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Human-Powered Rover Design for NASA Human Exploration Rover Challenge

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Project Scope

The goal is to design a human-powered rover for the 2025 NASA Human Exploration Rover Challenge. The rover is intended to traverse simulated extraterrestrial terrain that includes obstacles such as craters, boulders, inclines, loose regolith, and sharp turns. Although the team will not compete in-person, the project focuses on delivering a fully modeled and simulated rover system that demonstrates structural integrity, subsystem integration, and innovative design through CAD and FEA validation. The rover must be capable of supporting two drivers and performing effectively in terrain scenarios modeled after lunar and Martian surfaces.

Competition Constraints

- Human-powered by one male and one female
- Collapsible into a 5' × 5' × 5' cube
- Lightweight and safe (≤130 lbs)
- 15 in. minimum rider clearance
- Custom-designed, non-pneumatic wheels

Innovation

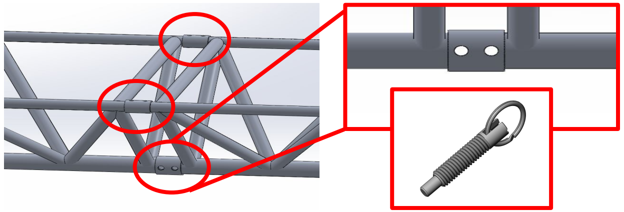

Figure 1: Frame and Collar Detachment Mechanism with Release Pin

Rather than relying on a traditional folding mechanism, our design implements a sleeved connection system that allows two separate frame sections to slide and lock into one another. This approach provides a more robust and structurally rigid connection while maintaining ease of assembly and disassembly for transport. The sleeved joint acts as an insert, aligning and securing the frame pieces without the need for complex hinges or folding components.

CAD Assembly

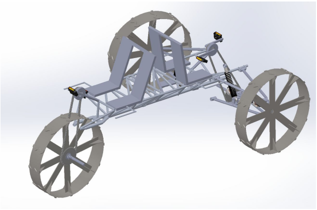

Figure 2: Full Assembly

The rover was modeled in SolidWorks to evaluate fit, packaging, and subsystem integration. The assembly guided FEA testing, drivetrain layout, suspension placement, and folding mechanism design for transport. Key subsystems include a triangular aluminum frame, chain drivetrain, front disc brakes, and custom non-pneumatic wheels.

Chain-driven system with a 2:1 gear ratio, designed for efficient torque transfer over rough terrain. ANSI #50 chain and custom sprockets selected for durability.

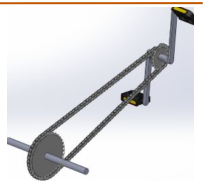

Figure 3: Drivetrain

Figure 4: Brake Assembly

Mechanical disc brakes mounted on the front wheels for reliable stopping power. Custom mounts were designed for integration with the wheel hubs.

Custom-fabricated non-pneumatic wheels featuring an aluminum base with rubber treads for traction and durability on varied terrain.

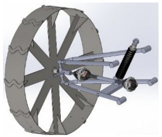

Figure 5: Wheel Assembly

Testing & Results

Subsystems were tested using SolidWorks FEA to validate strength, safety, and functionality under a 400 lb total load (rover + drivers).

Frame analysis showed a max stress of 43.6 MPa (below 275 MPa yield) and 2.21 mm max displacement. The **drivetrain** was tested with 100 lb pedal forces and 75 ft-lb torque, resulting in safety factors above 1.1. **Suspension** was tested under 4g dynamic loading (~2372 N per coilover) with minimal deflection (0.13 mm). **Wheels** were analyzed under 100 lb loads with negligible displacement (~0.027 mm).

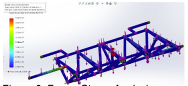

Figure 6: Frame Stress Analysis

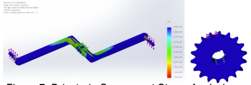

Figure 7: Drivetrain Component Stress Analysis

Figure 8 Suspension Stress Analysis

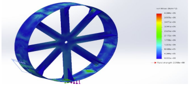

Figure 9: Wheel Stress Analysis

Steering was designed using Ackermann geometry with a calculated inner wheel angle of 24.8° and outer wheel angle of 19.4°, achieving a turning radius of 15 ft within HERC constraints.

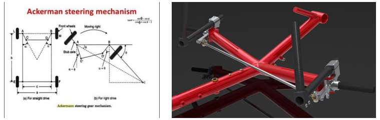

Figure 10: Steering Geometry and Layout

Acknowledgments

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