CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Marcus Catanzaro

Project Number

J0305

Project Title

Rock and Roll Derailment: Reducing Harmonic Oscillation in Trains

Abstract

Objectives

This project was inspired by harmonic rock and roll derailment. Harmonic rock and roll derailment is when the rail car derails due to harmonic oscillation at its resonant frequency. Railroad tracks are made with a series of rails welded together and sometimes one rail is higher than another at the joint. If the train hits six pairs of misaligned joints in a row the rail cars will begin to rock. The faster the train travels on the rails, the higher the frequency of the excitation. The frequency of the resonance is determined by the mass of the rail car, and the spring stiffness of the rail car suspension. The goal of this project is to determine which has a larger impact on the acceleration at resonance: the mass of the rail car or the spring stiffness of the rail car suspension.

Methods

I tested my hypothesis by building a mechanical model of a rail car and using a homemade vibration platform to measure the acceleration response at resonance. Springs and test masses were used to create a mechanical model of a rail car. I built the vibration platform using an aluminum honeycomb plate suspended on springs and excited with an acoustic thruster. I created computer code to sweep frequencies and drive the thruster. The program also recorded the data from two accelerometers. The harmonic response was defined as the amplitude of the acceleration of the model divided by the amplitude of the acceleration of the vibration platform. Two different springs were used for suspension and each set of springs was tested with three different masses.

Results

The response below, at, and after resonance was collected for each configuration. The maximum height of the response was compared for masses or spring rates. When I added mass to my test object the resonant frequency was lower and the maximum response was also reduced. When I increased the spring rate, the resonant frequency increased, but again the maximum response was reduced.

Conclusions

When the spring rate is low, the responses for all masses were higher than the responses at higher spring rate. When the mass increased, the response decreased for each spring. I normalized the responses, the masses, and the spring rates to understand the relative effect of mass and stiffness. When I doubled the spring rate or the mass, the response cut in half. This indicates that the effect of mass and spring rate on the response is the same.

Summary Statement

I showed that the mass and spring stiffness of a rail car can be changed to reduce the harmonic oscillation in trains.

Help Received

None. I designed, built, and performed the experiments myself.