



Combined Rear-Anti-Tip Device and Caregiver Push-Handle for Manual Wheelchairs

Introduction

Division of Physical Medicine & Rehabilitation

Dr. Kirby's goal is to create a product which serves as a combined rear-anti-tip device (RAD) and a caregiver push-handle for use in the QEII Rehabilitation Centre. His hope for the future is to expand the product to more hospitals and optimize it for personal use.

Project Scope

- This project has been conducted in two parts in the past: once for the RAD and once for the push-handle. The scope of this project is to integrate both devices in a single product.
- There are many fixed push-handles and RADs on the market, but the goal is to create a product which gives the user a range of adjustability options and helps caregivers comfortably push patients around.

Requirements

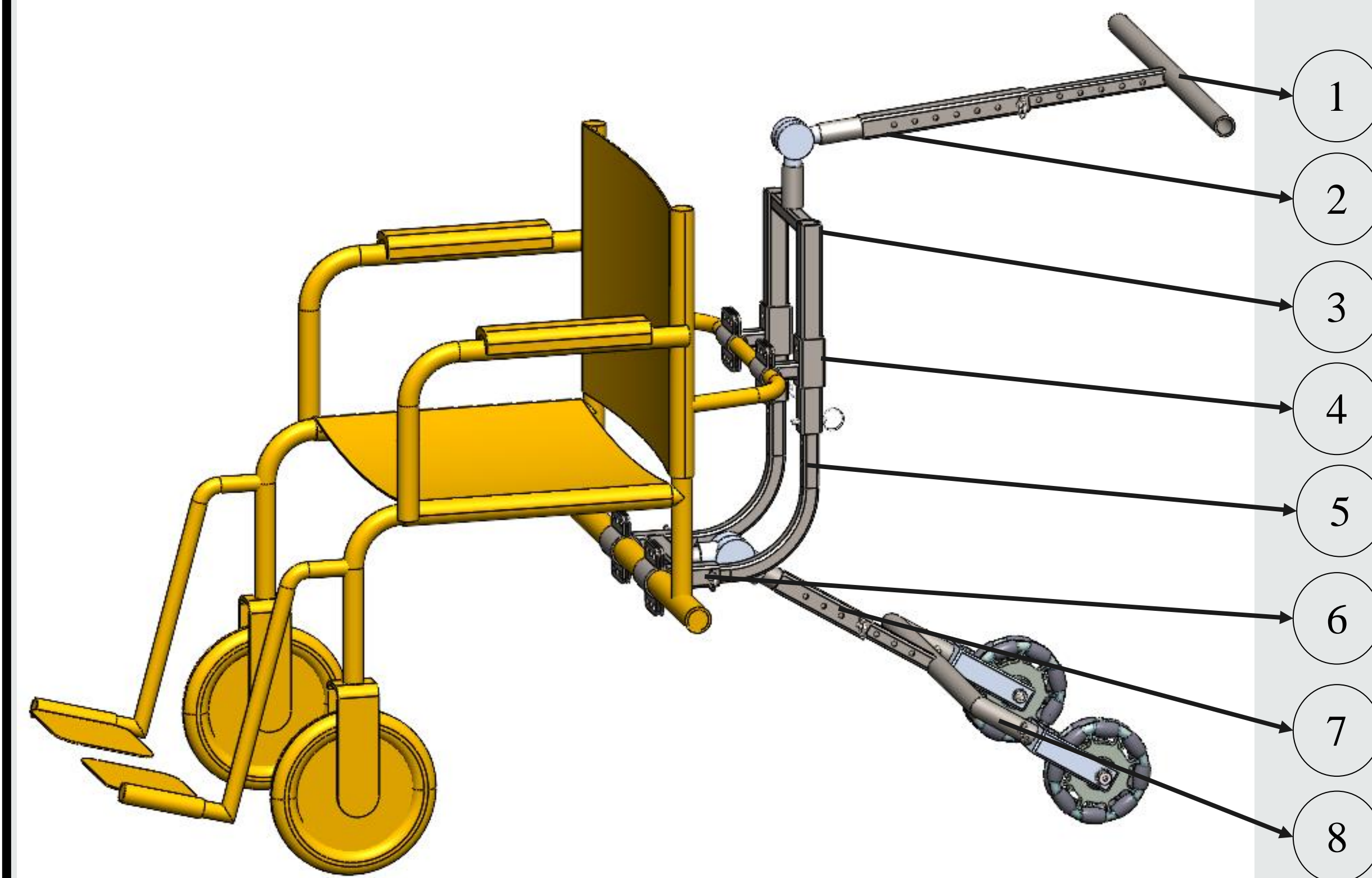
- Safely prevent rearward tipping of wheelchair to avoid injury for a person up to 200 lb.
- Allow the caregiver to adjust the angle of the RAD using a quick-release mechanism.
- Handle mechanism should not interfere with user's normal body movement.
- Successfully complete the Wheelchair Skills Test (WST) with the apparatus attached.

Design Process

- Researched previous RAD and push-handle designs.
- 3D modeled concept and conducted FEM analysis to verify loads were safe per requirements.
- Built prototype from PVC tubing to analyze caregiver ergonomics. Increased handle stem length and pivot height to avoid stepping into RAD.
- Changed design material from round tubing to square tubing to minimize machining time and improve alignment.
- Built and assembled the final design.
- Performed wheelchair skills test and shortened handle length for improved strength and maneuverability.



Design Details



ASSY. NO.	DESCRIPTION	QTY.
1	Handle	1
2	Handle Extension Post	1
3	Handle Fork	1
4	Rigidizer Bar Mount	2
5	J-Tube	2
6	Camber Tube Mount	1
7	RAD Extension Post	1
8	RAD	1

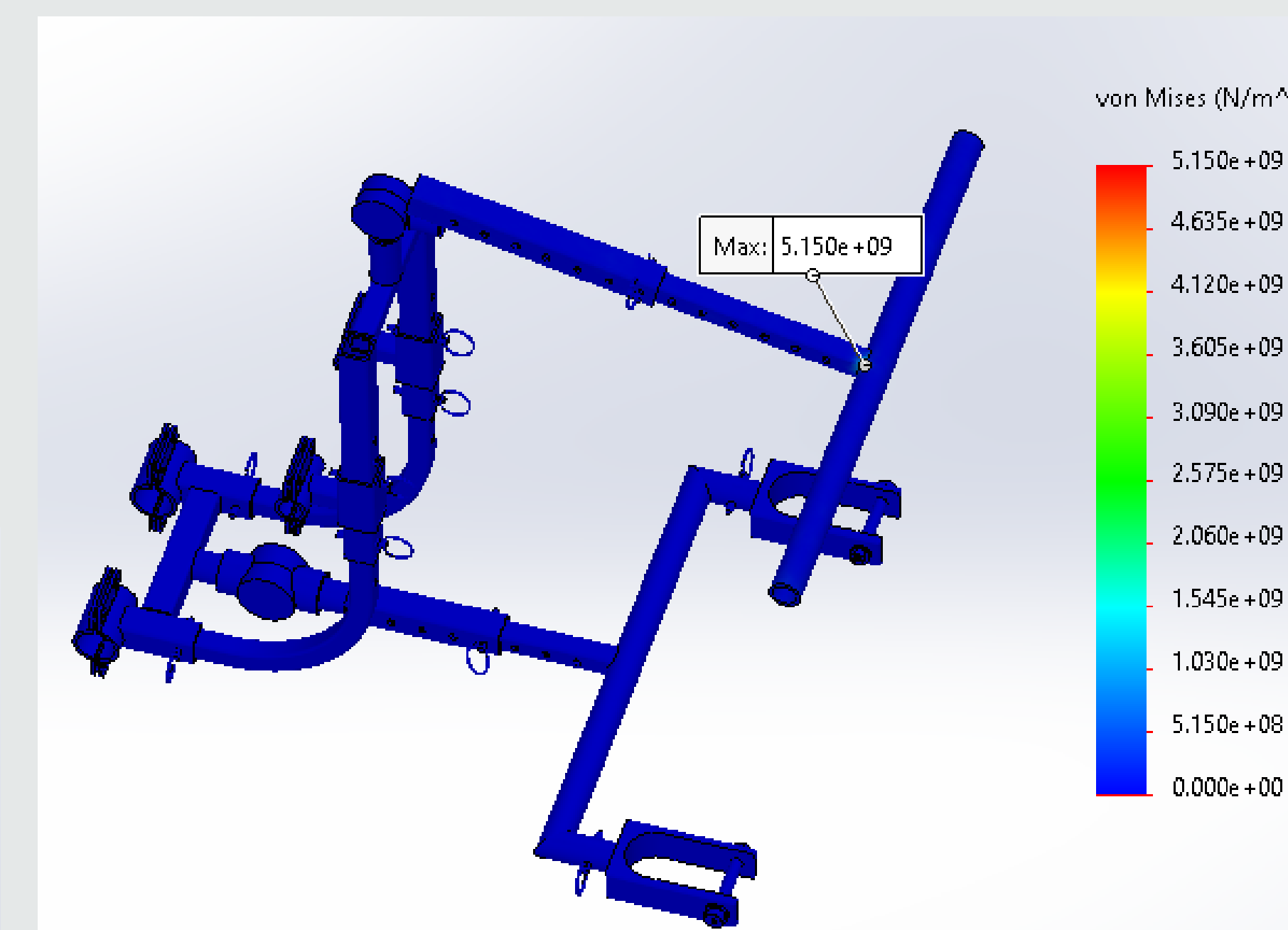
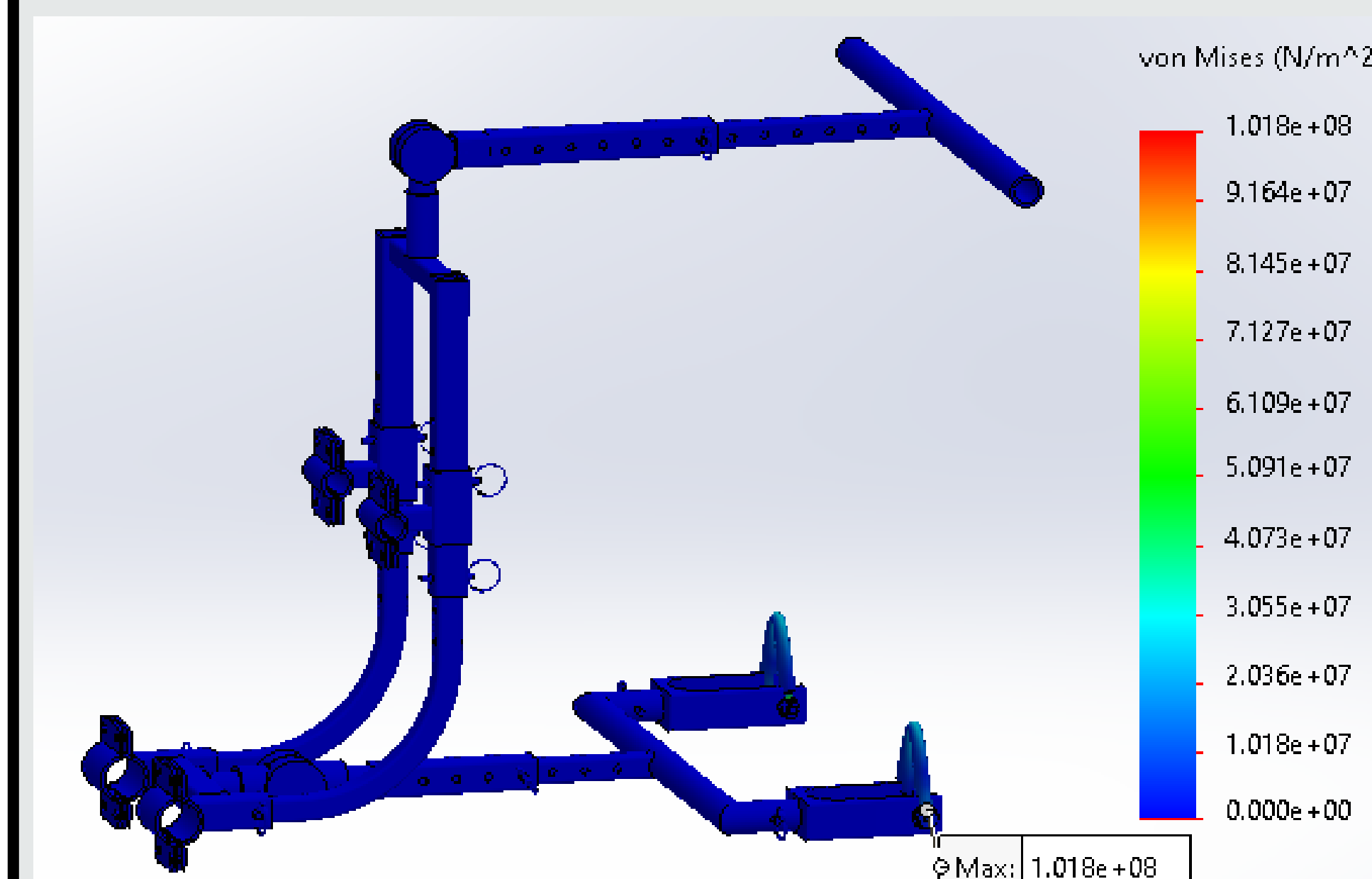


Design Features:

- 180° handle angle adjustability.
- 6" handle length adjustability.
- 90° RAD angle adjustability.
- 3" RAD length adjustability.
- All adjustments can be made "on the fly" using quick-release Hirth joints and pins.
- Quick detachment to allow wheelchair to fold

Push Handle Test:

- Max stress occurs at the connection between handle stem and handle.
- During testing the weakest point was found to be at the weld on the Hirth joint.



RAD Test:

- Max stress occurs at the Omniwheel shaft hole, which is less than the yield strength of its material.
- During testing the failure point was found to be at the stem of the Hirth joint.

Conclusion

Wheelchair Skills Test – Push-Handle

- Maneuverability of wheelchair by caregiver using push-handle was successful for the following tests:
 - Mount and dismount 10 cm curb
 - Push up and down incline (less effort with greater handle angle)
 - Wheeler up and down incline, as well as, on the spot
 - Ability for wheelchair user to move arms around unincumbered, such as when playing basketball
- The push-handle Hirth joint failed during the test of one wheel falling off the curb and the caregiver preventing the patient from falling sideways. This test was successful with a lighter patient and a shorter push-handle stem.

Wheelchair Skills Test – RAD

- Maneuverability of wheelchair by patient using the RAD was successful for the following tests:
 - Slow tipping with a light patient
 - Rolling back and forth in tipped position
 - Rotating in tipped position
- The RAD Hirth joint failed during the sudden fall test due to the high impact force. This test was successful with a lighter patient and a shallower RAD angle.

Recommendations

- Round tubing with tighter tolerance between nesting tubes for less lateral movement.
- Custom rotating joints with greater material strength to replace Hirth joints.
- Quick release clamps instead of pins for easy removal and assembly.
- Tempered aluminum with thicker sections instead of mild steel for similar strength and lighter weight.
- Wider camber tube mount and double stem for push-handle for greater strength.
- Ability of RAD mount to move along J-tube radius (tracks) for greater adjustability range.

References

- Kirby RL, Thoren FA, Ashton BD, Ackroyd-Stolarz SA. Wheelchair stability and maneuverability: effect of varying the horizontal and vertical position of a rear-antitip device. Arch Phys Med Rehabil. 1994 May;75(5):525-34. PMID: 8185444.