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Friction Force Analysis of Multi Axles Train Bogie System Using 3d Finite Element Model

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Abstract: There are several components of the train that are crucial to the passengers' safety and comfort. The bogie is one of the most crucial parts of a railroad train. The bogie is crucial to safe railroad operation because it securely holds the railcar body, maintains stability on both straight and curved tracks, and provides smooth riding. There are many kinds of bogie systems, but the focus of this study is on the analysis of the friction forces in multi-axle train bogie systems. Two railroads are utilized in the simulation. The axle load was calculated using information from previous bogie systems. The simulation's displacement, velocity, and acceleration data were recorded. The graph compares all the tabulated data. The result shows that there were no derailment issues when the speed hits maximum threshold.

Keywords: Multi-axles Train Bogie System, Friction Force, Finite Element Model

1. Introduction

Trains have been an important part of transportation and industry since the early 1800s. They can carry many people and goods over long distances. The first steam-powered train was built in the UK in 1804. Trains became widely used in the mid-1800s and helped many countries industrialize. Today, trains are still important for transportation because they are fast, environmentally friendly, and good for long trips [1].

Railcar bogies help trains run smoothly and safely on both straight and curved tracks. They make the ride more comfortable by absorbing vibrations and reducing the effects of centrifugal forces. However, when there is water or too much friction modifier, the friction can become very low, which can cause longer braking distances and wheel slippage [2]. Previous research has investigated the stress and dynamics of a train bogie system using SOLIDWORKS, a software for 3D modeling and simulation. However, the problem of derailing, which occurs when one or more wheels of the train leave the track, has not been addressed for the case of multi-axle bogies. Multi-axle bogies have more than two axles per bogie and are used to increase the load capacity and stability of the train. This research aims to fill this gap by studying the derailing behavior of multi-axle bogies using SOLIDWORKS and proposing solutions to prevent or reduce it.

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The main goal of this research study is its objectives and analysis are the primary topic of this study. The goals of this study are to analyze the friction effect between the rail and the train tyre of the multi-axle train bogie system by using 3D Finite Element Method and to create a straight and bend railway track in SOLIDWORKS for friction simulation. The scope of this project is to utilize the existing 3D model and simulation of friction analysis in SOLIDWORKS for analyzing the multi-axle train bogie system. The resources, details, and information for the multi-axle train bogie system were taken from the literature. The simulation on the existing 3D model of multi-axle train bogie system by using SOLIDWORKS and drawing the railway track by using standardized gauge dimensions gathered are part of this scope.

2. Methodology

This chapter outlines the steps for conducting the analysis and achieving the desired outcomes. There will be steps to simulate and how to gather the results from the simulation and design of the multi-axles train bogie system.

2.1 3D Model of Bogie

The three-dimensional model of the multi axles train bogie system was retrieved from the previous researcher. There were 5 axles with a pair of tires on each axle.

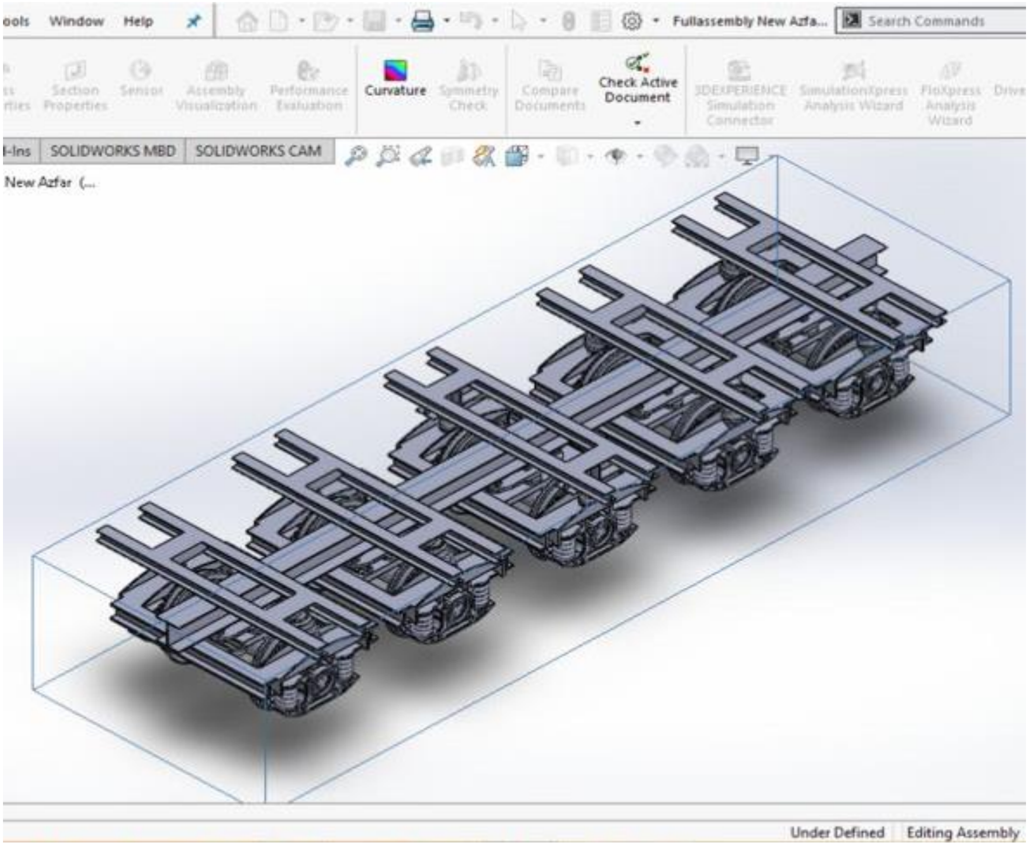

Figure 1: 3D model of multi axles train bogie system.

2.2 Methods

A flowchart is also provided to ensure that progress is made towards the study's primary goal.

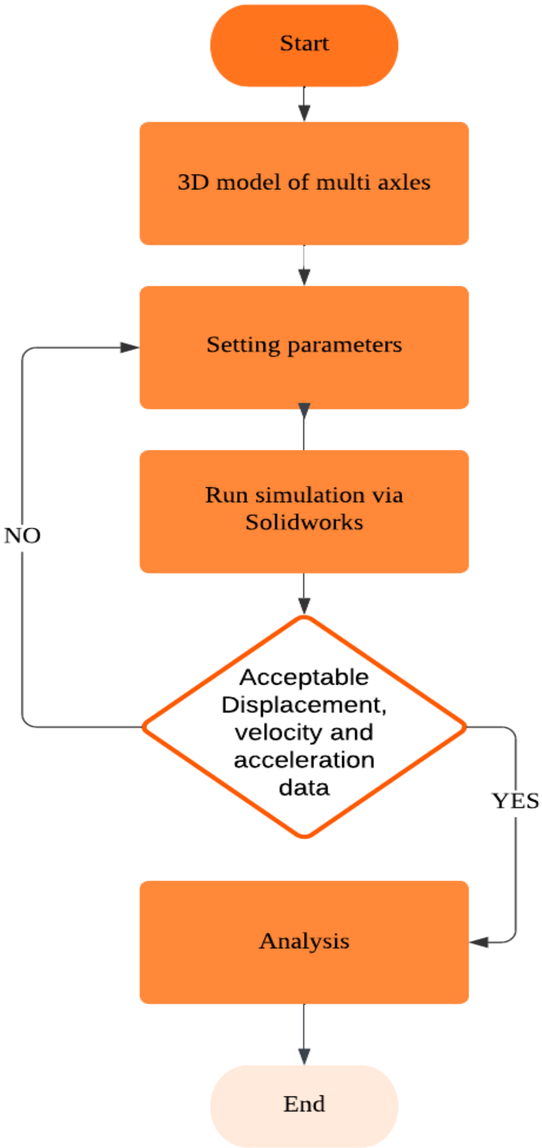

Figure 2: Flowchart

For the analysis will setting up the parameters by using three pairs of tires and their contact with the track. The friction between clean, dry steel is 0.8. The predicted maximum speed before the tire slides off is 3000 mm/s and the maximum friction force is 196200. In order to analyze the friction force, we will be using the software Solidworks. This powerful tool allows us to input the necessary values, such as the friction coefficient and speed, into the 3D model. By doing so, we can accurately calculate the friction force solution and gain a better understanding of the forces at play. This information is crucial for ensuring the success of our project and achieving our desired outcomes. The friction coefficient value from the parameters setting that has been stated will be used to tabulate the data of velocity, displacement and acceleration. The result of the friction force analysis will be collected from the table. The analysis will be compared between the straight and bend railway from the equation in literature review.

3. Results and Discussion

The simulation results of velocity, displacement, and acceleration of the three pairs of tires were compared with each other based on the straight and bend railways. The data and results obtained from the simulation were tabulated in graphs and tables. All the collected data were displayed in tables and graphs to facilitate comparisons between the two railways with various points of contact.

3.1 Results

The results of the simulation can be found in the appendix. **Appendix A**, **B** and **C** were gathered from bend railways while **Appendix D**, **E** and **F** were gathered from straight railways.

3.2 Discussions

Based on the graphs of displacement, velocity and acceleration gathered from pair 1, 2, and 3, the average velocity for when the bogie system to slip off the straight and bend railway is 5726.25 mm/s and 5709.25 mm/s respectively. Next, the maximum acceleration gathered from the straight and bend railways is similar which is 46433 mm/s2. Besides, the plotted graph of the displacement against time graph for the three pairs of wheelsets shows that it is increasing constantly for both straight and bend railway. Next, the velocity against time for the straight railway shows that the velocity is constant at 3000 mm/sec while the velocity decreases on the bend railway. Finally, the data form the acceleration against time graph shows that the bogie does not accelerate while on the bend railway the initial acceleration was from negative value and accelerate to 0 acceleration.

4. Conclusion

The analysis of the friction force produced by multiple axle train bogie system tyres coming into contact with the rail is a challenging issue that incorporates many different elements and variables. The coefficient of friction is one of the most crucial variables. The coefficient of friction used in this simulation is constant where we predicted the maximum speed that overcomes the friction force and when the tyre will slip off the rail. The linear displacement, velocity and acceleration of the tyres are kinematic variables that describe the motion of the tyres along the rail.

There are several recommendations that could be carried on by other researchers about this topic. Firstly, other than friction analysis, there are many other simulations that could be done for this topic which are static analysis. By this, we could study the forces and the effects when it is in stationary position. Next, we could study the dynamics of the multi-axles train bogie system. We can find the impact of load to evaluate the performance of the bogie system. We could also carry out the study in various humidity and temperature for better analyzing the characteristics of multi-axles bogie system. Finally, other than Solidworks, we also can utilize other FEA software such as Ansys. The program could evaluate mechanical properties such as frictional force, fluid flow, temperature, and vibration.

Acknowledgement

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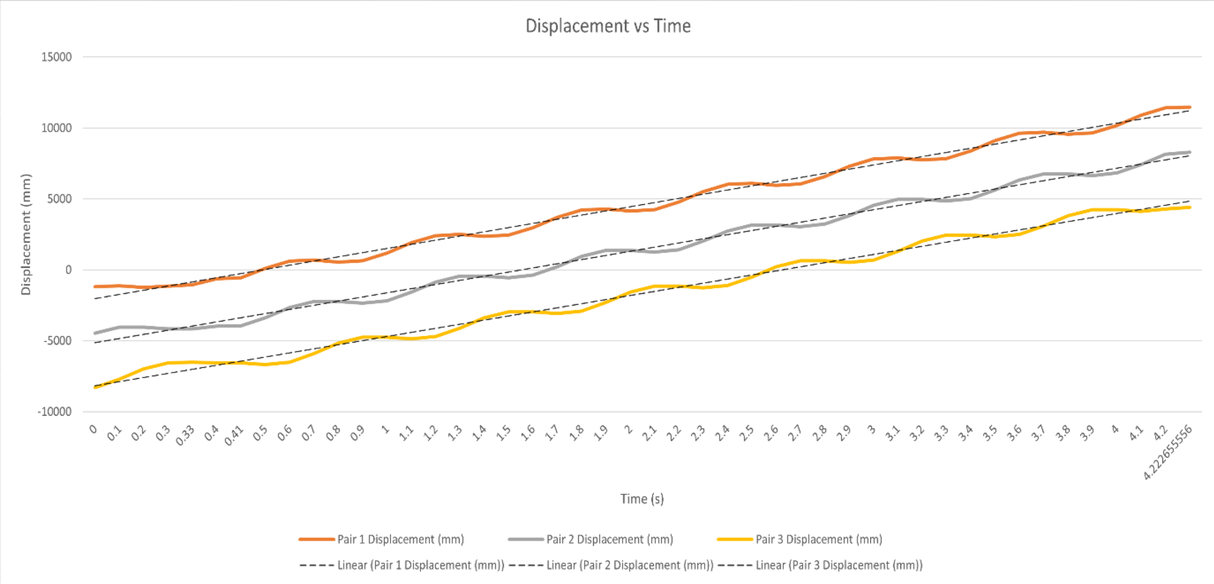
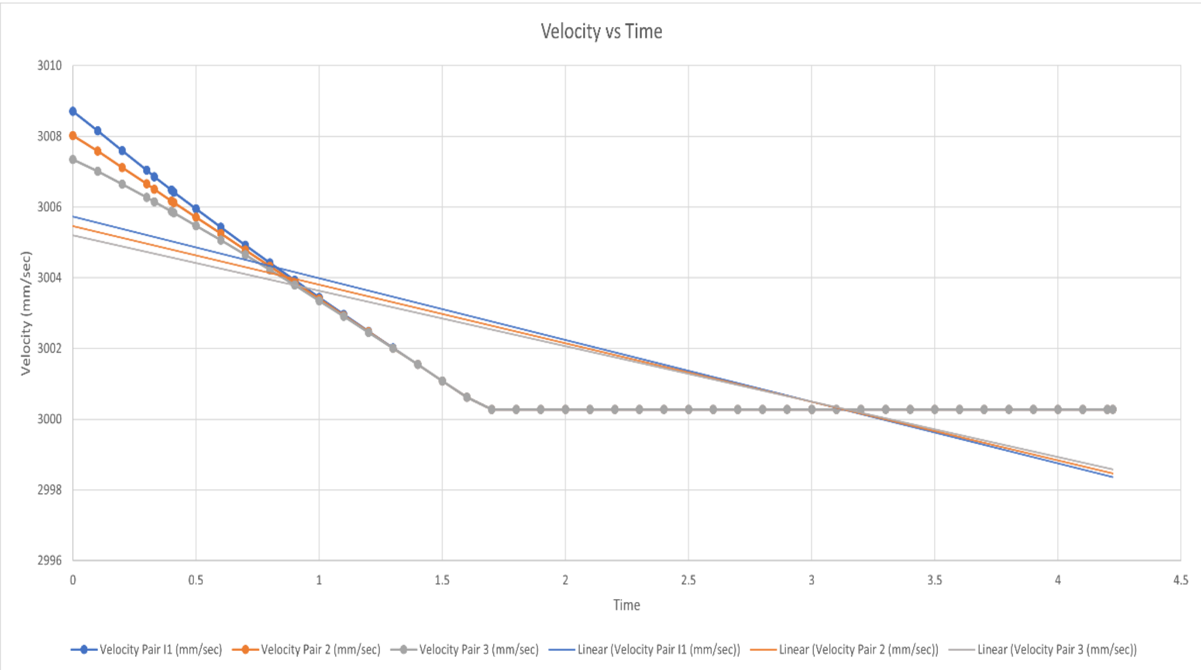
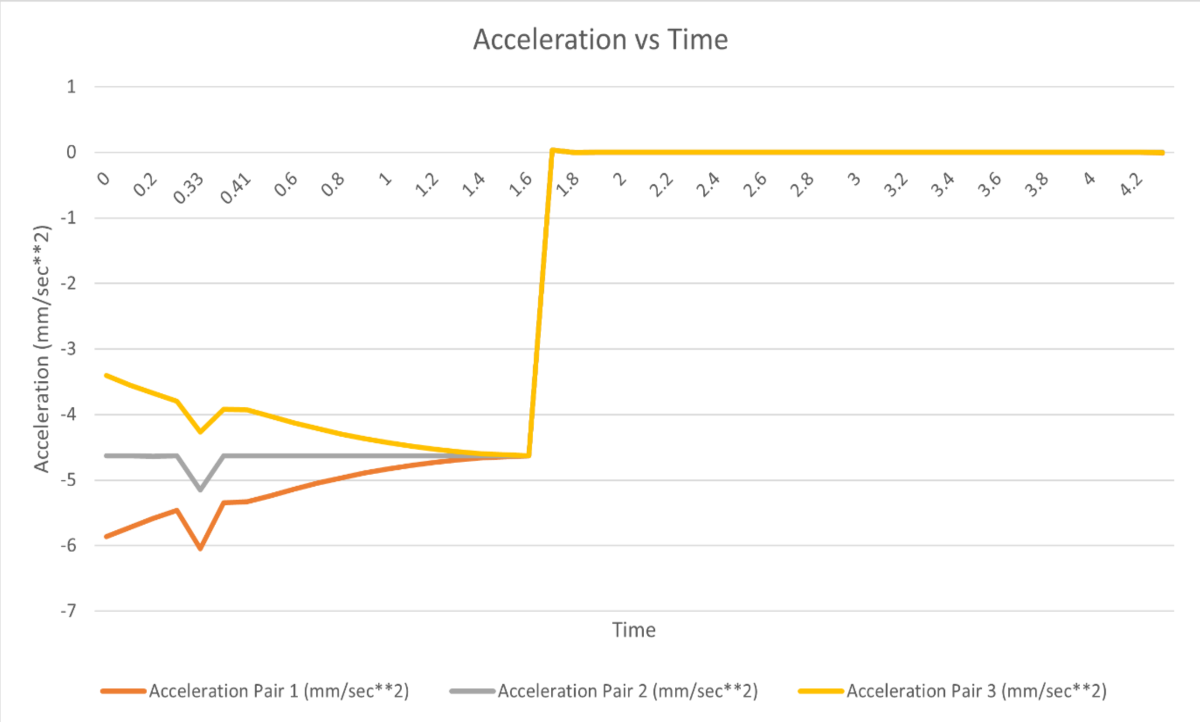
Appendix A



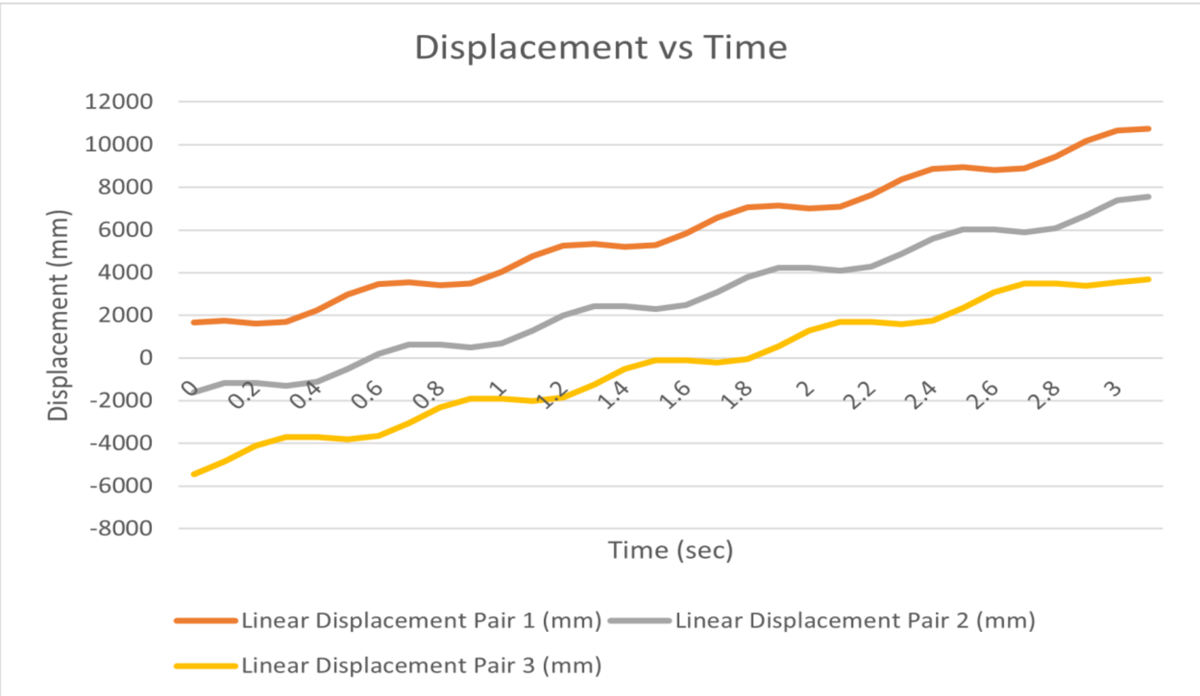
Appendix B



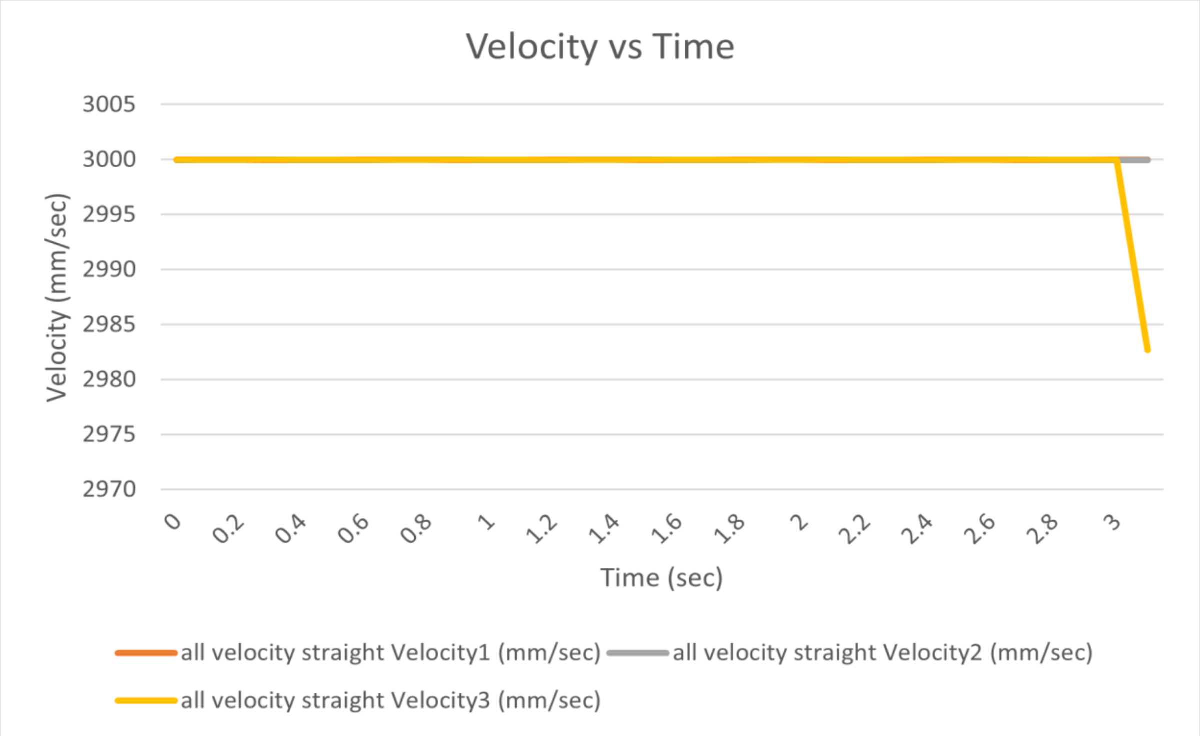
Appendix C



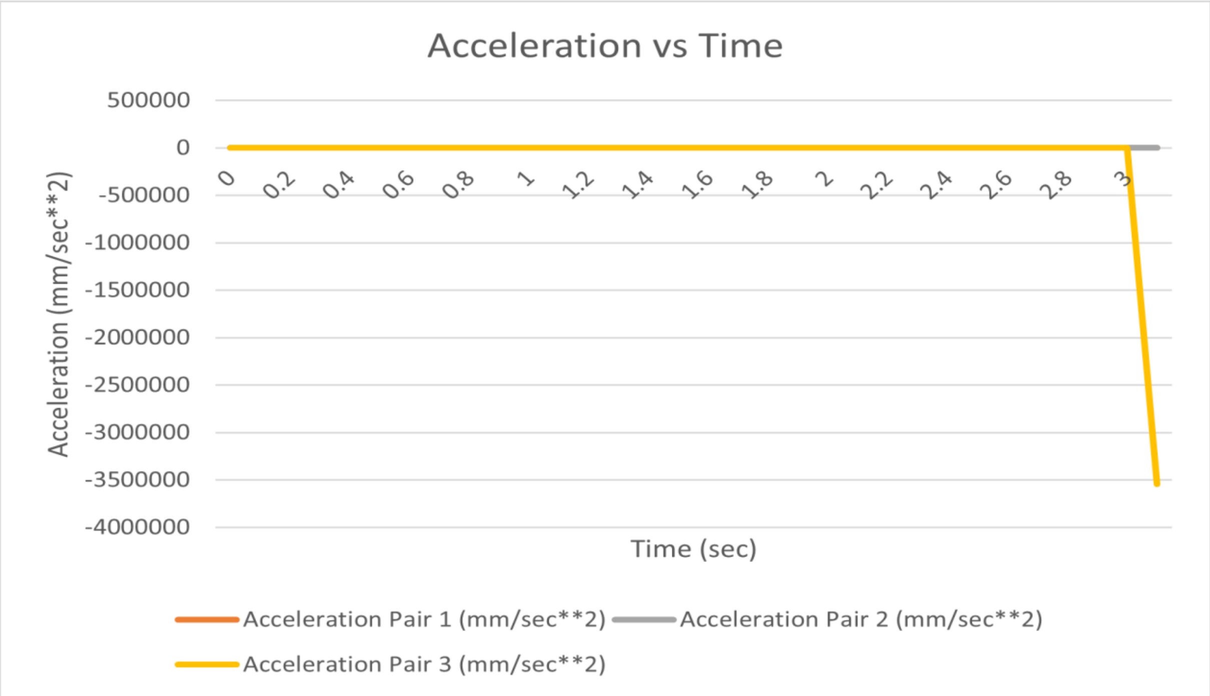
Appendix D



Appendix E



Appendix F



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