Carbon Fiber E36 T56 Transmission Mount

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by

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ABSTRACT

As a graduating student in the College of Engineering and Applied Science at the University of Cincinnati it is required that all seniors must pass senior design. The main purpose of senior design is to take what is learned in the classroom and during co-op and apply it to an approved project. Every student has the choice of choosing their own project or they have the ability to choose a project that is provided by the University. Each project must be vetted then either approved or denied by the faculty of CEAS. After consulting Dean Arthur, I decided that I would engineer, design, test, and manufacture a carbon fiber transmission mount for my senior design project.

I reached out to Cincinnati Super Cars during my project and they were gracious with their time, talent, and treasure. Chris Hundley the owner of Cincinnati Super Cars who assisted and taught me is an expert at making carbon fiber parts for cars such as Ferrari, Lamborghini, and McLaren.

This project would test my engineering skills and confidence. I have zero experience manipulating and producing carbon fiber parts. With Chris Hundley's help I was able to gain a better understanding of the Layup process of carbon fiber. I was also responsible for developing a schedule, budget, design, and analysis.

SPECIAL THANKS

I wanted to give a special thanks to Cincinnati Super Cars. If it wasn't for Chris Hundley and his wife Cassidy's time and effort, this project wouldn't have turned out the way that it did. Chris was able to teach me a lot about the carbon fiber process with his 11 years of experience. I couldn't have asked for a better partner to work with!

**There are somethings that cannot be mentioned in the following document since it is proprietary to the dealership.*

PROBLEM DEFINITION AND RESEARCH

PROBLEM STATEMENT

Now a day's car manufactures produce many vehicles and configurations. With new vehicles being produced every day, aftermarket parts and ideas are being engineered to improve the overall performance, aesthetics, and cost [4]. Looking specifically at the 1995 BMW M3 there is a wide range of changes and add-on's.

I am personally LS swapping my 95' BMW M3. A T56 transmission will be used to transfer the engines power to the driveshaft and rear wheels of the vehicle [1]. The two main purposes of a transmission mount are to:

- Hold and support powertrain
- Isolate vibrations

I choose to look into making a transmission mount that is not currently on the market. The senior design project that I choose has a specific application to any BMW E36 (1990 - 2000) with a T56 transmission. Ultimately, the goal of my senior design project is to design and manufacture a transmission mount that is 20% lighter & 20% cheaper than the state of the art.

RESEARCH

SCOPE OF THE PROBLEM

Over the years, many people are taking their RWD E36 BMWs and adding serious power by dropping LS Chevrolet engines in them. For the BMW to get the power to the ground there must be a transmission and in this certain application it will be a T56 transmission. The T56 is one of the more common transmissions for the LS application. With this custom swap,

there must be a cross member in order to hold the transmission in place. After doing my research, I found that the state of the art transmission mounts for this specific application are big/bulky and made out of materials such as aluminum and steel.

The reasons that this project is needed are:

CURRENT STATE OF THE ART

There are a few transmission brackets made for this application. One in particular is made by a company called Vorshlag Motorsports and Dallas Performance. The Figure 1.1 below is a Cross-member kit that cost $390.36 and weighs 5.0 lbs [2]. The kit includes: Transmission Mount, Polyurethane transmission bushing, M10 bolts, and washers [2].

Figure 1.1. Vorshlag Motorsports E36 T56 Transmission Mount

Powder-coated Steel

Pros

- Finish is more durable than paint
- Easy to weld
- Cheap
- Recyclable
- Formability

Cons

- Powder coating is bad for the environment
- Can become brittle
- Steel is corrosive

Another company that makes the transmission mount is Cxracing. The material that is used is 7-gauge stainless steel and costs $251.42. I was unable to find a weight for this mount.

Figure 1.2. below is the mount Cxracing offers.

Figure 1.2. Cxracing E36 T56 Transmission Mount

Stainless Steel

Pros

- Silvery finish
- Highly durable
- High tensile strength
- Corrosion resistant
- Fatigue resistance
- Safety & crash worthiness

Cons

- High cost
- Difficult to weld
- High cost of polishing & finishing

END USER

- Want a cross member that is durable and reliable.
- Has a BMW E36.
- Age range: Any age.
- Want a cost-efficient cross member.

CONCLUSIONS AND SUMMARY OF RESEARCH

Carbon Fiber

Pros

- High tensile strength
- High stiffness
- Low weight to strength ratio
- High chemical resistance
- Temperature tolerant
- Low thermal expansion
- 4x stronger than steel

Cons

- Long production time
- Expensive $$$
- Repairs & replacements are expensive

After careful examining of the competition, I believe making a carbon fiber transmission mount would be the best way to get the cost and weight 20% lower than the competition [3].

With carbon fiber having such a high tensile strength and stiffness the only variable that I would be worried about is the heat from the transmission. While looking up the max temperature of the transmission I found that it would not exceed 250°F which will not affect the carbon fiber. Lastly, understanding the competition, customer needs, and requirements will allow me to succeed at this design project.

CUSTOMER FEATURES

- A sturdy well engineered mount that reduces vibration & noises
- Longevity
- Light weight
- Cost Effective

PRODUCT OBJECTIVES

Efficiency & Load Capacity

- Quick disconnects
- Large carrying capacity
- Minimum moving parts
- Nice Finish
- Easy access for maintenance
- Overall Size
- Good fitment

QUALITY FUNCTION DEPLOYMENT

Engineering Requirements (units)

	Customer Requirements	**Importance wt.**	Hold weight (lb)	Cost $	Cross member weight (lb)	Roughness (micro in.)	Length (in)	Noise (db)									**Customer Satisfaction Rating** (0.00 - 1.00)			
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	CP	A	B	C
1	High Durability	0.20	3		3		3	3												
2	Protects Transmission	0.05	9			1														
3	Smooth Finish	0.05				9														
4	To Produce Little Noise	0.10						9												
5	Overall Size	0.20			9		9													
6	Reliable and Safe Performance	0.30	9	1	1		1													
7	Large Carrying Capacity	0.10	9		3															
8																				
9																				
10																				
	Total Importance	1.00																		
	Engineering requirement importance		4.7	0.3	3	0.5	2.7	1.5												

DESIGN

DESIGN DESCRIPTION

After researching the state of the art, I decided to make 3 different designs on solid works to try and make something similar. A problem that I ran into is that I kept thinking about designing something that was made out of metal and not carbon fiber. Once I changed my mindset I was able to make something that would resemble and compliment carbon fiber. Design number 4 is the mount that I decided to proceed with.

DESIGN ALTERNATIVES AND SELECTION

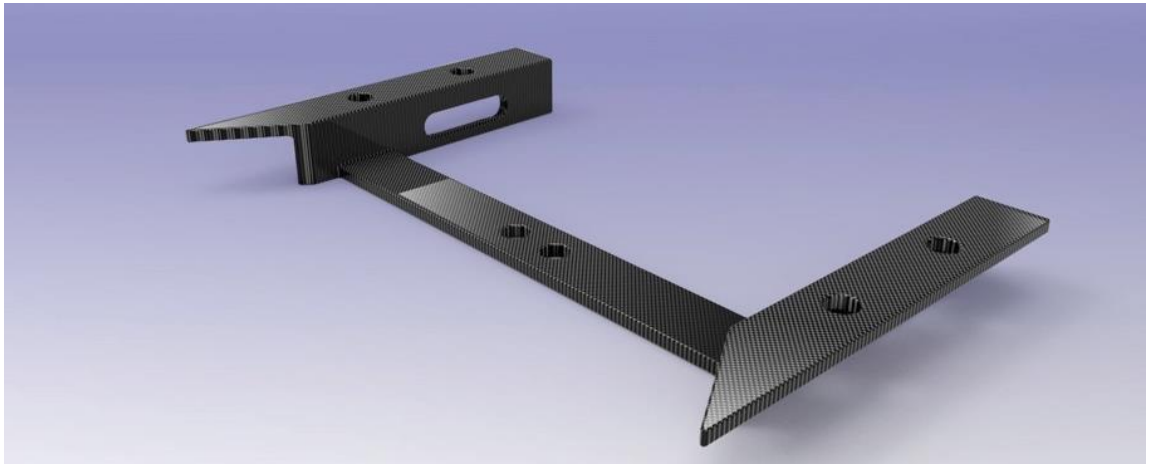


Figure 1.3. First Design of Transmission Mount

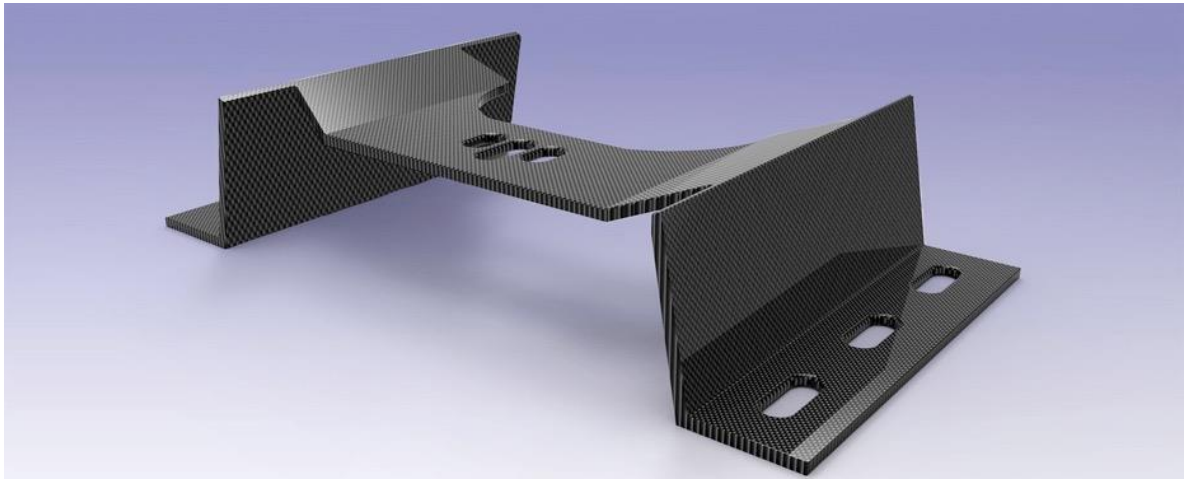


Figure 1.4. Second Design of Transmission Mount

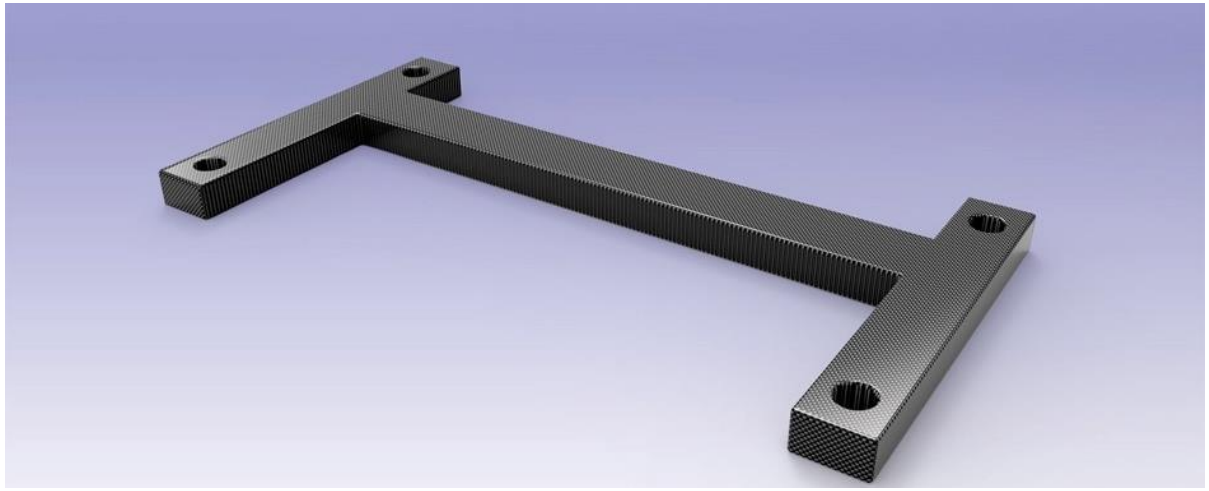


Figure 1.5. Third Design of Transmission Mount

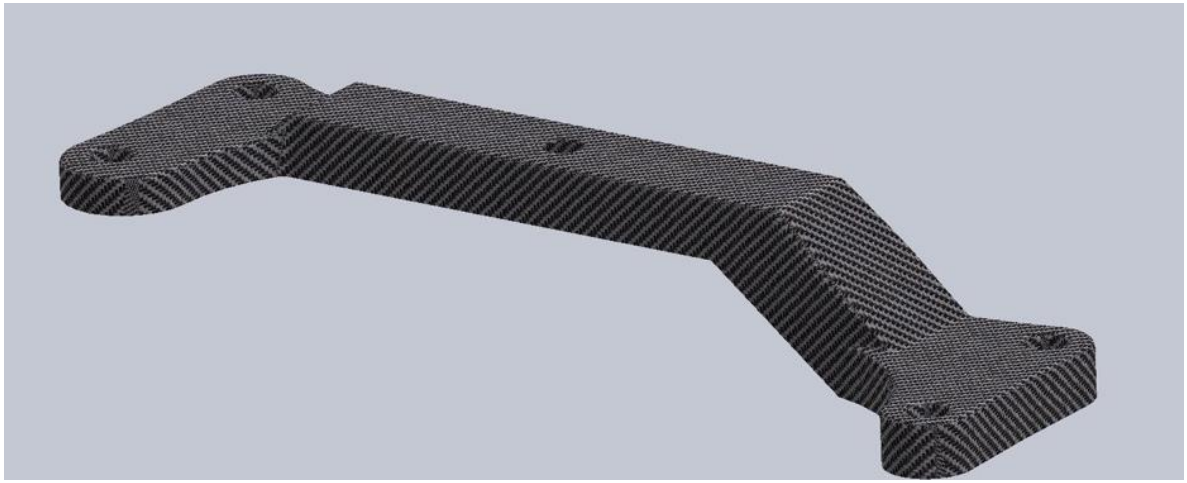


Figure 1.6. Final Design of Transmission Mount

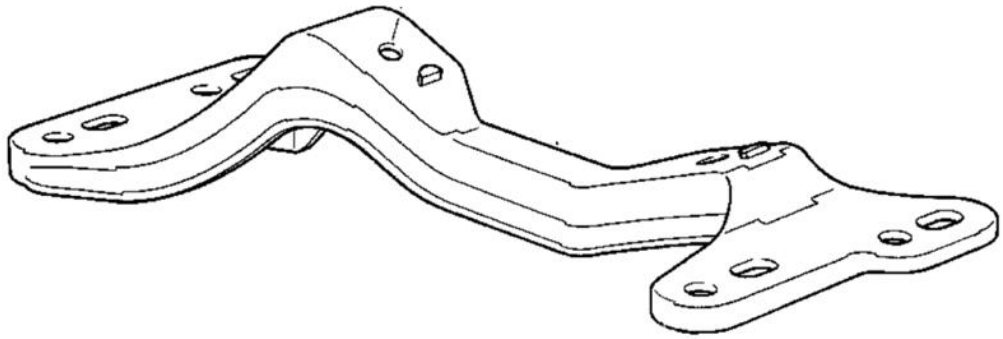


Figure 1.7. Original Automatic E36 Transmission Mount

Figure 1.8. Original Automatic E36 Transmission Mount Installed

Figure 1.9. Deciding Necessary Features

Figure 1.10. Piece used to make plug

Figure 1.11. Plug vs. New Carbon Fiber Part

LOADING CONDITIONS

In order to calculate the loading conditions, I needed to first figure out the amount of weight that the transmission mount holds. I jacked up the transmission to the desired location. Next, I grabbed a scale that would give me the read out of the amount of weight necessary at that specific point to hold the transmission. Then I put a bottle jack on top of the scale. A (4x6) block was placed on top of the bottle jack to get the correct spacing necessary. Lastly, I lowered the heavy-duty service jack which allowed the weight of the transmission to give me a read out on the scale. The readout on the scale was 107.0 lbs. I knew that I needed to subtract the amount of weight that the bottle jack and 4x6 block weighed which was 22.0 lbs. This left the me with a total weight of 85 lbs. acting on the transmission mount during a static state.

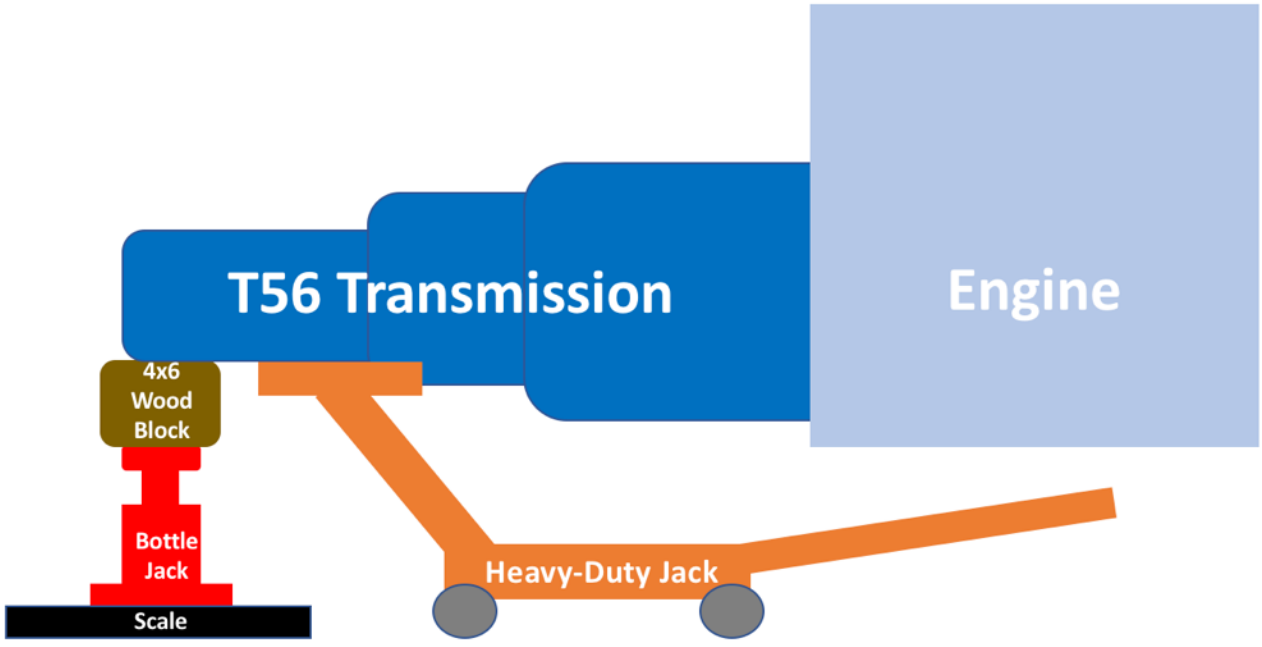


Figure 1.12. Representation of the setup explained above

Next, I had to develop a Free Body Diagram to understand the forces acting on the transmission mount.

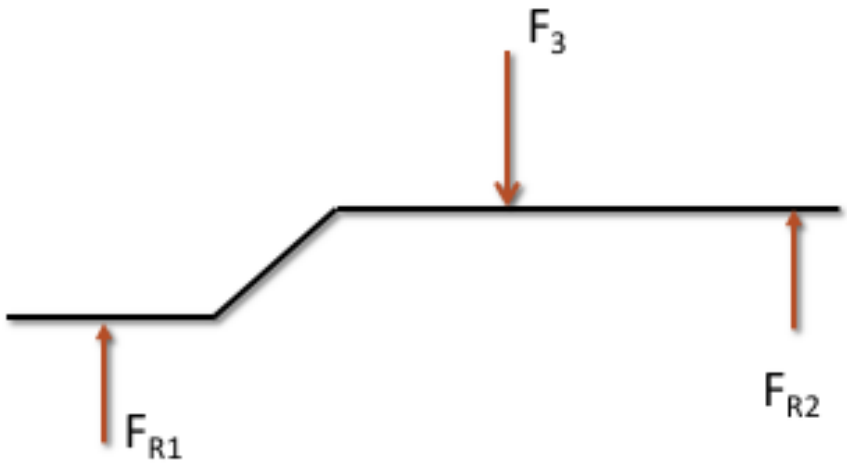


Figure 1.13. Free Body Diagram of Transmission Mount

Static Calculations

$F_3 = F_g = m * g$

$F_3 = F_g = 38.55kg * 9.81\frac{m}{s^2} = 378.23N$

$Distance\ from\ F_{R1}\ to\ F_3 = 0.219m$
$Distance\ from\ F_{R2}\ to\ F_3 = 0.155m$

$\sum M_{F_{R2}} = 0 = F_3 * (0.219m) - F_{R2} * (0.155m)$
$\sum M_{F_{R2}} = 0 = 378.23N * (0.219m) - F_{R2} * (0.155m)$

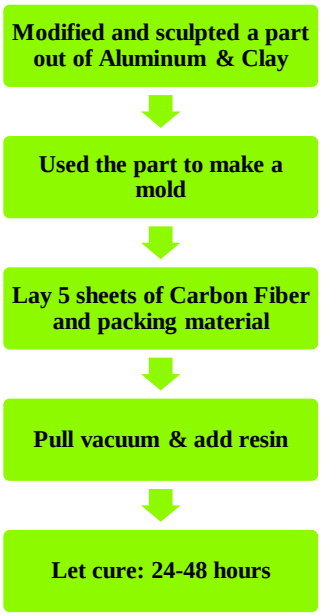
$F_{R2} = 221.5N$

$\sum F_y = 0 = F_{R1_y} + F_{R2_y} - F_{3_y}$

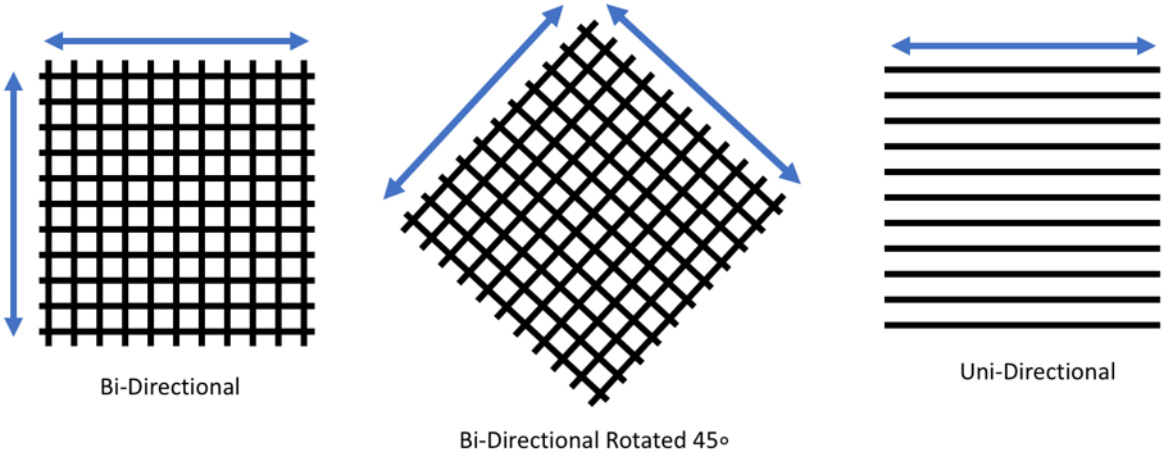
$\sum F_y = 0 = F_{R1_y} + 221.5N - 378.23N$
$F_{R1} = 156.7N$

PROCESS

The process consisted of the following:



**Process and Materials used are Proprietary to the Dealership that helped with this project.*



Understanding the different types of weave patterns was very interesting. When choosing what would be the strongest weave pattern for each layer, Chris the expert decided the order would be: Bi-Directional, Uni-Directional, Bi-Directional Rotated 45°, Uni-Directional, and lastly Bi-Directional. The blue arrows denote the strength of the strands. Carbon fiber is very strong in tension and compression.

TESTING

For testing purposes, I decided to make a wooden jig to mount the carbon fiber transmission mount to. After constructing the jig, I began to apply weights to the top piece of the wood to see if there was deflection in the transmission mount. There was a tape measure extended in the vertical position to measure deflection. The carbon fiber mount held an astonishing 430 lbs. I decided at that point that it was sufficient enough to remove the weight since that would be 4.25 times the weight necessary to hold the transmission in a static environment.

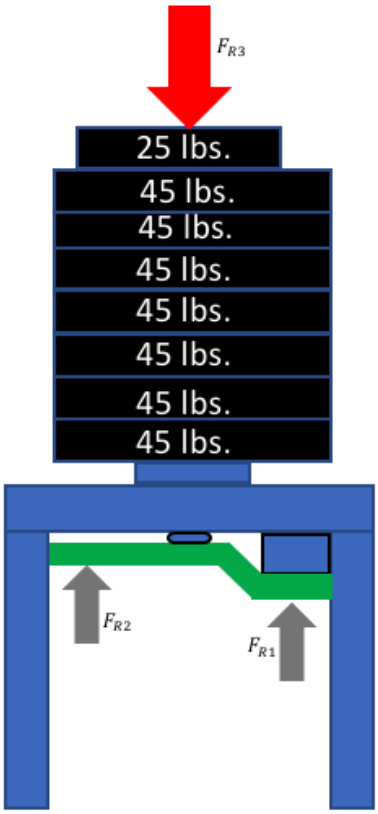


Figure 1.14. Pictorial representation of explanation above

MANUFACTURING AND SALES

After making four carbon fiber transmission mounts would we be at 20% cheaper than the state of the art. The reason we decided on four parts is because we needed to make sure the mold which is the most expensive process is paid for before we can make a profit. Chris thinks that the current mold that I made could yield roughly 50-75 parts. With this being said we would do a limited run of 20 parts to see how the customers respond. This particular application has a very small market but could be profitable. With this being the graph below represents our price vs the competition after four parts.

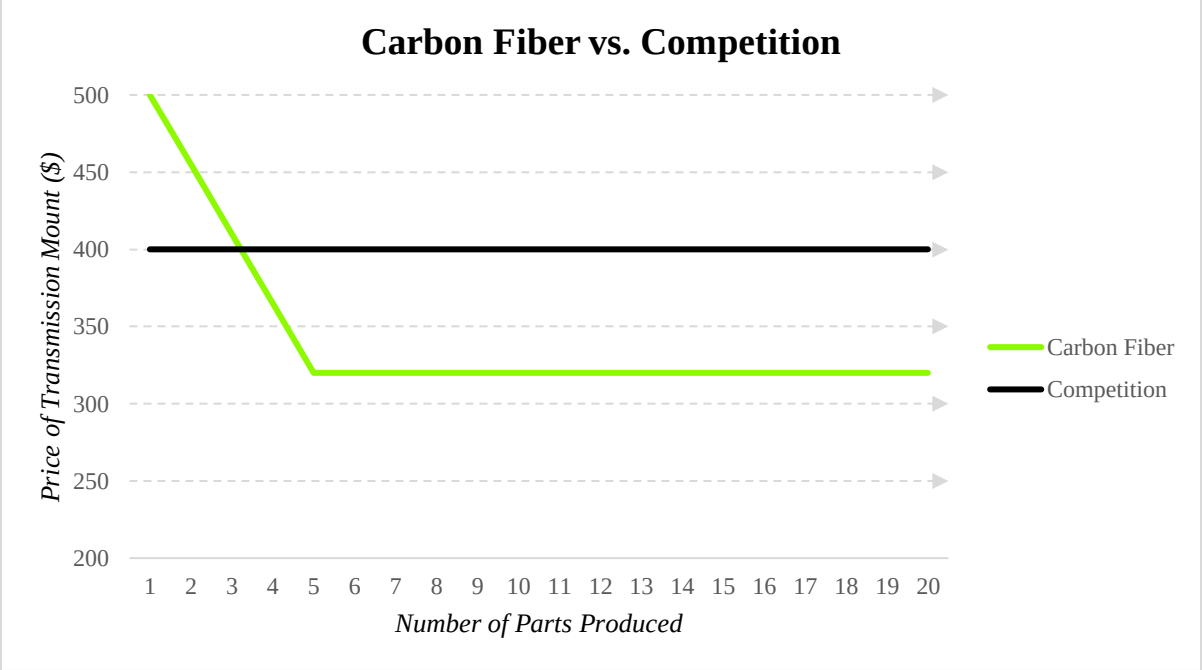


Figure 1.15. Carbon Fiber vs Competition

PROJECT MANAGEMENT

BUDGET, PROPOSED/ACTUAL

Proposed budget: $400 without adding my time involved.
**All materials used in the process of making the part are proprietary to the dealership*

Item Required	*Proposed*	*Actual*
Carbon Fiber	$200	$100
All Other Material	$200	$350
Time	21 Days x 8 hrs. x $20 = $3,360	7 Days x 8 hrs. x $20 = $1,120
Total	$3,760	$1,570

Table 1.1. Proposed Budget vs. Actual Budget

SCHEDULE, PROPOSED /ACTUAL

Figure 1.16. Tentative schedule & duration for each task

CONCLUSION

Overall, I was extremely pleased with the way this project turned out. I was able to finish the carbon fiber transmission mount in the morning before the Tech expo. The reason for this is because of some material issues and time conflicts. After the curing process for the mount lasted 24-48 hours I was finally able to test it and was able to stack 430 lbs. on it. I know that mount could hold an additional 200 lbs. The reason I stopped adding weight is because the wood jig began to crack, and I did not want a catastrophic failure. In order to find out of the mount itself was lighter than the competition I took the carbon fiber mount and weighed it. It came it at an astonishing 143g. The competition weighs roughly 5 lbs. or 2267.96 g. That is a 93.7% in weight reduction! When it comes to the price of the carbon fiber transmission mount Chris and I agreed that we would need to sell at least 4 mounts before we could begin to sell them for 20% cheaper than the competition ($320). The thickness of the mount itself was also impressive, it was only 0.005 in. thick. Compared to the competition which is either 2in. steel tubing or 7-guage stainless.

Looking back at the project I would have changed a few things. First, I noticed after making the mold that the original part itself that is used to make the plug was not as smooth as it could have been. If I would have spent an additional 3 days on the original part and removed most of the imperfections it would have made the part smoother and stronger. Second, I would have reached out to Chris a lot earlier. I had no idea that he and his company was so close to the Cincinnati area. His help on this project was greatly appreciated and I was impressed by his experience and knowledge about carbon fiber. Third, I would have liked to have been able to incorporate a Solid Works FEA. I ran into numerous issues with Solid Works on this project. With this particular project and carbon fiber being orthotropic it is

extremely hard to get a true FEA. With only using 5 layers of carbon fiber I was not able to figure out how to do layer patterns in Solid Works the same as my part.

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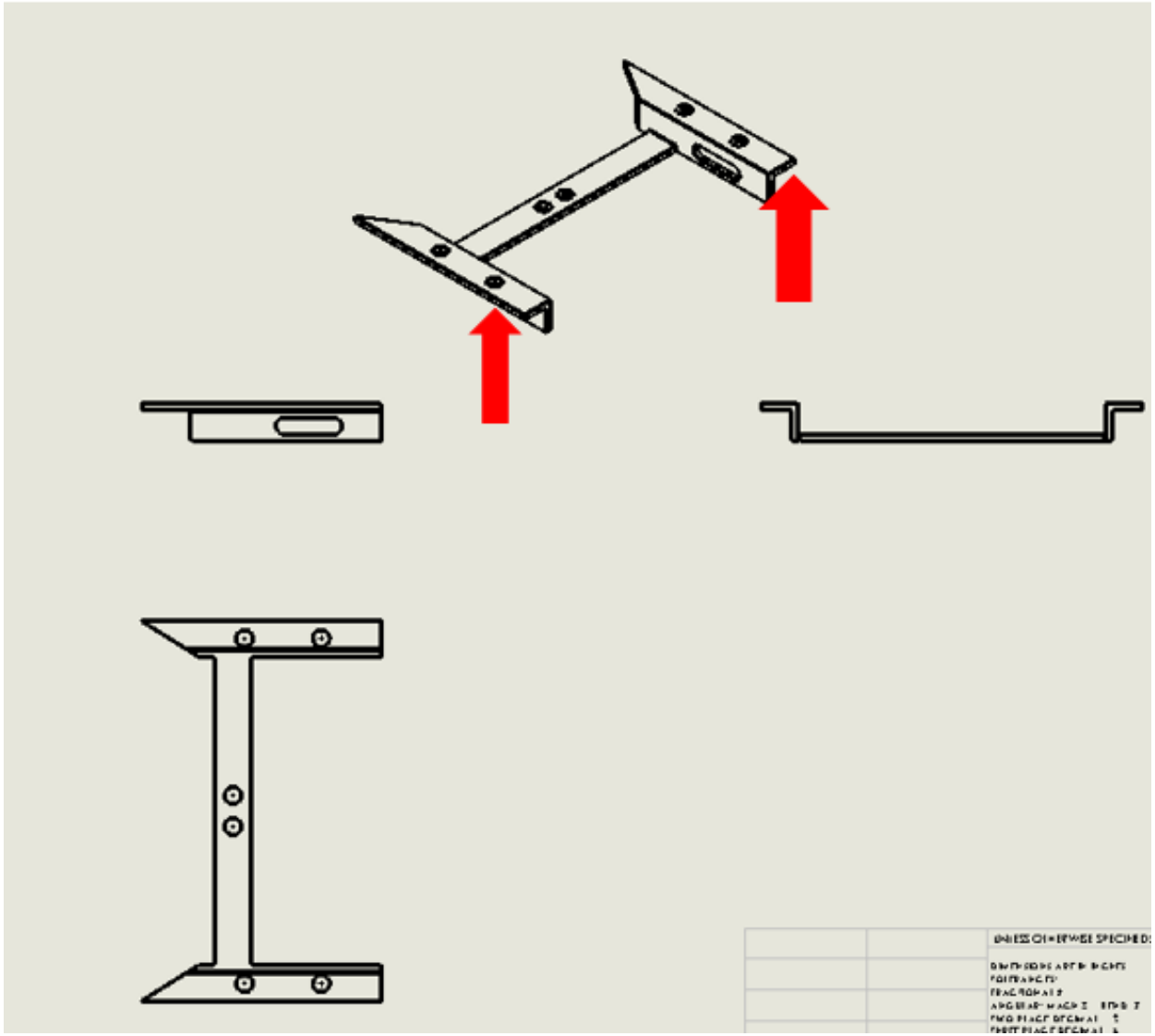
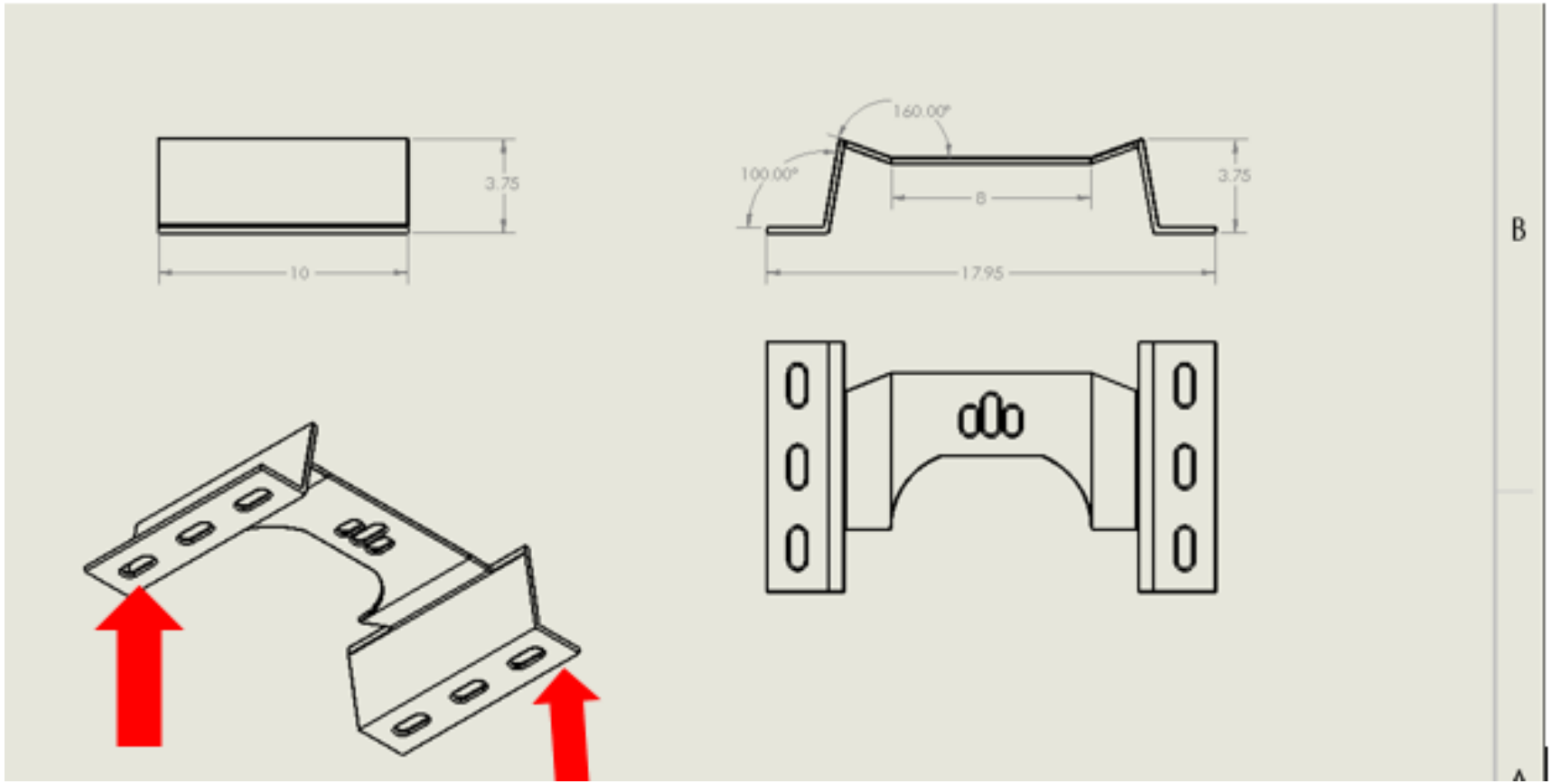
Your Bibliography: Schmidt, R. (2018). *Cars Made of Steel, Aluminum, or Carbon-Fiber: The Pros & Cons - Dent Goalie*. [online] [Accessed 30 Apr. 2018]. Dent Goalie. Available at: http://dentgoalie.com/manufacturing-comparison

[4] **In-text:** (Mueller, 2018)
Your Bibliography: Mueller, M. (2018). *Timeline: A Path to Lightweight Materials in Cars and Trucks*. [online] Energy.gov. [Accessed 30 Apr. 2018] Available at: https://www.energy.gov/eere/articles/timeline-path-lightweight-materials-cars-and-trucks

APPENDIX A – DRAWING FOR FIGURE 1.3.



APPENDIX B – DRAWING FOR FIGURE 1.4.



APPENDIX C – DRAWING FOR FIGURE 1.5.