Luke Skywalker's Model Lightsaber

MAE 3192: Manufacturing Process & Systems
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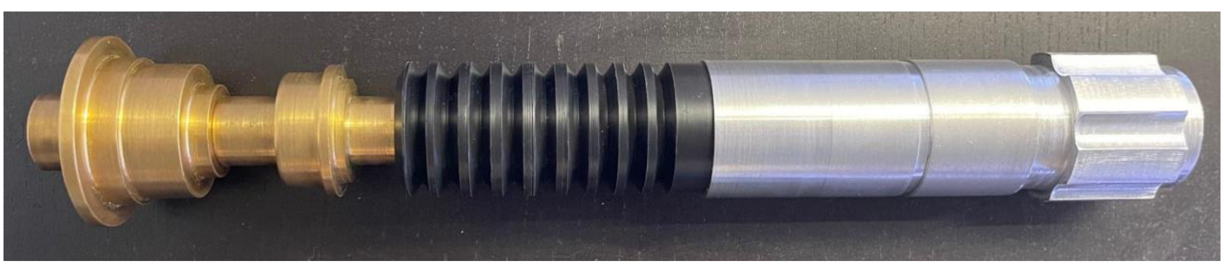
George Washington University
16 December 2021



i. Abstract

The purpose of this project is to familiarize students with the machine shop. The project allowed us to apply theoretical knowledge into a practical application, helping to reinforce our understanding of class topics and create skills applicable to our careers. We chose to create a model of Luke Skywalker's lightsaber because Starwars is something that us group members, as well as many other engineers, are big fans of. The saber was also a perfect product choice because we believed it would be a great test of our design skills in the virtual space, CAD, as well as a test of our ability to machine parts as each component required multiple different machining processes. The machining processes and tools involved include turning, milling, finishing, programming machines, horizontal bandsaw, tapping, threading, etc..

Our predictions were confirmed to be correct as we discovered that the project would take a great amount of time and thought needed in order to bring our concept to life. By the end of the project, we were able to appreciate the importance of a thorough process plan as we made many changes to it when advised by one of the shop staff members or when a step was omitted. Over the course of the build, many mistakes were made, yet, even more was learned making this project an invaluable experience that will help us kickstart our careers as mechanical engineers.

ii. Table of Contents

iii. List of Figures

iv. List of Tables

Component Number	Component Name	Material	Description	Length (in)	Max Diameter (in)
1	Top Brass	Brass	twists onto the end of the rod to squeeze everything into place	1.59	1.85

2	Bottom Brass	Brass	Slides onto the internal rod	1.59	1.34
3	Delron	Delron	Slides onto the internal rod	3.03	1.34
4	Top Aluminum	Aluminum	Slides onto the internal rod	2.12	1.42
5	Bottom Aluminium	Aluminum	Slides onto the internal rod	2.99	1.50
6	Internal Rod	Aluminum	twists onto the end of the rod to squeeze everything into place	9.82	0.50

Table iv.1

I.Introduction

Background: Students were tasked with designing "a manufacturing process plan for the project product and then implementing the plan in the machine shop." The project helps familiarize students with product design, building a process plan, navigating manufacturer websites (McMaster), communicating with team members and working with machine shop staff which is essential to the creation of any product in the engineering industry.

Objectives:

1. Use many different machining processes to complete your design (i.e. not just milling or turning)
    a. Introduction to NC machining
2. Use multiple materials
3. Attain hands on manufacturing skills (i.e. the best way to learn is to use the machines)
4. Apply basic GD&T concepts

II. Description of Product and Components

The product selected to be manufactured in the shop is a lightsaber hilt. It is nonfunctional, but the lightsaber can be disassembled into the various components that were built. The product was broken down into six parts of different materials. The top section of the saber was made in brass, the middle section was made in delrin, and the bottom two pieces and internal rod were manufactured out of aluminum.

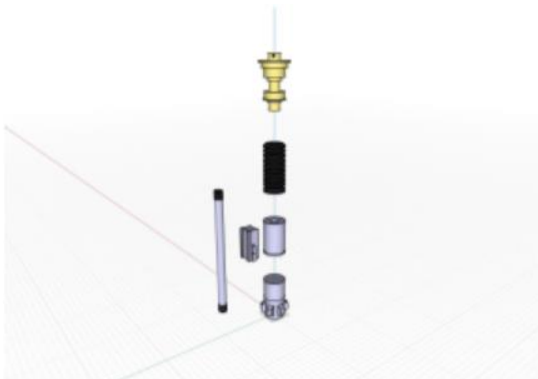


Figure 2.1 - Lightsaber Expanded View

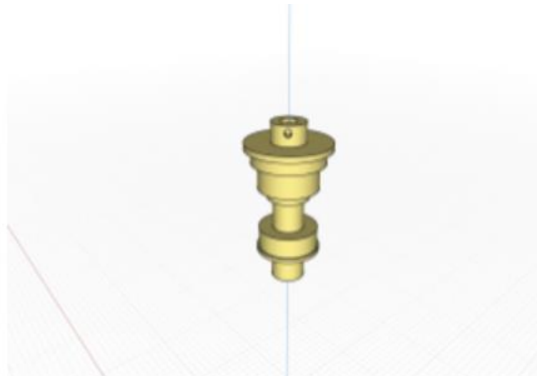


Figure 2.2 - Brass Section

Figure 2.3 - Delron Section

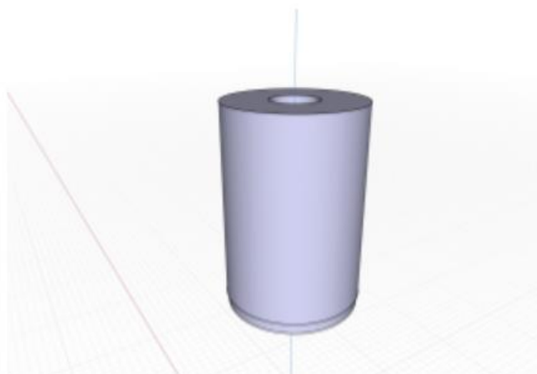


Figure 2.4 - Top Aluminum Section

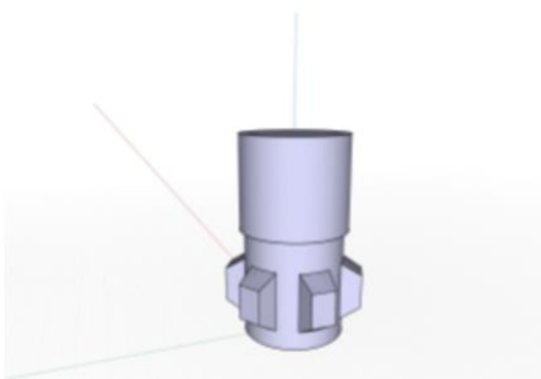


Figure 2.5 - Bottom Aluminum Section

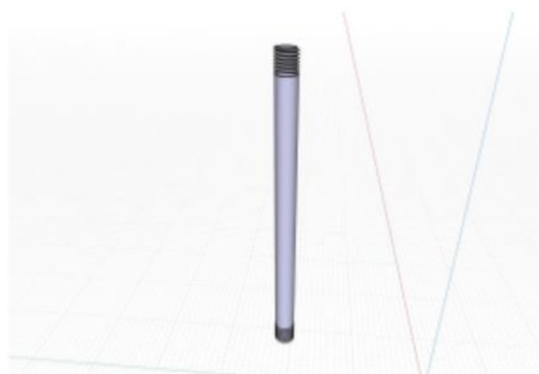


Figure 2.6 - Internal Aluminum Rod

Product: Model lightsaber
Components: 6 Parts

- Brass Section (Top and Bottom) (Figure 2.2)
- Delrin Handle (Figure 2.3)
- Top Aluminum Section (Figure 2.4)
- Bottom Aluminum Section (Figure 2.5)
- Internal Rod (Figure 2.6)

III. Design of Manufacturing Process Plan

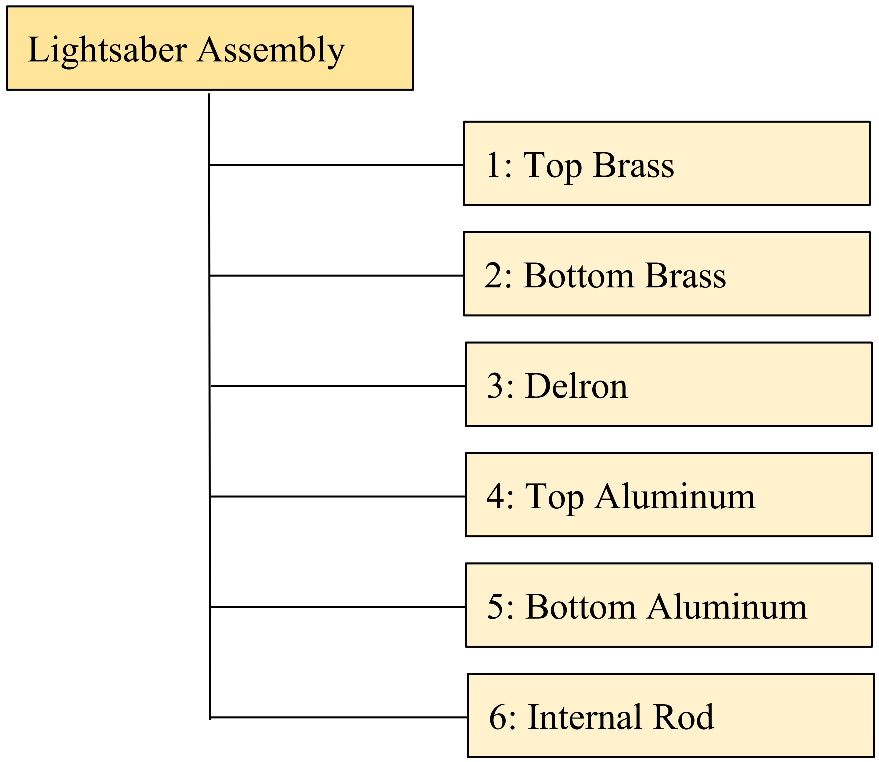


Figure 3.1 - Lightsaber Assembly Process Plan

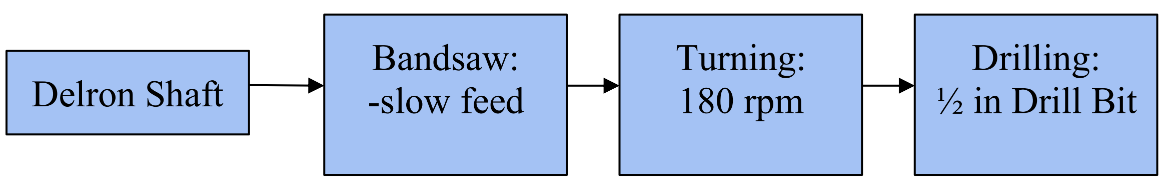


Figure 3.2 - Part 3 Process Plan

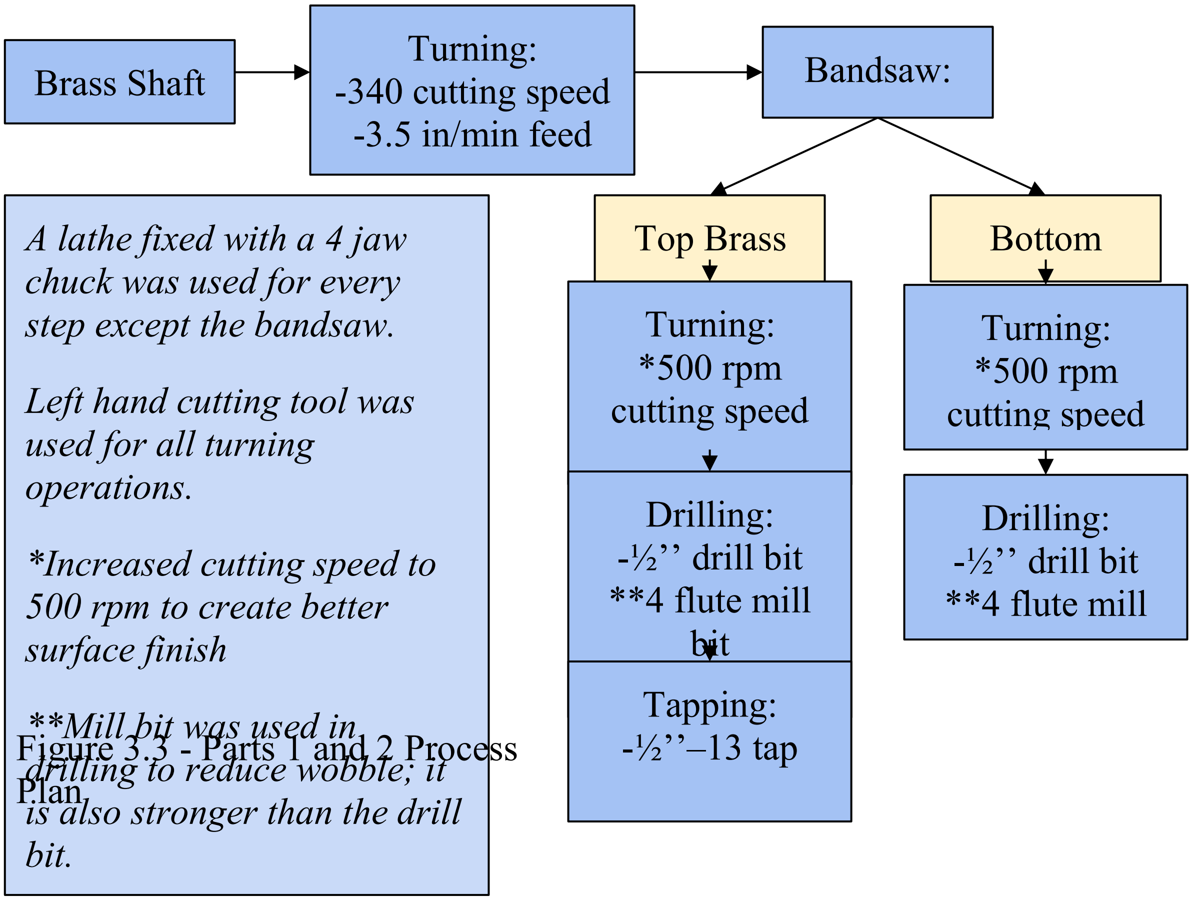
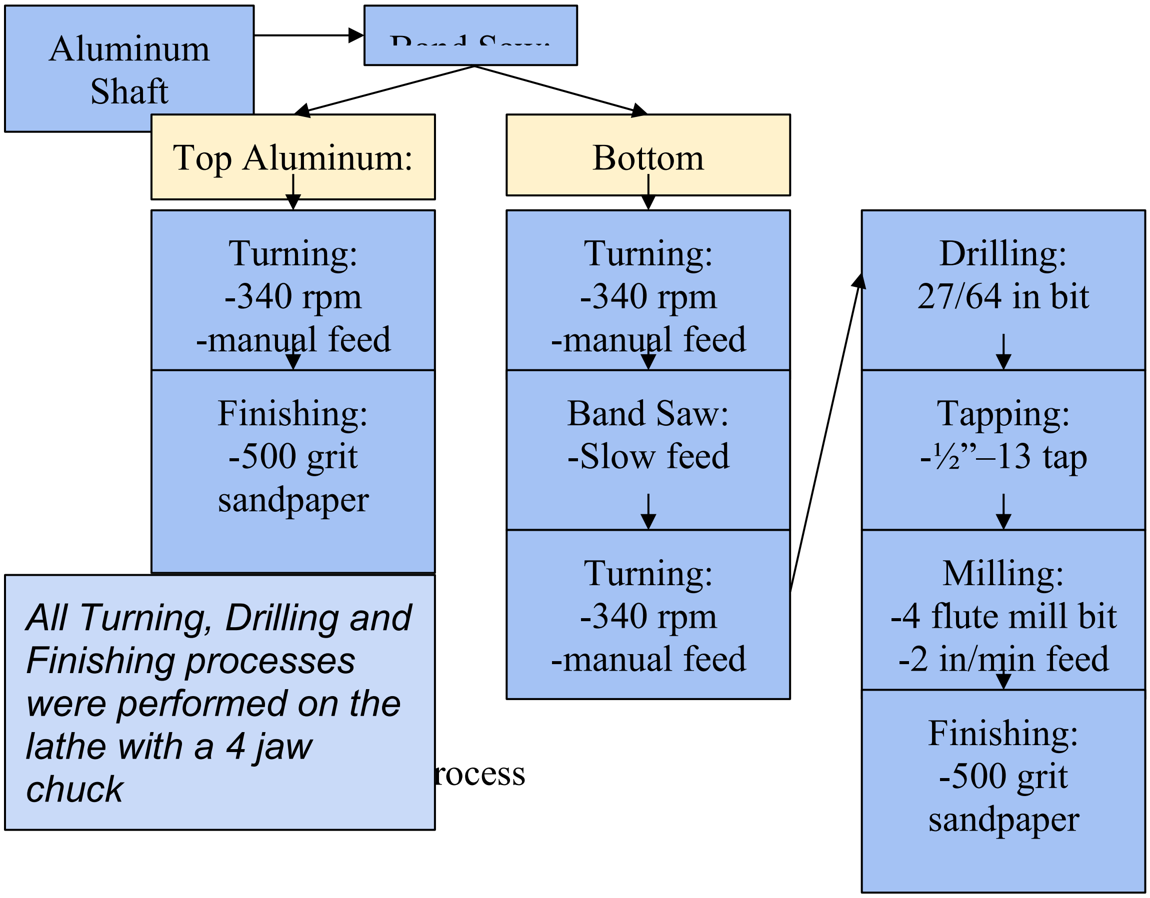


Figure 3.3 - Parts 1 and 2 Process Plan



rocess

IV. Implementation of Manufacturing Process Plan and Discussions

IV.1 Implementation

Top Brass Section

was first cut down using a band saw. The component was then turned at 340 RPM (Fig. 4.1). It was cut into shape using programmed turning. The program used 7 steps and 45 passes to complete the cut. After the piece was finished turning, it was first drilled about one inch in depth using a small diameter center drill bit on the lathe. A 27/64 inch diameter drill bit was then used to widen the hole to our final dimension. After this was done, a ½” - 13 tap was attached to the tailstock of the lathe and manually turned, making the needed thread cuts for the internal connecting rod to connect to.

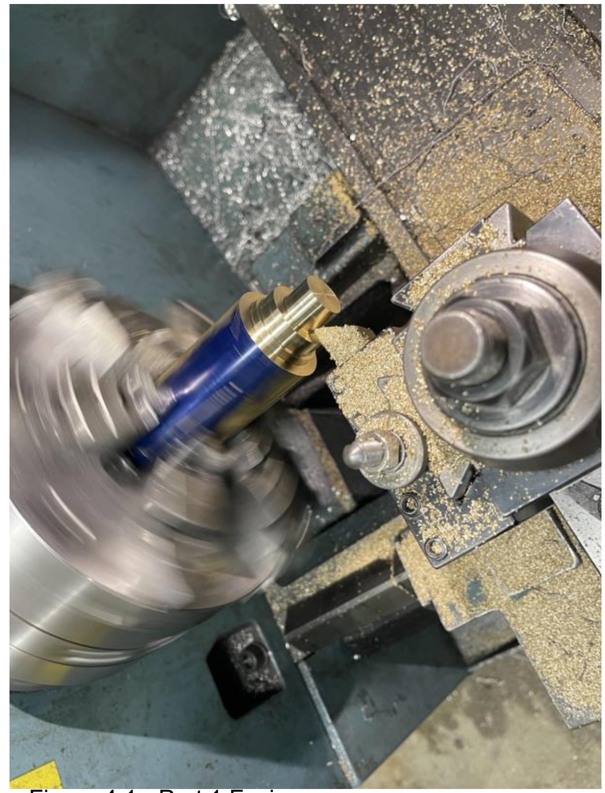


Figure 4.1 - Part 1 Facing

Bottom Brass Section

The bottom brass section was machined using the same method, it was also cut by a band saw and programmed manually using 9 steps and 45 passes (Figure 4.2 and 4.3), and turned at 340 RPM. After finishing, a small diameter through hole was drilled using a centering bit. Using a 0.5 inch diameter drill bit, the hole was widened to its final dimensions.

The Delron Section

The Delrin section was cut roughly to size on the bandsaw first. Then it was taken to the lathe where it was turned at 185 rpm. The grooves are all at different spacings. They were made manually on the lathe. The distance between each step could be monitored using the readout on the lathe to determine the position of each groove. A specially angled carbide-tip cutting tool was used to make the desired grooves. Once the Grooves were made the ends were faced on the lathe to make sure the surface was flat.

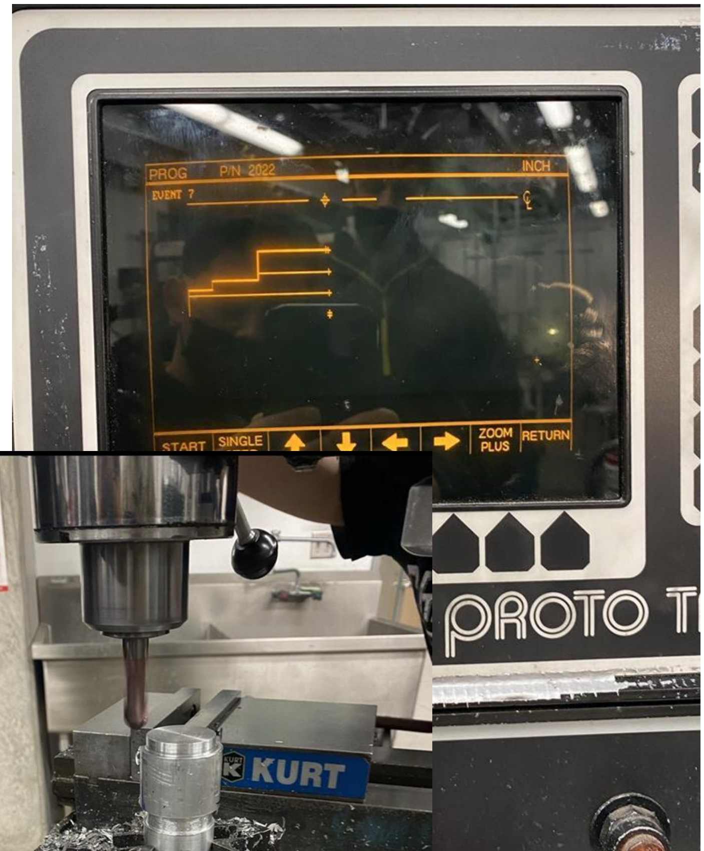


Figure 4.3 - Part 3 After Bandsaw

Figure 4.4 - Part 5 Milling

Top Aluminum Section

The top aluminium section was first cut down to size with a band saw (Fig 4.4). The top aluminum section was then turned at 340 RPM manually. A channeling tool was used to cut down the component to the desired dimensions. The chamfered end was cut to the desired length and diameter. (Figure 4.4)

Bottom Aluminum Section

The bottom aluminum section was cut to roughly the desired length. The section was turned down on the lathe at 340 rpm to cut the upper portion to the desired width. The bottom section was turned down to the outer diameter of the grooves. The piece was then taken to be milled. It was clamped down and a program was set to make six equally spaced grooves on the bottom portion of the piece (Fig. 4.5). The grooves and their insides were sanded down using 500, then 1500 grit sandpaper. Each side was then faced to make a flat surface with good surface finish. The section was then put back onto the lathe to be tapped. A 27/64 inch hole was drilled one inch deep into the workpiece. Then a ½ “-13 tap was used to make the threads.

Internal Rod

The *internal rod* is a ½ inch diameter rod that was cut down to rough dimensions using the horizontal bandsaw. Once cut, the rod was chucked into the lathe at 340 RPM in order to face both ends to their final dimensions. The ½“ - 13 thread was then programmed into the lathe (Figure 4.6), and using the thread cutting bit, we took off material bit by bit until the threading fit snugly into the internal threads of either end piece (Figure 4.7). We predicted that we would have tolerancing issues which would arise with inserting a ½ “ rod into a ½ “ hole. Upon test assembly, we discovered that the rod either did not fit or that it was an extremely tight squeeze. In order to resolve this problem, the internal components(bottom brass section, delrin grip, top aluminums section) were renamed to be slightly larger allowing for the internal rod to slide easily inside the other components.

Figure 4.5 - Threading Program

Figure 4.6 - Part 6 External Threading

IV.2 Manufacturability

There were machining issues with both the machining tool and cutting program. When drilling the brass components, a 4 flute, ½ inch diameter milling bit was required because of excessive chatter when using a standard ½ inch drill bit. We did this because the milling bit was sturdier and shorter than the drill bit which reduced the chatter greatly. There was also difficulty in writing the turning program for the top brass component because we initially tried to write the program as a linear function instead of a step function. This resulted in us inputting only half of the required coordinates needed for our part, however, no material was wasted as the program simulation displayed what the final product would look like which we immediately recognized was wrong.

IV.3 Tolerancing

Three of the components had tolerancing issues. The bottom brass and top aluminum sections needed to be reamed in order to slide onto the internal rod, indicating the bottom brass and top aluminum inside diameters were undercut. Also, The threads on the internal rod had to be run through the thread cutting program several several times in order for it to screw into the bottom aluminium and top brass components.

IV.4 Division of labor

Table 4.1: Division of Labor							
	Part 1	Part 2	Part 3	Part 4	Part 5	Part 6	Presentation Slides
Liam Colvin	x	x		x	x		10 to 13, 17
Ben Elwell	x			x	x	x	1 to 5, 17
Omar Hassan	x	x	x			x	6 to 9, 17

Nick Karlsson			x	x	x	x	14-16, 17

IV.5 Lessons Learned from teamwork

We learned that teamwork is essential to the quality, the ease of manufacturing, and the timely completion of the product at hand. A lesson in teamwork that we took is that every person is more comfortable working in their preferred set of units. For example, we initially modeled our lightsaber in CAD using millimeters only to find out that Bill heavily prefers units to be in inches. For bill, inches is what he has been accustomed to for many years so in order for him to assist us we had to convert our units to inches which led us to a second lesson in teamwork. The second lesson is to have groupmates double and triple check dimensions before, during, and after machining. We had a couple instances where millimeters were converted incorrectly, therefore creating mistakes in parts that were often realized the next day. This slowed down progress and could have been fixed by a simple double check from one of the group members.

V. Conclusions and Recommendations

The project was very successful. There were relatively few issues throughout the manufacturing process. The design plan was followed accurately which led to a smooth process, and a quality final product. Despite this, the project did have several shortcomings. There are a few overlooked burrs on some of the edges, and the surface finish on some of the uneven surfaces is only as good as we could get it with the given tools. The center hole through one of the pieces is slightly off and a piece of the delron section is slightly off. Nevertheless, the product turned out very good, and our group is satisfied with the results.

After completing this project, several things were learned for if we were to do it again. The machine shop gets very busy towards the end of the semester, and the deadline for the project comes much quicker than expected, so it is recommended to start early. Having a clear plan is important before going into the shop, since much time can be wasted if you are making your decisions in the shop. The help in the shop is also limited, so it is best to get there before other groups so your project can get done in a timely manner. Other than that the project went relatively smoothly.

If this project had a larger time frame, there are several things that would be done to improve this project. Primarily, one piece of the design had to be excluded due to time considerations. We would have made this piece and attached it to the top aluminum section using screws from McMaster Carr. Furthermore, the fins on the bottom section had to be simplified due to time considerations. This piece could have been made in the professional shop to our original design if more time was given. Also more time would have been taken to craft each piece perfectly, limiting any imperfections. Finally, the surface finish could be improved given more time.

VI. References

Kalpakjian, S., Schmid, S. R., SI Conversion by Musa, H (2009) *Manufacturing Engineering and Technology,* Sixth Edition in SI Units, Prentice-Hall, Inc.

VII. Appendices

Appendix A:

MAE 3192: Manufacturing Process and Systems Project Proposal

Professor Shen

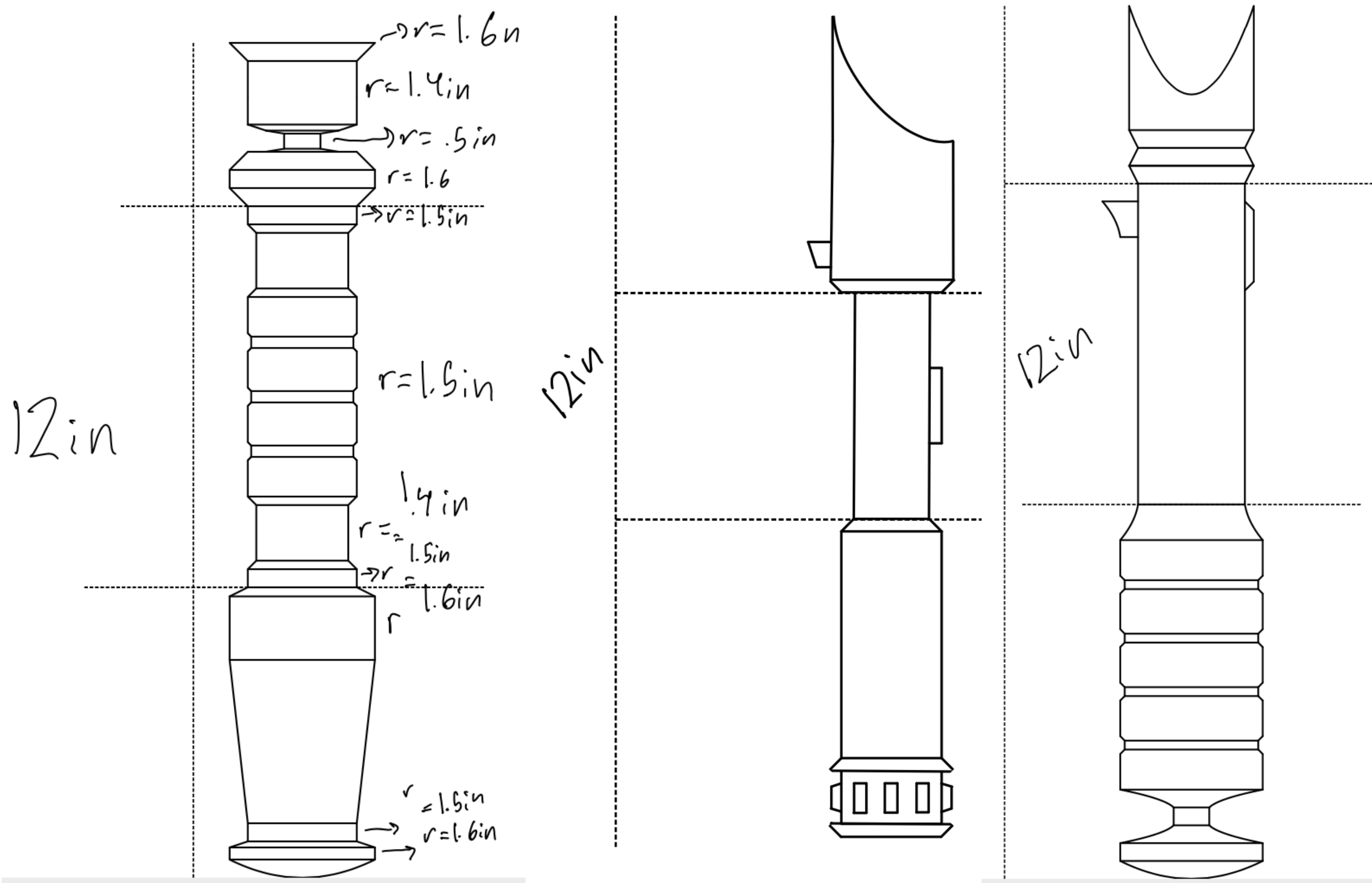
23 September 2021

Model Lightsaber

Team Members:
Liam Colvin
Benjamin Elwell
Omar Hassan
Nick Karlsson

Project Description:

Three to four piece model lightsaber constructed with brass, aluminium, and possibly black delrin. The pieces will be connected using male and female threaded adaptors allowing for easy breakdown as well as giving us the ability to connect multiple materials into one streamline piece. The techniques we expect to employ on this project include turning, milling, drilling/boring, and threading/tapping. Below are some rough sketches of some of our lightsaber designs, however, there are pre-made 3-D CAD models available for download such as the one linked below which could be useful.



Timeline to complete project:
Week of 9/19: Write project proposal
Week of 9/26: Get materials, finalize design, and create manufacturing process plan
Week of 10/3: Start machining.
Week of 10/10: Continue machining.
Week of 10/17: Finalize machining.
Week of 10/24: Have completed Model Lightsaber, continue working on powerpoint.
Week of 10/31:Compile pictures and notebooks for powerpoint presentation and report
Week of 11/7: Product is due. Work on powerpoint.
Week of 11/14: Finish powerpoint and presentation; due 11/18
Week of 11/21: Work on and finalize project write up and presentation.

Week of 11/28: Practice presentation

Resources:

https://grabcad.com/library/obi-wan-s-lightsaber-2