DEPARTMENT OF MECHANICAL ENGINEERING

Frostburg Team 2
Get-A-Grip

Robert Moffett, Ryan Schlauch, Kiersten Shirey

A. JAMES CLARK SCHOOL OF ENGINEERING

Motivation, Goal, Impact

•Improving grip strength solely through rock climbing is expensive, time-consuming, and impractical
•Grip strength must be improved to prevent injury

Market Analysis
•Almost 10 million people climb each year

Solution
•Weight-adjustable grip strength trainer
•Trains eccentric grip strength, which is the main type of grip strength needed for climbing

Requirements

Safety
•Emergency shutoff switch
•User friendly interface

Force Transmission
•Smooth Linear Motion
•Minimize loss of energy through friction force

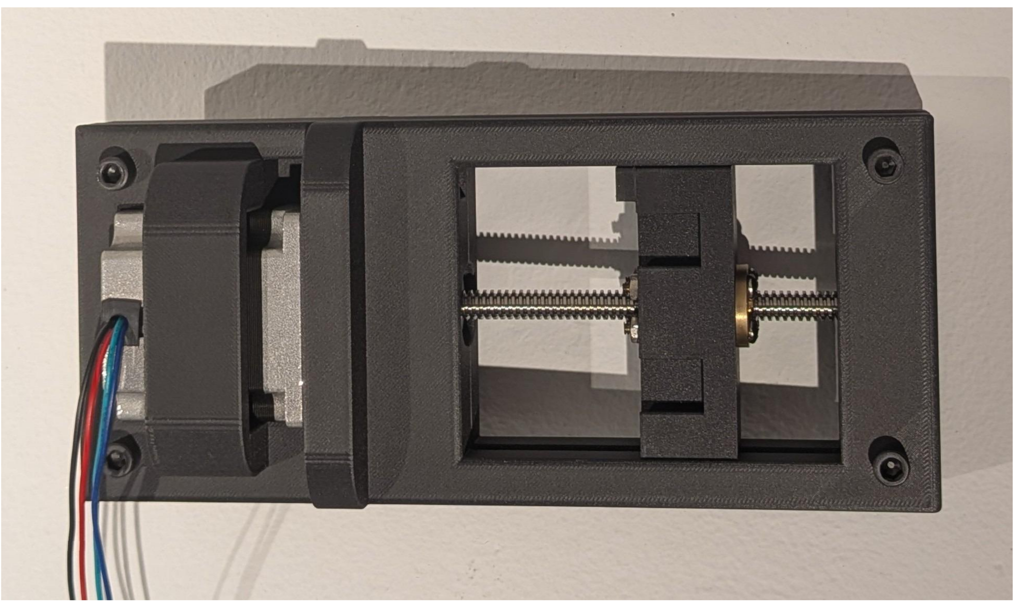
Structure
•Withstand cyclic loading
•Minimize deformation

Control and Power
•Programmable resistance
•Adjustable starting height
•Precise motion control
•Safety integrated into coding

Final Design

•Mechanical Components: Markforged Onyx 3D printed housing and grips, tr8x2 lead screw, 6.35mm to 8mm rigid coupler
•Electrical Components: NEMA 23 stepper motor, TB6600 stepper driver, buck converter, ELEGOO Mega 2560, Mega 2560 R3 shield board, push buttons, LCD1602 I2C 16x2 display module, 24V power supply
•Description: The final version of the prototype trains the users grip strength using a variety of hand grips. The user is able to adjust the speed of the motor from a standalone control panel. The mechanical housing also includes an emergency stop push button for safety.

Future Improvements:
•Reduce surface friction in walls
•Improve lead screw stability
•Improve mechanical housing connection



Design Calculations & Decisions

Calculations
•Motor step resolution:
$360°/1.8°$ per step = 200 steps/revolution
•Electrical input power:
$P = V \times I = 24V \times 2.8A = 67.2$ W
•Theoretical Maximum Axial Force:
$F_a = (2\pi T\eta)/p = (2\pi \times 1.26 \times 0.30)/0.002 = 1187.5$ N ≈ 267 lbf
•Ideal Force (No friction)
$F_i = (2\pi T)/p = (2\pi \times 1.26)/0.002 = 3958.41$ N ≈ 890 lbf
•Friction Force:
$F = F_i - F_a = (890 lbf) - (267 lbf) \approx 623$ lbf

Decisions & Analysis
•House of Quality (HOQ) analysis identified fail-safe coding, range of use, and maximum force as the most critical engineering characteristics for the design.
•A Pugh Chart was used to select the lead screw design from three proposed design ideas.
•Analytical Hierarchy Process (AHP) determined that safety and force were the most critical decision criteria, further validating the selection of the lead screw design.

Prototype & Test Results

•3D printed
•ABS filament
•Housing withstood force of motor at 300 RPM
•Grip withstood force of motor at 50 RPM