Team 8: Trains & Cheesecake

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Outline

Introduction
Problem Definition
Physics
Requirements
Key Milestones

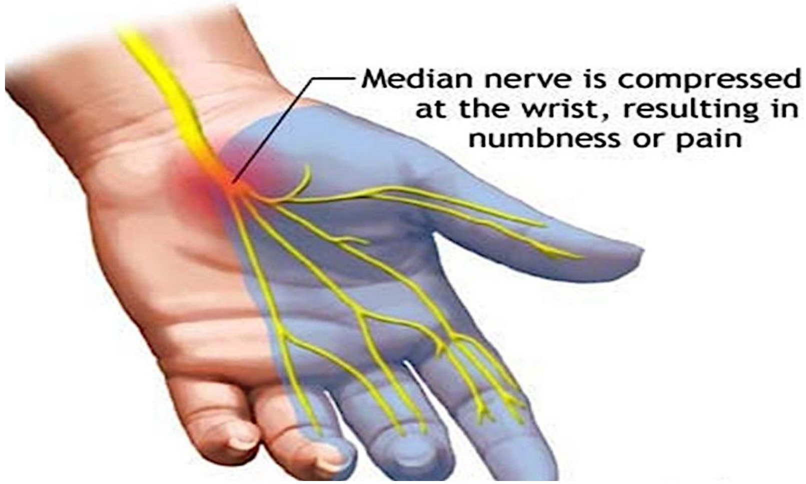
Discussion
FMEA
Problem Solving
Modern Tools
Validation

Design
Conceptual Design
Preliminary Design
Final Prototype

Conclusion
Performance
Lessons Learned
Summary
Questions?

Problem Statement

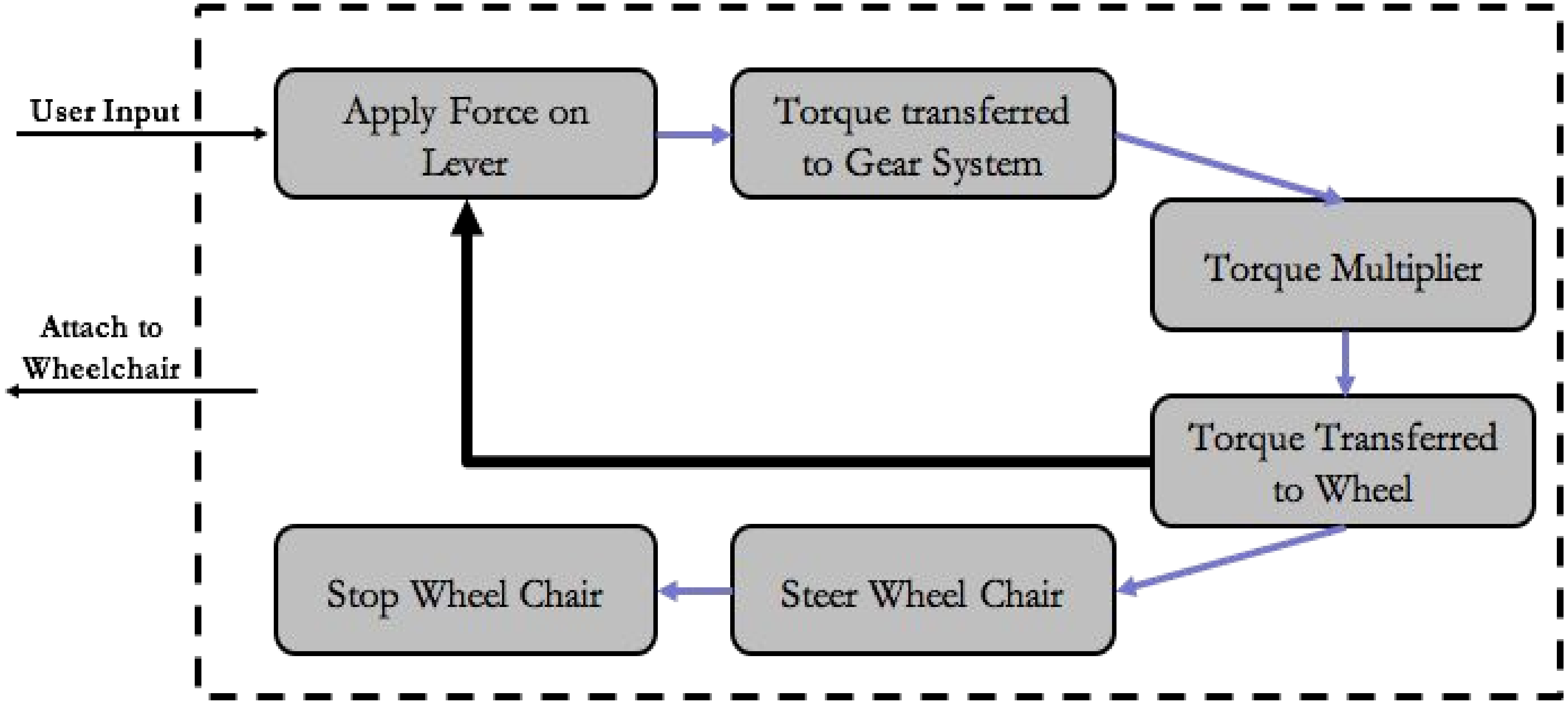
Modern wheelchair lack multiple modes of propulsion; currently models mostly focus on moving wheels using wrist motion. Causes repetitive stress injuries and suboptimal propulsion modes.



Consider…

- How to prevent injury to wrist from repetitive stress?
- How to allow users to climb slopes better?
- How to make wheelchair use for novice individuals easier?

Function Block Diagram



Function Block Diagram - Provide overview of product's functions to address and/or consider

Physics Development

$$T_{input} = 300Nm$$

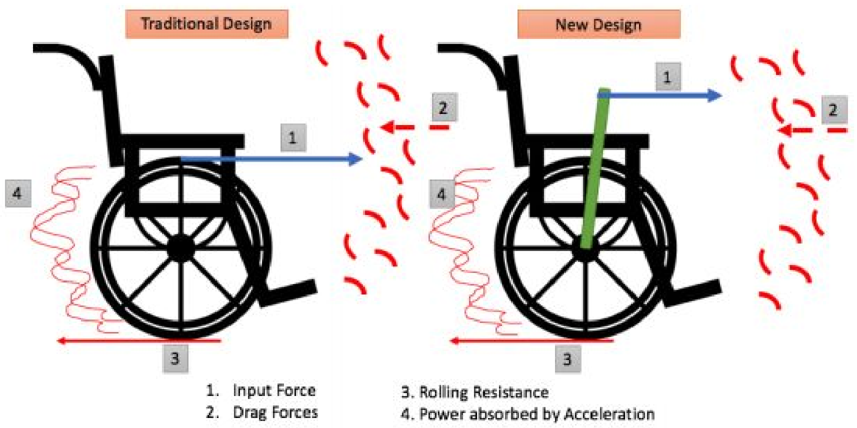
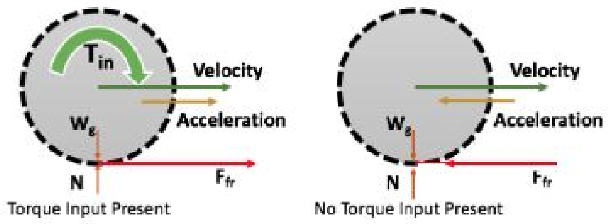


Figure 5.13: Defining Physics for Propulsion



***When Input Torque is present opposing torque from friction counteracts the moment. When no torque is present, the friction changes direction to prevent motion*

Figure 5.14: Defining Physics for Rolling with 'No-Slip'

1. Energy Equation Used to Compute power in vs. Power out

$$P_{Losses} = P_{Drag} + P_{RR} + P_{Translation} + P_{Rotation}$$

$$P_{Available} = P_{in} - P_{losses}$$

$$P_{Out} = \eta * P_{Available}$$

$$\eta_{new} = \frac{New\ P_{Available}}{P_{Out}}$$

2. Static & Kinematics equations used to calculate the acceleration of the system and th ed

$$F_1 R = T_{Normal} \qquad F_1 L = T_{New}$$

$$\frac{T_{Normal}}{R} = \frac{T_{New}}{L}$$

$$\Rightarrow \frac{N_1}{N_2} * L * \frac{T_{Normal}}{R} = T_{New}$$

$$\sum F_x = M A_{cc} = F_{friction}$$

$$\sum F_y = 0 = N - W$$

$$\sum M_{center} = T - F_{friction} * R = I * \alpha$$

$$A_{cc} = R * \alpha$$

$$A_{cc} = T * \left[\left(\frac{I}{R} + R * M \right)^{-1} \right]$$

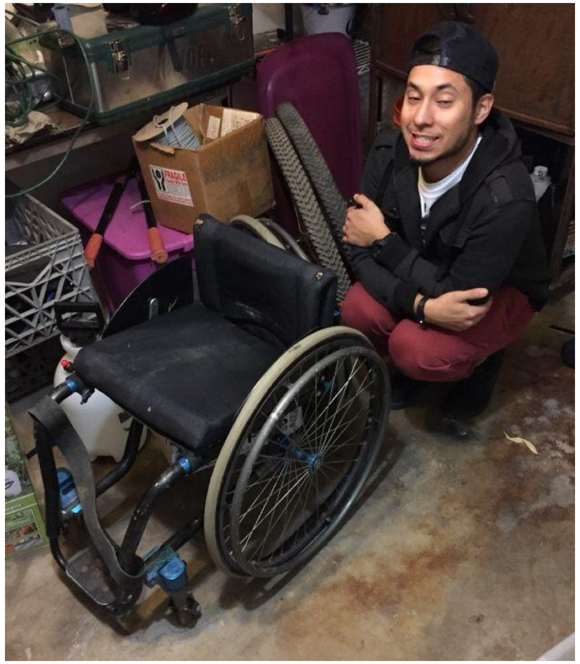
$$Distance\ Travelled = \frac{1}{2} A_{cc} t^2 + v_0 t + x_0$$

Requirements

Voice of the customer needs
Better propulsion efficiency
Gear Reduction
Compactable
Lighter weight
Durable
Safety

Requirements
Propulsion Efficiency
2x effective for trans
Usability
Durability
Tip angle
Lever Optimization
Weighs less than 10lb

Key Milestones

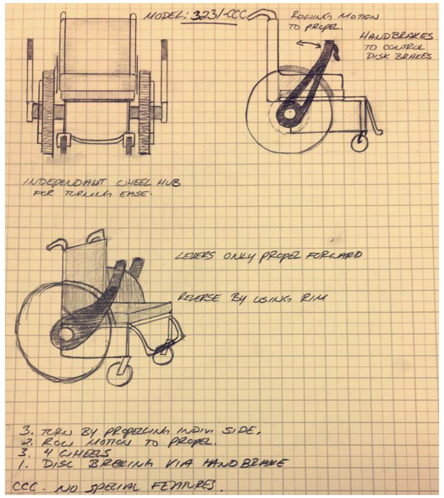


Wheelchair donation

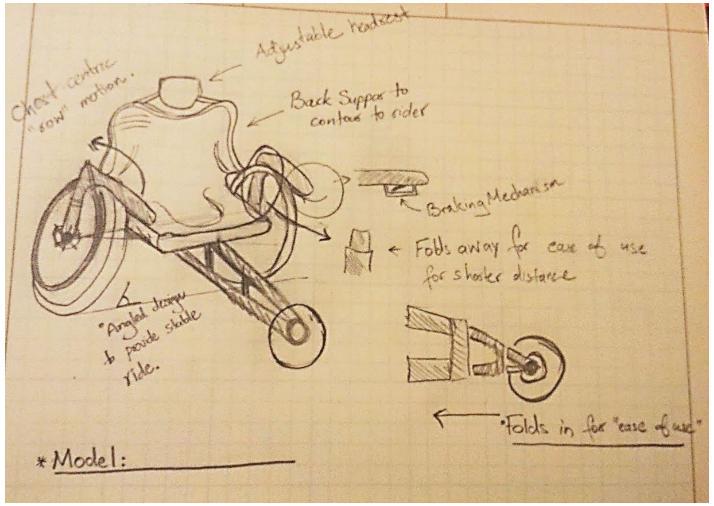
Left side drive

Major design modification

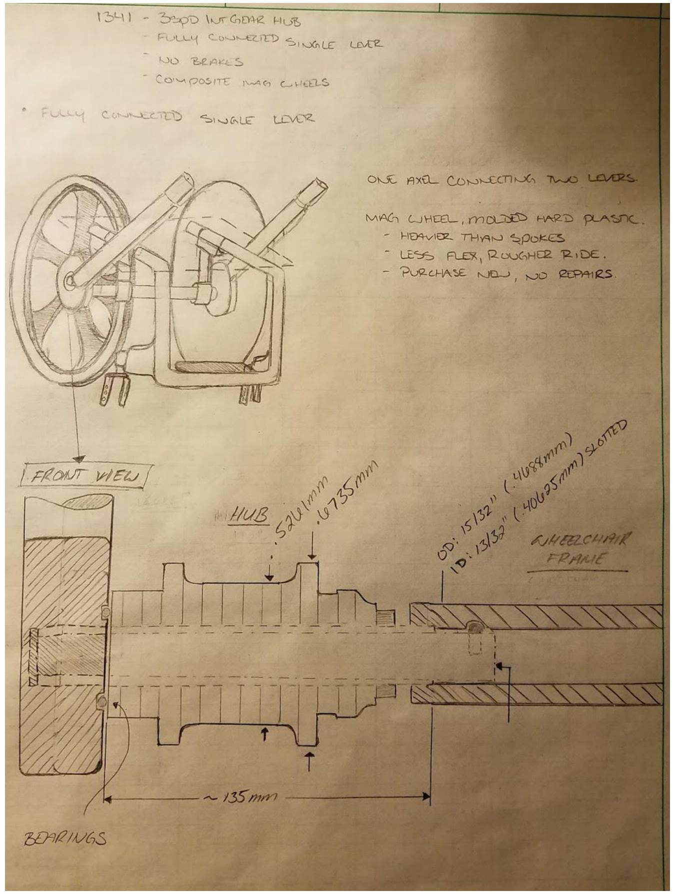
Conceptual Design



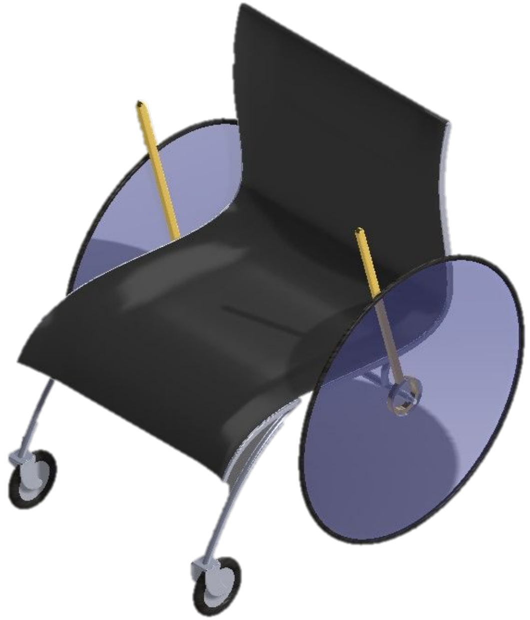
Model 3231-ccc



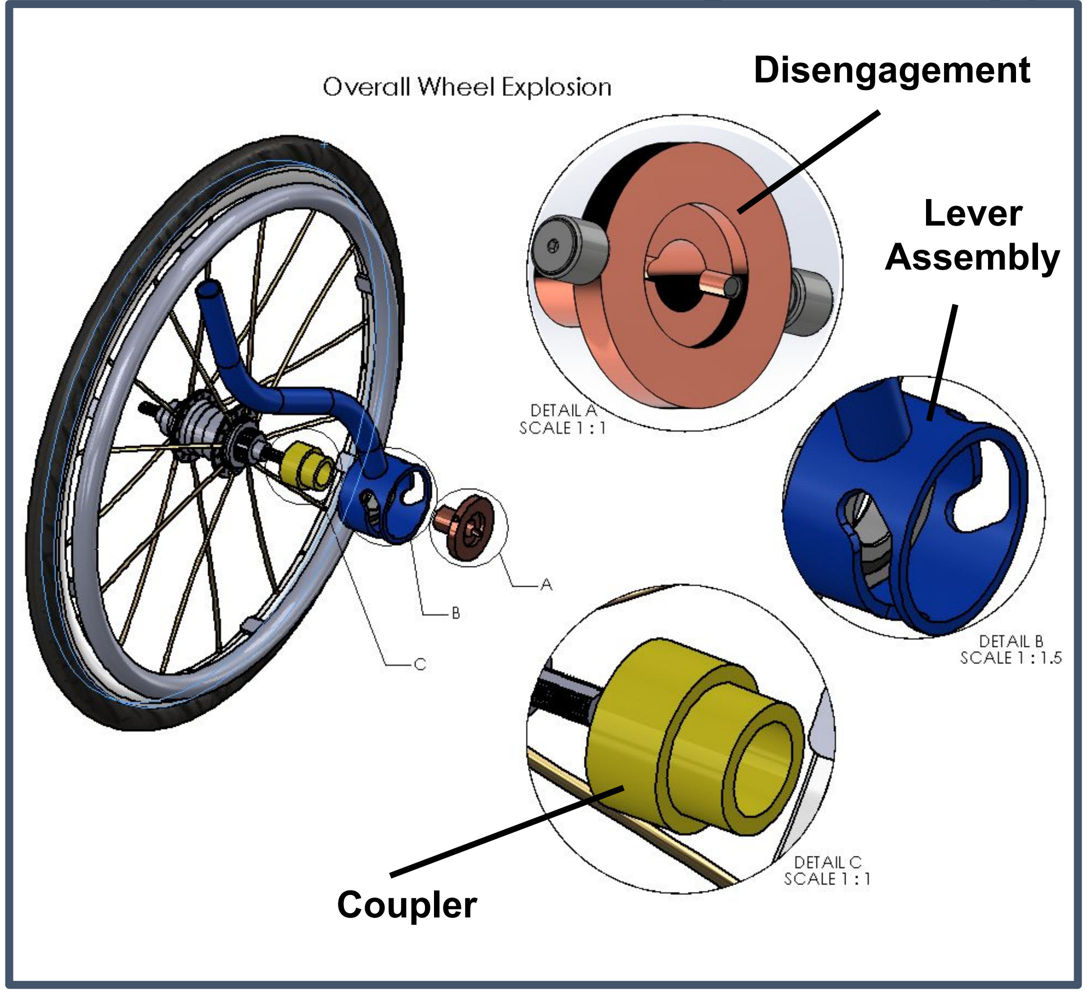
Model 3221-ccc



Model 1131-ccc

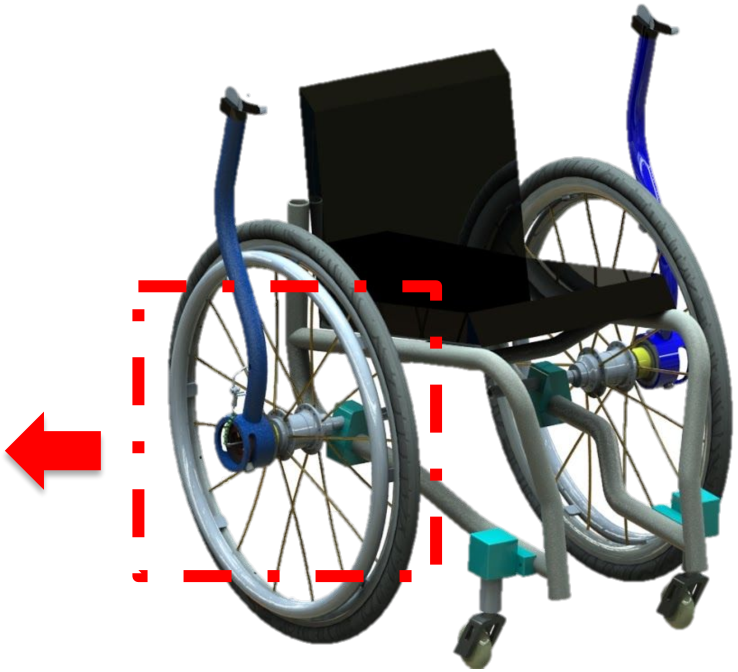


Preliminary Design



*Lever system has adjustable speeds based on gearing. The handle is hollow to have the wiring go through

Detailed Design



Final Prototype

Failure Mode Effect Analysis (FMEA)

#	Part Name	Function	Potential Failure Mode	Potential Failure Effect	SEVERITY	Potential Causes/Mechanisms of Failure	OCCURANCE	Current design Controls	DETECTION	RPN	Recommended Actions	Responsibility & Target Completion Date	Action Results: Action taken	pS	pO	pD	prpn
1	Lever	Method for introducing energy into the propulsion system.	Structural Failure; Bending or Breakage of lever	Immobility, Pinch point created, User's safety is endangered	8	Sheer stress exceeds yield stress of material due to excessive tnagential load	5	Physical inspection.	2	80	Design Change to eliminate stress concentration. Choose material with appropriate /high	Steven 02/10/2017	Redesigned Lever and choose better material.	8	4	2	64
3	Axel support	Helps as supporting componet & imparts rigidity to structure stability.	Structural failure, bending and sheering	Fracture leading to dislocation of structural components which in turn leads to mechanical and structural	10	High impact loading at site by external forces	4	FEA analysis for loading.	3	120	Redesign to resist stress fracture and increase FOS	Jessi 3/10/17	Choose materials with high yeild stress and conducted effective	8	4	2	64
4	Tires	Acts as point of contact with ground. Allow for acceleration, cornering and braking whatever	Puncture and wear	Inability to operate vehicle effectively vehicle & drivers safety compromised	6	Sharp object penatration, constant use	8	Visual Inspection	3	144	Restore tire pruessure.	All 3/10/17	none	6	7	2	84
5	Rim	it makes up the outer circular design of the wheel on which the inside edge of the tire is mounted to the	Mechanical failure	Inability to operate vehicle, vehicle & drivers safety compromised	10	Damage by hight impact or excessive loadings	4	FEA analysis for loading.	7	280	Verification of proper specification and testing	All - 03/15/17	varified specification s with ANSYS	8	3	5	120
6	Bearing	reduces friction & constrains motion between moving	Mechanical Failure, wear out.	Deterence to steering &/or vehicel motion.	8	Lubrication loss, contamination, improper mounting etc	4	FEA analysis for loading.	6	192	Proper Lubrication and Check alignment & provide Shielding.		varified specification s with ANSYS	6	3	4	72
7	Gears	Alter power input	Bending or grinding of gears.	Failure to propel wheelchair.	8	grinding of gear teeth, improper alignment of gears.	3	FEA analysis for loading.	4	96	Check for alignment, Lubrication & use material of higher strength & wear	Jessi - 03/15/17	varified specification s with ANSYS	6	2	3	36
8	Wheel	Roates on Axle bearing, moves wheelchair.	Bending, Breakage and structural failure due to excessive or	Failure to move wheelchair. Damage to driver & wheelchair in undesired	8	Yeilding / Bending of Wheel rim or spokes	4	Visual Inspection	3	96	Modify the wheel design to eleiminate stress concentration. & increase F.o.S	Jesse - 03/15/17	Redesigned Wheel (Spokes) & Increased FOS.	6	3	2	36

Failure Mode Effect Analysis (FMEA)

9	**Lever Tube**	Method for introducing energy into the propulsion system.	Structural Failure; Bending or Breakage of lever	Immobility, Pinch point created, User's safety is endangered	7	Sheer stress exceeds yield stress of material due to excessive tnagential load	6	Physical inspection. laboratory test Under worst case	5	210	Design Change to eliminate stress concentration. Choose material with appropriate /high	All - 03/15/17	Redesigned frame & Increased FOS.	5	5	4	100
10	**Disengagement Support**	Helps as supporting componet & imparts rigidity to structure stability.	Structural failure, bending and sheering	Disengagement fracture leading to dislocation of structural components which in turn leads to mechanical and	8	High impact loading at pin site by heavy user	4	Laboratory test for gradual & Impact Loading.	5	160	Redesign componet diameter to resist stress fracture and increase FOS	Thomas - 03/15/17	Choose materials with high FOS; Effective design and analysis	6	3	4	72
11	**Coupler**	Connects lever to internal gear hub	Structural failure, bending and sheering	Failure to move wheelchair, user injury	8	High loading and collison	3	Physical and Visual inspection.	7	168	Design Change to eliminate stress concentration. Choose material with appropriate /high	All - 03/15/17	Choose materials with high FOS; Effective	6	2	5	60
12	**Roller**	Disengages lever from coupler	Structural failure, bending and sheering, Mechanical Failure, wear	Failure to disengage lever, and use wheelchair normally	8	High loading and collison, frequent use	3	Physical and Visual inspection.	6	144	Design Change to eliminate stress concentration. Choose material with appropriate /high factor of safety(FOS).	Jessi - 03/15/17	System redesigned & Roller modified/lub ercation.	6	2	4	48
13	**Spring**	**Removed from Part during Preliminary design**			7					0							0
14	**Fixed gear hub**	To give the user a mechanical advantage through	Structural failure, bending,	Failure to move wheelchiar	8	High loading, collison, wear, and enviromental affects	2	Laboratory test for gradual &	3	48	Design wheelchair so that hub is protected for	Jessi - 03/15/17	Designed a type of housing for	6	2	2	24
15	**Wheel Nipples**	Connects Rim with each spoke	Bending, Rust or Surface Tear	Separation of Spoke and Rim, Failure to move	6	High Loading, Proper material not chooses, Environmental effect.	3	Visual Inspection	6	108	Change to alloy nipple as against brass.	All - 03/15/17	Material Change action taken.	4	2	4	32
16	**Spokes**	Connects wheel hub to spkes.	Structural Failure; Bending.	Flaiure to move wheelchair, Risk of injury to driver.	6	High Loading, Collision and Impact Loading.	5	Lab test for strength, Visual Inspection	3	90	Increase F.o.S and Modify to use more spokes per unit load.	All - 03/15/17	Redesigned, And Number of spokes increased	5	4	2	40

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Problem Solving Example

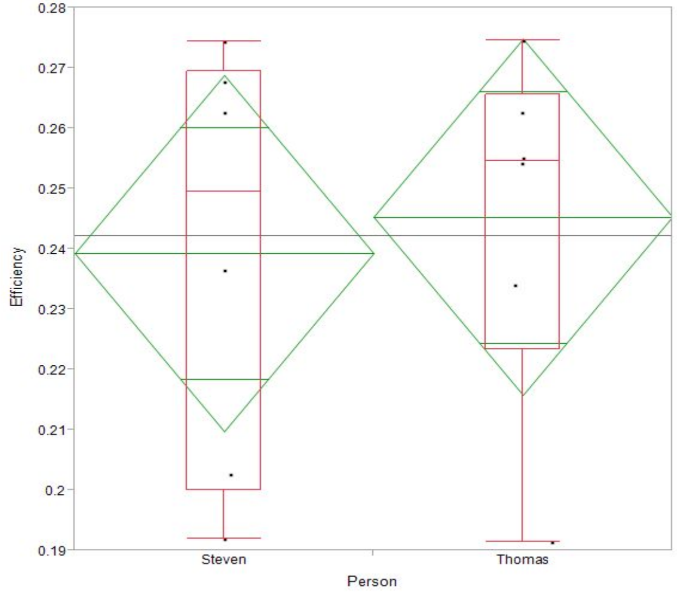
Problem:

- Conceptual design phase
- Determined current common internal hubs only work in one (1) direction

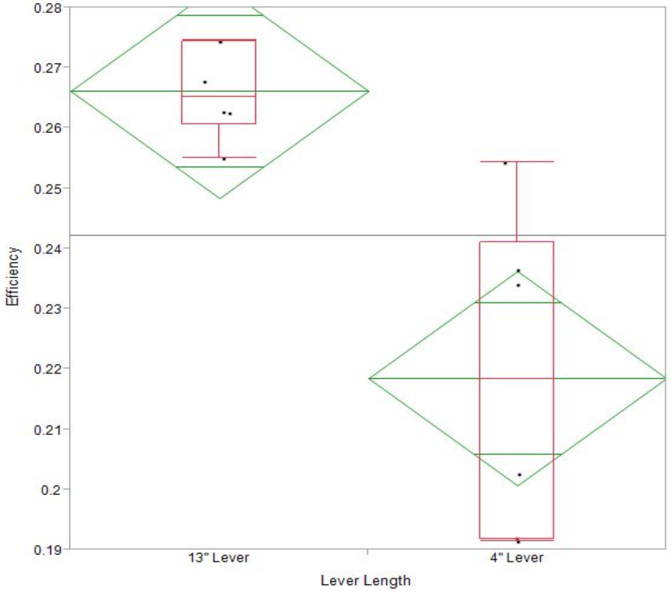
#1: Accommodating Traditional Hubs; Re-design of left side with multiple gears	#2: Research specifications for different hubs to integrate into design	**#3:** Design entirely new internal hub
Pro: Cheap; Available variety	Pros: continuing forward with design determined	Pros: extensive application of design skills
Con: Timing affecting fabrication & re-designing	Con: Expensive; Adjusted accordingly	Con: amount of time; complexity of solution; level considered a whole other capstone project

Example Testing: Proof of Concept

Propulsion Efficiency:
Testing the Efficiency of Power in (Calories) to Power (Out) - Watts Produced

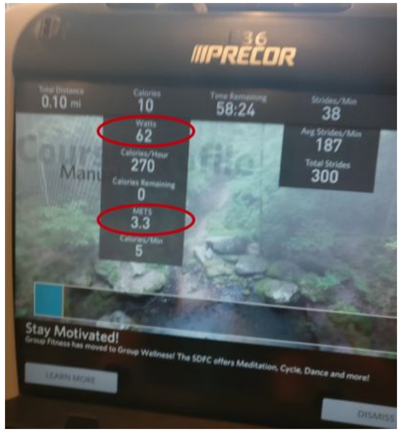


Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Person	1	0.00010924	0.000109	0.1036	0.7541
Error	10	0.01054080	0.001054		
C. Total	11	0.01065004			



Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Lever Length	1	0.00682481	0.006825	17.8416	0.0018*
Error	10	0.00382522	0.000383		
C. Total	11	0.01065004			



(b) Test-user Low & High Position

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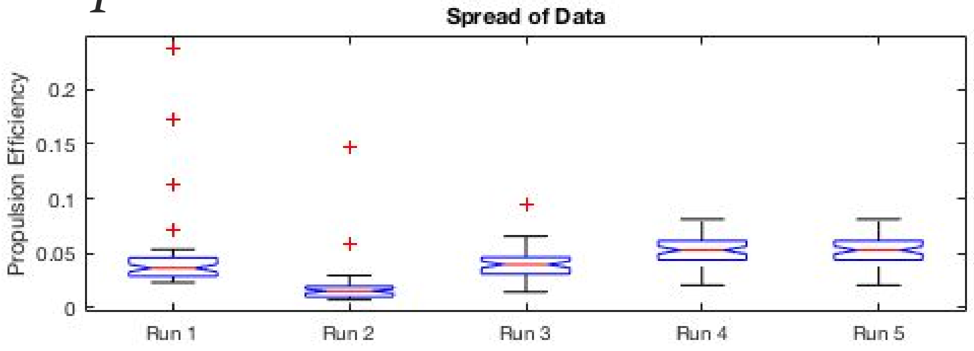
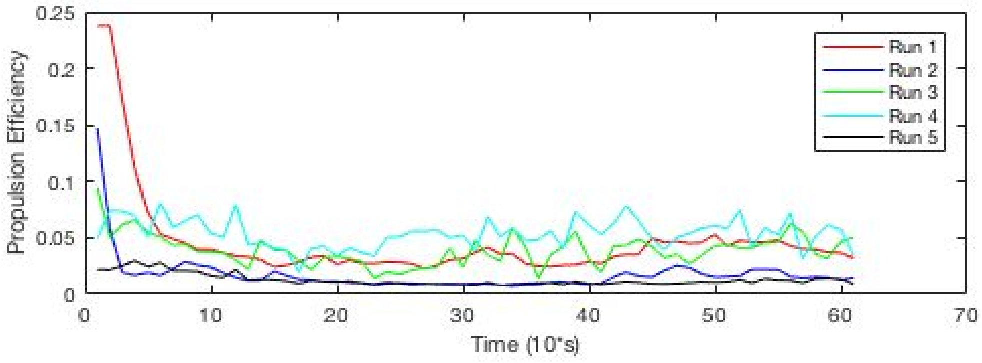
Example Testing:

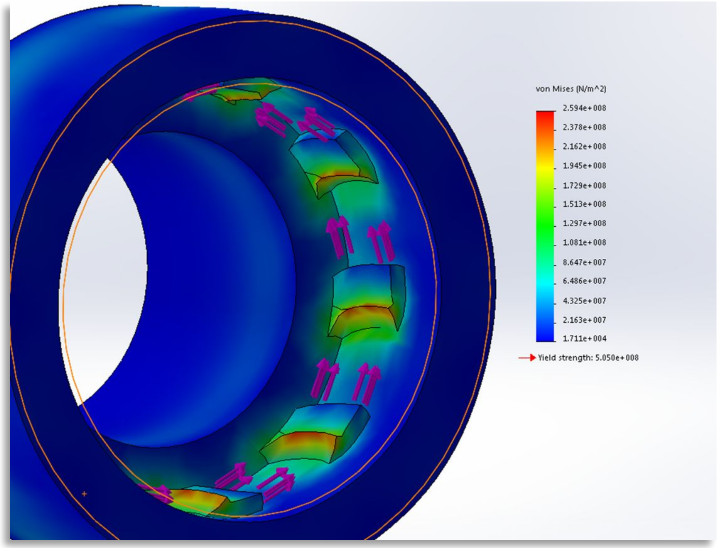
Propulsion Efficiency:
Testing the Efficiency of Power in (Calories) to Power (Out) - Watts Produced – *In process*





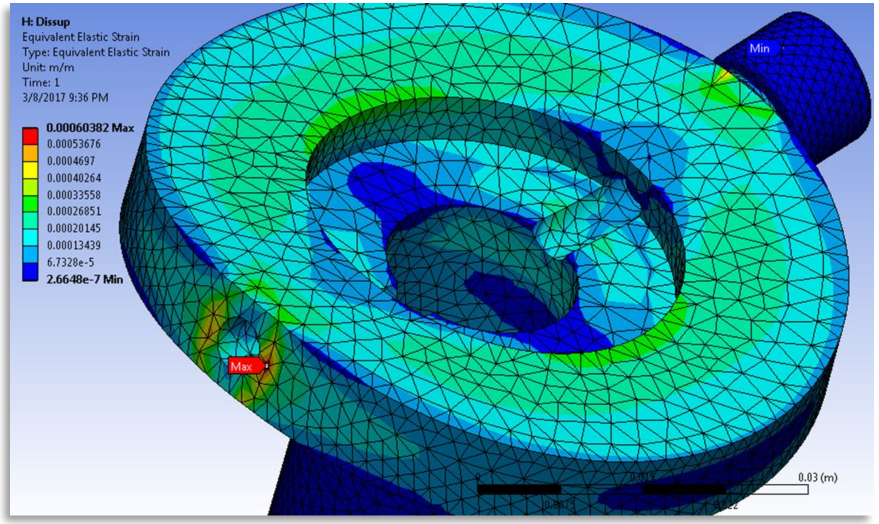
	Grand Population	1	2	3	4	5
Mean	0.034076663	0.046591	0.017827	0.0391722	0.0537143	0.013077625
STDDev	0.027224142	0.041356	0.018350	0.013826	0.012902	0.00527

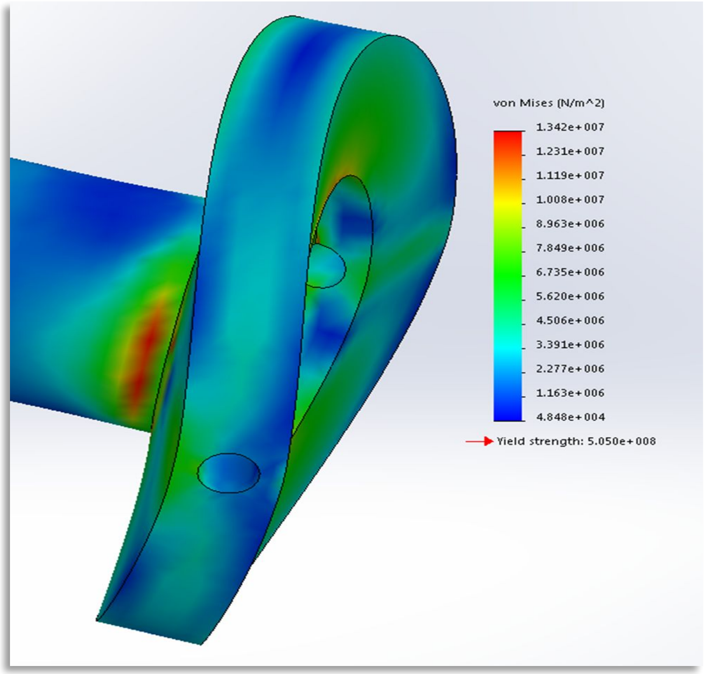
$$P_{out} = I\omega\alpha$$
$$P_{in} = Calories$$

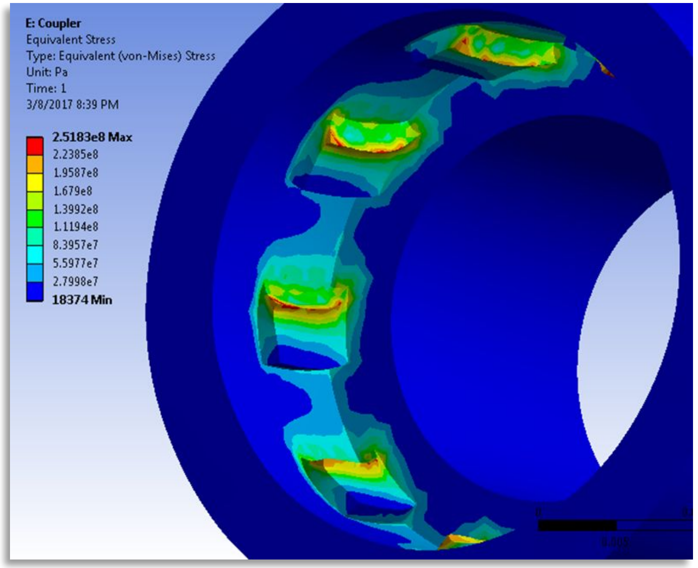


Modern Tools

ANSYS and Solid Works

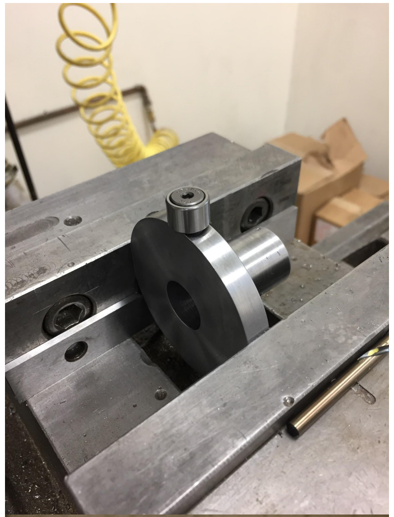


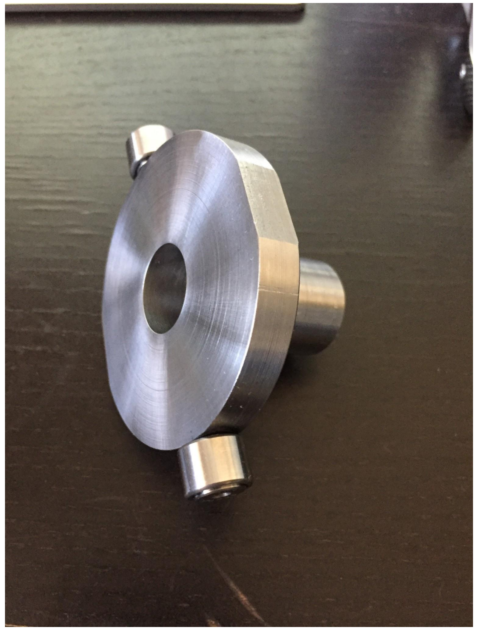




Modern Tools

Manufacturing

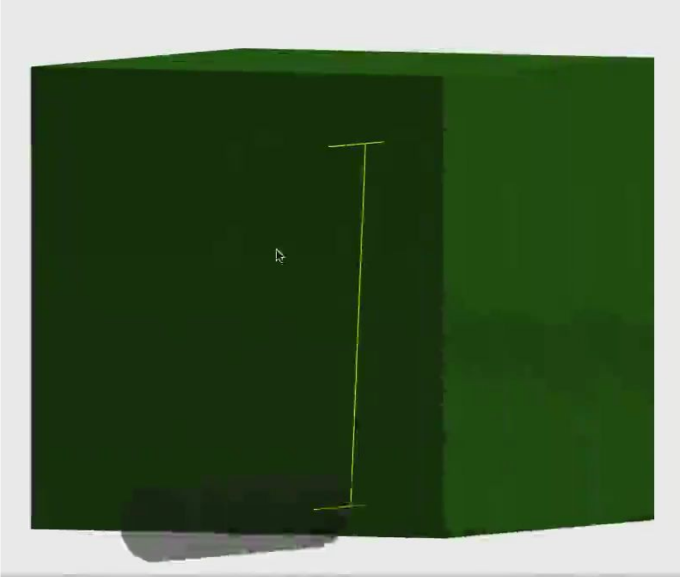


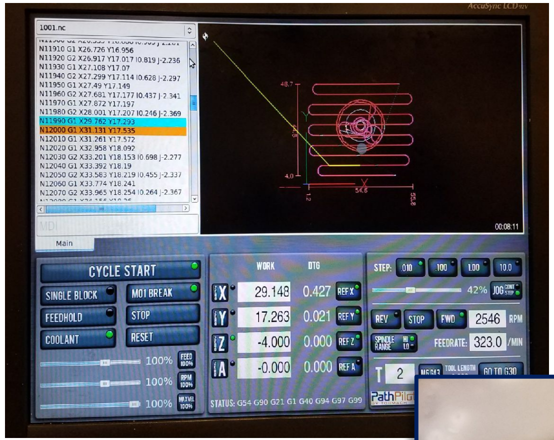


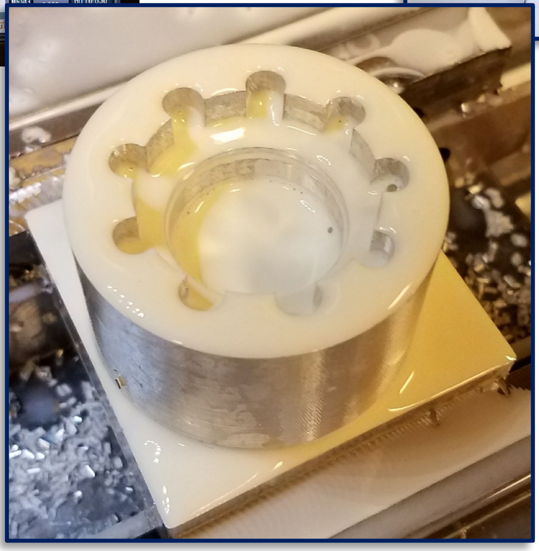
- ➢ Mill
- ➢ Lathe
- ➢ Welding

Modern Tools

Fusion 360 and Tormach (CNC machine)







- SolidWorks (CAD)
- AutoDesk Fusion (CAD)
- Autodesk CAM tools (CAM)

Validation

No.	Requirement	Method of Validation	Testing	Validation Status
1a	Propulsion Efficiency ≈ 20%	Hand Calculations	Use Engineering Equations	Complete
1b	Propulsion Efficiency ≈ 20%	Physical Testing	Heart beat and Caloric usage vs Energy Input	Incomplete
1c	Propulsion Efficiency POC	Physical Testing	Elliptical Lever Test	Complete
2a	New design is 2x as effective for transportation	Hand Calculations	Use Engineering Equations 1:1	Complete
2b	New design is 2x as effective for transportation	Hand Calculations	Use Engineering Equations for Hub specific	Complete
2c	New design is 2x as effective for transportation	Physical Testing	Slope-Multiplier Loading Test	*Removed
3	Usability and Everyday Use	Physical Testing	Functional Testing in a Building and Class environment	Complete

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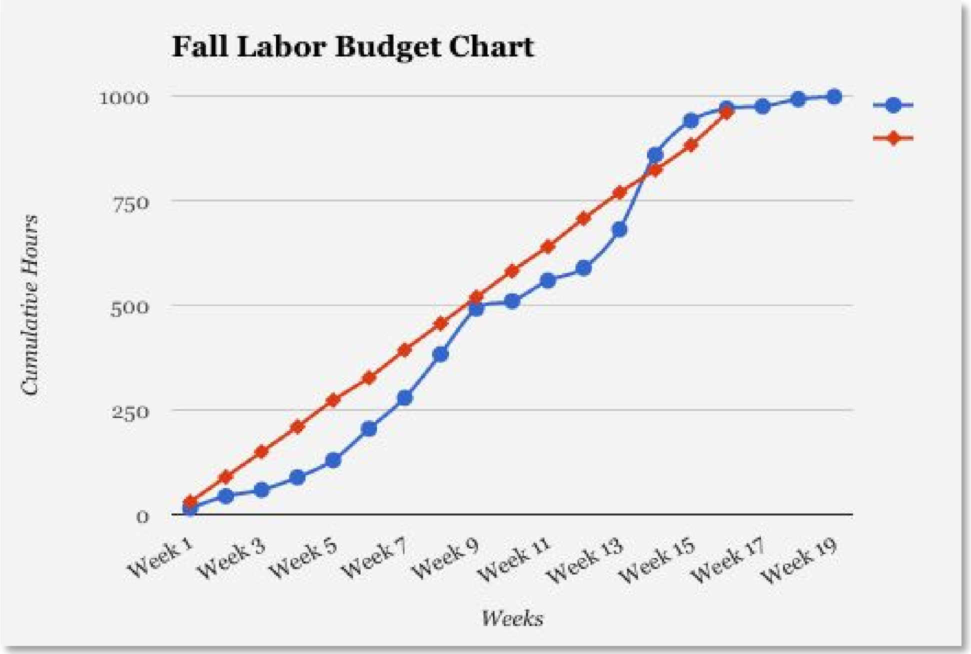
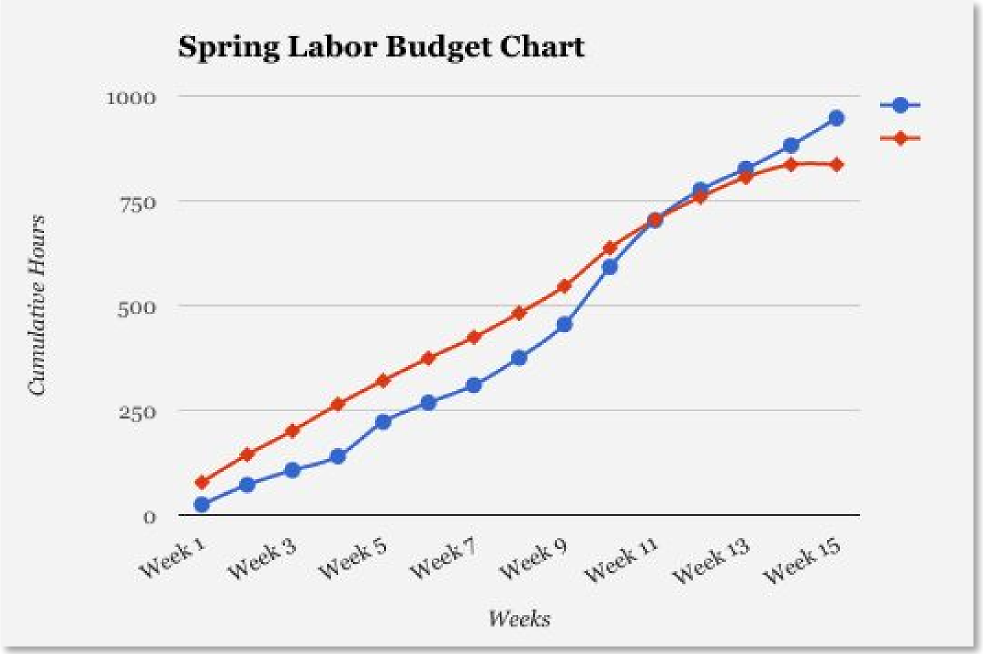
Validation cont.

4a	Durability and Strength	ANSYS	Load to last 50,000 cycles	Complete (Axel-fails)
4b	Durability and Strength	ANSYS	Withstand 300N force applied to Lever	Complete
4c	Durability and Strength	ANSYS	Withstand 200 lbs. Sitting	Complete (100 lbs.)
5a	Tip and Tilt Measure	Solid Works	Find Center of Mass and Angle from vertical	Complete
5b	Tip and Tilt Measure	Physical Testing	Tipping Angle Test as mentioned in ISO 7176-1	Complete
6	Lever Optimization Test	Physical Testing	Member Test Cases for comfort	Complete
7	Remain Under Budget > $600	Final Receipts	(none)	Complete ($698.17)
8a	Physical product less than 10 lbs.	Solid Works	Weight Feature	Complete
8b	Physical product less than 10 lbs.	Physical Testing	Weigh the prototype	Complete (9.834 lbs.)

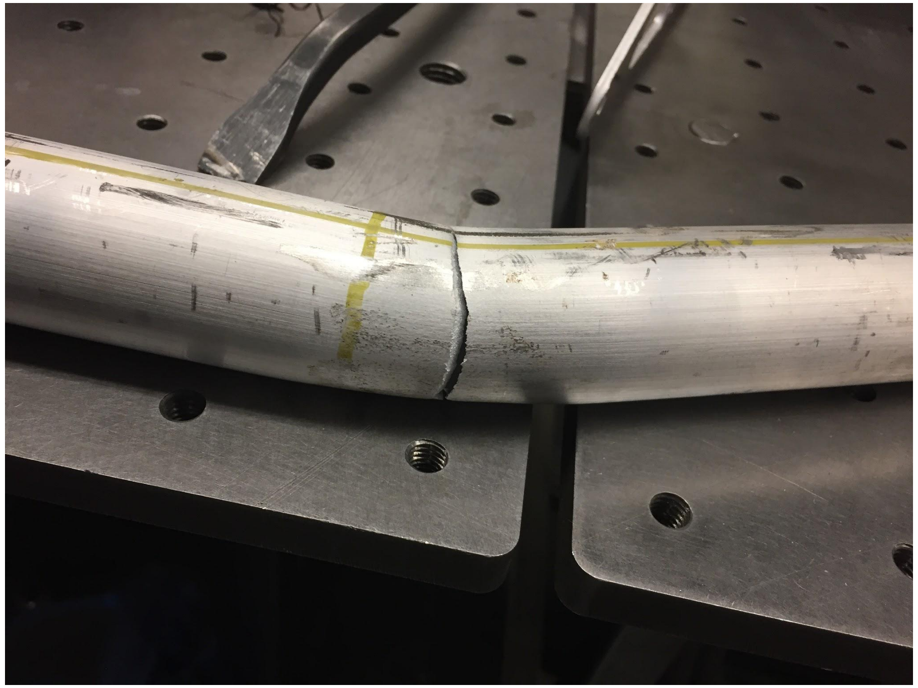
Performance



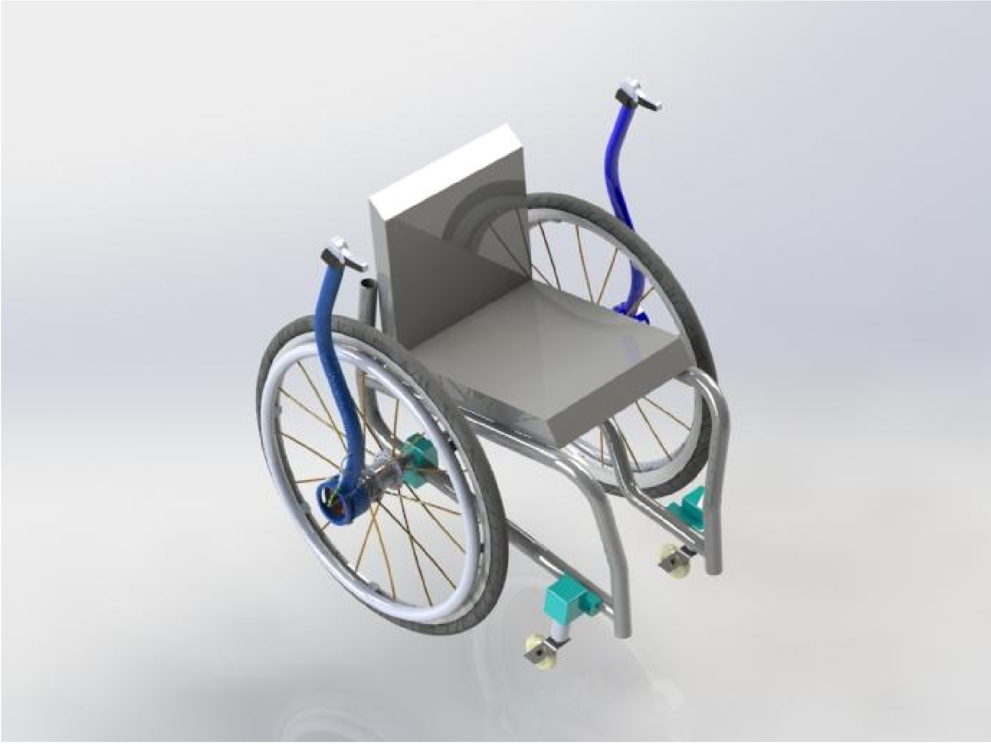


Lessons Learned

- Time Management
- Communication
- Manufacturing Techniques
- Testing Development



Summary



- Problem Statement
- Project Planning
- Design
- Testing
- Manufacturing
- Project Management

Questions?

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