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Formula SAE Team Final Report many FSAE team members, and discussion amongst the team, it was decided that the brake the final design changes from the.

Torsional Stiffness Experiment Setup This document will present an overview of the project, the project scope, and the design requirements for this project, while outlining the selected final design. This report will also contain a detailed team budget. Each system has been designed for maximum adjustability so that systems can be fine-tuned during vehicle testing, with focus on reliability, weight reduction, manufacturing, and universally compatible parts. The competition in Detroit, Michigan attracts over students from more than universities and colleges from around the world SAE International, The premise behind Formula SAE is that each student-run group has been approached by a fictitious manufacturing company to develop a small formula-style race car SAE International, SAE International outlines strict rules and regulations to ensure competition and vehicle safety. There is a strong need for this project, as the Formula SAE Rules state that teams wishing to compete on a yearly basis must have, as a minimum, a new frame for their vehicle each year Society of Automotive Engineers, The design group has enthusiastically accepted this challenge and a full description of the scope of the project and the components that constitute the chassis can be found in Section 4. For this project, the chassis is defined as including all frame members, with the forward vehicle limit being the front bulkhead, and the rear vehicle limit being the differential mounts. All mounting tabs other than those for the suspension and the engine are outside of the scope of this project. With regards to the suspension, wheel and brake selection are excluded. Steering will also be included as part of the chassis for this project. The project scope will include design selection, use of modeling tools and simulation, iterative design refinement, and construction of the final design. If any of these requirements are not met, the design will be considered unsuccessful. Must ensure the safety of the driver at all times. These criteria are not critical to the success of the chassis, however they will enhance performance. Improve engine packaging to allow for a removal time of less than two hours and eliminate the need of dismantling the suspension before removing the engine from the frame. Reduce size of uprights to eliminate contact with wheel. To select the final design, the design group divided the chassis into subsystems: After subjecting each subsystem to the design process outlined in the Design Selection Report, a final design was chosen based on the design requirements in Section 5. Table 1 shows the final design for each subsystem while Figure 1 shows the final design of the chassis. It is extremely important to note that all systems were designed simultaneously, as changes in one subsystem can drastically affect the design of another subsystem. The following sections will further explore each subsystem. Formula SAE Chassis 7. The ease of manufacturability, rigid structural Formula SAE guidelines eliminating the need for material testing and the reduced cost of the steel were the primary benefits that resulted in the selection of the steel space frame. For a full discussion on the material and manufacturing selections, please see Design Group Figure 2 shows the constructed frame. One of the main criteria for the frame was weight. Having a light frame is very important as a lighter car allows for faster acceleration, better handling and more efficient fuel consumption. The team aimed for a frame weight of 75 lbs or less and produced a frame weighing 65 lbs. This was accomplished through careful consideration of member placement and component packaging. The frame and suspension were designed simultaneously so that reinforced nodes on the frame corresponded to suspension arm nodes. This ensured that no frame member was put into bending or compression. This allows for a lower vehicle center of gravity CG which is important for handling and turning in many dynamic vehicle events at the Formula SAE competition. The number of bends was also minimized to only those required by the main and front roll hoops. This was an improvement over past Dalhousie Formula SAE vehicles, and this reduction was important as bends weaken the frame. There are several templates which must be able to pass through all points of the frame to ensure adequate spacing for the driver. Figure 3 shows both the cockpit internal cross section template and the cockpit opening template being able to pass through the frame. Another template is used to ensure that the 95th percentile male will be able to fit inside the cockpit. Formula SAE Templates 7. Figure 4 shows how the new frame meets this requirement as the ankles are nearly in line with the hips with one of the group members in the frame in the driving position. Figure 5 shows the final frame design with the design group being able to meet this Formula SAE requirement. Head Clearance Ruling To further improve driver ergonomics, the Dalhousie Formula SAE team also purchased a Tillett W3 formula-style racing seat from Tillett Racing Seats in order to provide the driver with a comfortable position, vehicle feedback, and proper support. The purchase of the racing seat was taken into consideration when designing the frame and creating frame mock-ups to ensure proper spacing. The design team has targeted an egress time of under 4. A faster egress time is directly linked to driver ergonomics, along with frame design. The side of the cockpit was designed so that it is lower at the point where the driver would exit the vehicle, making 7 it easier for egress. To test this deliverable, each group member was placed in the vehicle and the time to exit was recorded. This was done five times for each group member. Table 2 shows the results. However, since the method of egress used by the design group is not identical to that of the actual vehicle scenario, it has been determined that this design requirement was not fully met. The final seat location must be determined by the Formula SAE team, and the body side pods will also be attached to the frame. As an initial test, based on the results listed above, it appears that the Dalhousie Formula SAE team should have no problem with meeting the 5 second egress time. This year, a sub-frame was created around the engine, which allows for the engine to be easily removed by unbolting the engine from the frame and lifting the frame up and out of the way for engine access. The suspension does not have to be removed to access the frame, which results in quick access to the frame, which is important if quick adjustments to the frame are required. The torsional stiffness was calculated by fixing the rear of the frame and placing a weight of Newtons on one end of the frame. The deflection of the frame under the weight was calculated using digital micrometers at each side of the frame members. This was done for each side of the frame at two different locations: The experiment was done 5 times to ensure accuracy 8 and repeatability of the results. Figure 6 shows the experiment setup while Table 3 shows the results of the test. Torsional Stiffness Experiment Setup Table 3: The Formula SAE team is pleased with these results and it is believed that it is strong enough to effectively perform at the competition, while at the same time being able to absorb vibrations. The suspension arms incorporate threaded rod ends, which allows for fine tuning of the arms. In addition, the ability to adjust ride height and vehicle stance without affecting the spring preload and the wide range of potential motion ratios are advantages of this suspension type. An iterative design process was used such that the suspension mounts corresponded to nodes on the frame, establishing properly triangulated load paths. Figure 7 shows the full suspension assembly. The final front track width is mm 47 in , while the rear track width is mm It is anticipated that the relatively short wheelbase and wide front track width will result in a vehicle that is well suited for the tight corners seen in the autocross and endurance events. A floating hub design was selected over a fixed hub design as this allowed for more design freedom and eliminated the need for splines, simplifying and reducing the overall weight of the design. Finite Element Analysis was used to confirm the hub material as steel and to ensure the design could withstand the torque applied by both the wheels and the brakes. The hubs are attached to the wheel using a single anodized lock nut. A C-V joint is integrated with the rear hub as this reduces the overall number of parts for the vehicle. Figure 8 shows a picture of the rear hubs. The design team was able to successfully incorporate these changes and Figure 9 shows a comparison between the new and old upright in the wheel. With the new upright design, the design team is confident that interference between the upright and the wheel will not be an issue. Upright Size Comparison One of the main features of the new upright design is that they have been designed to be universally compatible. This is a design departure from former Formula SAE teams. In the past, due to the Formula SAE rules that the frame must be redesigned each year, every component of the vehicle was being redesigned year after year. These uprights have been designed so that they can be reused year after year, saving the Formula SAE team time, money, and manufacturing, as the uprights are a very complex part. To make the uprights universally compatible, adapter plates were designed to be attached to the uprights. These adapter plates are the only component that requires redesigning year after year as the adapter plates dictate the location of the suspension mounting points on the upright. Due to the Formula SAE ruling that the frame must be redesigned year after year, this means that the suspension geometry will change as well, resulting in the location of only the adapter plate needing to be redesigned each year, with the upright being able to be reused year after year. Figure 10 shows four different views of the uprights. On the left is the upright by itself, while the next two images show the front and rear uprights with their respective adapter plates. The final image on the right is a side view of the upright. As can be seen, shims were designed and added in between the upright and the adapter plates. By adding or removing the number of shims, the amount of camber can be adjusted, which allows the camber to be quickly fine tuned during full vehicle 12 testing. To date, the uprights have been set with a static camber of 1. Detailed Upright Views 8. The difference in spring stiffness between the front and rear of the vehicle is due to weight distribution, as the bulk of the weight is in the rear of the vehicle engine and related components. With regards to dampers, Penske double adjustable dampers were selected. These dampers were valved according to the calculated damping curve, based on vehicle parameters. These dampers can also be easily adjusted to fine tune the suspension system, which will be extremely useful during full vehicle testing. This was accomplished as an anti-roll bar was able to be installed in the rear of the vehicle. The anti-roll bar was designed to provide the additional stiffness required to achieve the target roll rate of 1. Moment arm lengths were calculated based on the maximum bending force applied and the stiffness of the anti-roll bar. The moment arms were made with slots so that the moment arm length can be adjusted and tuned for peak performance and handling. The anti-roll bar is attached to the bellcranks and is packaged in the rear of the vehicle with no interference with any of the other suspension components.

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with theoretical design to produce the final suspension geometry. This resulted in reducing the wheelbase of mm from the car to mm for the car.