Space Wrench

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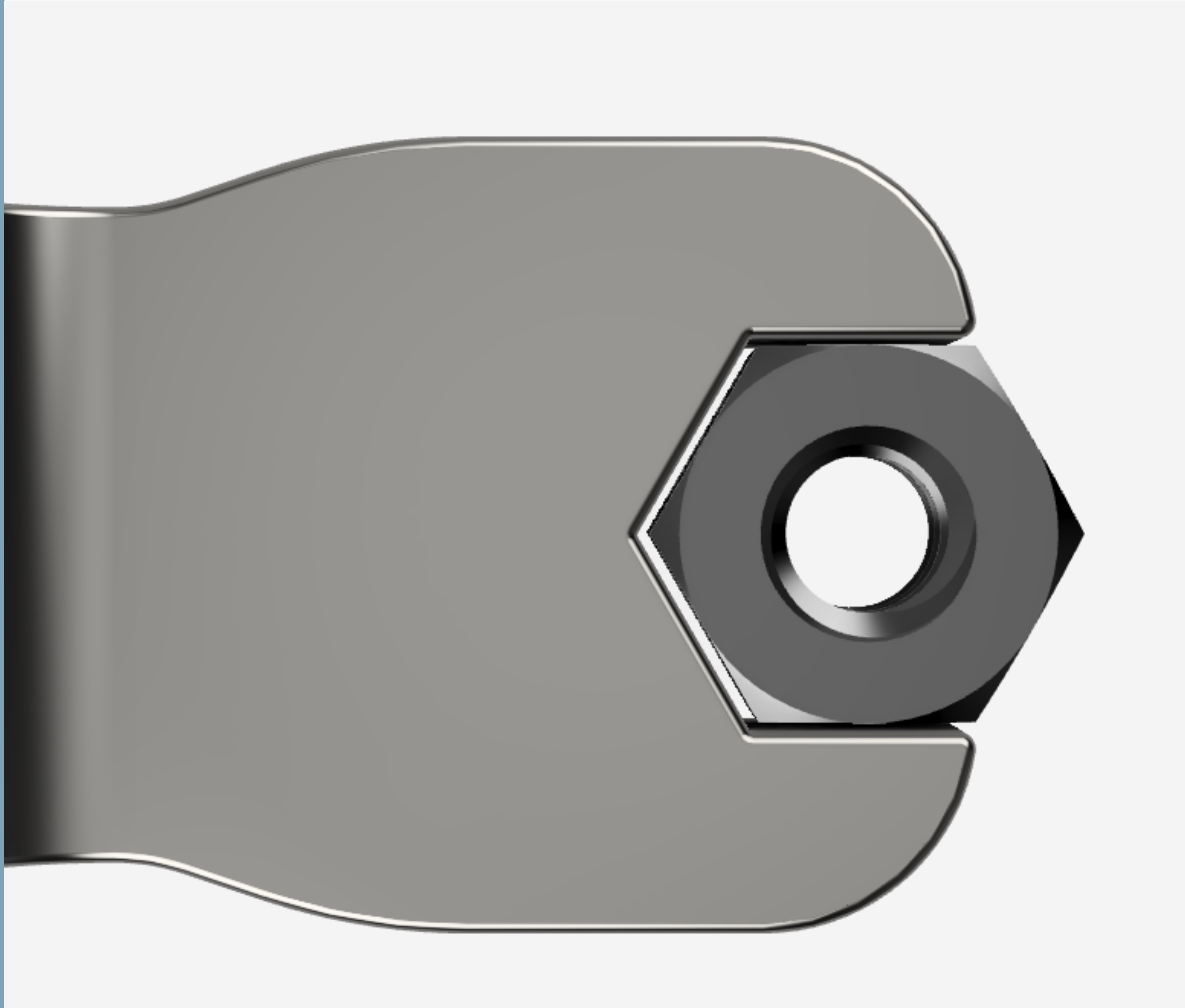
ME 127

Winter 2021



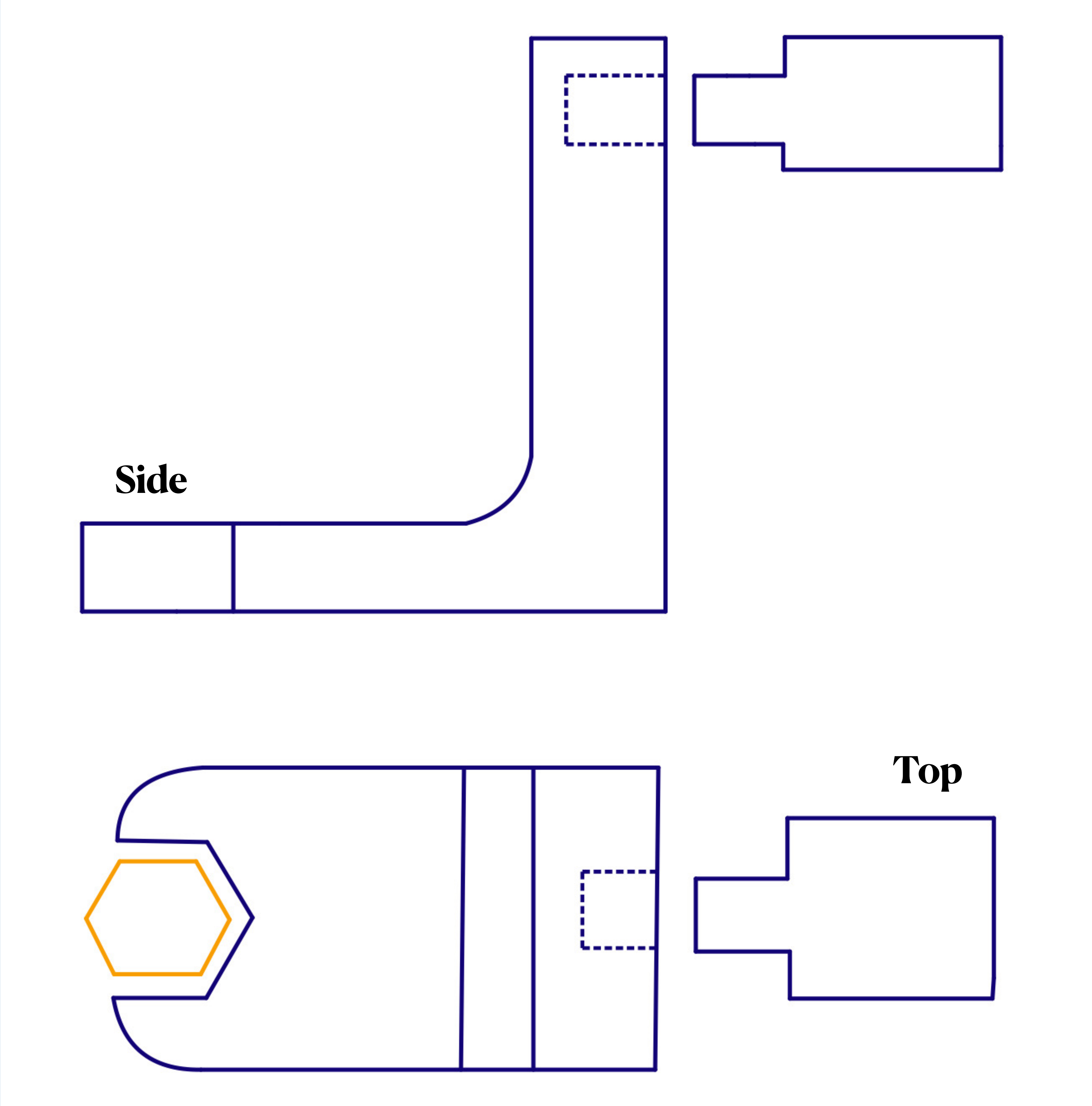
Design a printable wrench to tighten a fastener that is partially blocked by an access panel

Problem Statement

Ideation

- Design for ergonomic tool use, therefore hand grip orientation is parallel to wrench body

Design Goals



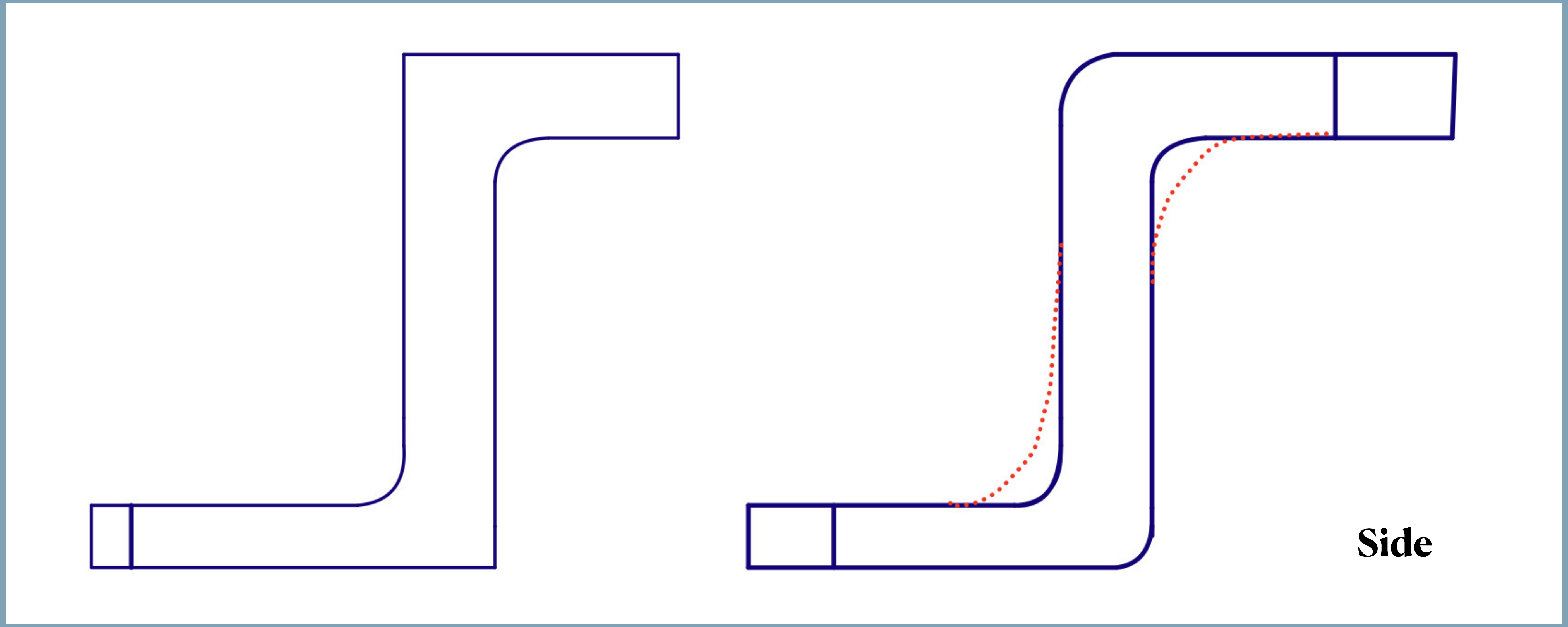
#1

- Separate handle with threads

But,

- Issues with threads can lead to mechanical failure

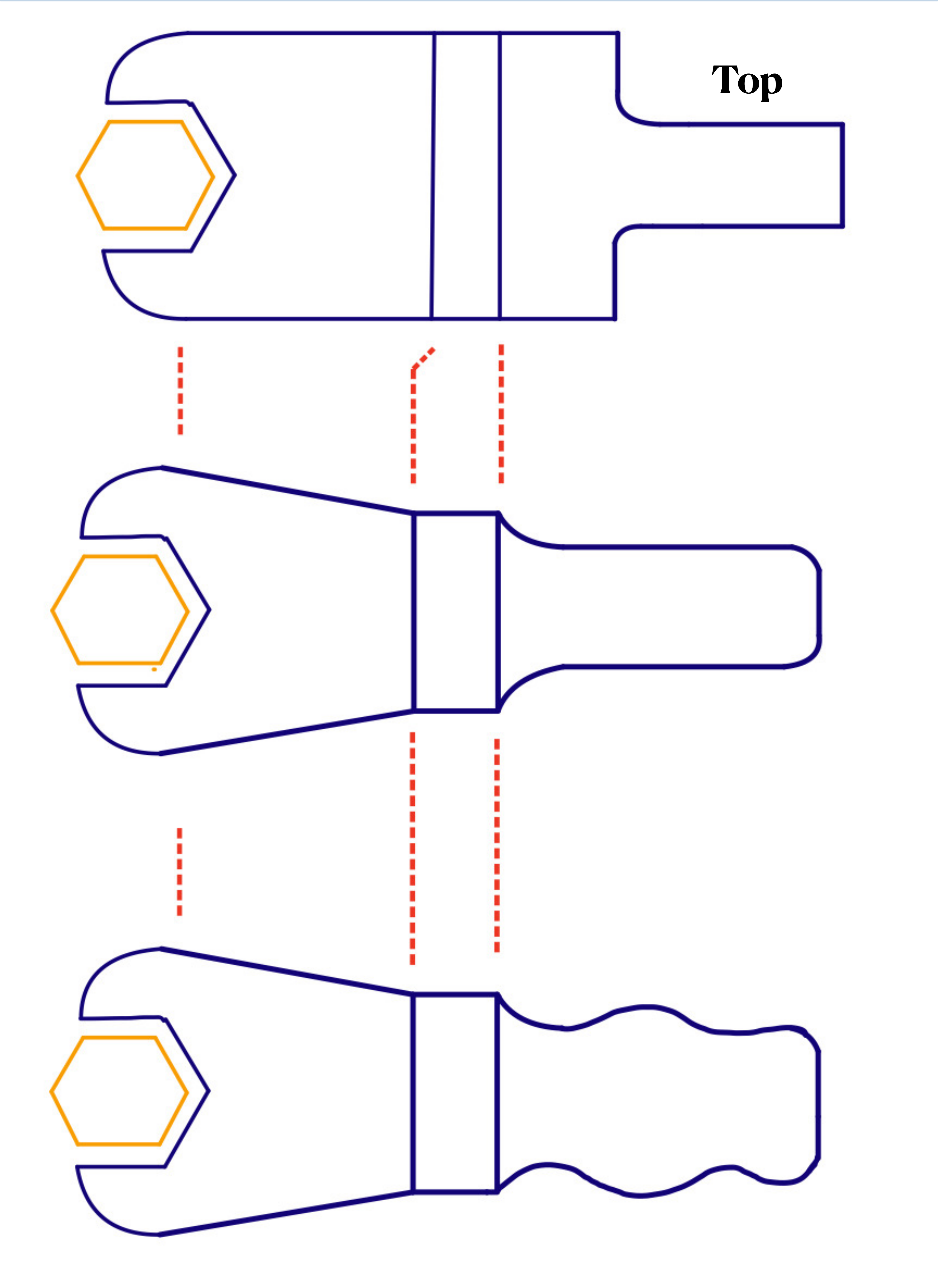
Concept Sketches



- **Single body with filleted corners to reduce stress concentrations**
- **Filleted body also improves usability and aesthetics**

#2

Concept Sketches

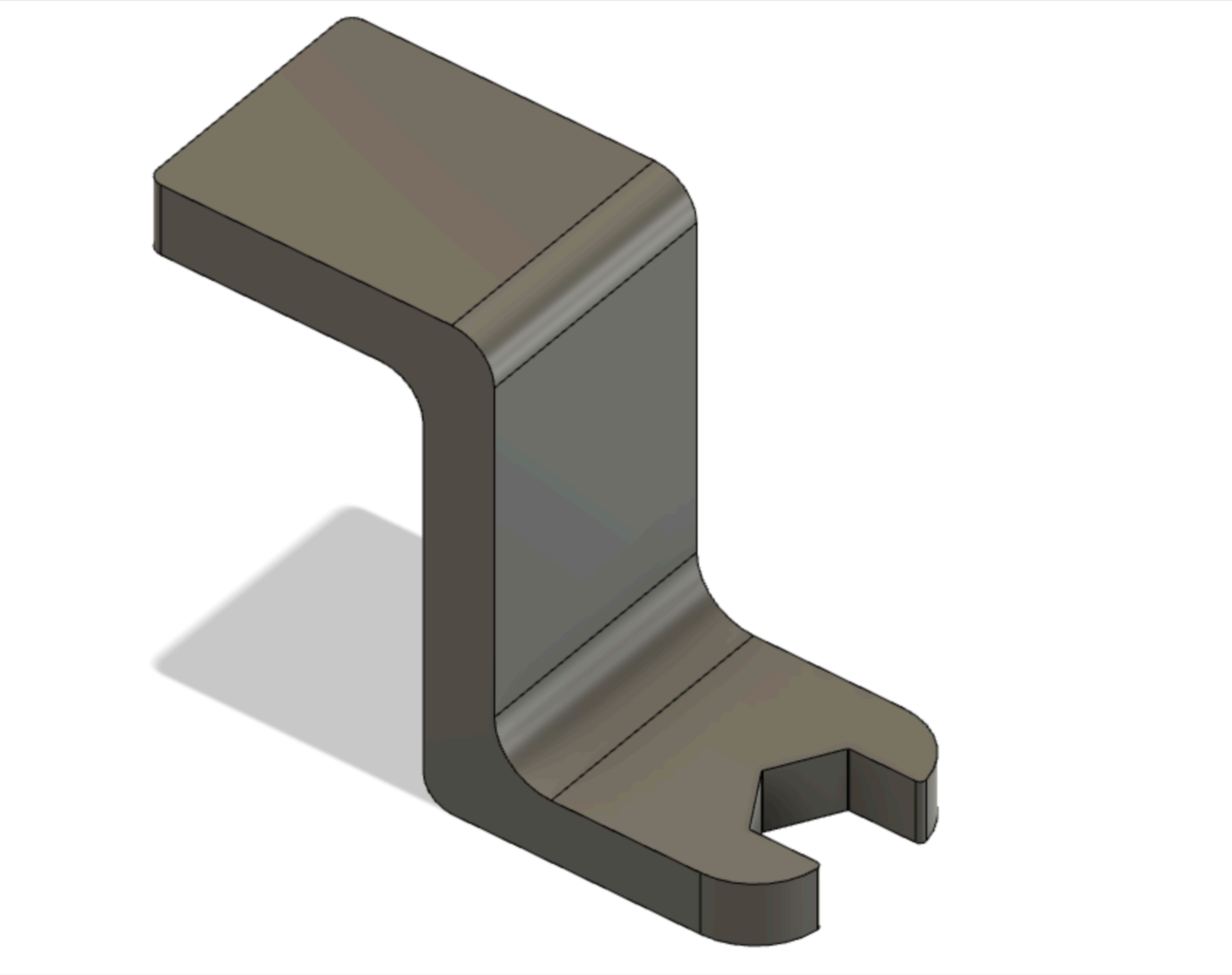


Head & Handle

- Ergonomic handle for ease of use
- Tapered head and body to improve mass efficiency

Concept Sketches

Design Iterations



- Thickness of wrench is 0.22” to match nut height

But,

- Lack of ergonomic form
- Arbitrary dimensioning
- No tolerance

First Iteration

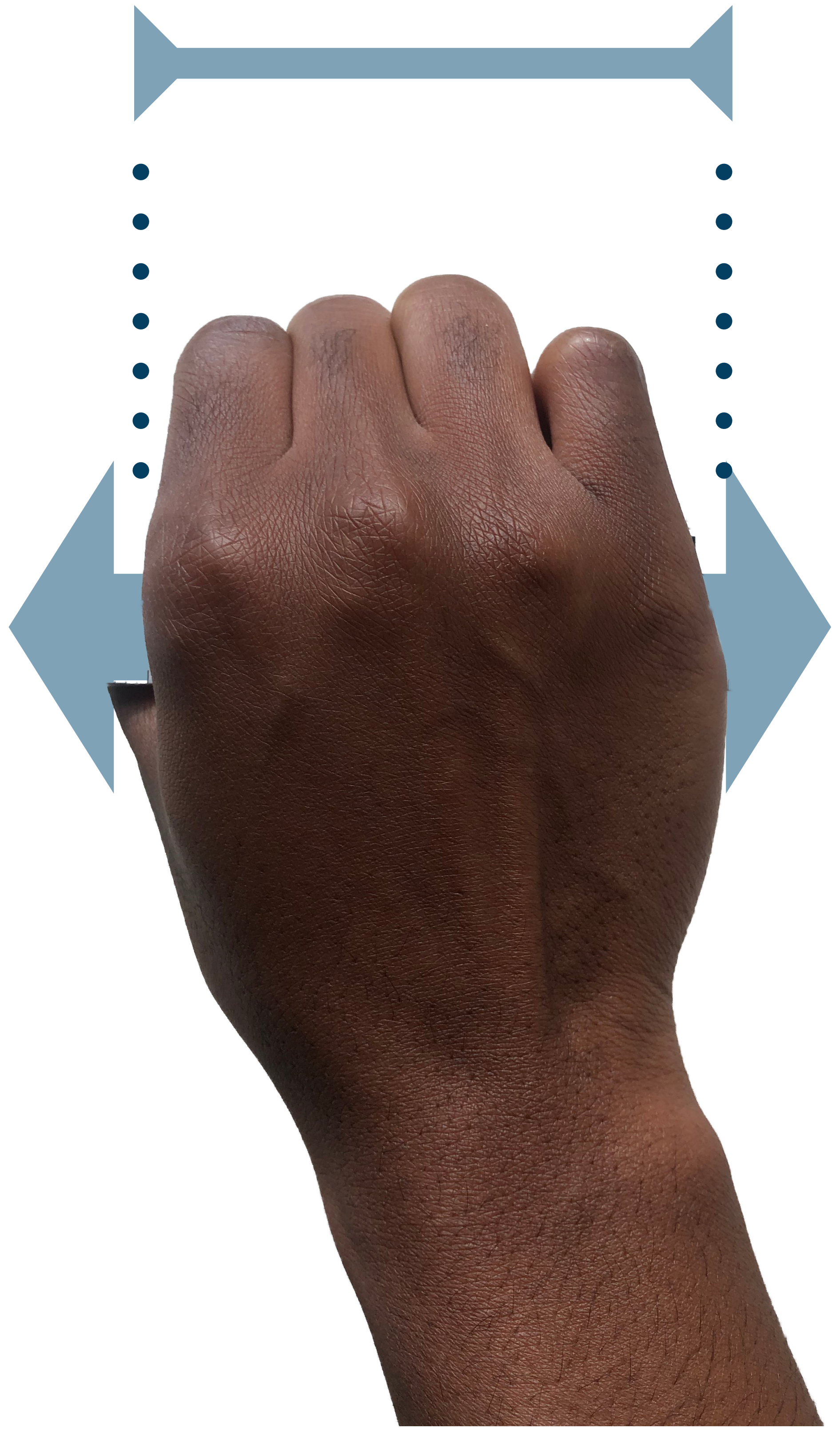
Inspirations for
tapered handle
from box cutter and
ergonomic wrench

Ergonomics

Ergonomics

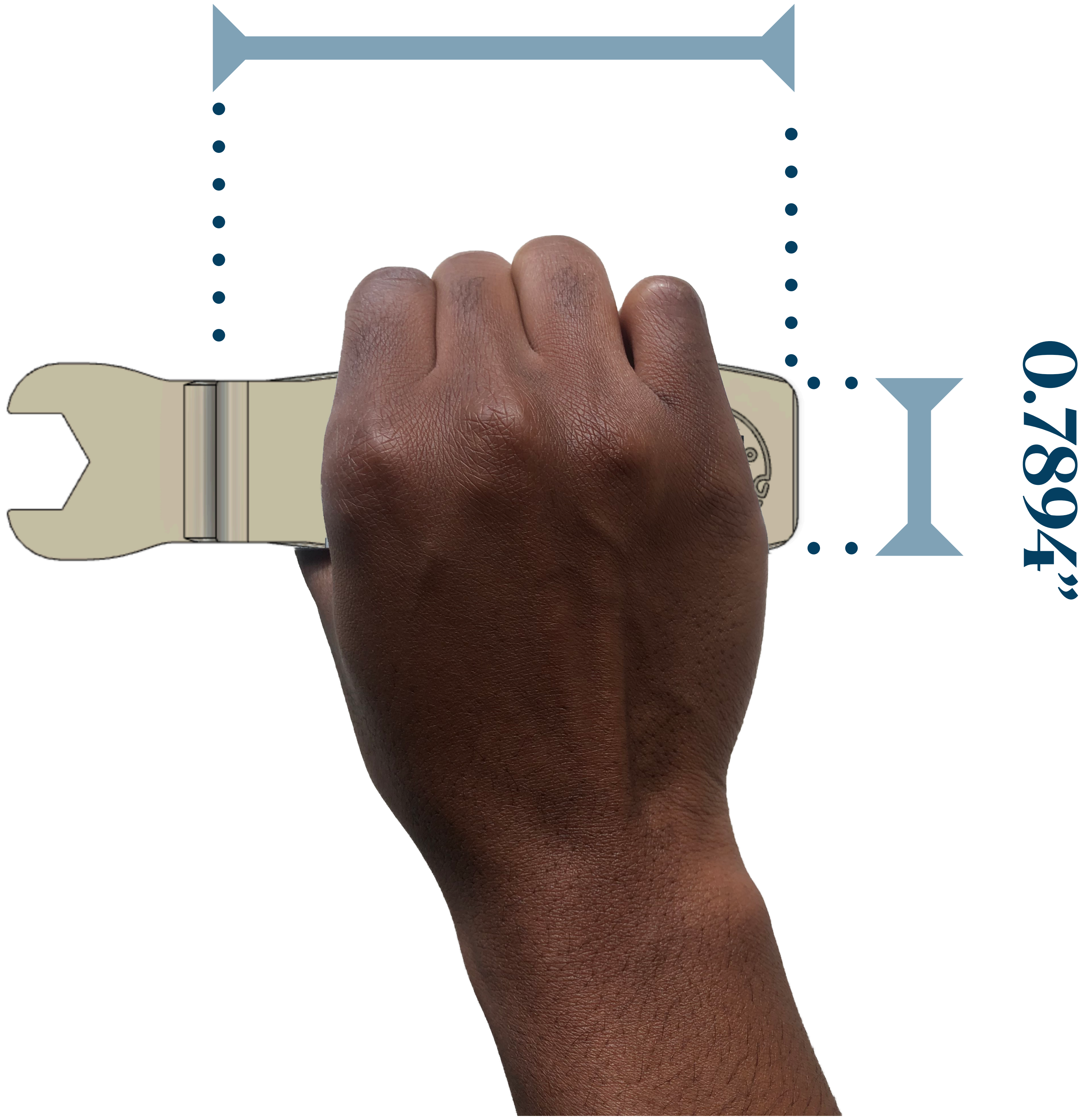
Hand span when gripping:

2.5” - 3.0”

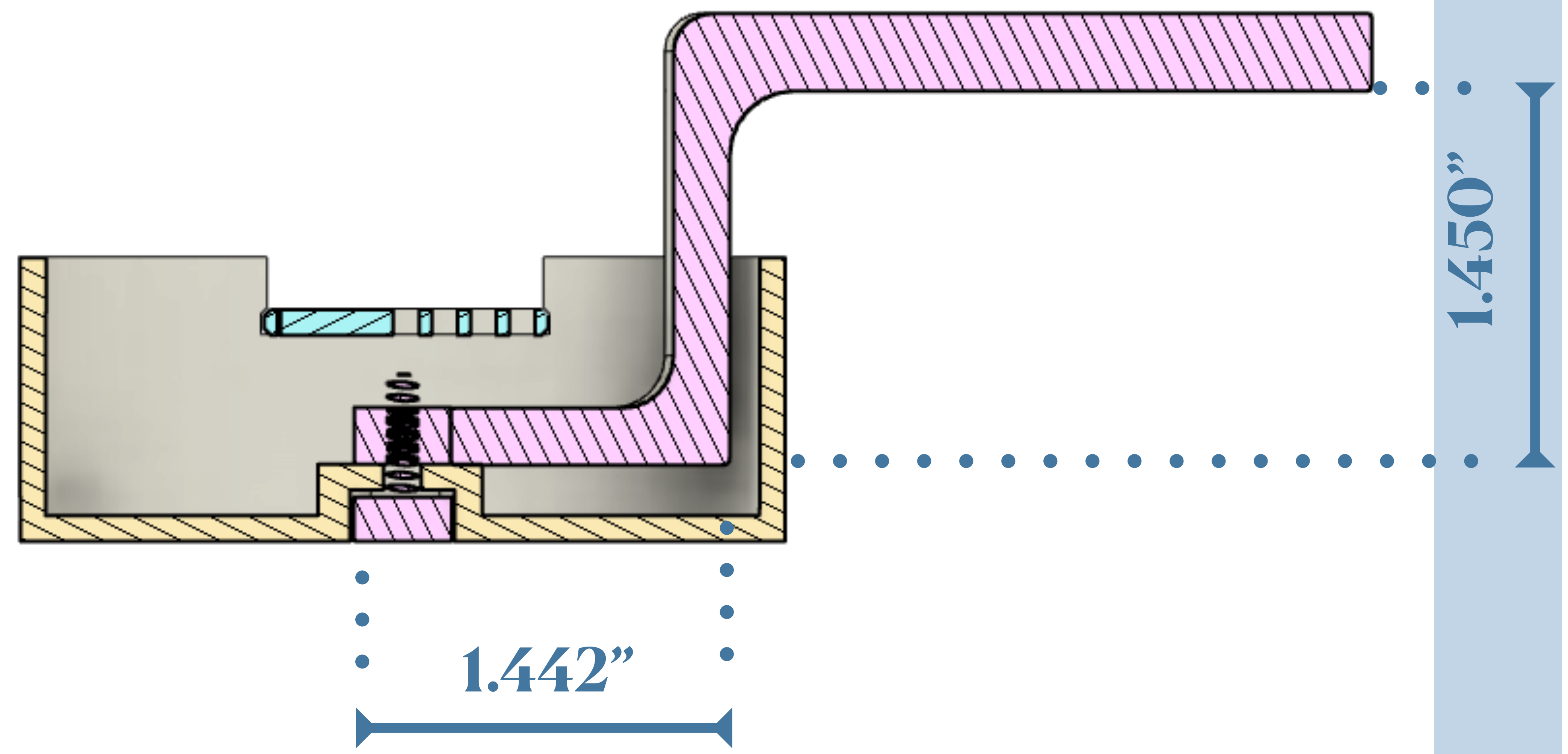


Handle length:

2.7180”

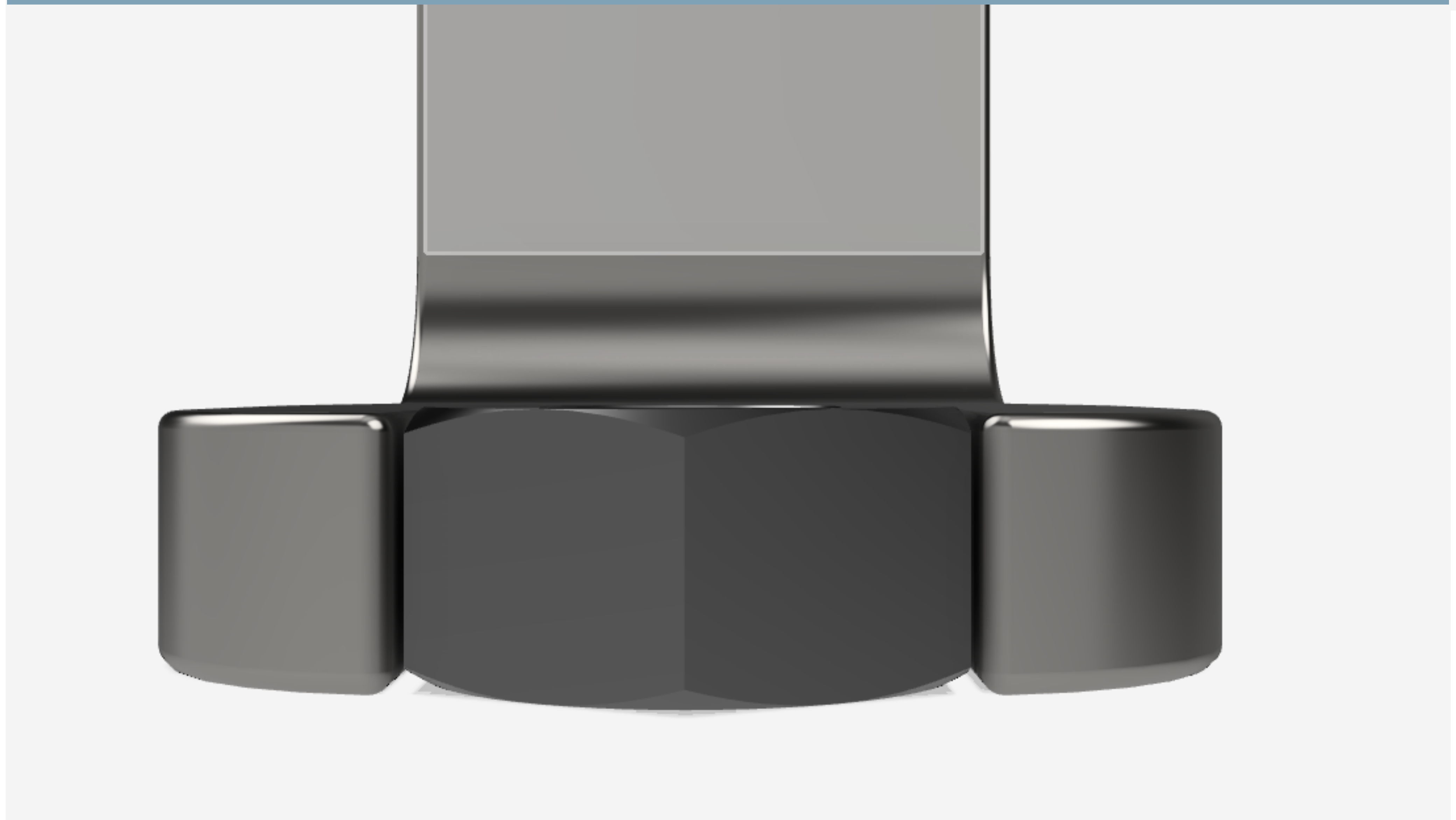


- **Length** and **width** of handle to **comfortably fit hand**
- **Medium handle length to minimize overhang**



- Length of head is 1.442" and vertical height is 1.450" to avoid interference with the test rig

Dimensions



- Fabrication clearance of 0.005”
- Additional tolerance of 0.015”
- Total tolerance : 0.020”

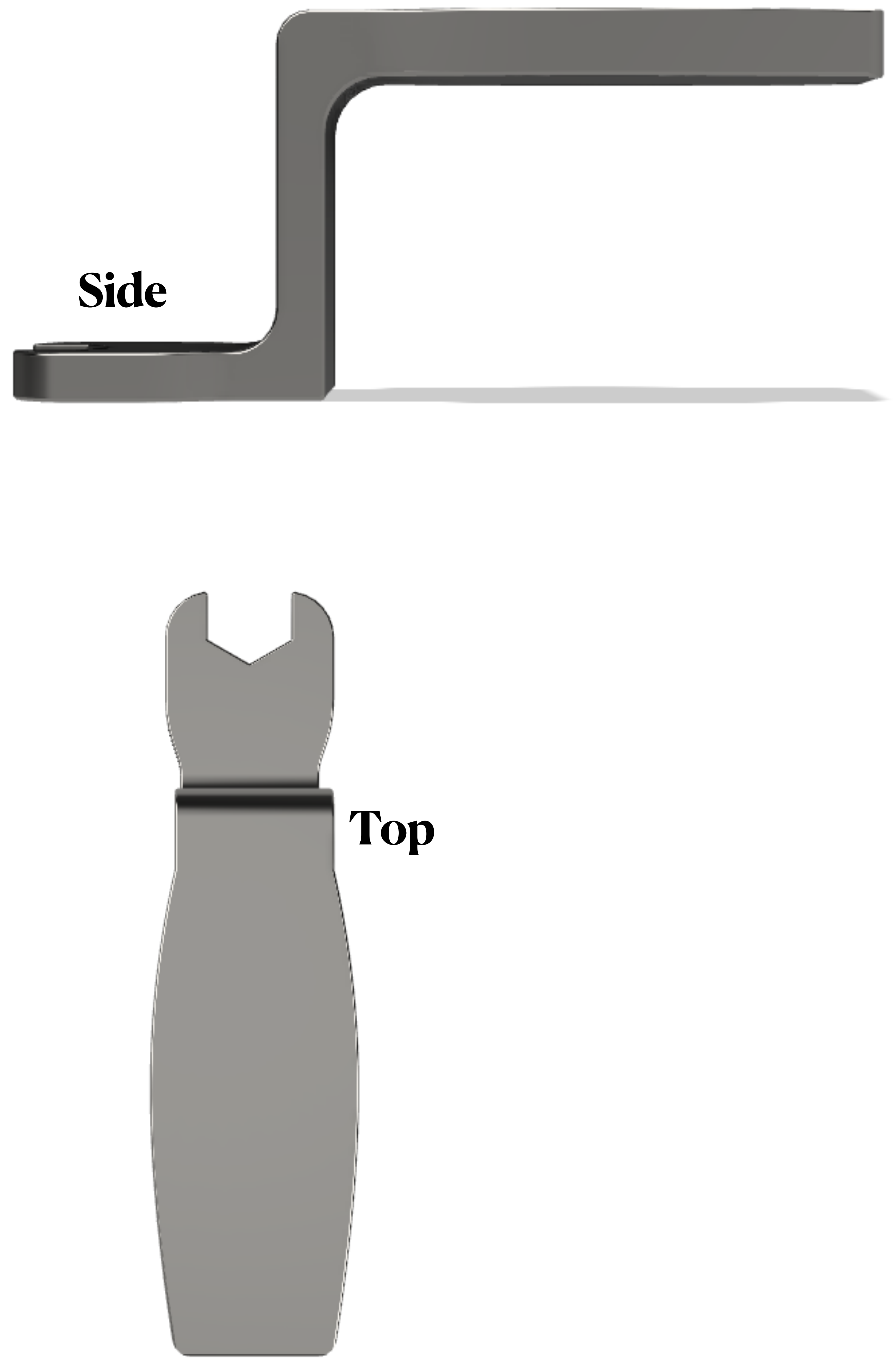
Tolerance

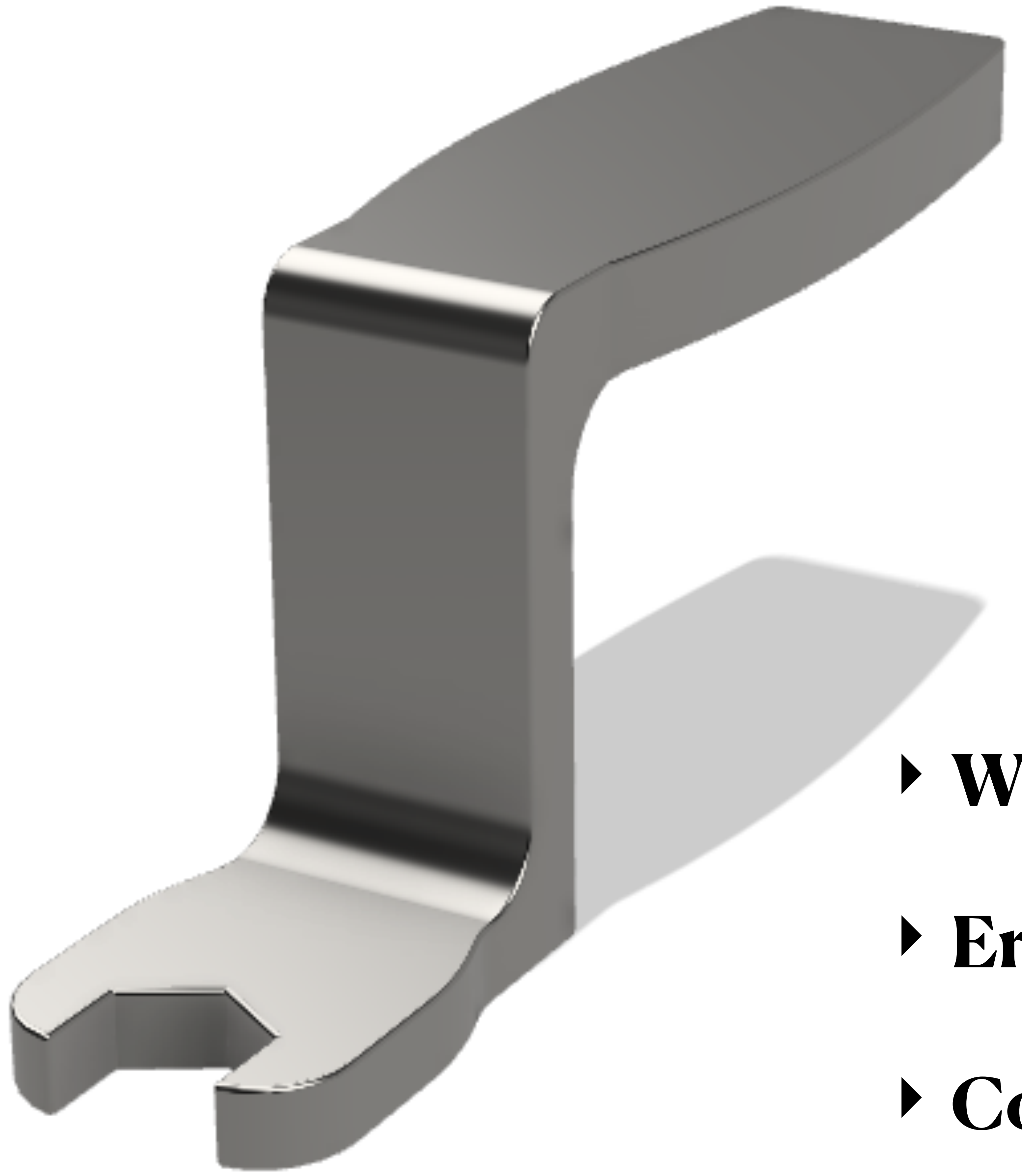
- Ergonomic handle
- Well dimensioned

But,

- Aesthetic extrusion on handle diminishes comfortable use
- Inconsistent chamfer

Second Iteration





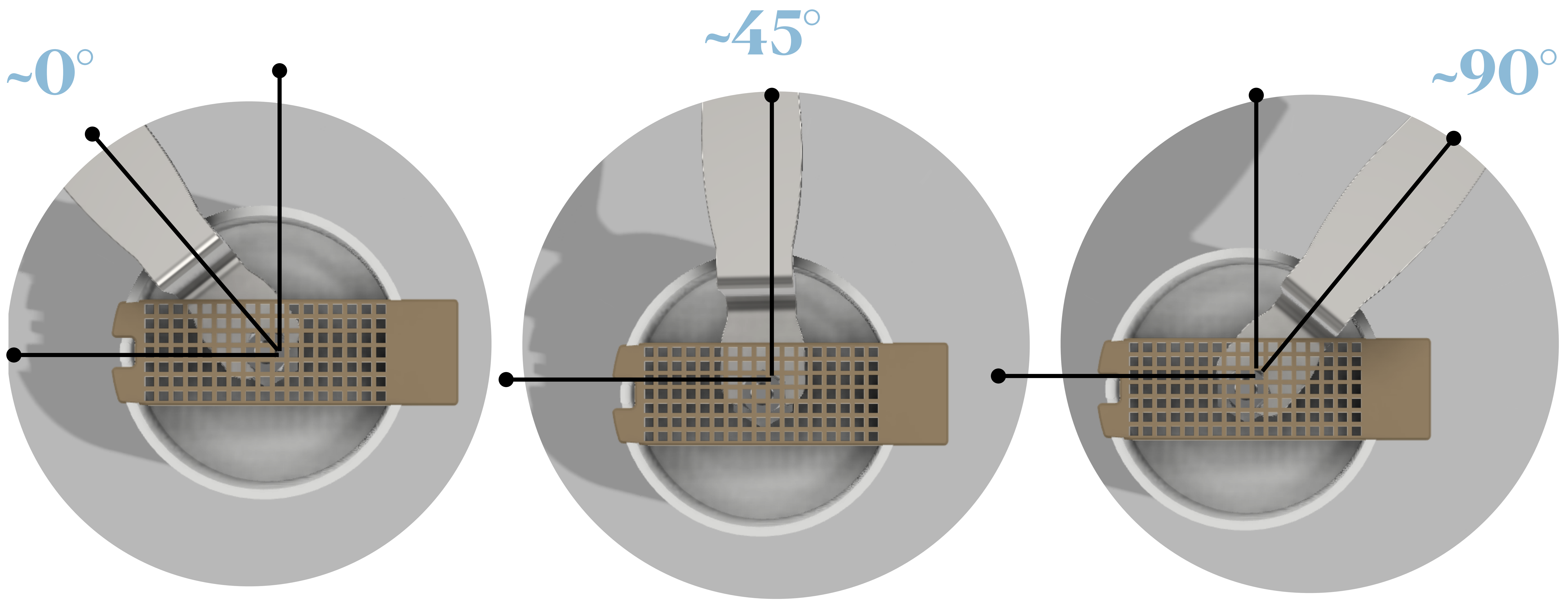
- Well dimensioned
- Ergonomic form
- Consistent chamfering also improves aesthetics

Final Design

Functionality

Steps

- ✓ Insert with wrench head vertical (facing ground)
- ✓ Once in test rig, rotate wrench through ~90°
- ✓ Take out and repeat

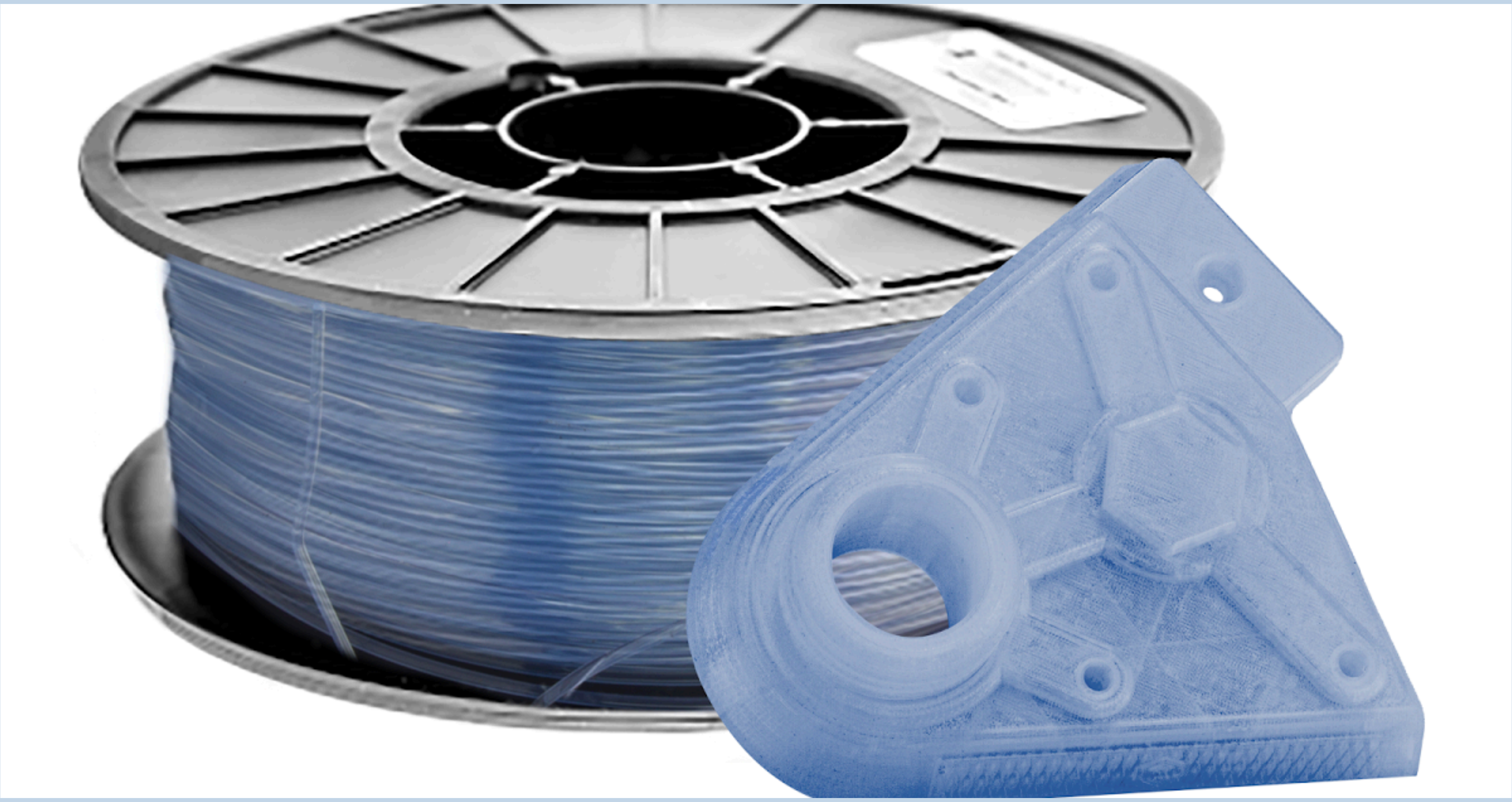


One full rotation is ~ 4 turns

Functionality

Material Analysis & Printability

PLA



- Source : matterhackers.com

Good because:

- Has medium impact strength
- Has medium stiffness

benefitting the space wrench design because:

- Resists mechanical failure
- Able to withstand sufficient torque

Material Analysis

ABS

- Source: imakr.com

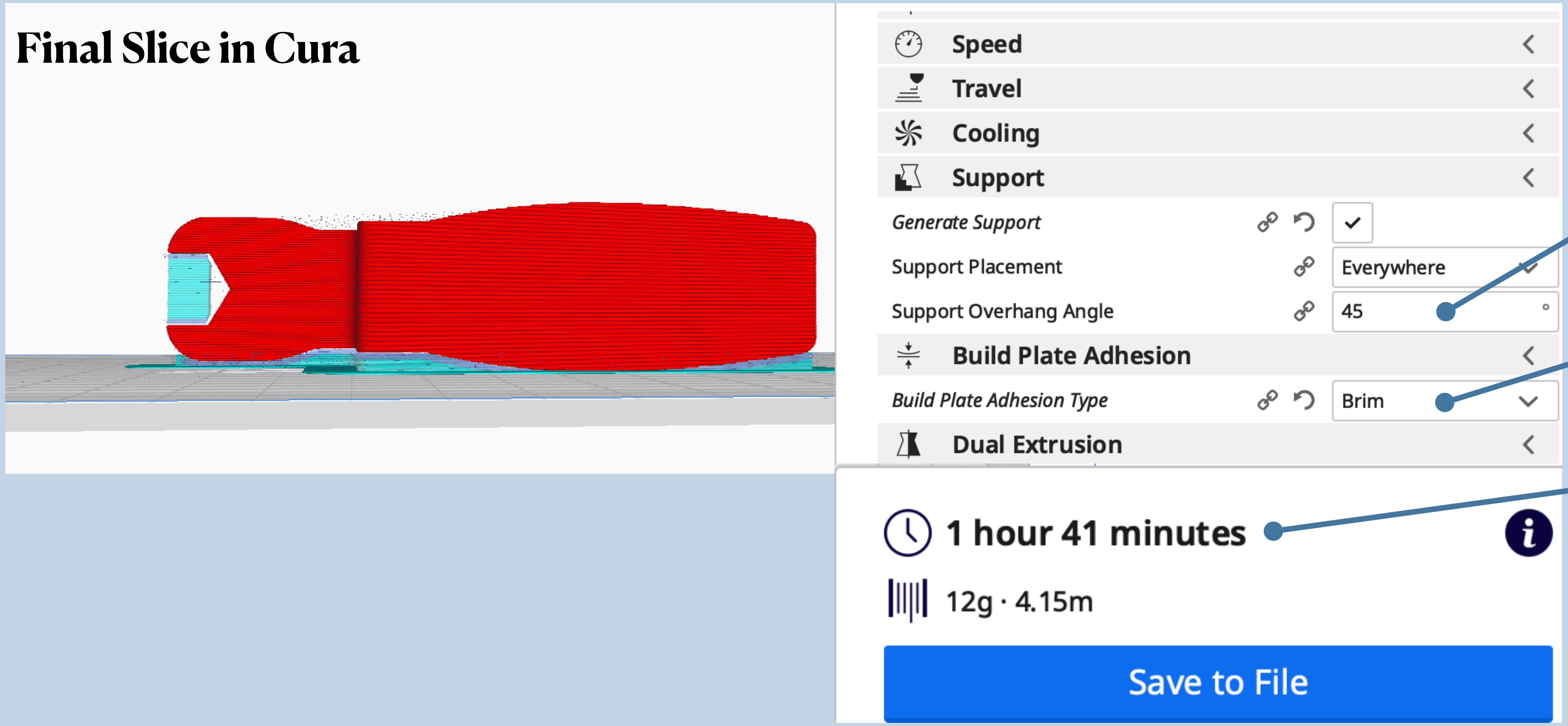
- Higher tensile strength
- Higher impact resistance

therefore, it would be a better material because:

- Greater resistance against mechanical failure
- Able to withstand higher torque
- Good for functional prototypes

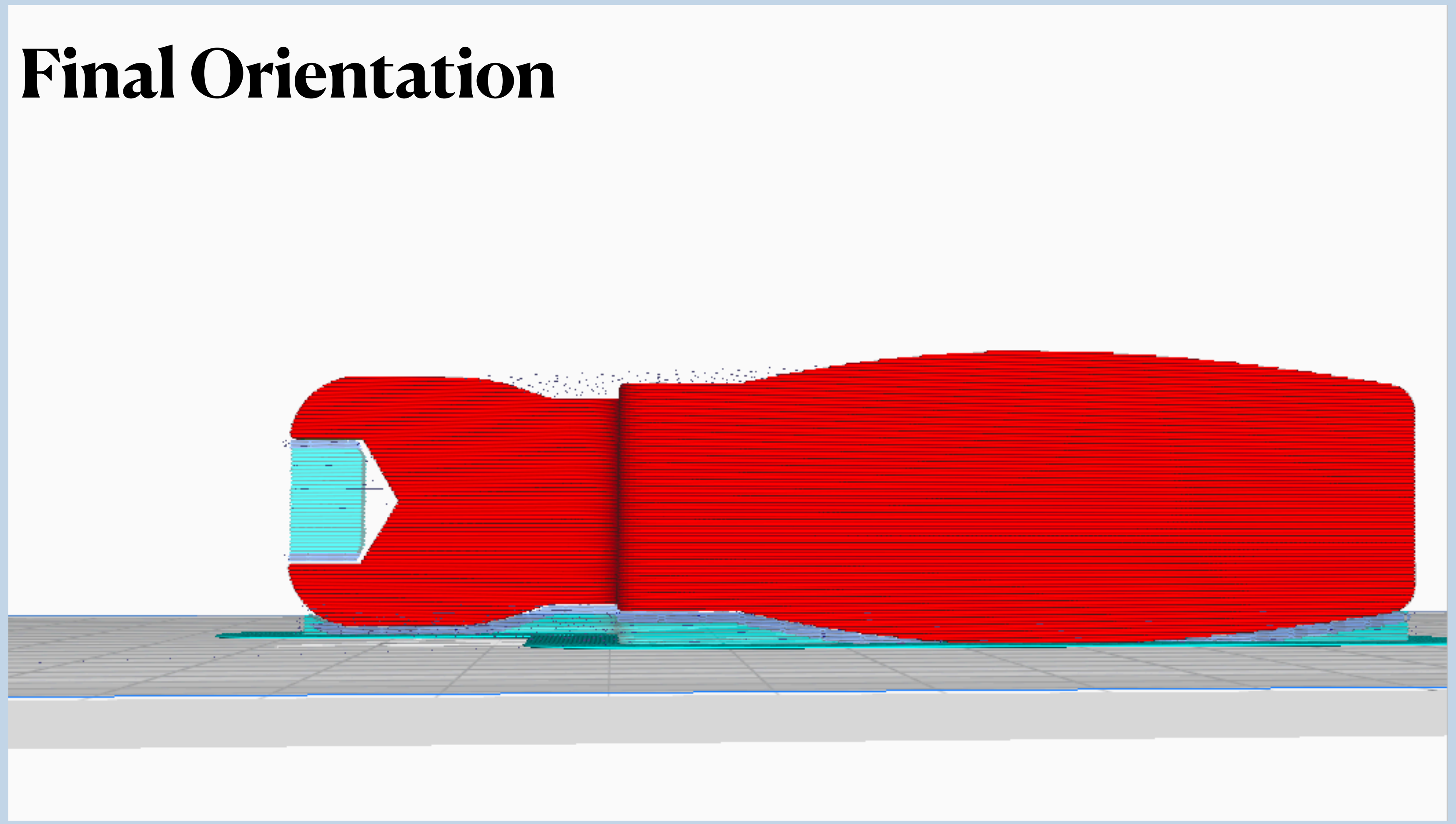
Alternative Material

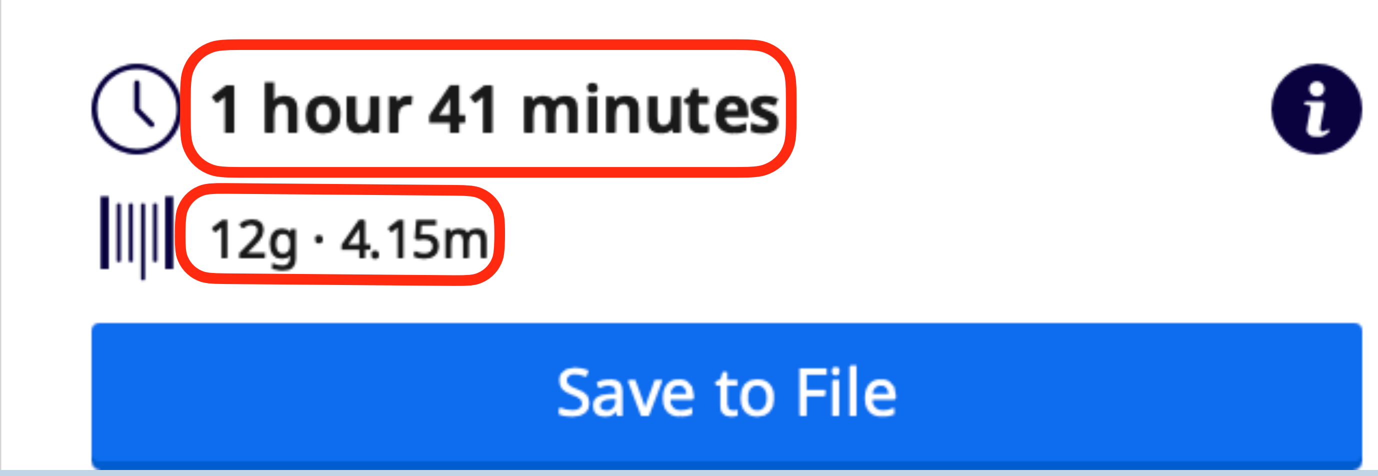
Final Slice in Cura

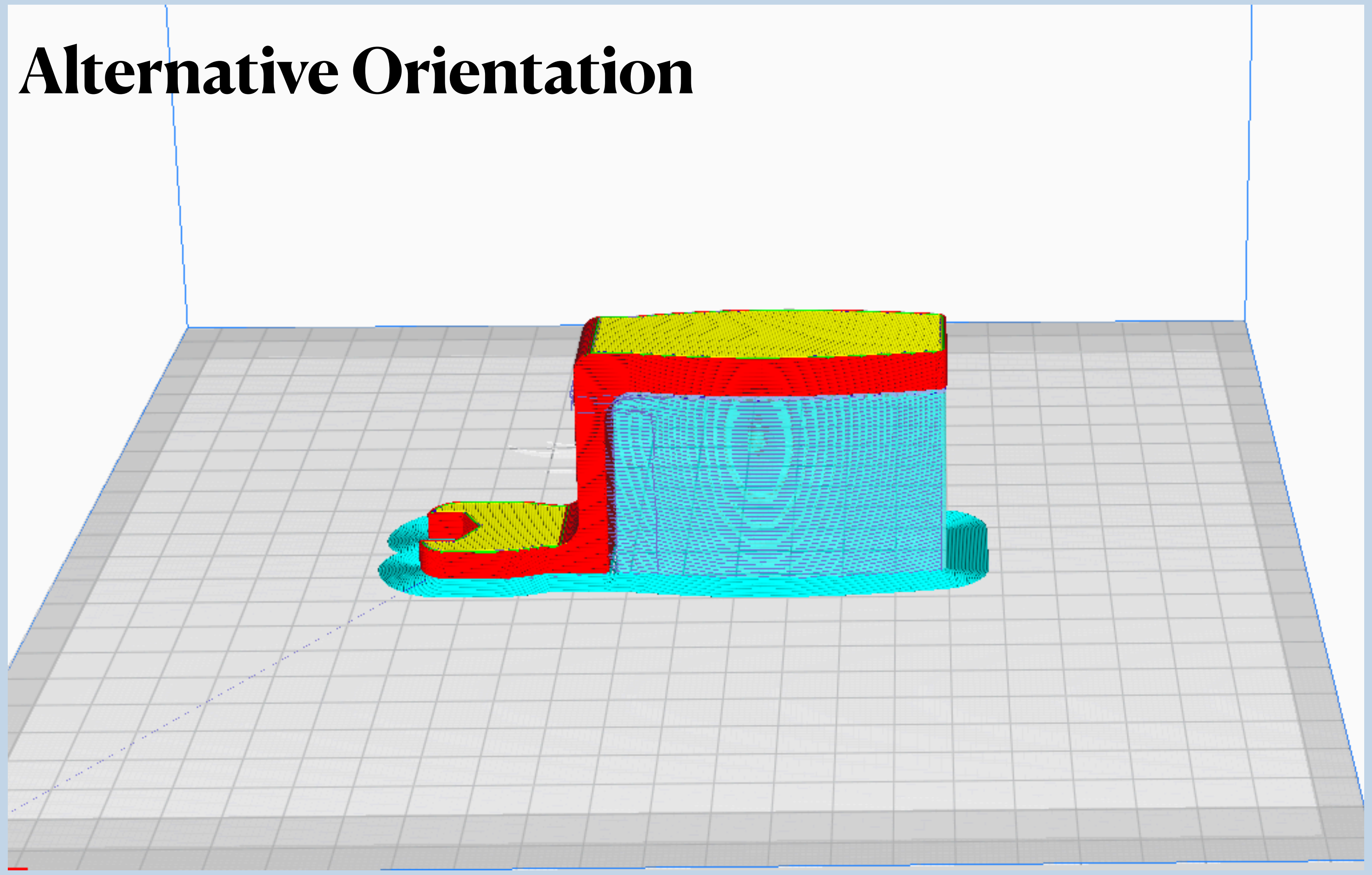


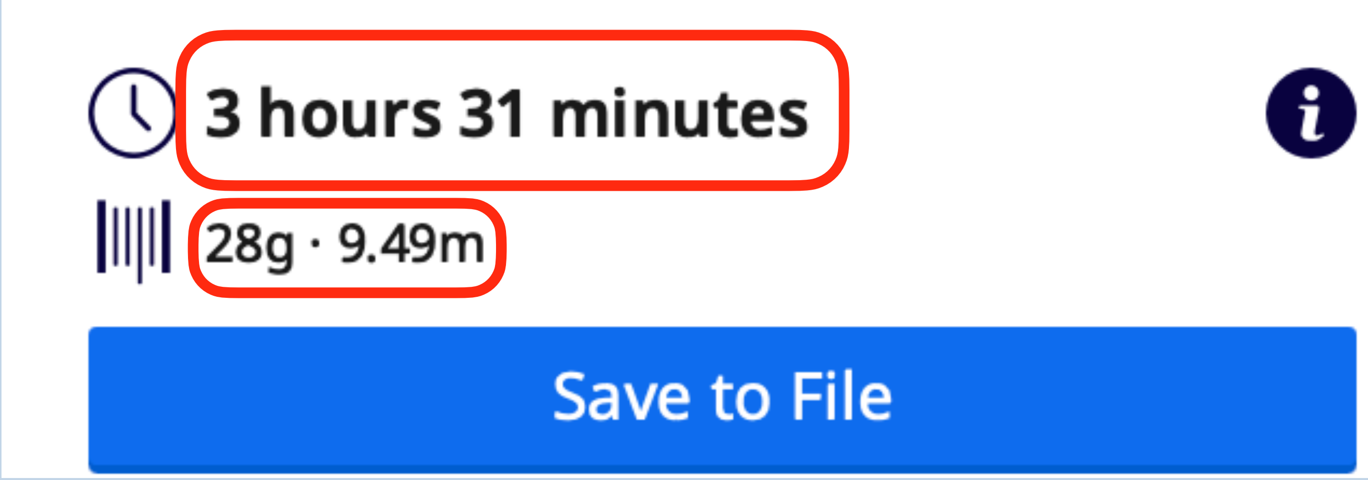
- Support wrench overhangs, which are equal or greater than 45°
- Brim for sufficient adhesion and minimizes warping
- Print time is 1 hour 41 min

Printability









Since FDM, flat (in x-y) orientation is best to:

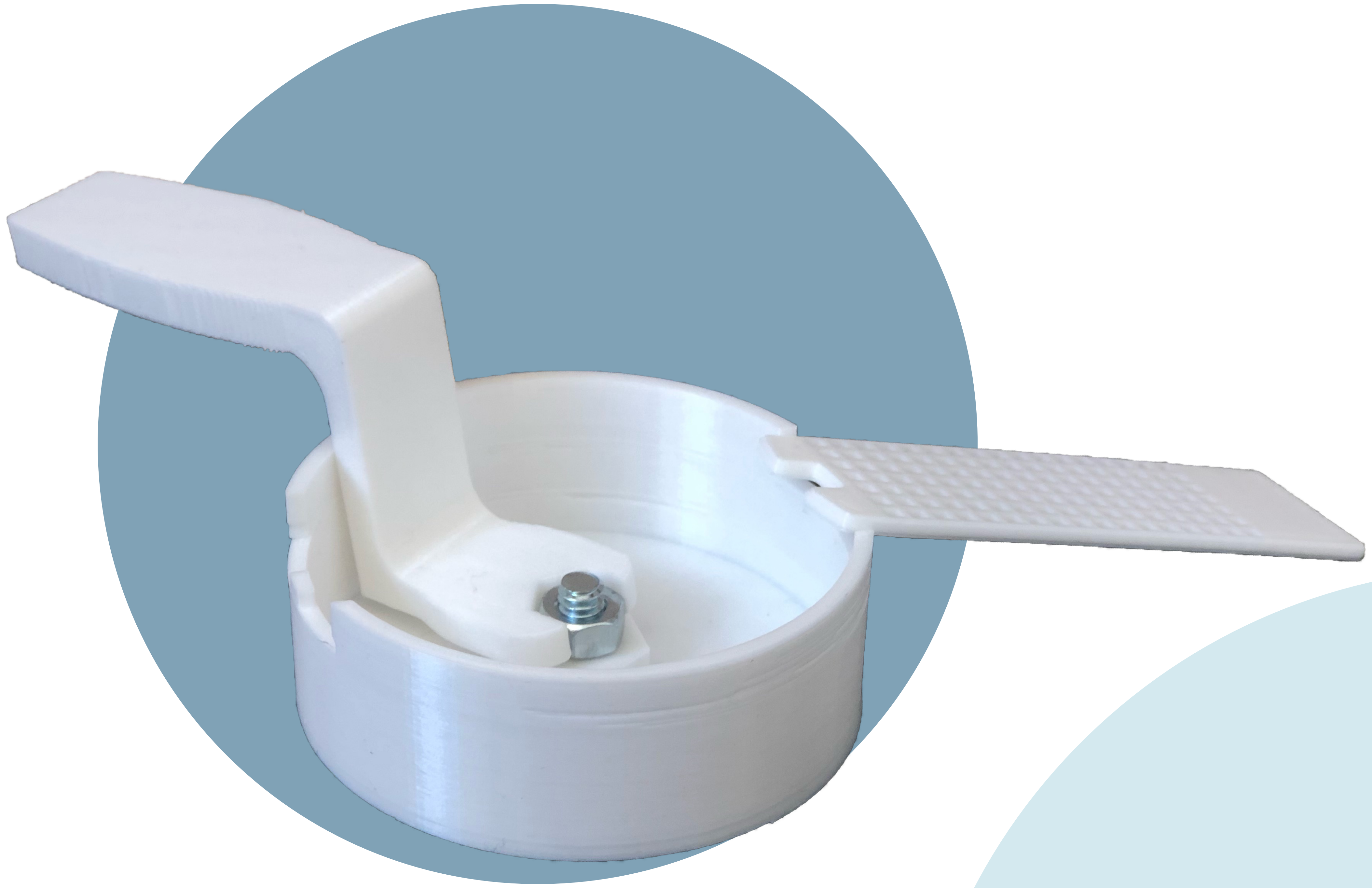
- maximize strength
- reduce warping of overhangs
- minimize print time and material use

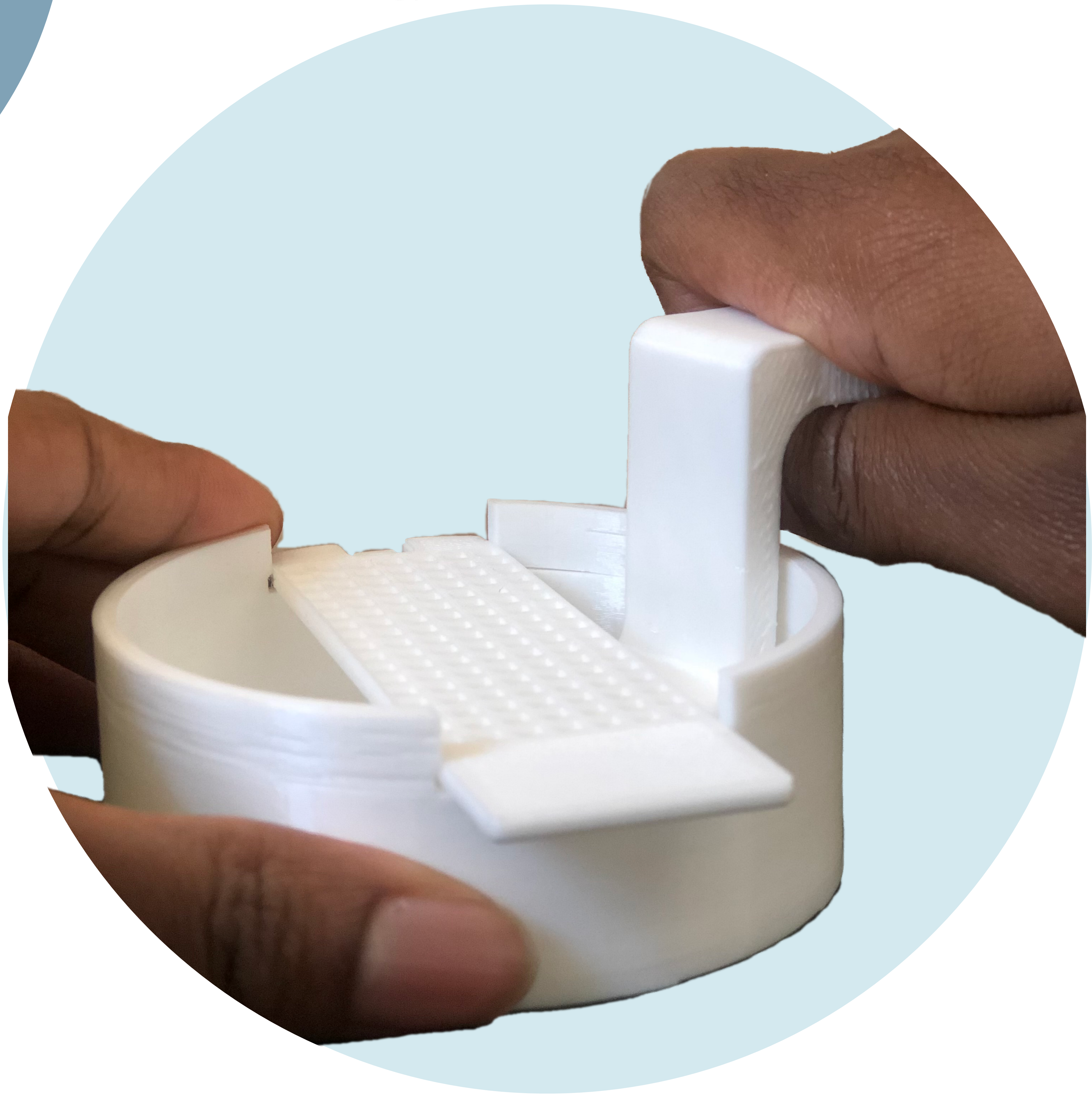
Additionally,

- filleting corners of wrench provides strength for build

Printability

Final Product





Final Product

Reflection

I approached the problem with a keen focus on usability during the first iteration of my designs. As a result, I honed in on features (such as the form of the handle) that would improve the user experience. In the process, I neglected to focus on key aspects that would be integral to the functionality, such as the wrench's dimensions.

In subsequent iterations, I began making revisions to improve functionality and leverage the capabilities of additive manufacturing. In the process, I relied upon mechanical design concepts. I applied heuristics about the locations of high stress concentrations, such as corners, and added fillets. Additionally, I minimized the surface area to improve the overall mass efficiency of my wrench. Furthermore, I oriented my part to leverage support and adhesion types that would strengthen my wrench during build.

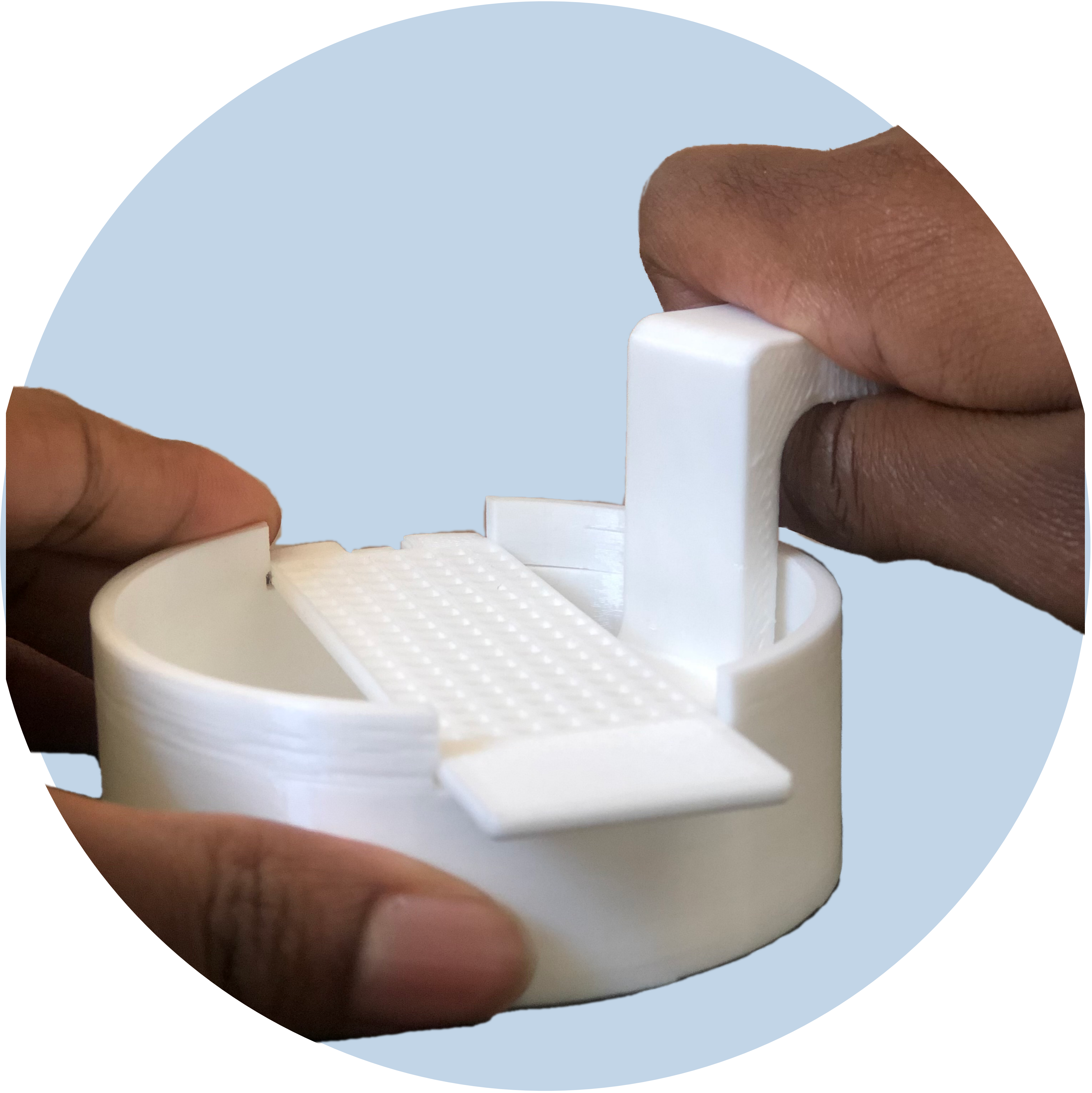
Throughout this process, I learned the importance of integrating my technical and analytical intuitions into my human-centered design process — the two processes should work in tandem to create robust, user-centered final products. This is a lesson I aim to strengthen throughout my engineering career.

- Sketching + Cataloguing : 1.5 hr
- CAD: 5hrs
- Documentation: 5 hrs

Total time spent was 11.5 hours

Process Reflection

One of my primary focuses was ensuring that my wrench was handle ergonomic. The orientation of the handle delivered a pleasant user experience as it was easy to apply torque without having to orient my hand in an awkward position. Further wrench iterations would have included a handle with rounded edges for increased usability. Additionally, the application of torque was sufficient to turn the nut. However, because of a failure to leave enough clearance at the interface between the vertical segment of the wrench body and the curved inner surface of the test rig, it was challenging to re-position the wrench head in order to tighten the nut. This resulted in it taking a longer time for me to tighten the nut (as evidenced in my demonstration video). This was a lesson to ALWAYS ensure you have enough clearance! :)



Product Reflection