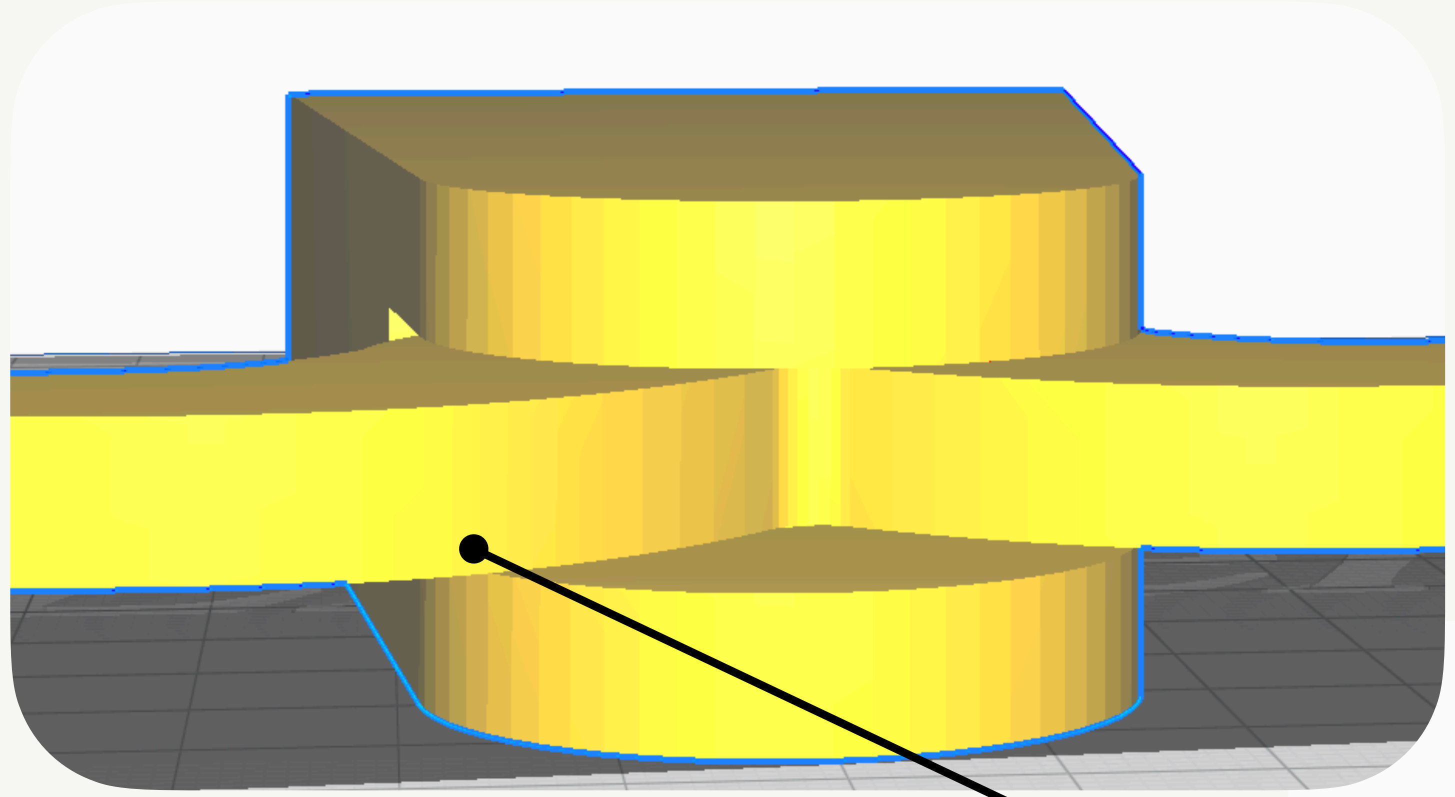


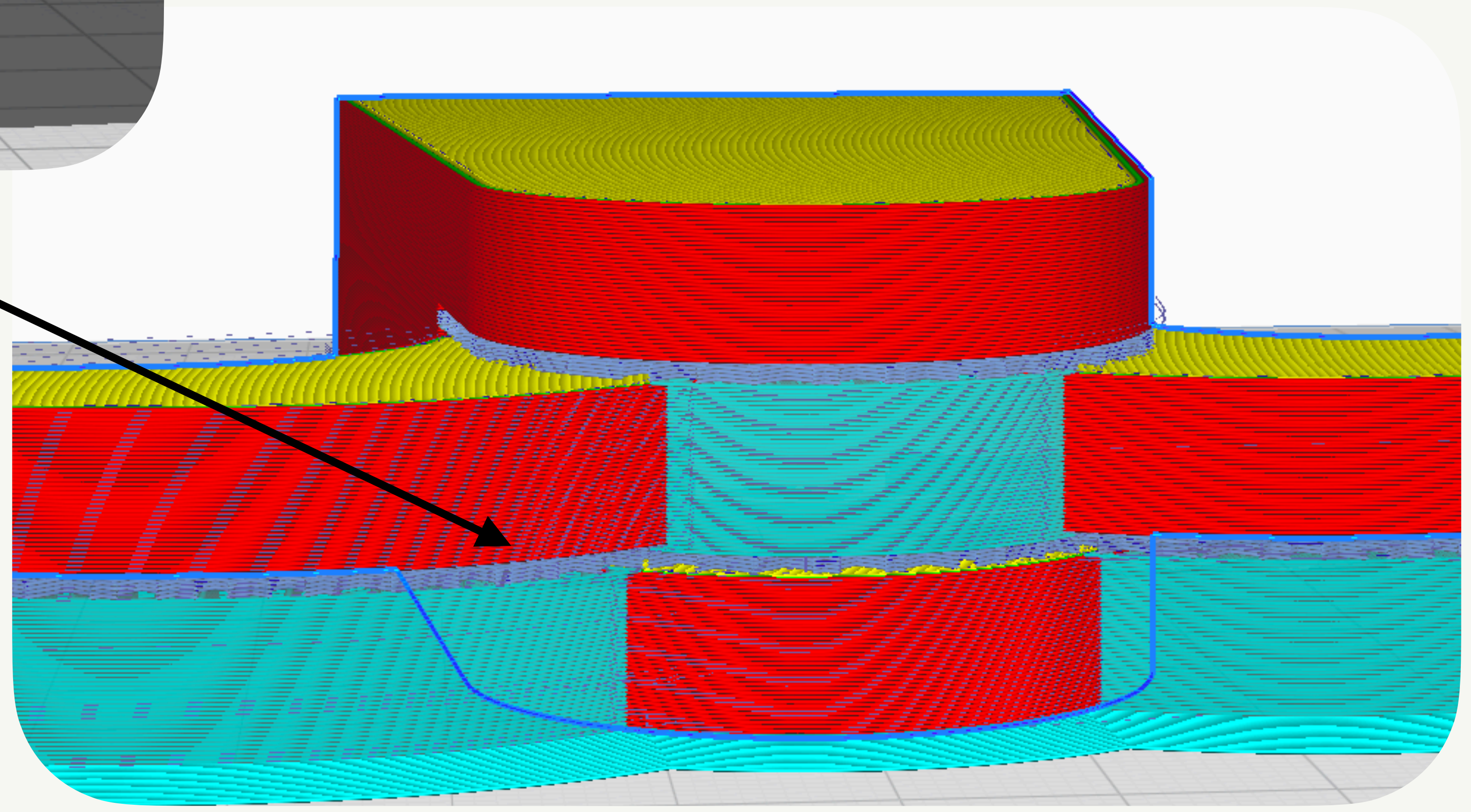
6 hours 24 minutes

59g · 19.70m

Using FDM, get the **most strength** with the **least material use** and **time**, I printed my assembly flat (in x-y)

Preparation - First Attempt



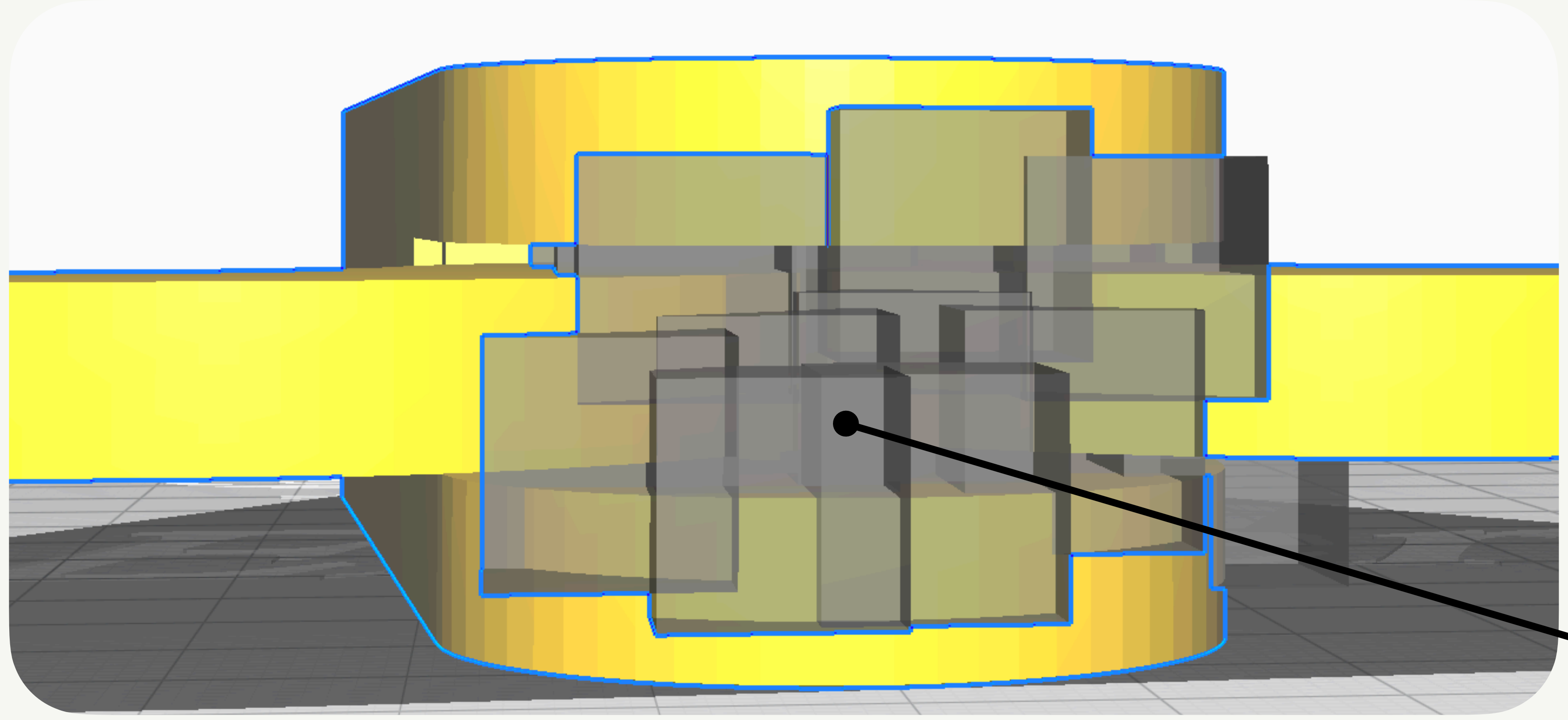


Slices of initial supports on assembly

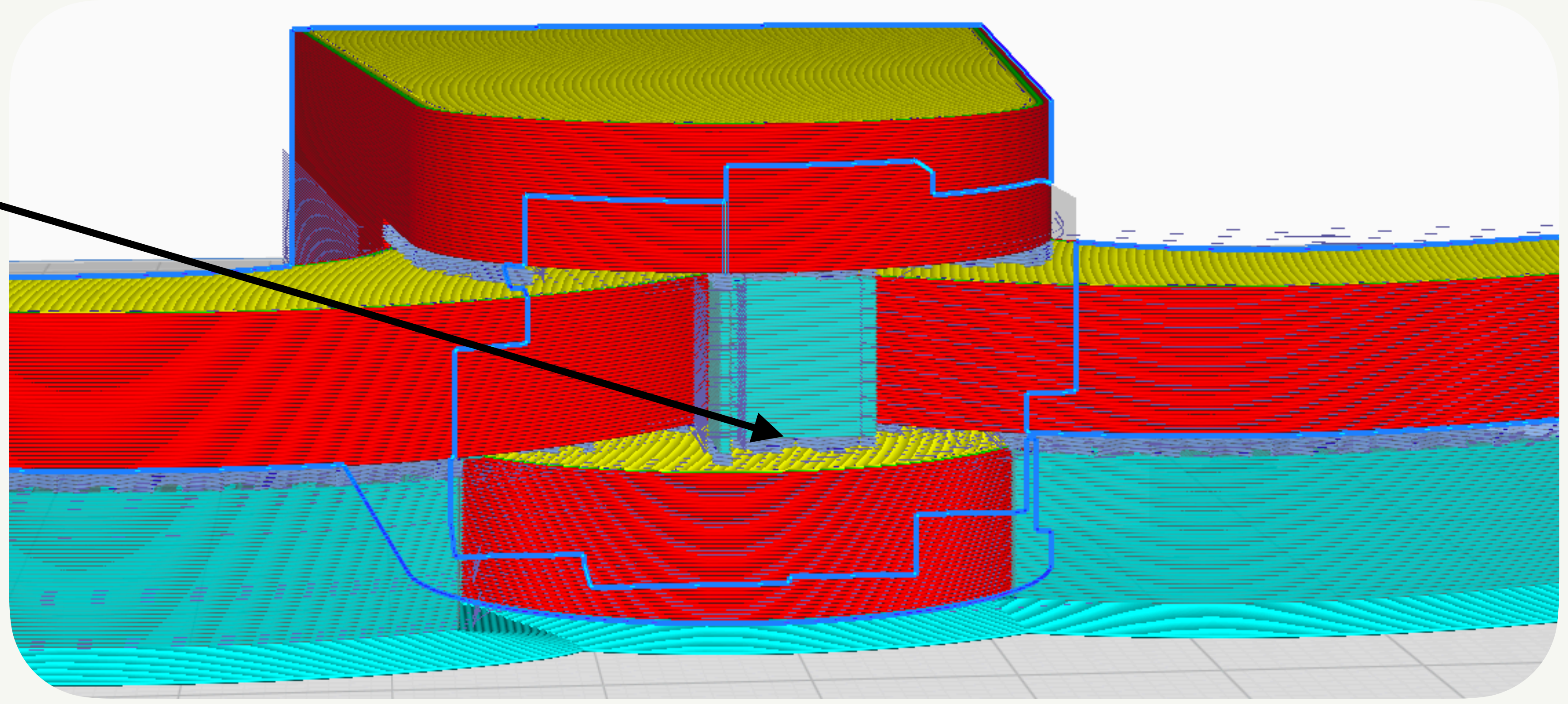
I began with supports all over...

Preparation - First Attempt

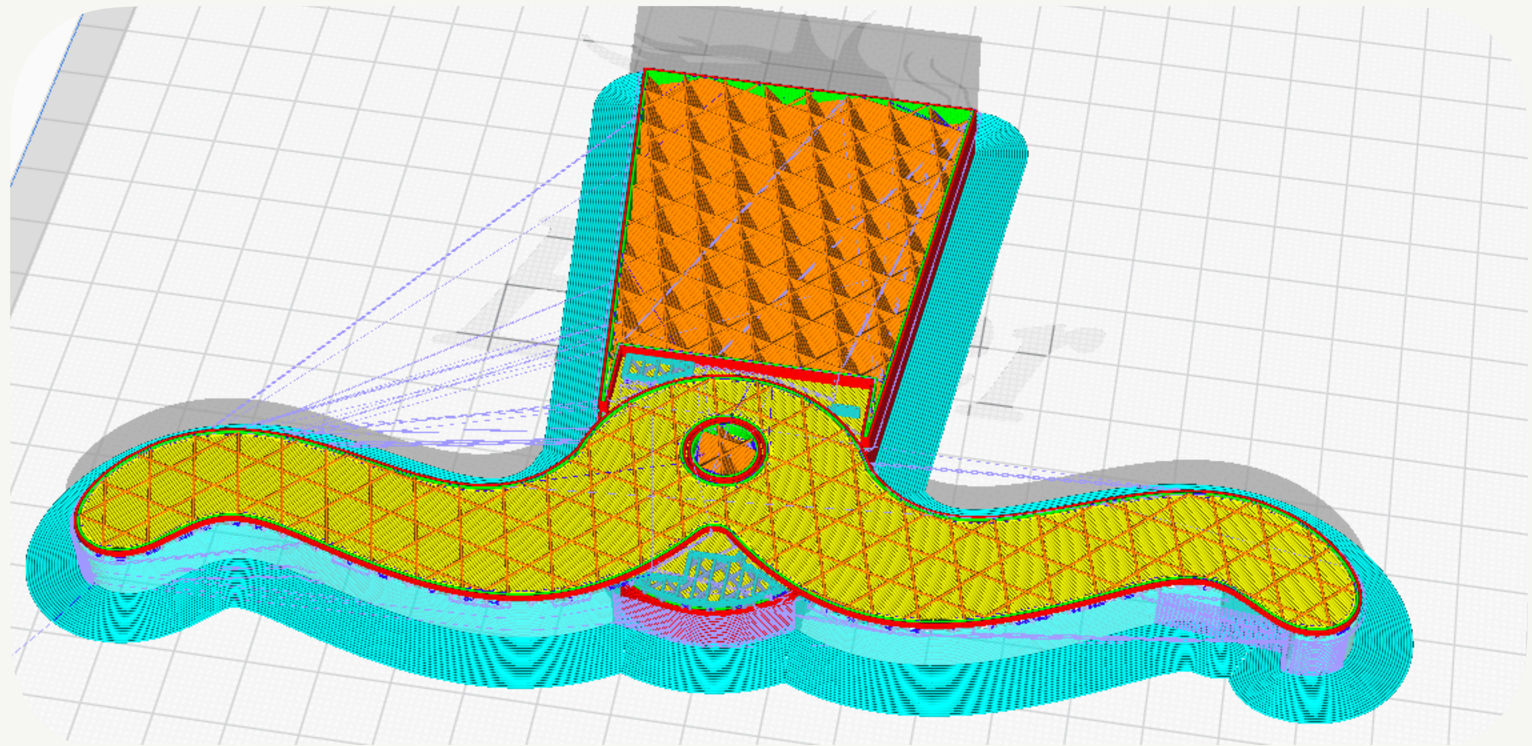
Then used **support blockers** to prevent more supports than I can feasibly remove post-print



Slices of initial support blockers on assembly



Fabrication - First fail

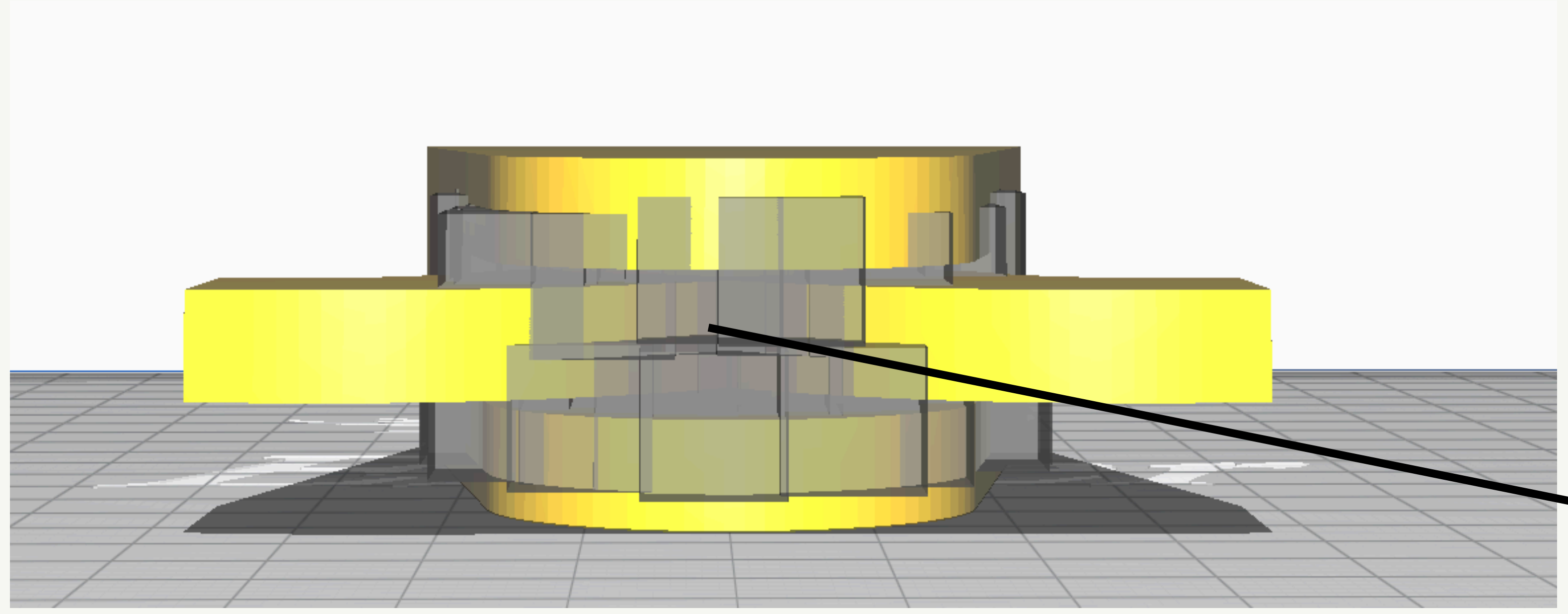


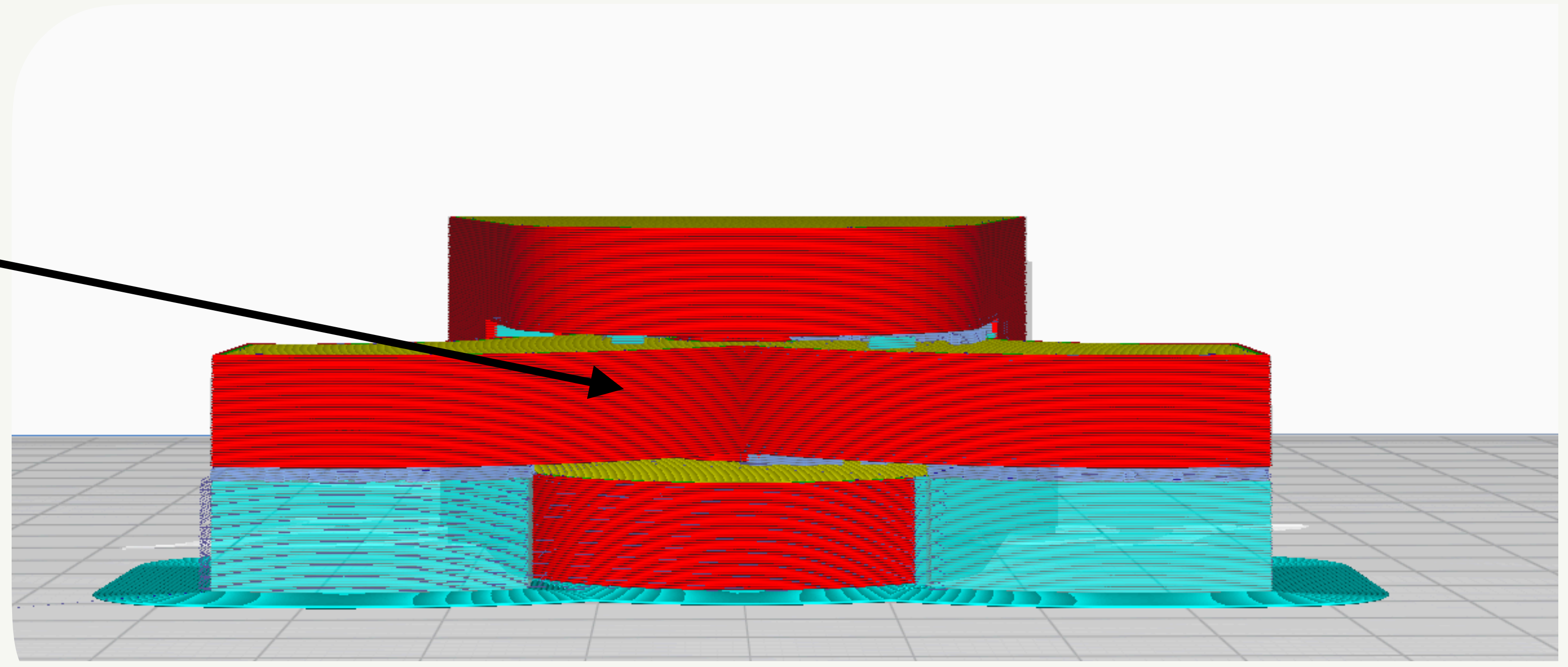
Location of part failure (at 49%)

But my part failed due to issues with my printer's extruder assembly

Preparation - Second Attempt

To quickly test the placements of blockers, I created a smaller assembly...





Slices of support blockers on test assembly

Fabrication - Second fail

Mini assembly print failure

But print failed again due to same extruder assembly issue :/

Despite my failures...

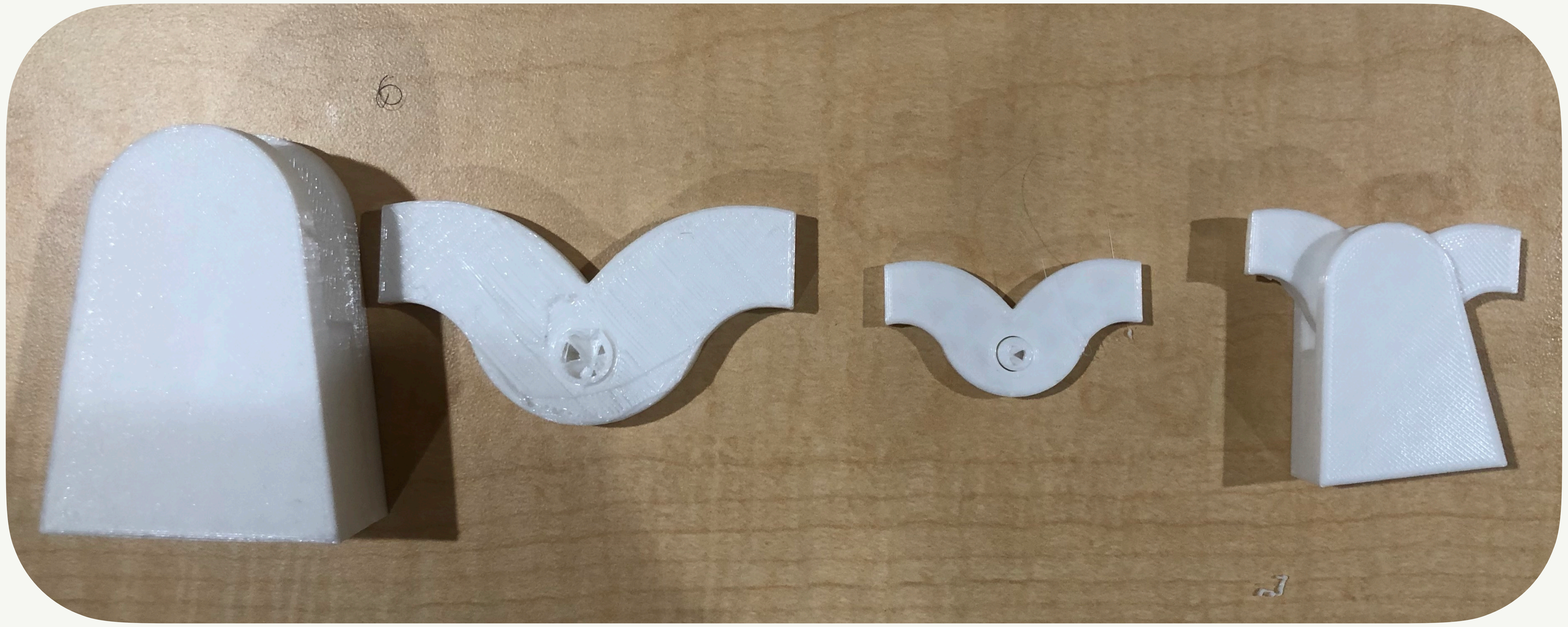
Near-final prototype use

Failed prototype in action

I was still able to consider what my final prototype would look like in action

After some trouble shooting, I worked through some iterations...

Iterations



Mini assembly test prints (from left to right):
First attempt: full assembly with fused pivot and hanger
Second attempt: pivot and hanger with sufficient clearance
Third attempt: functional full assembly

I completed **3 additional test prints** and iterated on my design to ensure that there was **0.05" clearance** between the **pivot** and **hanger** to avoid fusing during print

Then I printed my full part...

Final Product

Final product shots

Upon Reflection...

Reflection

Performing simulations was a key part of the design iteration process. While the factor of safety was quite high for my part due to applied loads being so small, the stress and deflection analyses were helpful in thinking about which geometric parameters could be changed in order to prevent failure modes (particularly deflection and compressive stress of the mask hanger when loaded). In addition to my engineering analysis, my growing understanding of designing for additive manufacturing enabled me to implement design considerations to maximize the printability of my part while also increasing its performance. I leveraged my understanding of the orientation of my assembly during print to maximize strength. Additionally, this project was my first time altering my print supports in order to print as an assembly. I created an assembly that included clearance for functionality and minimized supports near them to make post-processing easier.

For further iterations, I would like to explore methods of optimizing for mass efficiency to get a lighter part (potentially leveraging algorithmic design). Additionally, I would like to create a base for my stand to improve the overall aesthetics.

- **Ideating: 0.5 hr**
- **CAD: 4 hrs**
- **Simulation: 2hrs**
- **Documentation: 4 hrs**
- **Trouble shooting: ∞**
- **Iterating: 4 hrs**

Total time spent was 18.5 hours + ∞