Mechanical Analysis HW6

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Overview of the system:
The system that I chose is one of the four hypothetical mounting points for a racing seat I want to put in my car. The system consists of the bracket that would mount to the floor of the car, a bracket that would mount to the seat, and a bolt that holds the two other parts together. All components are steel alloy. It's assumed that the bracket that mounts to the floor of the car is fixed where it would interact with the floor, any load that the driver would put on the seat is evenly distributed between the four mounts and any load on the seat mount is distributed across the entire face of the seat mounting bracket where it interacts with the seat. Data for the loading cases was collected experimentally. The seat mount will have failed either if there is a noticeable deformation, $\pm$0.5mm, or if the von mises stress within any of the parts has a factor of less than four ass I also am also hoping to improve my tires which would increase the experienced g-forces further.

Hand Calculations:
For my hand calculations I choose to simplify the system to consist of a singular rectangular prism. This allowed me to use beam bending equations to calculate the deformation and stress within the system. Hand calculations are attached at the bottom of this document.

Sensitivity Analysis:
My parts were relatively simple and didn't have anywhere to implement mesh refinement so I decided to look into different ways of evaluating the sensitivity of my mesh. The one that caught my eye was using SOLIDWORKS's mesh quality plot function. What I found when looking at best practices for mesh quality plots, the aspect ratio of the mesh should be a majority below 5 or 6 with no maxes above 8. With this information I set my mesh to be relatively coarse but keeping my max aspect ratio below 7. I also ran multiple tests at different refinements to see if they remained similar as a check and they indeed did.

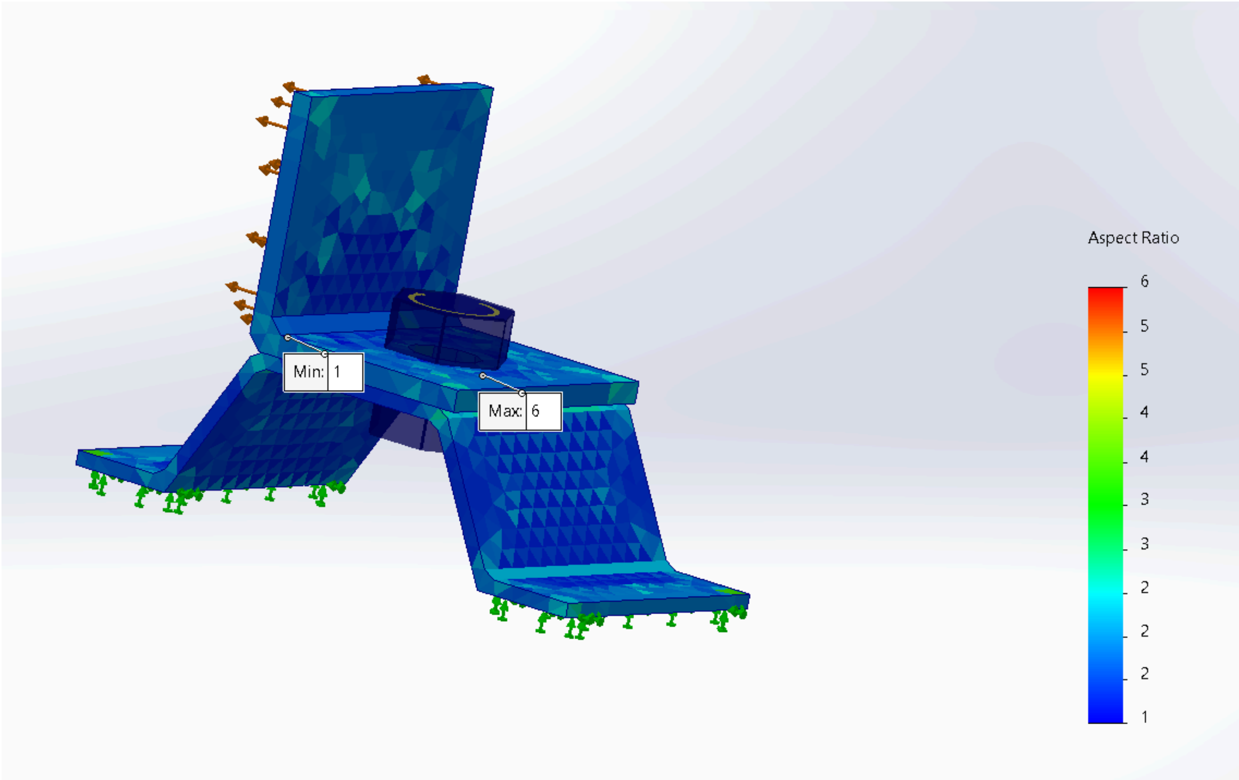

Fig 2. The mesh quality plot I ran demonstrating the aspect ratios in my mesh are within best practice.

Results Plot:

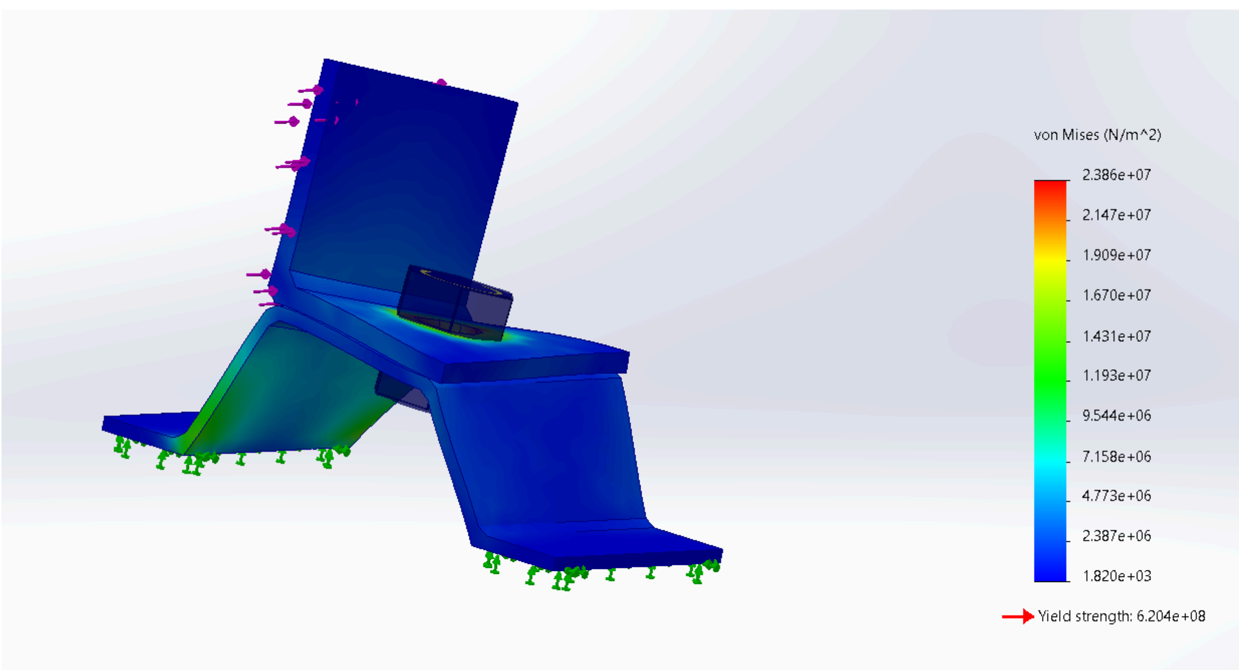

Fig 3. The stress plot for 1.26 G of breaking force

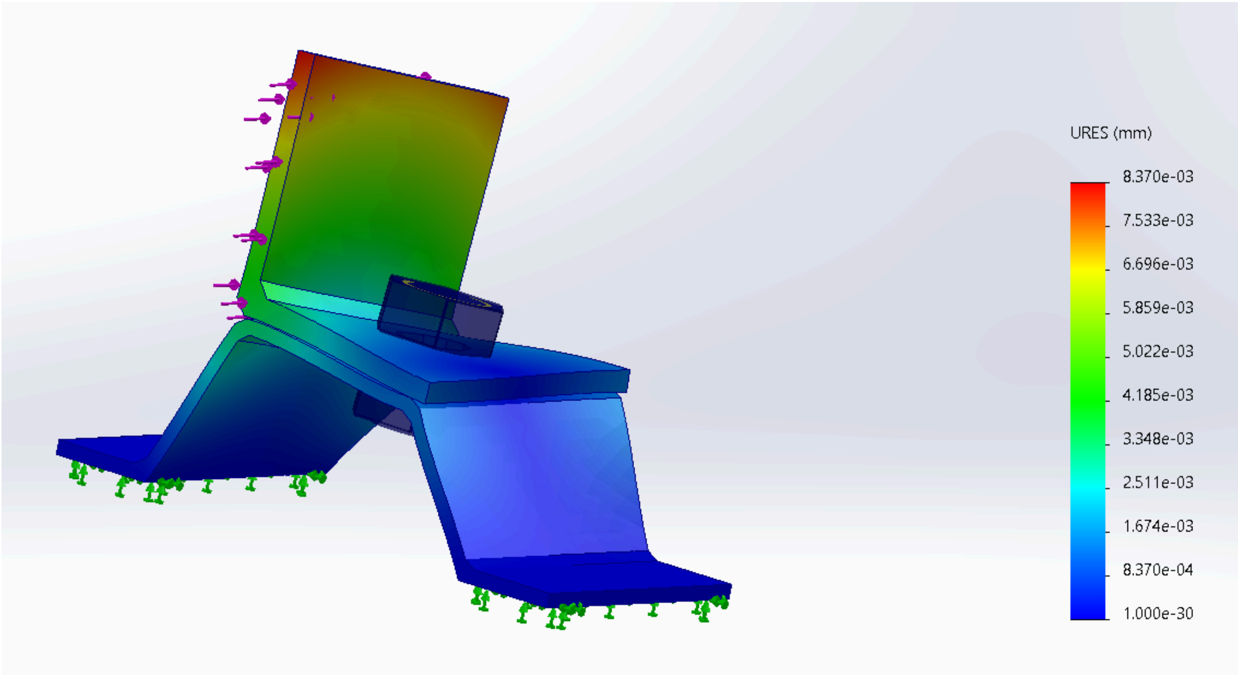

Fig 4. The displacement plot for 1.26 G of breaking force with the displacement scaled by 1000

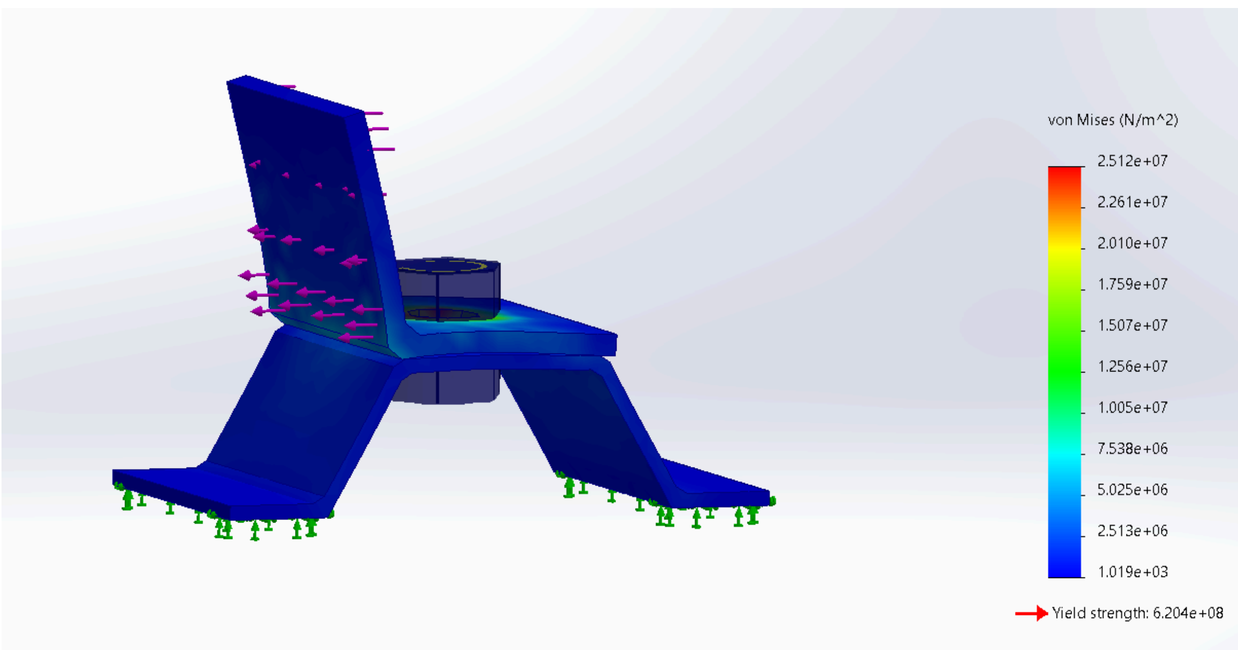

Fig 5. The stress plot for 0.64 G of lateral force

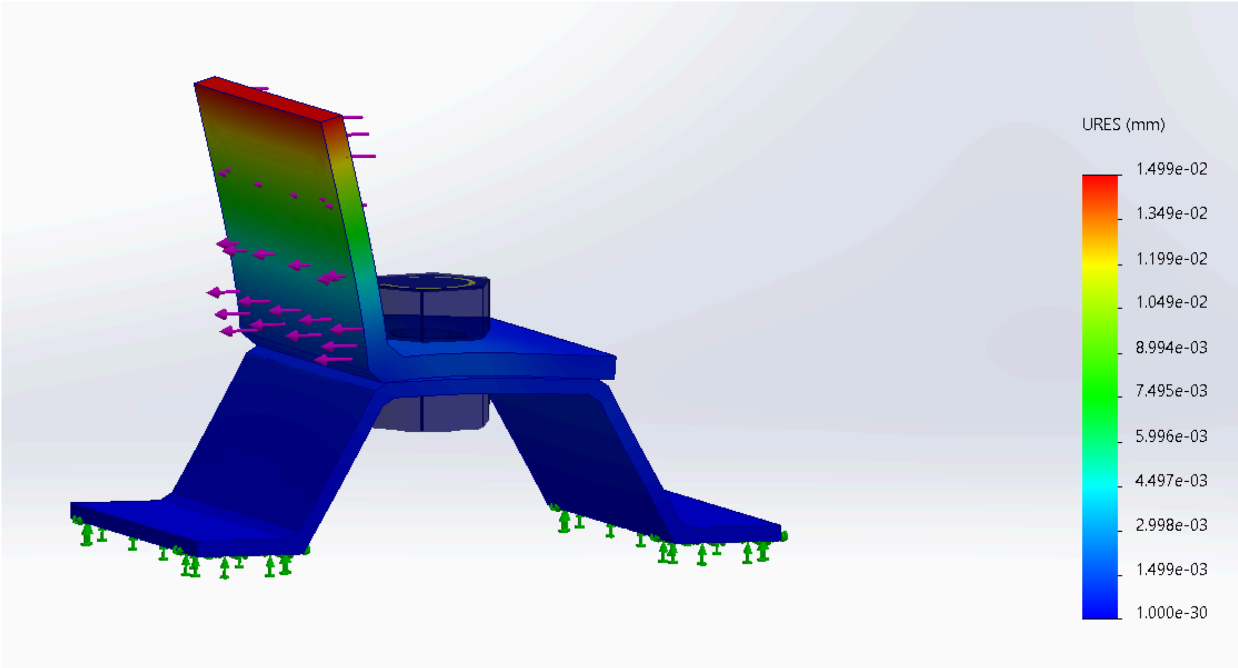

Fig 6. The displacement plot for 0.64 G of lateral force with the displacement scaled by 1000

Commentary:

Assumptions: The assumptions I used for both tests were that all the force from turning/ braking was all put into the seat and that all the force put into the seat was evenly distributed between the four mounting brackets and distributed evenly across the face of the mounting bracket that would be in contact with the seat. For the hand calculations I made the assumption that the brackets were just a singular rectangular prism fixed to the seat and the floor. For the FEA I used a more realistic and complex geometry where I attached the two halves of the bracket using a bolt with 15 Nm of preload.

Discrepancies between hand calculations and FEA: For the difference in geometry between what I used for my hand calculations and what I used for my FEA on my values are actually quite close. The values between the two are closer in the breaking direction, being off by roughly 0.00025mm, which I believe makes sense because the approximate geometry I used for my hand calculations in this direction is more similar to what the actual geometry used in my FEA that it is in the breaking direction. For how much of a simplification I made for my hand calculations I believe this is actually quite good as it gives you a rough idea of what might happen which is essentially all you'd be looking for from hand calculations in this use case. That being said, being off by an order of magnitude is significant, but in this specific case it is small enough that both my hand calculations and FEA calculations could be used to get an understanding of the system.

Takeaways: The good news is, based on the criteria I set, my seat brackets don't fail and my seat would remain stiff as I went around the track with a fair factor of safety. If I was going to continue to model this system I would first look into how the loading is actually distributed between the four corners and if there are loads other than just distributed loads being applied to the corners. If I found that the loading case was not as simple as proposed in this study(which is very likely the case) I would want to run those cases that are subject to different loading. After that I would also want to model all of the corners as a single system including the seat as having all corners being linked to each other would also likely affect the results. That being said the models are more or less behaving as I would have expected with the stress concentrations being located at the edges. Under braking most of the stress is in the lower bracket on the front and back edges that are under compression and tension and under turning most of the force is in the top bracket at the edge it starts to bend at. Both of these behaviors are what I would expect. I'm a little surprised the force isn't slightly more distributed between the two brackets for each case but still the behavior also matches what I'd expect. What surprised me a bit is that the maximum force for each case is where the bolt is attached. I'm not sure if this is just because there is too much preload, although I think 15 Nm should be reasonable, or if I didn't use the bolt tool correctly. Either way with this uncertainty I would want to look into this further if I were to run these tests again. Overall, the stress concentrations in the FEA look as I would expect and are close to the hand calculations so I think the way I have implemented the FEA and hand calculations is likely accurate enough to be useful in saying that the brackets would not fail.

```
%Breaking G force
Gs_B = 9.81*1.2;%G-force under breaking
my_weight = 95;%kg
breaking_force = Gs_B*my_weight;
force_chair_bracket_breaking = breaking_force/4
```

```
force_chair_bracket_breaking = 279.5850
```

```
%Turning G force
Gs_T = 9.81*0.64;%G-force when tunring
my_weight = 95;%kg
turning_force = Gs_T*my_weight;
force_chair_bracket_turing = turning_force/4
```

```
force_chair_bracket_turing = 149.1120
```

```
%dimnesioning braket
length = 0.072; %m
width = 0.051; %m
thickness = 0.0038; %m
I_break = (thickness*width^3)/12;
I_turn = (width*thickness^3)/12;

%material props
E = 2.1*10^11; %pascals

%area distributed load is not on
length_no_load = length - 0.042;%m
width_no_load = width;%m
thickness_no_load = thickness;%m
```

```
%bending under breaking
deflection_max_breaking = (force_chair_bracket_breaking*length^4)/(8*E*I_break)...
    - (force_chair_bracket_breaking*length_no_load^4)/(8*E*I_break);%m
deflection_max_breaking_mm = deflection_max_breaking*1000
```

```
deflection_max_breaking_mm = 1.0326e-04
```

```
%bending under turning
deflection_max_turning = (force_chair_bracket_turing*length^4)/(8*E*I_turn)...
    - (force_chair_bracket_turing*length_no_load^4)/(8*E*I_turn);%m
deflection_max_turning_mm = deflection_max_turning*1000
```

```
deflection_max_turning_mm = 0.0099
```