Kinematic Bicycle

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Project Background

Mountain bikes have risen in prominence over the last decade due to their ability to handle different types of environments with ease. These bikes have evolved to be a lot stronger and lighter which ultimately has improved the riding experience for users all around the world. A well-designed mountain bike requires a durable rear suspension and a unique frame design which will allow it to function effectively while on rough terrains.

Objective

The overall purpose of this project is to develop a mountain trail bike frame. The mechanical team was tasked with designing a frame that was lightweight and strong enough to operate at a high efficiency while riding on various types of terrain. Additionally, the electrical team's objective would be to convert a mechanical shifter into a wired electronic shifter that allows the rider to shift the gears on a pinion drive train electronically. Finite Element Analysis would be conducted on the frame itself to understand areas of failure and to determine the overall factor of safety. Lastly, a 3D printed prototype of the frame would be the result of this project.

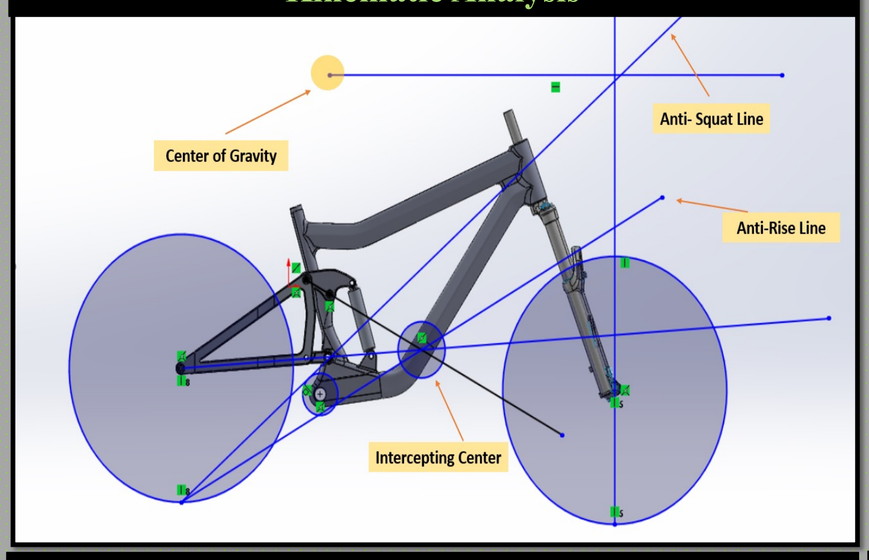
System Requirements

No.	Requirement	Performance Objective	Source of Requirement	Method of Verification
1.	Frame Cost	$2500 < Frame Cost < $3000	Customer	Economic Analysis
2.	Frame Weight	2250 grams < Frame Weight < 2500 grams	Customer	Visual
3.	Frame Material	High Strength to Weight Ratio Corrosion Resistant	Customer	Testing
4.	Rear Suspension	Anti-Squat should be at a 100% efficiency at 25%-wheel travel Anti-Rise should be at a 100% efficiency at 25%-wheel travel	Customer	Engineering Analysis
5.	Aesthetics	Frame Design	Customer	Visual
6.	Finite Element Analysis	2 < Factor of Safety < 3	Customer	Engineering Analysis

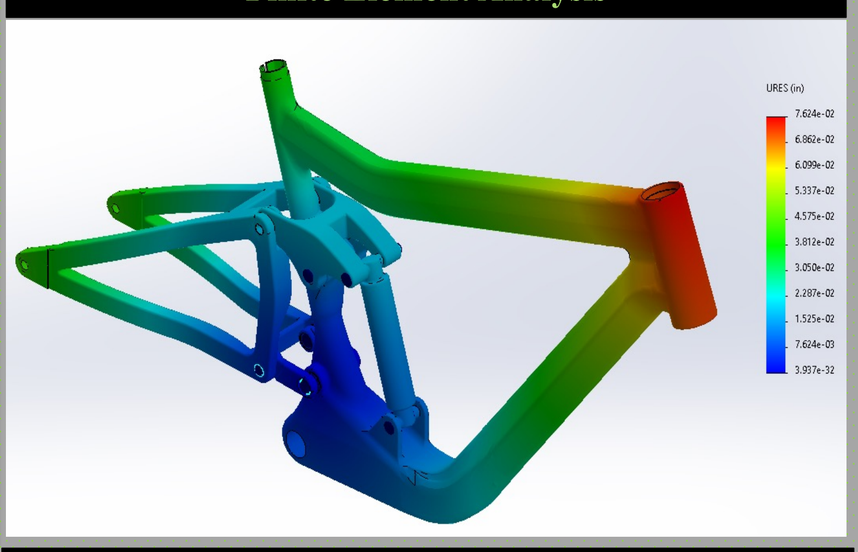
Overall Design Approach

MECHANICAL APPROACH

Kinematic Analysis



Finite Element Analysis



Results and Discussion

Kinematic Analysis Calculations

At 0% travel the Anti-Rise and Anti-Squat was determined to be 66.11% and 98.68% and at 100% travel resulted in 70.52% and 84.04% respectively.

CAD Model

Ideal Material: Aluminum 6061-T6
Frame Dimensions:
- **Length: 43.08 in**
- **Height: 20.8 in**
- **Width: 7.1 in**

Mass: 11.26 lbs
Overall Tube Wall Thickness: 0.2 in

FEA Analysis

Simulation Scenario: Rider is pedaling up a hill at an incline of 10°.
Min Deflection: 3.937E-32' in
Max Deflection: .07624' in
Min Stress: 11,180 PSI
Max Stress: 19,992 PSI
Aluminum 6061-T6 Yield Strength: 37,000 PSI
FOS: 2.57

Prototype Details

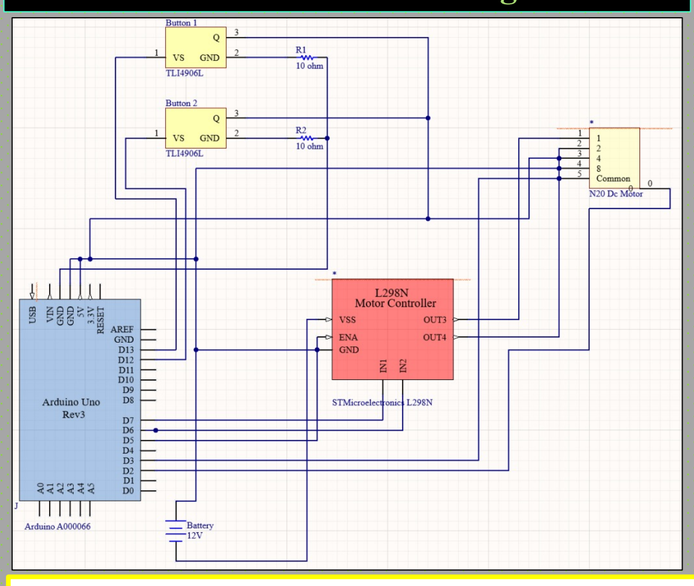
Manufacture Process: 3D-Printed
Material: PLA
Print Infill: 25%
Frame Assembly: Three Main sections (Front Frame, Rear Frame, and Bottom/Top Linkages)

CAD Model of Bicycle

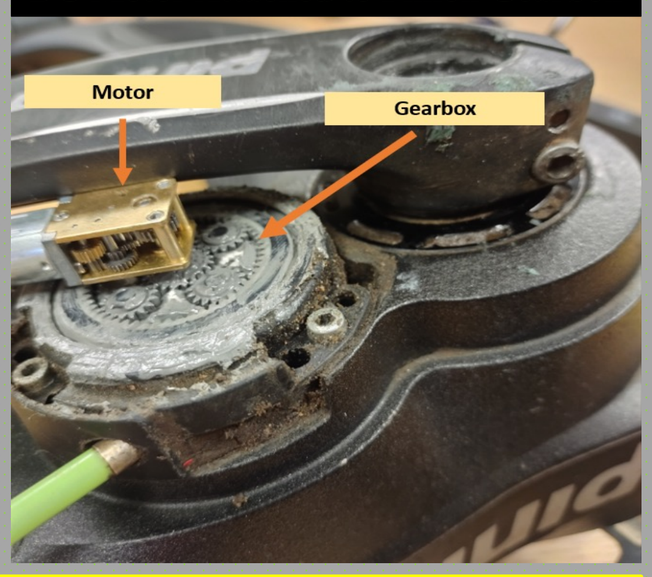
Frame Prototype

ELECTRICAL APPROACH

DC Motor Schematic Diagram



DC Motor Attached to Pinion Gearbox



We were able to produce a code that allowed the DC motor to spin using the required degree to make a complete gear shift. The schematic above shows how everything should be wired up and the picture to the right of it shows how the final product will look like without the cap that protects it.

Conclusion

- **Successfully designed and manufactured a prototype of the frame.**
- **The modification of the pinion gearbox allowed us to change it from mechanical to electrical gear shifting.**
- **5 out of the 6 system requirements for the frame were met, except for the weight requirement.**
- **FEA results proved to be realistic with an overall FOS of 2.57. The next step in the design process is to manufacture the frame out of Aluminum 6061-T6 and conduct a series of machine-based strength tests.**

Acknowledgements

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