2025

Lunzer Engineering

Project: Mobility

CAD +Mechanical Design
Solidworks
Bambu Labs H2D

Graham Lunzer

Project Overview

Objective

Project Mobility was developed following a football injury that resulted in a fractured fibula and torn ligaments in the left ankle. While immobilized, mobility was limited to a traditional knee scooter that required pushing with the healthy leg.

The goal of the project was to design a powered drivetrain that could propel the scooter independently, reducing physical strain while maintaining safe and controlled speeds for sidewalk use.

The project utilized existing electronic components and focused heavily on mechanical drivetrain design to convert a high-speed electric motor into a usable mobility drive system.

Key Features

- Motorized knee scooter drivetrain
- Multi-stage gear reduction system
- Modular sprocket drivetrain
- Wireless joystick control
- Rechargeable 24-volt battery system
- Interchangeable gearing for tuning torque

Design Problem

Background

Standard knee scooters require the user to continuously push themselves forward with their healthy leg. This quickly becomes physically exhausting, particularly when traveling longer distances.

Because the rider must also balance on the injured leg support, maintaining control while pushing can be difficult.

The challenge was to design a drivetrain capable of propelling both the rider and scooter while maintaining stability, safety, and smooth control.

Constraints

- Must support approximately 180 lb rider weight
- Must maintain safe sidewalk travel speeds
- Must operate using existing electrical components
- Must fit within the limited space of the scooter frame
- Must provide sufficient torque for acceleration

Success Criteria

- Capable of moving rider independently
- Smooth acceleration and controllability
- Reliable drivetrain with minimal maintenance
- Safe top speed for pedestrian environments

Design Process

Electrical System

The project began with several available components that formed the foundation of the power system.

- High-speed electric motor (5000 RPM)
- Motor control board
- 24-volt rechargeable battery
- Charging port
- On/Off power switch
- Bluetooth wireless controller with joystick

The joystick controller allowed precise control of throttle input, enabling the rider to accelerate, stop, and maneuver the scooter safely.

Because the motor produced high rotational speed but relatively low torque, a mechanical reduction system was required.

Engineering Details

Motor Speed Conversion

The electric motor used in the project rotated at approximately **5000 RPM**. While this speed is typical for small electric motors, it is far too high for direct drivetrain use in a mobility device.

The engineering challenge was to convert this high-speed, low-torque output into a low-speed, high-torque drivetrain capable of moving the rider.

Through gear reduction, the final drivetrain speed was reduced to approximately **150 RPM**, dramatically increasing torque.

This conversion allowed the system to move the rider efficiently while maintaining safe operating speeds.

Mechanism Overview

Drivetrain Operation

Project Mobility uses a multi-stage drivetrain designed to convert the motor's high rotational speed into usable torque for propulsion.

The electric motor produces approximately **5000 RPM**, which is far too fast and too low in torque to directly drive the scooter. To solve this, the system uses a combination of **gear reduction and chain-driven sprockets** to dramatically reduce rotational speed while increasing torque.

Power from the motor is transmitted through a **three-shaft gearbox**, which performs the initial speed reduction. The gearbox output then drives a **chain and sprocket system** connected to the rear wheel hub.

This drivetrain converts the motor output to approximately **150 RPM at the wheel**, allowing the scooter to move the rider smoothly while maintaining controllable speeds.

Key Mechanical Components

- High-speed electric motor (5000 RPM)
- Multi-stage gearbox with three shafts
- Chain and sprocket power transmission
- Modular rear hub sprocket mount
- Rear wheel drive assembly

Functional Goal

Convert **high RPM / low torque motor output** into **low RPM / high torque drivetrain power** capable of moving a **180 lb rider at sidewalk speeds**.

Prototyping

Initial Drivetrain Design

The first prototype used a simple reduction system intended to lower the motor speed and transmit power to the rear wheel.

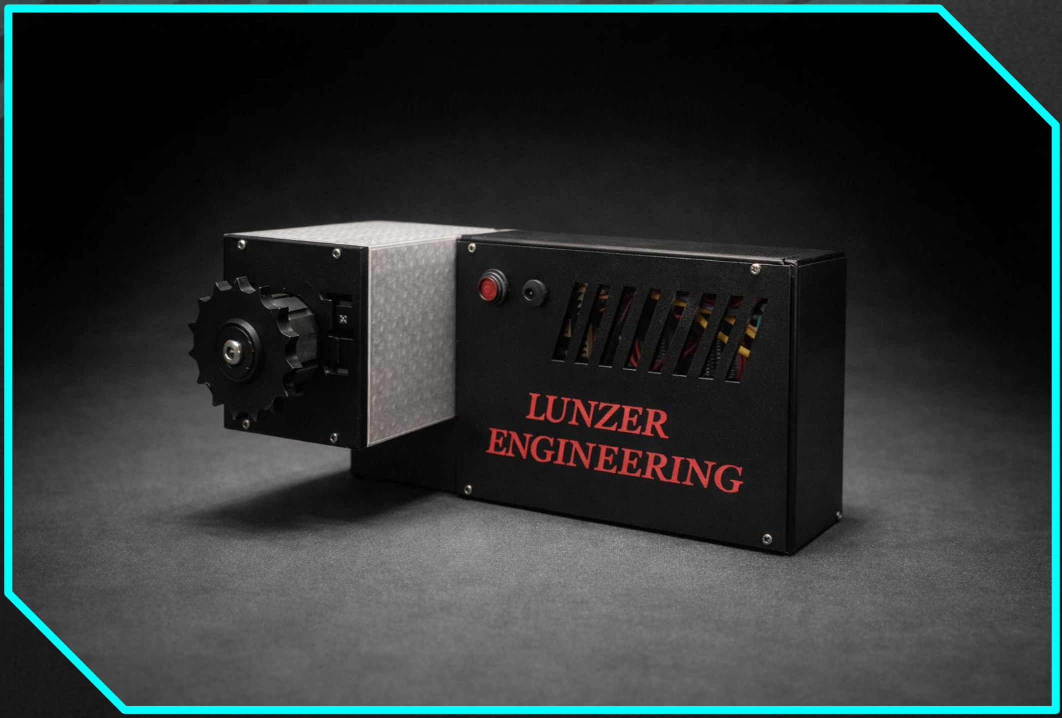
Although the system successfully reduced motor speed, the torque output was insufficient to move the scooter reliably with the rider onboard.

The scooter struggled during startup and acceleration due to the relatively high gearing.

Lessons Learned

- The drivetrain required significantly more torque
- Additional gear reduction was necessary
- The sprocket ratio needed adjustment

These findings led to the redesign of the gearbox.



Iterations

Multi-Stage Reduction System

To increase torque output, the drivetrain was redesigned using a **multi-shaft gearbox configuration**.

The updated gearbox included:

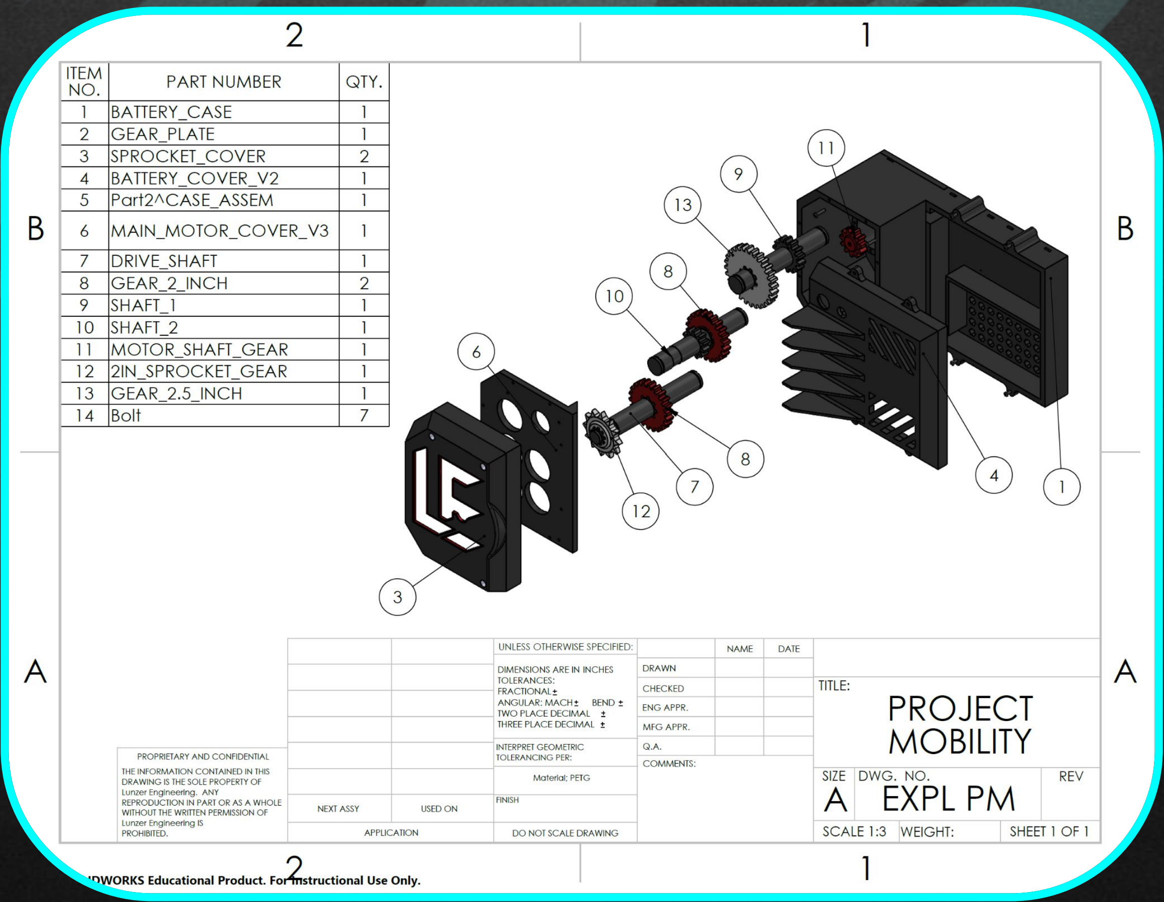
- Three total shafts
- Additional gear reduction stages
- Improved torque multiplication

This configuration allowed the system to achieve the required torque levels while maintaining manageable motor speeds.

Gear Reduction

Motor Speed: 5000 RPM
Final Drive Speed: ~150 RPM
Reduction Ratio: ~32:1

This reduction converted high-speed motor output into a drivetrain capable of moving the rider efficiently.



Final Design

Final Improvements

Additional modifications were made to increase torque further and improve acceleration.

These included:

- Larger rear sprocket
- Larger drive sprocket on the gearbox output shaft
- Increased overall gear reduction

These changes significantly improved startup torque and overall performance.

Project Outcome

System Performance

The final system successfully propelled the scooter and rider independently using joystick control.

Target Speed: ~8 mph (typical sidewalk speed)
Actual Top Speed: **10+ mph**

The scooter demonstrated smooth acceleration and reliable movement during testing.

The system effectively transformed a manual knee scooter into a powered mobility device.

Engineering Takeaways

Project Mobility demonstrated several key engineering concepts.

- Importance of torque vs rotational speed
- Value of iterative prototyping
- Real-world drivetrain tuning
- Modular design improves testing flexibility

The project highlighted how mechanical design can transform existing components into practical real-world solutions.