Space Wrench

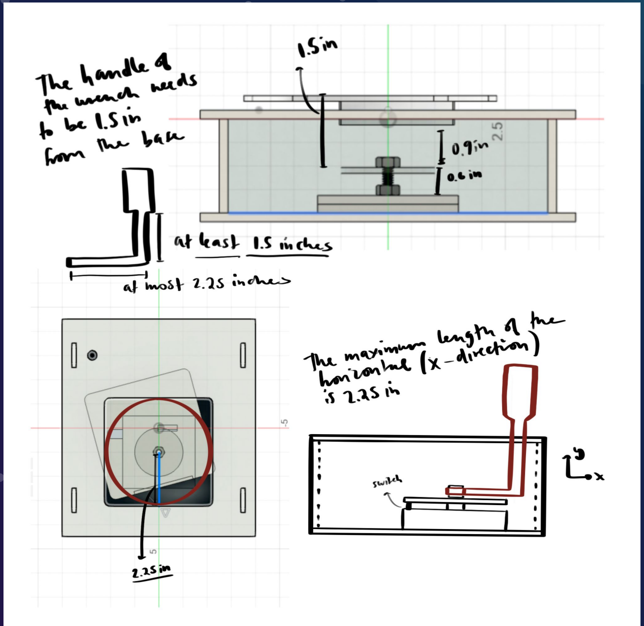
Brenden Koo, ME 127 Winter 2023, HW 1

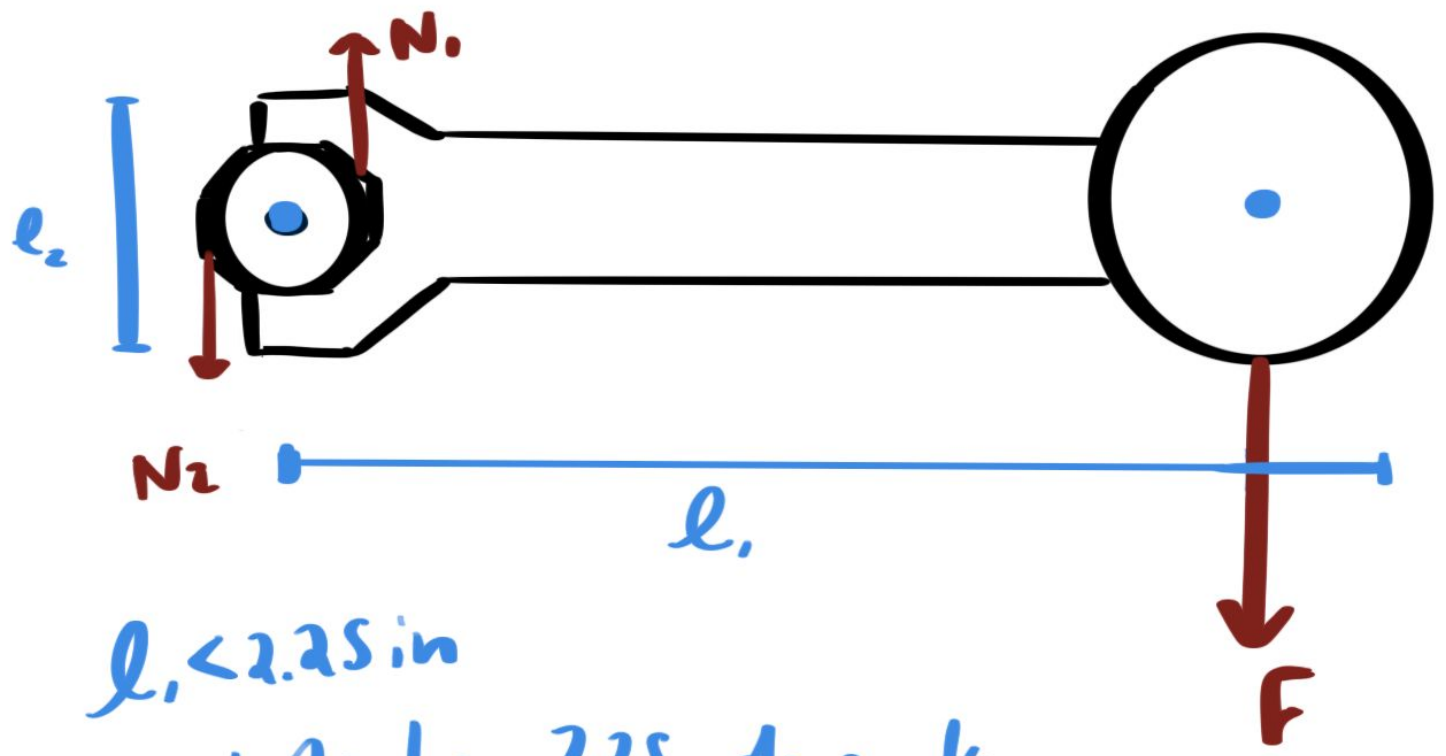
The Assignment

As a scientist at Stanford, I need to create a wrench that would be able to access and tighten a hex nut that is situated under a fixed panel situated askew over the top of a box (pictured right). I also have to be able to tighten the nut while wearing a bulky glove. My focus working on this project was to create a wrench that is shaped at an angle to be able to turn the hex nut. I wanted to focus on speed and ergonomic comfort.

Initial Thoughts

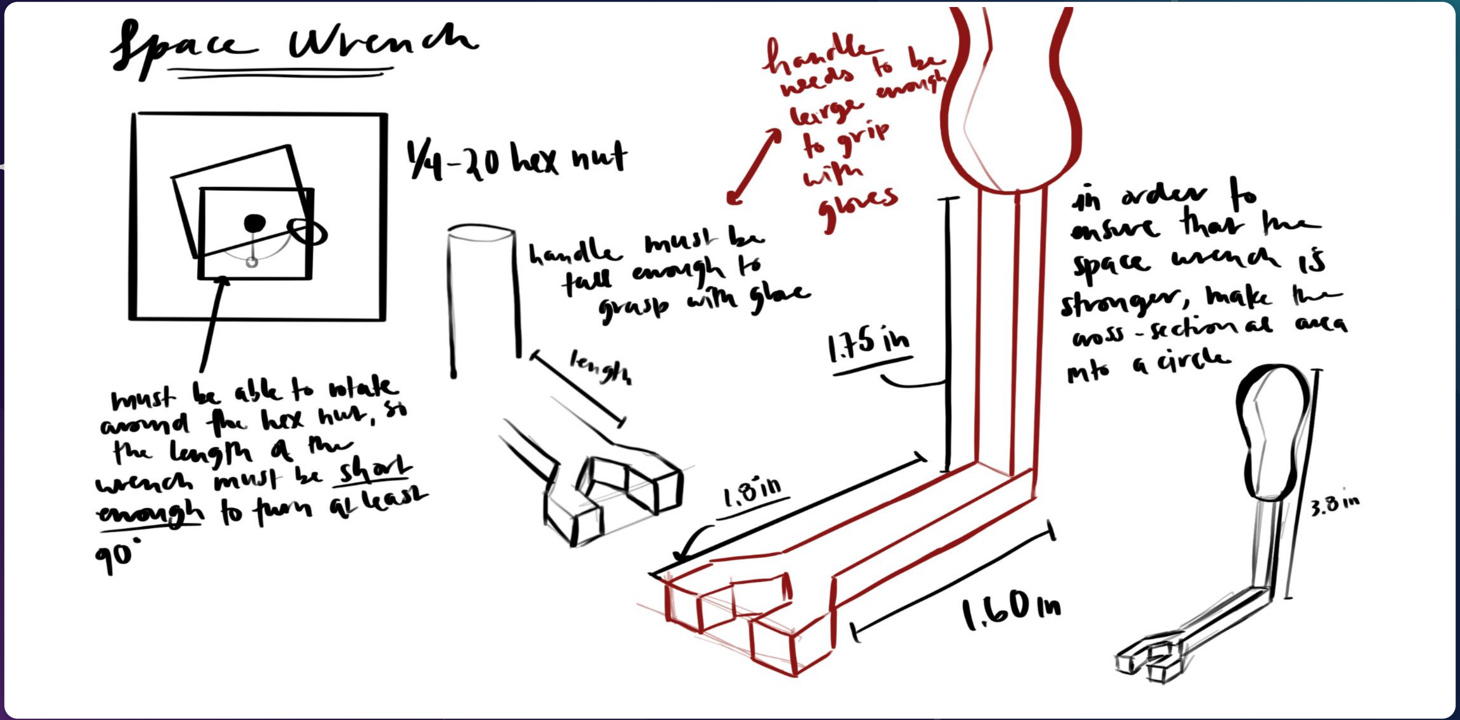
- My initial instinct was to create a simple L-shaped wrench design to get the job done
- I wanted to use **Tough PLA** to ensure minimal printing time but desired strength





$l_1 < 2.25$ in

cannot be 2.25 due to toleranancing, aim for less



Some of my initial Concept Sketches

Main Focus for Rapid Prototype

- There might be difficulties with tolerancing the wrench around the hex-nut
    - **Import the .stl file of the hex nut into Fusion and design the prototype from that geometry**
- One focus is to measure out the proper length of the wrench so that it does not interfere with the access panel


Space Wrench Rapid Prototype with printed wrench and wooden dowels glued together with hot glue

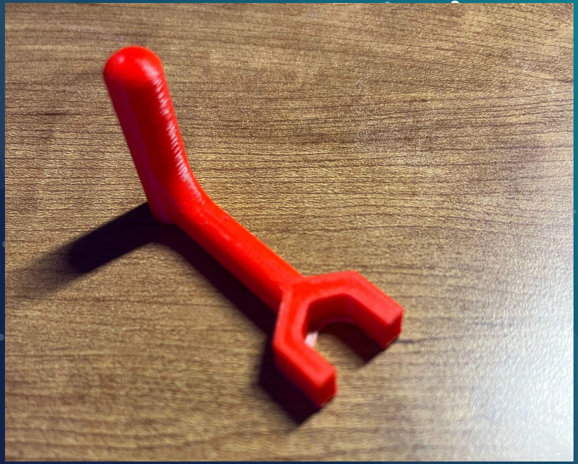
What I learned from my Rapid Prototype:

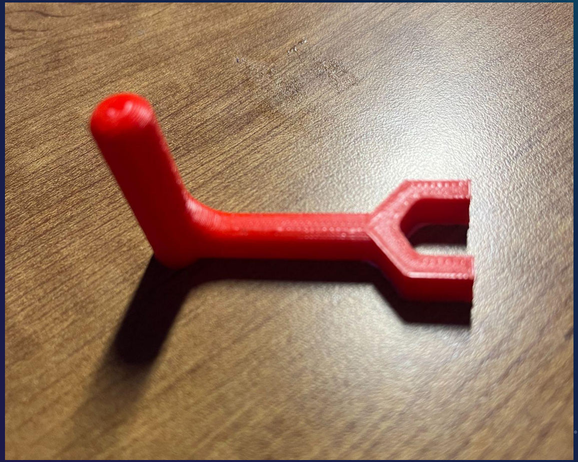
- The Wrench fit around the hex-nut
- My measurements for the handle **fit within the constraints of the box**, and it did not interfere with the access panel
- The handle of the wrench seemed a little loose (as it was assembled with glue) so **I needed to see if the PLA handle would be stronger**

Prototype 2

My second prototype was entirely 3D printed to see whether Tough PLA could be strong enough to withstand force via an L-shaped handle

- Printed a shorter handle to **save time** in the print
- Other measurements are accurate to design
- The wrench was printed with a fine profile and 100% triangular infill





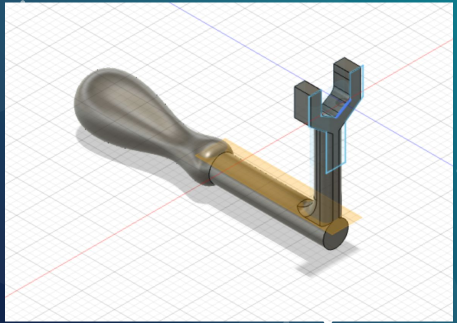
What I Learned:

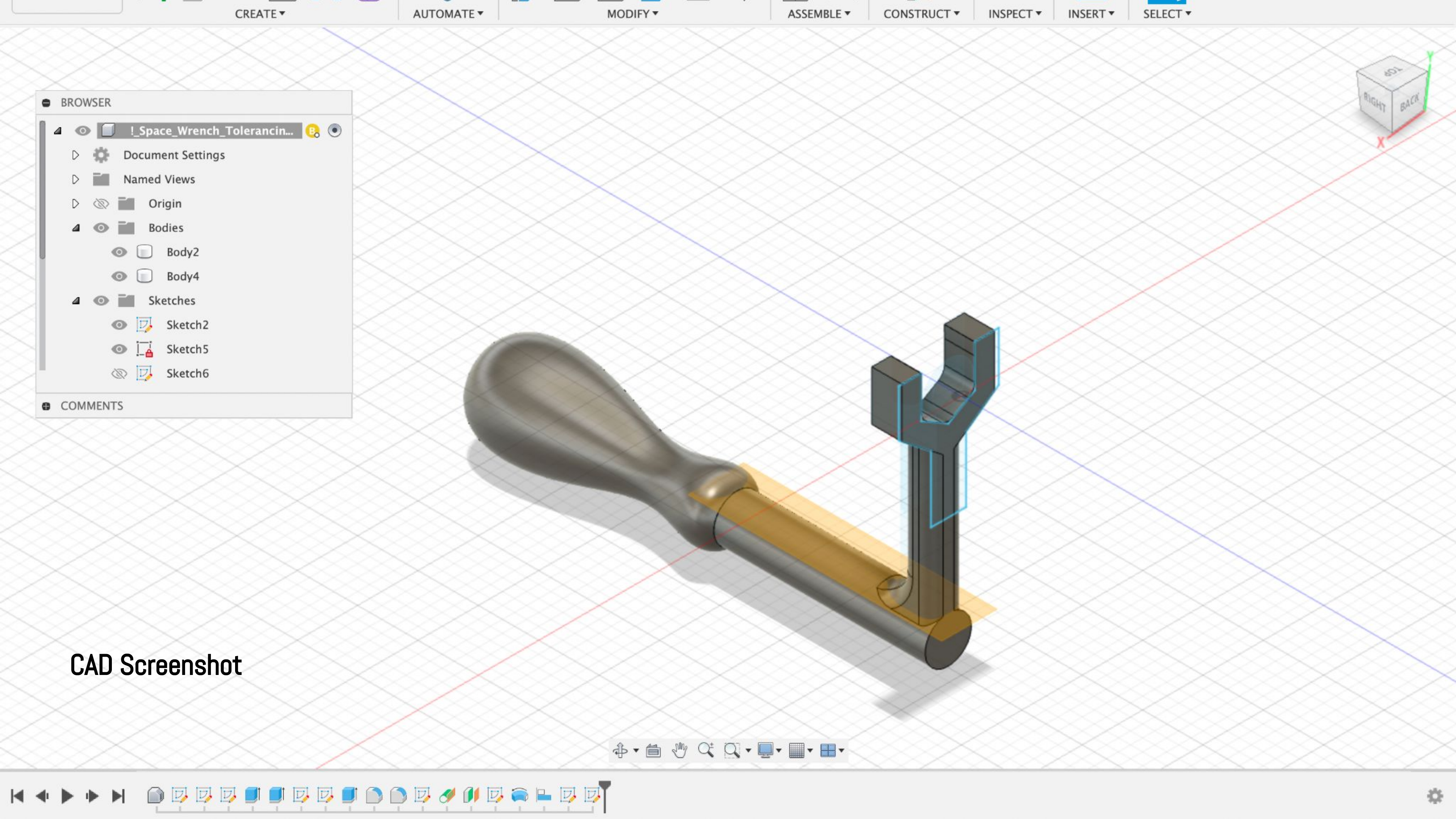
- The PLA was strong enough to withstand force in turning the hex nut
- The hex nut could be turned with a bare hand
- The handle was too short to be turned with a glove
- Orienting the wrench as depicted on the Print bed printed the layers horizontally, which was strong enough to withstand force

Prototype 3

My third prototype was also entirely 3D printed with a taller handle, molded to be easier to grip

- Designed a handle to try to accommodate the need to grip the handle and the "pinching" grip



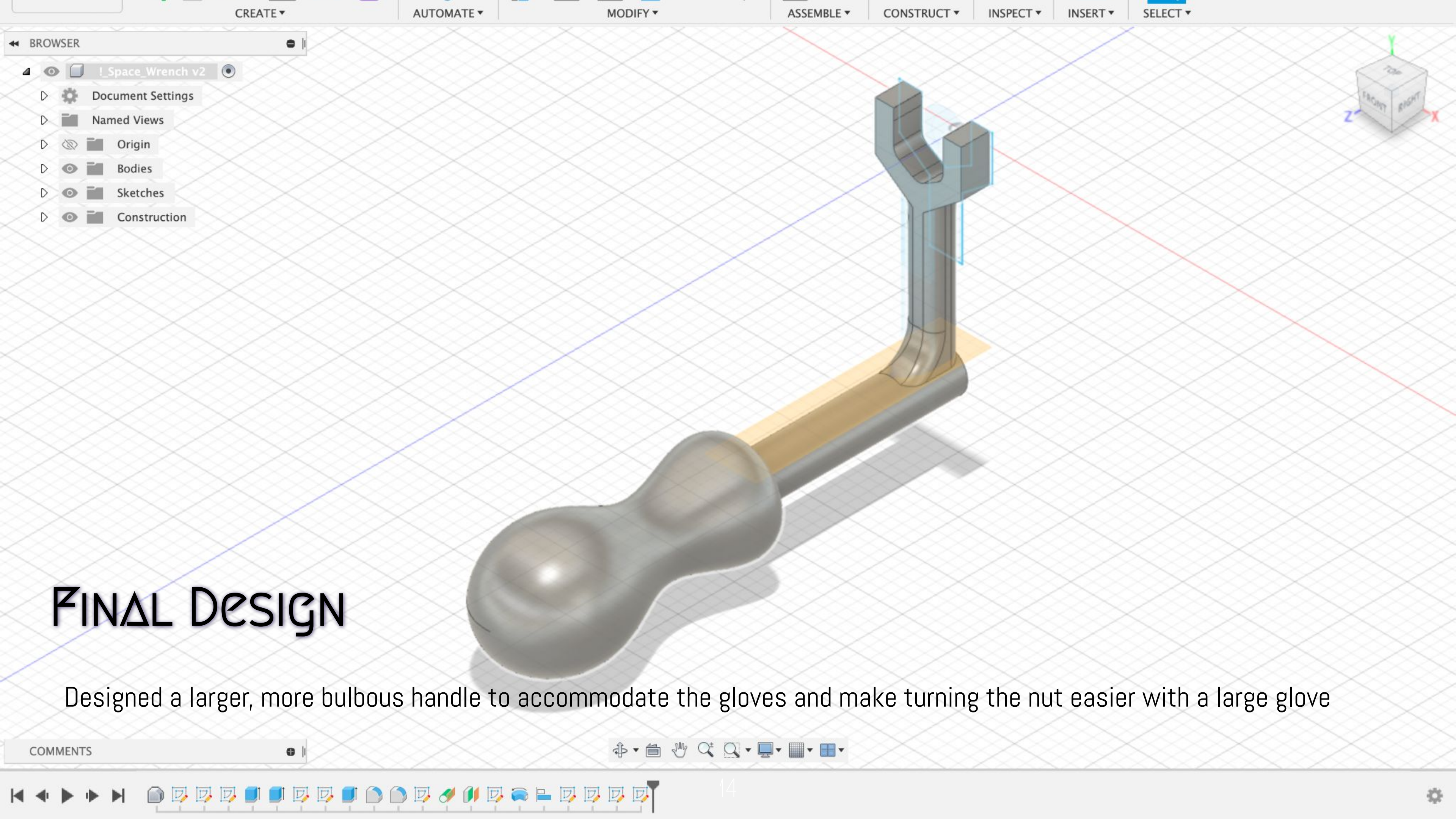


CAD Screenshot

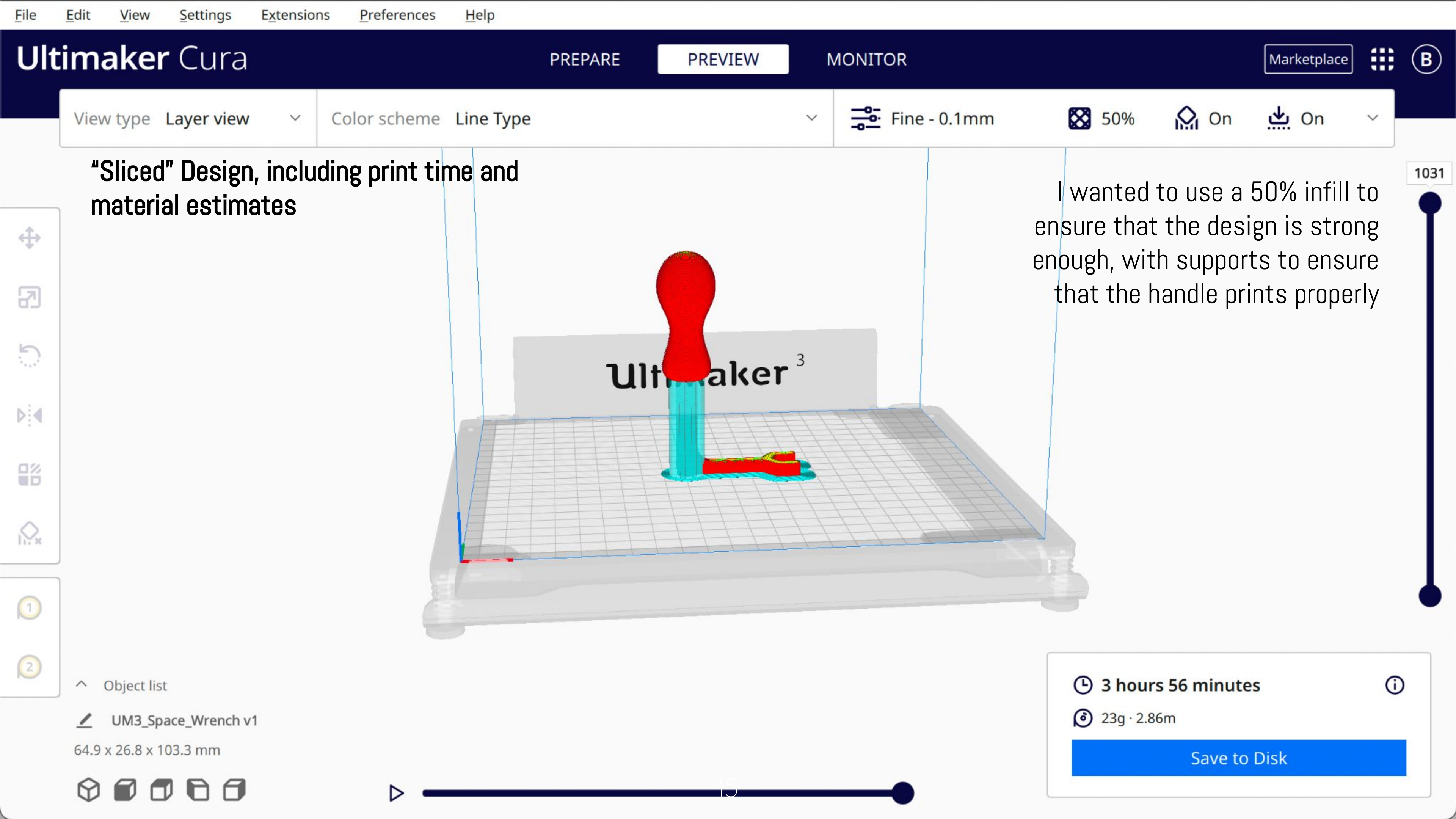
What I Learned:

- The wrench worked!
- The wrench was able to turn and tighten the hex nut in a timely manner!
- The design printed without supports, so some parts of the handle were a bit distorted
- The handle of the wrench was a bit skinny and difficult to grasp with the bulky gloves

Final Design



Designed a larger, more bulbous handle to accommodate the gloves and make turning the nut easier with a large glove


"Sliced" Design, including print time and material estimates
I wanted to use a 50% infill to ensure that the design is strong enough, with supports to ensure that the handle prints properly
File
Edit
View
Settings
Extensions
Preferences
Help
Ultimaker Cura
PREPARE
PREVIEW
MONITOR
Marketplace
View type Layer view
Color scheme Line Type
Fine - 0.1mm
50%
On
On
1031
Object list
UM3_Space_Wrench v1
64.9 x 26.8 x 103.3 mm
3 hours 56 minutes
23g · 2.86m
Save to Disk

Post-Processing

- Removed the Supports, sanded down the piece with 120-grit sandpaper to remove deformities
- The wrench works!

Final Part

Design Analysis

The wrench was **successful**! As desired, the wrench was able to turn the hex nut significantly with each actuation, even with the access panel interfering with direct access to the hex nut. The wrench profile was accurately dimensioned and toleranced, so that the wrench was able to fit around the hex nut but also remove itself in a timely manner to reset the actuation. The bulbous design of the handle was easier to grip, even with the bulkier glove. **Ultimately, the design was very simple and straightforward. If given more time, I would explore different designs, potentially even iterating unconventional designs, like angled tongs that could pinch around the nut.**

Reflection

I am very pleased with the outcome of this first project! I have a tendency to overthink projects, attempting to create complex designs and ultimately having to scale back later on in the design process. With this project, however, I found success in starting with a simple but effective design. I ensured that my design met the simplest specifications, and made small alterations to the design where necessary—the size of the handle, the infill of the print, etc.

In the future, I will definitely try to create more complex and challenging designs. However, I will stand by my current strategy of initially designing for simplicity and continuing the iterative process. Through this project, I embraced the "obvious," understanding that the complexity of my design—or lack thereof—did not compromise its effectiveness. Regardless, this project met my goals of designing for speed and ergonomic comfort, as the wrench tightened the hex nut at a pretty quick pace, and I found no difficulty in handling the wrench with the bulky glove.

Resource Cost

Item	Cost
¼-20 hex nut	$0.05
Prototype 1 Print	$0.16
Prototype 1 Dowels	$0.00 (found in Room 36)
Prototype 1 Hot Glue	$0.00 (found in Room 36)
Prototype 2 Print	$0.64
Prototype 3 Print	$1.83
Prototype 4 Print	$2.28
120-grit Sandpaper	$0.60
Total	$5.56

Total Time:
~13 hours