Improved Mobility Device

Team 526 - DR6
April 4th, 2019

Every step matters

Team Introductions

Michael Beech
Design Engineer

Dionsse Carti
Systems Engineer

Chase Craft
Material Engineer

Leah Fiedler
Project Manager

Sponsor and Advisor

FAMU-FSU Engineering

<u>Sponsor</u>
Michael Devine, Ph.D.

<u>Advisor</u>
Christian Hubicki, Ph.D.

Objective

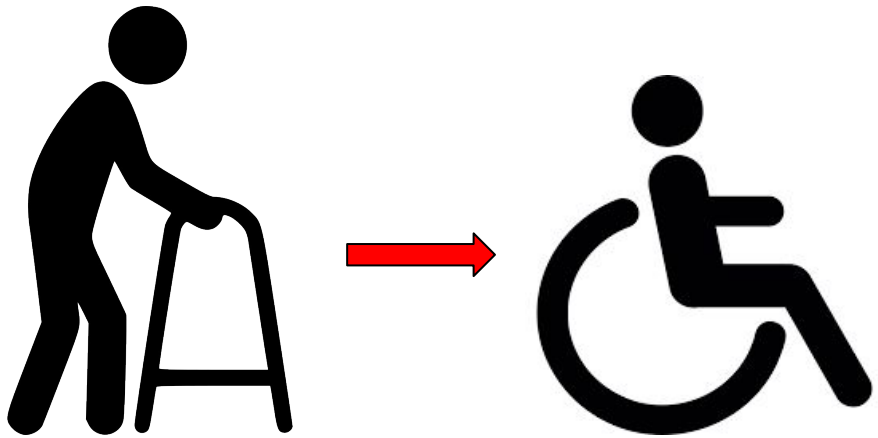
- Design an assistive mobility device that improves upon the capabilities of current mobility devices on the market.
  - Weight Reduction
  - Natural Gait Variation
  - Adjustability

Background

According to the U.S. Census Bureau:

- 3.6 million people in the U.S. over the age of 15 use wheelchairs
  - 11.6 million use a cane, crutches, or a walker
- 2 million new wheelchair

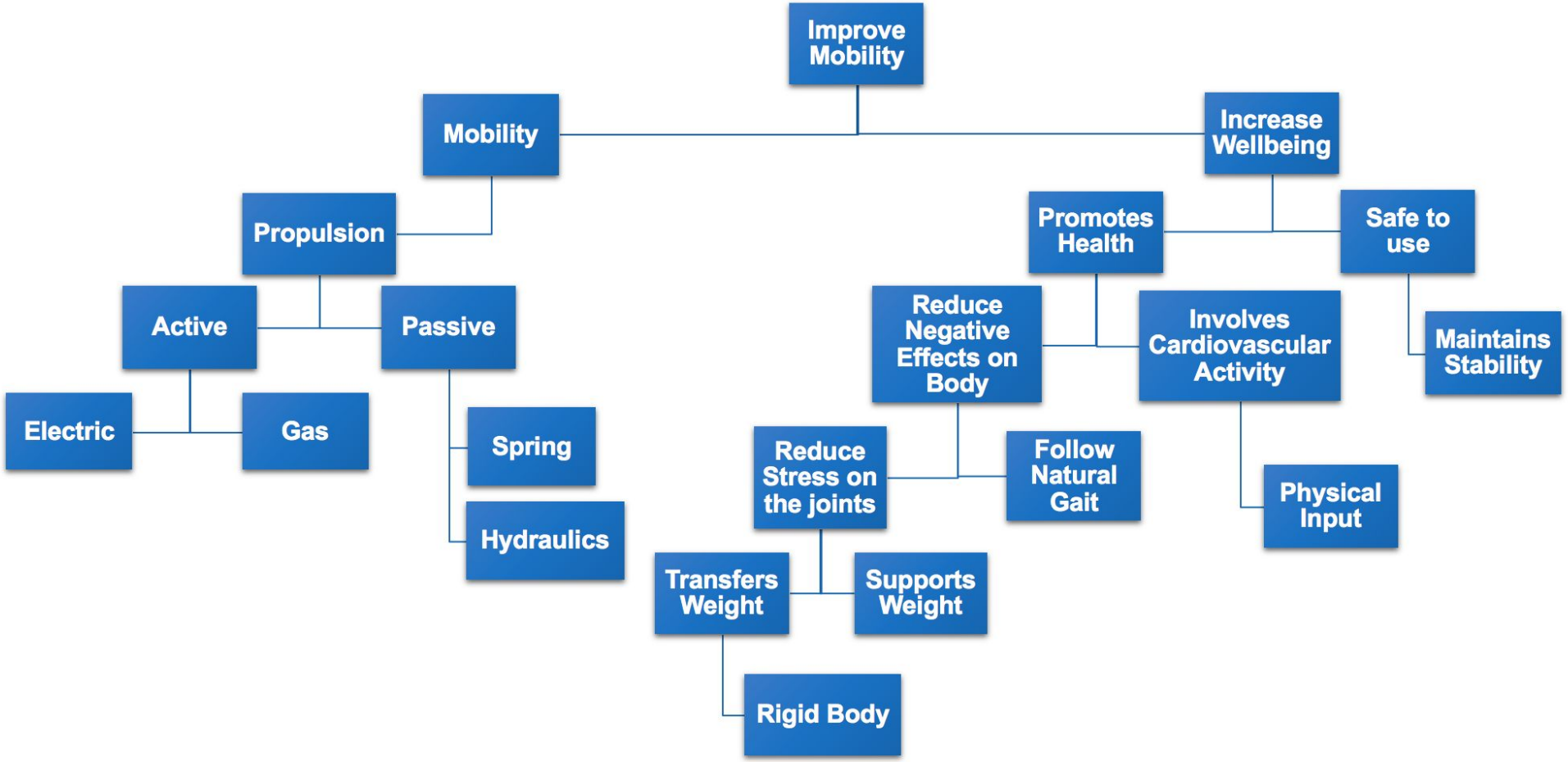
  users every year



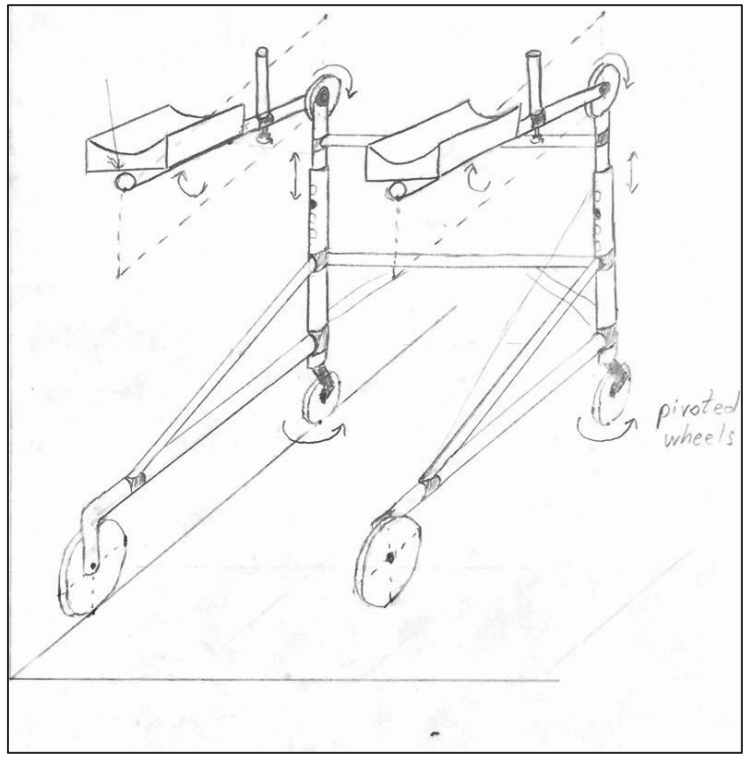
Customer Needs

- Designing for the market
  - Understand everyday issues that the mobility impaired deal with
  - Determine where the actual “need” within the market exists (putting a face behind the need)

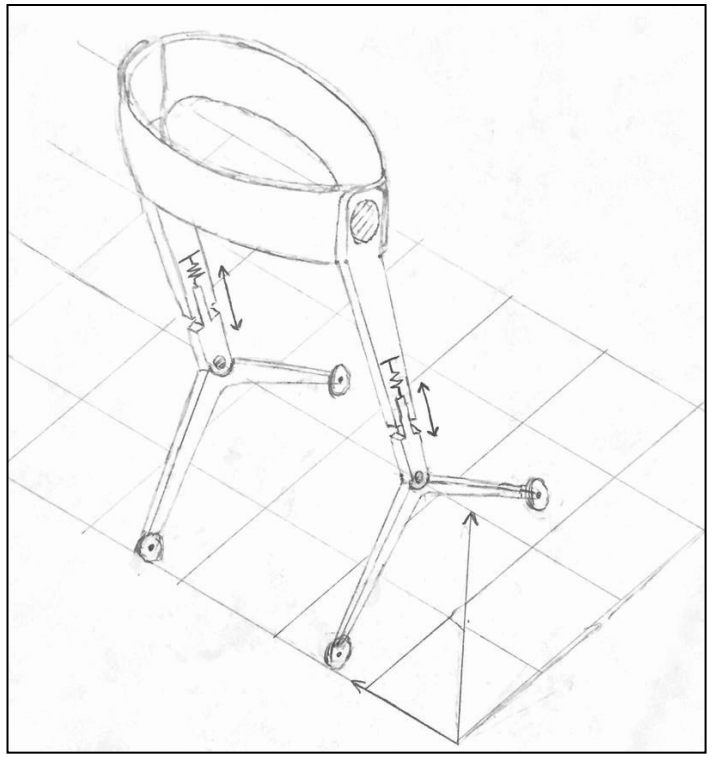
Functional Decomposition



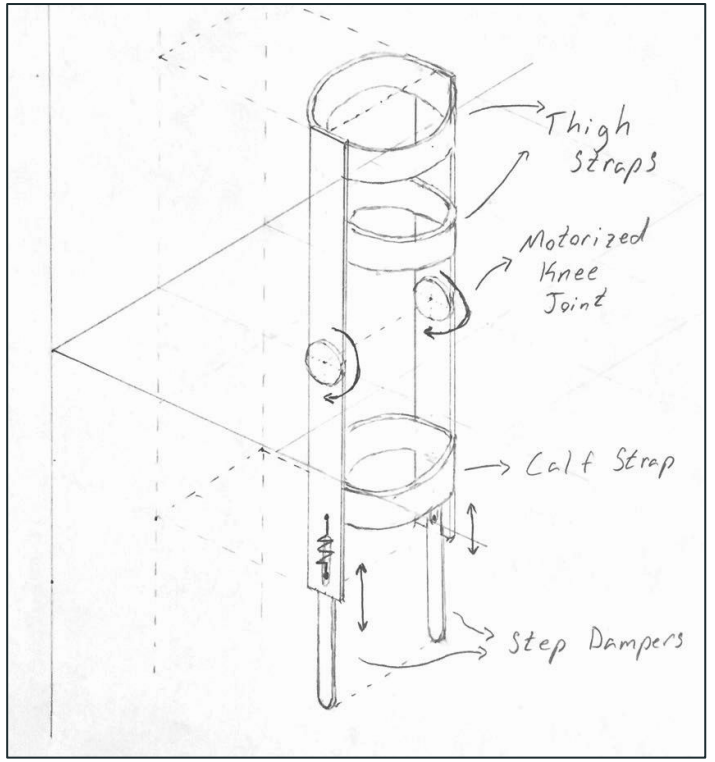
Concept Generation



Concept 1



Concept 2



Concept 3

Concept Selection

		Engineering Characteristics					
Improvement Direction		↑	↓	↑	↑	↓	↑
Units		lbs	%	◦/in.	bpm	$	in.
Customer Requirements	**Importance Weight Factor**	**Weight Reduction**	**Natural Gait Variation**	**Adjustability**	**Change of Heart Rate**	**Price**	**Compactability**
Affordable	3			3		9	3
Lightweight	1	1	1			3	
Provides Support	6	9	1	3			
Easily Maneuverable	5		3				
Uses Cardiovascular Activity	3	3	1		9		
Doesn't Affect Walking Pattern	3	1	9	3			
Raw Score (221)		67	52	36	27	30	9
Relative Weight %		30.3	23.5	16.3	12.2	13.6	4.1
Rank Order		1	2	3	5	4	6

		Pugh Chart			
		Concept			
Selection Criteria	**UPWalker**	**1**	**2**	**3**	**4**
Weight Reduction	Datum	S	+	-	-
Natural Gate Variation		+	+	+	-
Adjustability		+	+	+	+
Change of Heart Rate		S	-	-	-
Price		+	-	+	-
Compactability		S	+	+	+
	# of Pluses	3	4	4	2
	# of Minuses	0	2	2	4

Concept	Alternative Value
1	0.53
2	0.3169
3	0.1541

Embodiment Design

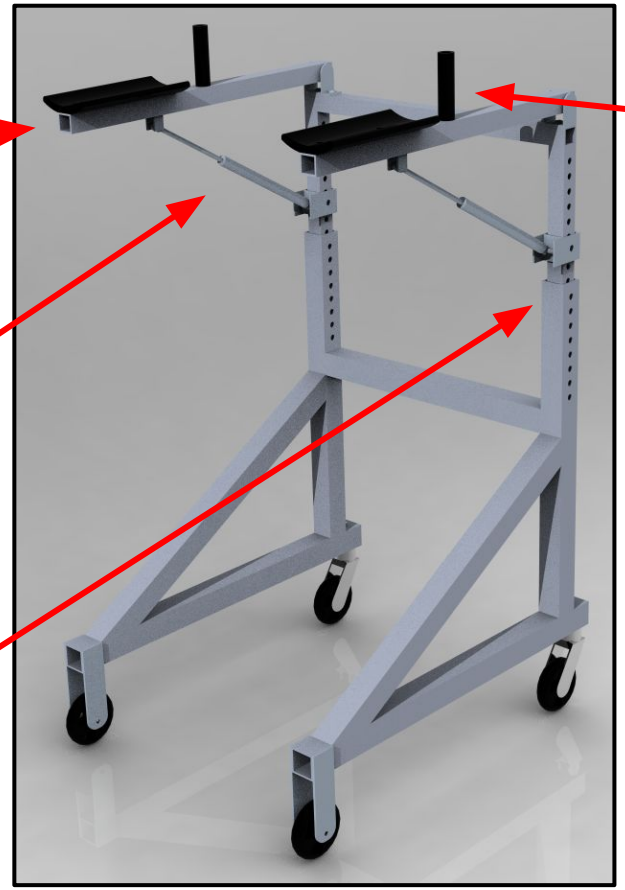
Presented by: Dionsse Carti

Detailed Design

Forearm Supports to provide comfortable weight support

Gas Shocks to reduce impact on joints

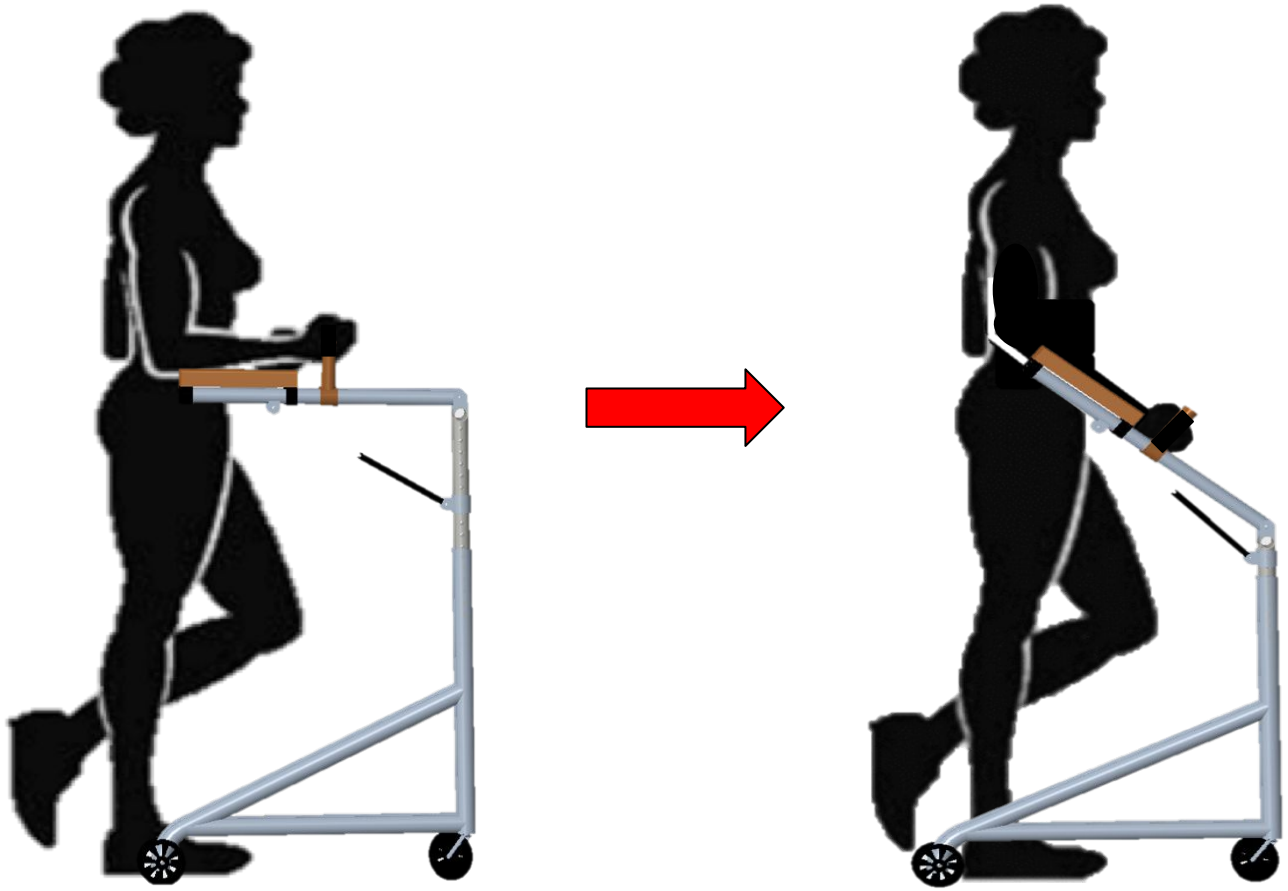
Variable Slide Mechanism to allow for height adjustment



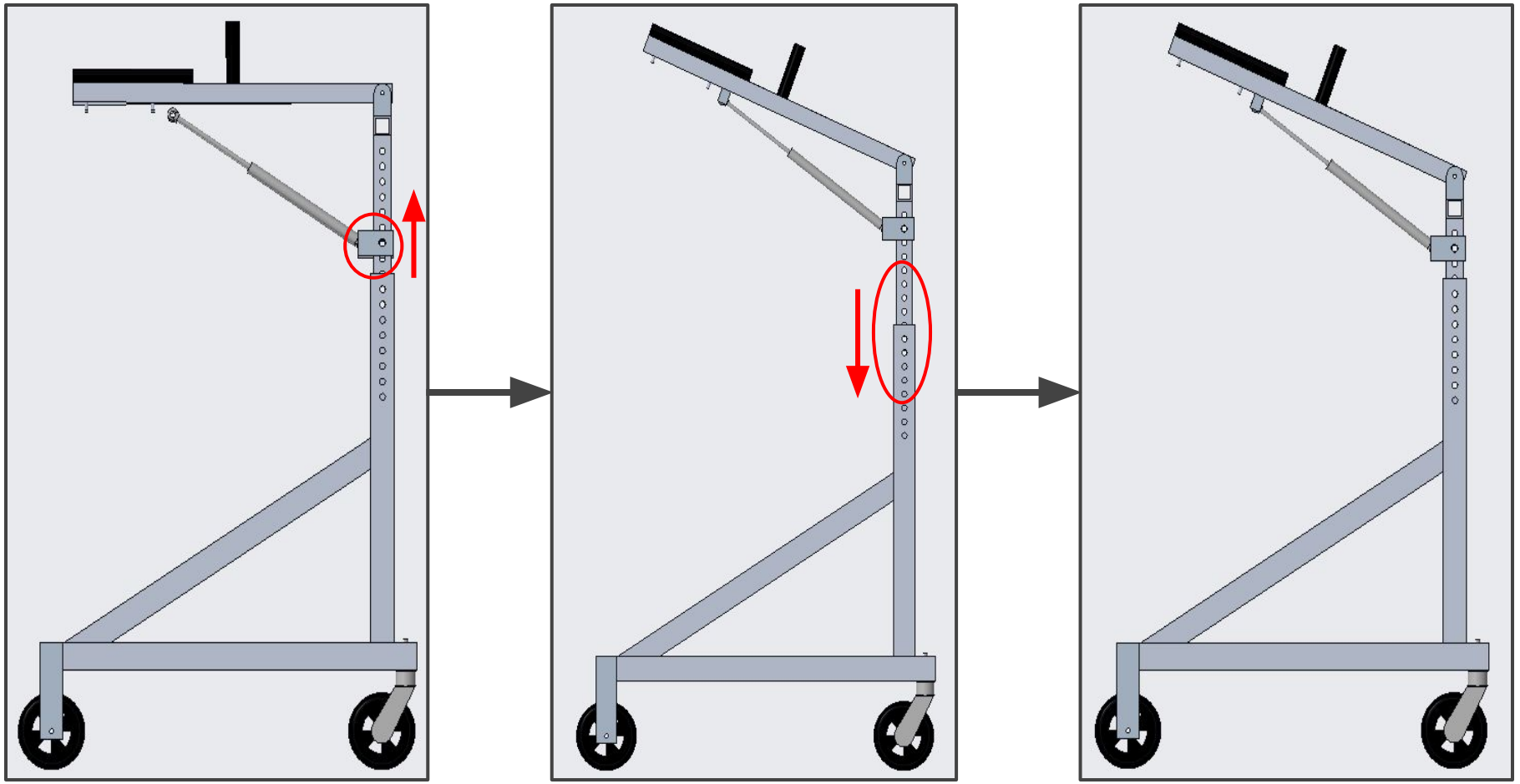
Hand Grips for extra support and sturdiness

Arm Support Adjustment to accommodate a relaxed elbow angle for walking

Device Operation

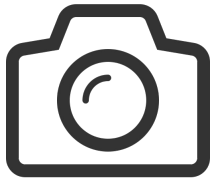


Device Adjustment



Proof of Concept

- Impairing our own mobility for testing
  - Aid in Mobility
    - Completion of an obstacle course while impaired with help of NewWalk.
  - Follow Natural Gait
    - Comparing walking along a straight line with and without NewWalk to ensure an improvement in stride consistency.

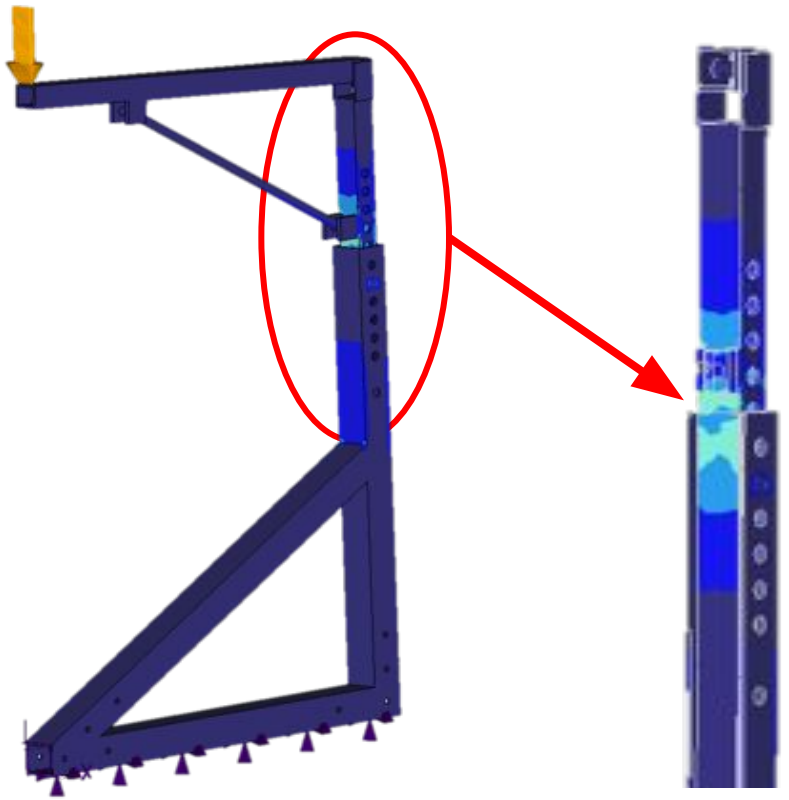


Proof of Concept

- Weight Support
  - Adding 250 pounds to device.
  - Using a scale to measure the users weight.

Finite Element Analysis

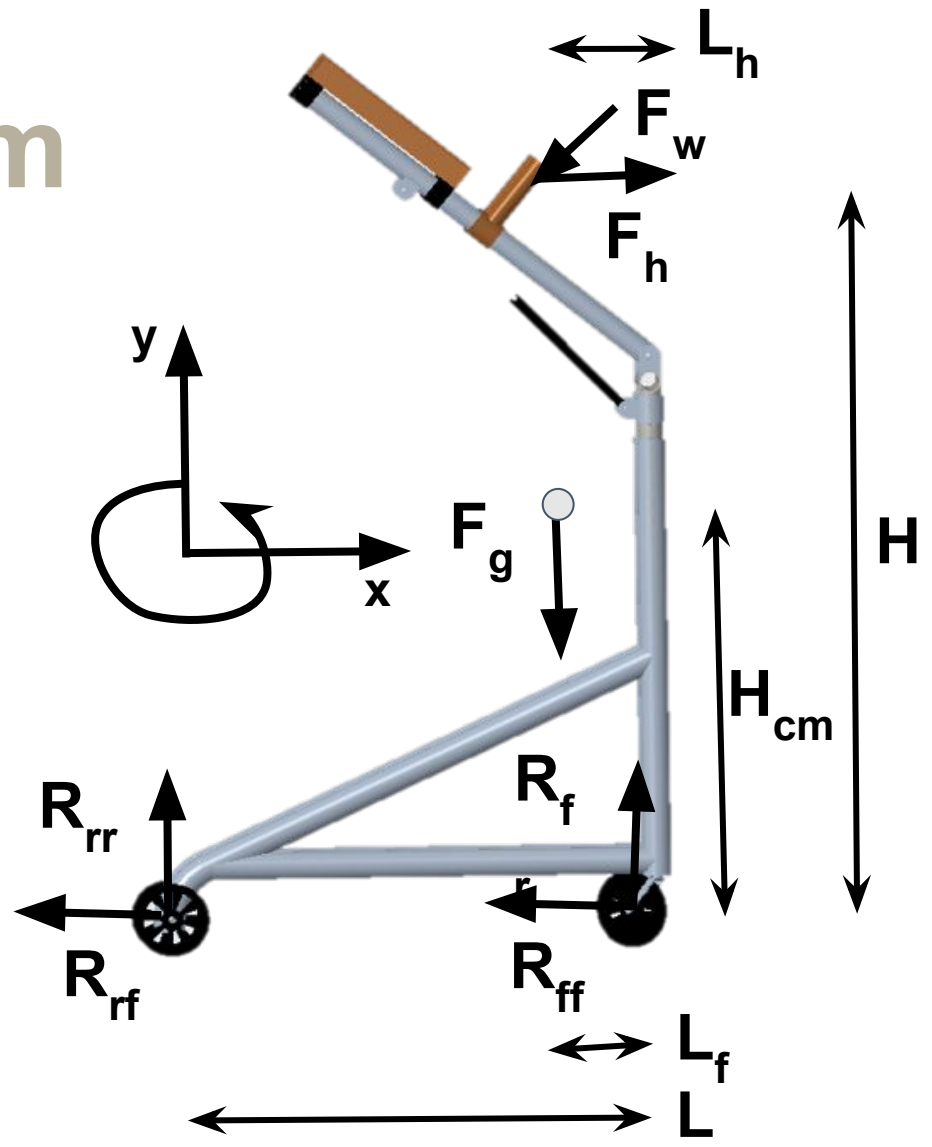
- Edge Load of 250 lbs ~113 kg.
- Gas shocks modeled as rigid steel bodies.
- Al-6061 Yield Strength: 310 MPa.
- Bending Stress Concentration.
    - Factor of Safety = 1.24.



Tipping Analysis

Free Body Diagram

- Weight of Device: 22.34 lbf.
- Weight of User: 250 lbf.
- Max acceleration: 13 ft/s^2.
  - from walker manufacturer.



Analysis

$$\sum F_x = m_w a$$

$$F_h = m_w(a + F_w sin(\theta) + \mu g) + F_w cos(\theta)$$

$$\sum M_{fw} = 0$$

$$F_g L_f + F_w cos(\theta) H + F_w sin(\theta) L_h - R_{rr} L - F_h H = 0$$

Analysis

$$R_{rr} = \frac{m_w(gL_f - F_w cos(\theta) - F_w sin(\theta) - \mu g - a) + F_w(Hcos(\theta) + L_h sin(\theta))}{L}$$

- Rrr<0, rear wheels lift.

$$R_{fr} = \frac{m_w(aH + F_w sin(\theta)H + \mu gH + g(L - L_f)) + F_w sin(\theta)(L - L_h) - Fwcos(\theta)H)}{L}$$

- Rfr<0, front wheels lift.

Analysis

$$L_{min} = \frac{F_w H cos(\theta) - a - F_w cos(\theta) - F_w sin(\theta) - \mu g}{-g c_l + \frac{F_w sin(\theta)}{m_w}}$$

$$L_{min} = 1.367 ft$$

- Wheelbase must be 1.367 ft.
- Current wheelbase is 2ft.
- Factor of Safety = 1.46

Manufacturing

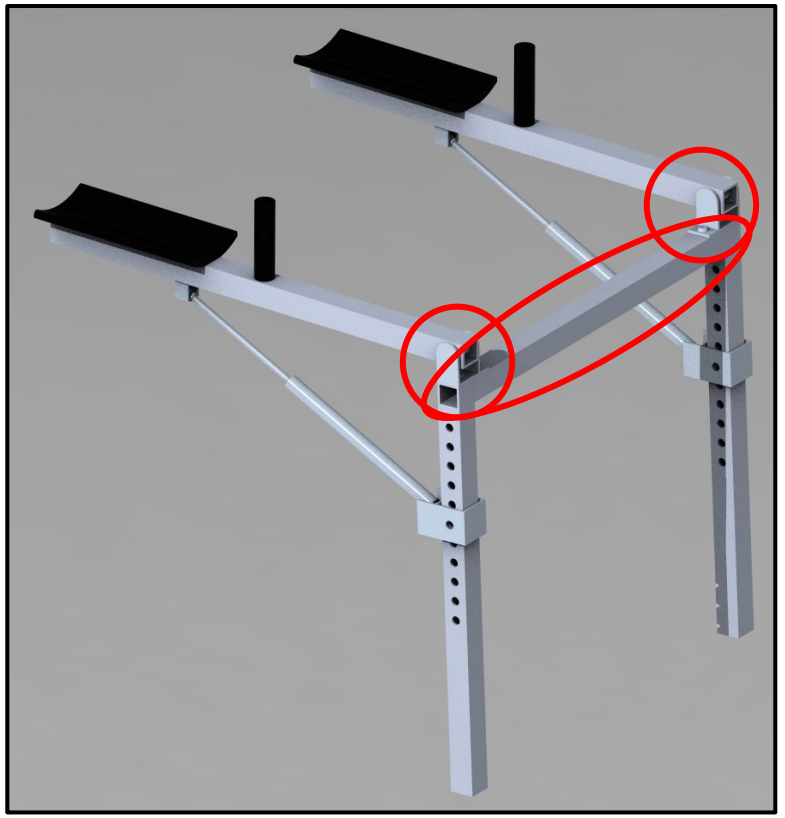
Presented by: Michael Beech

Base Frame

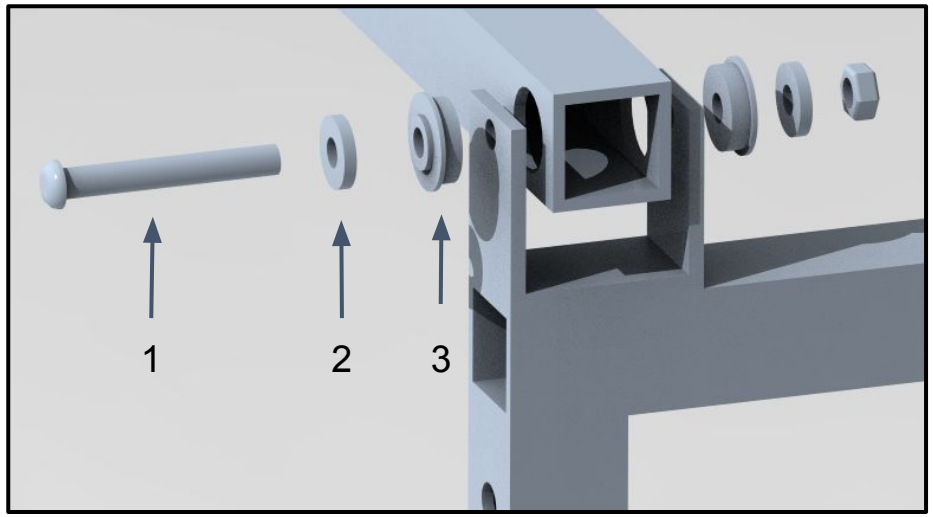
- Joints on the base of device will be welded.
    - Welding joints minimizes cost by reducing required materials (brackets, bolts, etc).
    - Square tubing minimizes manufacturing time .

Upper Frame

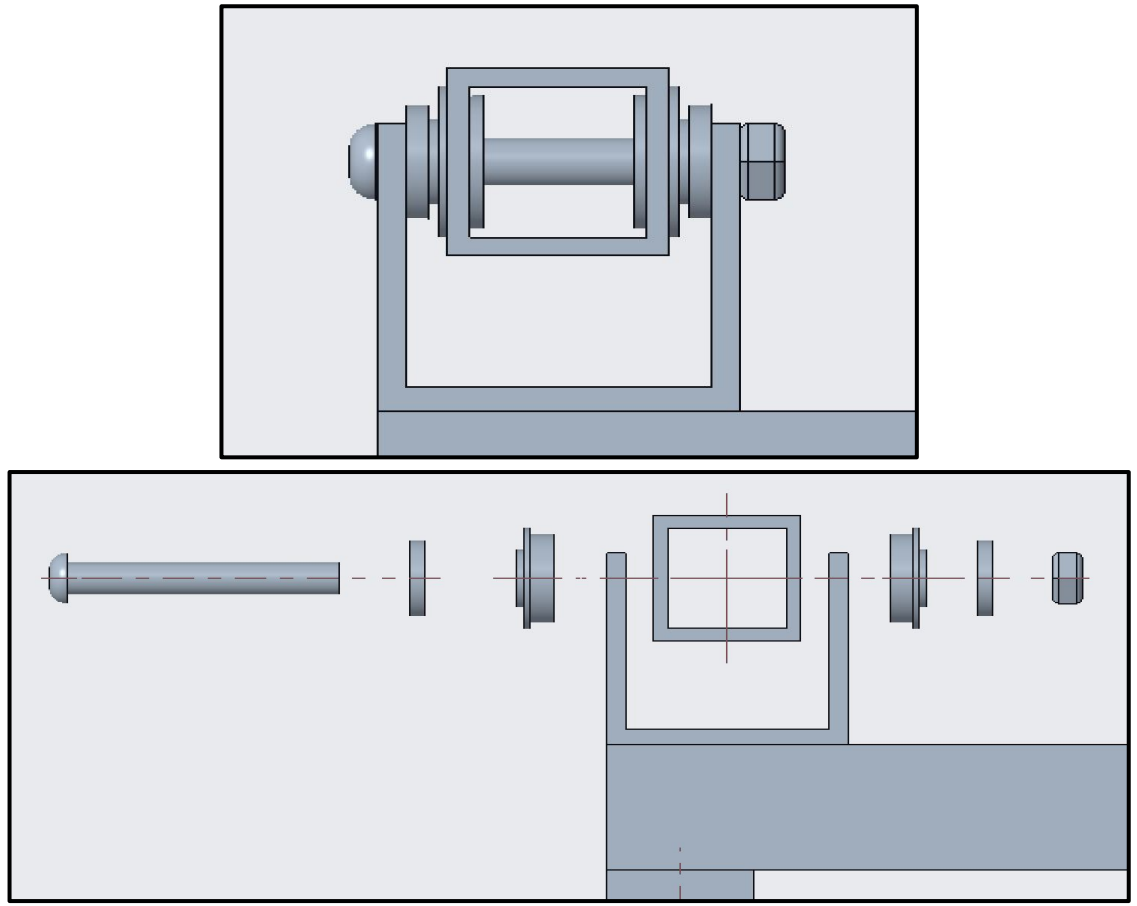
- Crossbar.
    - Placed on top of upright supports and welded.
- Pivoted arm supports.
    - Mounted to u-brackets on top of crossbar with bearings.



Arm Support Pivot Bearing Stackup

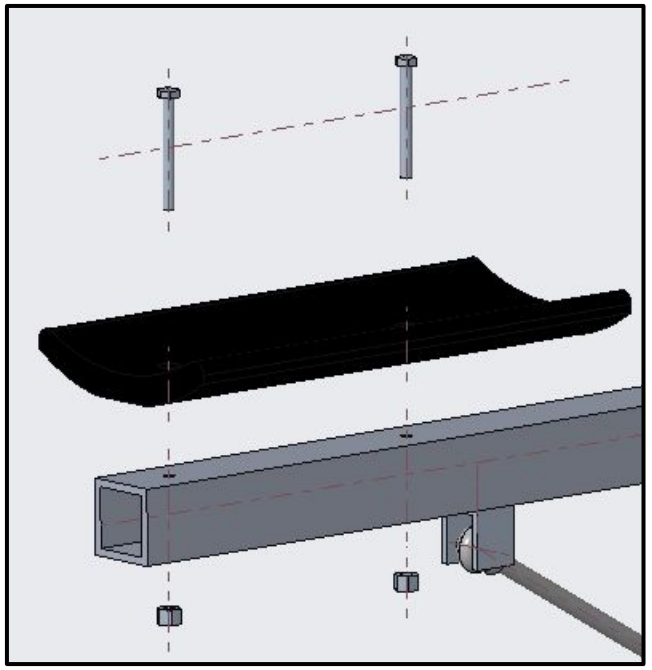


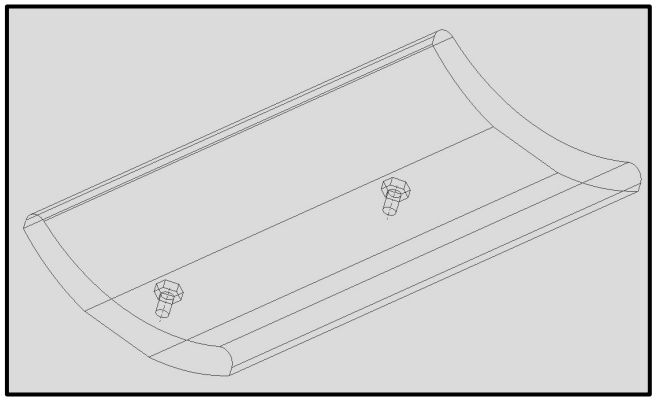
1. Bearing shaft.
2. Spacer.
3. Flanged Ball Bearing.



Forearm Supports

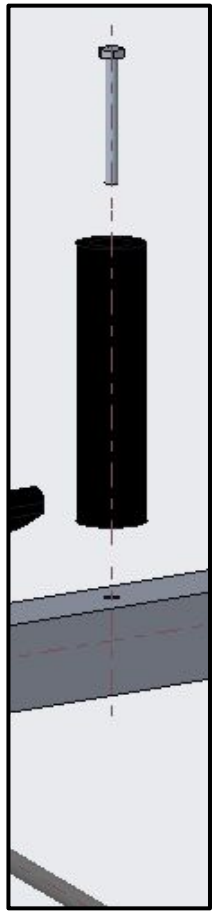
- Base is 3-D printed to reduce prototype costs.
- ½” Polyurethane foam sheet for comfort.
- 18-8 Stainless steel screws, 10-24 thread size, 2-½” long.
- Counterbore to allow tightening of bolt with no access to head.

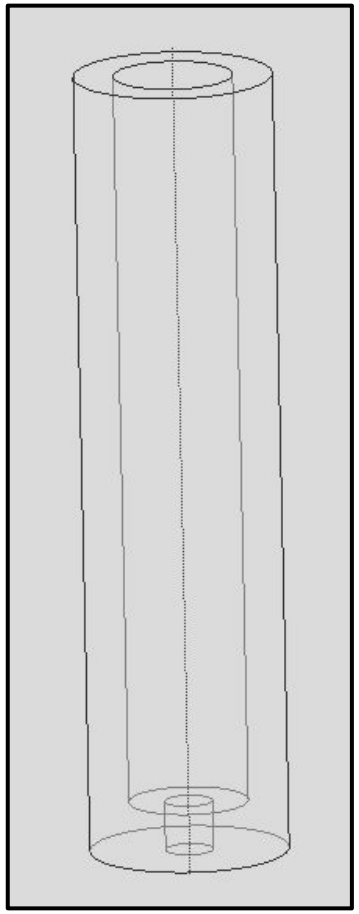




Hand Grips

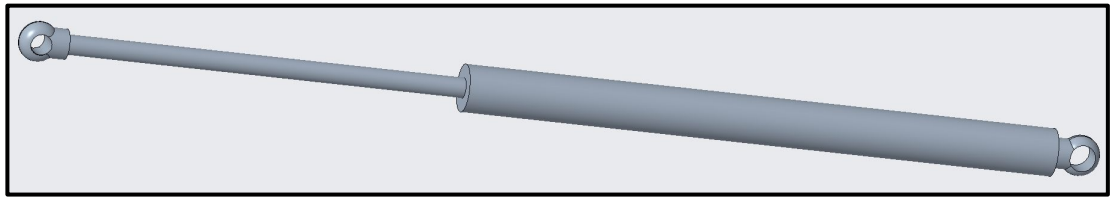
- Hand grips 3-D printed to reduce prototype costs and manufacturing time.
- 18-8 Stainless steel screws, 10-24 thread size, 2-½” long.

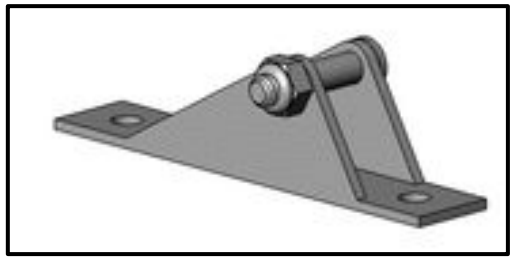


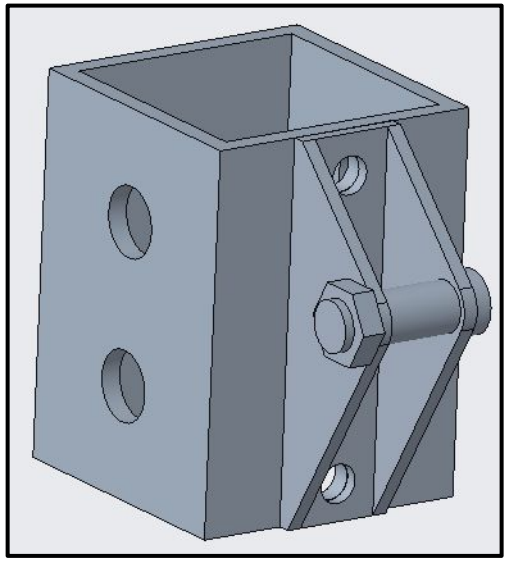


Gas Shocks

- Gas Shocks with 15.63"(inches) extended length.
    - Extension force of 130lb.
- Eyelet, M6 Thread Size, 0.32" ID
    - Thread these eyelet end fittings onto gas springs.





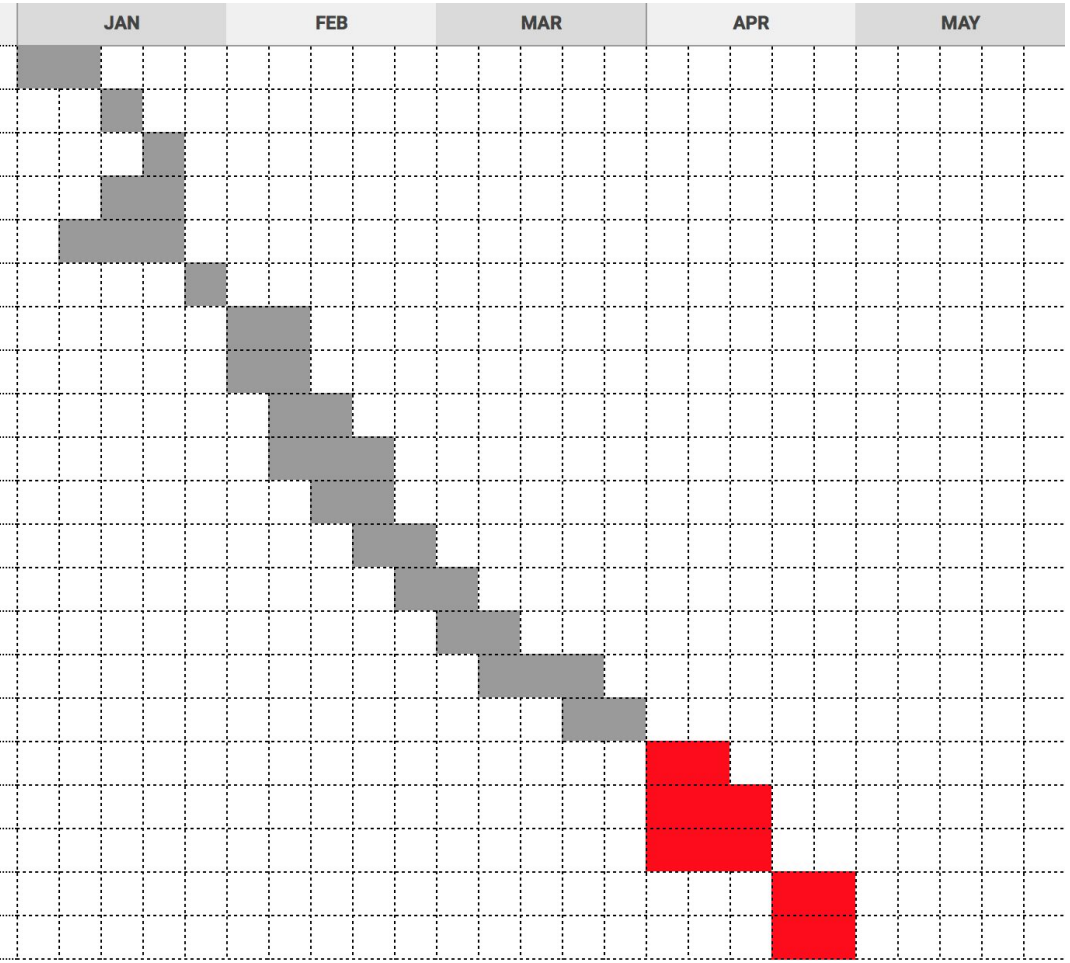


Project Management

Presented by: Leah Fiedler

Gantt Chart

Events/Activities	Dates
Abstract - First Submission	01/07 - 01/11
Web Master	01/10 - 01/11
Staff Meeting 1	01/17 - 01/17
Abstract - Second Submission	01/15 - 01/18
Design Review 4	01/10 - 01/18
Team Photo	01/21 - 01/21
Web Page Development	02/03 - 02/08
Abstract - Third Submission	02/04 - 02/08
Staff Meeting 2	02/13 - 02/14
Design Review 5	02/10 - 02/18
High Resolution Graphic	02/18 - 02/22
Risk Assessment	02/25 - 02/28
Web Page Update 1	02/28 - 03/01
Poster	03/01 - 03/08
Design Review 6	03/18 - 03/25
Operation Manual	03/25 - 03/29
Web Page Update 2	04/01 - 04/05
Engineering Design Day - Poster	04/01 - 04/11
Engineering Design Day - Presentation	04/01 - 04/11
Final Report	04/12 - 04/26
Prototype Demo	04/12 - 04/26



Prototype Cost

Total budget allocated:

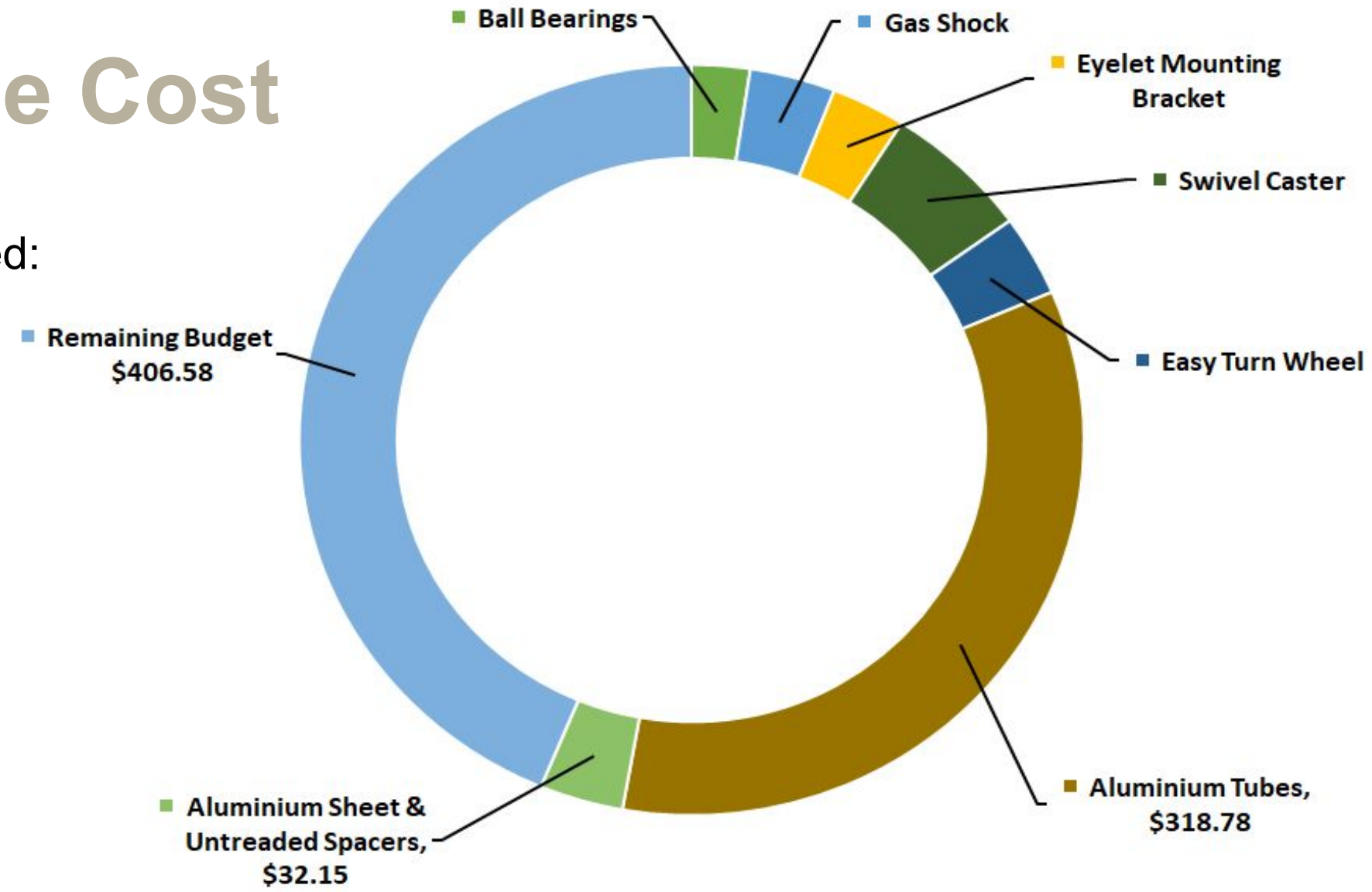
- $1000.00.

Amount spent:

- $593.42.

Remaining amount:

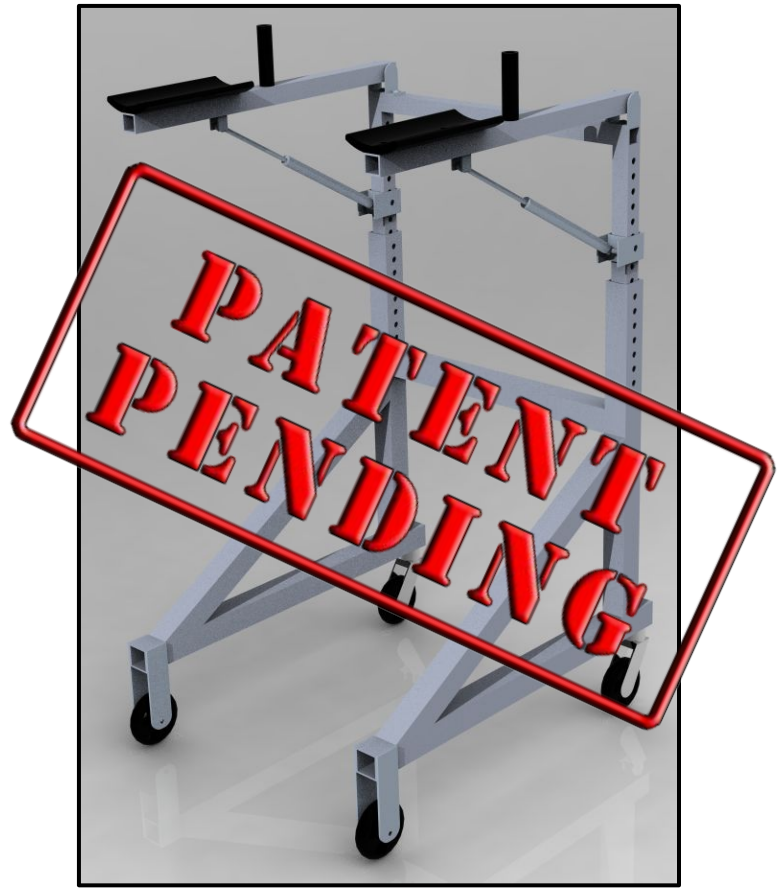
- $406.58.



Shark Tank Competition

April 18th 7:00 PM-8:30 PM.

- Continue editing and finalizing our business pitch.
- Look into getting a utility patent.



3 Most Important Points

1. Using square tubing to reduce manufacturing time.
2. Tipping calculations confirmed device will not tip.
3. FEM stress analysis confirmed device sturdiness.

Lessons Learned

1. To continue making updates to the purchase orders and to always have an updated BOM.
2. To perform initial calculations prior to the finalized design to avoid making design mistakes.
3. Start prototyping as soon as possible.

References

- U.S. Disability Statistics and Information. (2010). *Americans with Disabilities*. Retrieved from https://www.disabled-world.com/disability/statistics/info.php/
- Takanokura, M. (2014, August 27). Analysis for Minimal Wheelbase Length of Four-wheeled Walker for Prevention of Tipping on Sloped Surfaces. Retrieved from https://www.omicsonline.org/open-access/analysis-for-minimal-wheelbase-length-of-fourwheeled-walker-for-prevention-of-tipping-on-sloped-surfaces-2165-7556.1000128.php?aid=31404

Questions?