BME Design-Fall 2023 - Lael Warren
Complete Notebook

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SADIE ROWE

on

Dec 13, 2023 @10:24 AM CST

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Team contact Information

Gracie Hastreiter - Sep 08, 2023, 1:43 PM CDT

Last Name	First Name	Role	E-mail	Phone	Office Room/Building
Murphy	William	Advisor	wlmurphy@wisc.edu		
Dorszynski	Dan	Client	wetsand@gmail.com		
Warren	Lael	Leader			
Baumann	Liv	Leader/BSAC	apbaumann2@wisc.edu	(608) 566-5838	
Kothe	Amanda	Communicator	arkothe@wisc.edu	(612) 708-2960	
Rowe	Sadie	BWIG	skrowe2@wisc.edu	(303) 903-8280	
Hastreiter	Gracie	BWIG	ghastreiter@wisc.edu	(608) 698-8356	
Dugo	Juliana	BPAG	jdugo@wisc.edu	(847) 340-2370	

Project description

SADIE ROWE - Dec 11, 2023, 10:17 AM CST

Course Number: BME 200/300

Project Name: Low-interference wheelchair footrest

Short Name: Wheelies

Project description:

Wheelchair users who are not paralyzed are limited by existing wheelchair footrests. Current wheelchair footrest designs keep the users feet mostly fixed in place. While this keeps feet safe and can be supportive when a wheelchair tilts or reclines, it can prevent a wheelchair user from performing helpful movements like using feet to open doors or leaning forward to put feet on the ground to reach for doors or pick up objects from the floor.

Existing footrests designs are also restrictive in that there is no place on a wheelchair to store them when removed or not temporarily needed. They can also be heavy, bulky, and difficult for a person with other physical impairments to utilize.

The goal of this project is to create an alternative footrest that can be more adaptable to a person's abilities, allowing for more function while providing the benefit of footrests when necessary.

Problem Statement:

There are currently no wheelchairs on the market which allows those who are not paralyzed to perform helpful movements, such as opening doors with their feet or being able to pick up objects from the floor. In addition, current footrest models are heavy, bulky, and not easily able to be removed and stored when not in use. While footrests are crucial for support if the wheelchair tilts or reclines, it is imperative to design a wheelchair footrest that allows for more foot mobility- should the user require it- and for easier storage of said footrests. The updated footrests should be able to adapt to a person’s abilities, should be easily able to remove and store them when not in use, and be lighter and less bulky, while still providing the benefits of a footrest when necessary.

About the client:

The client, Mr. Dan Dorszynski, is a resident of the Madison, Wisconsin area who is looking for improvements to his wheelchair’s footrest design. He requires the team to manufacture a footrest that allows him more mobility and also is easier to handle when not in use.

2023/09/15 - Client Meeting 1

Lael Warren - Sep 15, 2023, 1:42 PM CDT

Title: Client Meeting 1 (9/15/2023)

Date: 9/15/2023

Content by: Lael Warren

Present: All

Goals: Talk with the client about his expectations and goals for the project

Content:

During the meeting we started by introducing ourselves and then meeting Dan. This is his first time working on the footrests, however he has worked with other design teams on different projects. He then gave us an overview of why he wants these footrests. He has mobility in his feet, but footrests make it so he can't do anything with them.

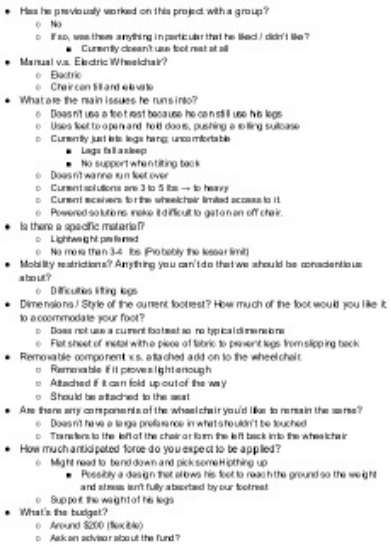
From a design perspective, he is pretty open to how we want to design it. Some suggestions he gave were using the castors to put the footrests on them in order for him to be able to raise himself up and put his legs in there. He also can't lift a lot of weight so if they are removable they need to lightweight.

The full list of discussed topics is attached to this document.

Conclusions/action items:

- Start researching designs and come with 3 design ideas each to next client meeting.

Lael Warren - Sep 15, 2023, 1:43 PM CDT



- Has he previously worked on this project with a group?
  - No
  - If so, was there anything in particular that he liked / didn't like?
    - Currently doesn't use foot rest at all
- Manual v.s. Electric Wheelchair?
  - Electric
  - Chair can tilt and elevate
- What are the main issues he runs into?
  - Doesn't use a foot rest because he can still use his legs
  - Uses feet to open and hold doors, pushing a rolling suitcase
  - Currently just lets legs hang; uncomfortable
    - Legs fall asleep
    - No support when tilting back
  - Doesn't wanna run feet over
  - Current solutions are 3 to 5 lbs → to heavy
  - Current receivers to the wheelchair limited access to it
  - Powered solutions make it difficult to get on an off chair.
- Is there a specific material?
  - Lightweight preferred
  - No more than 3-4 lbs (Probably the lesser limit)
- Mobility restrictions? Anything you can't do that we should be conscientious about?
  - Difficulties lifting legs
- Dimensions / Style of the current footrest? How much of the foot would you like it to accommodate your foot?
  - Does not use a current footrest so no typical dimensions
  - Flat sheet of metal with a piece of fabric to prevent legs from slipping back
- Removable component v.s. attached add on to the wheelchair.
  - Removable if it proves light enough
  - Attached if it can fold up out of the way
  - Should be attached to the seat
- Are there any components of the wheelchair you'd like to remain the same?
  - Doesn't have a large preference in what should't be touched
  - Transfers to the left of the chair or form the left back into the wheelchair
- How much anticipated force do you expect to be applied?
  - Might need to bend down and pick something up
    - Possibly a design that allows his foot to reach the ground so the weight and stress isn't fully absorbed by our footrest
  - Support the weight of his legs
- What's the budget?
  - Around $200 (flexible)
  - Ask an advisor about the fund?

Download

Client_Questions_-_09_15_2023.pdf (40.1 kB)

2023/09/29- Client Meeting 2

Lael Warren - Sep 29, 2023, 12:52 PM CDT

Title: Client Meeting 2

Date: 09/29/2023

Content by: Lael Warren

Present: All

Goals: Go over design matrix and designs with client and get feedback. Asses his range of motion and strength capabilities. Talk over future steps with client and set up next time for meeting. Also need to tell client that preliminary presentation is on October 6th

Content:

To start the client meeting, we had him show us his wheelchair and also how he moves it up and down. We also talked about the problems with his current wheelchair. We then took some pictures and measurements of where his feet sit and how big his feet are. After, we talked about of different designs and the things he did and didn't like about it.

Things that he would want different:

- Have the design be inserted into the caster hole

- Wants something that can flip back and in

- Wants it to be as close to the ground as possible

- Needs to be able to transfer to the left

- Don't block the locking mechanism for riding in the car

Conclusions/action items:

Start making preliminary Design and send to client

2023/09/15- Advisor Meeting 1

Liv Baumann - Sep 22, 2023, 1:34 PM CDT

Title: Advisor Meeting 1

Date: 9/15/2023

Content by: Lael Warren

Present: All

Goals: Talk to advisor about project and get a baseline

Content:

- Introduced the project to the advisor and talked to him about the client

- Talked about different questions we have about the project

- Do we need approval for human subjects testing? Look on the website and make sure the client signs them if we need it

- Talked about the PDS and how we might not know all the details but need to kinda talk about how we are going to find them

- Look into who else is making the design and see how they are doing that

- Its ok to subset and make groups to research or fabricate, but make sure to divide up and make it equal.

- Also addressed the budget question: Dr. Murphy will ask Dr. P about the funding and see if there is a fund that we have for this project.

Conclusions/action items:

- start researching design ideas.

2023/09/22 - Advisor Meeting 2

Liv Baumann - Sep 22, 2023, 1:43 PM CDT

Title: Advisor Meeting 2

Date: 09/22/2023

Content by: Liv Baumann

Present: Wheelies Group and Dr. William Murphy

Goals: Report our progress with initial designs and the project; Get feedback on our next steps

Content:

- Reported our current progress with initial brainstorms and client communications / information.

- Clarified requirements for university project funding proposal

- Discussed our initial setup of the design matrix and what to keep in mind to ensure it is useful and differentiates our designs

- Dr. Murphy looked over our PDS. He said it looks good at first glance but to ensure our requirements detail specific, quantifiable goals so our product can be effectively developed and evaluated with it.

Conclusions/action items:

We are currently restricted in our next steps as the client was unable to meet as initially planned and we need his feedback on preliminary designs as well as more information regarding his mobility restrictions.

- Email the client specific questions and requests for videos showing his mobility

- Continue refining the design matrix

- Meet with client to decide on a few central designs and put them through the matrix

- Make sure the PDS follows appropriate language

2023/09/29-Advisor Meeting 3

Lael Warren - Sep 29, 2023, 1:13 PM CDT

Title: Advisor Meeting 3

Date: 09/29/2023

Content by: Lael Warren

Present: All

Goals: Go over design matrix with advisor. See if he has any feedback on matrix or the designs. Also ask if he has any feedback on the PDS before it goes in the preliminary report. Go over timeline with him to make sure we have all the due dates correct.

Content:

Talked about the design matrix. And then talked about funding and how he hasn't heard back on funding yet. We then talked about how the ECB isn't functioning and how to work around that delay. Then talked about any feedback he has for our presentation. He said that everything is good so far. We then talked about upcoming goals and due dates. He will go over our slides if we send them to him by Wednesday.

Conclusions/action items:

Keep working on project.

2023/10/13 - Advisor Meeting 4

Liv Baumann - Oct 13, 2023, 1:41 PM CDT

Title: Advisor Meeting 4

Date: 10/13/2023

Content by: Liv Baumann

Present: Wheelies, Prof. William Murphy

Goals: Discuss feedback from preliminary presentations; Address any questions we have and next steps.

Content:

We started with Dr. Murphy reviewing the feedback on the preliminary presentation. This can also be found under the canvas submission. He noted he hasn't looked over the preliminary report yet, but will get it soon.

General Feedback:

- If you have specifics for anything always state what they are
- PDS: Good general specs, but not a lot of specific details. Some of the details were added later in the presentation but
- Wasn't clear how the evaluation process, specifically of the pros and cons, related to design specs; they seemed disconnected.
    - "How do characteristics of the design more or less meet the laid out specs"
- Text was too small sometime and difficult to read; make text consistent
    - This is also really important for the poster; consistency makes things easier to read.
- Try to avoid reading off slides.

How should we quantify it?

- Anthropometry tables to estimate length and weight.
- Create an evaluation that is directly testable.
- Certain testing does not necessarily need to be perform, but rather address how we aim to approach this

We asked about storage of the wheelchair base and Dr. Murphy said he will inquire about a location.

He said he doesn't mind using first-person language as long as we are being direct, clear, and concise.

Team lab should be fully accessible.

Conclusions/action items:

Use provided feedback to improve our deliverables and presentation.

Begin fabrication of our prototype.

2023/10/27- Advisor Meeting 5

Lael Warren - Oct 27, 2023, 1:28 PM CDT

Title: Advisor Meeting 5

Date: 10/27/2023

Content by: Lael Warren

Present: All

Goals: Ask advisor questions about how to use shop uw, what the best silicone to use is, and how to design testing protocols.

Content:

Stated the meeting by talking to the advisor about the progress we have made with the project. This included initially picking out materials and working on our cad drawing. Then asked him some questions that we have on the progress of the project, which included how to buy materials if there is a good silicone to use, and how we should design our testing protocols.

Conclusions/action items:

Need to start working on purchasing materials an finishing the testing protocols.

2023/11/10-Advisor Meeting 6

Lael Warren - Nov 10, 2023, 1:35 PM CST

Title: Advisor Meeting 6

Date: 11/10/2023

Content by: Lael Warren

Present: All

Goals: Talk with advisor about new design idea and the best way to use our time before Thanksgiving.

Content:

- Talked about the ideas presented to us during show and tell and how they would work with our design.

- Gave us the idea of splitting up into groups and working on different ideas in order to see which one is working the best

- Talked about different ideas on how to measure the inside of the castor in order to get dimensions. Scrapping the silicone idea in order to have more time and get more precise measurements of the castor.

-

Conclusions/action items:

We need to split into groups and decide who is doing what mini project in order to make a final design.

2023/12/4-Advisor Meeting 7

Lael Warren - Dec 04, 2023, 3:07 PM CST

Title: Advisor Meeting 6

Date: 12/4/203

Content by: Lael Warren

Present: All

Goals:

Content:

Conclusions/action items:

9/29/2023- Team Preliminary Designs

Gracie Hastreiter - Dec 12, 2023, 10:19 AM CST

Title: Preliminary Designs

Date: 9/29/2023

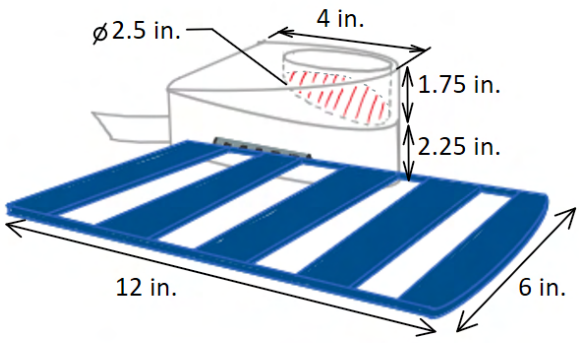
Content by: Gracie

Present: N/A

Goals: Each team member has created individual design ideas. We narrowed the groups design ideas into three very different designs. The three designs drawings and descriptions are below.

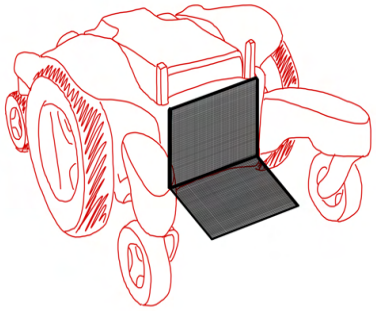
Content:

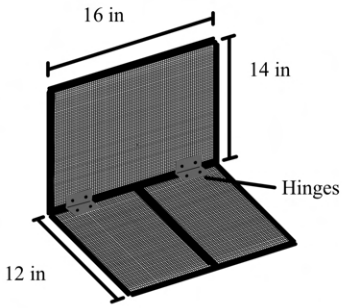
Fold-up footrest:



- Two separate components; one attaching to the right castor and one to the left
- Footplate components can fold upwards 90 degrees to be stored on the wheelchair
- Castor cap portion will be 3D printed, made of a plastic material
- Metal hinge connects the castor cap with the footplate
- Footplate made of metal/plastic material with holes cut out (prevent water to collect on top of the footplate)

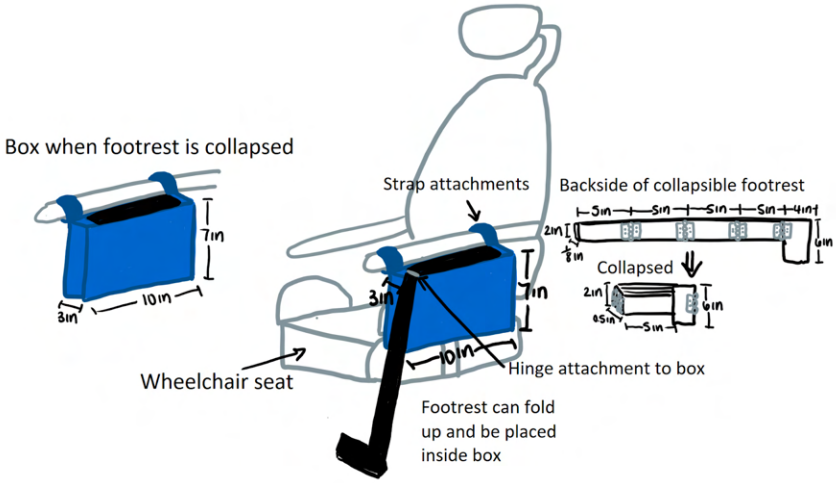
Folding Mesh Footrest:





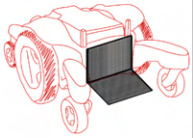
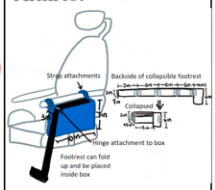
- One component
- Attaches to the front of the wheelchair base
- Folds down 90 degrees when in use
- Made of mesh material, frame made of a metal material (mesh material can be removed and washed)
- Hinge connects the lower and upper portions of the footrest

Airplane Armrest Footrest:



- Footrest stored on the side of the wheelchair, underneath the armrest
- When in use, the footrest folds downward and to the side (similar motion as an airplane tray table)
- Components of collapsible portion of the design are connected by hinges

Design matrix

	Design 1: Fold-Up Footrest	Design 2: Folding Mesh Footrest	Design 3: Airplane Armrest
			
Ease of use (25)	5/5	5/5	2/5
Storage (20)	5/5	4/5	3/5
Weight (15)	4/5	5/5	2/5
Size (15)	5/5	5/5	3/5
Ease of Fabrication (10)	4/5	5/5	1/5
Durability (10)	5/5	3/5	3/5
Cost (5)	3/5	5/5	2/5
Total (100)	93	92	47

We used this design matrix to determine which design to move forward with. We chose criteria which we believed were the most important criteria for our project. These included ease of use, storgar, weight, and size. We then weighed the criteria, more weight meaning a greater importance. We ranked each design on a scale of 1-5 in each criteria. We then multiplied the rank by the weighted criteria and added up the scores to find the total. The fold up footrest scored the highest, so we chose to move forward with the fold up footrest design.

Conclusions/action items: Our team will move forward with the fold up footrest design. The next steps include researching materials for the different components and beginning fabrication.

References: N/A

2023/11/10 - Design Matrix

SADIE ROWE - Dec 12, 2023, 11:24 PM CST

Title: Design Matrix

Date: 2023/11/10

Content by: Lael Warren, Liv Baumann, Amanda Kothe, Sadie Rowe, Gracie Hastreiter, & Juliana Dugo

Present: Lael Warren, Liv Baumann, Amanda Kothe, Sadie Rowe, Gracie Hastreiter, & Juliana Dugo

Goals: Evaluate Preliminary Designs

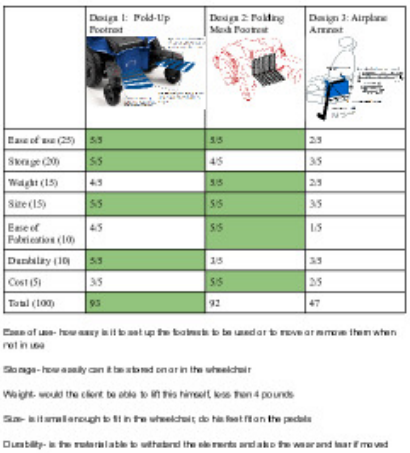
Content:

Document Attached Below.

Conclusions/action items:

According to the design matrix, the team decided to move forward with a modified version of Design 1: The ‘Fold-up Footrest’. In particular, its simple design allows for the most ease of use and greater potential for the use of lightweight durable materials. Several aspects of the design allow for the best storage capabilities. The fold-up aspect allows the device to be out of the way when not in use, but remain on the wheelchair. This eliminates the need for the user to do excess work. The design is also relatively confined to the castor region of the wheelchair and is therefore not a large hindrance to other wheelchair functions, both when in use and not in use. Compared to other designs, this one is slightly more difficult to manufacture. The modified design requires either a mold or a complete model of the castor in order to adequately create a casing to fit around them. However, the stability the design offers as a result outweighs this disadvantage, and the process for manufacturing this is nonetheless achievable. Design 2 did offer very similar advantages and was lower in cost, but its durability and storage disadvantages outweigh the disadvantages of Design 1. Design 3 did not perform high in any category.

SADIE ROWE - Dec 12, 2023, 11:25 PM CST



	Design 1: Fold-Up Footrest	Design 2: Folding Mesh Footrest	Design 3: Airplane Armrest
Ease of use (25)	5/5	5/5	2/5
Storage (20)	5/5	4/5	3/5
Weight (15)	4/5	5/5	2/5
Size (15)	5/5	5/5	3/5
Ease of Fabrication (10)	4/5	5/5	1/5
Durability (10)	5/5	3/5	3/5
Cost (5)	3/5	5/5	2/5
Total (100)	93	92	47

Ease of use- how easy is it to set up the footrests to be used or to move or remove them when not in use

Storage- how easily can it be stored on or in the wheelchair

Weight- would the client be able to lift this himself, less than 4 pounds

Size- is it small enough to fit in the wheelchair, do his feet fit on the pedals

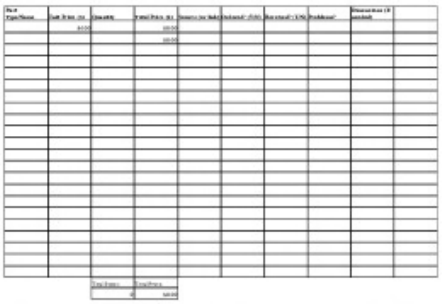
Durability- is the material able to withstand the elements and also the wear and tear if moved

Download

Design_Matrix.pdf (854 kB)

Materials & Cost Excel

Juliana Dugo - Sep 15, 2023, 1:29 AM CDT



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Materials_and_Costs_Wheelies_.xlsx (10.6 kB)

Final Materials & Cost Excel

Juliana Dugo - Dec 08, 2023, 11:11 AM CST

Part Type/Name	Unit Price ($)	Quantity	Total Price ($)	Source (or link)	Ordered? (Y/N)	Received? (Y/N)	Problems?	Dimensions	Link
Aluminum Sheet	$19.25	1	$19.25	Makerspace	Y	Y	N/A	6 in x 6 in x 1/8 in	
90 Degree Hinge	$3.75	4	$14.99	Amazon	Y	Y	Locking mechanism would be too difficult for our client	2.4" L x 1.8" W	link
100 Degree Hinge	$5.00	2	$9.99	Amazon	Y	Y	No, just had to modify our footplate by making a cutout	3.34" L x 2.44" W	link
Demo Cap	$12.88	1	$12.88	Makerspace	N	N/A	N/A	161 g (.08 cents/gram) Tough PLA	
Velcro Strap	$0.75	4	$3.00	Makerspace	Y	Y	N/A	12 in x 1 in	
3D Printed Cap	$10.89	1	$10.89	Makerspace	N/A	N/A		132 g (.08 cents/gram) Tough PLA	
		Total Items:	**Total Price:**						
		13	$71.00						

Part Type/Name	Unit Price ($)	Quantity	Total Price ($)	Source	Dimensions	Link
Aluminum Sheet	$19.25	1	$19.25	Makerspace	6 in x 6 in x 1/8 in	N/A
90 Degree Hinge	$3.75	4	$14.99	Amazon	2.4" L x 1.8" W	link
100 Degree Hinge	$5.00	2	$9.99	Amazon	3.34" L x 2.44" W	link
Demo Cap	$12.88	1	$12.88	Makerspace	161 g (.08 cents/gram) Tough PLA	N/A
Velcro Strap	$0.75	4	$3.00	Makerspace	12 in L x 1 in W	N/A
3D Printed Cap	$10.89	1	$10.89	Makerspace	132 g (.08 cents/gram) Tough PLA	N/A
		Total Items:	**Total Price:**			
		13	$71.00			

Juliana Dugo - Dec 08, 2023, 11:03 AM CST

Download

Materials_and_Costs_Wheelies_1_.xlsx (6.92 kB)

2023/11/01-Fabrication of Footplate

Juliana Dugo - Dec 08, 2023, 9:55 PM CST

Title: Fabrication of Footplate

Date: 11/01/2023

Content by: Lael Warren

Present: Lael Warren, Juliana Dugo

Goals: Fabricate the single sheet footplate. Will use this one to compare to the box footplate to see which will work better with the project.

Content:

The first thing we did was buy an aluminum alloy 6061-T6 sheet from the maker space. We settled for a 12 by 12 inch sheet with a 1/8 in thickness, to meet weight requirements and we were told that the 1/8 in would be a sufficient thickness in terms of strength for our purpose. Then in the team lab, we cut the sheet into 4 squares, each 6 by 6 inch using the bandsaw. After we had the squares, we decided to round out the edges. We used the vertical belt sander to round off the corners. To get rid of sharp edges and any persisting imperfections we used handheld files to smooth it out. Then for weather condition criteria and functionality purposes, we decided to drill 9 equidistant holes into it. This allows for any water or snow on the client's shoe to drain through the footplate. We created a grid of holes, where each hole was 2 inches apart from the others, and the outer holes were 1 inch from the edge. We used the drilling machine at the recommended speed of 850 RPM and used a 0.334 inch diameter drill bit. We also used cutting oil on the metal during the process to reduce friction which also keeps our metal at a stable temperature during the cutting process, since the reduction of friction reduces any heat build up. Using the cutting oil prolongs the life of both the drill bit and our material. The recommended speed of 850 RPM was picked from the guidelines for materials that were ¼ - ⅜ thickness of aluminum. Once all 9 holes were done, we wiped off the oil with a rag and cleaned up our workstations.

Conclusions/action items:

Need to make this outline more formal and a more cohesive summary. In addition, need to make fabrication plans for the box footplate and also fabricate the box footplate in order to be able to compare the two.

2023/12/01 Final Fabrication

Title: Final Fabrication Details

Date: 12/01/2023

Content by: Juliana Dugo

Present: All

Goals: Finish fabricating our final design for the end of the semester

Resources:

[1]https://www.google.com/urlq=https://ultimaker.my.salesforce.com/sfc/p/%23j0000000HOnW/a/5b000004UgTE/z40nDBo3Clypj7u9xI7MbeVe.CNpDM_Mq0nhvbpyne8&sa=D&sour

Content:

During this fabrication is where all three aspects of our design came together, to create our final design. First, we have the 3D printed castor cap the mechanical properties can be found. This was on the cheaper side while also having decent durability since its yield tensile stress is average plane. The 3D-printed castor cap came out as expected and the fit was verified by inserting it on top of the castors, refer to Figure 3. The next ste leaf of the 100-degree hinge doesn't sit flat, but rather has a protruding shape, we needed to modify our previously fabricated aluminum plates, t markings to center it and a calibrator to get a good measurement of how much aluminum needed to be cut out. We used the bandsaw to carve o diagonal cuts with the straight band saw, to cut the desired piece out. These random diagonal cuts slowly shaved off aluminum to create that de smooth the edges and flatten the deepest part of the rectangle that the bandsaw could not cut smoothly. Next, we had to drill holes for the screw smaller diameter than the largest diameter of the screw, in order to thread it for a precise snug fit. This would give the screws more stability. We RPM using the drill bit corresponding to the M4 x 0.7 x 12 mm screw (part number 43130). Then used the manual threading tools to carve in the t shown in Figure 4. We secured the screws on the end using a 9/32 " nut and used the torque wrench to secure it tightly. We had to use an adapte the corresponding 9/32" adaptation. Next in order to attach the hinge and aluminum footplate to the castor, we needed to drill holes into the 3D-p same size drill and threading as with the aluminum plate. We used the same process and the same screws and nuts to fasten them together secu step was using the Velcro straps to fasten it onto the castor. The 3D-printed caps have specific slits for inserting the Velcro straps through each

Figure 1: Table of mechanical properties of tough PLA [1]

Mechanical properties

All samples were 3D printed. See 'Notes' section for details.

	Test method	Typical value		
		XY (Flat)	YZ (Side)	Z (Up)
Tensile (Young's) modulus	ASTM D3039 (1 mm / min)	2797 ± 151 MPa	2797 ± 99 MPa	2696 ± 180 MPa
Tensile stress at yield	ASTM D3039 (5 mm / min)	45.3 ± 2.0 MPa	47.5 ± 0.5 MPa	33.4 ± 0.5 MPa
Tensile stress at break	ASTM D3039 (5 mm / min)	27.5 ± 7.8 MPa	31.3 ± 4.4 MPa	32.5 ± 0.8 MPa
Elongation at yield	ASTM D3039 (5 mm / min)	3.2 ± 0.0%	3.5 ± 0.0%	2.6 ± 0.1%
Elongation at break	ASTM D3039 (5 mm / min)	9.4 ± 1.9%	8.2 ± 1.8%	3.1 ± 0.7%
Flexural modulus	ISO 178 (1 mm / min)	2882 ± 61 MPa	2503 ± 45 MPa	2358 ± 78 MPa
Flexural strength	ISO 178 (5 mm / min)	91.6 ± 1.3 MPa at 4.1% strain	83.0 ± 1.4 MPa at 4.4% strain	61.3 ± 5.2 MPa at 3.4% strain
Flexural strain at break	ISO 178 (5 mm / min)	No break (>10%)	No break (>10%)	3.4 ± 0.5%
Charpy impact strength (at 23°C)	ISO 179-1 / 1eB (notched)	8.9 ± 0.8 kJ/m² (Hinge)	–	–
Hardness	ISO 7619-1 (Durometer, Shore D)	80 Shore D	–	–

Figure 2: The final CAD sketches of our castor cap

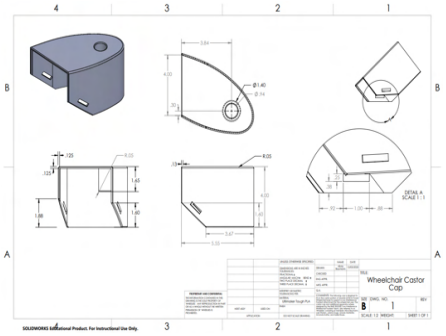


Figure 3: The 3D-printed cap resting on the castor

Figure 4: The aluminum plate attached to the 100 degree hinge

Figure 5: The final design with all pieces assembled together.

Conclusions/action items:

Now that we have a fully constructed design, the next step would be to test our design.

During testing, we anticipate the possibility that there could be reassessments and adjustments to our final design.

2023/12/08-Testing Protocols and Data

SADIE ROWE - Dec 12, 2023, 11:10 PM CST

Title: Testing Protocols and Data

Date: 12/08/2023

Content by: Sadie Rowe and Lael Warren

Present: Sadie, Amanda, Gracie

Goals: Write testing protocols and gather data

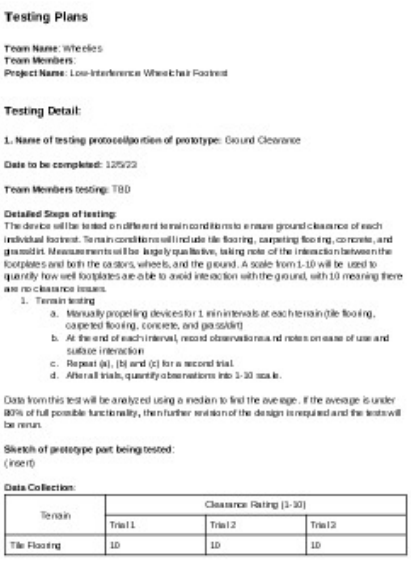
Content:

Testing was done on 12/3 by group members presents. First, the testing protocols were written and then experimentation was conducted. Data was collected in the same document that protocols were written in (attached below).

Conclusions/action items:

Write up final report on data collected from testing.

Lael Warren - Dec 08, 2023, 10:44 AM CST



Testing Plans

Team Name: Wheelies
Team Members:
Project Name: Low-Interference Wheelchair Footrest

Testing Detail:

1. Name of testing protocol/portion of prototype: Ground Clearance

Date to be completed: 12/5/23

Team Members testing: TBD

Detailed Steps of testing:
The device will be tested on different terrain conditions to ensure ground clearance of each individual footrest. Terrain conditions will include tile flooring, carpeting flooring, concrete, and grass/dirt. Measurements will be largely qualitative, taking note of the interaction between the footplates and both the castors, wheels, and the ground. A scale from 1-10 will be used to quantify how well footplates are able to avoid interaction with the ground, with 10 meaning there are no clearance issues.

1. Terrain testing
    a. Manually propelling devices for 1 min intervals at each terrain (tile flooring, carpeted flooring, concrete, and grass/dirt)
    b. At the end of each interval, record observations and notes on ease of use and surface interaction
    c. Repeat (a), (b) and (c) for a second trial
    d. After all trials, quantify observations into 1-10 scale.

Data from this test will be analyzed using a median to find the average. If the average is under 80% of full possible functionality, then further revision of the design is required and the tests will be rerun.

Sketch of prototype part being tested:
(insert)

Data Collection:

Terrain	Clearance Rating (1-10)		
	Trial 1	Trial 2	Trial 3
Tile Flooring	10	10	10

Download

Testing_Plans.docx (93.5 kB)

2023/12/12 - Testing Results

SADIE ROWE - Dec 12, 2023, 11:18 PM CST

Title: Testing Results

Date: 2023/12/12

Content by: Lael Warren and Sadie Rowe

Present: N/A

Goals: Analyze data using appropriate statistical methods, explain any relevant data used to evaluate prototype, and identify observations of salient features of results.

Content:

Each team member tested the wheelchair on all 3 terrains, meaning each terrain was tested 5 times. All scores of the terrain testing results were 10s, meaning that the prototype was able to clear all types of terrain and obstacles with at least a 3 inch clearance.

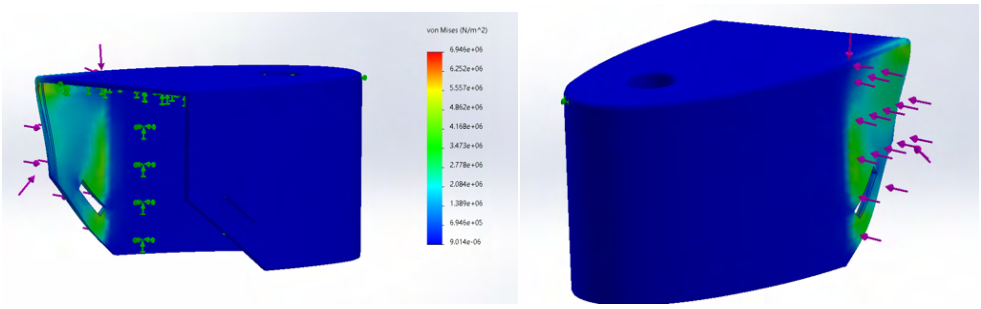


Figure 9 & 10 : *Results from Solidworks Force Testing*

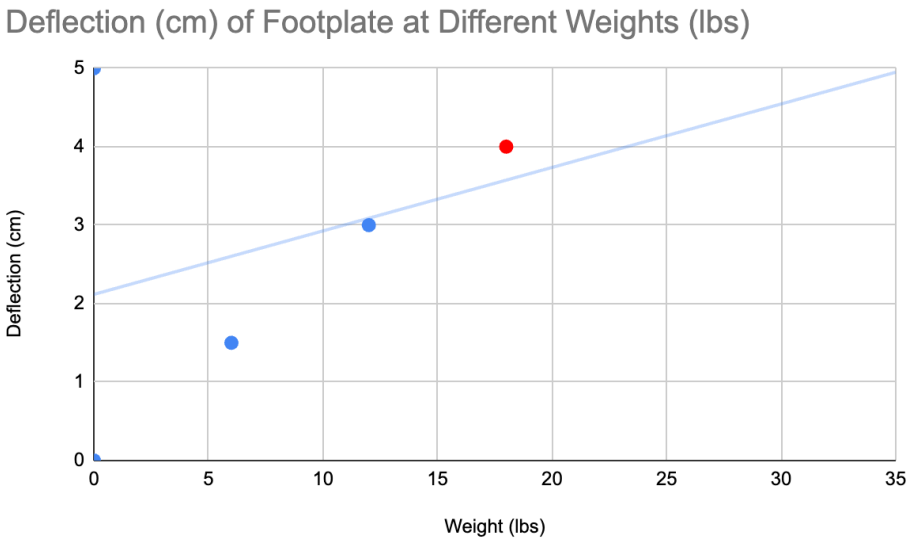


Figure 11 : *Graph of the Deflection (cm) of the footplate caused by different weights (lbs) being applied to it. Weights were applied in 6 lbs increments until the castor broke or the footplate deflected 4 cm. The red dot on the graph shows where the test failed, at 18 lbs. Not only did the footplate deflect 4 cm, the castor cap also broke.*

In order to determine if the prototype was able to hold the necessary weight in order to support the clients foot and leg, two different force tests were performed. The first test was on Solidworks and from where the force is applied, Figures 9 and 10 detail where the resulting force was on the castor. This test shows where on the castor it is most likely to break due to the force applied. The results of this test show that near the back end of the castor, towards the wheelchair, where there is a straightedge and a slit is the most likely place for resulting forces to show and for the castor to break. The Deflection vs weight test shows was conducted until the prototype failed, which was either when the footplate deflected 4 cm or the castor cap broke. In order for the test to be successful, the prototype needed to support at least 30.5 pounds, deflect less than 4 cm, and not break. When there was no weight applied, the footplate had no deflection and sat at 0-degrees. At 6 pounds and 12 pounds the footplate deflected 1.5 and 3 inches, respectively. Showing a linear trend of deflection. However once 18 pounds was applied to the footplate, the castor deflected 4 cm and broke, resulting in a failed test. The red dot in the graph marks at which point the test failed. Because the prototype failed on the first test, more tests could not be conducted on the prototype.

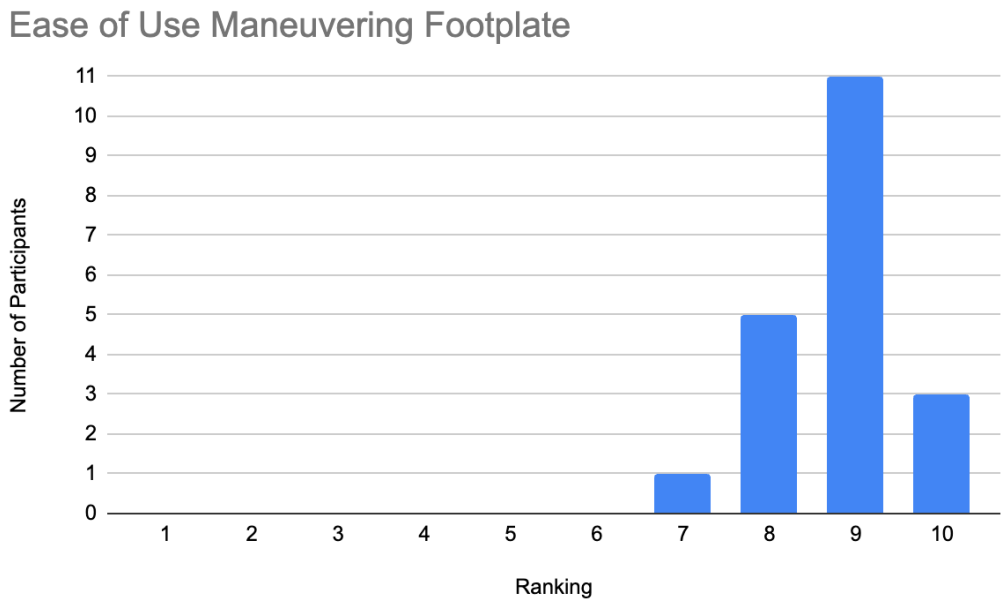


Figure 12 : *Histogram detailing the rankings that 20 participants gave for ease of use of maneuvering the footplate from the stored position to the usable position, and from the usable position back to the stored position.*

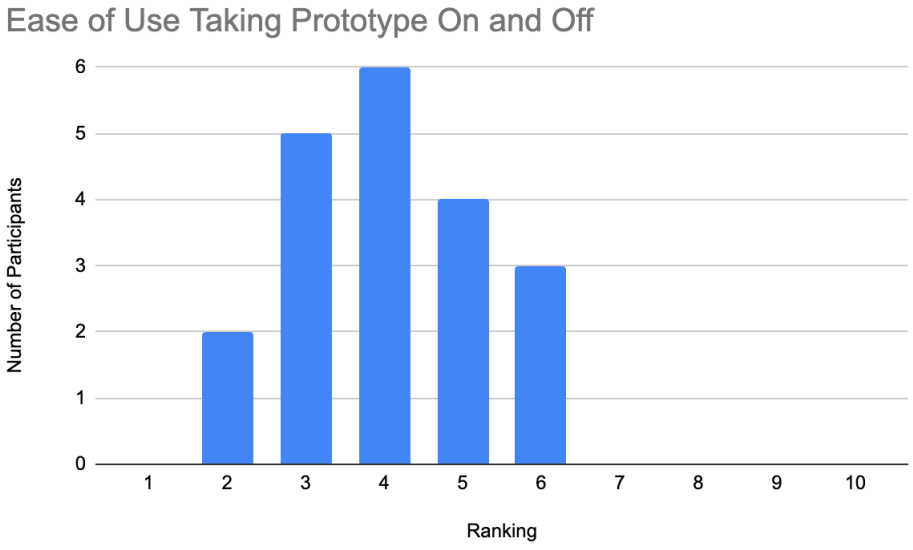


Figure 13 : *Histogram detailing the rankings that 20 participants gave for ease of use of taking the prototype off the castor and then putting the prototype back on.*

A second set of tests were conducted in order to determine the ease of use of the prototype. The first one conducted was the ease of use maneuvering the footplate. The results of the 20 UW-Madison students who attempted to put the footplate in the usable and storage position shows a graph with a concentration on the upper values of the chart. The mode of the results was 9, with 11 participants giving that score. Qualitative feedback on this test included that it is easier to move the footplate into the stored position rather than the usable position; and that the soft close is nice for when you are putting it down into the usable position. The second ease of use test conducted was taking the castor cap on and off the castors. The results of this graph show the response concentration towards the lower ranking values, with the mode being a 4. The rankings for this ease of use test were more evenly distributed between the values given (2-6). Qualitative feedback for this test included that it was not hard to remove the cap from the castor but it was hard to put it back on, specifically the velcro. Other comments included that it is hard to bed down in the chair to take the cap on and off, and the question of where you would store the caps and footplates on the wheelchair if they were not in use.

Conclusions/action items: Incorporate summary into final report

2023/12/12 - Discussion of Results

SADIE ROWE - Dec 12, 2023, 11:16 PM CST

Title: Discussion of Results

Date: 2023/12/12

Content by: Amanda Kothe, Sadie Rowe, and Juliana Dugo

Present: N/A

Goals: Reveal implications of results, discuss ethical considerations in the conduct of the research and use of the device, and identify all changes need to be made as a result of evaluation.

Content:

This product was designed around a specific model of a wheelchair, so it would only be useful for clients with a Quickie Power wheelchair. However, competing footrests often restrict leg movement and are not able to be removed while the wheelchair is in use. Therefore, it is possible that different clientele would benefit from a wheelchair footrest that can be stored on the wheelchair, allows for leg movement, and allows feet to reach the ground. In order to make the device more widely usable, different castor caps would have to be printed to fit the desired chair. The final design of the footrest consists of an aluminum footplate attached to a 3D printed castor cap with a 100 degree hinge.

Throughout the group’s testing and research, main ethical considerations consisted of ensuring that the final product is safe to use and does not inhibit any functions of the wheelchair. The product should not affect the movement of the wheelchair by restricting the movement of the front wheels. Through testing, we were able to determine that the footrest does not inhibit the main functions of the wheelchair in any way, as it does not get in the way of the wheels, even considering deflection of the footplates when force is applied. Additionally, the product should not permanently alter or damage the wheelchair by putting more force on the castors then they are able to support. Throughout the testing process, the group attempted to ensure the product is able to support the force of the client’s feet. However, when applying force during testing, the cap cracked and hindered the ability and safety of the footrest. Changes need to be made to the cap on top of the castor to ensure that it is able to support the weight of the client's feet without breaking. This could include support bars underneath the foot plate to help distribute the force, making the cap thicker, or adding extra support into the design so the cap fits the castor wheel better. The final ethical concern was that the product should not affect the client’s transfer on and off of the wheelchair. Due to the position of the footplate, the footrest should not have any effect on the client's transfer into the wheelchair.

Throughout various stress tests and calculations, we diligently replicated the client's weight and abilities. For instance, to assess ease of use, a team member tested flipping the plate up and down while simulating the client's motion, focusing on vertical foot movement. Leveraging the soft close feature of the hinge made the rotation effortless, requiring just a slight push. However, the accuracy of our simulation is subjective without testing with the actual client. For stress tests, we calculated the weight of the client's legs. We acknowledge the potential variations as the client might shift sides adding additional pressures, so our findings are merely an estimation. Our calculations indicated that the aluminum's yield stress far exceeded the applied stress, ensuring a significant factor of safety. The footplate's deflection was negligible, and with testing, it was confirmed that all deflection originates from the hinge. Our current hinge raised concerns due to potential material weakness and the not-ideal 100-degree angle led us to insert a metal piece limiting the angle to 80 degrees during unfolding, enhancing stability and preventing weight slippage. Another critical issue was the cap not being snug enough. This led to instability under eccentric loads, leading to torsion that twisted the cap out of its resting place, which added to the deflections observed.

Many different tests were completed to determine if the prototype meets the design specifications. Many of the design specifications were met for this prototype, however some were not. The prototype did have a combined weight below 3-4 pounds, and will have a lifespan of 4-5 years based on the material. Based on the properties of materials used, the device is also expected to be able to withstand 14-80 ℉ and be

waterproof. The device has a ground clearance of 3 inches, and footplates are constructed of aluminum which can withstand a stress of 0.423 lb/in^2. The production of the prototype did not exceed $100, and the footrests do have the ability to fold out of the way. However, the prototype was not able to support a weight of 30.5 lbs, and test subjects were not able to easily remove and reattach the footrests.

Possible sources of error could arise from inaccurate measurements of the force of the client's feet that will be applied to the footrest. The force of the client's feet onto the footrest changes depending on the angle of the client's legs or if they are leaning forward or backward. Additionally, the client could lean to one side or the other, which would put additional pressure on one of the footrests. This could make it difficult to find an exact number for the weight the footrest must support. Additional sources of error arose in the testing of the prototype. While undergoing the force test, the castor cap portion of the design cracked. The structural integrity of the footrest failed, meaning the team was unable to test the full capabilities of the footplate and hinge components of the footrest. Another source of error in the testing was in the ease of use test maneuvering the footplate test. The client was unable to test the device, so the team moved forward with testing with fellow students. In the ease of use test maneuvering the footplate test, students rated the ease of moving the footplate between the folded up and folded down positions with their feet. This data creates a source of error because the team tested with able bodied individuals whose ease of motion could be different than individuals with a disability.

Conclusions/action items: Include discussion of results in final report.

Progress Report 1

SADIE ROWE - Sep 15, 2023, 1:41 PM CDT

Low-Interface Wheelchair Footrest, Team Wheelies, BME 200/300

Client: Mr. Dan Doeszynski

Advisor: Prof. William Murphy

Team: Lael Warren lewarren2@wisc.edu (Team Leader)

Liv Baumann gsbaumann2@wisc.edu (Team Leader / BSAC)

Amanda Kothe arkothe@wisc.edu (Communicator)

Sadie Rowe slrowe2@wisc.edu (BWIG)

Gracie Hostetler ghostetler@wisc.edu (BWIG)

Juliana Diugo jdiugo@wisc.edu (BPAG)

Date: September 8 to September 14, 2023

Problem Statement

There are currently no wheelchairs on the market which allows those who are not paralyzed to perform helpful movements, such as opening doors with their feet or being able to pick up objects from the floor. In addition, current footrest models are heavy, bulky, and not easily able to be removed and stored when not in use. While footrests are crucial for support if the wheelchair tilts or reclines, it is imperative to design a wheelchair footrest that allows for more foot mobility- should the user require it- and for easier storage of said footrests. The updated footrests should be able to adapt to a person's abilities, should be easily able to remove and store them when not in use, and be lighter and less bulky, while still providing the benefits of a footrest when necessary.

Brief Status Update

The team has started doing research into wheelchair design, wheelchair patents, the types of disabilities that require wheelchair use, and the limitations of current wheelchair designs.

Summary of Weekly Team Member Design Accomplishments

- Team:
  - Establishing team roles
  - Setting up appropriate communication channels

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Wheelies-Progress_Report-1.pdf (68.5 kB)

Progress Report 2

Juliana Dugo - Oct 06, 2023, 1:26 PM CDT

Low-Interface Wheelchair Footrest, Team Wheelies, BME 200/300

Client: Mr. Dan Dorszynski

Advisee: Prof. William Murphy

Team: Lael Warren lawarren2@wisc.edu (Team Leader)

Liv Baumann gabaumann2@wisc.edu (Team Leader / BSAC)

Amanda Kothe akothe@wisc.edu (Communicator)

Sadie Rowe slrowe2@wisc.edu (BWIG)

Gracie Hasbrouck ghasbrouck@wisc.edu (BWIG)

Juliana Dugo jdugo@wisc.edu (BPAG)

Date: September 15 to September 21, 2023

Problem Statement

There are currently no wheelchairs on the market which allows those who are not paralyzed to perform helpful movements, such as opening doors with their feet or being able to pick up objects from the floor. In addition, current footrest models are heavy, bulky, and not easily able to be removed and stored when not in use. While footrests are crucial for support if the wheelchair tilts or reclines, it is important to design a wheelchair footrest that allows for more foot mobility- should the user require it- and for easier storage of said footrests. The updated footrests should be able to adapt to a person's abilities, should be easily able to remove and store them when not in use, and be lighter and less bulky, while still providing the benefits of a footrest when necessary.

Brief Status Update

The team is continuing to do research on current footrest designs on the market, materials, and patents. In addition, they are each brainstorming 3 designs to bring to the client meeting to get feedback on.

Summary of Weekly Team Member Design Accomplishments

- Team:
  - Met with client and discussed different design aspects he wants to incorporate
  - Designated who will research what subtopic (current designs, materials, patents)
  - Assigned parts of the Product Design Specification (PDS) to be worked on
- Last

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Wheelies-Progress_Report-2.docx (12.9 kB)

Progress Report 3

Juliana Dugo - Oct 06, 2023, 1:27 PM CDT

Low-Interface Wheelchair Footrest, Team Wheelies, BME 200/300

Client: Mr. Dan Dorszynski

Advisee: Prof. William Murphy

Team: Lael Warren lawarren2@wisc.edu (Team Leader)

Liv Baumann ejbaumann2@wisc.edu (Team Leader / BSAC)

Amanda Kothe akothe@wisc.edu (Communicator)

Sadie Rowe slrowe2@wisc.edu (BWIG)

Gracie Hasbrouck ghasbrouck@wisc.edu (BWIG)

Juliana Dugo jdugo@wisc.edu (BPAG)

Date: September 22 to September 28, 2023

Problem Statement

There are currently no wheelchairs on the market which allows those who are not paralyzed to perform helpful movements, such as opening doors with their feet or being able to pick up objects from the floor. In addition, current footrest models are heavy, bulky, and not easily able to be removed and stored when not in use. While footrests are crucial for support if the wheelchair tilts or reclines, it is important to design a wheelchair footrest that allows for more foot mobility- should the user require it- and for easier storage of said footrests. The updated footrests should be able to adapt to a person's abilities, should be easily able to remove and store them when not in use, and be lighter and less bulky, while still providing the benefits of a footrest when necessary.

Brief Status Update

The team worked on narrowing down design ideas to make the design matrix. The team also worked on deciding on what materials to purchase and submitted a funding proposal to the BME Design Board.

Summary of Weekly Team Member Design Accomplishments

- Team:
  - Narrowed down design ideas by combining elements from different designs
  - Made Design Matrix criteria and filled out design matrix
  - Made questions to ask client and list of actions we would like him to demonstrate
- Lael:

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Wheelies-Progress_Report-3.docx (725 kB)

Progress Report 4

Juliana Dugo - Oct 06, 2023, 1:27 PM CDT

Low-Interface Wheelchair Footrest, Team Wheelies, BME 200/300

Client: Mr. Dan Dorszynski

Advisee: Prof. William Murphy

Team: Lael Warren lawarren2@wisc.edu (Team Leader)

Liv Baumann ejbaumann2@wisc.edu (Team Leader / BSAC)

Amanda Kothe akothe@wisc.edu (Communicator)

Sadie Rowe slrowe2@wisc.edu (BWIG)

Gracie Hasbrouck ghasbrouck@wisc.edu (BWIG)

Juliana Dugo jdugo@wisc.edu (BPAG)

Date: September 29 to October 5, 2023

Problem Statement

There are currently no wheelchairs on the market which allows those who are not paralyzed to perform helpful movements, such as opening doors with their feet or being able to pick up objects from the floor. In addition, current footrest models are heavy, bulky, and not easily able to be removed and stored when not in use. While footrests are crucial for support if the wheelchair tilts or reclines, it is important to design a wheelchair footrest that allows for more foot mobility- should the user require it- and for easier storage of said footrests. The updated footrests should be able to adapt to a person's abilities, should be easily able to remove and store them when not in use, and be lighter and less bulky, while still providing the benefits of a footrest when necessary.

Brief Status Update

The team selected a final preliminary design and is working towards a CAD model. In addition they have narrowed down materials and hope to order them by the end of the week. Finally, the team continues to work on the preliminary presentation and preliminary report.

Summary of Weekly Team Member Design Accomplishments

- Team:
  - Picked Final preliminary design
  - Worked on preliminary presentation
  - Worked on preliminary report
  - Narrowed down materials list

Download

Wheelies-Progress_Report-4.docx (725 kB)

Progress Report 5

Juliana Dugo - Oct 06, 2023, 1:28 PM CDT

Low-Interface Wheelchair Footrest, Team Wheelies, BME 200/300

Client: Mr. Dan Dorszynski

Advisee: Prof. William Murphy

Team: Lael Warren lawarren2@wisc.edu (Team Leader)

Liv Baumann ejbaumann2@wisc.edu (Team Leader / BSAC)

Amanda Kothe akothe@wisc.edu (Communicator)

Sadie Rowe slrowe2@wisc.edu (BWIG)

Gracie Hasbrouck ghasbrouck@wisc.edu (BWIG)

Juliana Dugo jdugo@wisc.edu (BPAG)

Date: September 29 to October 5, 2023

Problem Statement

There are currently no wheelchairs on the market which allows those who are not paralyzed to perform helpful movements, such as opening doors with their feet or being able to pick up objects from the floor. In addition, current footrest models are heavy, bulky, and not easily able to be removed and stored when not in use. While footrests are crucial for support if the wheelchair tilts or reclines, it is important to design a wheelchair footrest that allows for more foot mobility- should the user require it- and for easier storage of said footrests. The updated footrests should be able to adapt to a person's abilities, should be easily able to remove and store them when not in use, and be lighter and less bulky, while still providing the benefits of a footrest when necessary.

Brief Status Update

Summary of Weekly Team Member Design Accomplishments

- Team:
  -
- Lael:
  -
- Liv:
  -
- Amanda:

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Wheelies-Progress_Report-5.docx (723 kB)

Progress Report 6

SADIE ROWE - Dec 06, 2023, 1:22 PM CST

Low-Interface Wheelchair Footrest, Team Wheelies, BME 200/300

Client: Mr. Dan Dorszynski

Advisee: Prof. William Murphy

Team: Lael Warren lawarren2@wisc.edu (Team Leader)

Liv Baumann ejbaumann2@wisc.edu (Team Leader / BSAC)

Amanda Kothe akothe@wisc.edu (Communicator)

Sadie Rowe slrowe2@wisc.edu (BWIG)

Gracie Hasbrouck ghasbrouck@wisc.edu (BWIG)

Juliana Dugo jdugo@wisc.edu (BPAG)

Date: October 13 to October 19, 2023

Problem Statement

There are currently no wheelchairs on the market which allows those who are not paralyzed to perform helpful movements, such as opening doors with their feet or being able to pick up objects from the floor. In addition, current footrest models are heavy, bulky, and not easily able to be removed and stored when not in use. While footrests are crucial for support if the wheelchair tilts or reclines, it is important to design a wheelchair footrest that allows for more foot mobility- should the user require it- and for easier storage of said footrests. The updated footrests should be able to adapt to a person's abilities, should be easily able to remove and store them when not in use, and be lighter and less bulky, while still providing the benefits of a footrest when necessary.

Brief Status Update

Received the wheelchair base file in the client. Have started making CAD Drawing and fabrication plans.

Summary of Weekly Team Member Design Accomplishments

- Team:
  - Received wheelchair base from client
  - Continued research on hinges
  - Made changes to preliminary design
- Lael:
  - Continued hinge research (60 min)

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Wheelies-Progress_Report-6.docx (725 kB)

Progress Report 7

SADIE ROWE - Dec 06, 2023, 6:00 PM CST

Low-Interface Wheelchair Footrest, Team Wheelies, BME 200/300

Client: Mr. Dan Dorszynski

Advisee: Prof. William Murphy

Team: Lael Warren lawarren2@wisc.edu (Team Leader)

Liv Baumann gabaumann2@wisc.edu (Team Leader / BSAC)

Amanda Kothe akothe@wisc.edu (Communicator)

Sadie Rowe slrowe2@wisc.edu (BWIG)

Gracie Hasbrouck ghasbrouck@wisc.edu (BWIG)

Juliana Dugo jdugo@wisc.edu (BPAG)

Date: October 20 to October 26, 2023

Problem Statement

There are currently no wheelchairs on the market which allows those who are not paralyzed to perform helpful movements, such as opening doors with their feet or being able to pick up objects from the floor. In addition, current footrest models are heavy, bulky, and not easily able to be removed and stored when not in use. While footrests are crucial for support if the wheelchair tilts or reclines, it is important to design a wheelchair footrest that allows for more foot mobility- should the user require it- and for easier storage of said footrests. The updated footrests should be able to adapt to a person's abilities, should be easily able to remove and store them when not in use, and be lighter and less bulky, while still providing the benefits of a footrest when necessary.

Brief Status Update

Received wheelchair base and made fabrication plans. Looked at different materials and made a list of purchases we want to make.

Summary of Weekly Team Member Design Accomplishments

- Team:
  - Met to talk about materials and fabrication plans
  - Made fabrication plans document
  - Made testings plans document
  - Made a list of final materials we want to purchase for preliminary prototype
- Lael:

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Wheelies-Progress_Report-7.docx (219 kB)

Progress Report 8

SADIE ROWE - Dec 06, 2023, 6:00 PM CST

Low-Interface Wheelchair Footrest, Team Wheelies, BME 200/300

Client: Mr. Dan Dorszynski

Advisee: Prof. William Murphy

Team: Lael Warren lawarren2@wisc.edu (Team Leader)

Liv Baumann gabaumann2@wisc.edu (Team Leader / BSAC)

Amanda Kothe akothe@wisc.edu (Communicator)

Sadie Rowe slrowe2@wisc.edu (BWIG)

Gracie Hasbrouck ghasbrouck@wisc.edu (BWIG)

Juliana Dugo jdugo@wisc.edu (BPAG)

Date: October 27 to November 2, 2023

Problem Statement

There are currently no wheelchairs on the market which allows those who are not paralyzed to perform helpful movements, such as opening doors with their feet or being able to pick up objects from the floor. In addition, current footrest models are heavy, bulky, and not easily able to be removed and stored when not in use. While footrests are crucial for support if the wheelchair tilts or reclines, it is important to design a wheelchair footrest that allows for more foot mobility- should the user require it- and for easier storage of said footrests. The updated footrests should be able to adapt to a person's abilities, should be easily able to remove and store them when not in use, and be lighter and less bulky, while still providing the benefits of a footrest when necessary.

Brief Status Update

Fabricated the footplate in the TeamLab. Emailed Dr. Puccinelli about purchasing pour silicone for molds. Finalized CAD plans and worked on elevator pitch for Show and Tell.

Summary of Weekly Team Member Design Accomplishments

- Team:
  - Worked on elevator pitch for Show and Tell
  - Research hinges to use for designs
  - Fabricate footplate in TeamLab
- Lael:
  - Researched pour silicone (60 min)

Download

Wheelies-Progress_Report-8.docx (219 kB)

Progress Report 9

SADIE ROWE - Dec 06, 2023, 6:01 PM CST

Low-Interface Wheelchair Footrest, Team Wheelies, BME 200/300

Client: Mr. Dan Dorszynski

Advisee: Prof. William Murphy

Team: Lael Warren lawarren2@wisc.edu (Team Leader)

Liv Baumann ejbaumann2@wisc.edu (Team Leader / BSAC)

Amanda Kothe akothe@wisc.edu (Communicator)

Sadie Rowe slrowe2@wisc.edu (BWIG)

Gracie Hasbrouck ghasbrouck@wisc.edu (BWIG)

Juliana Dugo jdugo@wisc.edu (BPAG)

Date: November 3rd to November 9th, 2023

Problem Statement

There are currently no wheelchairs on the market which allows those who are not paralyzed to perform helpful movements, such as opening doors with their feet or being able to pick up objects from the floor. In addition, current footrest models are heavy, bulky, and not easily able to be removed and stored when not in use. While footrests are crucial for support if the wheelchair tilts or reclines, it is important to design a wheelchair footrest that allows for more foot mobility- should the user require it- and for easier storage of said footrests. The updated footrests should be able to adapt to a person's abilities, should be easily able to remove and store them when not in use, and be lighter and less bulky, while still providing the benefits of a footrest when necessary.

Brief Status Update

The team has been working on ordering silicone materials and figuring out the best way to make a mold of the castor plate. In addition, they have been working on updating a multitude of documents including the PDS, Preliminary Report, Fabrication Plans, and Testing Plans.

Summary of Weekly Team Member Design Accomplishments

- Team:
  - Met to discuss silicone molding of castor
  - Researched hinges or other attachment devices
  - Worked on updating current documentation
- Lael:

Download

Wheelies-Progress_Report-9.docx (219 kB)

Progress Report 10

SADIE ROWE - Dec 06, 2023, 6:02 PM CST

Low-Interface Wheelchair Footrest, Team Wheelies, BME 200/300

Client: Mr. Dan Dorszynski

Advisee: Prof. William Murphy

Team: Lael Warren lawarren2@wisc.edu (Team Leader)

Liv Baumann gabaumann2@wisc.edu (Team Leader / BSAC)

Amanda Kothe akothe@wisc.edu (Communicator)

Sadie Rowe slrowe2@wisc.edu (BWIG)

Gracie Hasbrouck ghasbrouck@wisc.edu (BWIG)

Juliana Dugo jdugo@wisc.edu (BPAG)

Date: November 10 through November 16, 2023

Problem Statement

There are currently no wheelchairs on the market which allows those who are not paralyzed to perform helpful movements, such as opening doors with their feet or being able to pick up objects from the floor. In addition, current footrest models are heavy, bulky, and not easily able to be removed and stored when not in use. While footrests are crucial for support if the wheelchair tilts or reclines, it is important to design a wheelchair footrest that allows for more foot mobility- should the user require it- and for easier storage of said footrests. The updated footrests should be able to adapt to a person's abilities, should be easily able to remove and store them when not in use, and be lighter and less bulky, while still providing the benefits of a footrest when necessary.

Brief Status Update

The team has been comparing different ideas of the best way to attach the footplate to the castors. Ideas include an extended bolt from the castor, a 90 degree hinge, or a scissor hinge.

Summary of Weekly Team Member Design Accomplishments

- Team:
  - Researching different ways to attach the footplate the the castor
  - Researching different hinges
- Lael:

Download

Wheelies-Progress_Report-10.docx (398 kB)

Progress Report 11

SADIE ROWE - Dec 06, 2023, 6:03 PM CST

Low-Interface Wheelchair Footrest, Team Wheelies, BME 200/300

Client: Mr. Dan Dorszynski

Advisee: Prof. William Murphy

Team: Lael Warren lawarren2@wisc.edu (Team Leader)

Liv Baumann gabaumann2@wisc.edu (Team Leader / BSAC)

Amanda Kothe arkothe@wisc.edu (Communicator)

Sadie Rowe slrowe2@wisc.edu (BWIG)

Gracie Hasbrouck ghasbrouck@wisc.edu (BWIG)

Juliana Dugo jdugo@wisc.edu (BPAG)

Date: November 17th to November 30th, 2023

Problem Statement

There are currently no wheelchairs on the market which allows those who are not paralyzed to perform helpful movements, such as opening doors with their feet or being able to pick up objects from the floor. In addition, current footrest models are heavy, bulky, and not easily able to be removed and stored when not in use. While footrests are crucial for support if the wheelchair tilts or reclines, it is important to design a wheelchair footrest that allows for more foot mobility- should the user require it- and for easier storage of said footrests. The updated footrests should be able to adapt to a person's abilities, should be easily able to remove and store them when not in use, and be lighter and less bulky, while still providing the benefits of a footrest when necessary.

Brief Status Update

The team was able to meet and work on fabricating our final design. We also started working on the poster presentation and the final report.

Summary of Weekly Team Member Design Accomplishments

- Team:
  - Met to work on fabrication
  - Started working on poster presentation
  - Started working on Final Report
- Lael:
  - Updated Lab Archives (30 min)

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Wheelies-Progress_Report-11.docx (399 kB)

Progress Report 12

SADIE ROWE - Dec 06, 2023, 6:04 PM CST

Low-Interface Wheelchair Footrest, Team Wheelies, BME 200/300

Client: Mr. Dan Dorszynski

Advisee: Prof. William Murphy

Team: Lael Warren lawarren2@wisc.edu (Team Leader)

Liv Baumann ejbaumann2@wisc.edu (Team Leader / BSAC)

Amanda Kothe akothe@wisc.edu (Communicator)

Sadie Rowe slrowe2@wisc.edu (BWIG)

Gracie Hasbrouck ghasbrouck@wisc.edu (BWIG)

Juliana Dugo jdugo@wisc.edu (BPAG)

Date: December 1 to December 7, 2023

Problem Statement

There are currently no wheelchairs on the market which allows those who are not paralyzed to perform helpful movements, such as opening doors with their feet or being able to pick up objects from the floor. In addition, current footrest models are heavy, bulky, and not easily able to be removed and stored when not in use. While footrests are crucial for support if the wheelchair tilts or reclines, it is important to design a wheelchair footrest that allows for more foot mobility- should the user require it- and for easier storage of said footrests. The updated footrests should be able to adapt to a person's abilities, should be easily able to remove and store them when not in use, and be lighter and less bulky, while still providing the benefits of a footrest when necessary.

Brief Status Update

The team was able to finish fabrication on the prototype by attaching the footplates to the castor cap. The team then worked on testing, by seeing how much weight could be applied to the footplate, how much clearance the design had from the floor, and how easy the prototype is to use.

Summary of Weekly Team Member Design Accomplishments

- Team:
  - Finished
  - Worked on final report and poster presentation
  - Conducted testing

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Wheelies-Progress_Report-12.docx (399 kB)

2023/10/04- Product Design Specification Version 1

Lael Warren - Oct 11, 2023, 11:52 AM CDT

Title: Product Design Specifications Version 1

Date: 10/04/2023

Content by: Lael Warren

Present: All

Goals: Upload PDS to Lab Archives

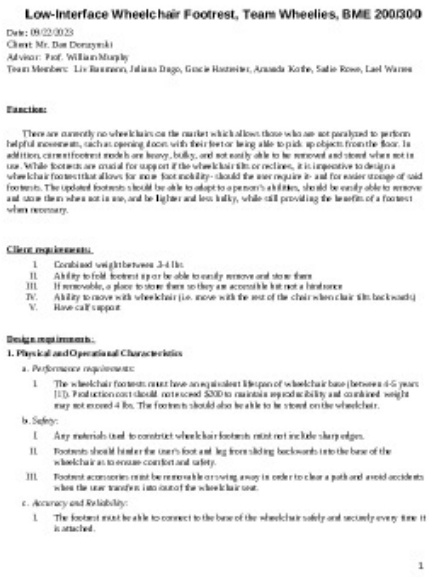
Content:

Below is the first version of the PDS submitted to canvas.

Conclusions/action items:

Keep editing PDS as semester goes on.

Lael Warren - Oct 11, 2023, 11:52 AM CDT



Low-Interface Wheelchair Footrest, Team Wheelies, BME 200/300

Date: 09/22/2023
Client: Mr. Dan Dorszynski
Advisor: Prof. William Murphy
Team Members: Liv Baumann, Juliana Diago, Gracie Hastreiter, Amanda Kothe, Sadie Rowe, Lael Warren

Function:

There are currently no wheelchairs on the market which allows those who are not paralyzed to perform helpful movements, such as opening doors with their feet or being able to pick up objects from the floor. In addition, current footrest models are heavy, bulky, and not easily able to be removed and stored when not in use. While footrests are crucial for support if the wheelchair tilts or reclines, it is imperative to design a wheelchair footrest that allows for more foot mobility- should the user require it- and for easier storage of said footrests. The updated footrests should be able to adapt to a person's abilities, should be easily able to remove and store them when not in use, and be lighter and less bulky, while still providing the benefits of a footrest when necessary.

Client requirements:

I. Combined weight between 3-4 lbs
II. Ability to fold footrest up or be able to easily remove and store them
III. If removable, a place to store them so they are accessible but not a hindrance
IV. Ability to move with wheelchair (i.e. move with the rest of the chair when chair tilts backwards)
V. Have calf support

Design requirements:

1. Physical and Operational Characteristics

a. *Performance requirements:*

1. The wheelchair footrests must have an equivalent lifespan of wheelchair base (between 4-6 years [1]). Production cost should not exceed $300 to maintain reproducibility and combined weight may not exceed 4 lbs. The footrests should also be able to be stored on the wheelchair.

b. *Safety:*

I. Any materials used to construct wheelchair footrests must not include sharp edges.
II. Footrests should hinder the user's foot and leg from sliding backwards into the base of the wheelchair so to ensure comfort and safety.
III. Footrest accessories must be removable or swing away in order to clear a path and avoid accidents when the user transfers into/out of the wheelchair seat.

c. *Accuracy and Reliability:*

1. The footrest must be able to connect to the base of the wheelchair safely and securely every time it is attached.

1

Download

Wheelies-PDS-version1.docx (14.2 kB)

2023/12/01- Product Design Specification Version 2

Lael Warren - Dec 01, 2023, 1:40 PM CST

Title: Product Design Specifications Version 2

Date: 12/01/2023

Content by: Lael Warren

Present: N/A

Goals: Make edits to existing version of PDS based upon advisors comments.

Content:

- Version 2 copy linked below.

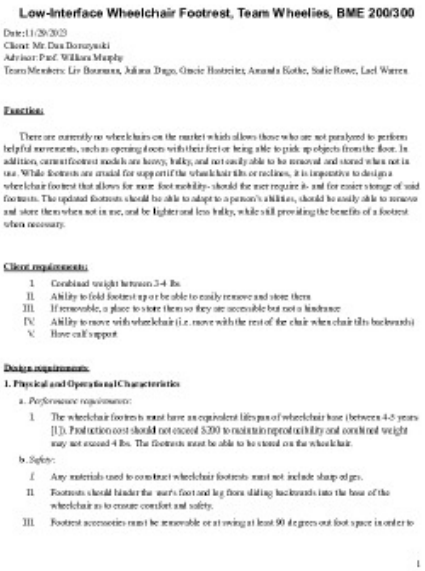
- went back into PDS and made edits based upon comment that we had good ideas for what we needed to look for, but nothing was testable.

- edits included adding a temperature range, force and stress measurements, and weight and height measurements.

Conclusions/action items:

These edits need to be reflected in the final report, both in the design specifications section and in the testing section. The criteria and design need to be compared to these original standards that were set for the project. .

Lael Warren - Dec 01, 2023, 1:40 PM CST



Low-Interface Wheelchair Footrest, Team Wheelies, BME 200/300

Date: 11/28/2023
Client: Mr. Dan Dorazynski
Advisor: Prof. William Murphy
Team Members: Liv Bateman, Juliana Dago, Gracie Hostetter, Amanda Kothe, Sadie Rowe, Lael Warren

Function:

There are currently no wheelchairs on the market which allows those who are not paralyzed to perform helpful movements, such as opening doors with their feet or being able to pick up objects from the floor. In addition, current footrest models are heavy, bulky, and not easily able to be removed and stored when not in use. While footrests are crucial for support of the wheelchair tilts or reclines, it is imperative to design a wheelchair footrest that allows for more foot mobility- should the user require it- and for easier storage of said footrests. The updated footrests should be able to adapt to a person's abilities, should be easily able to remove and store them when not in use, and be lighter and less bulky, while still providing the benefits of a footrest when necessary.

Client requirements:

I. Combined weight between 3-4 lbs.
II. Ability to fold footrest up or be able to easily remove and store them
III. If removable, a place to store them so they are accessible but not a hindrance
IV. Ability to move with wheelchair (i.e. move with the rest of the chair when chair tilts backwards)
V. Have calf support

Design requirements:

1. Physical and Operational Characteristics

a. *Performance requirements:*

I. The wheelchair footrests must have an equivalent lifespan of wheelchair base (between 4-5 years [1]). Production cost should not exceed $200 to maintain reproducibility and combined weight may not exceed 4 lbs. The footrests must be able to be stored on the wheelchair.

b. *Safety:*

I. Any materials used to construct wheelchair footrests must not include sharp edges.
II. Footrests should hinder the user's foot and leg from sliding backwards into the base of the wheelchair as to ensure comfort and safety.
III. Footrest accessories must be removable or at swing at least 90 degrees out foot space in order to

1

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Wheelies-PDS-version2.pdf (136 kB)

2023/10/06 - Preliminary Presentation

Juliana Dugo - Oct 06, 2023, 1:30 PM CDT

Download

Wheelies_Preliminary_Presentation.pptx (6.26 MB)

2023/10/11- Preliminary Report

Gracie Hastreiter - Dec 10, 2023, 1:33 PM CST

Title: Preliminary Report

Date: 10/11/2023

Content by: Lael Warren

Present: N/A

Goals: Outline the goals, progress, plans, and setbacks on the project to date in a concise document.

Content:

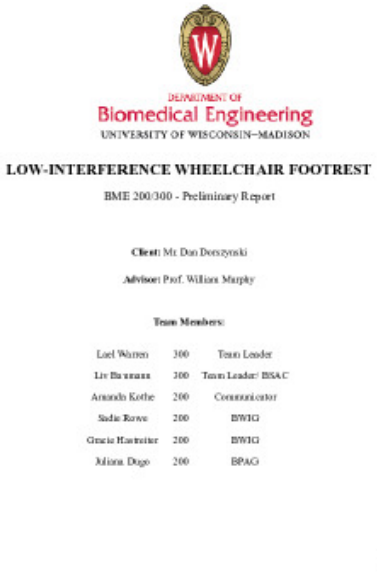
- Document linked below.

- At the point that the preliminary report was made, the team had not begun fabrication or testing. We were able to talk about the potential design, the design requirements, and also what we intended to do for testing and the results section. At the end of the semester, when the final report is made, the testing and results should reflect the intentions we had with the design and should prove, or disprove, our design requirements.

Conclusions/action items:

Begin to fabricate and test the prototype and from the data continue to update the preliminary report until it can become the final report.

Lael Warren - Dec 04, 2023, 3:24 PM CST



DEPARTMENT OF
Biomedical Engineering
UNIVERSITY OF WISCONSIN–MADISON

LOW-INTERFERENCE WHEELCHAIR FOOTREST

BME 200/300 - Preliminary Report

Client: Mr. Dan Dorszynski

Advisor: Prof. Willam Murphy

Team Members:

Lael Warren	300	Team Leader
Liv Baumann	300	Team Leader/ BSAC
Amanda Kothe	200	Communicator
Sadie Rowe	200	BWIG
Gracie Hastreiter	200	BWIG
Juliana Diggo	200	BPAG

1

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Wheelies-_Preliminary_Report.pdf (1.94 MB)

2023/12/08 - Final Poster

Gracie Hastreiter - Dec 10, 2023, 1:52 PM CST

Title: Final Poster

Date: 12/8/2023

Content by: Gracie Hastreiter

Present: N/A

Goals: To present our final design, testing, and the results of the testing our prototype. Additionally, we will use the results of our testing to describe future work that can be done to improve the design of the prototype.

Content:

- Document of poster linked below.

Conclusions/action items: N/A

Gracie Hastreiter - Dec 10, 2023, 1:35 PM CST

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Wheelies_Poster_Presenation.pdf (2.36 MB)

23/12/13 - Final Report

SADIE ROWE - Dec 13, 2023, 9:59 AM CST

Title: Final Report

Date: 2023/12/13

Content by: Sadie Rowe

Present: N/A

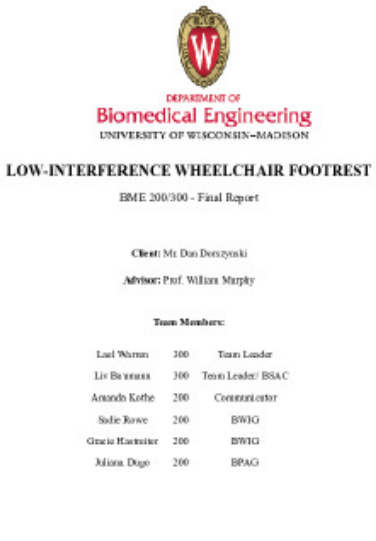
Goals: Outline the project, including a cover page, abstract, table of contents, introduction, background, preliminary designs, preliminary design evaluation, fabrication process, results discussion, conclusion, and references.

Content:

The final report is attached below.

Conclusions/action items: N/A

SADIE ROWE - Dec 13, 2023, 9:54 AM CST



DEPARTMENT OF
Biomedical Engineering
UNIVERSITY OF WISCONSIN–MADISON

LOW-INTERFERENCE WHEELCHAIR FOOTREST

BME 200/300 - Final Report

Client: Mr. Dan Dorszynski

Advisor: Prof. William Murphy

Team Members:

Lael Warren	300	Team Leader
Liv Baumann	300	Team Leader/ BSAC
Amanda Kothe	200	Communicator
Sadie Rowe	200	BWIG
Gracie Hastreiter	200	BWIG
Juliana Diggs	200	BPAG

1

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Wheelies-_Final_Report_1_.pdf (4.6 MB)

2023/09/08 - Team Meeting 1

Lael Warren - Sep 12, 2023, 8:33 PM CDT

Title: Team Meeting 1

Date: 09/08/2023

Content by: Lael Warren

Present: All

Goals: Go over team goals, expectations, concerns, important due dates, and contact client and advisor

Content:

- Introduced ourselves and spoke about our grades, intended majors, and other important facts about ourselves
- Went over important due dates, weekly progress reports, and the other reports due throughout the semester
    - Put important due dates in the calendar
- Discussed the expectations we have for ourselves, eachother, and as a group
    - Should be researching all semester
    - Do your part of the progress report on time
    - Make sure you are staying on task when we are together
    - If you have questions, ask
    - Be respectful of everyones own identity
    - This work should reflect the best effort we can give
- Assigned team roles
- Emailed advisor and client
- Discussed how we to go about research
    - For the first week everyone can compile different research they find
    - After the first week we will assign different aspects for everyone to look into
- Made first progress report and started to fill it out
- Ended by making a groupchat so we would be able to contact eachother outside of class

Conclusions/action items:

- Start researching
- Keep filling out progress report 1
- Schedule time to meet with client and make a questions list for him

- Figure out when our meeting time is with advisor

2023/09/15 - Team Meeting 2

Lael Warren - Sep 15, 2023, 1:55 PM CDT

Title: Team Meeting 2

Date: 09/15/2023

Content by: Lael Warren

Present: All

Goals: Go over what needs to be discussed with the client

Content:

- Started making questions to discuss with the client, client meeting is at 12:30 CT on 09/15/2023

- Questions include:

  - Has he previously worked on this project with a group?
    - If so, was there anything in particular that he liked / didn't like?
  - Manual v.s. Electric Wheelchair?
  - What are the main issues he runs into?
  - Is there a specific material?
  - Mobility restrictions? Anything you can't do that we should be conscientious about?
  - Dimensions / Style of the current footrest? How much of the foot would you like it to accommodate?
  - Removable component v.s. add on to the wheelchair.
  - Is there anything you don't want us to change on the wheelchair?

- After the client meeting we had a debrief about what we need to do and what to come with next week
  - Assigned who was researching what topic: current designs, materials, patents, and the wheelchair base
  - Assigned parts of the PDS
  - Need to be done by Thursday so we can go over them and discuss before the client meeting
  - Still have questions about how the budget works and where the funding comes from. Talked to advisor and he will check on this for us.

Conclusions/action items:

- Start researching and making design ideas.

2023/09/22-Team Meeting 3

Lael Warren - Sep 22, 2023, 1:18 PM CDT

Title: Team Meeting 3

Date: 09/22/2023

Content by: Lael Warren

Present: All

Goals: Look over upcoming dates, go over team designs, make a plan for upcoming weeks

Content:

- First when over upcoming important dates
    - PDS due tonight (9/22)
    - Design Matrix (9/29)
    - Preliminary oral presentations (10/6)
    - Preliminary deliverables due (10/11)

- Next went over any questions anyone had about any of those dates (what is it, what do I wear, who does what, etc) and then any questions about the PDS and the comments made on it

- The bulk of time was spent going over team designs and talking about the pros and cons of all of them. Picking top 3 designs on hold until meeting with client next week in order to discuss him range of motion and also what type of designs he likes better.

- Emailed client in order to find a time to meet with him next week and also to ask him to send videos on different range of motion

- Worked on design matrix criteria

- Finished up by making a plan for the upcoming weeks
    - start picking designs for design matrix
    - start assigning parts of preliminary oral presentations and preliminary deliverables.

Conclusions/action items:

- start working on design matrix.

2023/09/27-Team Meeting 4

Lael Warren - Sep 27, 2023, 9:26 PM CDT

Title: Team Meeting 4

Date: 09/27/2023

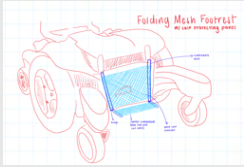
Content by: Lael Warren

Present: All

Goals: Complete Design Matrix

Content:

To start the meeting we finished the design matrix criteria and selected the 3 designs we wanted to use for the design matrix. We then evaluated them and compiled the scores.

	Design 1: Castor Central 	Design 2: Blue Box Blues 	Design 3: Airplane Armrest
Ease of use (25)	5/5	5/5	2/5
Storage (20)	5/5	4/5	3/5
Weight (15)	4/5	5/5	2/5
Size (15)	5/5	5/5	3/5
Ease of Fabrication (10)	4/5	5/5	1/5
Durability (10)	5/5	3/5	3/5
Cost (5)	3/5	5/5	2/5
Total (100)	93	92	47

To finish up the meeting we talked about upcoming due dates and what everyone needs to get done. We are going to assign parts of the preliminary presentation and preliminary deliverables on Friday.

Conclusions/action items:

Come to Friday's meeting ready to work with client.

2023/09/29-Team Meeting 5

Lael Warren - Sep 29, 2023, 1:32 PM CDT

Title: Team Meeting 5

Date: 09/29/2023

Content by: Lael Warren

Present: All

Goals: Go over designs and present them to client. Once we have the client meeting, go over and revise design matrix. Assign parts for Preliminary Report and Preliminary Presentation.

Content:

To start the meeting we went over our designs that we were going to present to the client so we were all on the same page. We then went to the client and advisor meetings. After those meetings we assigned parts for the preliminary presentation and the preliminary report.

Conclusions/action items:

Work on preliminary presentation and report.

2023/10/04-Team Meeting 6

Lael Warren - Oct 10, 2023, 6:32 PM CDT

Title: Team Meeting 6

Date: 10/04/2023

Content by: Lael Warren

Present: All

Goals: Practice Preliminary Presentation

Content:

Met with group to go over preliminary presentation. Started by finishing our slides and references page. Then worked on getting the timing and flow of the presentation down. Made changes to slide and speech as needed. Finished the meeting by running presentation full out 2 times.

Conclusions/action items:

Give the best presentation ever.

2023/10/10-Team Meeting 7

Lael Warren - Oct 10, 2023, 9:23 PM CDT

Title: Team Meeting 7

Date: 10/10/2023

Content by: Lael Warren

Present: All

Goals: Work on preliminary deliverables

Content:

Went over the report and what needs to be done. Used rubrics to make sure we had everything we needed in the report. Answered any questions that the sophomores had. Everyone agreed that the report should be done by tomorrow morning in order to go through and make edits.

Conclusions/action items:

Submit preliminary deliverables tomorrow.

2023/10/24-Team Meeting 8

Lael Warren - Nov 29, 2023, 4:32 PM CST

Title: Team Meeting 8

Date: 10/10/2023

Content by: Lael Warren

Present: All

Goals: Went over potential materials and then fabrication planning

Content:

Talked about how to order potential materials and making a plan to go to the makerspace and look at those materials. Made a list of questions to ask Prof M.. These questions included: how to use the shop uw, help with testing plans, what group is using the silicon mold and where can we get it. We then talked about how we are going to use the next week or so: by next week we will want to have a CAD drawing, ordered our materials, the silicon mold hardening, and the the footplate preliminary prototype made. Concluded with reminders about the progress report and making sure we complete those on time.

Conclusions/action items:

Keep researching brackets and hinges.

2023/11/17-Team Meeting 9

Lael Warren - Nov 29, 2023, 4:32 PM CST

Title: Team Meeting 9

Date: 11/17/2023

Content by: Lael Warren

Present: All

Goals: Order materials and make plan for rest of the semester.

Content:

Started the meeting by purchasing materials so they would come in after Thanksgiving break. We ordered 2 different hinges, in order to be able to try them and figure out which once works best. Liv also worked on the CAD drawing and updated us on the progress made. Her intention is to have it done when we return to break so we can start printing it. After we ordered materials and caught up on what has been done, we started making a plan on what we needed to get done in subsequent meetings. We need to fabricate our product, do testing, work on the poster presentation, and also work on the final report. In addition to this we need to continue to update Lab Archives. The goal is to fabricate and test over the week following Thanksgiving and then to work on the poster presentation and report over the weekend. That gives us the week of the poster presentation to make any final edits and practice our presentation before actually presentation.

Conclusions/action items:

We will resume work after Thanksgiving break.

2023/11/29-Team Meeting 10

Lael Warren - Nov 29, 2023, 4:40 PM CST

Title: Team Meeting 10

Date: 11/29/2023

Content by: Lael Warren

Present: All

Goals: Continue fabricating by making edits to the first castor cap design and attach hinges to footplates.

Content:

Liv was able to make the first prototype of the castor and we made edits to it for another round of printing. The main modifications that need to be made to it include making the edge closest to the wheelchair longer in order to fully fit on the castor without breaking. The hole used to get the cap on and off the castor did not 100% line up with the hole on the castor, therefore we had to remeasure and adjust where the hole was in order to make sure they fit this time. While Lael, Amanda, and Liv worked on this, Gracie and Juliana worked in the Team Lab to make cuts int he footplates in order to be able to attach the hinges.

After that work was done we made a plan to attach the footplate to the castor cap on Friday and then conduct testing on it. We also started mapping out who is going to do what on the poster presentation and the final report. This way we can start working on it and send it to Prof. M before the the due date for edits.

Conclusions/action items:

We need to individually work on our parts of the poster presentation and final report. Each individual is going to get as much as possible done before Friday so we can make edits to each other sections on Friday while we are all together doing testing. Then we will meet as a group over the weekend to continue working on the project.

2023/12/01-Team Meeting 11

Lael Warren - Dec 01, 2023, 2:20 PM CST

Title: Team Meeting 11

Date: 12/01/2023

Content by: Lael Warren

Present: All

Goals: Finish fabrication of prototype in TeamLab and start testing. Also, continue updating the poster presentation and final report.

Content:

Started the meeting by looking at the new castor cap made by Liv in the Makerspace. After assessing the new cap to see if it met the new specification we set, such as needing to be larger and adjusting where the hole was, the team went down to the TeamLab to attach the hinge and footplate to the castor cap. While some team members did that, others went to the Makerspace to get velcro strips for the underside of the cap.

After the fabrication was complete, the team began to set up testing. The team did not have enough time to start testing today, so we made a plan to meet over the weekend in order to finish up the testing.

In addition to working on fabrication and testing, the team also worked on the poster presentation and final report. The sections worked on today included design specifications, materials, and fabrication. We also made edits to PDS and added the second version to the final report.

Conclusions/action items:

The team was able to finish up fabrication and work on the reports due next week. The team is going to meet on Sunday to work on testing, since we were not able to get to that today. Once testing is completed, the the results can be analyzed and those sections can be added to the subsequent reports.

2023/12/3- Team Meeting 12

AMANDA KOTHE - Dec 03, 2023, 9:41 AM CST

Title: Preliminary Testing

Date: 12/2/23

Content by: Amanda Kothe

Present: Amanda and Juliana

Goals: Begin Testing of the Prototype

Content:

During this meeting, the team began preliminary testing of the prototype. The team first added some enhancements to the design to try to make it stronger (by adding a metal piece into the hinge and then tightening the screws), and then began testing. The prototype was able to hold/support a 2 lb weight, a 6 lb weight, and a 12 lb weight. After the 12 lb weight the team was unable to find any more weights to test with, so the meeting was concluded.

Conclusions/action items:

Preliminary testing was completed, however the team will need to find more weights to continue to test the prototype. The prototype needs to be able to hold at least 32 lbs per out calculations.

2023/12/4- Team Meeting 13

Lael Warren - Dec 04, 2023, 1:19 PM CST

Title: Preliminary Testing

Date: 12/4/2023

Content by: Lael Warren

Present: Amanda, Sadie, Gracie

Goals: Testing of the Prototype and working on the final report and presentation.

Content:

The team started by analyzing the ease of use data and making plots for those. After that we tried to find more weights for the force testing but could not. We then concluded testing by working on clearance testing from the ground. After the data was collected, the team started to work on different assigned sections of the report including the materials, methods, final design, testing, discussion, and conclusion. The team also began working on the poster presentation for review by Dr. M.

Conclusions/action items:

The team needs to continue to work on the final report and poster presentation so they are complete by their assigned due date.

2023/12/6- Team Meeting 14

Lael Warren - Dec 07, 2023, 10:25 PM CST

Title: Poster Presentation Practice

Date: 12/6/2023

Content by: Lael Warren

Present: Sadie, Gracie, Amanda, Juliana, Lael

Goals: Practice the flow of the presentation

Content:

The team met to work on the flow and timing of our presentation. We ran over it once as to get a feel of what we wanted to say for each part and then 2 times to get the timing down. Once we thought that we were talking cohesively, we went over any questions, what we needed to bring to the presentation, and what we need to be working on in the coming week.

Conclusions/action items:

We need to continue to work on the final report and feedback fruits.

2023/12/12- Team Meeting 15

Lael Warren - Dec 12, 2023, 5:48 PM CST

Title: Final Paper Review Session

Date: 12/12/2023

Content by: Lael Warren

Present: Sadie, Gracie, Amanda, Juliana, Lael

Goals: Use the comments given to us by advisor to edit the report and have it ready to turn in.

Content:

Started the meeting off by talking about how the presentation went. Then reviewed the comments given to us by Prof M. The main points that need to be fixed are adding more background information, adding some details to testing, and go over design criteria and what tests failed in the discussion. We then worked on those parts of the final report as a group until they were done. After we read over the report one more time we then went over what still needs to be done. Those tasks include 1) making sure lab archives is up to date, 2) submitting the final report 3) uploading lab archives to canvas 4) give feedback on feedback fruits and 5) review the feedback given to use once it is released.

Conclusions/action items:

Each member needs to make sure their lab archives are updated and give feedback to other group members.

2023/09/12- Wheelchair rider injuries

Title: Wheelchair rider injuries: Causes and consequences for wheelchair design and selection

Date: 09/12/2023

Content by: Lael Warren

Present: N/A

Link: https://books.google.com/books?hl=en&lr=&id=878PkR7AEHkC&oi=fnd&pg=PA58&dq=wheelchair&ots=yjd7q5rYzh&sig=lXkqTCztI1CAZGZTUIUWuP2QD7U#v=onepage&q=wheelch

Reference:

Goals: Learn about the different types of injuries wheelchair riders can sustain

Content:

- There were 253 incidents occurring within a 5 year period
  - 53% were on powered wheelchairs, the other 47% by manual wheelchairs
  - 42% (106) were tips and falls, 33% (84) component failures, and the other 25% (63) were "other" events
  - 27% (68) caused injuries requiring medical attention, including 13 hospitalizations
  - There are 1,411,000 wheelchair rides in the United States, half of which live outside of institutions

Table 1.
Participants' disability types.

	# of Participants	%
SCI Quadriplegia	27	25
SCI Paraplegia	16	15
Cerebral Palsy	20	18
Neuromuscular Diseases	16	15
Other Disabilities	30	27
Totals	109	100

-
    - Table explaining the types of disabilities the participants had/have
  - There is limited stability of current indoor/outdoor wheelchairs
    - Most injuries are the result of tipping or falling out of the chair

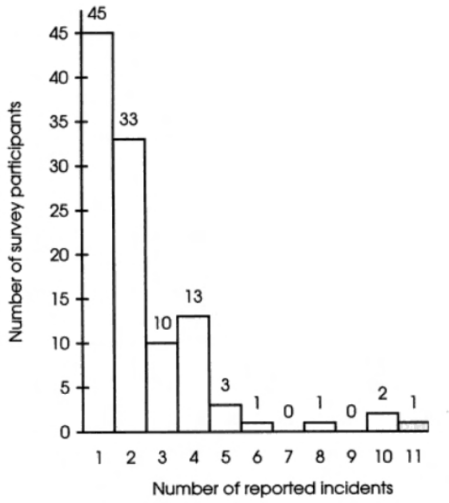


Figure 1.
Number of incidents reported by individual survey participants (total 253 incidents among 109 participants).

Figure showing how many incidents and individual had over a 5 year period.

- Reported injuries types included: 117 cuts and bruises, 29 fractures, 19 head injuries, 15 muscle and tendon injuries, 1 dental, and 13 unspecified injuri totaling 134

- Injuries were almost evenly distributed between manual and powered wheelchair incidents

- No incident categories had a statistically significant tendency to result in severe injury

- For tips and falls, there was a relationship between the direction of the fall and the type of wheelchair. Manual wheelchairs tend to fall forwards or backwa whereas powered wheelchairs had less common sideways falls.

- Forwards and sideways falls were associated with injuries requiring medical attention ($p = 0.036$), whereas backwards ones were not.

Conclusions/action items:

- Learn more about wheelchair configuration and disabilities that require wheelchair use.

2023/09/13- Main Wheelchair components (manual and powered)

Lael Warren - Oct 04, 2023, 7:53 PM CDT

Title: Main wheelchair components in a manual and powered wheelchair

Date: 09/13/2023

Content by: Lael Warren

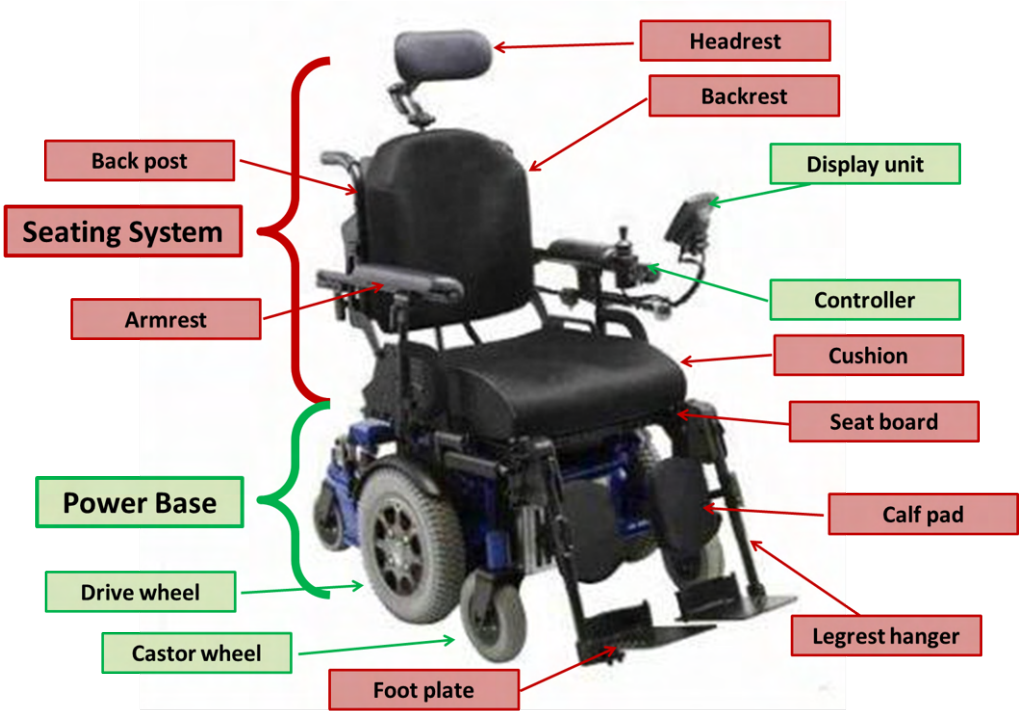
Present: N/A

Goals: Learn about the different parts of a manual and powered wheelchair. Want to see where the overlapping components are, what differs, what's crucial, and what is more an accessory.

Content:

Manual wheelchair (https://otassessments.wordpress.com/wheelchair-management/)

Powered wheelchair (https://aci.health.nsw.gov.au/networks/spinal-cord-injury/spinal-seating/module-10/keep-the-big-picture-in-mind)



When looking at both of these and seeing the footrest design, and having worked with wheelchairs before, the main issues with how these work is 1) The footrests and calf pads only flip outwards which creates more of a restrictive environment 2) to be able to swing the footrests out or take them off there is a button on the far side of the wheelchair (near the wheels) on either side, this would be hard to reach if you were sitting in the wheelchair 3) the footrests have a large radius when they swing out so its not possible to leave them out when not using them and 4) taking them off can be really hard and not easy to do if you are in the wheelchair. In addition to these problems there is no where to store them and also they are bulky and heavy.

Conclusions/action items:

See what type of wheelchair the client is using and talk to him about any ideas or concerns he has for the footrests. Also get hands on a wheelchair in order to be able to mess with them and see how they move.

2023/09/20- Types of Footrests

Lael Warren - Sep 20, 2023, 11:02 AM CDT

Title: Types of Footrests

Date: 09/20/2023

Content by: Lael Warren

Present: N/A

Link: https://mobilitybasics.ca/wheelchairs/footrests

Goals: Learn about the different types of footrests there are fro wheelchairs and some benefits and concerns with them.

Content:

There are 2 main types of footrests: the standard footrest and also the leg rest. The main difference between the 2 is that footrests only have the footplate for the user's foot to rest on, while a legrest has a calve pad to support the lower leg.

Footrests:

- most common and pretty basic

- usually removable and swing to the side in order to make transfers easier

- normally there are different styles of footplates for the user to choose from

- footrest hangers usually available in 2 or 3 different angles

    - children's footrests are usually kept at 90 degrees

    - optimally, adults would also be kept at 90 degrees, however that is not always possible, so options of 70 or 60 degrees

Legrests:

- not nearly as common as footrests

    - however pretty standard on relining or tilting wheelchairs (most users who benefit for tilt and recline also benefit from elevating legrests)

- heavy and therefore not used if trying to make the wheelchair lightweight

- difficult to set the footplate position to be comfortable in all the positions they can be set at

    - because of knee mechanics, footplate needs to be adjusted to be longer when the leg is extender than when it is bent

        - if set properly when extended, will be too long and hitting the floor when lowered

        - if set properly when bent, will be too short when elevated and will force knees into the air and put pressure on the butt

Conclusions/action items:

Client wants calf support so therefore we need to make a leg rest, not a footrest. However his can't be heavy so that is an adjustment we would need to make. Also work on making the extending and compression of the footrest easier so that he is able to do it himself.

2023/09/20- How footrest height can affect pressure ulcers

Lael Warren - Sep 20, 2023, 11:10 AM CDT

Title: How footrest height can affect the development of pressure ulcers.

Date: 09/20/2023

Content by: Lael Warren

Present: N/A

Link: https://www.nature.com/articles/sc2014242

Goals: Determine if there is a correlation between footrest height and the development of pressure ulcers.

Content:

Goal: To describe the effect of wheelchair footrest height on sitting pressures in persons with paraplegia

Method: Seventeen manual wheelchair users with paraplegia underwent a seat pressure examination while footrests were elevated from the initial position with the thighs parallel to the seat (p0), by 10% (position p10) and by 20% of the fibula length (position p20). We analyzed average pressure (AP), the contact surface of the body with the seat (CS), pressures on the ischial tuberosities—left (LIP) and right (RIP)––and average pressure on both ischial tuberosities (AIP).

Results:

A gradual increase in footrest elevation was accompanied by significant increases in AP (p0: 57.24±14.31; p10: 60.65±14.85; p20: 62±15.3 mm Hg; Kendall coefficient of concordance W=0.962), AIP (p0: 159.35±54.95; p10: 176.35±53.3; p20: 184.26±54.09 mm Hg; W=0.896), LIP (p0: 165.24±54.05; p10: 183±52.08; p20: 193.18±56.32 mm Hg; W=0.751) and RIP (p0: 153.71±71.23; p10: 167.35±72.19; p20: 175.35±70.84 mm Hg; W=0.524) and a significant decrease in CS (p0: 1218.2±100.8; p10: 1131.8±134.6; p20: 1065±142.6 cm^2; W=0.985).

There was a moderate correlation between the relative increase in LIP and RIP between p0 and p10, and between p10 and p20 (Pearson's correlation coefficient for LIP r=0.66; P=0.04, for RIP r=0.77; P=0.003), and a high correlation between relative changes in AIP (r=0.87; P<0.0001).

Conclusion: Wheelchair footrest elevation caused a steady rise in AIP; however, left to right side pressure differences changed variably, suggesting that the risk of pressure ulcers may increase disproportionately with footrest elevation.

Conclusions/action items: Need to be cognizant that the height of the footrest can aid in development of pressure ulcers so need to account for that in models.

2023/10/18- Different types of hinges

Lael Warren - Oct 18, 2023, 9:34 PM CDT

Title: Different types of hinges

Date: 10/18/2023

Content by: Lael Warren

Present: N/A

Goals: Figure out different types of hinges to use for the foot plate

Link: https://www.thisoldhouse.com/doors/21594142/types-of-hinges

Content:

List of different types of hinges and what they are most commonly used for. The barrel hinge looks ideal because it is small and easy to use because you just have to screw it into place, but can also withstand a substantial amount of force. Which is what we are looking for in our hinge. Hospital hinges were also looked into. The main difference for these is that they have rounded edges, that doesn't seem necessary for our project.

Conclusions/action items:

Find a hinge that only fold to 90 degrees

2023/10/18- 90 Degree Hinges

Lael Warren - Oct 18, 2023, 9:36 PM CDT

Title: 90 degree hinge

Date: 10/18/2023

Content by: Lael Warren

Present: N/A

Goals: Find a hinge that fold 90 degrees instead of 180

Content:

https://www.amazon.com/Degree-%EF%BC%8CCabinet-Cabinet-Hinges%EF%BC%8C-%EF%BC%88Silver%EF%BC%89/dp/B07Z32NWR3/ref=sr_1_10?keywords=90+degree+hinge&qid=1697682753&sr=8-10

Link leads to a set of 4 hinges that and we could put 2 on each side that fold to 90 degrees on the footplate.

Conclusions/action items:

Find footplate material to use

2023/11/01-Dragon Skin Pour Silicone

Lael Warren - Nov 03, 2023, 11:37 AM CDT

Title: Dragon Skin Series, High Performance Silicone Rubber

Date: 11/01/2023

Content by: Lael Warren

Present: N/A

Goals: Investigate the properties of Dragon Skin and see if it would be a good rubber to use for the mold we need to make of the castors

Content:

- low viscosity, high performance

- Mix 1A and 1B in a 1:1 ration by weight or volume. You will then need to mix thoroughly for 3 minutes before using. A uniform flow will help minimize trapped air.

- pot life of 15 min

- cure time of 75 min at room temperature

- can be thickened or thinned to different consistencies

- can not be used with other tin or platinum based silicone

- room needs to have proper ventilation

- need to wear safety glasses, long sleeves, and rubber gloves to minimize contamination risk. Wear vinyl gloves only, rubber gloves will inhibit the cure of the rubber

- can use a release agent if necessary

- Depending on what type of Dragon Skin used, there are different levels of viscosity, tensile strength, youngs modulus, and shrinkage. For our purposes, I do not see any of these being a problem as we just need it in order to take measurements and build a cad model.

https://pdf.live/edit?url=https%3A%2F%2Fwww.smooth-on.com%2Ftb%2Ffiles%2FDRAGON_SKIN_SERIES_TB.pdf&guid=a122f460-b73d-6198-17e9-ed1b87378a5d&installDate=092523&source=google-d_pdftab_crx

Conclusions/action items:

Need to compare different types of silicone with group and decide which to purchase for project. This needs to be done within the next couple of says to stay on schedule for project.

2023/09/20- NYOrtho Design

Title: NYOrtho Wheelchair Foot-Rest Extender Elevating Pad - Leg Cushion Protector | Secures Easily with Quick-Release Strap Seat Widths 16" - 20", 2" Foot Platform

Date: 09/20/2023

Content by: Lael Warren

Present: N/A

Link: https://www.amazon.com/NYOrtho-Wheelchair-Footrest-Extender-Rest/dp/B005DTOF0Y/ref=sr_1_9?hvadid=580633372779&hvdev=c&hvlocphy=9018948&hvnetw=g&hvqmt=e&hvrand=17958119212822230934&hvtargid=kwd-941260781&hydadcr=21877_13323198&keywords=wheelchair+footrests&qid=1695226625&sr=8-9&ufe=app_do%3Aamzn1.fos.18ed3cb5-28d5-4975-8bc7-93deae8f9840

Goals: Look at competitors design and see what the pros/cons are of them

Content:

Pros:

- Lightweight

- Provides some calf support

- Easily cleanable material

- Would recline with him

- Affordable

Cons:

- Hard to remove himself

- Bulky

- Doesn't retract into wheelchair

Conclusions/action items:

Start designing different footrest ideas

2023/09/20- Miracle Mobility Wheelchair

Lael Warren - Sep 20, 2023, 12:13 PM CDT

Title: Miracle Mobility Silver 6000 Plus Folding Electric Wheelchair

Date: 09/20/2023

Content by: Lael Warren

Present: N/A

Link: https://www.amazon.com/dp/B0C3F7JYQZ/ref=syn_sd_onsite_desktop_0?ie=UTF8&psc=1&pf_rd_p=75127947-5eb8-45ab-b49a-e5324ce5ef2c&pf_rd_r=S3WWA541TMRGBW7K5H1G&pd_rd_wg=Hstms&pd_rd_w=Ws7KL&pd_rd_r=cbb24a70-eb55-4da5-b3f4-ca76b963bad6

Goals: Look at competitors design and see what the pros/cons are of them

Content:

Pros:

- Small

- Durable material

Cons:

- Close together

- Does recline

- Not removable or foldable into wheelchair

- Expensive

Conclusions/action items:

Start designing different footrest ideas

2023/09/20- Seat Footrest

Lael Warren - Sep 20, 2023, 8:31 PM CDT

Title: Seat Footrest

Date: 09/20/2023

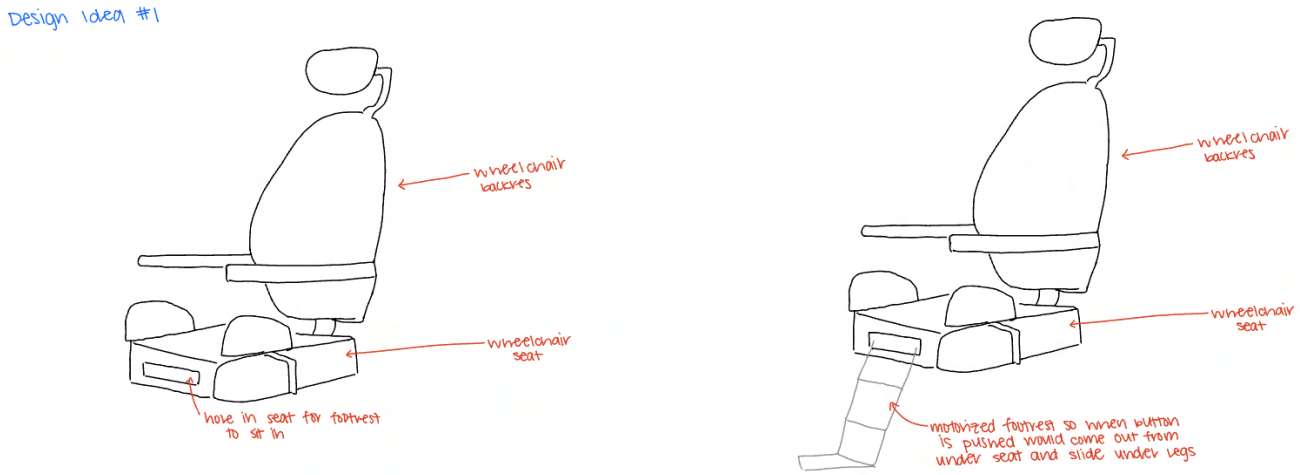
Content by: Lael Warren

Present: N/A

Goals: Sketch a preliminary design to show client

Content:

For this design idea we would cut a whole in the bottom cushion of the seat and place the footrest on there. One thing we could have to be careful of is how much cushion is on top in order to not have the client sitting directly on the footrest. The footrest would be motorized so when the client pushes a button it would feed out behind his legs.



Conclusions/action items:

Get with team and client and decide on a final preliminary design.

2023/09/20- Airplane Snack Tray Footrest

Lael Warren - Sep 20, 2023, 8:28 PM CDT

Title: Airplane Snack Tray Footrest

Date: 09/20/2023

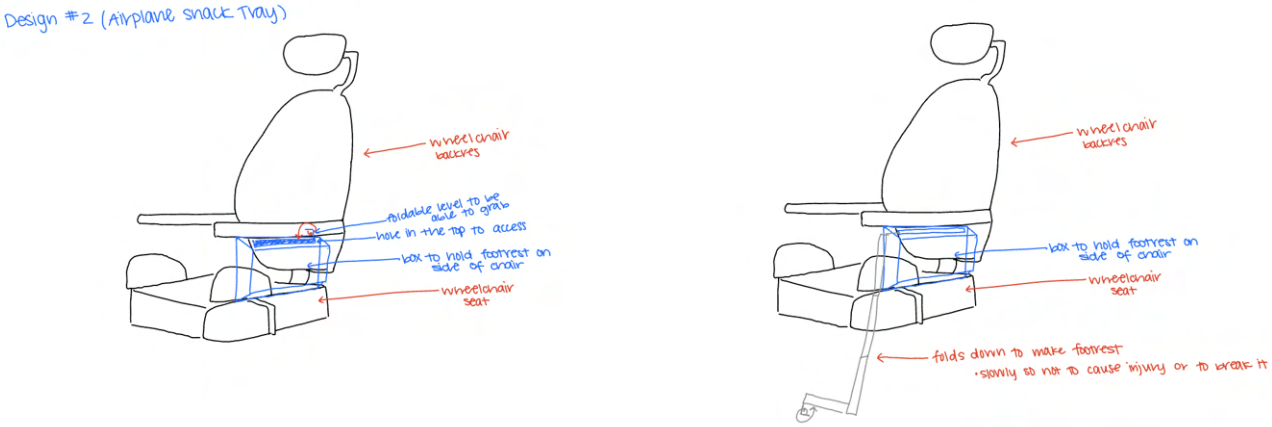
Content by: Lael Warren

Present: N/A

Goals: Sketch a preliminary design to show client

Content:

This design would be like the airplane snack trays. The footrest would actually be contained in a box that sits on the side of each armrest. There would be a little lever that the client could pull on which would release the footrest from the box. The footrest would have to be built to be slow moving as to counteract gravity and not to damage the client, the footrest, or the wheelchair. To put it away the client would be able to grab it from the base and lift up and it would slowly collapse back in on itself.



Conclusions/action items:

Get with team and client and decide on a final preliminary design

2023/09/20- Caster Box Footrest

Lael Warren - Sep 20, 2023, 8:17 PM CDT

Title: Caster Box Footrest

Date: 09/20/2023

Content by: Lael Warren

Present: N/A

Goals: Sketch a preliminary design to show client

Content:

This design would be built in between the casters. We could take the front panel off and put a box there instead. In the blow there would be a slot where the footrest would come out of. The footrest would be motorized so when the client pushes a button the footrest would extend out from the box.

Conclusions/action items:

Talk with team and client about designs and pick a final design.

2023/10/10- Final Preliminary Design

Lael Warren - Oct 11, 2023, 11:46 AM CDT

Title: Final Preliminary Design

Date: 10/10/2023

Content by: Lael Warren

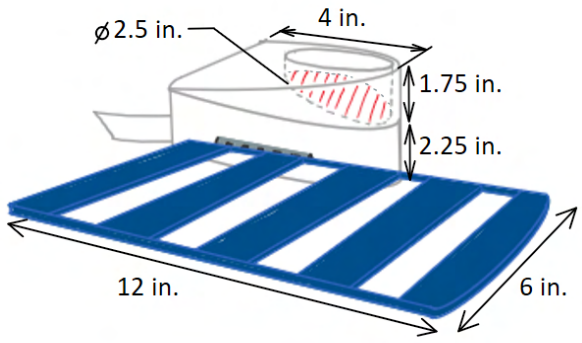
Present: N/A

Goals: Have a final preliminary design ready to start fabrication process

Content:

Final preliminary design sketches. Went with Fold Up Footrest design but instead of fabric holding it on, we will insert a piece into the castors to support it.

One change that needs to be made is we want to add more support to the footplate, maybe by adding a bar across the bottom or a foldable support system.



Conclusions/action items:

2023/10/10- Design Matrix

Lael Warren - Oct 11, 2023, 11:49 AM CDT

Title: Design Matrix with Teams 3 Preliminary Designs

Date: 10/10/2023

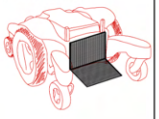
Content by: Lael Warren

Present: All

Goals: Rank the 3 preliminary designs

Content:

The criteria includes 7 categories, where each category has a specific percentage in which they contribute to the total point system. First category is ease of use, weighted 25 percent which is the highest. Ease of use is extremely important since the design needs to be easy and simple to function for the client since they have limited mobility. Next is storage, weighted 20%. This category assesses how well the design is able to be low interference. The ideal design needs to be stored discreetly on the wheelchair, so it can be spatially low interference. The storage aspect must also not interfere with the other functionalities of the wheelchair. Next is weight, weighted 15%. A lightweight footrest design is lacking in competing designs. The weight category assesses how well the design satisfies the outlined maximum weight of 4 pounds, to accommodate the clients needs. Next is size, weighted 10%. Size has a similar assessment to storage. This category assesses if the design has a good balance between being small enough to be low interference spatially, and an appropriate size to fit the client's feet. Next ease of fabrication, weighted 10%, assesses how easy the design is to fabricate. Next durability, weighted 10%, assesses how well the design can withstand day to day usage and potential weather elements. The footrest is desired to have the same lifespan as the wheelchair, which is about 5 years. Finally cost comes in last, weighted 5%, which assesses how expensive the design is. Higher the scores reflect a less expensive cost. This category is rated lower since the client's needs come first.

	Design 1: Fold-Up Footrest 	Design 2: Folding Mesh Footrest 	Design 3: Airplane Armrest 
Ease of use (25)	5/5	5/5	2/5
Storage (20)	5/5	4/5	3/5
Weight (15)	4/5	5/5	2/5
Size (15)	5/5	5/5	3/5
Ease of Fabrication (10)	4/5	5/5	1/5
Durability (10)	5/5	3/5	3/5
Cost (5)	3/5	5/5	2/5
Total (100)	93	92	47

Conclusions/action items:

Start fabricating preliminary design

2023/02/19: Biosafety Training

Lael Warren - Feb 19, 2023, 10:05 PM CST

Title: Biosafety Required Training Proof

Date: 02/19/2023

Content by: Lael Warren

Present: N/A

Goals: To get the required training to complete course.

Content:

See attached file below

Conclusions/action items:

N/A

Lael Warren - Feb 19, 2023, 10:06 PM CST

Download

Screenshot_2023-02-19_at_10.06.46_PM.png (155 kB)

2023/02/19: OSHA Chemical Training

Lael Warren - Feb 19, 2023, 10:04 PM CST

Title: OSHA Chemical Safety Certificate

Date: 02/19/2023

Content by: Lael Warren

Present: N/A

Goals: To get the required training to complete course.

Content:

See attached file below

Conclusions/action items:

N/A

Lael Warren - Feb 19, 2023, 10:04 PM CST

Download

lwarren_1_.pdf (114 kB)

2023/02/21: Green Permit

Lael Warren - Feb 21, 2023, 4:38 PM CST

Title: Green Permit Required Training

Date: 02/21/2023

Content by: Lael Warren

Present: N/A

Goals: To get the required training to complete course.

Content:

See attached file below

Conclusions/action items:

N/A

Lael Warren - Feb 21, 2023, 4:38 PM CST

Download

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2023/02/19: Red Permit

Lael Warren - Feb 19, 2023, 10:09 PM CST

Title: Red Permit Certification

Date: 02/19/2023

Content by: Lael Warren

Present: N/A

Goals: To get the required training to complete course.

Content:

See attached file below

Conclusions/action items:

N/A

Lael Warren - Feb 19, 2023, 10:09 PM CST

Download

Screenshot_2023-02-19_at_10.07.54_PM.png (76.1 kB)

2023/11/10-Tong Lecture

Lael Warren - Nov 10, 2023, 12:42 PM CST

Title: Tong Lecture

Date: 11/101/2023

Content by: Lael Warren

Present: N/A

Goals: Learn from Tong Lecturer about her life and how it can apply to mine.

Content:

- wanted to be a doctor but was bored in normal biology classes

- thrives in problem based learning and working with teams

- worked on microspheres when she was here at UW- Madison (injectable drug therapy)

- thins she encourages us to do: find your people, do things that scare you, laugh until you cry and cry until you laugh

- someone is counting on you

- invest in your people, if they are really your people you will be able to pick up where you left off.

- big take away: you need to lean into your passions, they will not leave you tomorrow.

Conclusions/action items:

2023/22/09 - Individual Brainstorm Idea 1

Liv Baumann - Oct 11, 2023, 9:12 PM CDT

Title: Liv Individual Brainstorm Idea 1

Date: 09/22/2023

Content by: Liv Baumann

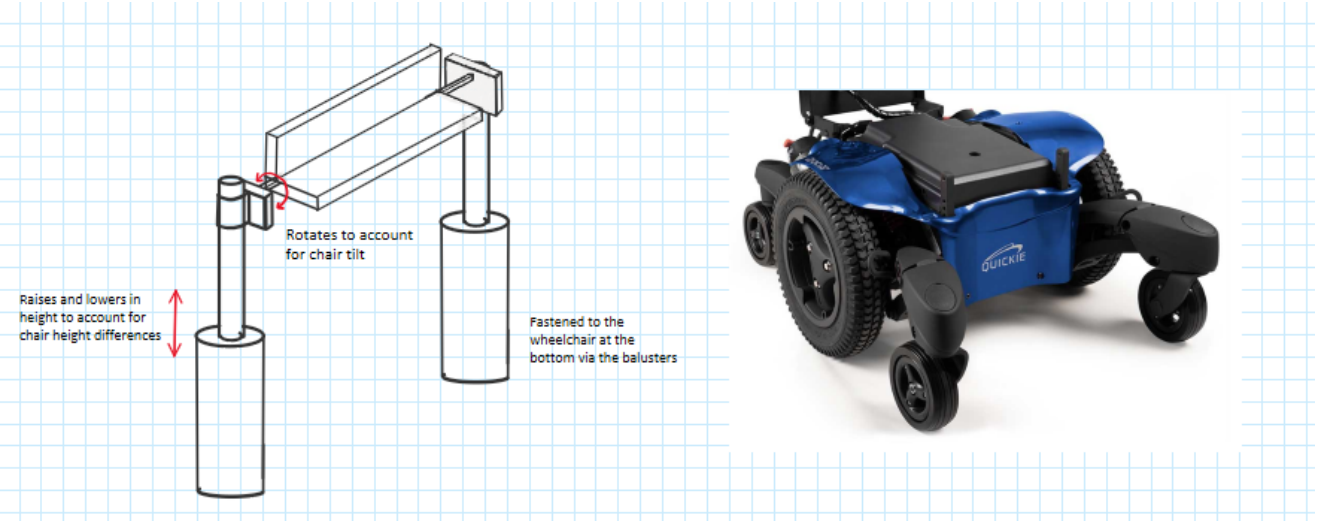
Present: N/A

Goals: Brainstorm concepts and create sketches of initial design ideas to fulfill the problem statement.

Content:

Automatic Adjustable Foot Rest

The following design is comprised of two column structures and a foot rest portion. The columns consist of two pieces, an inner cylinder and out cylinder, that allow the height to be adjusted. This may be achieved using an actuator and electrical components or possible other mechanical methods. The foot rest is attached to the cylinders via an axle (likely square), that allows it to tilt with the wheelchair. This design would be attached via the castors of the wheelchair base.



Advantages:

- Incorporates wheelchair tilt and height varieties; can compensate for varying degrees of both.
- Automatic; requires little to no mechanical input from the user.
- Can easily be stored on the wheelchair

Disadvantages:

- Despite its adjustability, its possible the design could still interfere with the use of the users low extremities when they so desire.
- Heavy; If the user were to decide to remove, it would definitely exceed weight requirements
- Difficult to manufacture; the system is more complex, would contain more moving and interconnected parts and would therefore be more difficult to make.

Conclusions/action items:

After developing several individual ideas, we will compile them all into a central document for team members to review. We will meet as a team and present all of our solutions and decide a few that we feel best meet the clients request and our own criteria. These will then be presented to our client and then evaluated in a design matrix.

2023/22/09 - Individual Brainstorm 2

Liv Baumann - Oct 11, 2023, 9:20 PM CDT

Title: Liv Individual Brainstorm Idea 2

Date: 09/22/2023

Content by: Liv Baumann

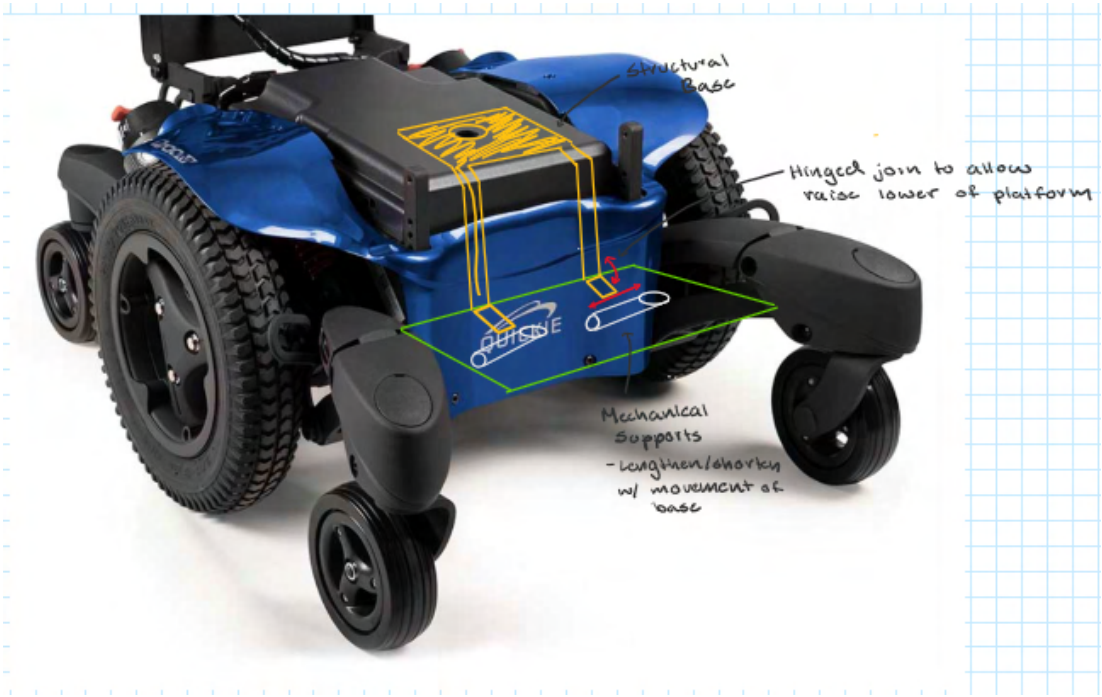
Present: N/A

Goals: Brainstorm concepts and create sketches of initial design ideas to fulfill the problem statement.

Content:

Single Plate Flip-Up Design

The following design is very simple. It simply flips up and down. The yellow portion demonstrates how it connects to the wheelchair. By placing it on the base there is greater mechanical advantage in the supports. This connects to the footplates via to protruding segments that lead to a hinge. This hinge allows the foot plate to flip vertical, flush with the base, or horizontal, parallel to the ground. Two diagonal components connects to the foot plate and rest against the base to provide support. These are not fully constrained and would move with the footplate such that they are vertical when the plate is flipped up and diagonal when it is in the horizontal position.



Advantages:

- Attaches to the wheelchair and therefore requires very little manual work.
- Very simply and easy to manufacture.
- Wide footplate allows feet position to be adjusted based on user preference
- Easily flips out of the way when not in use

Disadvantages:

- Despite supports incorporated into the design, more might need to be down to maximize load bearing abilities

- It is unclear if the attachment method (on top of the wheelchair base) is a viable option/space and that it would not impede wheelchair use.

Conclusions/action items:

After developing several individual ideas, we will compile them all into a central document for team members to review. We will meet as a team and present all of our solutions and decide a few that we feel best meet the clients request and our own criteria. These will then be presented to our client and then evaluated in a design matrix.

2023/22/09 - Individual Brainstorm 3

Liv Baumann - Oct 11, 2023, 11:15 PM CDT

Title: Liv Individual Brainstorm Idea 3

Date: 09/22/2023

Content by: Liv Baumann

Present: N/A

Goals: Brainstorm concepts and create sketches of initial design ideas to fulfill the problem statement.

Content:

Garage Door Design

The following design is modelled similar to the panels of a garage door and would be added to an existing foot rest design. The calf rest aspect would be left, but the foot plate would be removed. Two L shaped channels are placed on either side of the foot rest and several panels slide up behind the foot rest or down for the user to place their feet on. This design also accommodates for wheelchair tilt since this particular foot rest is attached at the seat. When the panels are slid up, it is essentially an open space that allows for the user to use their feet.

Advantages:

- Does not significantly modify feet space when not in use.
- Accounts for chair tilts

Disadvantages:

- Would likely require electrical components or some mechanical switch, making fabrication difficult

Conclusions/action items:

After developing several individual ideas, we will compile them all into a central document for team members to review. We will meet as a team and present all of our solutions and decide a few that we feel best meet the clients request and our own criteria. These will then be presented to our client and then evaluated in a design matrix.

2023/11xx - Castor Cap Solidworks Model 1

Liv Baumann - Nov 28, 2023, 10:35 PM CST

Title: Castor Cap Solidworks Model 1

Date: 11/xx/2023

Content by: Liv Baumann

Present: N/A

Goals: Create a cap for the wheelchair castors that accurately fits the dimension of the castor and is capable of holding the hinge of the footplate without disrupting other wheelchair functions.

Content:

Conclusions/action items:

2023/11/28 - Castor Cap Print 1

Liv Baumann - Nov 28, 2023, 4:40 PM CST

Title: Castor Cap Print 1

Date: 11/282023

Content by: Liv Baumann

Present: Makerspace Staff (assisted with the print process)

Goals:

- Print version 1 of the castor cap
- Use test print to evaluate model accuracy; make adjustments and reprint

Content:

The file 'Wheelchair Footrest Castor Cap_Version 1.sldprt' was saved as a 'Wheelchair Footrest Castor Cap_Version 1.stl' (attatched below) and then sliced to print on the Ultimaker 3D printer.

Relevant Print Details:

- Material Type: Tough PLA
- Amount of Material: 161 g
- Print Time: 14 hours
- Infill: 30%

Images:

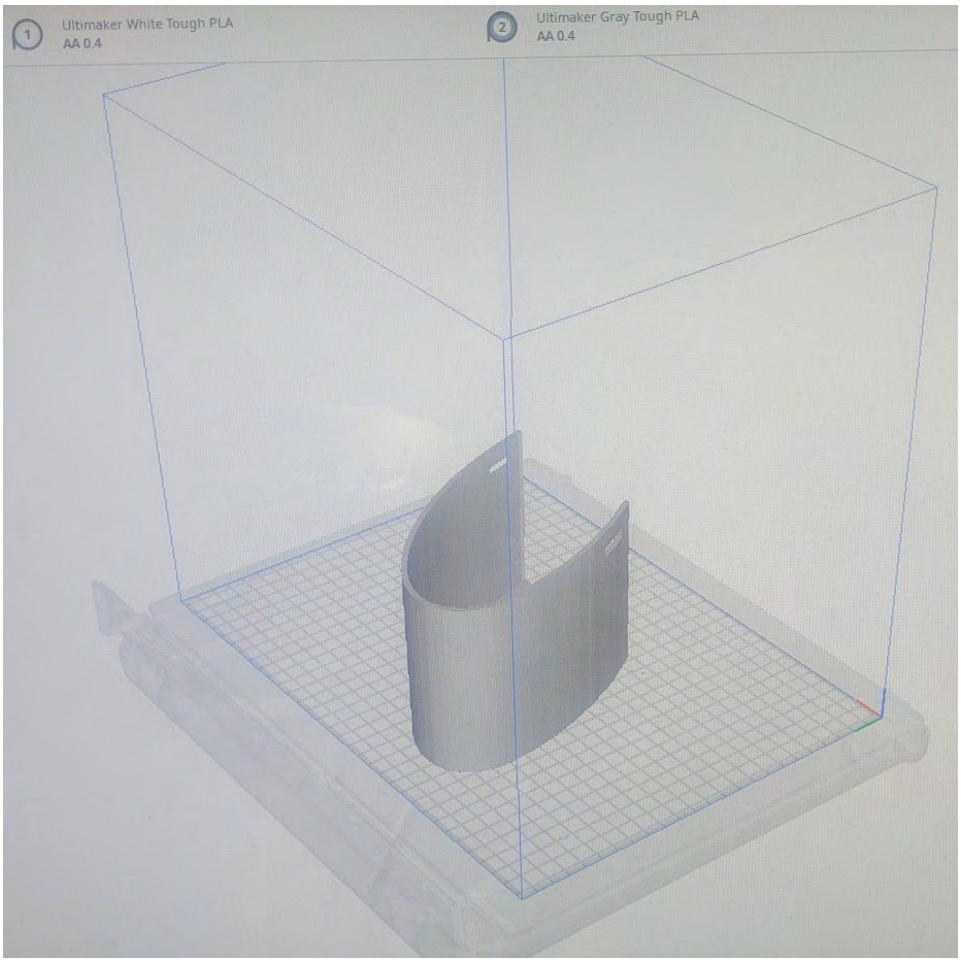


Image 1: Sliced STL file of the Castor Cap version 1; the respective STL file for version 1 is attached below

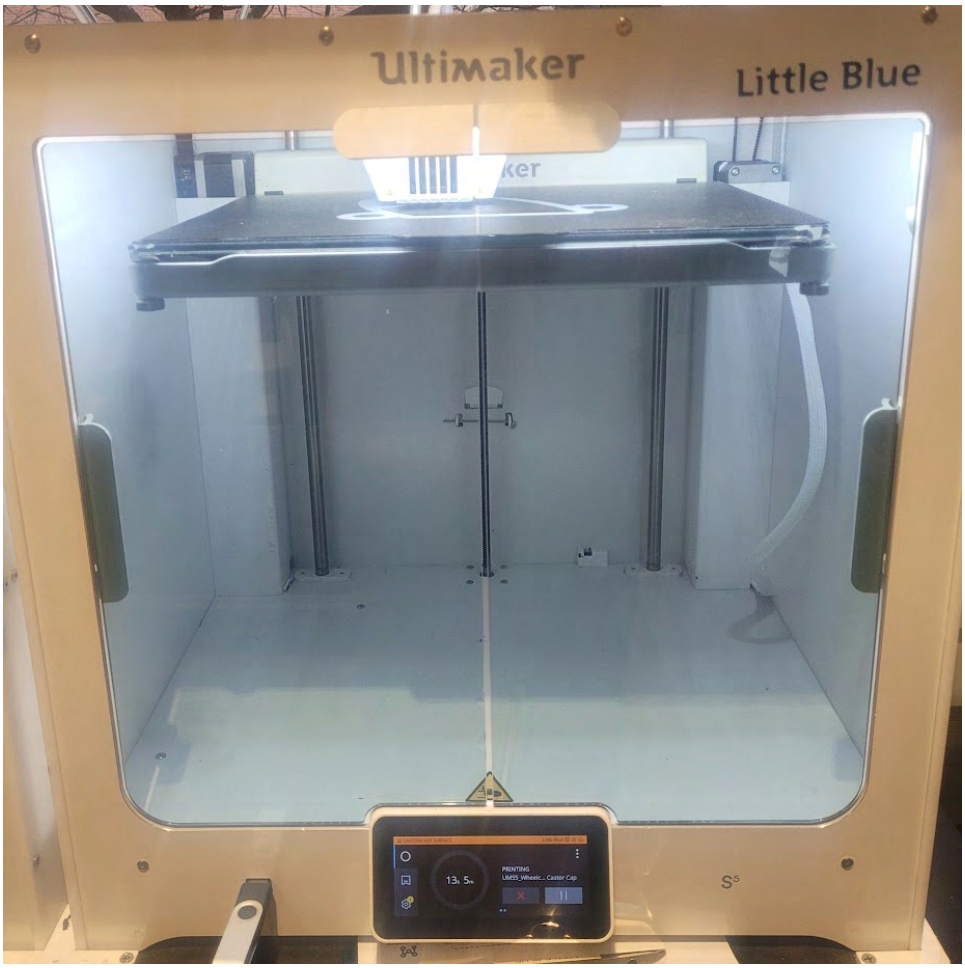


Image 2: The first part was printed on the Ultimaker printer 'Little Blue'. This picture shows the printer and it's set up during the start of the print.

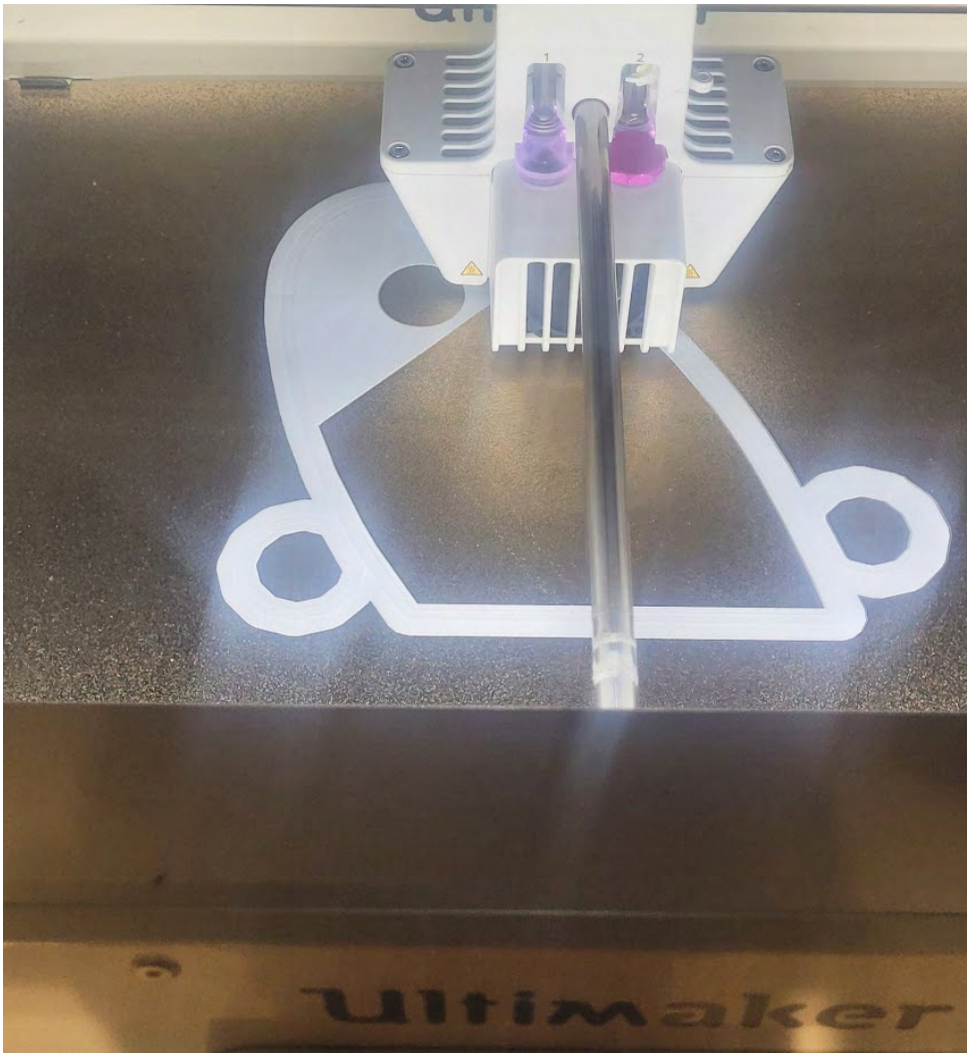


Image 3: Start of Print 1; it is being printed with Tough PLA at a 30% infill.

Conclusions/action items:

The print will not be finished prior to the makerspace closing today, therefore it will have to be picked up and evaluated tomorrow (provided no issues arrise with the print). Once Version 1 is picked up, its fit on the castor will be evaluated. Specific things to note include the following:

- Does the it fit on the castor? Is it too loose / too tight?
- Does the hole align with the hole on the castor?
- Does the hole portion need to be longer / shorter?

After the necessary adjustments are made, a flat surface perpendicular to the ground that protrudes from the side may also be added to the front, inner corner of the cap for easier attachment of the hinge to the cap. However in order to determine if the model was accurate this was not yet necessary and would only incur an unnecessary cost. Moreover more details on the hinge type and method of attachment are required to do this more accurately.

Liv Baumann - Nov 28, 2023, 3:48 PM CST

Download

Wheelchair_Footrest_Castor_Cap_Version_1.STL (44.5 kB)

2023/11/10 - Tong Distinguished Lecture

Liv Baumann - Nov 10, 2023, 12:56 PM CST

Title: Tong Distinguished Lecture - Travelle F.F. Ellis, MD, PhD

Date: 11/10/2023

Content by: Liv Baumann

Present: BME Program undergrads

Goals: Hear from Dr. Ellis about her journey as an engineer to where she is now.

Content:

"One Engineer's Journey: Where Preparation Meets Opportunity -

Travelle (Franklin-Ford) Ellis is Health Equity Director at Exact Sciences. Previously Dr. Ellis was Associate Director of Minority Initiatives at Zimmer Biomet. She is a lifetime member of the Student National Medical Association, serving as National President from 2009-2010. She received her PhD'11 in BME and MD'13, both from UW-Madison. In 2020, she was named to the National Minority Quality Forum's 40 Under 40 Leaders in Minority Health and was in the documentary: Changing the Face of Medicine: Black Women in Medicine. She is the 2023 recipient of the College of Engineering's Early Career Achievement Award from the Department of Biomedical Engineering."

Epilogue: Wants to hear her story but learn from our story

Journey:

- Her first engineer was her dad; her dad is her hero
- Originally wanted to be a doctor in order to help people -- found she was bored in class
- In her observation encountered a left ventricular assist device -- inspiration
    - This prompted her to find a passion and reestablish the steps to get there; had to learn the basics
    - In the long term, she realized she wanted to be a biomedical engineer and found it was an environment she was very successful in.
- Accepted into UW Madison Medical Scientist Program (MSTP).
- She wanted to use technology to assist people in having better lives -- worked on microspheres

Grad School Lessons:

- How to prevent complicated science; is it clear, concise and what are you trying to present
- Don't leave the things you gained behind

After grad school, it was messy and not linear -- Now works for exact sciences

Advice:

1. Find your people -

- Need people in your corner that you'll least expect when they'll show up for you; these people don't necessarily need to be from the same experiences as you.
- In her times of struggle--like fresh out of school without a job--she had to lean on her network of people for help
- She feel's the people behind her are still part of her--so she wants to connect in the direction and let the pattern continue

2. Do the things that scare you

- If it's too comfortable, it's too easy
- What you can accomplish when you feel like you can't in the short term is a lot
- President of National Association for minority Med Students
- Take risks

3. Laugh until you cry, cry until you laugh

- Being in grad school, having relationships, etc is not easy
- Didn't match for residency -- failed; she learned she had to lean into that
    - From her failure -- redefined herself for herself
- Finished grad school and left Wisconsin in a low place and not where she expected herself to be

* Someone is counting on you

Health Equity Director; Exact Sciences

- Now lives her dream -- to help people with technology
- Searching to eradicate cancer for all people
- Her story is coming together

Your passions today will not leave you tomorrow - use that to keep going

Alan Iverson quote: "It's just practice" -- lean into practice at UW Madison

This is just her story; she want's to share her story to encourage us to evaluate and look at our own story. How we got here and where we're going.

*Everyone is counting on you - we are all connected and all count on each other.

You will do this.

Questions:

- How to get over failure and what prompts you to realize you need to pivot/reevaluate/change direction?
    - Gather all information and evaluate option --> Evaluate strengths --> What are possible paths --> Evaluate logistics
    - Pushed forward in these paths and kept busy so she wasn't wallowing in failure; reached out to network and initiated action
    - Industry was good because a 9-5 was a more realistic fit for her life then
    - Lean into breaks in mental health too
- Dr. William Murphy: "Agrees pivots in career etc are completely normal" "In her current position in a company that is pioneering personal medicine, what does she see in the future of her position and what might it look like in 10 - 20 years."
    - Short term goal: Take what she is doing in one disease state or issue and apply it to another area in order to be an aid an resource to all people
    - Equity can be apart of infrastructure-- how can we innovate and develop in order to reach the most people with specific
    - We don't know what we don't know; also admits AI is a big part of that not fully aware how it will impact her
- What does it look like to her to keep in touch with the people in her life
    - Relish's the Sunday morning conversations with her mom--as an adult looking back realizes it was a dedicated time to just decompress

    - Have to be intentional -- when you have spare time, etc. calls at least one friend she hasn't talked to; when she shows up in someone's city, let them know she's there, even if they haven't talked in a while.
- Took an internship when pivoting into industry -- what other positions has she had?
    - Medical Science Liaison - Degreed professional goes on behalf of the company to discuss science and clinical evidence in a peer to peer manner; have educated and high level conversations about products, gain feedback
    - Grew her leadership and than got into her roles with equity.
- How can you make equitable access profitable and accessible to other Biotech companies?
    - People see it as charity however Dr. Ellis sees it on the contrary
    - Equity does not mean everyone is receiving the same care; customizing the care doesn't really impact the long term costs
    - Overall you've served more people better and established a better relationship with your audience
- Appreciates her perspective on science, what resources do you plan on giving your children to put them in a better position than you were?
    - As a parent she feels it is important to guide her children in the options provided to her
    - Her 4 children go to four different schools because they have different needs and ways of learning
    - She feels that the challenge with her children is that they are being provided so many opportunities - wants to make sure they know grit and perseverance, etc.
    - Give her kids what the need to be successful without over doing it or under doing it.
- What are your thoughts on information equity in AI medical fields?
    - Tough because she is at a crossroads - Loves technology and its use but also recognizes that technology can be very harmful
    - Making sure they acknowledge and are aware of the bias in technology -- some thinks there is some oversight but it is not perfect
    - Some self learning is outpacing and could cause divide, but believes in people to advance and work for the common good.
- What do you feel is the one thing that has helped you balance everything?
    - Doesn't sweat somethings - Ex: Presenting, working, receiving an award etc. it was a big task with unexpected details --> If the little details aren't perfect, it is what it is.
    - Figure out what she can control and what she can't; don't take things too seriously because if you worry about everything nothing will get down -- do we need to obsess about this or find a solution.

Conclusions/action items:

I really enjoyed listening to Travelle and hearing her story. As someone w

9/14/23 Who uses wheelchairs

Title: Diseases/circumstances that can require wheelchairs

Date: 09/14/2023

Content by: Juliana Dugo

Present: N/A

Link: https://www.redmanpowerchair.com/disabilities-that-require-wheelchairs/

Reference: N/A

Goals: Find out about potential users of our project. Mainly focused on non-paralyzed patients since our product implies the patient needs a footrest that doesn't disrupt movement.

Content:

Overall 10% of the population suffers from a disability and another 10% would benefit from wheelchair access

Individuals who benefit from wheelchairs may have...

- Alzheimer's
  - 1 in 14 people over age 65 have Alzheimer’s, and 1 in 6 over the age of 80
  - no cure
  - late-stage patients require a wheelchair for mobility

- Amputations
  - Amputations involving surgically removing toes, feet, or legs
  - Our product can be applied to those with amputation condensed to only one side since they have their other leg should be mobile
  - The specialized wheelchairs especially can provide comfort and movement
  - Wheelchairs as an assistive tool has the main goal of providing patients with more mobility, especially for those who can't or don't want prosthetics

- Amyotrophic Lateral Sclerosis (ALS)
  - 16,000 people, no cure
  - neurodegenerative disease that impacts the nerve cells in the brain and spinal cord
  - this impacts the motor neurons which die and the patient loses the ability to control the muscles across their entire body
  - As a result impacts the patient's mobility, leading to the requirement for wheelchairs
  - As the disease progresses, it can lead to total paralysis
  - our device can help those who are in their earlier stages of ALS and provide them with more opportunities to move and function
  - progression can vary though electric wheelchairs offer the best support

- Cerebral Palsy (CP)

    - Nearly 800,000 people
    - 1,200-15,000 children are diagnosed **
    - CP results from brain damage occurring from childbirth
    - Effects on the brain and its motor functions
    - Symptoms include limited muscle control, reflex problems, and lack of coordination and control, including oral motor.
    - standing electric wheelchairs prove more useful due to better circulation

- Diabetes
    - disease affecting the body's production and use of insulin
    - insulin helps glucose (digested from food intake) to the cells for energy though Type 1 inhibits the production of insulin, hindering this process
    - More common type, Type 2 is where the body has trouble using insulin properly
    - Half of the diagnosed type 1 patients experience nerve damage (diabetic neuropathy)
    - Foot complications can also result like ulcers and poor circulation, which can lead to amputation
    - wheelchairs provide better health and mobility

- Multiple Sclerosis (MS)
    - Estimated 1 million people in the U.S. and 2.5 million worldwide
    - disease in which the body's immune system attacks its central nervous system
    - affects the brain, spinal cord, and optic nerves
    - symptoms include muscle spasms, stiffness, fatigue, walking difficulties, tremors, dizziness, and seizures
    - in severe cases walking and standing are hard or impossible, so electric wheelchairs provide independence
    - **though standing wheelchairs are sometimes needed depending on their needs and those examples won't apply to our design since our is for seated wheelchairs??

- Muscular Dystrophy
    - 16-25 / 100,000 people
    - no cure however therapy and medication can slow the progression
    - disease that leads to muscle loss and progressively weakens the body
    - gene mutations affect the production of proteins that make muscles
    - commonly occurs in childhood frequently in boys but some present in adulthood
    - The most common form is Duchene type (DMD) which is associated with difficulty with motor activities (walking and sitting up), muscle stiffness, pain, frequent falling
    - **though standing wheelchairs are sometimes needed depending on their needs and those examples won't apply to our design since our is for seated wheelchairs??

- Parkinson's Disease
    - more than 10 million
    - More likely in men and older individuals (after age 60)
    - progressive nervous system disorder
    - impacts movement and motor functions
    - can start out as a slight hand tremor and progress severely

    - it is common for muscles on one side of the body to be affected first
    - recommended to use a tilting and reclining chair to help circulation and blood pressure. or a standing power chair to help slow the progression
        - **therefore I don't know if this applies to the wheelchair designs we will be working on

- Rheumatoid Arthritis (RA)
    - 1.5 million people in the U.S
    - progressive autoimmune and inflammatory disease where the immune system attacks itself
    - mostly attacks the joints like in the hands, wrists, back, knees, and feet
        - wide range of symptoms but some can be debilitating which is where a wheelchair can come into play
    - in some cases it attacks organs like the heart lungs and kidneys
    - motorized wheelchairs help the most and provide optimal comfort and health**
    - standing and reclining power chairs are good for independent standing **

- Scoliosis
    - curvature of the spine that can be problematic
    - 3 % of adolescents
        - develops most often during the accelerated growth period right before puberty
        - can also be a result of Muscular dystrophy or cerebral palsy
    - Not all cases are disabling
        - however spine deformities become progressively more severe in children/ adolescents as they grow
    - in the more severe cases wheelchairs are needed for mobility and comfort

- Spina Bifida
    - Birth defect that causes improperly forming with the spine and spinal cord
        - when the neural tube (formed early in pregnancy) fails to develop or close properly
    - early treatment like surgery can resolve the problem completely
        - however complications can follow and cause difficulty walking and hinder mobility
    - nerves used to control the leg muscles don't function properly
    - The nervous system is compromised
        - muscle weakness in the legs and sometimes paralysis
    - Manual or electric wheelchair depending on the condition's severity and needs

- Spinal cord injuries
    - *Most common disability that requires a wheelchair*
        - though this one coincidently might apply the least to our project ***
    - injuries can lead to different range of impairments depending on the area affected
    - quadriplegia = loss of function of arms legs and body (doesn't apply to our design)
    - paraplegia = loss of function to lower extremities, legs, and lower body
    - motorized wheelchairs are most effective and sometimes standing one

- Traumatic brain injury (TBI)

- "According to the Centers for Disease Control and Prevention (CDC), about **166 Americans die from TBI-related injuries each day**."
- Results from a physical blow, jolt, or bump to the head/body or in some cases a penetrating object to the brain (ex: bullet or knife) which compromises the brain
- severity ranges
  - mild forms temporarily impact cognitive ability
  - Servere forms result in bruising, torn tissues, and bleeding and can result in long-term symptoms or death
  - can experience losing the ability to walk or independent mobility
- some require specialized power wheelchairs
- standing, tilting, or reclining, electric chairs are also commonly used depending on severity and needs

Questions formed after research:

- Are we considering designs for only seated wheelchairs or standing ones as well
- Are we considering only adult-sized wheelchairs or those used by children as well
- Are we considering nonelectric, electric, or both
  - I feel like a potential design would be to have an electronically controlled footrest that is able to move out of the way, which could be extended on the electronics of an already electronic wheelchair or a potential attachable electronic device on normal wheelchairs.

9/21/23 Potential Material Research

Juliana Dugo - Nov 09, 2023, 12:48 PM CST

***Title**: Materials Research*

***Date**: 09/21/2023*

***Content by:** Juliana Dugo*

***Present:** N/A*

Links:

[1] Pros and Cons of Using PVC Pipes on Projects | 2014-08-18 | ACHRNEWS | ACHR News

[2] How Much Is PVC Pipe? (Types & Price) (pipsisland.com)

[3] How Strong is PVC Pipe? (With PVC Strength Charts) (pvcfittingsonline.com)

[4]20 Pros and Cons of Aluminum 2023 | Ablison

[5]Different combinations of aluminium alloys | Download Table (researchgate.net)

[6]Aluminum Yield Strength Table | Letter G Decoration Ideas (hcarrier.blogspot.com)

[7] Literature mechanical properties of aluminium 6061-T6 alloy [18] | Download Table (researchgate.net)

[12] Mechanical properties of Al 7075 | Download Table (researchgate.net)

[14] Density Of Polycarbonate | The Ultimate Guide - PlasticRanger

***References**:*

[8] Specification for Aluminum and Aluminum-Alloy Sheet and Plate (metric) (Report). B07 Committee. doi:10.1520/b0209m-14

[9] "ASM Material Data Sheet: Aluminum 6061-T6; T651" by ASM

[10] "Corrosion of Aluminum and Aluminum Alloys" by J.R. Davis.

[11] "Aluminum Properties and Physical Metallurgy" by John E. Hatch.

[12] "Welding Metallurgy and Weldability of Aluminum Alloys" by John C. Lippold, Damian J. Kotecki.

[13] "Plastics Engineering Handbook of the Society of the Plastics Industry, Inc." by Michael L. Berins.

***Goals:** Research potential materials to help decide which one is best based on criteria including cost, density, workability, durability in terms of tensile strength and longevity to conditions.*

***Content**:*

Polyvinyl Chloride (PVC pipe)

- *Lightweight [1]*
- *Density is 1.38 g/cm^3*
- *Affordable ex: [2]*
- *1/2 in. x 10 ft. schedule 40 pipe: $0.54 per foot*
- *3/4 in. x 10 ft. schedule 40 pipe: $0.71 per foot*
- *1 1/4 in. x 10 ft. schedule 40 pipe: $1.34 per foot*

Pipe Size	Tensile Strength (lb)	
	Schedule 40	Schedule 80
0.50"	264	344
0.75"	362	487
1.00"	581	727
1.25"	859	878
1.50"	954	1,225
2.00"	942	1,542
2.50"	2,093	2,890
3.00"	2,786	3,839
4.00"	4,119	5,820
5.00"	5,491	6,864
6.00"	7,165	11,384
8.00"	10,384	17,332

- *2 in. x 10 ft. schedule 40 pipe: $1.95 per foot*
- *Durable and good longevity [1]*
- *Resistant to corrosion*
- *Suitable for weather conditions*
- *Con: does not have a good heat stability [1]*

- *Con: can become brittle in cold temperatures [1]*
- *Good Tensile strength (see image) [3]*
- *Con: Might be difficult to work with, design wise, since the pipe shape is set.*
- *Workability is limited to adjusting length and purchasing a specific radius*
- *Plus because its environmentally friendly and recyclable*

*Aluminum (2 types of potential alloys) *
***Typically used for wheelchair footrests based on competing designs*

AA6601-T6

- *Commonly used to make fire department rescue ladders [4]*
- *Workability is very good and allows design flexibility*
- *it is highly weldable [4]*
-
- *Flexible and formable [11]*
- *High strength to weight ratio*
- *Weight reduction won't compromise structural integrity*
- *Lightweight*
- *density = 2.70 g/cm^3 [9]*
- *Durable and strong because of tensile strengths and other properties (see image) [7]*
- Stiff and stable
- *Corrosion resistance [10]*

Base Material	Tensile Strength (MPa)	Yield Strength (MPa)	Percentage Elongation
AA6061-T6	283	235	26
AA7075-T6	485	410	12

-

Property	Al 6061-T6
Young's modulus	68.9 GPa
Poisson's ratio	0.33
Tensile yield stress	276 MPa
Ultimate tensile strength	310 MPa
Elongation at break for 12.7mm (1/2 in.) diameter	17%
Brinell hardness	95
Fracture toughness K_{Ic} (T-L orientation)	29 MPa$\sqrt{m}$

-

AA7075-T6

- *High strength to weight ratio*
- *Weight reduction won't compromise structural integrity*
- *Lightweight*
- *Density = 2.8 g/cm^3*
- *Durable and strong because of tensile strengths (see images)[7]*
- *Stiff and stable*
- Fatigue resistance
- *meaning it can withstand an extender service life*
- *Perfect for a wheelchair footrest which is used daily*
- *Corrosion resistance*
- *Can withstand weather conditions or harsh environments [10]*
- *Workability is very good and allows design flexibility*
- *it is highly weldable [12]*

Density	2.81g/cc
Hardness, Vickers	175 HV
Ultimate Tensile Strength	572MPa
Tensile Yield Strength	503MPa
Modulus of Elasticity	71.7GPa
Thermal Conductivity	130 W/m-K
Melting Point	477-635°C

-

Plastic

- *Various types of plastics could be used*
- *polypropylene, polycarbonate, or ABS (Acrylonitrile Butadiene Styrene) [13]*
- *Lightweight*
- *Density (ABS) = 1.06 g/cm^3*
- *Density (polycarbonate) = 1.21 g/cm^3 [14]*
- *Workability is good and allows design flexibility [13]*
- *Moldable*
- *Price is doable*
- *$40 for 32 ounces for epoxy resin @ Hobbylobby.com*

Wood

- *I think wood can be rules out due its lack of durability with weather conditions and not as durable as our other options since it could chip or crack easily*

Conclusions/action items:

In conclusion, I think our best option would be aluminum or plastic. Aluminum is the best of the two given its durability and tensile strength. We just have to keep weight in mind and hopefully using aluminum can still meet our design specifications for weight.

We need to figure out the exact size of our footplate design and to see if the weight of either aluminum alloy would be possible. And we need to research and consider the availability of either alloy.

Juliana Dugo - Sep 22, 2023, 12:50 PM CDT

Title: Materials Research

Date: 09/21/2023

Content by: Juliana Dugo

Present: N/A

Links:

[1] Pros and Cons of Using PVC Pipes on Projects [2014-08-11] | ACHRNEWS | ACHR News

[2] How Much Is PVC Pipe? (Types & Price) (pipeinstall.com)

[3] How Strong is PVC Pipe? (With PVC Strength Charts) (pvcfittingsonline.com)

[4] 10 Pros and Cons of Aluminum [2023] | Alfmon

[5] Different combinations of aluminium alloys | Download Table (researchgate.net)

[6] Aluminum Yield Strength Table | Letter G Decorations Ideas (lgcarrier.blogspot.com)

[7] Literature mechanical properties of aluminium 6061-T6 alloy [18] | Download Table (researchgate.net)

[12] Mechanical properties of Al 7075 | Download Table (researchgate.net)

[14] Density Of Polycarbonate | The Ultimate Guide - PlasticRanger

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[8] Specification for Aluminum and Aluminum-Alloy Sheet and Plate (metric) (Report). B07 Committee. doi:10.1520/b0209m-14

[9] "ASM Material Data Sheet: Aluminum 6061-T6; T651" by ASM

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[12] "Welding Metallurgy and Weldability of Aluminum Alloys" by John C. Lippold, Damian J. Kotecki.

[13] "Plastics Engineering Handbook of the Society of the Plastics Industry, Inc." by Michael L. Berins.

Goals: Research potential materials to help decide which one is best based on criteria including cost, density, workability, durability in terms of tensile strength and longevity to conditions.

Content:

Polyvinyl Chloride (PVC pipe)

- Lightweight [1]

Download

9_21_23_Materials_Research.docx (242 kB)

Juliana Dugo - Sep 22, 2023, 12:48 PM CDT

Download

9-21-23_Materials_Research_-_Google_Docs.url (110 B)

10/4/23 Fabrication/Development Process (section of Prelim report)

Juliana Dugo - Oct 11, 2023, 11:12 PM CDT

I. Fabrication/Development Process

Materials

At this point in the design process, the material selection has not been finalized. The final design will potentially be composed of Aluminum Alloy 6601-T6 and or a plastic such as polycarbonate. Both fit many of the outlined criteria.

AA6601-T6 allows for design flexibility since it is highly weldable. It is also relatively lightweight with a density of 2.70 g/cm^3 [10] while also providing a high strength-to-weight ratio which means weight reduction won't compromise the structure's integrity. The high strength and durability of the material can be stated from the fact it can withstand a tensile stress of 276 MPa [10]. The material is also corrosion resistant [11] and can be reliable against a variety of weather conditions. This meets the criteria of longevity where it can last as long as the wheelchair, which is about 5 years [2].

Polycarbonate also allows for design flexibility since it is moldable and has a mold temperature of 90-320 degrees Fahrenheit [12]. Polycarbonate is extremely lightweight with an average density of 1.20 g/cm^3 [12] while also providing a fair strength-to-weight ratio however it doesn't nearly compare to the strength of AA6601-T6. The strength and durability of polycarbonate is stated from the fact that it can withstand an average tensile stress of 64.2 MPa [12]. Polycarbonate has no risk of corrosion and can prove steady in terms of weather conditions. This meets the criteria of longevity in which it can last as long as the wheelchair, which is about 5 years [2].

Methods

Since the castors and the existing holes are the focal points of attachment, a mold will be taken for fabrication. A potential and likely method of approach is constructing a CAD design of the castors with the negative holes to then 3D print. This 3D print model can be used as a mold to construct the cap piece of the design that will be inserted into the castors. For the other components, a 90-degree hinge can be purchased to satisfy the design's function of rotating a total of 90 degrees. The hinge will be reinforced via screws, which will also attach the footrest plate to the cap. The actual footrest plate can be purchased to eliminate the need to fabricate. However, if no appropriate products on the market exist that fit the weight, size, and material criteria, then fabricating one would be necessary.

Testing

A variety of testing methods are outlined for execution. The final design must be tested to fit and function on the client's wheelchair base. The design is made to attach to the castors in which existing holes on the castors provide the intended attachment method. The design must fit these existing holes snuggly for maximum support and stability. This testing will ensure the manufactured measurements were correct. The overall function of the design can be tested by ensuring that the footplate can rotate down to the desired position and angle. Additionally, it must be verified that the footrest design does not hinder any functions of the client’s electric wheelchair. For example, the design must not touch or invade the function of the nearby wheels. Quality assurance testing must also be conducted. Verification and validation of the structure integrity can be done by applying similar compressive and tensile forces to the extent the client will apply on the footrest design. Before physically testing such, the maximum allowed force can be calculated. For either material, the maximum force can be calculated by using the maximum tensile stress and multiplying it by the measured cross-sectional area of the material that is perpendicular to the anticipated force. The anticipated forces applied can be verified as allowable by comparing this number to the calculated maximum. The anticipated load must meet

the requirement of being within an allowable factor of safety, in which the ratio between the maximum load and anticipated load falls within 1.25-4.

10/25/23 Aluminum Plate Fabrication Research

Juliana Dugo - Oct 27, 2023, 1:26 PM CDT

Title: Aluminum Plate Fabrication Research

Date: 10/25/2023

Content by: Juliana Dugo

Present: N/a

Goals:

- Discover different possible designs and geometries
- Find the ideal one, which has the most rigidity and strength under compressive forces.

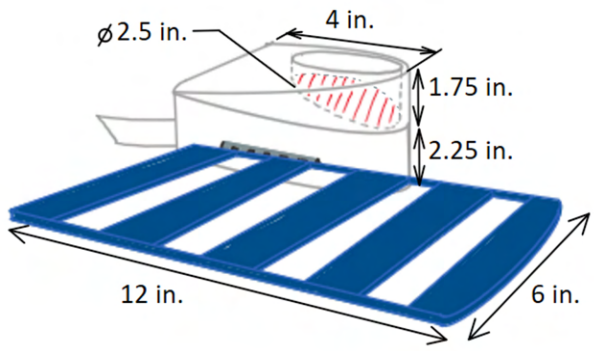
Sources:

[1] S. Benson, “Strategies for bending aluminum 6061-T6,” The Fabricators, https://www.thefabricator.com/thefabricator/blog/bending/strategies-for-bending-aluminum-6061-t6 (accessed Oct. 25, 2023).

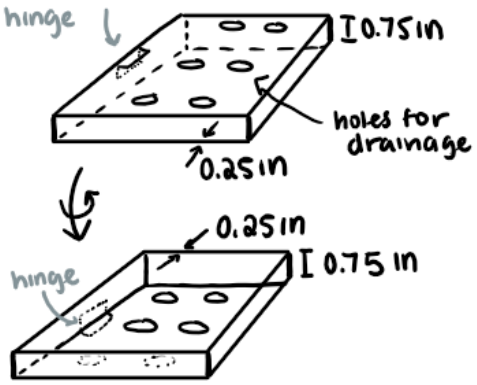
Content:

Flat Aluminum Footplate

Current Design:



Folded Aluminum Footplate



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I have designed a plate with a 90-degree bend of a material thickness of 0.75 in since the thickness I have for the aluminum sheet is for 0.25 in

- There were recommendations of having a minimum bend radius of 3 to 4 times the materials thickness [1].
- Further testing will have to confirm if this is the correct thickness and bend size for our project
- I also designed it with holes for drainage, and I think this will be more sturdy than having those huge cut out slits.

Things to keep in mind:

- “When bending 0.25-in.-thick 6061-T6, you might see cracking when bending past an outside angle of just 86 degrees. You’ll likely never make it to 100 degrees without cracking” [1]
- Draw a bend line for fabrication
- Three bending strategy for 90 bending:
  - To minimize damage to material and perform clean bend
    - 2 degree bend in front of bend line
    - 2 degree bend behind bend line
    - 86 degree bend in the center of bend line

Conclusions/action items:

- In conclusion, the aluminum sheet with small bend sides has enhanced strength and rigidity in the direction defined by the bends.
- It is effective at resisting compressive loads that might cause bending, making it suitable for our applications.
- However, it may be less rigid out in the center. Because the thickness of the metal has to be thinner in order to bend the sides.

Fabrication Methods:

For the bending design we can use either

- The Grizzly 48” Brake where the max thickness for aluminum is “0.194 (6 GA)”
- The Pexto 24” Brake where the max thickness for aluminum is “0.060 (16 GA)”

Action:

We can fabricate both designs and through further testing we can make a decision. Testing can include applying loads to discover which one keeps it from plastic deformation. After testing we will choose the design that did the best in resisting bending.

Also playing around with the aesthetics and functionality of the design. For example if we want to incorporate those slots or holes for drainage, or if we find those changes interrupt the structural integrity of our design. Since the strength and durability comes above the aesthetics and minor functionality cases like that.

10/30/23 Hinge Research

Juliana Dugo - Nov 01, 2023, 2:05 PM CDT

Title: Hinge Research

Date: 10/30/2023

Content by: Juliana Dugo

Present: N/A

Goals:

- Learn more about hinges and things to consider when picking the hinge for our project
- Look at other hinges that are not 90-degree stop in the event we have to consider alternative designs
- If the 90-degree hinge is unrealistic, our design can be modified utilizing one of these different types.

References:

[1] Emily, “How hinges work - everything you need to know,” The Creative Folk, https://www.thecreativefolk.com/how-hinges-work/ (accessed Nov. 1, 2023).

Content:

Hinges allow for rotational moments between two objects

Parts of a hinge:

Leaf: the (usually) rectangular piece that is screwed into the object and provides support since this piece stays fixed. (Most hinges have two leaves)

Knuckle: the space between two leaves put together. The knuckle forms and usually is a hollow tube shape

pin: the piece that goes through the knuckle to secure the two leaves together and prevents separation

Types of hinges:

(relevant and potentially alternatives)

Barell hinge:

- a screw is protruded through two separate barrels, both with a small leaf for attachment
- best with horizontal applications (like our project)
- bulky but are incredibly stable since they are widely used on heavy doors/objects.
- 

Knife hinge:

- Leaves connect by a pivot pin, in which the two leaves flap away and fold in overlapping one another
- **This hinge would change our anticipated design
    - but could be a possible plan B if a 90-degree hinge does not work

- 

Piano hinge:

- A long continuous hinge that is the length of the object that is attached to
  - Pro: since more surface area of attachment to our footplate can provide more stability
  - Con: potentially could not work if we can't attach such a long hinge to the cap
  - Con: rarely available with a 90-degree stop
  - 

Soft closing:

- Operates using a spring that pushes the latch that keeps it closed.
- con: spring that pushes on latch with a force towards the base mounted axle hold. which when it is in the process of closing

  it resists opening any more than 10 degrees

Self-closing;

- powered by a solid all-metal coiled spring recoiled manually or with the flick of a switch.
- includes guide rails that help it move in the opposite direction when the door is opened again and an internal catch prevents pinching fingers.

Conclusions/action items:

For our project, some of these types can work, given they specifically have a 90-degree stop. The soft closing or self-closing features might be an extra plus. The self-closing can be beneficial for our client who has a limited range of motion. If we can have a self-closing one mechanically or electronically, it would have a huge advantage for ease of use for our design.

11/9/23 AA6601-T6 Calculations for Deformation

Juliana Dugo - Nov 10, 2023, 3:57 PM CST

Title: AA6601-T6 Calculations for Deformation

Date: 11/9/2023

Content by: Juliana Dugo

Present: N/A

Goals: Use the numerical values of the specifications of AA6601-T6 to quantify the allowable force applied and deformation

Content:

I used the numbers provided from my previous research about the materials AA6601-T6

[1] ***Literature mechanical properties of aluminium 6061-T6 alloy [18] | Download Table (researchgate.net)***

[2] **Defining Factor of Safety for Design and Use | SafetyCulture**

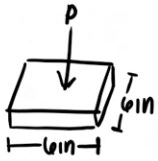
Based on this research I went with a really high factor of safety of 4 [2] since it will be incredibly safe for our application, and the stress yield is very large even with an FOS of 4, the allowable stress is still very high and workable with.

$E = 68.9\ GPa$

$\sigma_Y = 276\ MPa$

$L = 6in = 0.152\ m$

$A = 6in \times 6in = 0.914 m^2$



$F.O.S = 4$ reccomended

$$F.O.S = \frac{\sigma_Y}{\sigma_{allowable}}$$

$$4 = \frac{276\ MPa}{\sigma_{allow}}$$

$$\sigma_{allow} = 69\ MPa$$

$$\sigma_{allow} = \frac{PL}{AE}$$

$$69\ MPa = \frac{P(0.152m)}{(0.914m^2)(68.9GPa)}$$

$$P = 2.858 \times 10^{19}\ N$$

[1]

Deformation

$$\delta = \frac{PL}{AE}$$

$$\delta = \frac{2.858 \times 10^{9}\,N\,(0.152\,m)}{(.914\,m^2)(68.9 \times 10^{9}\,Pa)}$$

$$\delta = 69 \times 10^{6}\,m$$

$$\%\ \text{Deformation} = \frac{\text{Final} - \text{Initial}}{\text{Initial}} \times 100$$

$$\frac{69 \times 10^{6}\,m - 0.152\,m}{0.152\,m} \times 100 = 4.5 \times 10^{10}$$

$$\text{allowable } \% = 4.5 \times 10^{10}\ \%$$

Conclusions/action items:

I am unsure how we should use these numbers because our numbers are so big in terms of our dimensions so they yield very large unrealistic approachable values.

Action:

Get a second opinion from Professor Murphy and maybe Professor Mikkelson.

*****Updated Action Plan after meeting with Professor Murphy:**

Use the calculation process and specifications of AA6601-T6. But instead of calculating the force or deflection using a factor of safety, I can use the force P calculated and use a ratio between the measured force during testing, to comprise a factor of safety that our design has for its purpose.

I can also do a similar thing with deflection. Deflection measurements can be taken from testing. This number can be used to solve for the force P inflicted, and this calculated P can be compared via a ratio to the Max P to get a factor of safety.

11/16/23 Fabrication/Methods Details

Juliana Dugo - Nov 16, 2023, 8:09 PM CST

Title: Fabrication/ Method Details

Date: 11/16/2023

Content by: Juliana Dugo

Present: N/a

Goals: Figure out the Methods section details for final paper

Content:

Making the footplate:

Rough outline

Material: Aluminum sheet 12 by 12 in and ⅛ in thickness

- Cut sheet into 6 by 6 in squares using the bandsaw
- Round and sand edges with vertical belt sander
- Use hand sander to smooth out any lasting imperfections
- Drill 9 holes into each footplate in grid formation. The outer holes are 1 in from the edge and have two inches between each hole.
- Drill bit size: .334 in diameter
- Use Drilling machine on the recommended speed of 850 RPM to drill holes
- Recommendation info: (for ¼ - ⅜ thickness of aluminum is recommended to have a speed of 850 RPM)
- Used cutting oil fluid while drilling (Cutting oil reduces friction between the drill bit and the material it is drilling into. The reduced friction results in less heat build-up, which prolongs the life of both your drill bits and the metal and/or material being drilled).

Conclusions/action items:

The Methods section of the final paper is detailed but concise.

- **I need to put the fabrication into a more concise cohesive form**
- **Figure out our design plan and outline more fabrication processes and add it**

12/1 Fabrication Details

Juliana Dugo - Dec 01, 2023, 10:13 PM CST

Title: Fabrication Details in Team Lab

Date: 12/1

Content by: Juliana Dugo

Present: Sadie, Gracie, Amanda, Liv, and Lael

Goals: Fabricate the materials together and get a working prototype

Content:

Updates

- **We decided to use the 100-degree hinge since the 90-degree hinge was not feasible since it has a locking mechanism that required you to push the pin.**
  - **This did not fit our PDS requirements of ease of use.**
- We needed to cut out a hole in the aluminum footplate to make it fit the hinge, the hinge has a protruding piece along the line of the screw plate.
  - We used a band saw to cut this out, about ___ mm wide
- Next we drilled holes into the plate for the screws
  - I used a .33 mm drill bit and then threaded it for the pattern of the M4 .70 mm
  - We first used the M4 .70 mm x 16 mm then decided it was too long and switched to the M4 .70 mm x 12 mm
- Then we used a torque wrench to fasten a bolt onto the end for securement
- Then we used a hand drill to drill a hole into the 3D printed cap, which we also threaded, using the same sizes for the same screws
- Then we repeated attaching the screws through the 3D cap, placing it so that the little hooks, hand onto the top of the edge.
- We also got Velcro to put into the Velcro cutouts designed into the 3D printed cap, to fasten it underneath the castors to hold it steady in place.

Conclusions/action items:

Now that we have a functioning prototype it is necessary to start testing right away and get numerical results to add to our final project.

12/3 Final Report Materials section in Fabrication/Development Process

Juliana Dugo - Dec 09, 2023, 9:33 PM CST

Title: Final Report Materials section in Fabrication/Development Process

Date: 12/3/2023

Content by: Juliana Dugo

Present: N/A

Goals: Write a concise paragraph explaining why we chose the two materials, aluminum AA6061-T6 and tough PLA for our fabrication.

Content:

I. Fabrication/Development Process

Materials

For the fabricated footplate, the team chose the aluminum alloy 6601-T6 because its properties outcompeted alternative materials when considering design specifications. AA6601-T6 allows for design flexibility as it is easy to cut and sand, making fabrication simple. The main benefit of this material is its high strength-to-weight ratio, meaning that weight reduction won't compromise the structure's integrity. The density of the alloy is 2.70 g/cm^3 [15] and it is highly strong and durable, with capability of withstanding a stress of 276 MPa [15]. For our project specifications which pertain to the cross sectional area and weight of our clients legs, a compressive stress of 2921.54 Pa will be applied. This applied stress equates to a factor of safety of 94488. The material chosen is also corrosion resistant [16], will not deteriorate when in contact with water, and will remain stable at the temperature ranges 14-80 ℉ as stated in our design specifications, therefore reliable in a wide variety of weather conditions. This meets the lifespan design specification in which the designed footplate must have a longevity equivalent to that of the wheelchair: approximately 5 years [2].

For the 3D printed castor cap, the team opted to utilize tough PLA. This plastic option is low in cost and strong in durability. Tough PLA is less brittle than regular PLA and has a yield stress of 47.5 MPa [17] in the vertical direction, meaning it will not undergo plastic deformation if our anticipated load of 2921.54 Pa is applied. It costs $0.08 per gram, making it reasonable within our budget. Additionally, tough PLA should not be exposed to temperatures greater than 136.4 ℉ [17], and is non porous and waterproof, therefore it fits within our weather resistance requirements.

Conclusions/action items:

Get feedback from professor Murphy during the meeting on 12/4

12/5 Final Presentation Script Draft

Juliana Dugo - Dec 08, 2023, 11:27 AM CST

Title: Final Presentation Script Draft

Date: 12/5/2023

Content by: Juliana Dugo

Present: N/A

Goals: Write up all the details and key points I want to discuss during my sections for the presentation: discussion and future work

Content:

Discussion Section:

During different stress testing as well as calculated, we tried our best to mimic the client's weight and abilities. For example, for the ease of use, one of our members tested flipping the plate up and down while mimicking our clients ability, in which the foot only exhibited vertical motion. We found it was fairly easy since the hinge has the soft close feature, so it doesn't need a constant load to rotate, it just needs a little push. Flipping it down, was possible if the client just places his foot on the edge and applies a small force. However this might have some inaccuracy since it is subjective and we cannot exactly test the product under his specific mobility, without the client. Also for the stress tests, we calculated the weight of his legs. This could be another error, since we do not know if he will shift to one side, and apply additional pressure. With our calculations, we found that the aluminum would not be of concern since the load applied and yield stress is a ridiculously high factor of safety. The deflection of the footplate itself is insignificant. Testing proved this, since all the deflection came from the hinge. Our current hinge is a main concern for two reasons. We suspect the materials are too weak and the 100 degree angle is not ideal. Like we mentioned, inserting a metal piece to stop it at a 80 degree angle when folded down, helped hold the weights during the stress test.Another main concern was the stability of the cap under eccentric load, causing a moment and twisting the cap. The cap was not snug enough around the castors curves and the velcro straps might not be the ideal reinforcement.
As we mentioned, our budget requirements were met. All purchases totaled up to 71 dollars.

Future work:

In future semesters, to improve the strength and functionality of our design, there are a few adjustments anticipated that need to be made. One key adjustment involved improving the hinge quality to handle significant loads and distribute stress more evenly. Currently the hinge is a concern for stress concentrations resulting in deflection originating from the hinge’s axle. Additionally, modifying the folded angle from 100 to 90 degrees or smaller can counteract deflection and better support clients' feet. Either by replacing the hinge or permanently modifying it similarly as we did with that little metal piece inserted. Also a support under the footplate is another idea to consider. A redesigned cap, addressing fit issues and adjusting wall thickness for durability, is also a consideration. Lastly, improvements enhancing the support mechanisms for the castor cap, and exploring alternatives to the current velcro straps, such as a more efficient mechanism better suitable for the client's mobility. It's also important to test the functionality of the product on the client's current wheelchair and collect data for long term usage and specifically how stress builds and wear and tear occurs.

Conclusions/action items:

Re-edit to make it more concise and polish it up for presentations. DONE

Practice and memorize these parts and content DONE

New version....

Discussion:

Throughout testing, we replicated the client's weight and abilities. A team member evaluated ease of use by mimicking the client's range of motion, focusing on vertical foot movements. The soft close hinge made the rotation effortless, requiring just a slight push. However, the accuracy of our simulation is subjective without the actual client. For stress tests, we calculated the weight of the client's legs. We

acknowledge the potential variations as the client might shift so our findings are an estimation. Our calculations however indicated that the aluminum's yield stress far exceeded any applied stress, ensuring a significant factor of safety. During testings, the original hinge couldn't support weight at a 100-degree angle, so we added a metal piece limiting it to 80 degrees, improving stability and preventing weight slippage. After adjustments it held12 lbs however this still does not meet our weight criteria and the design experienced major deflections. Also, the cap is not a perfect fit, leading to instability under eccentric loads, twisting the cap out of place, and adding to observed deflections. As you can see in Figure 9, stress concentrations occur on the face where the hinge in attached as it absorbs some of the stress.

In future semesters, we anticipate enhancing our design's strength and functionality. A crucial adjustment involves upgrading the hinge to handle significant loads and evenly distribute stress. Currently, deflection stems from the hinge, suggesting using a stronger hinge or a permanent modification, similar to the metal piece insertion or underneath supports. To counteract deflection, the folded angle should be adjusted to 90 degrees or smaller. Another consideration is redesigning the cap to address fit issues and adjusting wall thickness for durability. Future semesters can also explore alternatives to Velcro straps, for a more stable reinforcement, ideally one that is more tailored to the client's mobility. Lastly testing the product on the client's current wheelchair is important for gathering data on compatibility, stress distribution, and wear and tear from long-term usage.

12/7/2023 Final Report Methods

Juliana Dugo - Dec 11, 2023, 11:53 PM CST

Title: Final Report Methods

Date: 12/7/2023

Content by: Juliana Dugo

Present: N/a

Goals: Write and finish up the Methods section of the report, where the fabrication process is explained in a concise but detailed way.

Content:

Methods

We initiated the fabrication process using a 12 by 12 inch sheet of aluminum alloy 6061-T6, with a thickness of ⅛, and using a bandsaw, to divide the sheet into four 6 by 6 inch squares in the Team Lab. Subsequently, we rounded the edges using a vertical belt sander and refined the surface with handheld files. To meet weather conditions and functional criteria, we drilled 9 equidistant holes, forming a 2-inch spaced grid. We used a 0.334-inch diameter drill bit on a drilling machine at the recommended speed of 850 RPM, with cutting oil to reduce friction and prolong the life of both the drill bit and our material. This meticulous hole arrangement facilitates drainage of water or snow. After cleaning off the oil residue, our aluminum footplate was ready for integration.

In tandem, our 3D-printed caster cap was designed via SolidWorks and printed using tough PLA. After printing, it was verified that the cap was compatible, and the holes lined up. The subsequent step involved modifying the aluminum plate to accommodate the 100-degree hinge. Markings and a calibrator guided the removal of a rectangular section using a bandsaw, and handheld files were used for finishing. We used M4 x 0.7 x 12 mm screws to screw the hinge into place onto the aluminum plate. Drilling was done using the drill press machine at 850 RPM and manual threading tools were then employed. The hinge was secured using screws, a 9/32" nut, and a torque wrench. Drilling and threading into the 3D-printed cap followed the same process, except a handheld drill was used. Finally, Velcro straps were employed to fasten the assembled components onto the castors, completing our comprehensive fabrication process for our final design as illustrated in Figure 8.

Figure 8 : *Final Prototype of castor cap and footplate assembled with a 100-degree hinge from top view.*

Conclusions/action items:

-Add to the report

-Finish small edits to report for submission

9/20/23 Size Research

Juliana Dugo - Dec 12, 2023, 6:20 PM CST

Title: Size Research

Date: 09/20/2023

Content by: Juliana Dugo

Present: N/A

Link: amazon.com and The Brannock Device Company | The Brannock Device Company

Reference: [1] "Brannock Device® Foot-Measuring Device User Guide" by The Brannock Device Co., Inc.

Goals: Find out the information needed to decide on the dimensions of the footrest

Content:

Examples of dimensions (footrest attachments on Amazon)

- **Product Dimensions:** 17.3 x 9 x 4.6 inches; 4.65 Pounds
- **Package Dimensions:** 17.04 x 9.72 x 4.49 inches; 4.76 Pounds
- **Package Dimensions:** 16.69 x 8.86 x 4.65 inches; 4.78 Pounds

The average seems to be around 17 x 9 x 4.5 inches and based on the common material use of aluminum plates, weighs around 4.70 lbs.

Though it's important to note, dimensions for this specific part have been incredibly hard to find and some only give the package dimensions.

In my opinion, it could be helpful to estimate based on the men's average shoe size:

- Ideally the footrest should accommodate wider than the shoe's width but can be shorter while supporting the majority of the foot's length.
- The size of our footrest should accommodate a variety of sizes and can be based on average shoe sizes.
- Men's average range from 9 to 12 shoe size
- This makes the average shoe size 10.5 which has measurements of 11.645 by 4.25 inches [1]

Based on these criteria I would estimate an ideal size to be 7 inches in length and 5 inches wide.

Conclusions/action items:

Use this information in the design criteria to take into account for sizing the aluminum foot plate

9/21/23 Collapsing Pipe Footrest

Juliana Dugo - Oct 11, 2023, 12:33 PM CDT

Title: Collapsing Pipe Footrest

Date: 09/21/2023

Content by: Juliana Dugo

Present: N/A

Goals: Sketch a preliminary design to show team members and client

Content:

This design features a collapsible pipe that is attached on the wheelchair base on both sides, between the base and the wheel. It can be attached via screws for maximum support. The pipe also has attached to it a foot plate that has a 90-degree hinge to allow it to fold vertically to horizontal. When the pipe is fully extended the footrest plates can be rotated down to be parallel with the group. To put the design in its compact storage position, the footplates need to be flipped up vertically (ordinated perpendicular to the ground) and then forces need to be applied to compress the pipe and decrease its length so that it can store to a length where it is closer to the base front.

9/21/23 Simple Hinge Footrest Design

Juliana Dugo - Oct 11, 2023, 12:28 PM CDT

Title: Simple Hinge Footrest Design

Date: 09/21/2023

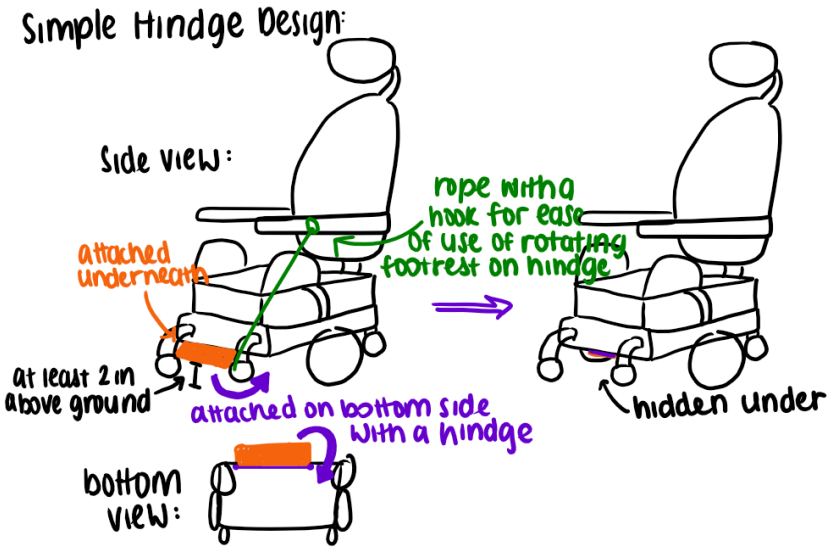
Content by: Juliana Dugo

Present: N/A

Goals: Sketch a preliminary design to show team members and client

Content:

This design has a simple footrest plate attached to the bottom of the base via a hinge that allows for 180-degree rotation. The design has a rope that attaches to the armrest, which keeps the footrest locked in place in its extended position. The compact position of the design, stores underneath the wheelchair base, which maximizes the low interference aspect. The plate however needs to be short enough to clear the ground for rotation. It would be planned that when it is halfway through its rotation it clears the ground at least 2 inches.



9/21/23 Waterfall Hinge Footrest

Juliana Dugo - Oct 11, 2023, 12:22 PM CDT

Title: Waterfall Hinge Footrest

Date: 09/21/2023

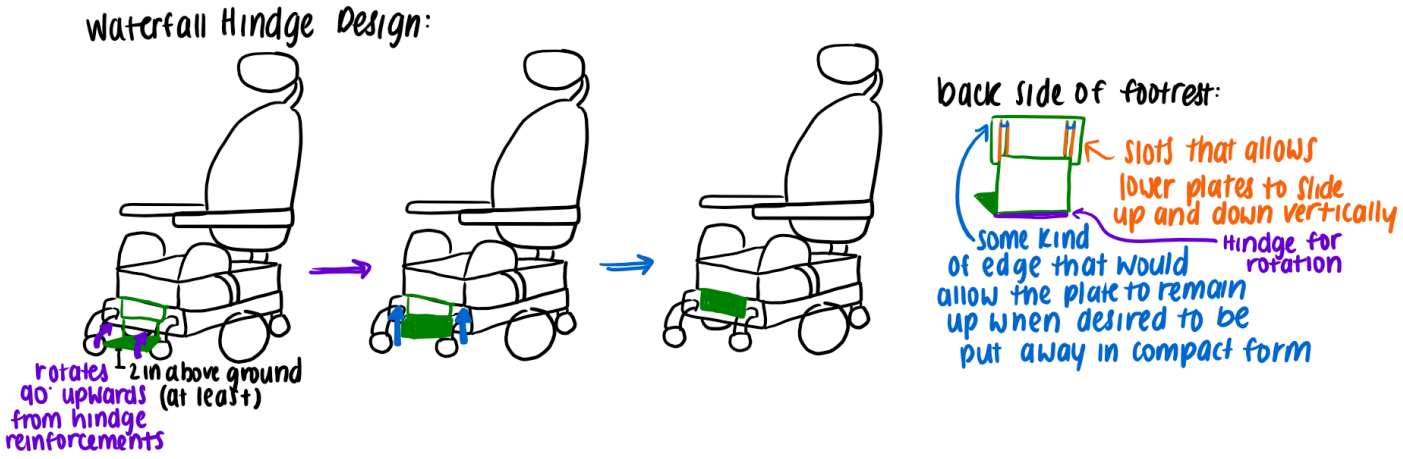
Content by: Juliana Dugo

Present: N/A

Goals: Sketch a preliminary design to show team members and client

Content:

This design would consist of two plates, which one can cascade down, via a slot track on the back. Then attached to the bottom plate would be another plate and a 90-degree hinge providing a footrest plate for the feet to rest on. The fully expanded design would be at least 2 inches above the design to minimize disruptions. the fully compact design will lay parallel against the base of the wheelchair.



10/10/23 Preliminary Design Evaluation.

Juliana Dugo - Oct 11, 2023, 11:11 PM CDT

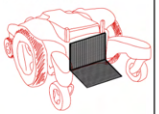
Design Matrix

The design matrix is a tool employed by the design team to evaluate preliminary designs in terms of important selected criteria. The criteria chosen by the design team was evaluated based on the client's requirements, what was most readily accomplishable in a semester, and by the amount of background knowledge that the design team has.

The criteria includes 7 categories, where each category has a specific percentage in which they contribute to the total point system. First category is ease of use, weighted 25 percent which is the highest. Ease of use is extremely important since the design needs to be easy and simple to function for the client since they have limited mobility. Next is storage, weighted 20%. This category assesses how well the design is able to be low interference. The ideal design needs to be stored discreetly on the wheelchair, so it can be spatially low interference. The storage aspect must also not interfere with the other functionalities of the wheelchair. Next is weight, weighted 15%. A lightweight footrest design is lacking in competing designs. The weight category assesses how well the design satisfies the outlined maximum weight of 4 pounds, to accommodate the clients needs. Next is size, weighted 10%. Size has a similar assessment to storage. This category assesses if the design has a good balance between being small enough to be low interference spatially, and an appropriate size to fit the client's feet. Next ease of fabrication, weighted 10%, assesses how easy the design is to fabricate. Next durability, weighted 10%, assesses how well the design can withstand day to day usage and potential weather elements. The footrest is desired to have the same lifespan as the wheelchair, which is about 5 years. Finally cost comes in last, weighted 5%, which assesses how expensive the design is. Higher the scores reflect a less expensive cost. This category is rated lower since the client's needs come first.

The matrix results applied the discussed criteria. For ease of use, The Fold-Up Footrest design and Folding Mesh Footrest scored full points since both have simple operations of flipping up 90 degrees for the optimal storage position. The storage category awarded full points to the Fold-Up Footrest since it proves to maximize low interference and does not crowd the front area or other functions of the wheelchair. The weight category awarded full points to the Folding Mesh Footrest since the footplate being made of mesh fabric will be extremely lightweight. The ease of fabrication category awarded full points to the Folding Mesh Footrest since it does not require complex mechanical procedures. The durability category awarded full points to the Fold-Up Footrest, since the sturdy foot plates made of either plastic or aluminum and hinge reinforcements, will withstand constant forces and weather. Finally cost awarded full points to the Folding Mesh Footrest since the use of mesh fabric minimizes the cost of the entire design.

Table 1: *Design Matrix. Evaluation of feasible design ideas amongst different criteria. Highlighted areas indicate the highest score per category. Scores out of 5.*

	Design 1: Fold-Up Footrest 	Design 2: Folding Mesh Footrest 	Design 3: Airplane Armrest 
Ease of use (25)	5/5	5/5	2/5
Storage (20)	5/5	4/5	3/5
Weight (15)	4/5	5/5	2/5
Size (15)	5/5	5/5	3/5
Ease of Fabrication (10)	4/5	5/5	1/5
Durability (10)	5/5	3/5	3/5
Cost (5)	3/5	5/5	2/5
Total (100)	93	92	47

11/10/23 Redraw Design 3: Airplane Armrest Footrest Design

Juliana Dugo - Nov 10, 2023, 3:52 PM CST

John Puccinelli - Nov 03, 2014, 3:20 PM CST

Title: Redraw Design 3: Airplane Armrest Footrest Design

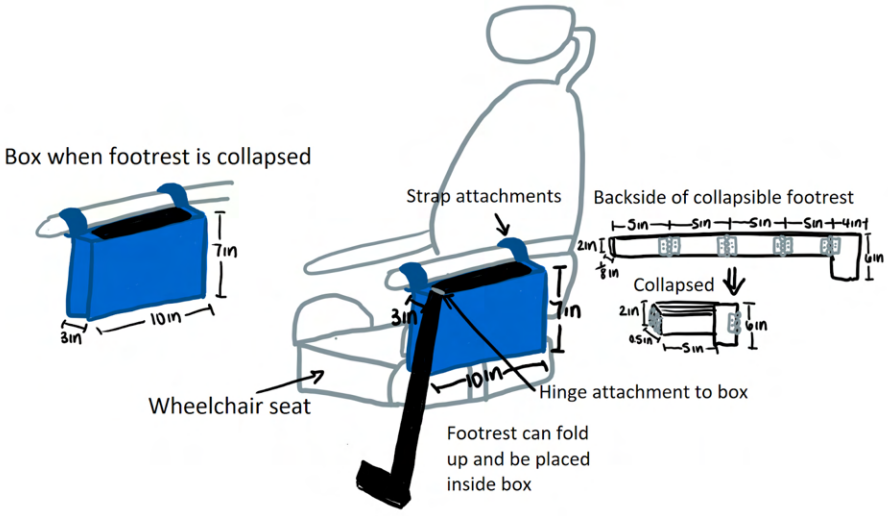
Date: 11/10/2023

Content by: Juliana Dugo

Present: n/a

Goals: Feedback from the preliminary presentation was that our design three lacked a detailed drawing. The goal is to update the design's drawing and clarify the design.

Content:



Conclusions/action items:

Now that the design has an updated picture, with measurements and clarifying depictions it can be used in our future reports and presentations. Action: replace this picture in previous documents for future documents to copy this new image over.

9/27/2022 Red Permit

Juliana Dugo - Dec 09, 2023, 7:54 PM CST

Title: Red Permit Certification

Date: 9/27/2022

Content by: Juliana Dugo

Present: N/A

Goals: To get the required training to complete the course and be able to work in the team lab.

Content:

Conclusions/action items:

N/A

11/10/23 Tong Distinguished Entrepreneurship Lecture

Juliana Dugo - Nov 10, 2023, 12:57 PM CST

Title: Tong Distinguished Entrepreneurship Lecture

Date: 11/10/2023

Content by: Juliana Dugo

Present: N/a

Goals: Listen to the presentation and learn important takeaways about navigating through an engineering pathway

Content:

- Original plan was to become a doctor
- She went to the University of Pittsburgh and freshman year she was bored and uninterested
  - She had to reassess
  - But she got inspiration from her undergraduate
- She wanted to help people and there was more to her journey
- She came here to UW Madison for grad school where she studied biomaterials and she worked with microspheres.
- Her graduate experience was more engaging and fulfilling
- Works at Exact Sciences now
- She had friends and networking that got her first job

Sometimes things don't go to plan but just because you failed your initial goal, and switched tracks, doesn't mean you did something wrong.

Takeaways:

- Find your people
  - open your world view to meet new people, "when you open a door there is always someone behind you"
- Do the things that scare you
  - get outside of your comfort zone
  - push your limits
- Laugh until you cry, and cry until you laugh
- Everyone is counting on you
- Lean into help and don't take things too seriously.

Conclusions/action items:

After watching this presentation and learning all of these insightful things I feel inspired by the uncertainty of my own journey. Going forward I will take her takeaways and apply them to my life and journey to succeed.

9/21/2023- Quickie Q700M Wheelchair Research

Gracie Hastreiter - Oct 11, 2023, 12:51 PM CDT

Title: Quickie Q700M Wheelchair Research

Date: 9/21/2023

Content by: Gracie

Present: Gracie

Goals: The goal is to research our client's wheelchair, the Quickie Q700M. More specifically, to research the base of the wheelchair and how we could potentially attach a footrest onto the base.

Content:

Model Name: Quickie q700m

- Seat is able to elevate 12’’
- 25” base
- Seat to floor 16.5”-19”
- If footrest attaches to casters, then our client would be able to move seat up to get feet onto footrest
- Attaching footrest to casters might not be very secure, coil put more pressure on the caster than they can handle, could affect the wheels

([1])

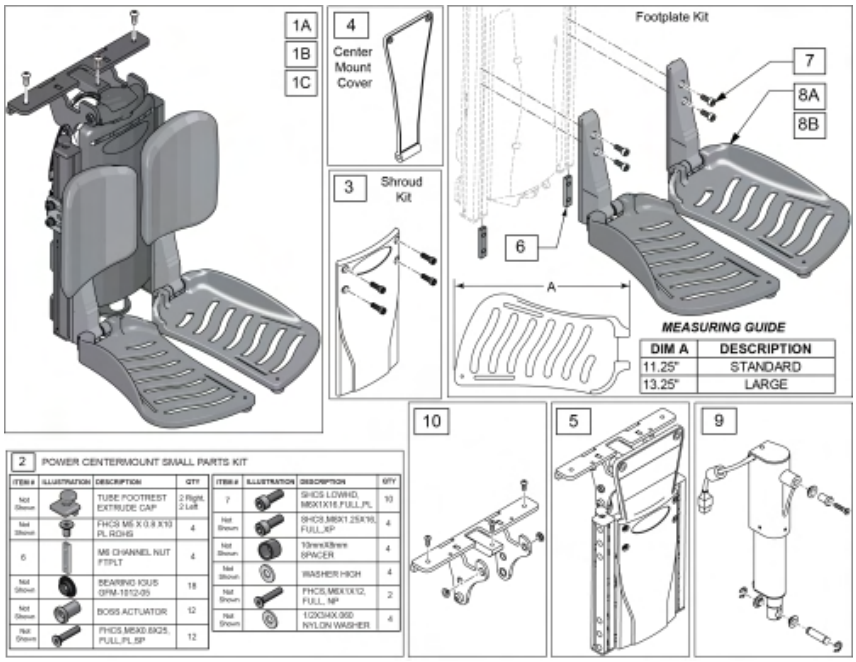
Details of various parts of the Q700M wheelchair from the Southwest medical website

Product Width:	25"
Product Length:	36.5"
Seat Width:	• SEDEO PRO ADVANCED: 16" to 22" • SEDEO PRO: 16" to 26" • SEDEO LITE: 15" to 20" • Captain Seat: 16", 18", 20"
Seat Depth:	• SEDEO PRO ADVANCED: 15" to 20" • SEDEO PRO: 14" to 22" • SEDEO LITE: 16" to 22" • Captain Seat: 16" to 22" Note: Back cushion can cause 2" loss of effective depth.
Seat-to-Floor Height:	16.5" to 19"
Back Height:	• SEDEO PRO ADVANCED: 21" to 28" • SEDEO PRO: 21" to 30" • SEDEO LITE: 18" to 30" • Captain Seat: 25"
Turning Radius:	23.5"
Ground Clearance:	3"

[2]

Current footrest:

- Attaches to the bottom of the seat, therefore moves with the seat movement (up/down and back/forward)
- We would have a secure way of attaching our footrest (to the seat where the original footrest attached to)
- Current footrest locked in same position, could make something similar where the bottom folds back so client is able to reach the ground (this could be hard for the client to fold up w limited mobility in legs)



- [3]
- How the existing footrest attaches to the wheelchair seat
- Could create a new component to replate (8B) above, component would be able to fold upwards/to the side to make room for the client to reach the ground
    - Could it be difficult for client to get his feet onto the footrest + would it be difficult for client to fold footrest out of the way

- Other option: footrest attaches to the casters
    - Less stable
    - Easier for client to get his feet onto the footrest

Attaching the footrest to chair

- The pros of attaching the footrest to the chair are that when the client moves the chair up/down or tilts the chair, the footrest will move with the seat. This would mean that the clients feet would always be supported no matter the position of the chair. Additionally, there is more support when attaching the footrest to the chair, as it is much larger and more stable than the castors. Another pro is that we could use the mechanism that attaches the current footrest to attach our new design.

Attaching footrest to castors

- Pros of attaching the footrest to the castors is that it would be easier for our client to get his feet onto the footrest because he could us the up/down movement of the wheelchair seat to get his feet onto the footrest. However, this also means that his feet might not be supported if he

moved his wheelchair up too far or tilted it back too far.

Conclusions/action items:

I have obtained measurements of the wheelchair and the wheelchair base. There are two options to attach the footrest to the wheelchair, to attach the castors or to attach to the seat of the wheelchair. There are pros and cons to each route so we will have to discuss as a group which direction we will move forward with. The next steps of the process involve brainstorming different design ideas and choosing a preliminary design to move forward with.

References:

[1] https://www.sunrisemedical.com/power-wheelchairs/quickie/mid-wheel-drive/q700-m

[2] https://www.southwestmedical.com/replacement-parts/sunrise-medical/quickie-q700-m-series/ergo-legrest/power-center-actuator-kits

[3] https://www.southwestmedical.com/replacement-parts/sunrise-medical/quickie-q700-m-series/sedeo-lite-legrest/power-center-mount-mechanical-ext-elr-parts

[4] https://www.sunrisemedical.lat/getattachment/9dd6da3d-3162-4584-8493-11ff33a6aaae/.aspx

9/14/2023- Types of Competing Designs

Gracie Hastreiter - Oct 11, 2023, 12:55 PM CDT

Title: Types of Competing Designs

Date: 9/14/2023

Content by: Gracie

Present: Gracie

Goals: The goal is to research footrests that are currently on the market and determine the pros and cons of various types of footrests. The goal is to also determine what type of footrest would be the best for our client's specific needs.

Content:

- Current wheelchair footrest designs keep the users feet mostly fixed in place, which is ideal if someone is looking for complete support for their legs. Our client wishes to use move his legs because he often uses his legs to help him open doors. Additionally, our client wishes to be able to reach the ground with his feet and many existing footrests prevent this motion as well.

Two Piece vs One Piece

[1]

Two piece footrest- this footrest allows: feet can move with footrest in and upward/downward motion, 11 different footrest postions

- this is an example of a footrest that moves with leg movement, but only allows up and down leg movement. Our client wishes to use his legs to open doors or reach the ground, so this type footrest would not be useful.

- the two separate pieces could be a useful design, as our client could move one piece out of the way to have one foot on the ground while the other is still supported.

This is an example of a one piece footrest

- pros of this footres: removable from the wheelchair

- removability is ideal for our client, however it seems he would have to transfer off of his wheelchair in order to remove this type of footrest, so this would not be a useful footrest for our client.

Articulated and Elevated leg rests [2]

- Articulated leg rests: allow more freedom of movement, adjustment in length (not manual), can extent your legs with feet still in the footrest, movement only up and down
    - Keep feet in place, would be difficult to move legs as they are quite secured into the position of the footrest
- Elevated leg rests: if the user needs to keep their leg straight if it cannot be bent
    - Keep legs very stabilized, not much room for movement

- For our client's specific needs, we will be leaning more towards an articulated leg rest, as it allows for more freedom of leg movement, which is very important for our client

Ideas for our design:

- Two piece footrests, allow one piece to be removed at a time, which would allow our client to have one foot on the ground while the other is still supported. Additionally, a two piece footrest would be easier to store on the wheelchair, as they are smaller and less bulky.

- Elevated and articulated foot rests (articulated foot rests are more what we are looking for for our client, allow more up and down leg movement)

Conclusions/action items:

Through my research, I have concluded that a two piece footrest would be ideal for our client. Two piece footrests are generally smaller than one piece footrests, which would make them easier to store on the wheelchair. Additionally, I think an articulated foot rest would be a better type of footrest to aim to create for our design because they allow more freedom of movement.

References:

[1] https://www.lohmedical.com/p/quickie-2-wheelchair/

[2] https://www.passionatepeople.invacare.eu.com/wheelchair-legrest/#:~:text=There%20are%20two%20types%20of,increase%20circulation%20to%20prevent%20swelling.

9/14/2023- Drive Elevating Legrest

Gracie Hastreiter - Oct 11, 2023, 12:55 PM CDT

Title: Drive Elevating Legrest

Date: 9/14/2023

Content by: Gracie

Present: Gracie

Goals: The goal is to research competing wheelchair footrests on the market to see what components we might want to include in our designs and also what features we might want to avoid when creating our designs. I will be researching the Drive Elevating Legrest for Drive Power Wheelchair.

Content:

Drive Elevating Legrest for drive Power Wheelchair

- Elevating legrest (moves up/down with the client's feet)
- Swing away (swing footrests to the sides when getting on wheelchair and swing them back to the middle once on the wheelchair)
- Clips onto the seat of the wheelchair
- For drive Power Wheelchair
- Calf supports

Pros of this design:

- The footrests are able to swing away, which would allow our client to reach the ground and use his feet to move doors, ect.
- The design has calf supports
- The footplate of this design is quite small, easy to store

Cons of this design:

- There wouldn't be a place to clip the footrests onto our client's wheelchair
- The footrests would attach to the seat of the wheelchair and not the base (base is preferred by our client)
- When the footrests swing away they could be bulky on the side of the wheelchair or bump into things

Conclusions/action items:

There were many components of this design that we can pull inspiration from when creating our own designs, such as the swing away component and the calf supports. The swing away design of this footrest could be very useful for the our design, however we would have to find somewhere to

attach the footrest to on the base of the wheelchair opposed to the wheelchair seat. I also think the calf supports would be a good idea to carry over into our designs.

References:

[1] https://www.carewell.com/product/drive-elevating-legrest-for-drive-power-wheelchair/

9/14/2023- Removable Padded Foot Plate

Gracie Hastreiter - Oct 11, 2023, 1:52 PM CDT

Title: Removable Padded Foot Plate

Date: 9/14/2023

Content by: Gracie

Present: Gracie

Goals: The goal is to research other footrest options that are currently on the market and determine their pros and cons. The goal is also to see how we can make a design that differs from existing design that will be more useful to our client than what he currently uses.

Content:

ɹmfort

- Connects to any footrest with velcro (easily attached and removed)
- Removable
- Sides curve up to prevent foot from sliding off the footrest
- Constructed out of plastics and foam

Pros of this design:

- The footrest is removable
- Attaches easily to an existing footrest (velcro around the bottom of an existing footrest)
- Curved sides to prevent foot movement
- Lightweight design means our client could easily transport the footrest as well as put it on/take it off easily while still on the wheelchair

Cons of this design:

- We would have to create a device that the foot plate would attach to because there currently is not a footrest on our client's wheelchair
- One piece (opposed to a two piece design) limits the client's leg mobility, our client would have to completely remove the device to reach the ground

Conclusions/action items:

In conclusion, I think we can take away many ideas from this design including the top layer of foam for comfort and the curved sides to prevent the feet from falling off the footrest. From this design, we can also get an idea of how a one piece footrest could

potentially attach to the wheelchair.

References:

[1] https://www.sportaid.com/removable-padded-foot-plate-by-wheel-comfort.html

10/5/2023- Footplate Materials Research

Gracie Hastreiter - Dec 11, 2023, 7:55 PM CST

Title: Materials Research for Footplate

Date: 10/5/2023

Content by: Gracie

Present: N/A

Goals: The goal is to find materials that we can fabricate the footplate component of our design out of. It is important to keep in mind that our footrest must weigh less than 4lbs, so the material should be relatively lightweight. Additionally, we have a budget of 100 dollars, so the material must also be cost effective.

Content:

Materials should have the qualities:

- Lightweight material (footrest must weigh under 4 lbs)
- Inexpensive (100 dollar budget, also take into account we many have to make more than two if we have to alter the design)
- Able to withstand outdoor conditions/ weather conditions
- Easy to fabricate with

[1]:

Lightweight metals: Aluminum, Titanium, and Magnesium:

Titanium:

- 4.51g/cm^3, can resist very high temperatures, resists corrosion
- Commonly used in aerospace components because of its lightweight but durable qualities

Aluminum:

- 2.70 g/cm^3, less expensive than titanium and magnesium, resists corrosion
- High machinability and weldability
- Often used consumer products and architectural elements

Magnesium:

- More expensive than aluminum, less expensive than titanium
- Vulnerable to corrosion
- Lighter than aluminum and titanium, 1.74g/cm^3
- Dangerous to work with (magnesium dust is highly combustible)

[2]:

Aluminum properties:

- Aluminum can be a useful building material due to the following properties
    - High strength to weight ratio (lightweight but durable)
    - Ease in fabrication and assembly
    - Low handling costs (cost effective, easy to come by)
    - Corrosion resistance
    - Easy to maintain

Conclusions/action items: In conclusion, we should move forward with aluminum our material for the footplate portion of our design. Aluminum is ideal for this project because it is a very strong material, while relatively lightweight for a metal. This is essential for this project because the footrest must weigh under 4 lbs and be able to support the force of our clients legs. Aluminum is also easy to fabricate with, which is another advantage of this material. Additionally, aluminum resists corrosion and is easy to maintain. This is essential for our product because our product will be outside and will experience weather conditions of rain and snow so it is essential that the material will be able to withstand these conditions.

References:

[1] **https://www.china-machining.com/blog/lightweight-metals/#:~:text=While%20many%20plastics%20are%20available,aluminum%2C%20titanium%2C%20and%20magnesium.**

[2] **https://theconstructor.org/building/properties-aluminium-building-material/12789/**

10/12/2023- Castor Cap Material Research

Gracie Hastreiter - Dec 11, 2023, 8:45 PM CST

Title: Materials Research for Castor Cap

Date: 10/12/2023

Content by: Gracie

Present: N/A

Goals: The goal is to research materials that we could use to create the castor cap portion of our design. The castor cap will be 3D printed, so I will be looking into materials that can be printed. I am looking for a sturdy, lightweight material that is cost effective, as we will most likely be printing multiple versions of the cap.

Content:

[1]:

PLA:

- Commonly used when creating concept models
- Does not have high tensile strength
- Not recommended for functional and mechanical parts
- Loses properties over time
- Easy to print

Tough PLA:

- As easy to print as PLA
- Higher tensile strength than PLA
- Often used for functional prototyping
- Temperature resistance to 60 degrees celsius
- Increased impact resistance than PLA
- More expensive than PLA

PETG:

- Often used in industrial environments and functional prototypes
- Greater toughness and wear resistance compared to PLA
- Higher temperature resistance than PLA (76 degrees celsius)
- More expensive than tough PLA

ABS:

- Often used for objects that require toughness and durability
- Often used for prototyping
- Higher temperature resistance than PETG (85 degrees celsius)
- Affected by UV light

Conclusions/action items: I think the team should move forward with tough PLA or PETG as material for the castor cap. I think PLA could be useful for very early prototypes, because it is less expensive than the other materials. I think we should first print a cap with PLA to ensure the cap fits correctly and the dimensions are correct. For the final prototype, however, I think we should use a more sturdy, long lasting material such as tough PLA/PETG. These materials will be able to withstand more force, therefore better supporting the footplate. Although ABS is more durable than the other materials, it is also affected by UV light. Our prototype will be outdoors, so this will not be a practical material for this project.

References:

[1] https://support.makerbot.com/s/article/1667337612208#:~:text=Tough%20PLA%20combines%20the%20ease,have%20a%20more%20matte%20appearance.

11/1/2023- Materials Research for Attachment Device

Title: Materials Research for Attachment Device

Date: 11/1/2023

Content by: Gracie

Present: N/A

Goals: The goal is to research materials that can act as an attachment device in our design. The attachment device portion of our design connects the footplate to the ca

Content:

[1] 30N/7 lb Gas Support Cabinet Door Hinge Safety Lift Support, Gas Shock, Lid Support, Soft Close Support and Cushioning Retractable Cabinet Door Rubber Head G Length (2 Pack)

- $9.99 for two
- Dimensions: 3.9 x 0.8 x 0.3 inches
- Material: Nylon, Stainless Steel
- Load Bearing: 3-4 kg
- Extendable length: 0-63mm
- Total Length (Approx.): 213mm/8.38"
- Hydraulic support, automatic expansion
- 6.3 ounces

Pros of this device:

- Can be used for extra support underneath the footplate
- Relatively lightweight, will add support while not adding much weight (footrest must be under 4 lbs)
- Durable, made of stainless steel, can support 3 to 4 kg

[2] SUUJI 2 pcs Scissors Hinges, Sink Front tip Out Tray Hinges for Kitchen or Drawer Bathroom Cabinet Organizer, Nickel Plated Steel

- $7.98 for two hinges
- Dimensions: 4.29 x 2.4 x 1.54 inches
- Material: nickel plated steel
- Weight: 6.7 ounces
- Self closing hinge is concealed when front is closed
- Drawer tilt out hardware widely used on face frame or frameless cabinetry

Pros of this device:

- This hinge is very lightweight (footrest needs to be less than 4 lbs)

- The hinge can be used to fold the footplate out of the way to be stored
- Hinge is durable, made of plated steel

[3] MIAO JIN 4Pcs 80 Degrees Scissor Hinges Tip Out Tray Hinges for Kitchen Sink-Front Drawer, Folding Sofa or Bathroom Cabinet Organizer Nickel Plated Steel Sprin

- $15.99 for 4 hinges
- Dimensions: 7.1 x 4.3 x 1.6 inches
- Materials: Nickel
- Weight: 1.17 pounds
- Nickel plated surface, with durability and corrosion resistance, no rust
- 80 degrees opening angle

Pros of this hinge:

- Durable, made of nickel
- Corrosion resistance which is helpful as the prototype will be used outside and have to withstand weather conditions of rain/snow
- The 80 degree opening angle allows the footplate to swing out of the way to be stored on the wheelchair.

Conclusions/action items: Either hinge could work as the attachment device portion of our design. The hinges would allow the footplate to swing to the side, allowing th ground. Additionally, the Gas Support Cabinet Door Hinge could be used underneath the footplate to provide extra support to the footrest.

References:

[1] https://www.amazon.com/Gas-Support-Retractable-Spring-Length/dp/B09ZQTQV2Q/ref=sxin_14_pa_sp_search_thematic_sspa?content-id=amzn1.sym.9e5 b834-24761033aedf%3Aamzn1.sym.9e5188ef-9cc8-48bb-b834-24761033aedf&crid=2J9ZCCN54JIS7&cv_ct_cx=scissor%2Bhinge%2Bmechanism&keywords=scissor%2Bhinge%2Bmechanism&pd_rd_i=B09ZQTQV2Q&pd_ 49e6-a313-7eb0abd1ca69&pd_rd_w=ue6No&pd_rd_wg=FLFBT&pf_rd_p=9e5188ef-9cc8-48bb-b834-24761033aedf&pf_rd_r=9D1JBFWY80KSEX0W7TCS&qid=1702352488&s=hi&sbo=RZvfv%2F%2FHxDF%2BO5021pAnSA%3D%3D&sprefix=scissor%2Bhing%2 3-364cf978-ce2a-480a-9bb0-bdb96faa0f61-spons&sp_csd=d2lkZ2V0TmFtZT1zcF9zZWFyY2hfdGhlbWF0aWM&th=1

[2] https://www.amazon.com/SUUJI-Scissors-Kitchen-Bathroom-Organizer/dp/B0B19QRD3T/ref=sr_1_6?crid=2J9ZCCN54JIS7&keywords=scissor+hinge+mechanism&qid=1702353004&s=hi&sprefix=scissor+hing%2Ctools%2C157&sr=1-6

[3] https://www.amazon.com/dp/B0CC8RHQN1/ref=sspa_dk_detail_0?pd_rd_i=B0CC8RHQN1&pd_rd_w=pVjAA&content-id=amzn1.sym.eb7c1ac5-7c51-4df5-b ca810f1f119a&pf_rd_p=eb7c1ac5-7c51-4df5-ba34-ca810f1f119a&pf_rd_r=8W8R1G3KYCQ12PW5XS9Q&pd_rd_wg=nk5C0&pd_rd_r=01fcdbdd-5d7f-44bd-a77d-31deae8dd027&s=hi&sp_csd=d2lkZ2V0TmFtZT1zcF9kZXRhaWw&th=1

11/9/2023- Materials Research for Hinges

Title: Materials Research for Hinges

Date: 11/9/2023

Content by: Gracie

Present: N/A

Goals: The goal is to find a hinge to act as the attachment device mechanism portion of our design. This hinge will attach the footplate to the castor cap and be used to fo position to the folded down position. I am looking for a hinge that locks at 90 degrees so when the footplate is folded down it sits parallel to the ground.

Content:

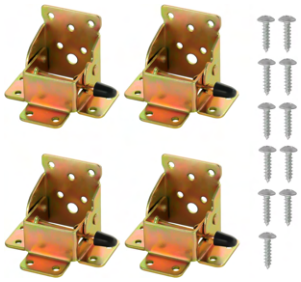
[1] Suiwotin 4pcs Folding Hinge Bracket, Self Locking Hinges 90 Degree Foldable Table Bracket, Heavy Duty Leg Fittings Angle Braces for Folding Table, Workbench, Be

- $15.99 for 4 hinges ($4 a piece)
- Folded Size: 2.4" x 1.8" x 2.6"
- 0.74 Kg (1.63 lbs)
- Material: iron
- Made of zinc plated iron, the folding table bracket is rustproof, high-strength, colorfast and durable. The load bearing is up to 265 lbs
- Designed with 0-90 degree adjustable self locking bracket

Pros of these hinges:

- these hinges lock at a 90 degree angle, which is what we are looking for for our design
- the hinges are very durable and able to withstand up to 265 lbs, which is far above what our footrest needs to support
- Rustproof, which is essential because our prototype will be outdoors and will face weather conditions such as rain/snow

[2] DLUNO Folding Table Legs Brackets 4 PCS, Table Chair Bed Folding Leg Feet Hinge, Kitchen Folding Table Extension Rack Hinge, Ninety Degree Side Brake Foldin



- $20.99 for 4 hinges ($5 per hinge)
- Material: Alloy Steel
- Dimensions: 2.95"L x 2.36"W
- Weight: 1.39 lbs
- When folding the legs, just press the button on the hinge and it will automatically lock to ensure stability
- Ninety-degree side brake folding hinge

Pros of this hinge:

- Locks at 90 degrees, which provides additional stability to the overall footrest
- Hinge is very durable, made of steel
- Easy to fold, press the button on the hinge

[3] Skelang 2-Pack Folding Brackets, Lock Extension Hinge, Foldable Leg Brackets Hardware for Table, Workbench, Platform

- $12.57 for two hinges ($6.25 each)
- Material: Steel
- Dimensions: 2.68"L x 2.48"W
- Weight: 1.01 pounds
- Weight limit: 500 lbs
- Featuring with spring-activated locking function, folding brackets can be locked at 0° or 90° as needed, press the latch to fold or unfold the bracket

Pros of this hinge:

- This hinge locks at 0 and 90 degrees. This would be ideal for our design because the hinge could lock at 0 degrees for the stored position and 90 for used positior
- This hinge is very durable, it can withstand up to 500 lbs
- This hinge is relatively lightweight compared to other hinge options

[4] Berta (2 Pieces) Inset Soft Close Frameless Hinges, 110 degree 6-Ways 3-Cam Adjustment Concealed Kitchen Cabinet Hinges (2 Pieces)

- $8.55 for two hinges ($4.25 for each)
- Dimensions: 6"L x 3"W
- Material: Alloy Steel
- Weight: 0.418 lbs
- Opening angle: 110 Degree
- Quiet, slow close

Pros of this hinge:

- Very lightweight, which is essential for our design because our footrest must weight under 4 lbs
- Slow close could make it easier for the client to move the footplate
- Less expensive relative to other hinges on the market

Conclusions/action items: I think we should move forward with the Skelang 2-Pack Folding Brackets for the attachment device portion of our design. These hinges are lbs. This hinge locks at 0 and 90 degrees. This would be ideal because the idea behind our design is that the footplate would fold upwards 90 degrees to be stored and th position and the used position. Additionally, this hinge is relatively lightweight at 1 pound, which is essential because our prototype must be less than 4 lbs.

References:

[1] https://www.amazon.com/Suiwotin-Folding-Foldable-Fittings-Workbench/dp/B0C6D1PQCB/ref=asc_df_B0C6D1PQCB/?tag=hyprod-20&linkCode=df0&hvadid=673742428744&hvpos=&hvnetw=g&hvrand=14372022098930990130&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&2204745109343&mcid=d7e18a0513fa38e2ac752d85e1a84745&th=1

[2] https://www.amazon.com/dp/B0CGV83NVB/ref=sspa_dk_hqp_detail_aax_0?psc=1&sp_csd=d2lkZ2V0TmFtZT1zcF9ocXBfc2hhcmVk

[3] https://www.amazon.com/dp/B088LXDGM8/ref=sspa_dk_detail_5?pd_rd_i=B088LXDGM8&pd_rd_w=MEC3A&content-id=amzn1.sym.386c274b-4bfe-4421-9 a1a56db557ab&pf_rd_p=386c274b-4bfe-4421-9052-a1a56db557ab&pf_rd_r=V2NNXZVCYNZHGCKVE7DP&pd_rd_wg=wsbjQ&pd_rd_r=1ebc4103-bc27-4d35-b8 835051f6d547&s=hi&sp_csd=d2lkZ2V0TmFtZT1zcF9kZXRhaWxfdGhlbWF0aWM&th=1

[4] https://www.amazon.com/gp/aw/d/B07V87K3MC/?_encoding=UTF8&pd_rd_plhdr=t&aaxitk=a824e1cf070a3ca82bcbe6ec6f7eb27c&hsa_cr_id=447988055040&9e67e56a-6f64-441f-a281-df67fc737124&ref_=sbx_be_s_sparkle_mcd_asin_1_img&pd_rd_w=KJ3v1&content-id=amzn1.sym.417820b0-80f2-4084-adb3-fb61255&80f2-4084-adb3-fb612550f30b&pf_rd_p=417820b0-80f2-4084-adb3-fb612550f30b&pf_rd_r=53HPXKRPX432A0460JG1&pd_rd_wg=7CgsV&pd_rd_r=237b6e8d-d0&f924b8844be2&th=1

9/20/2023- Fold-Up Preliminary Design

Gracie Hastreiter - Sep 22, 2023, 12:58 PM CDT

Title: Fold-Up Preliminary Design

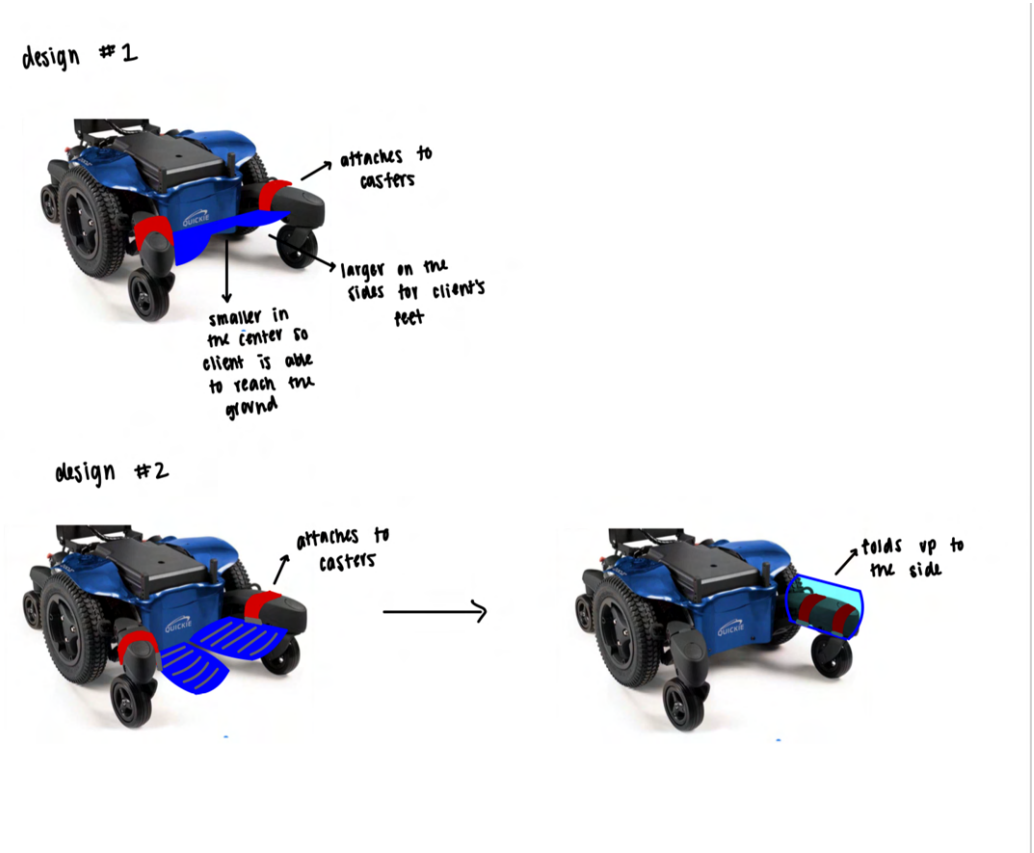
Date: 9/20/23

Content by: Gracie

Present: Gracie

Goals: The goal is to create a preliminary design idea to solve our client's problem, to create a wheelchair footrest that will support our client's feet while also not restricting leg movement or our client's ability to reach the ground.

Content:



The Fold-Up Footrest Preliminary Design (Design #2 above)

This design consists of two separate footrests, one for each foot. The footrests attach to the casters on either side of the wheelchair. The footrests fold to the side so the client is able to reach the ground.

Conclusions/action items: We need to continue to communicate with our client to inspect the wheelchair and assess the strength of the casters and whether will they be able to support the footrests. We also need to discuss with our client if they will be able to fold up the footrest or if mobility restrictions will prevent them from folding up the footrests.

9/20/2023- One Piece Footrest Preliminary Design

Gracie Hastreiter - Oct 11, 2023, 12:20 PM CDT

Title: One Piece Footrest Preliminary Design

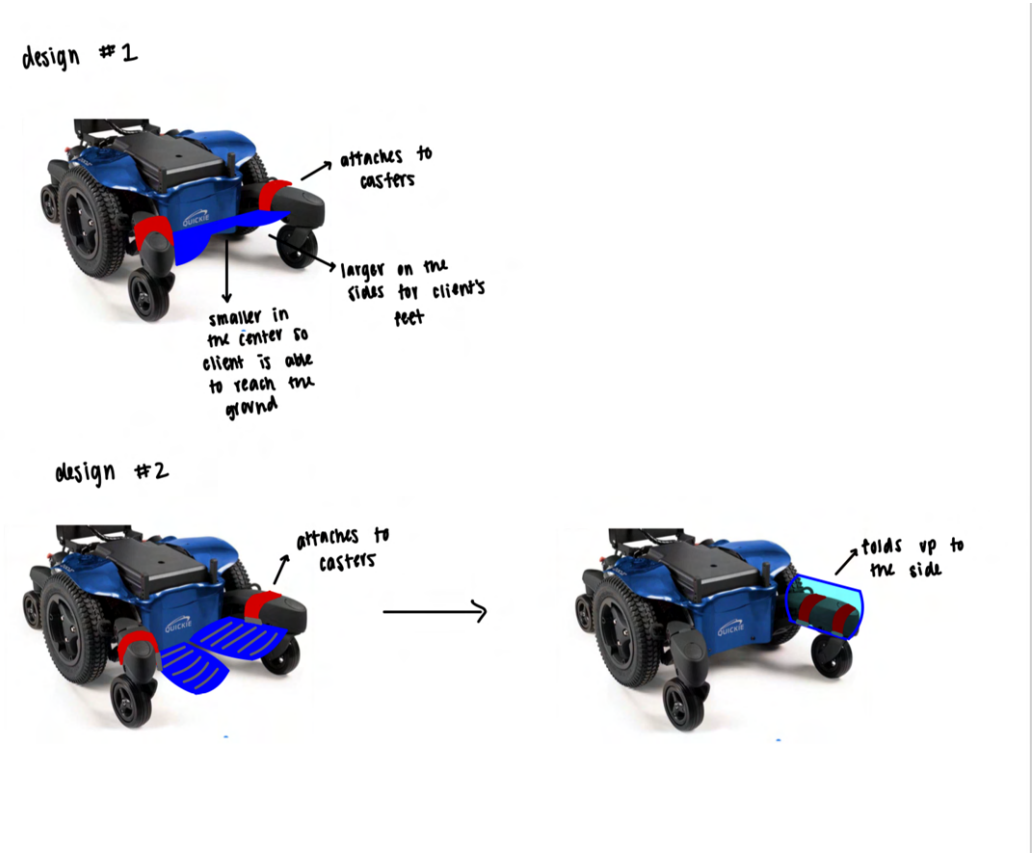
Date: 9/20/23

Content by: Gracie

Present: Gracie

Goals: The goal is to create a preliminary design idea to solve our client's problem, to create a wheelchair footrest that will support our client's feet while also not restricting leg movement or our client's ability to reach the ground.

Content:



One Piece Footrest (Design #1 above)

The one piece footrest design consists of one piece that attaches to the casters and extends between the two casters. The piece is thicker on the sides (near the casters) where he will rest his feet. The piece is also thinner in the center so the client is able to reach the ground with his feet when he needs to. However, we have not been able to meet with the client and assess exactly how much room is available between the casters.

Conclusions/action items: In conclusion, we need to meet with our client and assess his wheelchair in order to move forward with this design with exact measurements. In addition, we need to assess the casters to create a design for how to attach the footrest to the casters.

10/25/23 Hinge Research

AMANDA KOTHE - Oct 25, 2023, 10:44 PM CDT

Title: Hinge Research

Date: 10/25/2023

Content by: Amanda Kothe

Present: N/A

Goals: Learn more about potential hinges we can use for our prototype.

Content:

Ball Bearing Hinge: Heavy duty and durable, the type of hinge helps to reduce friction and make the movement of the hinge smoother.

Barrel Hinge: likely not good for the project as it is not good for load-bearing applications.

Heavy Duty Hinge: Good for higher loads, provide more support and stability.

Piano Hinge: Longer hinge, central pin with same sized leaves that run the length of the hinge.

Strap Hinge: Has long, narrow leaves, which provide more stability for heavy duty applications.

Childers, K. (2023, April 18). *Different hinge types and where to use them*. Family Handyman. https://www.familyhandyman.com/list/different-hinge-types-and-where-to-use-them/

Conclusions/action items:

The best hinges to use are likely a ball bearing hinge, heavy duty hinge, or a strap hinge, however we need to find something that stops at 90 degrees.

11/9/23 90 Degree Hinge Research

AMANDA KOTHE - Nov 09, 2023, 2:14 PM CST

John Puccinelli - Nov 03, 2014, 3:20 PM CST

Title: 90 Degree Hinge Research

Date: 11/9/23

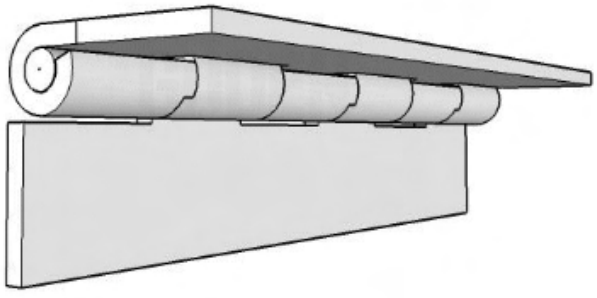
Content by: Amanda

Present: N/A

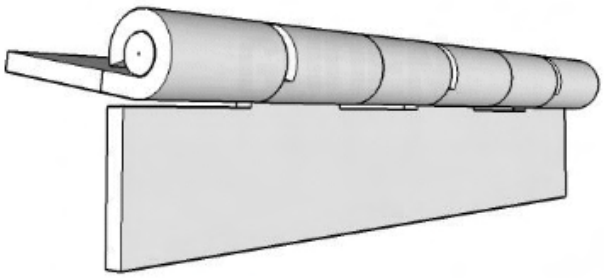
Goals: Learn more about 90 degree hinges

Content:

Many 90 degree hinges work by using interlocking "knuckles" to stop the hinge from rotating.



90° **Outside** Stop Hinge



90° **Outside** Stop Hinge

There are inside or outside stop hinges. However, since 90 degree hinges are hard to find, an alternative option is using Swage and Offset to affect the maximum open angle of the hinge.

Link

Conclusions/action items:

There are a few potential options for our hinge, we just need to find what works best for our project (whether that be finding a 90 degree hinge or using swage and offset to get out hinge to only open to 90 degrees).

9/21/2023- Existing Patents Research

Title: Existing Patents

Date: 9/21/2023

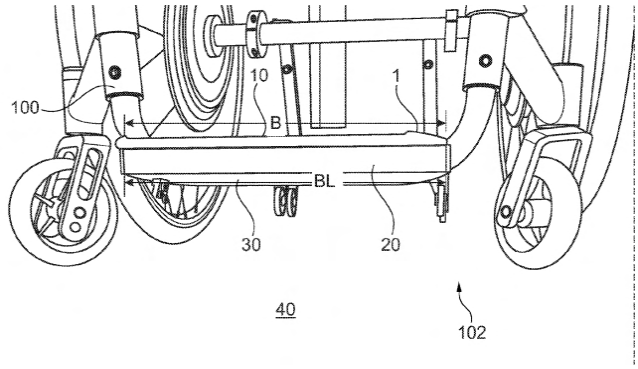
Content by: Amanda Kothe

Present: N/A

Goals: Learn More about existent patent research

Content:

Simple Wheelchair Footrest (Patent N0: US 11,173,082 B2)



This wheelchair footrest has continuous support from two separate foot supports. This footrest also has a light attached to the bottom, which is not necessary for our project.

Electric Force Amplifier: act directly on the wheel hubs and support the user during drive movement.

Features of this wheelchair footrest:

- Continuous foot support
- Light strip beneath the footrest to illuminate the floor area in front of the wheelchair
- Footrest is attached to the base of the wheelchair

Extendable/retractable foot/leg rest for a wheelchair:

Important aspects - externally protruding pivot arms (need safety, weight, and appearance problems)

This patent describes the importance of acknowledging the fact that the length of human legs change when bent at the knee.

This wheelchair footrest uses external pivot arms to help extend their effect on extension and contraction.

This design eliminates the need for pivotal arms.

Other elements of the footrest:

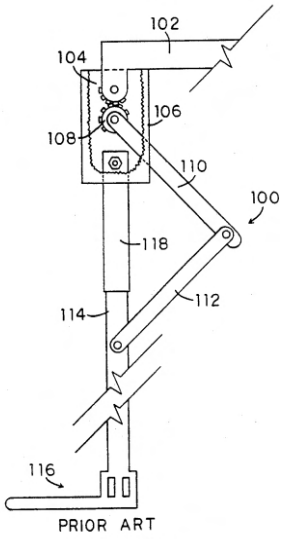


FIG. 1

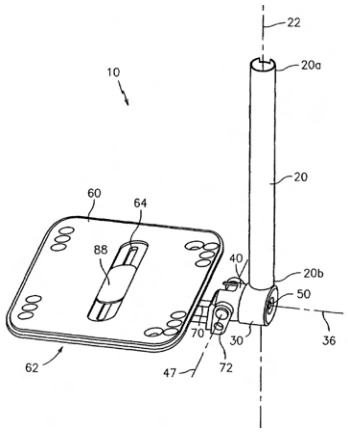
Other elements of the footrest:

- Light
- Dual rack
- Pinion-like assembly

Mount for a wheelchair footrest

The purpose of a wheelchair footrest is to provide support for the feet and have a socket that can attach to the wheelchair.

There is a swivel which allows for rotation with the socket.



The benefit of this wheelchair is that it is able to get out of the way of the user due to the swivel element. You would also be able to give various shapes and sizes of footrests depending on the user. Essentially, the main benefit of this wheelchair footrest is that there is positional adjustment capability.

References

[1] Harris, Vance (2005). Mount for a Wheelchair Footrest. Patent No.US7425010B2. United States Patent and Trademark office. https://patentimages.storage.googleapis.com/0d/85/14/f93fbfc574ad58/US7425010.pdf.

[2] Huprich, Micheal (2018). Wheelchair Footrest. Patent No.US11173082B2. United States Patent and Trademark office. https://patentimages.storage.googleapis.com/1d/1c/b2/3514e889acc461/US11173082.pdf.

[3] Cottle, David (1992). Extendable/retractable foot/leg rest for a wheelchair. Patent No. US5259664A. United States Patent and Trademark office. https://patentimages.storage.googleapis.com/31/97/07/c8286ec70b5c7a/US5259664.pdf.

Conclusions/action items:

There are many different aspects of wheelchair footrests that seem to be the most important to most designers. Those aspects are safety, providing support, the ability for movement, and the ability for the footrest to get out of the way (whether the footrest be retractable or removable). There are also many different customizable options for footrests, such as being able to pivot, adding lights to the bottom of the footrest to make it easier for the user to be able to see, or having the ability to extend and contract with the leg.

The next steps will be to decide which of these features are the most important to our client, and determine which ones to utilize in our project.

9/21/23 Flipping Footrest Design

AMANDA KOTHE - Sep 22, 2023, 12:46 PM CDT

Title: Flipping Footrest Design

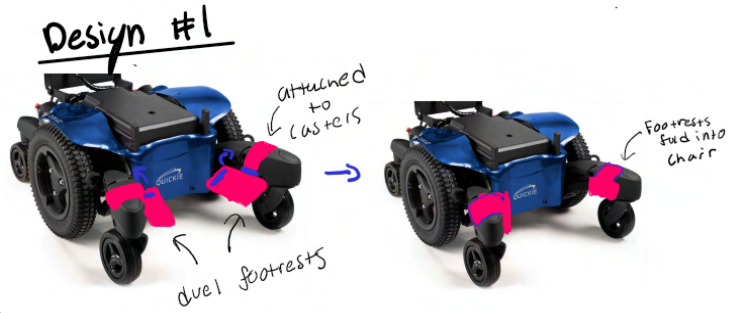
Date: 9/21/2023

Content by: Amanda Kothe

Present: N/A

Goals: Come up with 3 Initial Design ideas to present to the team.

Content:



This design would feature 2 individual footrests attached to the casters of the wheelchair which could flip up and to the side out of the way of the wheelchair. It would also feature backing to the footrests for comfort of the client.

Conclusions/action items:

Significant Features:

- Attach to casters
- Flip up to the side
- Backing for footrests

The next thing to do would be to talk to the client about features he does and does not like in the design idea, as well as his mobility for removing the footrests.

9/21/23 Tray Footrest Design

AMANDA KOTHE - Sep 22, 2023, 12:49 PM CDT

Title: Tray Footrest Design

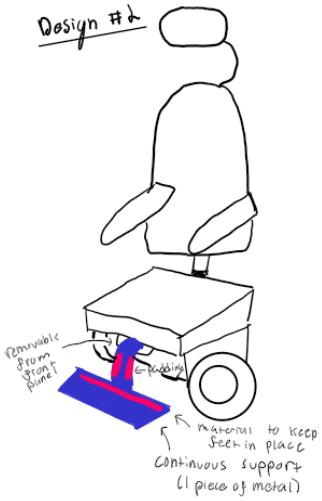
Date: 9/21/2023

Content by: Amanda Kothe

Present: N/A

Goals: Come up with 3 Initial Design ideas to present to the team.

Content:



This design would feature 1 “tray” to be used as a footrest by the client. It would attach to the front of the chair and be able to flip up/back to be out of the way of the client.

Conclusions/action items:

Significant Features:

- Attaches to front of the chair
- Flip up/back
- Fabric/material on back of the footrest to keep feet from sliding

The next thing to do would be to talk to the client about features he does and does not like in the design idea, as well as his mobility for removing the footrests/ and or moving the footrest out of the way.

9/21/23 Car Pedal Footrests

AMANDA KOTHE - Sep 22, 2023, 12:50 PM CDT

Title: Car Pedal Footrests

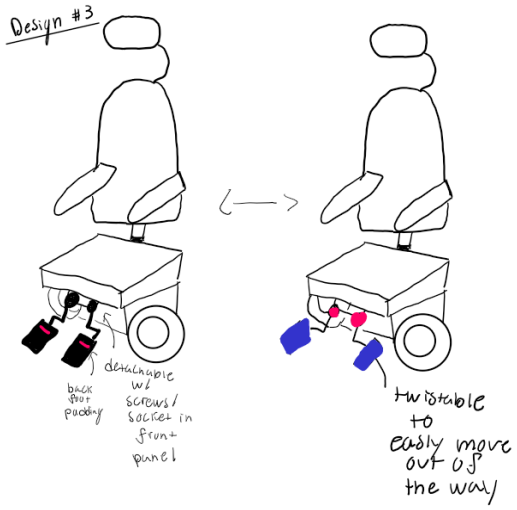
Date: 9/21/2023

Content by: Amanda Kothe

Present: N/A

Goals: Come up with 3 Initial Design ideas to present to the team.

Content:



This design would feature 2 individual footrests attached to the front of the chair. These footrests would be able to flip up and to the side to be out of the way of the client.

Conclusions/action items:

Significant Features:

- Attaches to front of the chair
- Flip to the side
- Fabric/material on back of the footrest to keep feet from sliding

The next thing to do would be to talk to the client about features he does and does not like in the design idea, as well as his mobility for removing the footrests/ and or moving the footrest out of the way.

Design Specifications

This design is built specifically for our client, but there is potential for an expanded customer base for those in wheelchairs with foot mobility. The client's requirements include the footrest having the ability to be stored on the wheelchair itself or be easily removable from the wheelchair, have a combined weight of 3-4 lbs, and the ability to move with the wheelchair. The footrest should have an equivalent lifespan of a typical wheelchair base (4-5 years) [13]. Additionally, the wheelchair should hinder the user’s foot and leg from sliding backwards into the base of the wheelchair to ensure the safety and comfort of the client. The device should be able to support the force of the clients feet when in use. The footrest must not hinder the user's transfer onto or off of the wheelchair. Finally, the footrests should allow for foot movement from the client when in use, and should not interfere with any leg or foot movement that the client wishes to perform.

Conclusions

Current footrests available to wheelchair users do not allow for users to perform useful movements, such as picking up objects from the floor or opening doors with their feet. The available footrests are also bulky, heavy, and difficult to remove from the wheelchair. Though footrests are important for support of feet and legs when in use, and this function should not be inhibited, these footrests should allow for more mobility of the user. The updated footrests should adapt to the abilities and mobilities of the user, should be easily removable and storable on the wheelchair when not in use, and should be lightweight and less bulky. However, it is imperative that the footrests still provide the main functions and benefits of a typical footrest of a wheelchair when necessary.

The final design consists of two footrest pieces that will connect to the caster wheels on the base of the wheelchair. These two footrests will support one foot each. An attachment device will be used to secure the footrests to the caster wheels. A hinge attached to the attachment device will lock the footrests at 90 degrees, parallel to the ground, when in use. When the footrests are not in use, they will fold up 90 degrees to the side, and will be stored in this position. This will keep the footrests out of the way of the user, but easily accessible on the wheelchair. The team developed three different design ideas, and determined the chosen final design based on weighted scores in various design criteria. These criteria were chosen based on the clients requirements for the device. Thus, the team worked to create a final design that incorporated all the criteria the client desired, and that improved on current wheelchair footrest devices.

If the time were to do this portion of the project again, there would be greater emphasis on design metters where the team members discussed the specifics of each design. This includes the mechanisms for each device's storage, and the mechanism for stability when the device is in use. Additionally, the team would have asked the client questions about his mobility earlier on in the process, making it easier to understand the importance of different aspects of the design, such as the storage of the device.

In the future, the team will need to develop the specifics of the footrest, and fabricate the device. This will include determining a final attachment piece to secure the device to the casters, and determining how to keep the footrest in place when in storage mode. Once the prototype is fabricated, the group will perform various testing procedures to ensure that the device is functioning properly. Once the testing phase is complete, the team will determine if any revisions need to be made to the final design, and then move on to final testing. Once the final testing is complete, any final changes necessary will be made.

11/10/2023 Tong Distinguished Lecture

AMANDA KOTHE - Nov 30, 2023, 3:36 PM CST

Title: Tong Distinguished Lecture

Date: 11/10/2023

Content by: Amanda Kothe

Present: N/A

Goals: Learn about the speaker's experiences in engineering

Content:

- Originally, she planned to become a doctor
- Attended University of Pittsburgh for undergraduate
- Wanted to help people
- Attended UW Madison for grad school and studied biomaterials (worked with microspheres)
- Works for Exact Sciences
- Networking helped her land her first job

Main Points:

- Find your people
- Do the things that scare you
- Laugh until you cry, cry until you laugh
- Everyone is counting on you

Conclusions/action items:

This lecture really helped me learn a lot about the possible twists and turns of jobs in the engineering industry. Her advice was very helpful, and it was nice to hear the perspective of someone currently working in the industry. In the future, I will try to keep her experiences in mind when I am trying to figure out my own journey in engineering.

2023/09/30 - Posture Research

SADIE ROWE - Nov 08, 2023, 11:23 PM CST

Title: Importance of Wheelchair Footrest

Date: 0/30/2023

Content by: Sadie Rowe

Present: N/A

Goals: Understand why proper positioning must be maintained by wheelchair footrests

Content:

Proper leg and foot support is immensely important to the comfort of wheelchair users:

- long-term use of improper foot or leg rests can lead to lower back pain and excess pressure on the user's thighs and buttocks area

- Wheelchair footrests offer posture support and play a significant role in supporting appropriate pelvic and lower limb positioning

Proper posture should complement the natural 'S' shape curve of one's spine:

- 'S' shape is maintained when weight is distributed equally across both hips & both feet are flat on a solid surface [1]

- Footrest support on wheelchairs allows for proper seated positioning -> contributing to an equal distribution of weight below torso, increased blood flow, and eased pressure in legs, hip joints, muscles, and lower back regions [2]

Sources:

[1] J. R. Davis, *Corrosion of Aluminum and Aluminum Alloys*. Materials Park: ASM International, 1999.
[2] Overview of materials for polycarbonate, molded, https://www.matweb.com/search/DataSheet.aspx?MatGUID=84b257896b674f93a39596d00d999d77 (accessed Sept. 20, 2023).

Conclusions/action items: Wheelchair footrests are designed to provide proper foot support for wheelchair users. This support in turn affects spinal and lower limb positioning. Therefore, it is important to design a footrest that allows our client to have increased comfort and usability. The device should allow for the user's legs to be positioned in a way that maintains the natural 'S' curve of the spine.

2023/10/10 - Biology and Physiology

Title: Biology and Physiology

Date: 10/10/2023

Content by: Sadie Rowe

Present: N/A

Goals: Enter section of preliminary report titled: "Biology and Physiology"

Content:

There are many different conditions that require the use of wheelchairs; including quadriplegia, paraplegia, cerebral palsy, and various neuromuscular disorders. All of these conditions res range of motion [3]. The broad goal of this project is to design footrests that are able to adapt to differing levels of mobility in wheelchair users.

Proper leg and foot support is immensely important to the comfort of wheelchair users as long term use of improper foot or leg rests can lead to lower back pain and excess pressu Wheelchair footrests also offer posture support and play a significant role in supporting appropriate pelvic and lower limb positioning. Proper posture should compliment the natural 'S' sh when weight is distributed equally across both hips and both feet are flat on a solid surface [11]. The support of footrests on wheelchairs allows for proper seated positioning which contrib the torso, increased blood flow, and eased pressure in the legs, hip joints, muscles, and lower back regions [12].

[3] "Wheelchair rider injuries: Causes and consequences for wheelchair design and selection ," Google Books, https://books.google.com/books?hl=en&amp%3Blr=&id=878PkR7AEHkC&oi=fnd&pg=PA58&dq=wheelchair&ots=yjd7q5rYzh&sig=lXkqTCztI1CAZGZTUIUWuP2QD7U#v=onep Sept. 8, 2023).

[11] "Why are wheelchair footrests essential for posture?," Passionate People by Invacare, https://www.passionatepeople.invacare.eu.com/wheelchair-footrests-essential-posture/ (accessed

[12] "Guide to good posture," MedlinePlus, https://medlineplus.gov/guidetogoodposture.html (accessed Sept. 20, 2023).

Conclusions/action items: N/A

2023/10/10 - Existing Devices and Current Methods

Title: Existing Devices and Current Methods

Date: 10/10/2023

Content by: Sadie Rowe

Present: N/A

Goals: Enter section of preliminary report titled: " Existing Devices & Current Methods

Content:

While there are many different types of wheelchairs on the market, there are two major categories of foot support. The most common category is a footrest. A wheelchair footrest generally consists of a footrest hanger and footplate. Footrest hangers attach to either side of the seat and are often made of aluminum alloys or other lightweight but durable materials. Additionally, the footrest hanger is often designed to be adjustable in order to accommodate different leg lengths among wheelchair users. The footplate is a small plastic or metal piece fixed at a 90° to the end of the footrest hanger. Footplates are often made to swing-away, in line with the footrest hanger, in order to make transitions in and out of the wheelchair less cumbersome. There are several different types of footplates on the market, including individual standard footplates and rigid wheelchair footrests. Standard footplates consist of two separate components designed to rest both feet separately while rigid wheelchair footrests consist of a single platform designed for both feet to rest beside each other [5]. The other type of foot support available are legrests. Legrests are not as widespread as footrests and are most common on tilting wheelchairs where they are able to move with the chair to provide leg support in both seated and reclining positions. Legrests generally consist of the same components as a footrest with the addition of a calf-support pad perpendicular to the footrest hanger [6]. Due to its additional components, legrests are often heavy and bulky, making them less than ideal for users with limited mobility who require a lightweight design. It is also difficult to set the footplate to a comfortable position when the leg rest is adjusted. [7].

There are many wheelchair footrests and leg rests on the market currently. Both Drive Medical [8] and Invacare Corporation [9] offer traditional wheelchair footrest designs with a removable footrest hanger and footplate. In addition, the Drive Medical model includes a heel strap for increased foot support. The inclusion of a foot strap on footplates adds significant support without the addition of substantial weight and may be ideal for users who reposition often. The footplates for both of these designs are 7” x 6” and swing upwards 90° to create foot space when needed. Both Drive Medical [8] and Invacare Corporations [9] also offer legrest designs which feature calf pads. These calf pads are fixed rigidly on the footrest hanger and may not be adjusted, but the length of the hangers themselves can be altered accordingly. Most wheelchair companies offer a variety of footrests designed specifically for their type of chair, but a majority of designs model closely to the ones described above. Prices for wheelchair foot supports generally start at $40 and range upwards of $300, with some exceptions [10].

Existing designs include large and bulky components which might be difficult for users with mobility issues to attach and remove independently. If a new wheelchair footrest can be designed that allows for a greater accessibility, gives users increased range of motion, and maximized ease of use while still being lightweight and cost effective, wheelchair users would be allowed increased independence in their daily lives.

[5] “Footrest options to support function and mobility,” Tips and advice, Motion Composites, https://www.motioncomposites.com/en_us/community/blog/tips-and-tricks/footrest-options-to-support-function-and-mobility (accessed Sept. 20, 2023).

[6] D. Stewart, “Wheelchair footrests,” Wheelchair Footrest Information, https://mobilitybasics.ca/wheelchairs/footrests (accessed Sept. 20, 2023).

[7] A. for C. Innovation, “Spinal Seating Modules,” Keep the big picture in mind | Agency for Clinical Innovation, https://aci.health.nsw.gov.au/networks/spinal-cord-injury/spinal-seating/module-10/keep-the-big-picture-in-mind (accessed Sept. 30, 2023).

[8] “Swing-away footrests,” Swing-Away Footrests | Accessories | Wheelchairs | Mobility | Products | Drive Medical US Site, https://www.drivemedical.com/us/en/for-use-with/swing-away-footrests/p/1215-1 (accessed Sept. 20, 2023).

[9] “Invacare Corporation - Product Catalog,” Invacare Homecare, http://www.invacare.com/cgi-bin/imhqprd/inv_catalog/prod_cat.jsp (accessed Sep. 20t, 2023).

[10] “Drive Medical Swing Away Footrests,” Vitality Medical. https://www.vitalitymedical.com/wheelchair-swing-away-footrests-stds3j24sf.html (accessed Sept. 20, 2023).

Conclusions/action items: N/A

2023/10/11 - EcoFlex Silicone Research

SADIE ROWE - Nov 17, 2023, 6:26 PM CST

Title: Ecoflex Silicone Research

Date: 2023/10/11

Content by: Sadie Rowe

Present: N/A

Goals: Better Understand how Ecoflex Silicone works and if it might be applicable to our project

Content:

Types of Silicone:

- Ecoflex 00-10
  - Hardness 00-10
  - Cure time: 4 hours
  - Pot life: 30 mins
- Ecoflex 00-20
  - Hardness: 00-20
  - Cure time: 4 hours
  - Pot life: 30 mins
- Ecoflex 00-30
  - Hardness: 00-30
  - Cure time: 4 hours
  - Pot life: 45 mins
- Ecoflex 00-50
  - Hardness: 00-50
  - Cure time: 3 hours
  - Pot life: 18 mins
- Ecoflex 5:
  - Hardness: 5A
  - Cure time: 5 mins
  - Pot life: 1 min
- Ecoflex GEL
  - Hardness: 000-35
  - Cure time: 2 hours
  - Pot life: 15 mins
- Ecoflex GEL 2:
  - Hardness: 000-34
  - Cure time: 50 mins
  - Pot life: 20 mins

How to make a silicone mold (EXL Ecoflex 00-35):

- Parts A and B are mixed 1:2 by weight or volume
- Allow mixture to cure at room temperature and watch for shrinkage
- Add pigment (if needed)
- Pour mixture into mold
- Allow silicone to cure (dependent on type of silicone)
- Remove with release solvent slowly
- NOTE: proportions might need to be adjusted as needed

Source:

[1] “EcoflexTM Series, Super-Soft, addition cure silicone rubbers,” Smooth, https://www.smooth-on.com/product-line/ecoflex/ (accessed Nov. 17, 2023).

Conclusions/action items: The list of silicones above can be referenced when choosing silicone to create the castor insert mold for our device. According to the specs listed above, it seems that Ecoflex 00-30 might be the best for our needs in this project.

2023/11/08 - Hinge Research

SADIE ROWE - Nov 08, 2023, 11:47 PM CST

Title: Hinge Research

Date: 2023/11/08

Content by: Sadie Rowe

Present: N/A

Goals: Find possible hinges or attachment mechanisms that can be used to attach footplates and will stop at 90 degrees.

Content:

90-degree heavy-duty soft-down mechanism:

- Designed for writing desks.

- Securely latches a flap closed and holds in a fully opened position (90 degrees)

- Left and right-handed

- Manufacturer: Sugatsune

- Torque Moment is calculated by multiplying 1/2 of the door height by the door weight

- $27.20

- Link

90 Degree Self-locking Folding Hinge:

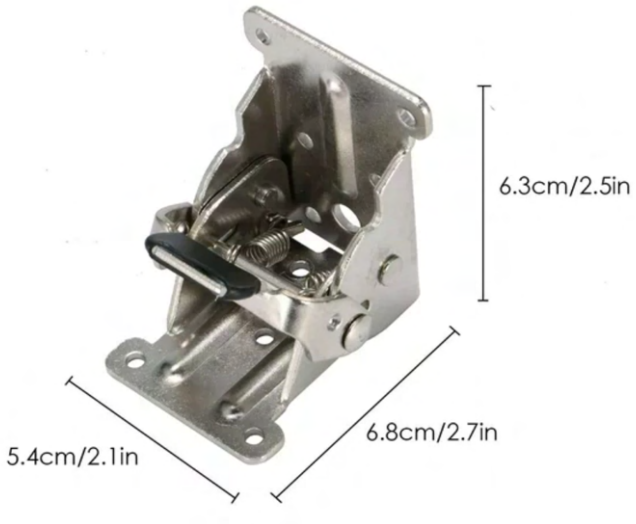
- Hinge is made of galvanized metal

- Brackets have a spring-activated self-lock function that can be fixed in the open position.

- Large bearing capacity

- $10.50

- Link



Locking 90-degree hinge with spring auto-closing

- Thickened manganese steel material

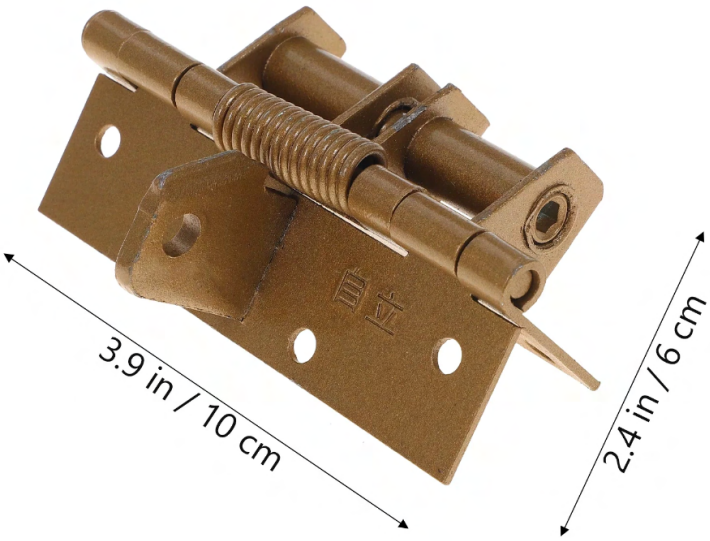
- Manufacturer: FRCOLOR (part #:23hao15710236)

- Large bearing capacity

- Long Service Life

- $10.79

- Link



Conclusions/action items: Each hinge or attachment device may be used to connect the foot plate for the castor wheel covers. It is important to consider the spring and locking mechanisms in each design to ensure the footplates will be held securely in an upright position when not in use.

2023/09/20- Wheelchair Footrest Background

SADIE ROWE - Oct 11, 2023, 10:21 PM CDT

Title: Wheelchair Footrest Background Research

Date: 09/20/2023

Content by: Sadie Rowe

Present: N/A

Goals: Better understand the importance of having footrests on a wheelchair and learn about the different types of footrests currently available on the market.

Links: [1] https://mobilitybasics.ca/wheelchairs/footrests & [2] https://wheelchaired.com/wheelchair-footrest-guide

Content:

Importance of foot support on a wheelchair:

- Proper leg and foot support is important to the comfort of wheelchair users
- Long term use of improper footrests/legrests can lead to lower back pain and excess pressure on the buttocks or lower thigh area

Important Factors to consider:

- Premium comfort is determined by good posture
  - Good posture means an equal distribution of weight across both hips, feet spread across a flat solid surface
  - 90 degree angle between Femur & Tibia
  - Once properly seated -> equal distribution of weight below torse: promoted blood flow & eases pressure in legs, hips joints, muscles, and lower back regions
  -

Types of Wheelchair footrests:

- 2-3 types of foot support
  - Footrest: footrest hanger & footplate to rest foot
  - Leg Rest: includes calf pad mounted on elevated hanger to support lower leg
- Footrests:
  - Usually removable & swing away to the side to ease transfer process
  - Adults usually have a choice of 70° or 60° hangers to keep bottom of footrest clear of casters
- Legrests:
  - Not as common on normal wheelchairs but often standard on reclining & tilting wheelchairs for extra support
  - Cons:
    - Often heavy
    - Difficult to set the footplate position to be comfortable in all positions
    - Footplate adjustment needs to be longer when the leg is extended than when bent in seated position (makes it difficult to achieve right length)
  - Articulating Legrests: solve issue of footplate length when elevation of seat is changed
    - Often found in power wheelchairs
    - Designed to allow freedom of movement

- Fixed front end wheelchairs:
    - Angle adjustable footboard mounted directly to front of the wheelchair frame
    - Lightweight
    - Most common in sports wheelchairs or ones built for performance

Footplate options:

- Standard footplates
    - Aluminum or plastic composite material
    - Set to 90° to downtube of footrest hanger
- Angle adjustable footplates
    - Usually aluminum
    - Generally longer and support more of the foot than standard footplates
- Footboards
    - Provide larger full width platform for the feet to rest on
    - Will be same angle as footplates they are attached to

Refrences:

[1] D. Stewart, “Wheelchair footrests,” Wheelchair Footrest Information, https://mobilitybasics.ca/wheelchairs/footrests (accessed Sept. 20, 2023).

[2] J. Conner, “How to choose the right footrest for your wheelchair,” Wheelchaired, https://wheelchaired.com/wheelchair-footrest-guide/ (accessed Sept. 11, 2023).

Conclusions/action items: Achieving proper leg and foot support in a wheelchair is vital to the comfort of users and proper posture must be maintained. When considering different footrest options on the market, there are two main varieties. Footrests offer limited support and are often smaller while leg rests offer substantially more support but tend to be heavier and more expensive options.

2023/09/20- Competing Designs

SADIE ROWE - Oct 11, 2023, 10:16 PM CDT

Title: Competing Wheelchair Footrest Designs

Date: 9/20/2023

Content by: Sadie Rowe

Present: N/A

Goals: Get a better understanding of the current market alternatives for wheelchair footrests and how the existing designs could be improved.

Content:

Competing Designs:

- **Drive Medical STDS3J24SF Swing-Away Footrests [1]**
  - **Link**
  - Designed for reclining wheelchairs
  - Made of durable plastic
  - Easy to install
  - Heel strap
  - No dimensions provided
  - Swing-Away feature
  - $46 for pair
  - 

- **Invacare Footrest Assembly (FR411PL/PR) [2]**
  - **Link**
  - Complete footrest assembly to fit most Invacare wheelchair swing away footrests.
  - Top latching w/ 3 ⅛ pin spacing
  - No heel strap
  - 7” Wide x 6”
  - Deep Black Compositie footplate
  - $67 for pair
  - 

- **Invacare Hemi Elevating Leg Rests w/ padded calf (T94HAP) [2]**
  - **Link**
  - Removable
  - No dimensions provided
  - $75 for pair
  - Calf pads provide additional support
    - Made of thick padded foam w/ a high resistance
    - Aluminum provides clean finish
    - 

- **Comfort Company Calf Protector [3]**
  - Link
  - Calf panel designed to provide additional protection & support lower legs of wheelchair users
  - Soft, breathable material
  - Designed to attach to footrests
  - Easy attachment & removal (velcro)
  - Prevents feet from dragging
  - $54
  - Available in rigid & flexible options
  - 

- **Therafin Ankle Supports (6025XX) [4]**
  - Link
  - Velcro Closures
  - Reinforced black panel & durable finish
  - Hook & loop closure
  - Attaches to footplate w/ footman looks, bold, and nuts, or self-tapping screws
  - Differing sizes depending on ankle circumference
  - $145 for pair

- **Welsoon Wheelchair Foot Sling**
  - Link
  - Designed for “people who do not like the bulky and troublesome traditional wheelchair petals
  - Adjustable straps
  - Sturdy foot strap
    - Woven from umbrella ropes
  - Lightweight alternative
  - Prevent wide pedals from hitting objects & interfering with user independence
  - $16

- **Drive Medical Swing-Away Elevating Leg rests LK3JELR [5]**
  - **Link**
  - Swing-away foot pedals
  - Elevating feature reduces inflammation by promoting blood flow to the lower extremities
  - Non-Skid Footplate
  - Tool-Free assembly
  - Material: Chrome, plastic, nylon
  - Weight: 8.4 pounds (for pair)
  - Non-adjustable calf pad
  - $52 for pair

User Review Trends:

- Generally, footrests with a heel strap seem to be rated more highly
  - Users who purchased footrest without heel straps felt unsteady and experienced their foot slipping from the footplate frequently
- Non-adjustable calf pads tend to cause issues with differing leg lengths among wheelchair users

References:

[1] "Drive Medical Swing Away Footrests," Vitality Medical. https://www.vitalitymedical.com/wheelchair-swing-away-footrests-stds3j24sf.html (accessed Sep. 20, 2023).

[2] "Invacare Corporation - Product Catalog," Invacare Homecare, http://www.invacare.com/cgi-bin/imhqprd/inv_catalog/prod_cat.jsp (accessed Sep. 20, 2023).

[3] "Wheelchair positioning," Quickie Wheelchairs, https://www.quickie-wheelchairs.com/Wheelchair-Positioning/Lower-Exteremity/Comfort-Calf-Protector/27557p (accessed Sept. 20, 2023).

[4] "Wheelchair positioning," Quickie Wheelchairs, https://www.quickie-wheelchairs.com/Wheelchair-Positioning/Lower-Exteremity/Ankle-Supports-Velcro-Closures/45759p (accessed Sept. 20, 2023).

[5] "Swing-away footrests," Swing-Away Footrests | Accessories | Wheelchairs | Mobility | Products | Drive Medical US Site, https://www.drivemedical.com/us/en/for-use-with/swing-away-footrests/p/1215-1 (accessed Sep. 20, 2023).

Conclusions/action items: Many wheelchair footrests on the market fit the description of the client's problem. They include large and bulky components which might be cumbersome for users with mobility issues to attach/remove independently. Footrests with heel straps positioned behind the footplate seem to provide extra support without adding substantial weight to potentially irritating obstacles. Upon research, I was interested to find the wheelchair foot sling and fabric calf support panel, both of which seem to offer a substantially more lightweight alternative while still providing foot and leg support. Additionally, non-skid footplates are a common trend noticed among competing models as the additional grip prevents user's feet from sliding off of the foot plate.

2023/09/29 - Footplate and Materials Research

Title: Sadie Rowe

Date: 9/29/2023

Content by: Sadie Rowe

Present: N/A

Goals: Better understand differing footplate designs for wheelchair footrests and their common material makeups.

Content:

Footplate Design [1]:

Link: https://www.motioncomposites.com/media/contentmanager/content/Guide-des-options-et-accessoires_ENGLISH.pdf

- Rigid Wheelchair Footrests:
  - Tubular open loop (FP12)
  - Tubular with ABS footplate (FP13)
  - Adjustable angle - Aluminum (one-piece) (FP31)
  - Adjustable angle - Carbon fiber w/ rubber inserts (one piece) (FP32)
  - Flip back, adjustable angle - Carbon with rubber inserts (one piece) (FP15)

- Footplates:
  - Standard - Composite (FP01)
    - Solid plate
  - Newton adjustable angle - Aluminum (FP02)
  - Newton adjustable angle - Composite (FP03)
  - Newton adjustable angle - Carbon fiber with rubber inserts (FP04)
  - Newton adjustable angle extra deep - Aluminum (FP05)
  - One piece adjustable angle flip-up (FP06, FP07)
  - One piece auto-folding adjustable angle (FP28, FP29)

Common Footrest Materials

- Composite: a combination of several materials
    - Carbon fiber is often an element in composite materials.

-
    - Carbon Fiber: fibers about 5 to 10 micrometers in diameter
        - Link: https://www.innovativecomposite.com/what-is-carbon-fiber/
        - Composed of mostly carbon atoms
        - Sometimes known as graphite fiber
        - Advantages:
            - High stiffness
            - High tensile strength
            - High strength-to-weight ratio
            - High chemical resistance
            - High-temperature tolerance
            - Low thermal expansion
            - Lightweight, high-strength
        - Disadvantages:
            - Relatively expensive compared to similar fibers
        - Commonly combined with other materials to form a composite
            - Ex: Combined w/ plastic resin to form carbon-fiber-reinforced polymer

    - Aluminum: a silvery-white, lightweight metal
        - Link: https://www.rsc.org/periodic-table/element/13/aluminium
        - Often used as an alloy b/c aluminum itself is not a particularly strong material
            - Lightweight but strong alloys: combined with copper, manganese, magnesium, and silicon
        - Properties:
            - Low Density
            - Soft & malleable
            - High thermal conductivity
            - Excellent corrosion resistance
            - Can be easily cast
            - Non-magnetic
            - Non-sparking

References:

[1] “Footrest options to support function and mobility,” Tips and advice, Motion Composites, https://www.motioncomposites.com/en_us/community/blog/tips-and-tricks/footrest-options-to-support-function-and-mobility (accessed Sep. 20, 2023).

Conclusions/action items: The following research was conducted for the purpose of better understanding a small but very important component of wheelchair footrests. The Rigid Wheelchair footplates shown above offer additional support with a reinforced bar surrounding the footrest, but this additional support adds significant weight to the device. The free-standing floorplate options seem to offer a lightweight alternative but may not be as durable in the long run. Carbon Fiber, Aluminum, and Composite materials are most commonly used for wheelchair footrests due to their lightweight yet strong construction. These varying materials and any alternatives should be explored further and tested during the design process.

2014/10/25 - Footplate Support Research

Title: Footplate Support Research

Date: 10/25/2023

Content by: Sadie Rowe

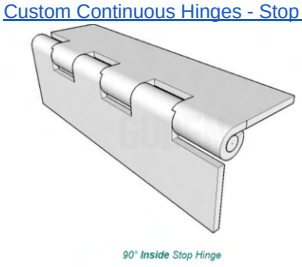
Present: N/A

Goals: Research different kinds of supports that could potentially be used as an additional force holding the client's footplate stable. b

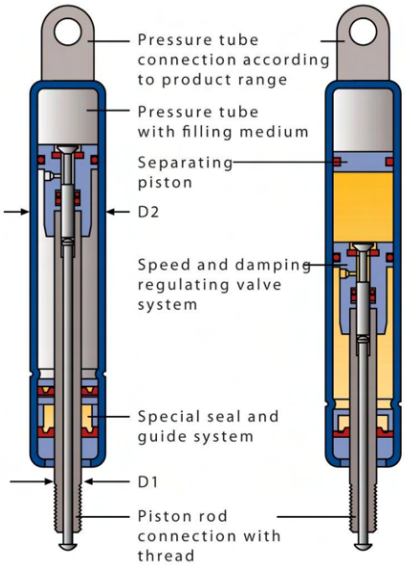
Content:

Support Research for foot pedal

- Folding bracket
  - PRO: Provides necessary support
  - CON: folds downwards or would be in way if set to fold upwards
  - 

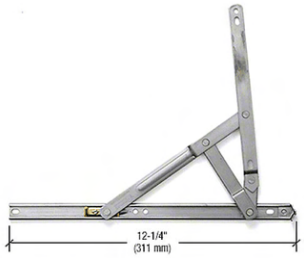
- 90 degree inside stop hinge
  - Stop Hinges are used to limit the rotation of a lid or door by use of interlocking notches in the knuckles
  - 90 degrees when folded outwards.
  - Parallel when folded inwards.
  - Custom Continuous Hinges - Stop Hinges - Guden [1}
  - 

- **Gas Spring:** type of spring that unlike a typical mechanical spring that relies on elastic deformation, uses compressed gas contained within an enclosed cylinder sealed by a sliding piston to pneumatically store potential energy and withstand external force applied to parallel to the direction of the piston shaft
  - Provide direct support for safely lifting, positioning, lowering, and counterbalancing weights
  - Because of the high pressure of the gas inside it, a gas spring can be much more compact than a metal spring that would provide the same amount of force
  - Average life span of 5 years with proper use [2]
  - How does the gas spring work?
    - Filled with pressurized nitrogen gas and oil
    - Completely sealed so nothing can escape
    - Gas allows the spring to store energy while the oil slows and smooths the movement of the piston & provides lubrication
    - The Size of the force a gas spring produces is equal to the area of the piston times the internal pressure
  - Explanation VIDEO



- How gas springs work - Explain that Stuff [3]
- gas_springs_overview.pdf (clarendonsf.com) [4]

- 90 degree four bar hinge
  - Designed for casement window applications and provides 90 degrees of opening
  - Too large?



Sources:

[1] “Custom Hinge Selection Tool,” Guden, https://www.guden.com/customize/continuous-hinges/more-operations/stop-hinges (accessed Oct. 25, 2023).

[2] J. Spring, “Typical lifespan of stainless steel springs: Coil Spring Design,” Typical Lifespan of Stainless Steel Springs | Coil Spring Design, https://www.jamesspring.com/news/how-long-do-springs-last-answers-to-your-questions/#:~:text=They%20normally%20wear%20at%20the%20same%20rate%2C%20and,spring%20life%20of%20about%205%20years%20on%2erage. (accessed Oct. 25, 2023).

[3] Chris Woodford. Last updated: March 19, “How gas springs work,” Explain that Stuff, https://www.explainthatstuff.com/gassprings.html (accessed Oct. 2 2023).

[4] Gas springs general overview-standard - clarendonsf.com, https://www.clarendonsf.com/usercontent/doc/9112/tech_specs.pdf (accessed Oct. 25, 2023)

Conclusions/action items: As suggested by one of our peers, the team has decided that it will be necessary to include an additional support aspect aside from the 90-degree inside stop hinge that will attach our footplate to the caster. After further research, it seems applicable to use a small gas spring underne the footplate in order to provide additional support. Gas Springs are lightweight, compact, relatively cheap, extremely reliable, and can last many years with having to be replaced. In addition to providing support, the Gas Spring may assist the client in lifting the footplate to its full upright position without decrease strain.

2023/09/21 - Removable Sling Footrest

SADIE ROWE - Nov 29, 2023, 11:13 PM CST

Title: Removable Sling Wheelchair Footrest Sketch

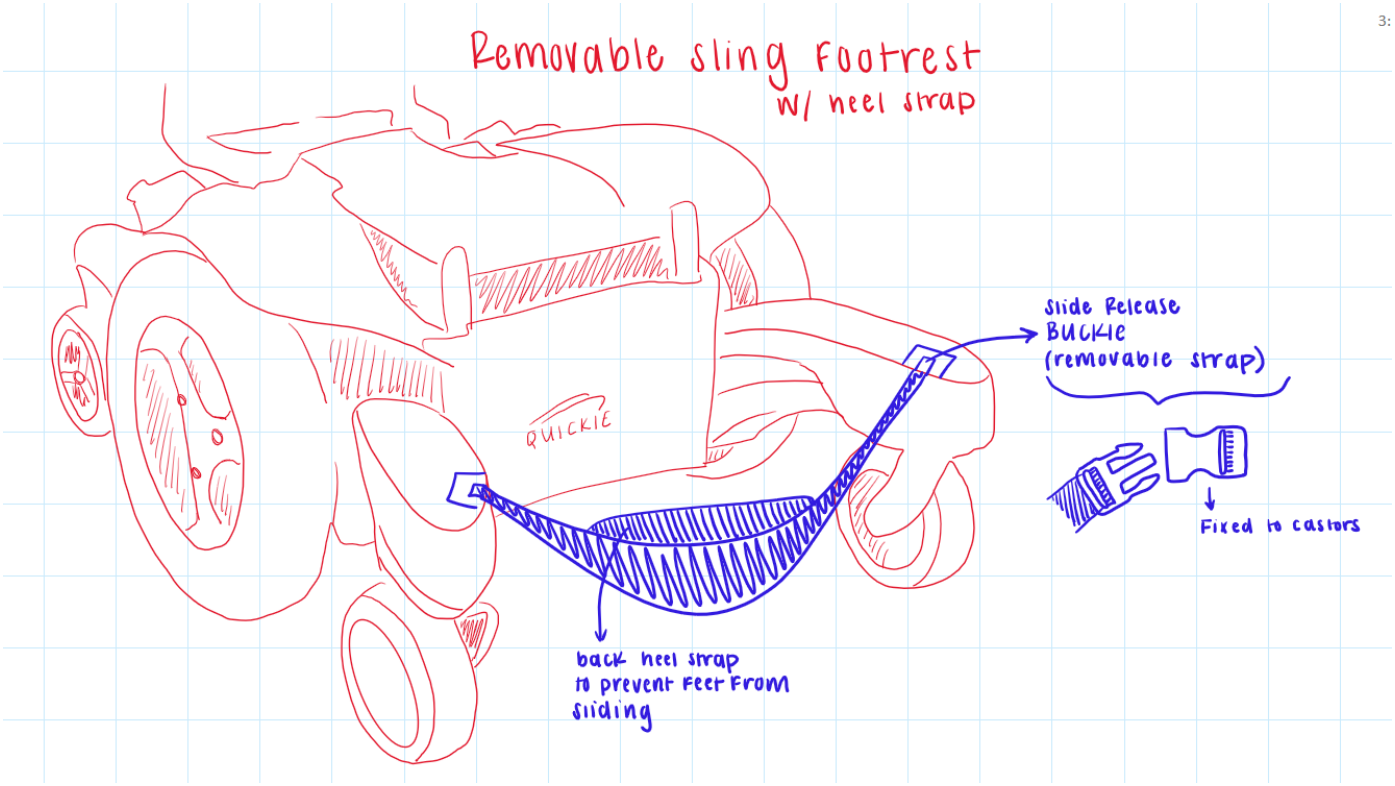
Date: 9/21/23

Content by: Sadie Rowe

Present: N/A

Goals: Create a Preliminary Sketch of a Low-interference wheelchair footrest that meets the client's requests.

Content: Design Sketch #1 (Removable Sling Footrest w/ heel strap)



Conclusions/action items: The design sketched above features a sling footrest attached with buckles on either side of the castors at the base of the wheelchair. The footrest would be made of fabric material, making it lightweight and easy to maneuver. Additionally, the sling would have a fabric backing for heel support to prevent the client's feet from sliding backward into the base of the chair when reclining. A potential concern with this device is due to the footrest not having a fixed position. When the client reclines, their feet may swing back into the base of the chair. This is something that should be looked into. A potential next step is to determine if the client would prefer their feet and legs to be held in a fixed position, or if he would prefer free movement.

2023/09/21 - Classic Swing Away Footrest

SADIE ROWE - Sep 22, 2023, 5:37 PM CDT

Title: Classic Swing-Away Wheelchair Footrest

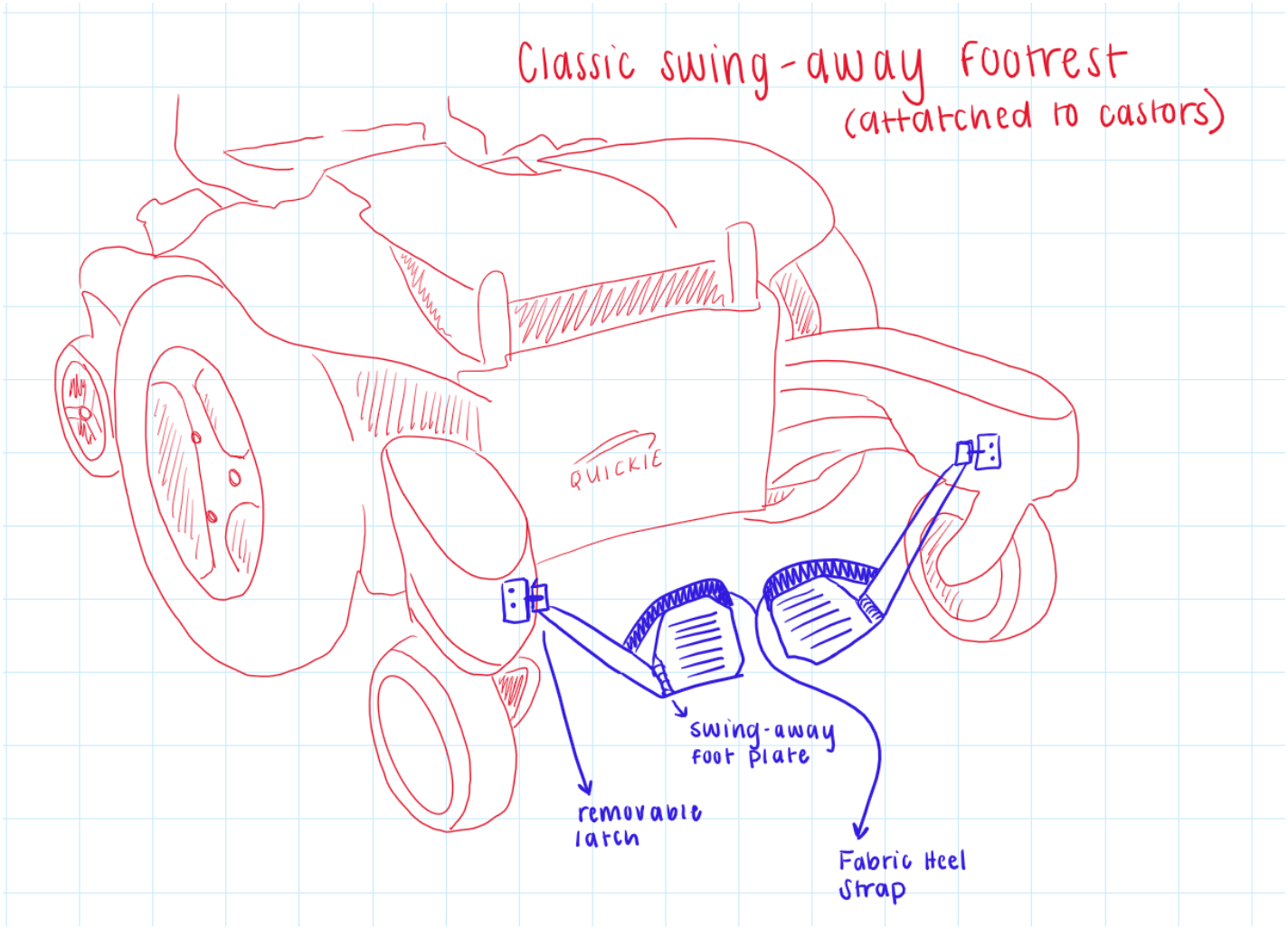
Date: 9/21/23

Content by: Sadie Rowe

Present: N/A

Goals: Create a Preliminary Sketch of a Low-interference wheelchair footrest that meets the client's requests.

Content: Design Sketch #2 (Classic Swing-Away Wheelchair Footrest)



Conclusions/action items: This Design Sketch is modeled closely to traditional wheelchair footrests on the market but with alterations. Unlike alternatives on the market, these footrests are designed to attach the castors on both front wheels. The footrests are able to be latched onto the side of the chair and can be removed if necessary. Additionally, a fabric heel strap on both foot plates, preventing the user's foot from sliding backward. Both footplates on this model are able to swing upwards, moving out of the way, and allowing an easier transition for the client when moving into and out

of the wheelchair. Possible downsides to this design include potentially bulky components which could be difficult for a client with limited mobility to manage.

2023/09/21 - Folding Mesh Footrest

SADIE ROWE - Sep 22, 2023, 6:09 PM CDT

Title: Folding Mesh Wheelchair Footrest

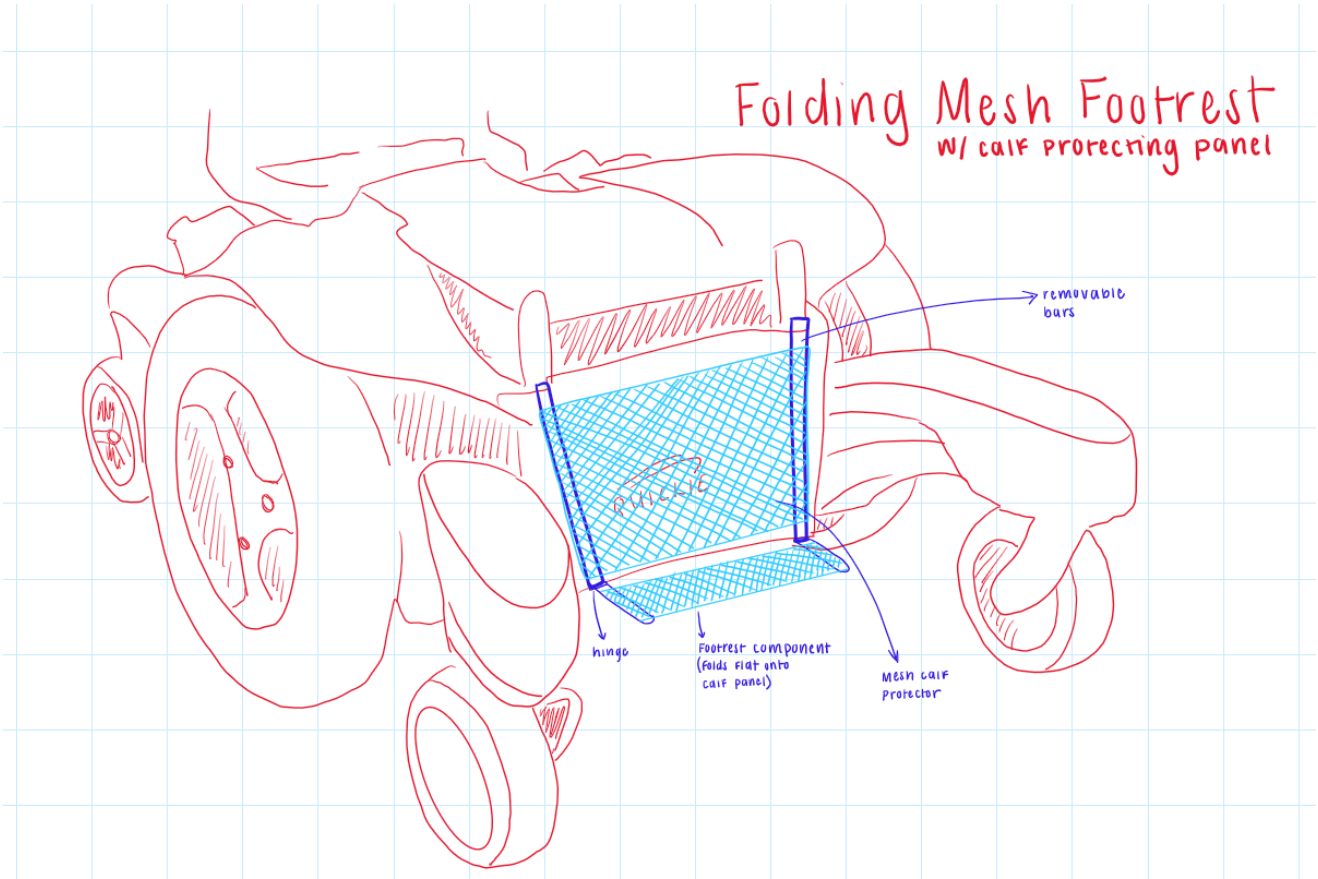
Date: 9/21/23

Content by: Sadie Rowe

Present: N/A

Goals: Create a Preliminary Design sketch of a wheelchair footrest to meet the clients needs.

Content: Design #3 - Folding Mesh Footrest with Calf Protecting Panel



Conclusions/action items: The Folding Mesh Footrest design features two bars fixed to the base of the chair. A fabric strip wraps around each of these bars to create a panel for the user's calves to rest against. At the bottom of the bars, there are two hinges attaching two smaller bars where a thin strip of fabric is designed to attach for the foot support component. The smaller bottom strip folds 90 degrees inward so that it may lie flat against the calf panel and out of the way when not needed. All fabric panels can be easily removed and washed if necessary. This design offers a lightweight but supportive alternative to the traditional wheelchair footrest.

2023/11/10 - Testing Plans Outline

Title: Testing Plans Outline

Date: 11/10/2023

Content by: Sadie Rowe

Present: N/A

Goals: Insert Testing Plans Outline (in progress)

Content:

Testing Plans

Team Name: Wheelies
Team Members:
Project Name: Low-Interference Wheelchair Footrest

Testing Detail:

1. Name of testing protocol/portion of prototype: Ground Clearance

Date to be completed: 12/5/23

Team Members testing: TBD

Detailed Steps of testing:
The device will be tested on different terrain conditions to ensure ground clearance of each individual footrest. Terrain conditions will include tile flooring, carpeting flooring, concrete, and grass/dirt. Measurements will be largely qualitative, taking note of the interaction between the footplates and both the castors and the ground. A scale from 1-10 will be used to quantify how well footplates are able to avoid interaction with the ground, with 10 meaning there are no clearance issues.

1. Terrain testing
    a. Manually propelling devices for 1 min intervals at each terrain (tile flooring, carpeted flooring, concrete, and grass/dirt)
    b. At the end of each interval, record observations and notes on ease of use and surface interaction
    c. Repeat (a), (b) and (c) for a second trial.
    d. After all trials, quantify observations into 1-10 scale.

Data from this test will be analyzed using a median to find the average. If the average is under 80% of full possible functionality, then further revision of the design is required and the tests will be rerun.

Sketch of prototype part being tested:
(insert)

Data Collection:

Terrain	Clearance Rating (1-10)		
	Trial 1	Trial 2	Trial 3
Tile Flooring			
Carpeted Flooring			
Concrete			
Grass/Dirt			

2. Name of testing protocol/portion of prototype: Force Testing

Date to be completed: 12/5/23

Team Members testing: TBD

Detailed Steps of testing:
Footrests will be tested with various weights to test stability and structural integrity. The footrests must be able to withstand the weight of the clients legs while resting in addition to any applied force if the footrests are used as leverage when moving around. This will consist of a load to failure test.

1. Weight will be tested at 20 pound increments for visible changes and failures in structural integrity
    a. Photos of the footrests will be taken at each weight increment
    b. Measurement of aluminum deformation will be tested after each new addition of weight
    c. ____% deformation is acceptable
    d. Footrests should support a minimum weight of ____ lbs
    e. Weight of failure will be recorded unless device can withstand over ___ lbs

Sketch of prototype part being tested:

Data Collection:

Weight	Measurement
30	
40	
50	
60	
70	
80	
90	
100	
110	
120	
130	
140	
150	
160	
170	
180	
190	
200	
210	
220	
230	
240	
250	

3. Name of testing protocol/portion of prototype: Ease of Use

Date to be completed: 12/5/2023

Team Members testing: TBD

Detailed Steps of testing:

The testing will be completed using a survey in which a minimum of 5 participants will rank the ease of use of footrests on a scale of 1-10.

1. Each participant will be asked to move the footrests from their usable position to their stored position and then repeat the opposite action (from usable to stored position)

Sketch of prototype being tested:

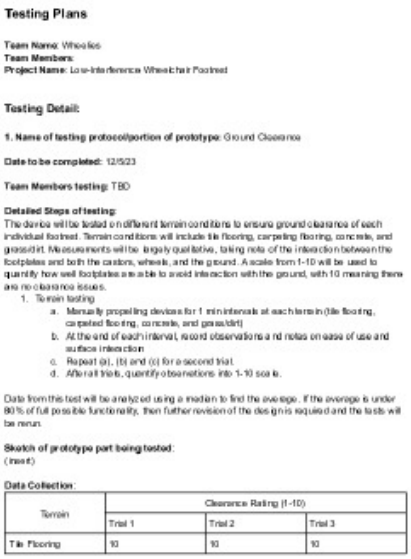
Data Collection:

Participant	Ease of Use Score (1-10)

Conclusions/action items: The testing plans outlined above are a preliminary plan and are subject to change.

2023/12/06 - Testing Results

SADIE ROWE - Dec 06, 2023, 6:06 PM CST



Testing Plans

Team Name: Wheelies
Team Members:
Project Name: Low-Interference Wheelchair Footrest

Testing Detail:

1. Name of testing protocol/portion of prototype: Ground Clearance

Date to be completed: 12/5/23

Team Members testing: TBD

Detailed Steps of testing:
The device will be tested on different terrain conditions to ensure ground clearance of each individual footrest. Terrain conditions will include tile flooring, carpeting flooring, concrete, and grass/dirt. Measurements will be largely qualitative, taking note of the interaction between the footplates and both the castors, wheels, and the ground. A scale from 1-10 will be used to quantify how well footplates are able to avoid interaction with the ground, with 10 meaning there are no clearance issues.

1. Terrain testing
   a. Manually propelling devices for 1 min intervals at each terrain (tile flooring, carpeted flooring, concrete, and grass/dirt)
   b. At the end of each interval, record observations and notes on ease of use and surface interaction
   c. Repeat (a), (b) and (c) for a second trial
   d. After all trials, quantify observations into 1-10 scale.

Data from this test will be analyzed using a median to find the average. If the average is under 80% of full possible functionality, then further revision of the design is required and the tests will be rerun.

Sketch of prototype part being tested:
(insert)

Data Collection:

Terrain	Clearance Rating (1-10)		
	Trial 1	Trial 2	Trial 3
Tile Flooring	10	10	10

Download

Testing_Plans_1_.pdf (129 kB)

2023/12/06 - Testing Synonypsis

SADIE ROWE - Dec 06, 2023, 6:42 PM CST

Title: Design Testing Synopsis

Date: 2023/12/06

Content by: Sadie Rowe & Gracie Hastreiter

Present: N/A

Goals: Summarize the objective of testing

Content:

Various tests were conducted to test the functionality, stability, and ease of use of the prototype. The ground clearance test was designed to test the device on various terrain conditions to ensure that the footplate does not interfere with the ground or obstruct any movement of the wheelchair base and wheels. Measurements for this test were largely qualitative. A team member pushed the wheelchair base with the device on the various terrains for 1-minute intervals. The terrains tested included tile floor, carpeted floor, concrete, and grass. Afterward, the device was rated on a scale of 1-10, with 1 meaning the device had significant clearance issues and 10 meaning the device had no clearance issues with the ground or other parts of the wheelchair base.

A force test was also performed to determine if the device is capable of supporting the force of the client's legs, a minimum of 15.25 lbs, while also maintaining structural integrity. The device should be able to support a minimum of 15.25 lbs without a deflection of 4 cm or greater. If the device deflects more than 4 cm, the footplate will no longer be level with the ground, and the client's feet would be able to slip off the footplate. To test these requirements, weights are placed on the footplate in increments of 6 lbs. After each plate was added to the footplate, the deflection was measured and observations were recorded.

Two tests were performed to determine ease of use of the device. The first was designed to test ease of use when maneuvering the footplate from its upright position to its usable position. In order to do so, 20 participants were asked to move the footplate from its upright position to its usable position and back again. Each participant was asked to rank the ease of their task on a scale from 1 to 10. A second similar test was conducted to measure the ease of use of attaching and removing the entire footrest device from the wheelchair castors. 20 participants were asked to take the prototype off of the castor by undoing the velcro strap and removing the cap. They were then asked to reattach the prototype and rank the ease of their task on a scale from 1 to 10.

Conclusions/action items: The paragraph above summarizes our testing procedures.

2023/12/07 - Project Conclusion

SADIE ROWE - Dec 07, 2023, 11:52 AM CST

Title: Project Conclusion

Date: 2023/12/07

Content by: Sadie Rowe and Juliana Dugo

Present: N/A

Goals: Summarize findings and discuss potential future work

Content:

Wheelchair users with limited movement capability are restricted by existing wheelchair footrest models. Current footrest models are heavy, bulky, and difficult to store. Because footrests are crucial for lower-body support, it is imperative to design a wheelchair footrest that allows for increased lower-body mobility—should the user require it. The goal of this project was to create a low-interference wheelchair footrest that provides increased adaptability, functionality, and simplicity compared to existing models. To improve user experience, the team has developed design ideas and a detachable footrest prototype that is able to be moved from a usable position to a stored position on the wheelchair. Additionally, the group has conceptualized potential changes in the original design which may improve functionality and facilitate future work.

To begin the project, market research was conducted and the proposed final design was chosen after careful comparison to competing market designs. The team produced three design sketches and decided upon a final design based on comparison of weighted scores in various design criteria categories. The team’s final proposed design was a variation of Design 1: The ‘Fold up Footrest’. This prototype was created with attachment of a 3D-printed castor cap to a 6” by 6” aluminum footplate via a 100 degree soft-close hinge. The castor cap was fit to insert into an existing hole on the castors and attached more securely with velcro straps for increased stability.

Several tests were conducted to evaluate the design specifications. The design successfully passed the ground clearance and ease of use maneuvering footplate tests. During testing, however, it was revealed that the selected design was not fit to accommodate adequate force and failed to support upwards of 18 lbs without significant deflection of the footplate. Additionally, the device does not meet design criteria pertaining to ease of use when attaching and removing the footrests as testing revealed that participants had a difficult time performing these tasks. Some aspects of the design worked well and should be incorporated into a revised prototype, such as the aluminum footplate, height of the footrests, and the general design concept. Although the selected hinge was unable to properly support necessary force, the aluminum footplate proved to be made of a sufficiently strong material and cut to a proportional size according to the client’s feet. Additionally, the height of footrests allows adequate space for clearing any objects on the ground which might obstruct wheelchair movement and will likely be maintained in future revisions. The concept of the design proved to be an effective and lightweight alternative to current market options, but changes are required to improve the longevity and usability of the footrest design.

In future semesters, we plan to enhance our design's strength and functionality. A crucial adjustment involves upgrading the hinge to handle significant loads and distribute stress more evenly. Currently, stress concentrations and deflection stem from the hinge's axle, prompting consideration for a stronger hinge or a permanent modification, akin to the metal piece insertion we previously implemented. To counteract deflection, we're exploring a folded angle adjustment from 100 to 90 degrees or smaller, providing better support for clients' feet. Adding support under the footplate is also under consideration. Redesigning the cap to address fit issues and adjusting wall thickness for durability is another focus. Improvements to support mechanisms for the castor cap and exploring alternatives to Velcro straps, such as a more efficient

mechanism tailored to the client's mobility, are essential. Testing the product on the client's current wheelchair is imperative for gathering data on long-term usage, stress distribution, and wear and tear.

Conclusions/action items: Action must be taken to make any necessary edits and submit writing in Final Report.

2023/12/05 - Future Work Brainstorming

SADIE ROWE - Dec 07, 2023, 11:58 AM CST

Title: Future Work Brainstorming

Date: 2023/12/05

Content by: Sadie Rowe

Present: N/A

Goals: Brainstorm possible areas of improvement for future semesters.

Content:

What worked/did not work:

- Worked:
  - Aluminum footplate size and material
  - Height of footrests
  - Soft-close hinge (hold at upward position)
- Did not work:
  - Curved edge of castor cap - does not allow hinge to attach securely (loose)
  - 100 degree hinge (should be >100)
  - Thickness of 3D-printed castor cap on the side where force is applied
  - Velcro straps - too weak and need to be on both sides for simple removal/attachment.

What we would do differently/future work

- Different Hinge - stronger, >100 degrees, longer
  - OR alteration of existing hinge to decrease deflection and increase strength.
  - Use of multiple hinges to reinforce strength.
  - Smaller angle if required to minimize deflection of wheelchair footplates
- Reprint castor caps to mold perfectly to castor caps: no gap for wobble.
- Thicken sides of castor cap: capable to supporting more weight
- Heavy-dutyy duty Velcro or different attachment mechanism (stronger likely)
  - The attachment mechanism should be on either side of the castor cap so it does not need to be removed every time the cap comes off

Conclusions/action items: Summarize bulleted thoughts into more cohesive Project Conclusion.

2022/9/22 - Red Permit

SADIE ROWE - Dec 07, 2023, 2:44 PM CST

Title: Red Permit

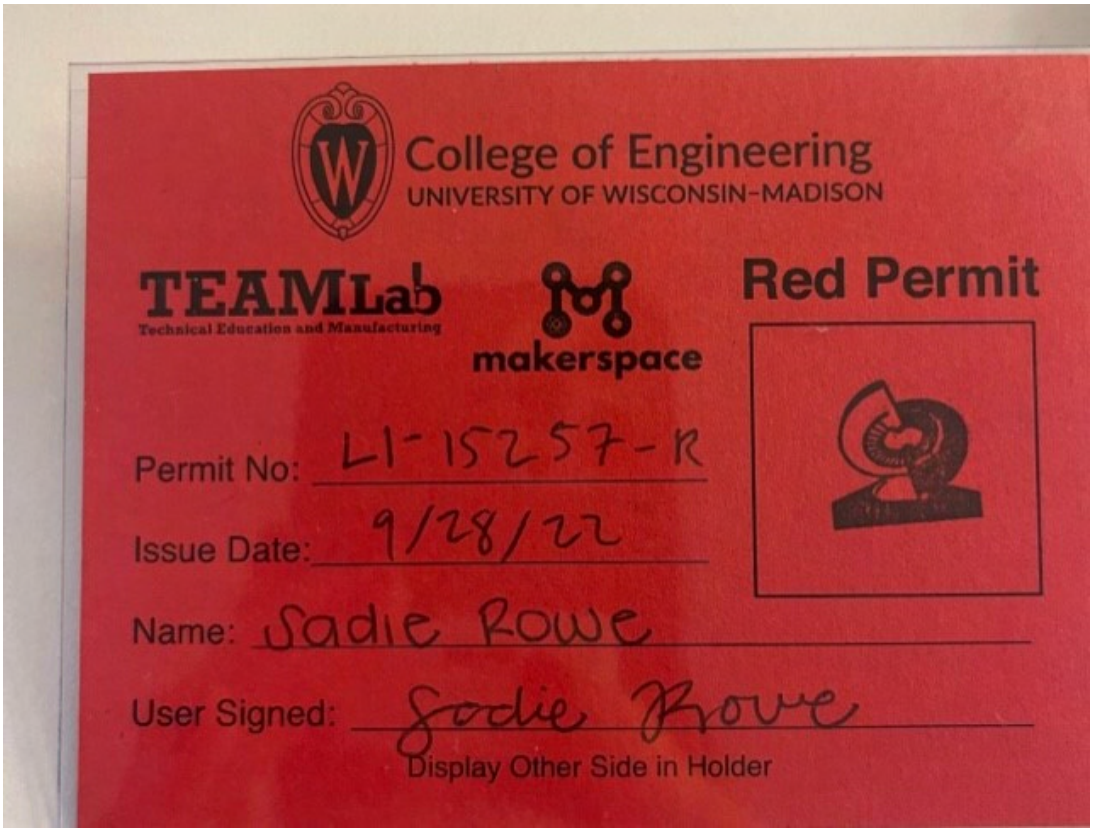
Date: 2022/9/22

Content by: Sadie Rowe

Present: N/A

Goals: Show Proof or Red Permit

Content:



Conclusions/action items: N/A

2023/10/11 - Tong Distinguished Lecture Notes

SADIE ROWE - Nov 17, 2023, 6:04 PM CST

Title: Tong Distinguished Lecture Notes

Date: 2023/10/11

Content by: Sadie Rowe

Present: N/A

Goals: Record takeaways from Tong Distinguished Lecture

Content:

Background:

- Originally decided to pursue medical school and be a doctor.
- Attended the University of Pittsburgh but found herself bored and uninterested in the classes that she was taking.
    - Had to reevaluate what her passions where and what she wanted to do in life
- Came to UW Madison for graduate school and found her passion
    - began researching microspheres
    - found her people
    - a very difficult but rewarding and eye-opening time in her life
- Now: works as exact sciences and loves what she does

Advice:

1. Find your people: the people make the place (find the people that can be your support system)

2. Do the things that scare you: push yourself (you can't grow into a better person if you don't do something uncomfortable)

3. Laugh until you cry, cry until you laugh: Laughter gets you through the hardest parts of life (don't lose yourself or take things too seriously)

4. Someone is counting on you: you're not alone in this (this idea can be overwhelming but use this as motivation to push yourself)

- Major takeaway: lean into your passion even if it's a challenging choice
    - If you do something solely for others or for the status, it won't be worth your time and energy in the long run
    - Your passions will not go away quickly

Conclusions/action items:

I found this lecture incredibly impactful and genuine. I especially resonated with the idea of "finding your people" in college. School is very difficult, especially engineering, and finding the people who can support you along the way is something that I have also found to be incredibly important. Additionally, this lecture motivated me to explore my interests further and try to find what I am truly passionate about.

2014/11/03-Entry guidelines

John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity, subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.

2014/11/03-Template

Juliana Dugo - Dec 08, 2023, 11:09 AM CST

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items: