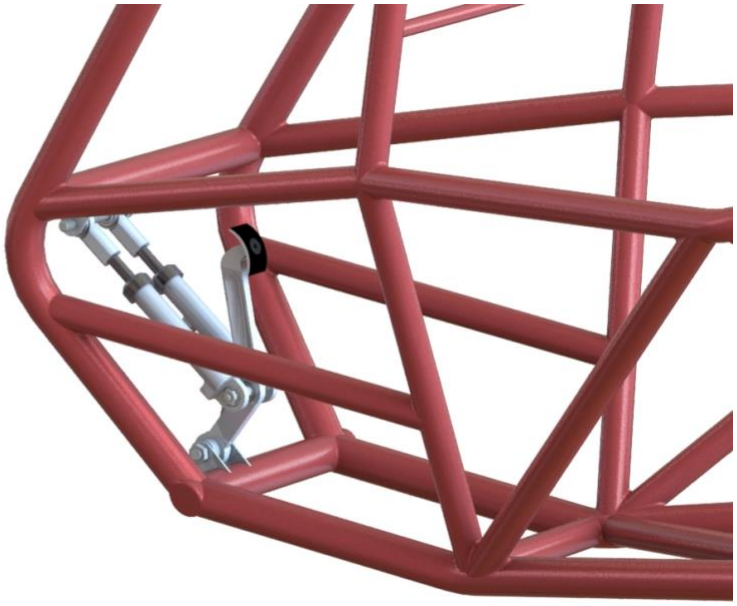
Pedal Bay Fall 2017 Tech Report

By Joaquin Jerez



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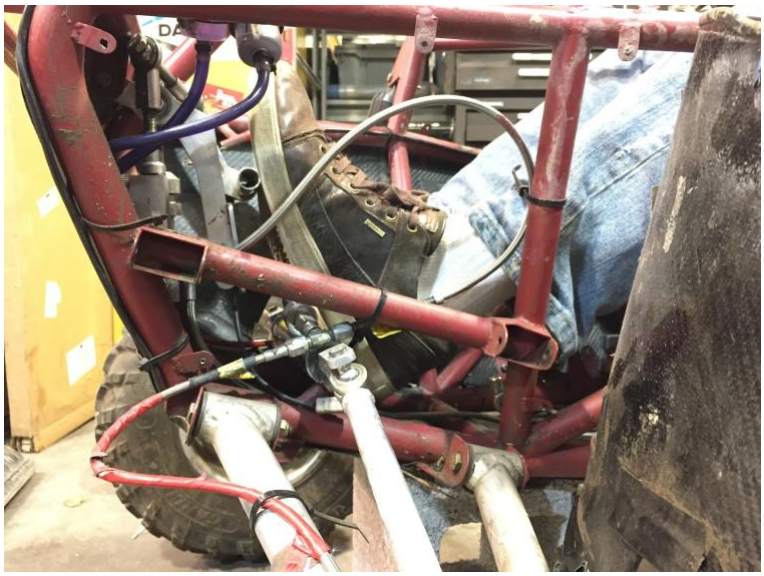
Overview

This semester I set out to design the pedal bay for M14. I wanted to create a pedal bay that wouldn't give the driver too much trouble when braking, while also being comfortable when the pedal is in its resting position. Thus, the pedal bay had to be both effective and ergonomic. The interesting part about the pedal bay, and the brake pedal in specific, is that it there are many different geometries that could work. This makes it difficult to choose which geometry is most effective in terms of what the driver is looking for. The driver did not have any complaints about the throttle pedal, so I decided to focus my efforts on the brake pedal and use the same throttle pedal from OD13.

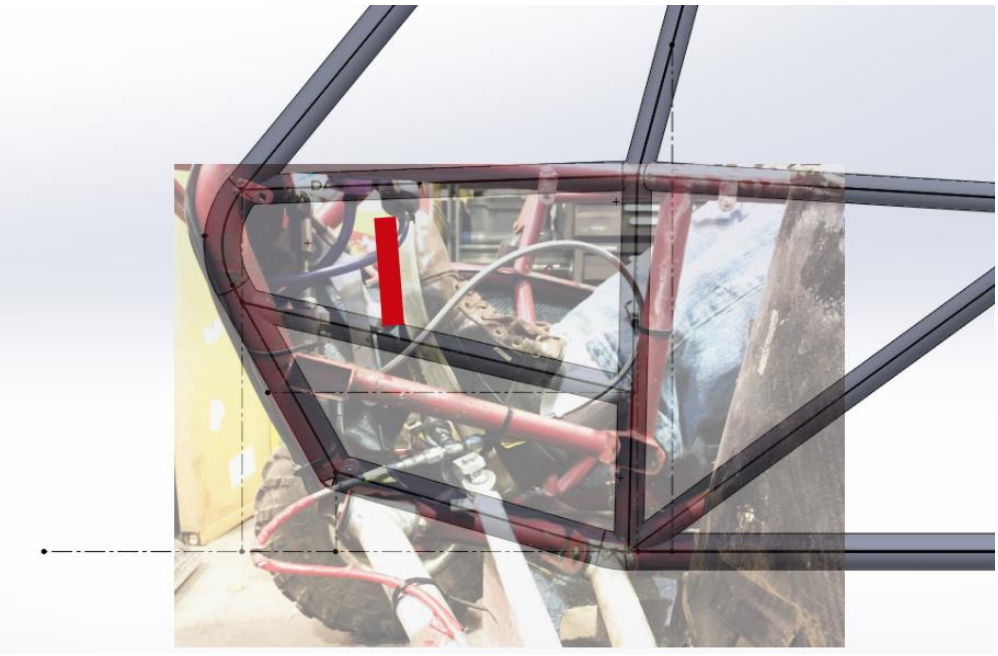
Design problems

I began my research by asking our main driver, Jake, what problems he encountered with last year's pedal bay, and pedals bays from the years before. His biggest issue was the pedal bay was not in a comfortable position when driving. He mentioned that he really needed to extend his heels to prevent himself from accidently pressing on the pedal. This gets very exhausting when driving the car for the endurance race, which is 4 hours long. He also complained about the poor mechanical advantage.

Pedal face location



I began by taking pictures of Jake in the car. First we took pictures of him using OD13's pedal bay. Then I disconnected the brake pedal and asked him to show me the position where he felt most comfortable driving (this is shown in the image to the right). I took three images of each and took the average position. I chose to use OD13's frame because it is the most like M14's frame. I took this image and superimposed it on the M14 frame CAD and then marked the position where his foot was in resting position. I took this value, which was around 4-5 inches off the top frame bar, and used this position as the pedal face location.



Mechanical Advantage

Last year we decided to try a top-mounted design for our pedal bay. This was a good idea for a variety of reasons. The flow of the pedal face is downwards because the pivot is mounted above. This seemed like a good idea considering the driver was sitting above the pedal bay. It also provided easier assembly with the masters. The biggest problem with the top mounted design is since our top bar is only an inch or two above the pedal face, it is hard to get a good mechanical advantage (can't make as big a lever arm). For this reason, I explored mostly bottom mounted designs, which allows for a much higher mechanical advantage.

Longer Masters

We drastically changed the design of our Master cylinders this year, which made them almost twice as long as they were last year. This provided some difficulty in finding the location and orientation of the masters with respect to the brake pedal.

Design Solutions

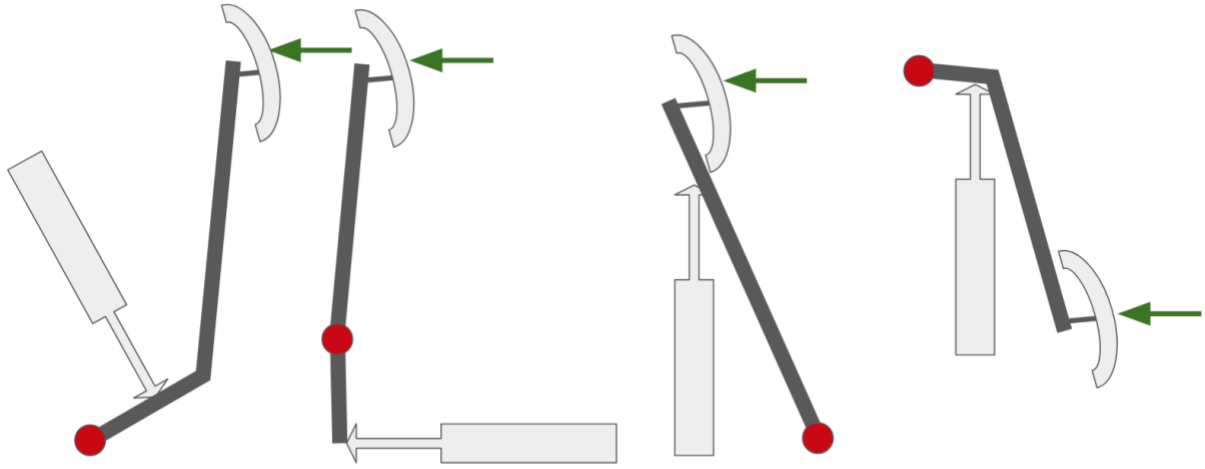
Balancing Mechanical Advantage and Ergonomics

When designing the brake pedal, there are a couple of tradeoffs that you need to consider. The brake pedal is essentially a lever, therefore by increasing your mechanical advantage, you are also increasing the pedals travel. This becomes an issue when attempting to find an optimal pedal placement. The more travel you have, the further back the resting position of the pedal

is. This is a big draw back because our car is very small, so the pedal face needs to be already very close to the front of the car.

Pedal Placement

I began by considering different geometries and evaluating their pros and cons.



These are the options that I considered. The red dot indicates where the pivot point is. The oddly shaped arrow is the master cylinder. The calculations for mechanical advantage are done by using the following equation:

$$(Green\ Arrow) \times (distance\ between\ pedal\ face\ and\ pivot) = (Master\ Arrow) \times (distance\ between\ master\ and\ pivot)$$

This is the calculation at full compression. I thought of what I thought the most important aspects of the brake pedal was, and rated each pedal based off those characteristics.

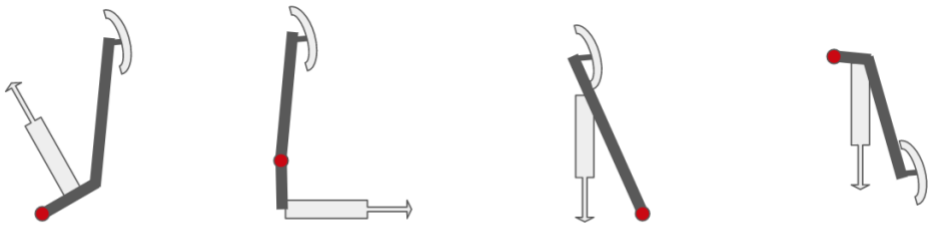
-Pedal Placement – Ergonomics of the pedal face

-Max Mechanical Advantage –Maximum mechanical advantage available

-Adjustability –How easy it is for a new driver to adjust the pedal

-Stroke Optimization –How much of the force you put in, goes into the pedal

-Integration –How well it integrates with the frame and the rest of the brake system

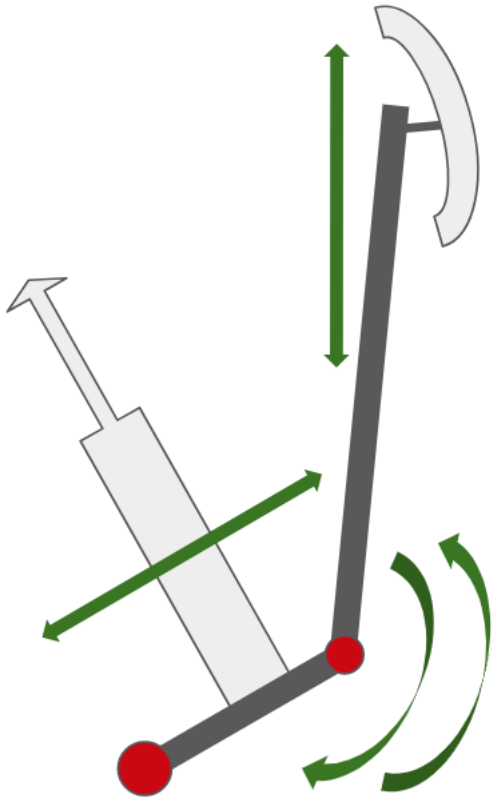


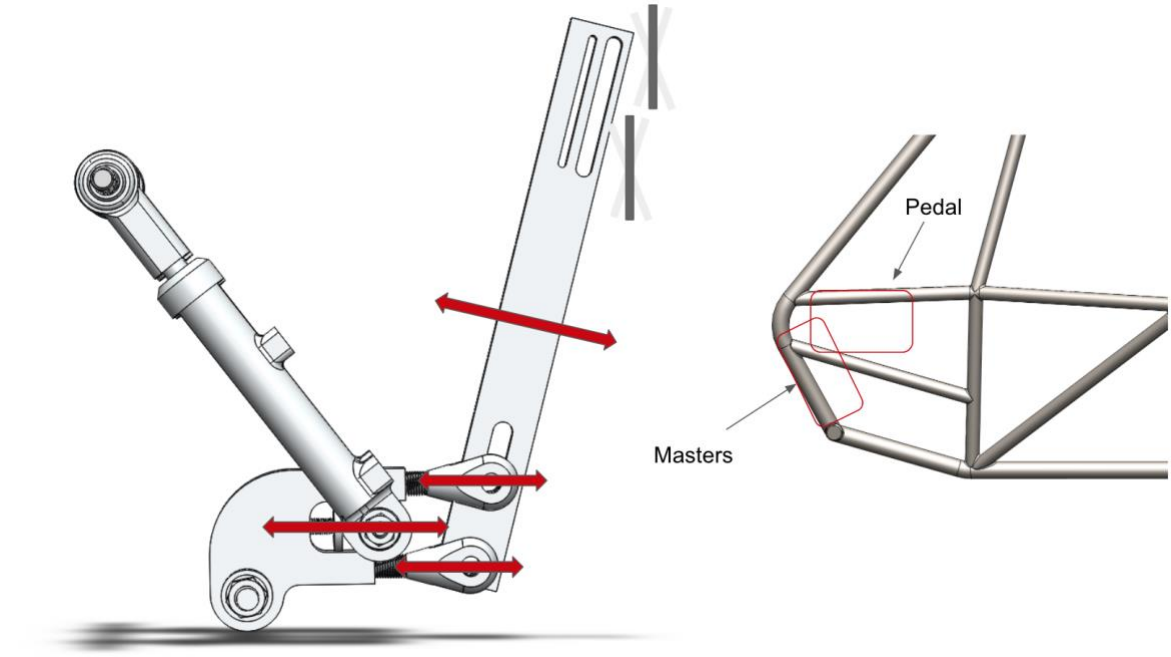
Option 1		Option 2		Option 3		Option 4	
Pros	Cons	Pros	Cons	Pros	Cons	Pros	Cons
+Pedal Placement +Max MA +Adjustability +Stroke Optimization +Integration		+Pedal Placement +Max MA +Adjustability +Stroke Optimization	-Integration	+Pedal Placement +Max MA +Adjustability +Integration	+Stroke Optimization	+Max MA +Adjustability +Stroke Optimization +Integration	+Pedal Placement

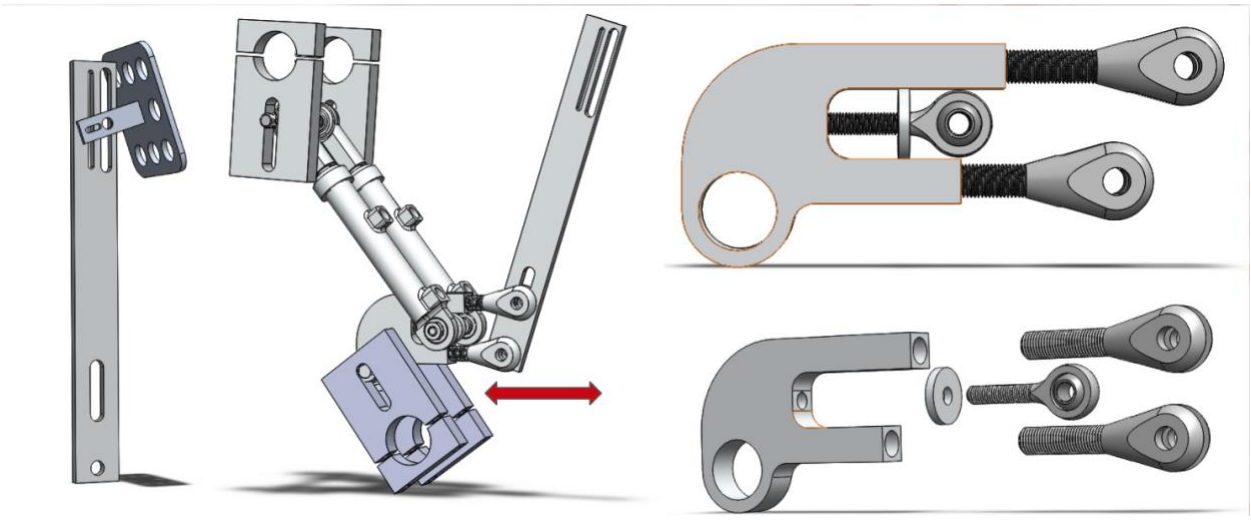
From my analysis, option 1 was the best option with these things considered. When considering the placement of the front frame bars, the first option made the most sense. The bottom frame bar where the pivot is mounted is closer to the driver, and the top frame bar where the master is mounted is further away. This brings our pedal bay much closer to the front of the car, thus maximizing our mechanical advantage without bringing the pedal face too close to the driver. The picture to the right is a CAD render of the final pedal bay, option 1.

ADJUSTABILITY

One of the aspects I worked on in the beginning of the semester was how to make the pedal adjustable. I came up with a couple solutions that would allow the pedal to be adjusted so a new driver, such as the acceleration driver who is much smaller, can comfortably press on the pedal. I came up with a couple solutions that would allow for this, but in the end, this made the pedal a lot heavier. I came up with a second idea which was to create a temporary fully adjustable pedal that will be used until we find the most comfortable position for the driver. Once we find that "sweet spot" we can manufacture a proper pedal with the same dimensions. The final pedal will not be adjustable, but it will be tailored to the endurance drivers comfort. Since the seat has some adjustability, the seat can be brought forward for our smaller acceleration drivers. The adjustable pedal bay can be modified as shown in the diagram to the right. On the next page you can see a CAD of the adjustable brake pedal:



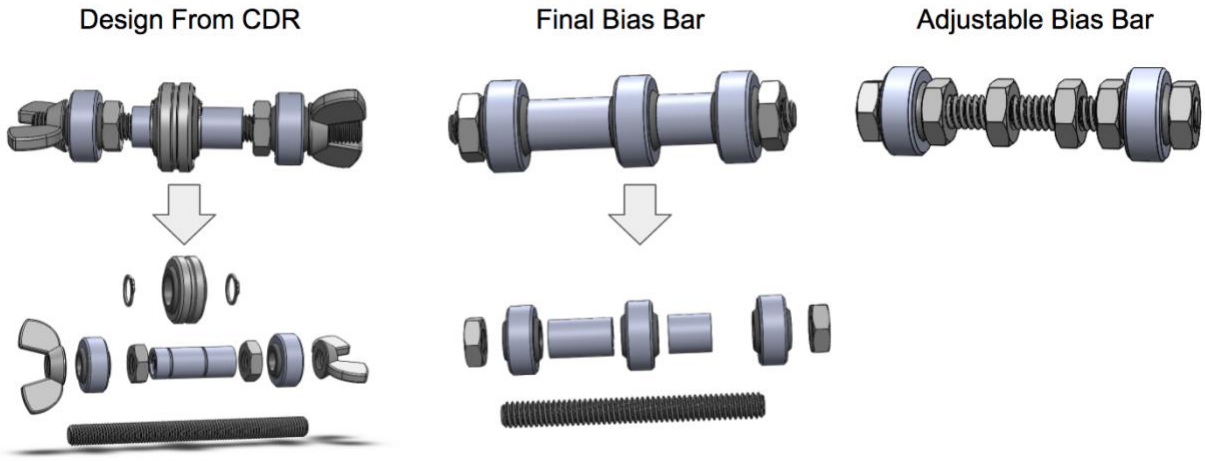




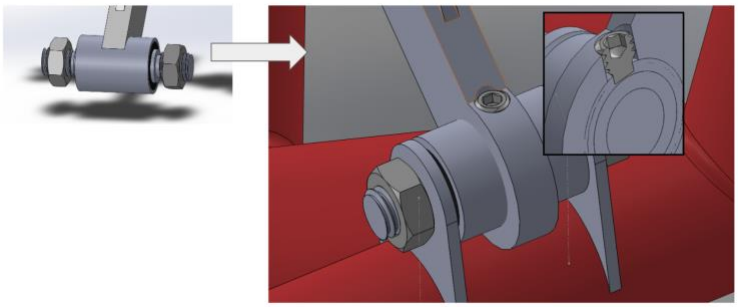
The ways in which you can adjust the pedal are shown by the red arrows. The adjustability is mainly due to the bottom bracket. The bottom bracket was recently 3D printed, and the rod ends are threaded in and out of the bottom bracket depending on what angle you want the pedal stem to be at. The pedal face is also adjustable so that you can slide it along the pedal stem and change the angle. This is what will have most of an effect on the mechanical advantage. The top and bottom of the assembly are mounted to the frame using adjustable tabs with slots. This allows for complete mobility of the system. The reason why I wanted complete mobility is so that we could ensure that the path of travel is as comfortable as possible, along with the other reasons of balancing mechanical advantage and ergonomics.

Bias Bar and Rotary Cuff

I also wanted to improve the bias bar. In previous years, we would machine spacers to create the bias, and then change the bias over time using washers. This year I wanted to avoid that by having an adjustable bias bar. The first design (from CDR) shows a threaded rod with swivel bearings that are held together by snap rings and nuts. The bias can be adjusted by rotating the center cylinder in either direction. After CDR we decided this design was too complicated and unnecessary, so I decided to have two bias bars. The preliminary bias bar would be adjusted using lock-nuts that could be adjusted easily using a wrench. Once we find the ideal bias, then we can machine spacers that match the spacing on the adjustable bias bar.



Another thing that I considered was to create a “rotary cuff”. I wanted a mechanism that would prevent he pedal from wobbling. I created the rotary cuff which is essentially two cylinders that are sandwiched together with delrin in between. In other words, a poor man’s bearing. The assembly would be secured with a press fit and a set screw. This press fit would prevent the pedal from wobbling, and the wide bearing would ensure that the pedal remains vertical. This idea was eventually thrown away because we decided that the wobbly pedal wasn’t that big an issue that it needed to be fixed.



CONCLUSION

This project has been interesting because I had to consider ergonomics. I haven't had a project like this yet, and finding out the best way to design the pedal bay has been really challenging. Coming into this project I was planning on creating a MATLAB script that would calculate what the best mechanical advantage was given a certain geometry. After a while I realized that this project was a lot more about making the driver comfortable when he wasn't pressing on the pedal, and ensuring that the driver can easily press the pedal when he/she chooses to brake. Finding an ergonomic solution wasn't as technical as other projects that I have had on Baja, but it forced me to come up with creative ideas on how to satisfy the ergonomic aspect of the brake pedal while also maximizing mechanical advantage. I realized MATLAB wouldn't be able to consider these things, so I decided to create the adjustable pedal. After some testing on the adjustable pedal, I will go back into the CAD of the final design, and modify the dimensions to match the adjustable pedal.