**Contents of thumb drive:**

This thumb drive contains all essential components of the team’s project completed throughout the semester. Apart from this word document, there is also a presentation folder and a project folder. The presentation folder contains a PowerPoint file used for the in-class presentation. The PowerPoint presentation outlines the team’s progression of the project including modeling features, FEA, CFD, visualization, team collaboration, skeleton models, key parametric relationships, outcomes from the project, as well as hardships experienced throughout each step of the process. In the project folder, there are a series of subfolders that contain the work completed by the team. These folders included are labeled Inspire, Images, Modeling, Data transfer, Visualization, Mass Properties, FEA, and CFD. The containments of these folders are described below.

The “Inspire” folder holds all the topology models and results files. This includes topology results from front bumper and chassis analyses. Pictures (.png files) and .SLDPRT files are included in this folder.

The “Modeling” folder includes all the part and assembly files separated into two folders (“Backups and Old Saves” and “Final Assembly”), as well as a CADReadMe.doc word document with instructions on how to load, access, and run all the models. The “Final assembly” folder contains the most recent and up-to-date files to use. The “Backups and Old Saves” was an optional folder used for organization and retention purposes in case there was any issues with resaving any of the updated parts. Do not refer to these files.

The “FEA” folder contains pictures (.png files) of each of the FEA tests run. FEA was performed on the chassis, front bumper, and rear bumper. The pictures are labeled accordingly for each of the parts tested, as well as the result type shown (displacement, stress, and mesh). In this file is also all the FEM and SIM part and assembly files.

The “CFD” folder contains all the files used in the Controlled Fluid Dynamics portion of this project. This includes the analyses results and Star -CCM+ models that populated the data. In this folder, there is a “Pics” folder that houses all the .png images collected for plots and CFD analyses from simulation. There is also a folder called “SimCenterFiles” that includes the specific .sim files. Outside of the subfolders, there are two .prt files that were created in NX and used in CFD simulation for analysis.

The “Data Transfer” folder contains models that were used across multiple CAx systems. These models were largely sourced from GrabCad and imported into NX for full assembly. Copies of the original CAD part files are included as well as the reparametrized CAD model reconstructed for our assembly.

The “Mass Properties Folder” is where the results are organized, comparing the actual measured results of weighing the RC car and components with the mass properties gathered through software. The images (.png files) contained in this folder show all the results.

The “Visualization” folder includes any corresponding results in renderings and animations collected through the analyses performed within the project. Each member of the team designed their own parametric shell modeled and rendered their model for visualization purposes. Images from this are included in this folder (.png files).

The “Images” folder contains images of both the physical car and the modeled car. Physical car images taken by the team are in the folder labeled “Physical Car” and the remaining pictures outside of this folder are of the modeled car.

**How to use thumb drive:**

To navigate the thumb drive, open the folder labeled “Final Project”. This folder holds all the work and organization from the team. Within this folder, there is a PowerPoint labeled “Final Presentation” that includes the groups work laid out in a presentation (that was shown in class).

There is a “ReadMe.xlsx” Excel file that houses the team’s organization with component designation, subassemblies, pictures, and naming convention under the tag labeled “CAD Plan”. The naming convention used for the project is described at the top where each major component was labeled by subassembly tag, part number, and part name. The second tab labeled “Online CAD” hosts the links for the components imported from GradCad. The third tab labeled “Tracked Hours” holds the table outlining the amount of time contributed to the project by each team member.

Back on the first level of the thumb drive under “Final Project”, there is also a file labeled “Review 1.pptx” that the team used for the first design review. This does not incorporate all the finished work by the team and was used as a supplement earlier in the semester. It is kept on the thumb drive for retention purposes but should not be used in the final grading of the project.

The rest of the folders listed under the “Final Project” folder are described above (in this document under “Contents of Thumb Drive”). Refer to the descriptions above to identify what is contained within each of these folders respectively.

Within the folder labeled “Modeling”, there is another Word document labeled “CADReadMe.docx”. This work document outlines how to open, load, and run all necessary models. The necessary software needed to open the corresponding files is included below under “Necessary Software to view models, data files, and images”.

**Necessary Software to view models, data files, and images:**

The tools used in this project and necessary to view our files include Siemens NX (Version 2027 Build 3302), Altair Inspire 2021.0.1, and Simcenter STAR-CCM+ Client (2302). The team used OneDrive as the data repository through which files were uploaded and retrieved. The team slides should be viewed in PowerPoint and image files viewed in any software that can open .png files. The team also used email and text messaging to efficiently communicate.

**Learned, Accomplished, and Completed by each team member:**

Jackson Emerson:

Throughout this project, I was responsible for several major contributions that helped move the team’s work forward. One of my primary tasks was designing the car shell, where I gained valuable experience in modeling complex, organic shapes. This process taught me how to work with surface modeling techniques, which are critical when creating smooth, aerodynamic forms that cannot easily be built with traditional solid modeling approaches. I learned how to control curvature, maintain continuity between surfaces, and troubleshoot the unique challenges that come with modeling freeform designs.

Another key responsibility was creating the final assembly, which incorporated all the team’s parts. Through this, I developed a stronger understanding of parametric modeling and the importance of maintaining well-defined relationships between components. By using parametrics, I was able to ensure that parts adapted correctly to changes and stayed properly aligned, which helped reduce errors and improve the overall flexibility of the design.

In addition to assembling the final model, I personally created a majority of the parts used in the assembly. This experience helped me refine my skills in precision modeling, part organization, and documentation. Overall, these tasks gave me a much deeper appreciation for the role of careful planning and parametric discipline in producing complex, collaborative CAD projects.

Alex Bell:

Throughout this project, I was responsible for the CFD and contributed to CAD modeling and project organization. One of the biggest realizations I had from a modeling perspective was the importance of taking the time to plan how the modeling should be executed. In past projects involving complex assemblies, my workflow was often disorganized. I believe we improved significantly in this area during this project. At the beginning, I created a file organization system that helped streamline the CAD process and identify the critical components and key reference points for our assembly skeleton. From there, we moved into modeling the actual components.

The other main area where I learned the most was CFD. Although I feel like I’ve only scratched the surface, learning how to use the various tools in Simcenter was valuable, and I now feel confident performing relatively simple fluid simulations. I learned the importance of scrutinizing model details, such as the number of points being imported, identifying gaps or errors in geometries, and how to clean them up. I also discovered how to use several lesser-known Simcenter tools, such as the built-in CAD modeling functions, to repair broken geometries.

Will Bethke:

Throughout this project I learned many different things from Computational fluid dynamics (CFD) to finite element analysis (FEA). I learned how to properly utilize these tools and analyze bodies in order to optimize them for a car. More importantly, I learned about the difficulties that come with collaborative modeling and in what ways it can be challenging and where it can be made easier through collaboration. One of the unexpected difficulties that came with collaborative modeling was that we needed to be conscious about who was editing and updating which parts at all times. We solved this by notifying everybody when we were working with the main assembly and having an excel sheet that detailed who was working on which parts and assemblies. Collaborative modeling made the process easier because we were able to split up the work more so that one person wasn’t doing everything. My contributions to the project started with making a gantt chart in order to track our progress throughout and making sure we were staying on track. I also tackled all of the electronics and purchased internal parts. These proved to be challenging because a majority of them were glued into the chassis so I had to be creative with how I measured the dimensions and weights of each part. I also completed the finite element analysis for the front and rear bumpers along with the topology optimization that was performed for the front bumper. The rear bumper did not have topology optimization due to the already optimized structure.

Dawson Cadamore:

This project taught me a lot about coordinated collaborative modeling within groups in a much more complex way than I have worked with before. Through this class and CGT 163, I have modeled individual parts previously and created assemblies. However, modeling the specific components on a high level and parametrically incorporating each of these into the assemblies that others have worked on proved to be a much more complicated and detailed-oriented task. I learned how inter-part expressions can be used to efficiently update model sizes and scaling the geometry of large 3D models. This was completed through modeling of subassembly components such as the toe controls, axles, steering motor, and some of the additional components that held accessory parts to the chassis. I also learned how surface modeling contrasts with solid modeling, especially when applying mass properties for testing and analyses (FEA and CFD). Finally, I learned how to import and reparametrize parts from other CAx systems by downloading parts off GrabCad and importing them into NX (such as the drive motor and the steering motor).

Zach Noel:

During this project I learned about the many challenges and advantages of working on a shared assembly. It required constant and detailed communication to make sure our parts worked together and were organized. I learned that the planning and preparation in making the parametric assembly skeleton is crucial for determining how smoothly the rest of the project will go. The key is to create something that is not too complex nor too simple and that all team members understand what all the components in the skeleton represent. Furthermore, this project gave me the opportunity to do more complex modeling that I have not done before, such as the surface modeling for the car shell. One major part of the project that I was responsible for and accomplished was the FEA and topology analysis for the chassis. I was able to generate a FEA simulation that highlighted week spots for the chassis where more deformation and stress would occur under high loads. I also created two different topology-optimized chassis and imported them from SolidWorks back into NX. Finally, the parts I created were the chassis, rear connecting block, and an individual car shell.

**Attempted, in process, and incomplete by each team member:**

Alex Bell:

I was able to successfully perform a few different CFD simulations; however, they were often not as accurate to our model as I would have liked. After spending far too many hours trying to fix our original shell, I ended up creating another one with simpler geometry. I believe it would have been possible to fix our shell with a better understanding of how the mathematics of the CAD system operates. I also would have liked to get better results visualizing the streamlines of the airflow. Additionally, I think it would have been interesting to explore other types of meshers, as I am unsure how accurate the results are from the automatic mesh, even with a lower base size. Jackson Emerson:

While much of my work reached a finished state, there were a few areas that remained incomplete or could have been improved with more time and refinement. The wheel hubs were one component that I attempted but felt could benefit from further detailing and optimization. Although functional, their geometry and fit could be refined to better integrate with the overall assembly and meet higher precision standards. Similarly, the front and rear brackets were completed to a basic level but lacked some of the fine-tuning necessary for full realism and manufacturability. These parts would benefit from additional attention to mounting points, structural reinforcement, and detailed sizing adjustments to improve their performance and integration with the rest of the model.

In addition, the suspension components and A-arm used in the final assembly were sourced from GrabCAD. Because they were imported rather than natively modeled, they did not adapt optimally to parametric changes within the assembly. In particular, the suspension parts had no morphing in length, which made it difficult to properly adjust or fine-tune their fit in the overall car design. As a result, their integration was more rigid and less flexible than the rest of the assembly, and they did not fully match the dynamic behavior we had hoped to achieve.

Will Bethke:

Much of the work that I set out to do I eventually got done to a level that I feel confident in. The two issues that I ran in to be the assembly finite element analysis and the computational fluid dynamics for my personal made shell. The assembly finite element analysis I was unable to complete due to multiple errors. I needed to complete it on my laptop which does not have a lot of computational. This combined with a larger number of triangles needed to make an accurate mesh led me to be unable to complete the finite element analysis, so I had to request that someone else in the group tackle it. I also was unable to complete the computational fluid dynamics for my personal shell as I had hoped which led me to need to use the remote-control car model which turned out well.

Dawson Cadamore:

One area where I tried to help but fell short and sought help was with the CFD of my individual shell model. After completing the model and uploading it to STAR-CMM+, I quickly realized that my shell had a few features that were misconfigured and could not be meshed for analysis. This became an issue but was resolved when another team member found another way to complete the CFD for our project. Additionally, a few parts (such as the front/rear bumpers) tested my capabilities to accurately model complex framework using swept features. While I was able to configure some basic models on my own, they were not nearly as accurate and easy to implement in the final assembly. Jackson was able to create and adapt a much more accurate representation that we used for our model.

Zach Noel:

One area that I was not able to complete were some of the finer details on the models I created. For example, the chassis I made was an accurate model as far as the general shape and size but lacked some of the internal structure. These internal structures include frames around the internal components, like the servo, battery, and motor. Also, some areas of the chassis and rear connecting bracket were difficult to get dimensional measurements for, so those spots are less accurate in the car assembly. Another task I wasn’t able to complete was the data exchange for my second optimized chassis. The first optimized chassis was able to be exported from SolidWorks as a .x\_t file and imported into NX as a .prt file, but the second model had issues with being exported and saved properly for various types of files.