Bike Suspension

Postmortem

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January 22, 2021

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Introduction

Initially, the goal statement for this project revolved around creating a database for mountain bike riders to use to help them adjust or tune their suspension. After some initial discussions, the team decided to take a slightly different route that still met the customer's needs. The new route for the project was based around creating a mathematical model to help riders adjust their suspension to various terrains. Once this idea was thought out and in motion, the team decided to create a physical device that helps riders adjust suspension on the fly with the help of our mathematical model. This memo intends to lay out the team's purpose and goals as stated in the team charter, then present how the team either followed the rules and/or the consequences when the rules were broken. Then, an analysis of the project performance and improvements will be discussed followed by the problems and solutions experienced throughout the semester. A brief discussion about the technical takeaways for the semester will be discussed to conclude this memo.

Contributors to Project Success

The Team Charter's goals included understanding and achieving all of our client's requirement. However, due to the lack of any requirements from our client that was not a possibility. Though we did inform our client of any changes that we plan of implementing into the project and we always applied the advices he gave us. Other goals were researching the topic, and product development, and making a product for clients from all financial levels. The topic and product development were researched successfully which led to us learning the limitations and possibilities of this project. As for targeting clients from all financial levels, we seem to be on a path were this is still achievable. However, we cannot achieve that goal until after we make the product. For this project, the team was budgeted a full suspension mountain bike into the final budget. Fortunately, we reached out to several bike companies and were able to get a bike sent to us from Niner Bikes. This bike left the team with little to no cost for now but testing and prototyping a design will help us spend some of our budget. Due to the previous semester being focused on research, most of our physical goals are yet to be competed. Though, we were able to pave the way to achieving those goals in the future. Some examples would be making the mathematical model, staying within the budget, and achieving high grades in this class. For the mathematical model we went through the tedious process of getting half of the team copies for the Linkages x3 program which will be the cornerstone of making the model. As for the budget, we contacted many companies in the hopes of getting spare parts, and we successfully got a company to give us a bike for our testing, free of charge, leaving more of the budget for other needs. Lastly, we were thankfully all able to get grades that we are satisfied with in the last semester, which means we competed the first step of completing this goal of getting the grades we are aiming for in this class.

The team established ground rules and positive coping strategies to ensure that team members do not feel discouraged or not included. The ground rules consisted of each team member completing their portion of work, for this allows the distribution of work to be even amongst all team members. Completing assignments on time is another rule that ensures the team that the reports will be completed on time and not rushed at the last minute. And finally, the last ground rule is to attend every meeting if possible, for if teammates miss meetings, the quality of work would decrease and slow the team down. If any of these ground rules are broken, the team did not address them in a negative way but rather in a positive form through communication. Team members may have busy schedules or important matters to deal with, so as a team we simply encourage others to complete the material early so they can handle their personal businesses outside of capstone. In fact, all of these ground rules and coping strategies worked for the team last semester. Every team member had a different class schedule which made meeting for the mathematical model a little difficult along with COVID-19, however, through communication the team was able to find time slots that worked best for everyone. Through every team report, the material was divided evenly to ensure that the workload was not heavily relied on by one person. With this, last semester went rather smooth due to the circumstances that every team had to go through. All in all, the only portion that the team did struggle with would be when a team member had COVID, for this made it

difficult to meet with every member in person when conducting testing data. Hopefully, this semester does not bring us to this, and as a team we can meet to conduct prototyping and continue testing.

As a team we were satisfied with the progress made throughout our first semester of capstone. There were many aspects of the project we felt were handled well and performed great as a team. The main positive aspect our project was teamwork and communication. As a team we meshed and worked extremely well together. The team has various backgrounds and utilized this array of problem solving and diverse ideas to approach each step with confidence and options to consider. With the new, primarily online, approach last semester we often used this communication to address completing tasks efficiently regardless of the situation that arose. Along with team communication we did a great job with client communication between Dr. Trevas, Brandon Lurie, and Niner bikes. This communication allowed us to quickly seek guidance and troubleshoot problems that came up with Dr. Trevas and Brandon, as well as led to the sponsorship with Niner bikes. This proactive communication helped us reach out to Niner bikes who generously lent us a bike to perform testing and prototyping with. This not only propelled the project forward but also aided in helping us keep cost minimized so we have ample budget to utilize for testing and prototyping. Goal setting through use of a Gant chart was another strong suit of the team. This helped us move forward through the project during the entire semester and make constant progress. These positive attributes led to our success last semester and are already aiding in a quick and efficient start to this semester.

A major tool utilized during the semester was Microsoft Teams. By using a platform such as Teams, our group was able to communicate easier, share documents, and hold Team meetings remotely. Being able to keep documents in one place and share ideas through a platform like Teams helps us to stay organized and keep everyone up to date on current assignments. Methodologies for this project spanned from client meetings where Brandon, our client, would give us tips on creating the mathematical model. Some tips included simplifying the model as much as possible, then building in complexity and being able to first make a model for a static system which can translate into a dynamic system. These methodologies learned for creating a mathematical model helped the team understand how to build a more complex model that can change over time. Some practices that impacted the team negatively included prioritizing other classes, procrastinating assignments, and not working toward a common goal. For this upcoming semester, the team plans on limiting these negative practices as much as possible.

Each team member learned their own technical lessons and shared with the team their findings. Erik found that mountain bike air shocks require large spring stiffnesses in the range of 6000-7500 N/m in order to withstand harsh trail conditions comfortably. Suliman determined that air shocks are generally tuned for an average damping coefficient near 1500 kg/s. Dylan researched the formulas which feature the relationship between spring stiffness and damping coefficient. Tyson used these values and formulas to develop the mathematical model. Initially, Tyson tried MATLAB as the model platform, but quickly discovered that Microsoft Excel lends itself much better to the calculations involved. Jacob found in his SOLIDWORKS stress analysis of a generic bike frame that most of the force experienced while riding concentrates in the seat stay, chain stay, and bottom bracket. This information was helpful for Austin, who discovered a proprietary bike suspension software called LinkageX3, which is helpful for kinematic analysis of bike frames. The team acquired three licenses in time for the spring semester. The software will help the team further develop the mathematical model and conduct testing on the full suspension bike supplied by Niner Bikes in Colorado.

Opportunities for Improvement

Throughout our progress last semester there were also a few instances that were not as positive. The main negative from last semester is that the troubleshooting in the mathematical model took up a lot

of time. This held us back from beginning the design process as early as we had hoped. This is not detrimental, as we now are making positive progress both on the model and the design process. Learning from last semester we split the team into two subgroups: Mathematical model team and Design process team. These are not hard splits but rather will allow the teams to each mainly focus on one of the two major tasks. This is going to allow progress moving forward to be optimized and streamlined. One other negative from last semester was problems with institutional communication. This was in the form of trying to gain access and get approved for hardware and software purchases to aid in testing. We have been in better communication with the channels that were difficult to access last semester and are emphasizing the importance of some hardware and software to expedite gaining access. Overall, the team has reflected on what worked well and what held us back last semester and are confident in our ability to take advantage of these reflections as we push forward.

Towards the start of the semester, the team lacked direction. Unfortunately, our client was not passionate about mountain bikes and did not know about the entire sport of mountain biking. This led to some unclear expectations and direction for the project. For about the first half of the semester, the team was not working cohesively; rather individuals were working to accomplish their weekly tasks instead of working towards the project. Once the team was able to establish a better plan, the execution of tasks began to mesh more. Another problem the team seemed to be drive and motivation for this class. Sometimes tasks were rushed, or it felt like the best work may have not been executed. A major point to blame for this is the new world we are living in with COVID affects people in several ways and it can hinder the performance of the time. Whether this meant assignments being pushed off to the last minute or missed meetings, most of the team experienced some of these small mistakes.

With all the problems the team encountered last semester, steps need to be taken to make sure the project gets done in time. The first big thing that the team will do is create a Gantt chart to help facilitate the timings of goals that have to be achieved by the end of the semester. The Gantt chart will split up the project into smaller pieces that can be done in a timely manner by members of the team. For example, the team has decided to split into two groups in order to work on the two biggest pieces of the project which are finishing the mathematical model and designing the final device. Since neither of these things require the whole team to work on any single one, it is better to split up the work so that they get done more efficiently. On top of the Gantt chart, the team will also meet at-least once a week to make sure every member knows what they should be doing during the nine hours outside of classroom that each team member should be spending on the project. Before each meeting, each team member should have a list of ideas or thoughts to give to the other team members. This way, there is always something for the team to talk about which will help with keeping the project moving forward. On top of these weekly group meetings, the team has a meeting time with Dr. Trevas and another for our client weekly and bi-weekly respectively. These meetings give the team a chance to get outside opinions on the project and also gives the team a chance to report on all project happenings. All these things will help the team get the project done in a timely and efficient manner.