Design and Evaluation of a Propulsion Aid Device for Folding Wheelchairs

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Project Overview

Upper-body injuries caused by overuse from manual wheelchair propulsion is a common challenge that many wheelchair users face. While there are propulsion aid devices on the market, these devices are often expensive, increase the footprint of the wheelchair, or do not fulfill the necessary requirements for physical movement and accessibility. Our team sought to create a propulsion aid that would address these issues by improving ease of use, enhancing maneuverability, and engaging in sustainable prototyping processes.

Market Review

Classification	Evaluation of the Design
Push-rim controlled [1] 	•Difficulty traversing surfaces and obstacles •Difficult to visualize due to placement •Risk of upper body injuries is not entirely mitigated •Covered by Medicare •Cost: $6,600
Joystick controlled [2] 	•Device and accessories are heavy •Difficulty traversing surfaces and obstacles •Expensive and complicated electronics •Accommodates for wide range of user ability •Cost: ~$8,000
Tiller controlled [3],[4] 	•Most devices increase chair footprint and have a large turning radius •Increase traction on power-wheel for obstacle traversal •Attachment for placement behind footplates may require trunk control •Cost: $1,000-3,000

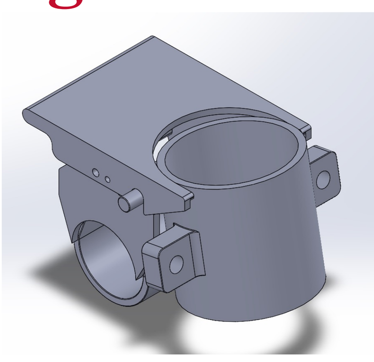
Prototyping

(a) Initial prototype of a mechanism in which attachment motion lifts caster wheels and locks in place using recycled materials
(b) Fixed attachment created for testing the power-column

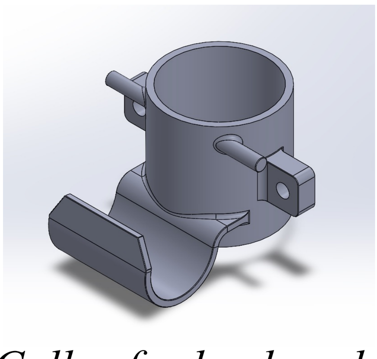
(a)

(b)

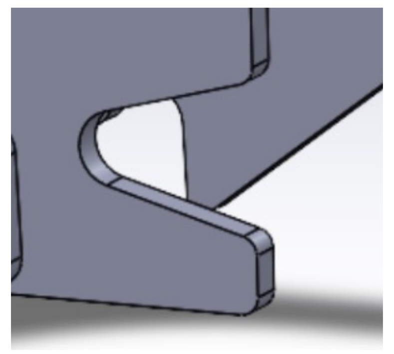
Design Iterations



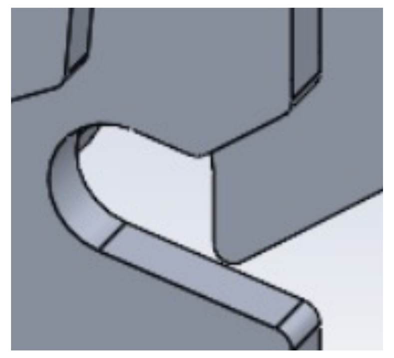
Hook and latch design



Collar for hook and latch design



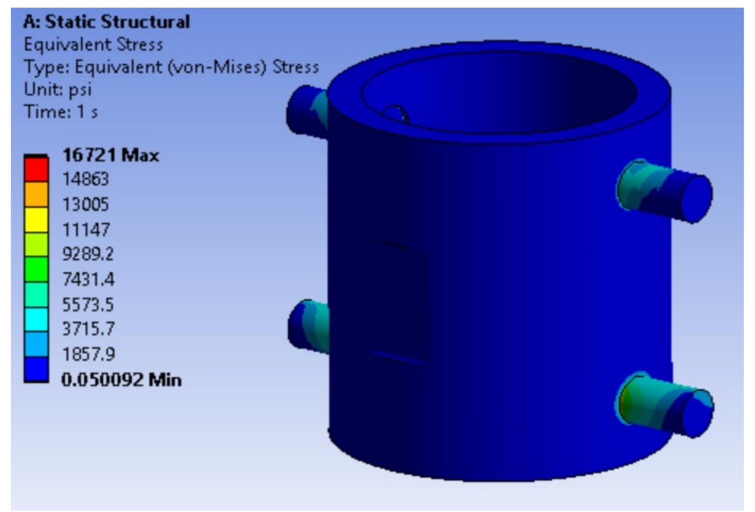
Original peg path



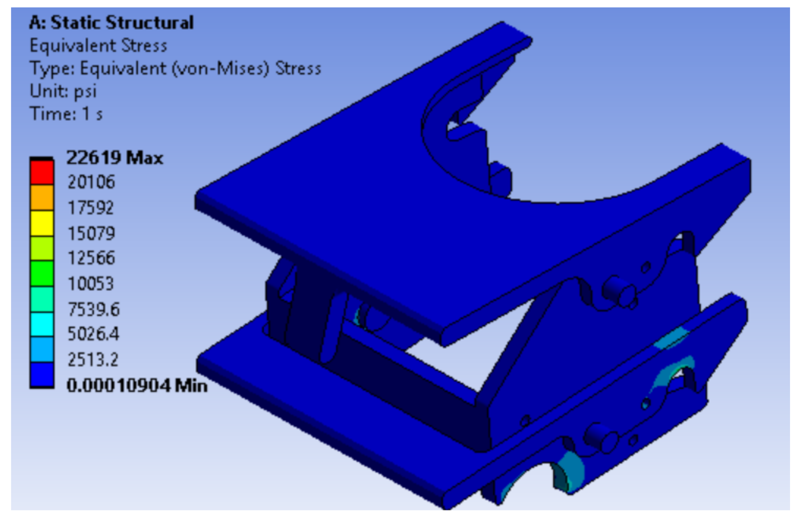
Final peg path for better force distribution

Finite Element Analysis

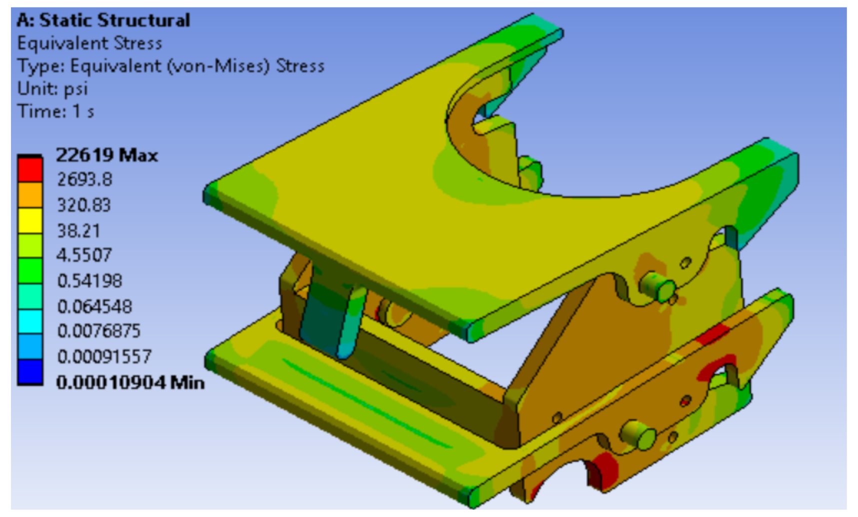
- 8 simulations accounting for different loading scenarios
  - Attachment system and individual components during stationary loading, moving forwards, and moving backwards
- Iterative process - implemented 6 design changes based on results



True scale simulation results for the collar during forward acceleration



True scale simulation results for the latch mechanism during forward acceleration

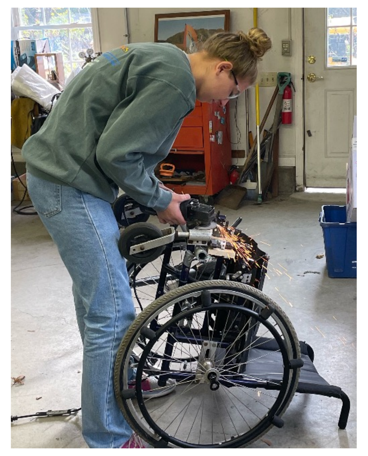


Logarithmic scale simulation results for the latch mechanism during forward acceleration

Manufacturing

CNC milling the latch tops

Crossbar and latch bottom after welding



Using hand-tools during assembly

Design Verification

Specification	Result
Must fit the wheelchair and device in a sedan trunk	Fail; semi-permanent crossbar was used
Must be able to fold without the use of tools	Fail; semi-permanent crossbar was used
Weight: ≤ 28.6 lbs [5]	Pass; 17.17 lbs
Force to operate latch: ≤ 5 lbs [6]	Pass; 1.86 lbs
Turn radius: 360° in a 5 ft circle [6]	Pass; 6 out of 9 attempts
Ramp angle: 7.125° for maximum incline length of 20 ft [6]	Pass; 8° for 120 ft incline length
Attachment angle: ≤ 30° with the ground	Pass; 60°
Weight Limit: 250 lbs [5]	Pass; driven with 250 lbs
Factor of Safety: 2.5–3.0 [7]	Pass; 2.835

Future Recommendations

- Telescoping crossbar allowing easy removal
- Better electronics and improved wire management
- Lighter battery and motorized wheel
- Create a bearing box with the geometry of the collar
- Improve the braking system

References

[1] "The SmartDrive Power Assist Drivec| RGK Wheelchairs." Accessed: Nov. 20, 2023. [Online]. Available: https://rgkwheelchairs.com/wheelchairs/power-solutions/smartdrive.html [2] "SPINERGY ZX-1," Rolling In Paradise. Accessed: Nov. 25, 2023. [Online]. Available: https://www.rollinginparadise.com/product-page/spinergy-zx-1 [3] "Firefly 2.5 Electric Scooter Attachment," Rio Mobility. Accessed: Apr. 10, 2024. [Online]. Available: https://riomobility.com/products/firefly-2-5-electric-attachment [4] "The UNAwheel Mini — Move Your Wheelchair in Style." Accessed: Nov. 20, 2023. [Online]. Available: https://livingspinal.com/products/unawheel-mini.html [5] "Quickie 2 Wheelchair | Authorized Quickie Dealer | DME Hub," DMEHUB.NET. Accessed: Feb. 27, 2024. [Online]. Available: https://www.dmehub.net/product-p/qui-184wm32.htm [6] "ADA Requirements: Wheelchairs, Mobility Aids, and Other Power-Driven Mobility Devices | ADA.gov." Accessed: Nov. 20, 2023. [Online]. Available: https://www.ada.gov/resources/opdmds/ [7] "Factors of Safety - FOS." Accessed: Feb. 27, 2024. [Online]. Available: https://www.engineeringtoolbox.com/factors-safety-fos-d_1624.html