ME 476C

To: Prof. David Trevas

From: Bike Suspension Team (20FB14)

Date: 2/12/2021

Re: Hardware Review 1

Introduction

This memo will include a brief summary of what each team member has been working on and how that contributes to the current state of the project. Since our project is based on a creating a mathematical model and a device with three team members working on each part, this memo will include different topics of contribution. Dylan, Jacob, and Suliman will be discussing their progress on the design of a physical device, while Austin, Erik, and Tyson will be discussing progress on the mathematical model.

Review

Erik Abraham:

For this project, I have been working with Austin and Tyson on the mathematical model and starting my own research for my Honor Capstone assignment. Starting with the mathematical model, my goal has been to find initial shock velocities for our model, help vary the inputs for each terrain, then convert our mathematical model outputs in suspension inputs on the bike. The initial shock speed seemed relatively easy to find by just performing a momentum balance and solving for velocity. Our values for initial shock speed were higher than the previous values in the model which led to some more problems in the model. The second main part I was working on was changing values that needed to vary for each terrain. This took a bit of time but now our excel should be able to adjust for each terrain type better. Lastly, I am currently working on a way to turn our model outputs into actual adjustments on the bike. This is my main goal for the next couple of weeks and might take some time to ensure the adjusts made are correct for different sized people. For the Honors portion of my project, I have been researching vibrations, Nyquist frequencies, and the FFT. I have been looking at academic sources such as presentations from other universities and plan on continuing my research. The initial goal was to study spring rate and find the Nyquist frequency with this, but after more in depth research this does not seem viable. Instead, I plan on using an Arduino sensor (Grove - Vibration Sensor (SW-420)) to measure the vibrations of the shock at different the different compressions settings to see how the suspension performs on different terrains, then performing a FFT with this data. So far, I have a rough understanding of vibrations and the analysis I intend to perform but now that I have a more set path it should be easier to get more work done quickly.

Suliman Alsinan:

In this semester we reached the point of requiring physical modelling and testing. Thus, we spill into two sub teams. As a member of the physical design team, I contributed with generating 10 sketches in total for five different sections of the device. Going back to the previous self-learnings we did in this semester and the last I chose topics that both help in my knowledge and skills in using SolidWorks. The first self-learning I did was e SolidWorks finite element analysis (FEA), which will be extremely helpful in using simulations to test the concepts generate after deciding what generated concepts are best from the Pugh Chart we made. My second self-learning topic was Geometric Dimensioning & Tolerancing, which is going to be helpful is making sketches of the device in SolidWorks. In the next couple of days, I will discuss with the team the two categories I am interested in handling, after that we will start working more individually on our respective categories.

Jacob Cryder:
After being placed into the design section, our team began the design process through generating various sketches based upon the design requirements. Each member contributed a total of ten sketches (2 per design category). After this section was complete, the team then focused on the Pugh Chart through each section with the DATUMS. After meeting with our client and Dr.Trevas, each team member in the design section will be focusing on two specific components. With this, I will be continuing to focus on the bike mount along with the component that mounts to the bike mount. Through this process I will generate detailed design sketches that will have dimensions that can be used in solid works to create a 3D model. Additionally, I will continue to work with the design group in all aspects to achieve the end goal in designing a working proto-type model.

Austin Coyne:
For these first couple of weeks of the project, I have been working with Tyson and Erik on the mathematical model. I originally decided to join this team because I felt like I could offer my research on bicycle linkages from last semester. This semester I started with modelling our bike in the Linkage x3 program which is a great tool for mountain bikers to learn about their bikes and adjust certain parameters of their bikes to maximize performance. For our purposes, the software is just a great way to get a leverage ratio for our bike which can be used in our mathematical model. I started by researching the bikes that were already in Linkage x3 that were close to our bike in order to get an idea of what it will look like when I am done. I then got a side view picture of our bike and used it to "build" the bike in the software. After finishing the bike in the software, I was able to adjust certain geometry parameters and output the leverage ratio data in order to get an average leverage ratio. I got a leverage ratio of 2.5 on the first test which is very close to the leverage ratio that the manufacturer states: 2.55. I knew that there would be some amount of error in the leverage ratio due to me not being able to match the model perfectly to the bike. In order to combat this, I built the bike two more times in the software and was able to get an average of 2.3 for the three bikes which is not as close as the one but at least gives a leverage ratio that is probably more closely related to our bike. From here I plan to help Tyson and Erik finish up the math model and then move on to testing with our Arduino device.

Dylan Klemp:
This semester the team decided the best way to approach the goals for the project was to split into two sub-teams, modelling and design. Myself, Jacob, and Suliman make up the design team and have been focusing on working towards prototyping a design for the project. So far, I have

contributed to the engineering design process for part design, composed of brainstorming, sketching, and a Pugh chart. Now that the Pugh chart has highlighted the top sketch designs for each component type studied, the design sub team will be taking two sub components each to continue fine tuning the design prototyping stage. I will be focusing on knob adjustment and power transfer. These are the primary methods of actually changing settings on the bike suspension. The design sub team focusing on individual parts will allow us to each specialize on specific design components leading to a better fine-tuned end result in the prototyping stage. I plan to continue with the design process and begin utilizing CAD to construct physical renders and soon physical prototypes of the design.

Tyson Spencer:
Since the team acquired a full suspension mountain bike from Niner bikes in Colorado, I have been developing the Arduino hardware and code necessary for physical testing. The current setup pulls data from a 6-axis accelerometer and an Adafruit VL53L0X laser time of flight distance sensor, and writes it to a .txt file on a micro-SD card breakout board. This yields air shock oscillation over time, as well as impulse data. Data can later be viewed and manipulated in Microsoft Excel. The team hopes to use one or two data sets from two different riders on similar terrain to validate the mathematical model, and then allow the model to predict datasets from other riders/trail types.
I also designed a box and mounting bracket in SOLIDWORKS for the Arduino board and sensors. They will easily attach to the bike near the front fork and rear shock. We plan to pick them up from the Makerlab Sunday or Monday, and begin validation testing as soon as possible. Erik and Austin have been helping with final development of the mathematical model. Once validation is finished, it should be complete. Then we can focus on extending physical testing to include all the predicted trail types included in the model, relating math model outputs to physical suspension adjustments, and developing the suspension adjustment apparatus.