EML 3022: CAD PROJECT

Fall 2023

Concert Flute

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Introduction

I decided to model a concert flute for my project. I am an avid flautist and I always wanted to learn how the mechanics of the modern concert flute work. The body of the flute has a series of keys and underlaying tone holes. These keys are connected to a mechanism that allows them to be opened and closed by the player's fingers. The combination of opened and closed holes determines the pitch of the note played. Covering more holes generally produces a lower pitch, while opening them raises the pitch.

The modern flute was developed by Theobald Boehm, a German musician. Boehm made his design sometime around the mid-19th century. His key mechanism introduced a series of rods and pivot-mounted keys. Besides being a musician, this mechanism was the main inspiration for me choosing to model a flute.

Design

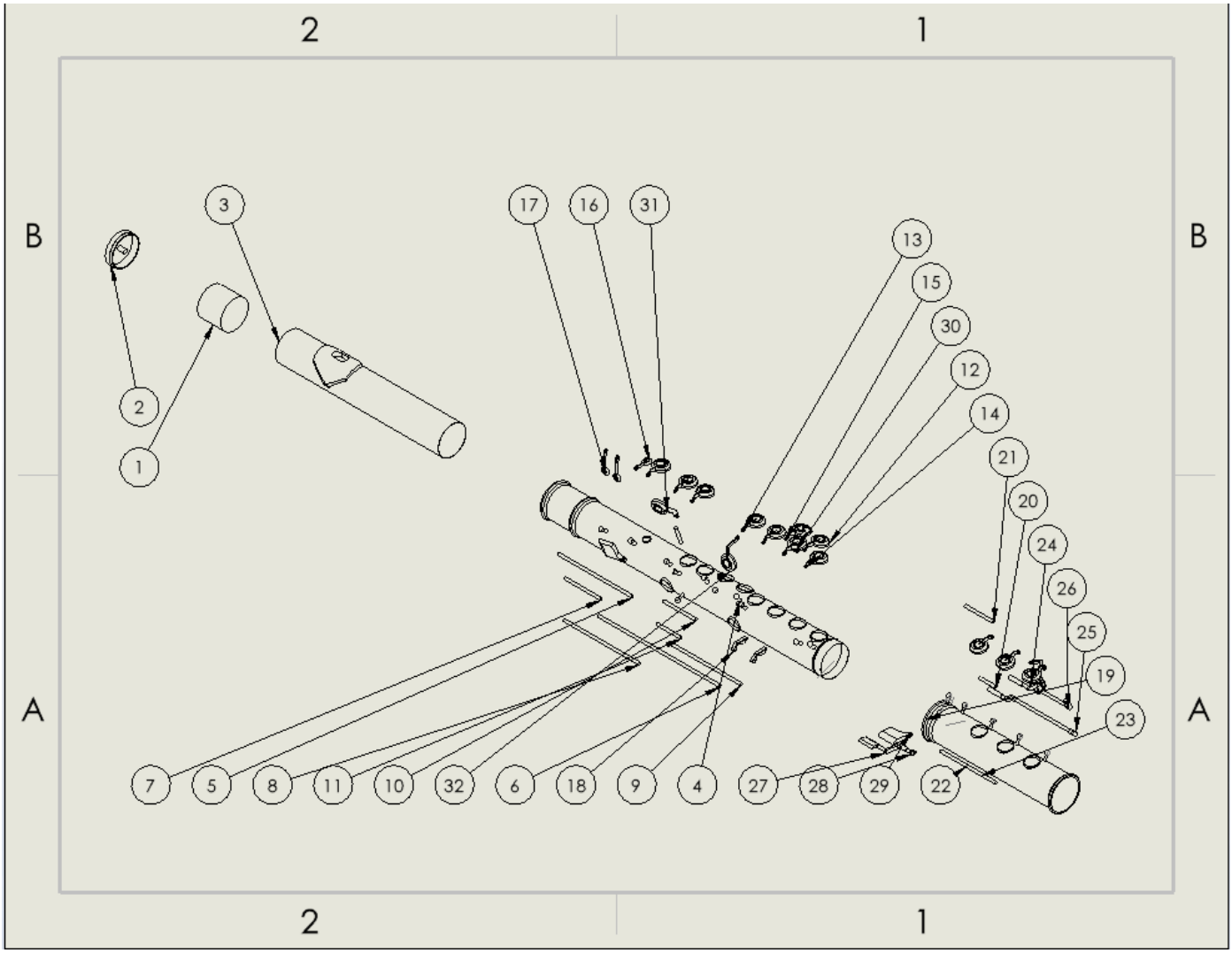
I used my own flute as a basis to model the flute in SolidWorks. The headjoint, the body, and the footjoint were all cut from pure silver (99.6%), while the mechanism is made out of a combination of stainless steel and silver plated nickel. There is debate among flautist whether the flute material significantly affects the sound, beginner flutes usually consist of an nickel body plated with silver with a nickel/steel mechanism, intermediate flutes usually consist of a full silver (Coin/Sterling/Steel) tubing, or at least a silver headjoint. Some professional flautist opt for flutes made out of Gold spanning from 6 karat to 24. If someone is really affluent with cash they may decide to purchase a platinum flute. I don't really believe the material makes an significant difference in the sound, but I'm sure if the flute consist of higher quality metals, the workmanship quality will slimily increase.

I faced many difficulties in design. Just modeling the body part, itself without any additional parts required nearly 30 reference planes, I spent most of my time on trying to simply understand the complexity of a modern concert flute's structure, then modeling and simulating each component in SolidWorks.

Furthermore, I only had a 10cm ruler to measure my own flute, which created several achieving precise measurements and scaling, leading to initial inaccuracies in my prototype's

dimensions and key placements. Such measurements are not easily found on the web. Furthermore, there was some mechanical motion that I could not logically replicate in SolidWorks, I have deduced that there is intricate movements within the interior of some of the rods, that I was unable to accurately observe.

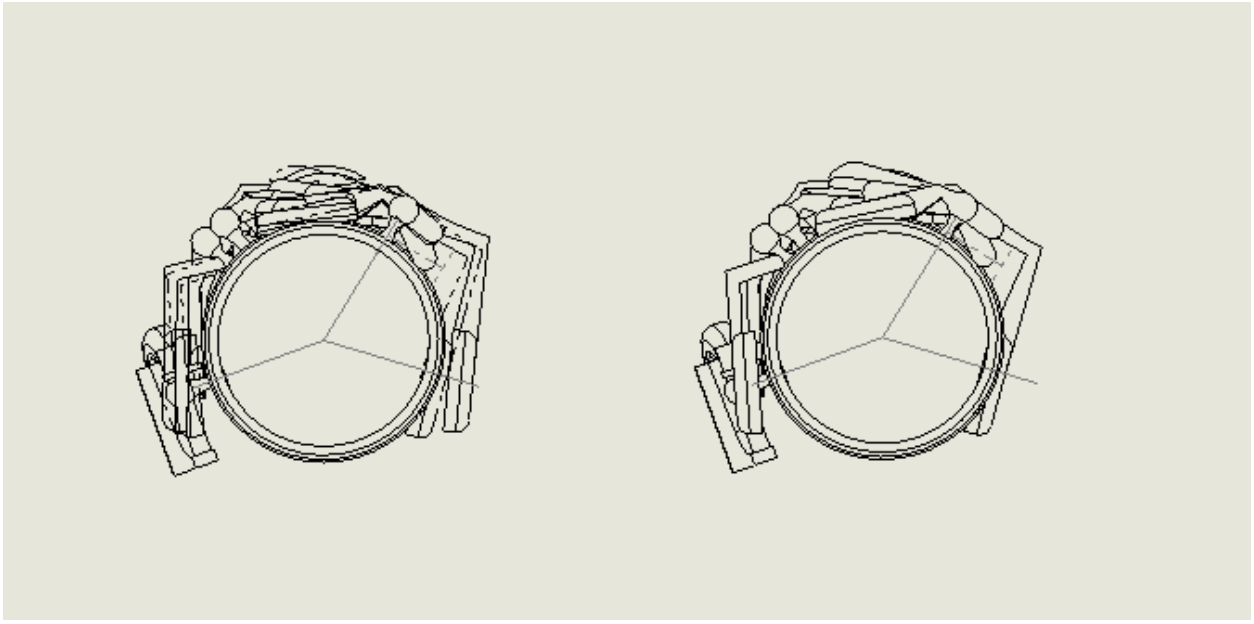
Exploded View



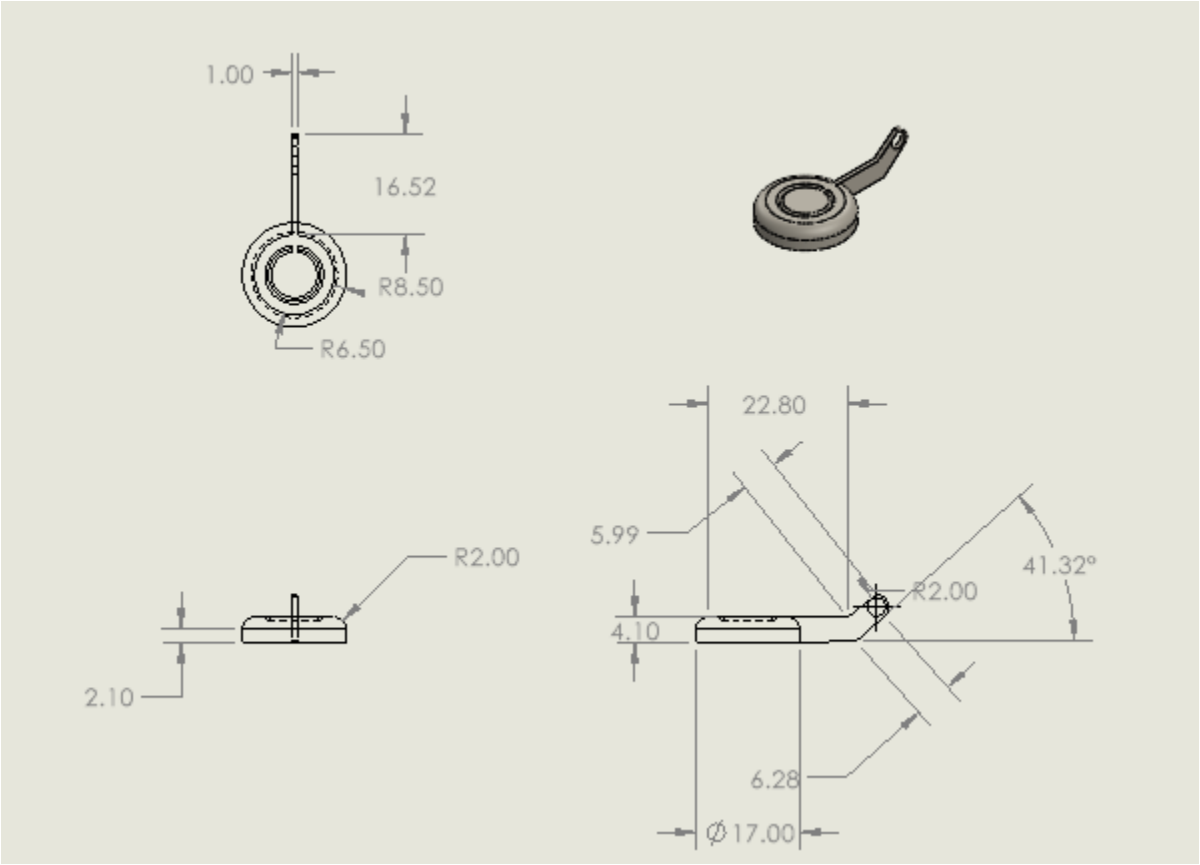
Bill Of Materials

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Cork		1
2	Crown		1
3	Headjoint		1
4	Body		1
5	Body Rod A 1		1
6	Body Rod A 2		1
7	Body Rod B 1		1
8	Body Rod B 2		1
9	Body Rod B 3		1
10	Body Rod C 1		1
11	Body Rod D 1		1
12	Basic Key Rod C		1
13	Basic Key		5
14	Basic Key Open Hole		5
15	Basic Key Rod C Open Hole		1
16	Small Basic Key		1
17	Small Basic Key Rod A		2
18	Basic Key Shortcut		2
19	Footjoint		1
20	FootJoint Rod A		2
21	FootJoint Rod B		1
22	FootJoint Rod C		1
23	FootJoint Rod D		1
24	Basic Key Rod C FootJoint		1
25	Footjoint B Lever		1
26	Footjoint C Lever		1
27	Footjoint D Flat Lever		1
28	Footjoint D Lever		1
29	Footjoint Other D lever		2
30	Basic Key Shortcut Pinkie		1
31	B Key		1
32	Pinkie Key		1

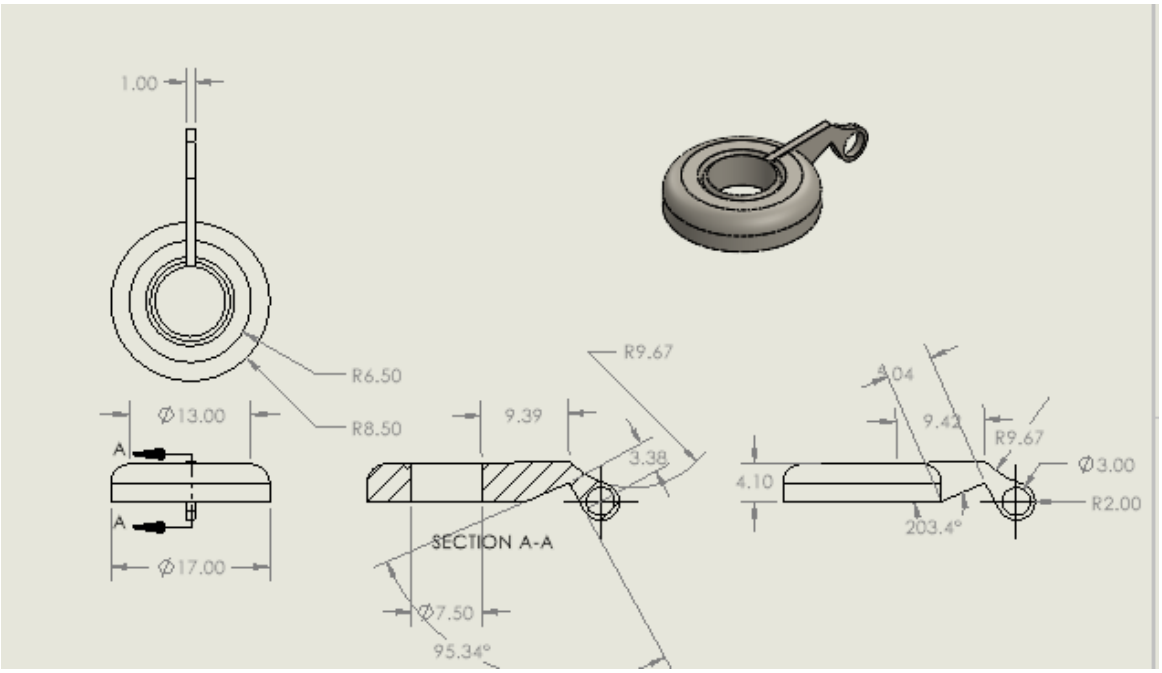
Alternate Position Drawings



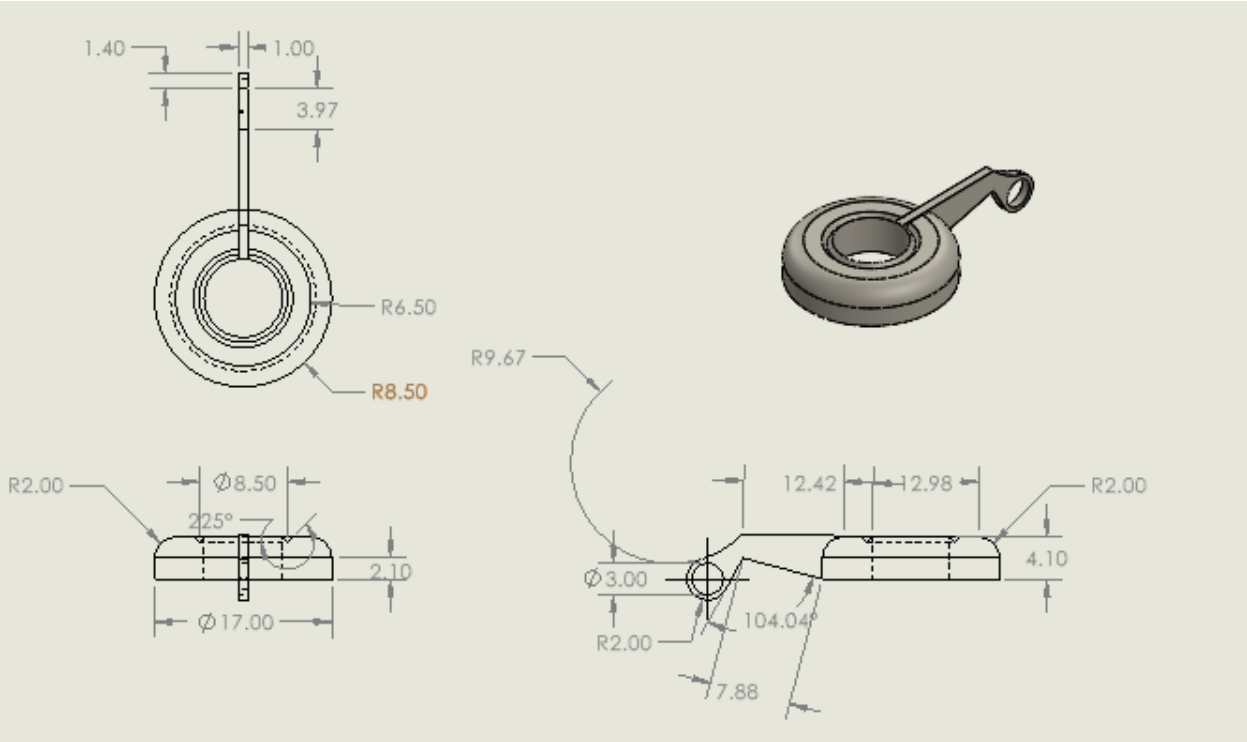
B Key



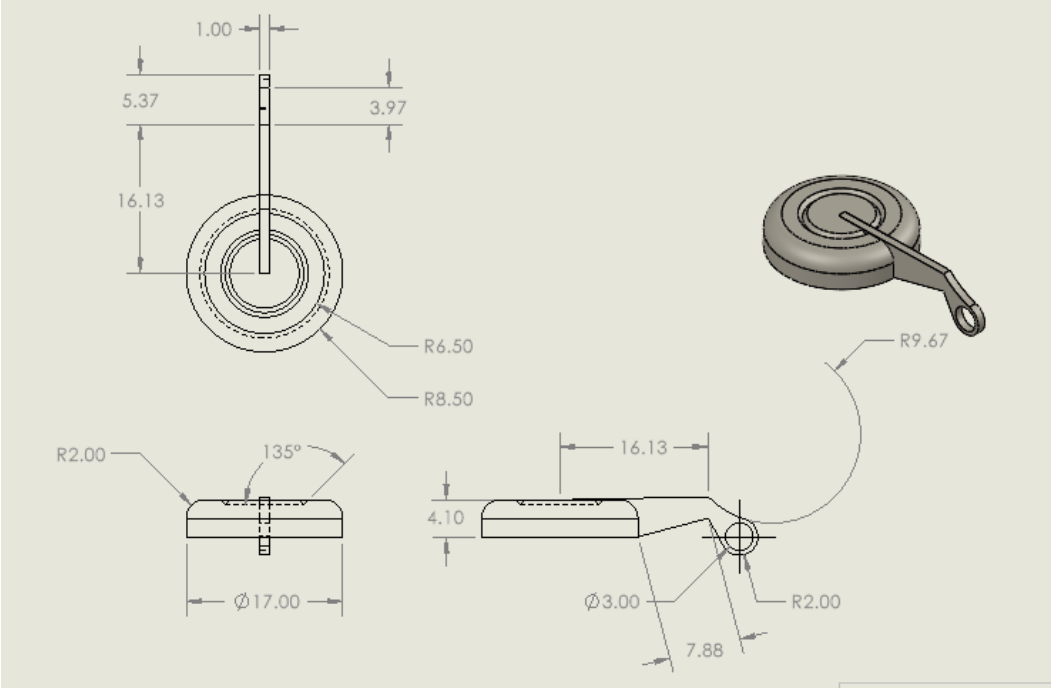
Basic Key / Open Hole



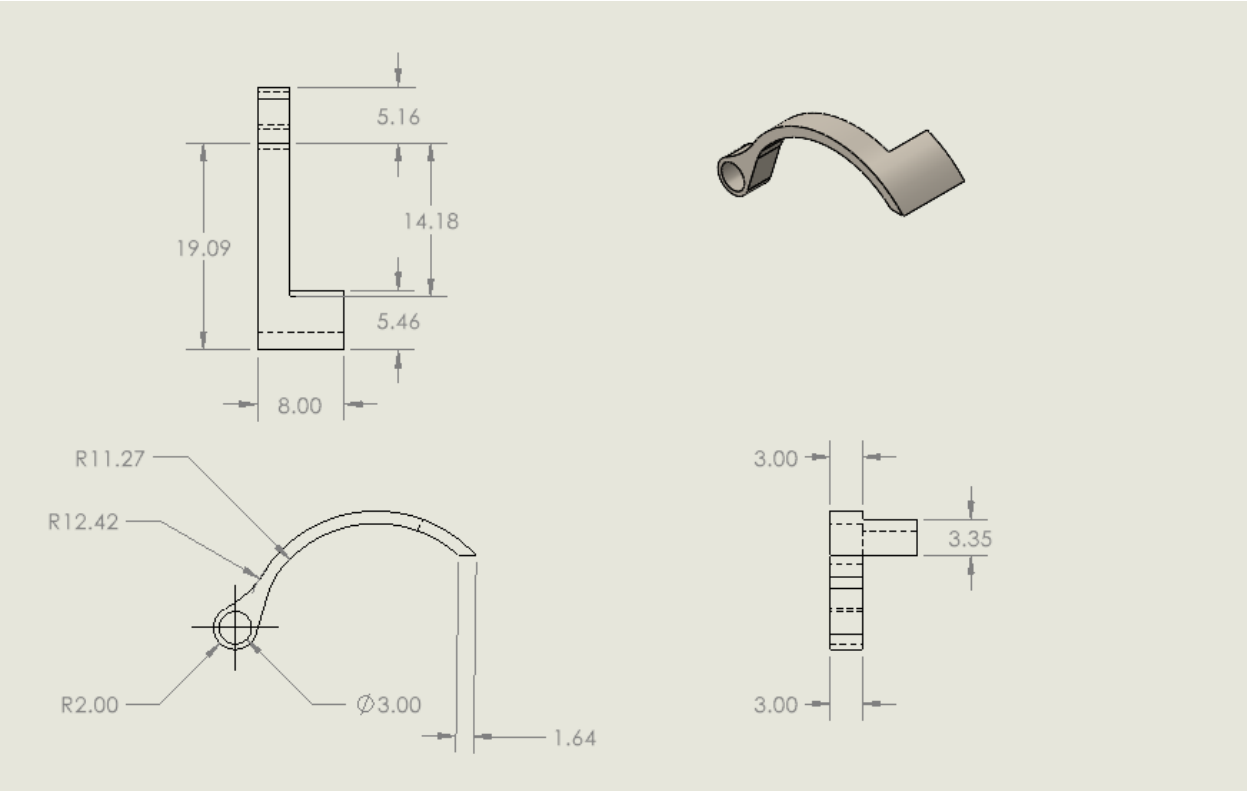
Basic Key C / Open Hole



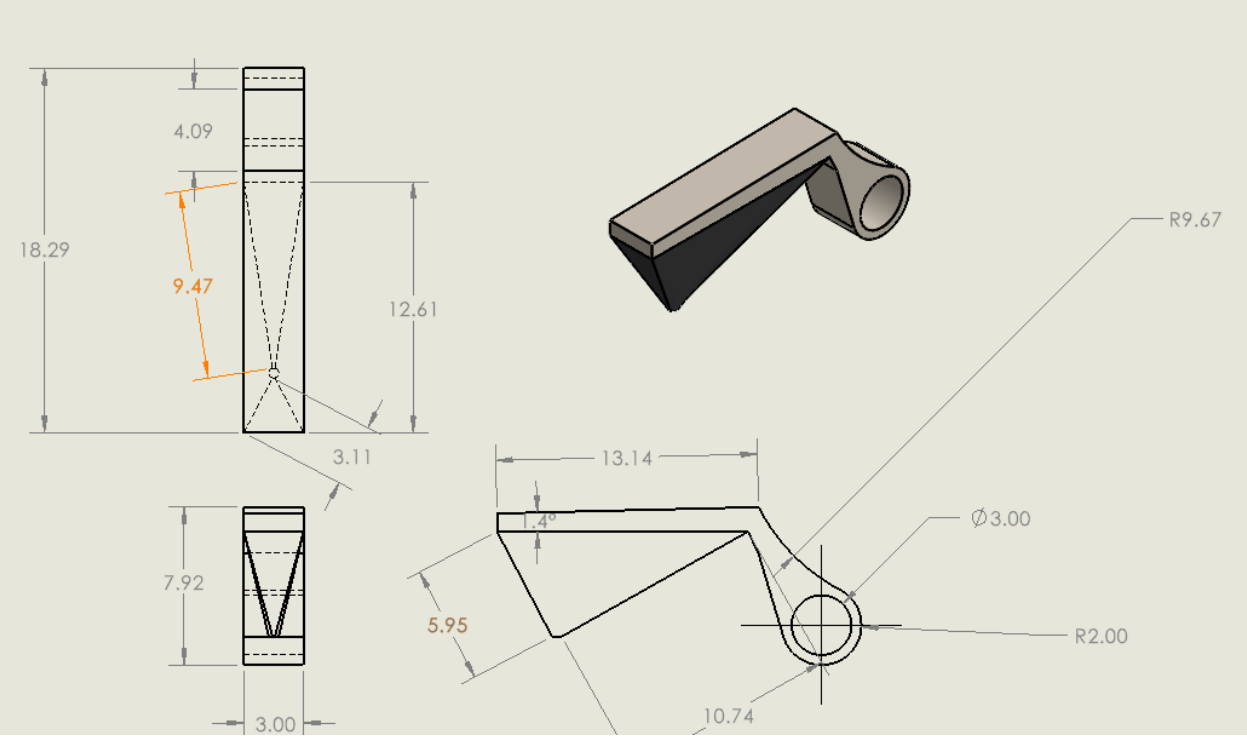
Basic Key Rod / C



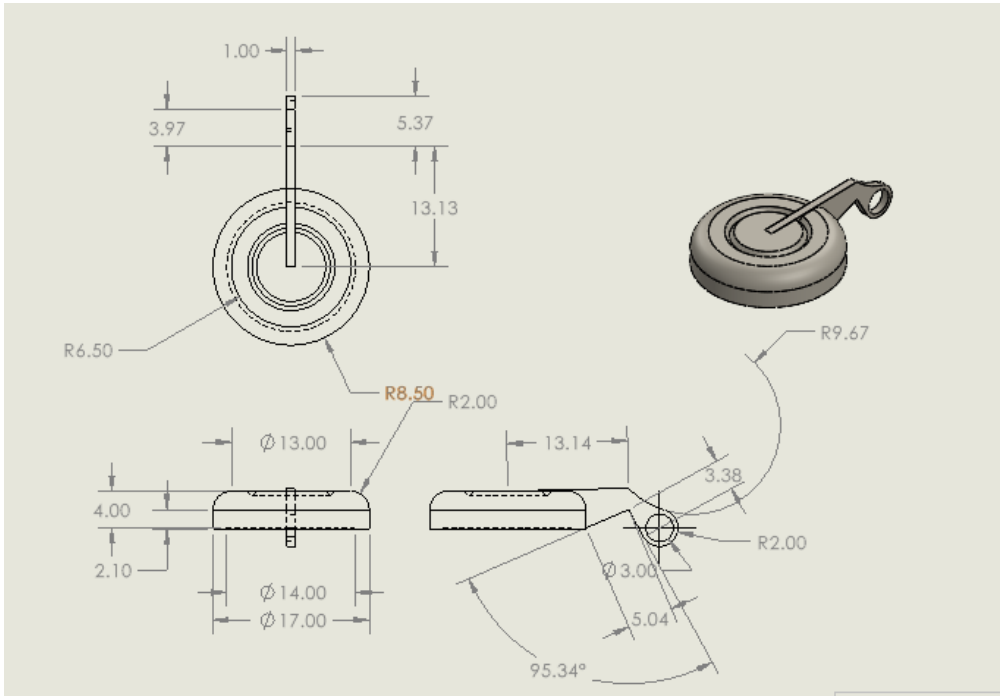
Basic Key Shortcut Pinkie Finger



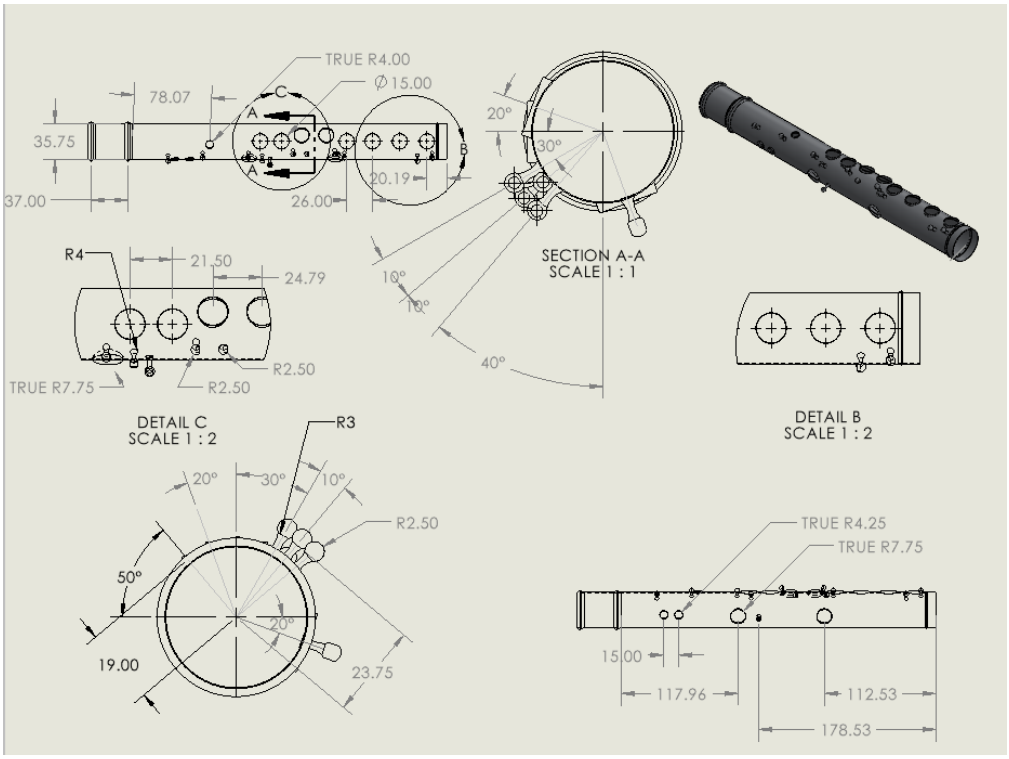
Basic Key Shortcut



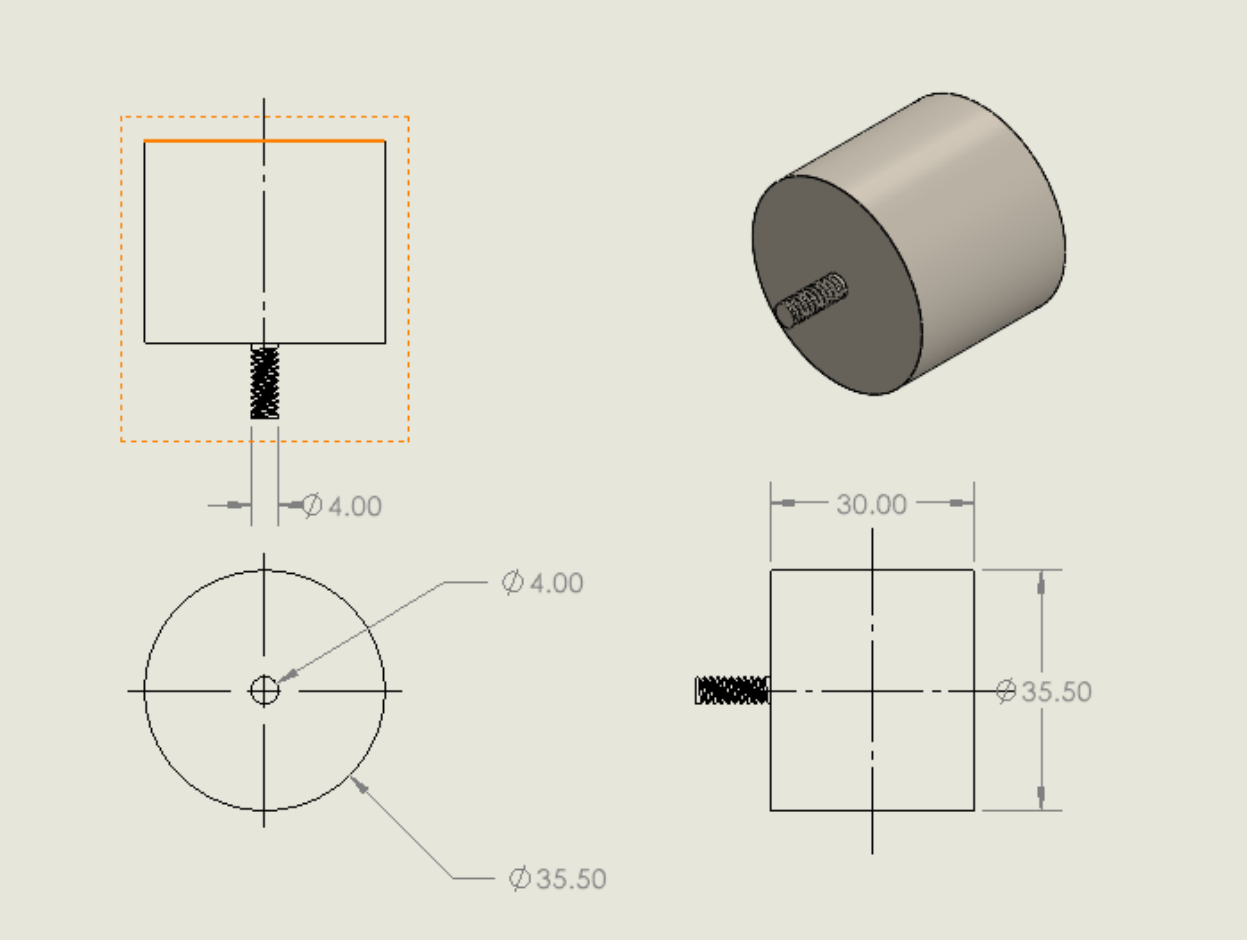
Basic Key



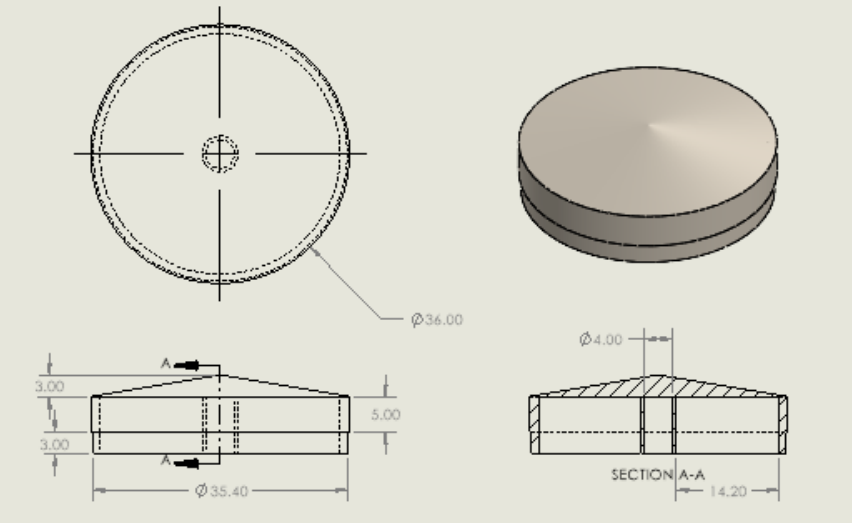
Body



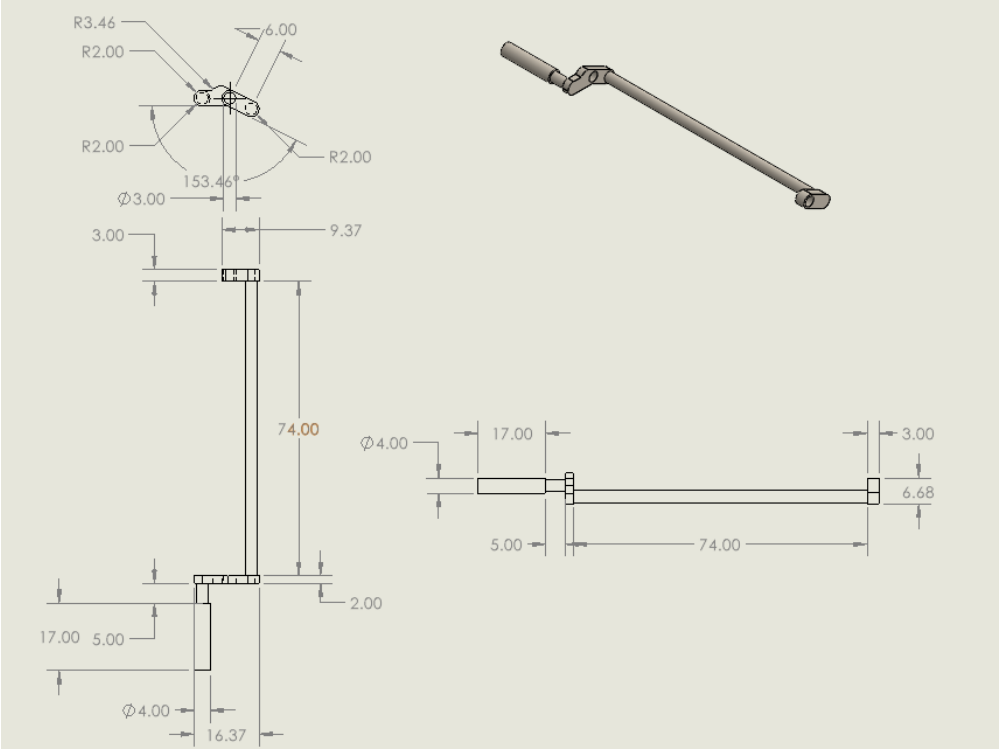
Cork



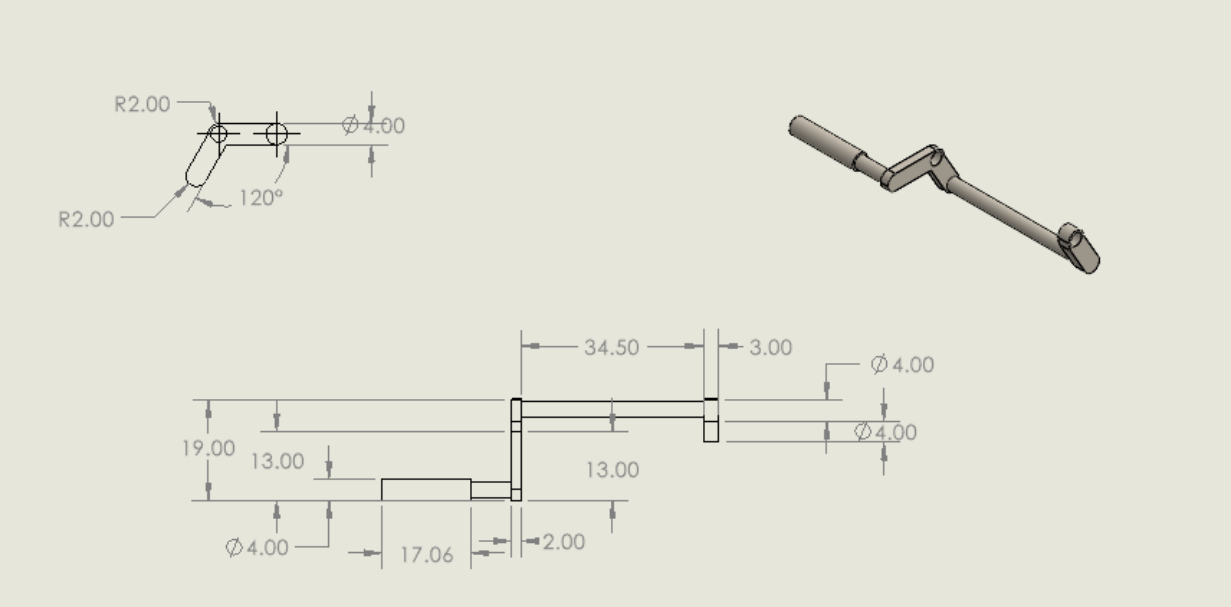
Crown



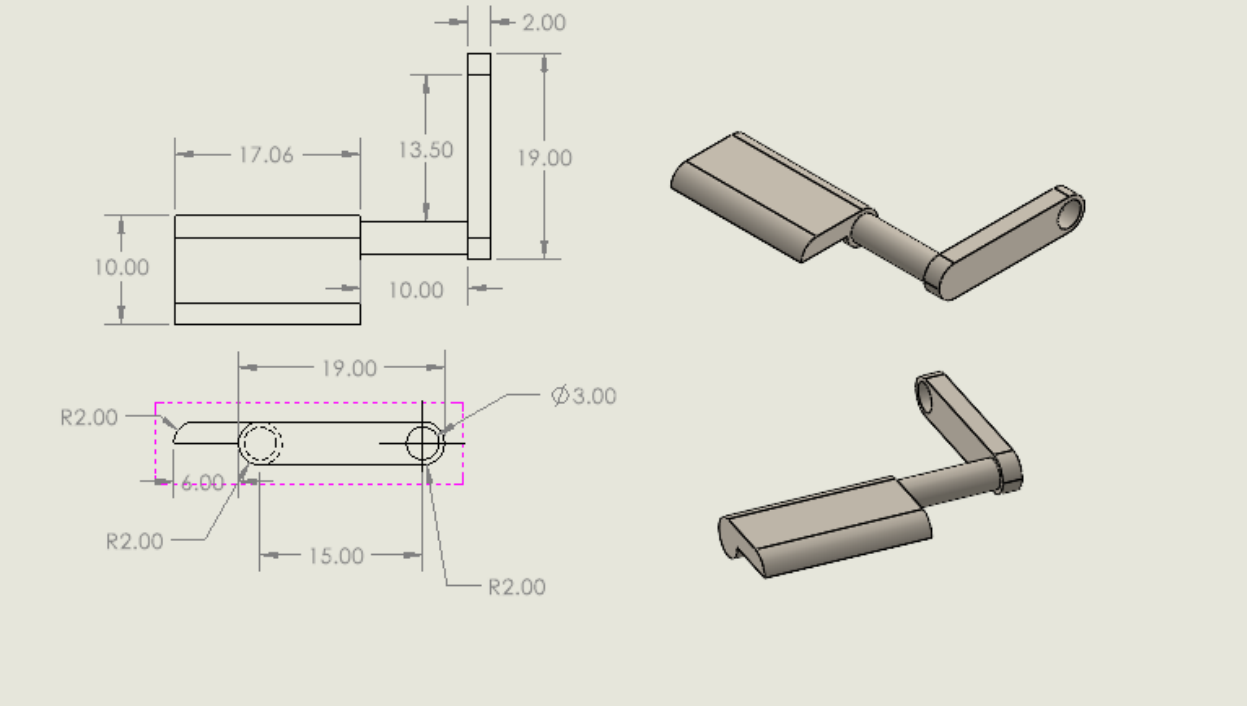
Footjoint B Lever



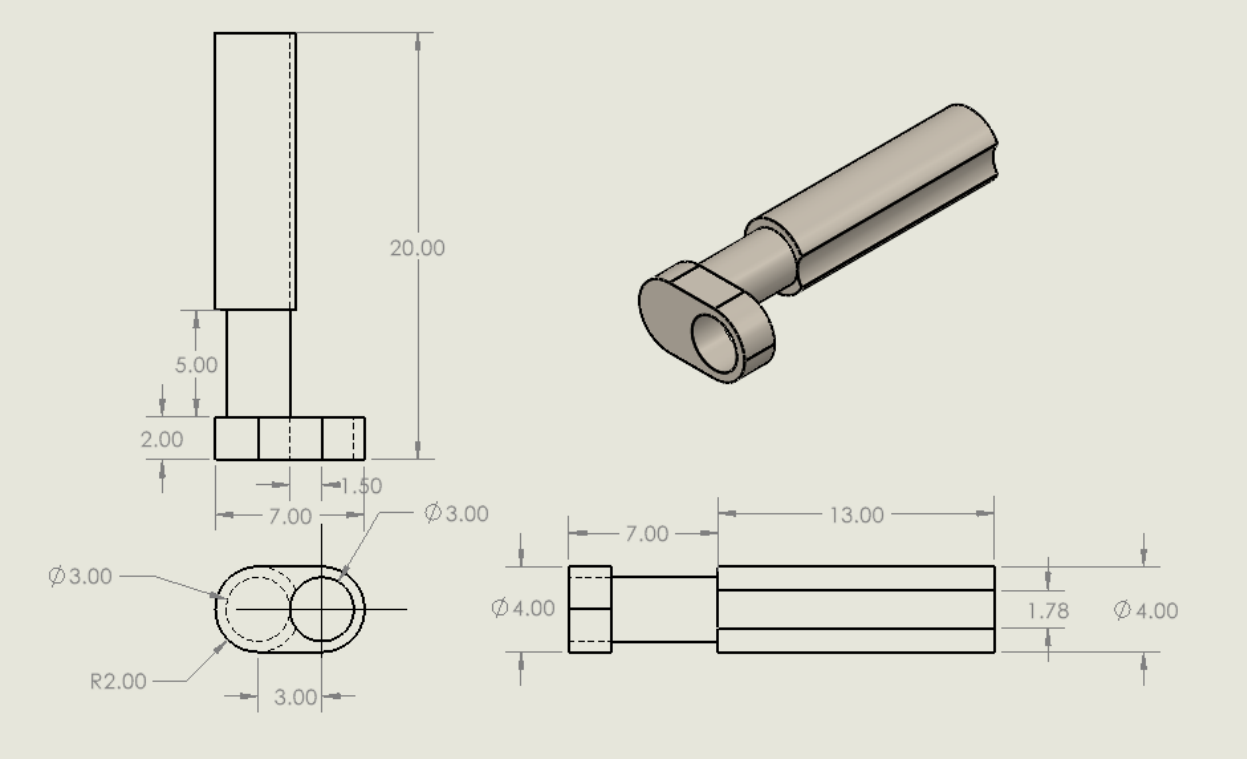
Footjoint C Lever



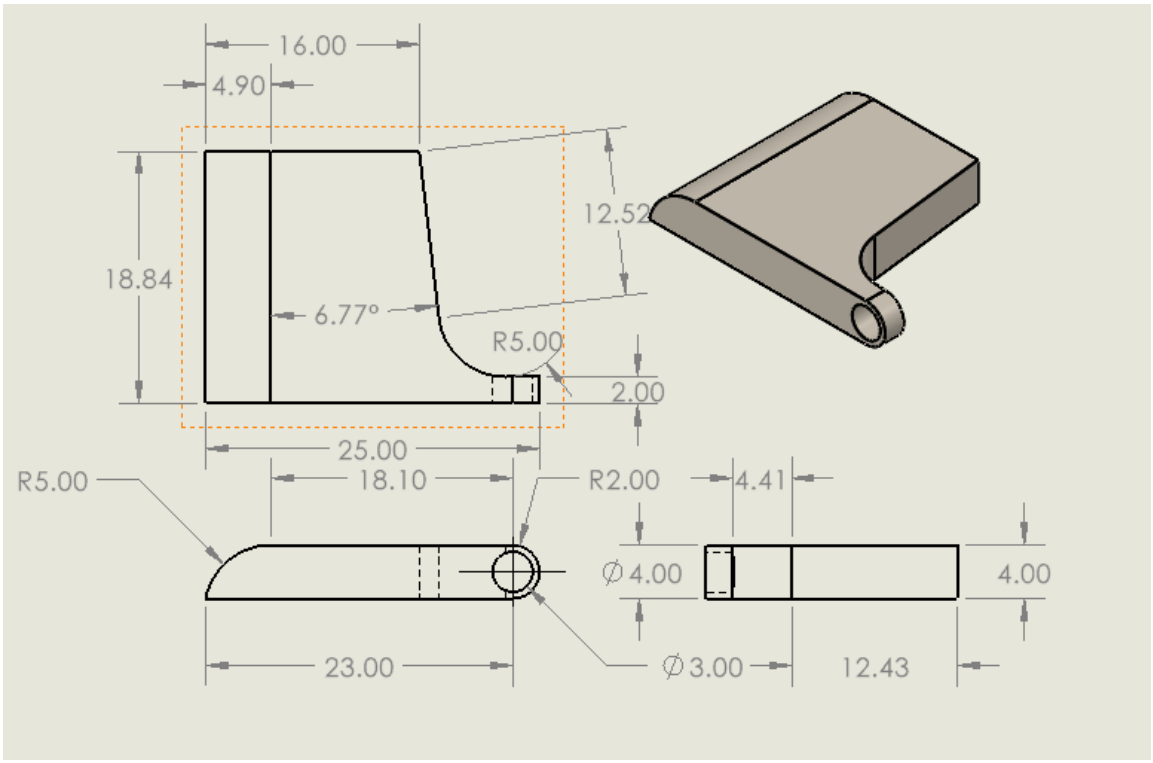
Footjoint D Flat Lever



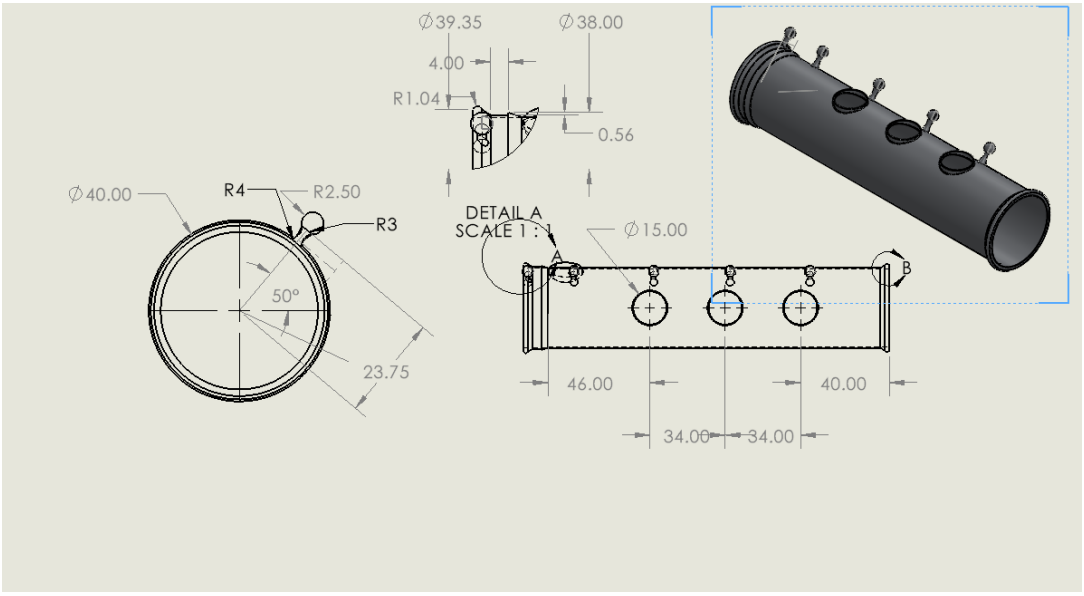
Footjoint D Lever



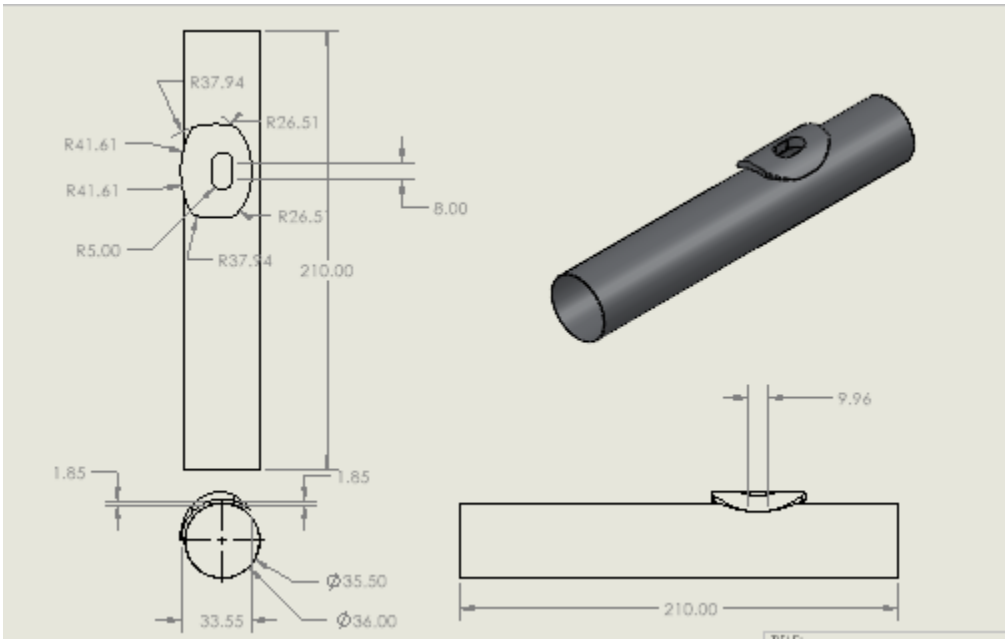
Footjoint Other D Lever



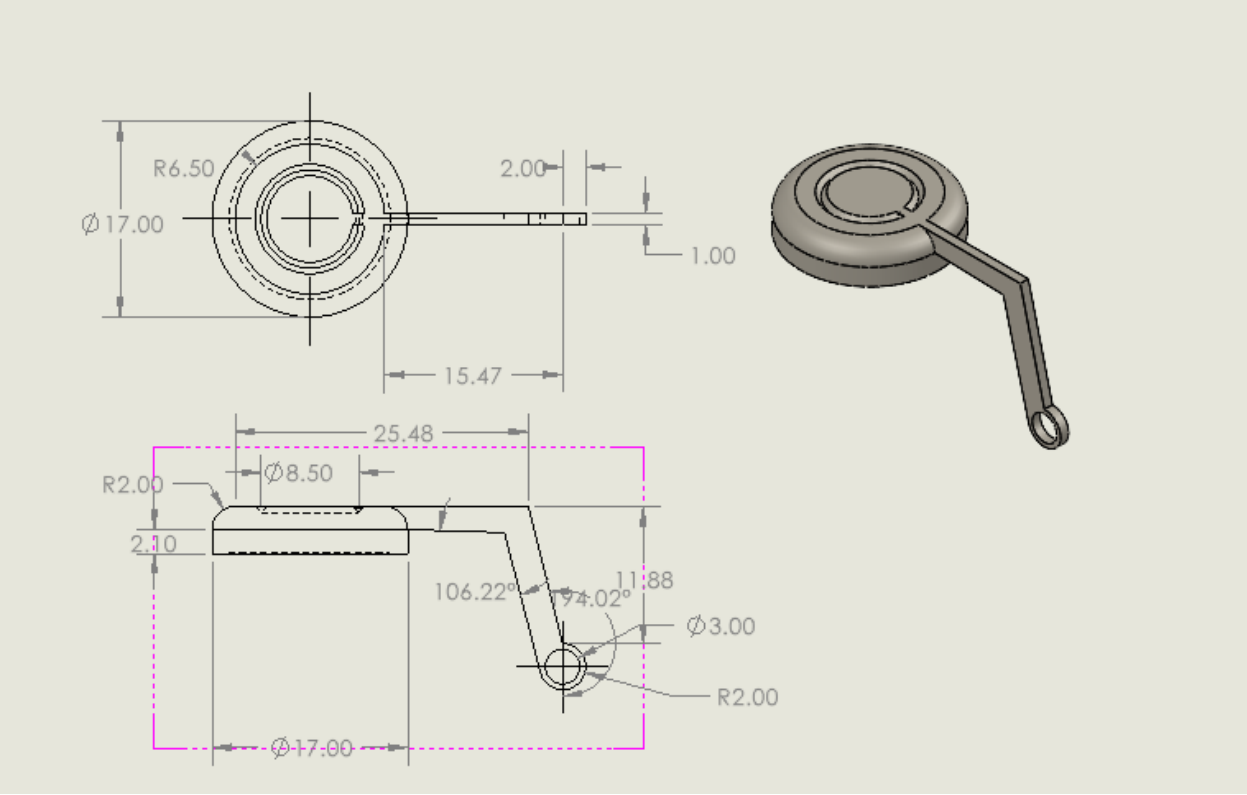
Footjoint



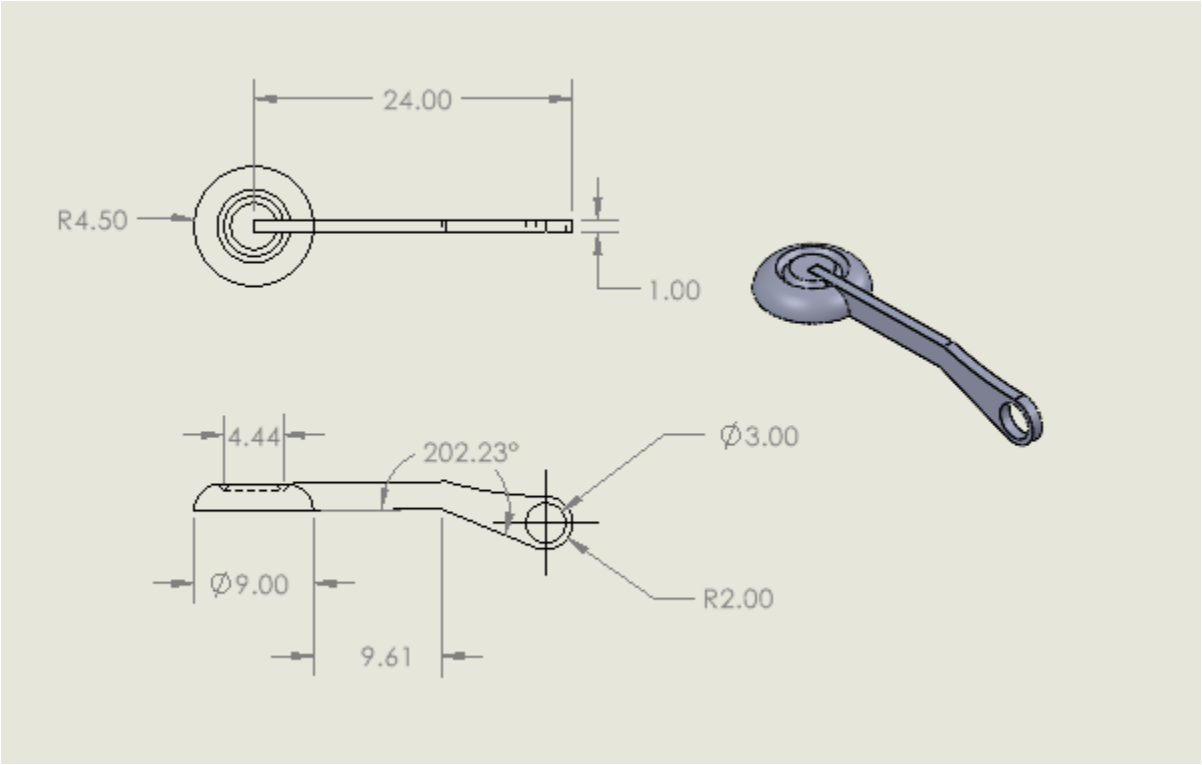
Headjoint


R37.94
R26.51
R41.61
R41.61
R26.5
R5.00
R37.94
210.00
8.00
1.85
1.85
Ø35.50
33.55
Ø36.00
9.96
210.00

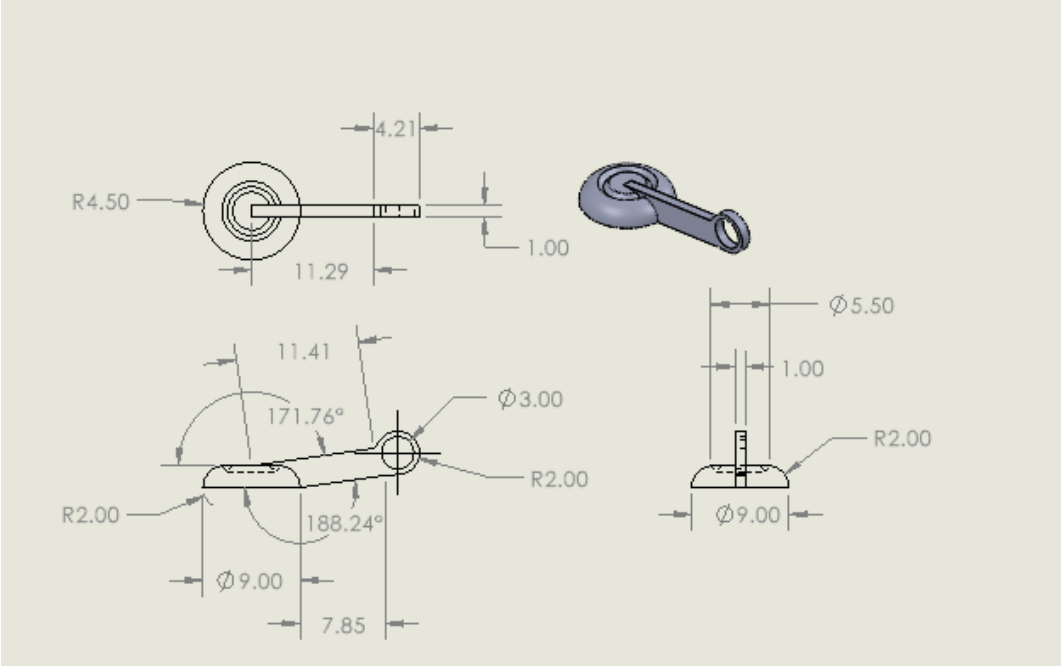
Pinkie Key


R6.50
2.00
Ø17.00
1.00
15.47
25.48
Ø8.50
R2.00
2.10
106.22°
94.02°
11.88
Ø3.00
R2.00
Ø17.00

Small Basic Key Rod A



Small Basic Key



Analysis

The system I modeled ended up much more complex than I was expecting. I had to be very careful adjusting the system when working in the assembly, sometimes I would adjust one key, and 5 different parts would start moving unintentionally. I omitted some of the rod drawings, they're simply a cylinder with a diameter of 3mm of varying length.

Overall, though this project helped me a lot with understanding the mechanics of both the concert flute and how SolidWorks 'works'. I used gear mates, to match the movement of the hinged keys, with rotating rods, which then would transfer the movement to several different rods, which would animate other keys. All of this interconnectivity led to a lot of room of error in the mechanics.

Concluding Remarks

This project was probably the longest project I overtook this semester. I am thoroughly satisfied with my work, however there is a lot to improve upon. More accurate measurements of my flute would help, as well as a deeper understanding of the mechanics involved. I'd like to one day redo this model, and perhaps build a flute of my own.

Appendix

An image of my flute, and the ruler I used for measurements.

Features Checklist

A minimum of 10 different commands should be used from the following table

Put a checkmark next to the features that you used

Boss/Base
Extrude.. ✓
Revolve.. ✓
Sweep.. ✓
Loft.. ✓
Boundary..
Thicken..

Cut
Extrude.. ✓
Revolve.. ✓
Sweep..
Loft.. ✓
Boundary..
Thicken..
Wrap..

Features
Fillet/Round.. ✓
Chamfer..

Hole
Simple.. ✓
Wizard..
Draft..
Shell.. ✓
Rib..
Scale..
Dome..
Freeform..
Deform..
Indent..
Flex..

Pattern/Mirror
Linear Pattern.. ✓
Circular Pattern.. ✓
Mirror.. ✓

Curve
Split Line..
Projected..
Composite..
Curve Through XYZ Points..
Curve Through Reference Points..
Helix/Spiral..

Reference Geometry
Plane..
Live Section Plane..
Axis.. ✓
Coordinate System.. ✓
Point.. ✓
Center of Mass..
Mate Reference..
Grid System.. ✓

Tables
Bill of Materials.. ✓

Any other features used for your work

Estimate number of features used in the project:

17