BME Design-Spring 2022 - Josh ANDREATTA
Complete Notebook

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Josh ANDREATTA

on

May 03, 2022 @09:01 PM CDT

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Team contact Information

Cate Flynn - Jan 28, 2022, 1:42 PM CST

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Project description

Josh ANDREATTA - Feb 23, 2022, 5:43 PM CST

Course Number:

BME 301, Lab 305

Project Name:

JOHNSON HEALTH TECH: ADAPTIVE INDOOR ROWER FOR WHEELCHAIR USERS

Short Name:

Adaptive Rowing Machine

Project description/problem statement:

Individuals with injuries or disabilities have trouble utilizing typical workout machines due to a lack of exercise equipment that is accessible for them. One affected group are individuals who require the use of a wheelchair. People require wheelchairs for a multitude of physical disabilities or injuries to the brain, spinal cord, or lower extremities. The majority of exercise machines are not designed for wheelchair use, and thus exercise options for wheelchair users are limited. In order to solve this issue, modifications need to be made to current manufactured machines. A standard Matrix rowing machine [1] will be adapted to accommodate individuals who require the use of a wheelchair. The Adaptive Rower will secure the wheelchair into the rowing machine, preventing the user from tipping backwards during the course of the workout. This modified design will increase the accessibility and ease of use of a rowing machine by individuals in wheelchairs, and will help to improve their overall well being through exercise.

[1] “Rower | Matrix Fitness - United States.” https://matrixfitness.com/us/eng/group-training/cardio/rower (accessed Feb. 07, 2022).

About the client:

Ms. Staci Quam is a Mechanical Engineer and lead of the Biomech Lab at Johnson Healthtech.

Client Meeting 02/04/22

Cate Flynn - Feb 04, 2022, 4:25 PM CST

Title: Client Meeting

Date: 02/04/22

Content by: Cate

Present: Dhruv, Tim, Sam

Goals: Meet with the client for the first time to ask initial questions

Content:

The team met with the client to ask the preliminary questions we wrote about the project. More detailed notes are attached and included below. The team has agreed to meet with the client in person for a tour and a viewing of the rower at 3 pm next Friday.

Questions for the Client:

- Of the 4 rowing machine types, which one will the team be making modifications on? (Water, Air, Magnetic, Hydraulic)
  - Magnetic
- 1. What is the overall goal of the project?
  - Are there specific requirements that you want the team to follow?
  - Will the user be capable of using their legs in any capacity?
  - ANS:
    - Up to us how far we want to take it
    - Take a rower from them and possibly add attachments or modifications to allow for people in wheelchairs to use it
    - Would like to have a prototype if possible, but realizes it might take more than a semester
    - Would be easier if machine was completely converted to an adaptive rower
      - Ideally would be able to switch back and forth
    - Adaptive rowers on the market don't even have the slide shaft
- 3. Should the user remain in the wheelchair, or would they ideally be placed into the adapted rower?
  - ANS: they usually should stay in the wheelchair
- 2. Who is the target group for this machine?
  - Rehab patients?
  - Permanently disabled patients?
  - Athletes?
  - Age group?
  - Experience with rowing machines?
  - ANS: sometimes will be people with sports injuries, people who could be paralyzed below the waste; basically people that have limited movement in the their legs and are in wheelchairs
    - Except full movement in the arms and upper body
- 4. Should the modification made by the team be reversible, so other users can use it in its standard form?
  - Are certain modifications off limits?
  - ANS: doesn't have to be reversible
- Material preferences or constraints?
- 5. Should the overall changes allow the patient to use the machine on their own?

        - Or is help allowed?
        - The user should be able to place themselves onto the machine on their own
- What are the most important safety concerns?
    - ANS: need to find out how to overcome possible wheelchair from tipping over
        - A lot of force backwards whenever you pull back
- What is the budget?
    - ANS: typically around $200 and she is working on getting us a rower frame
- What progress would you like to see by the end of the semester?
    - Ideally a prototype

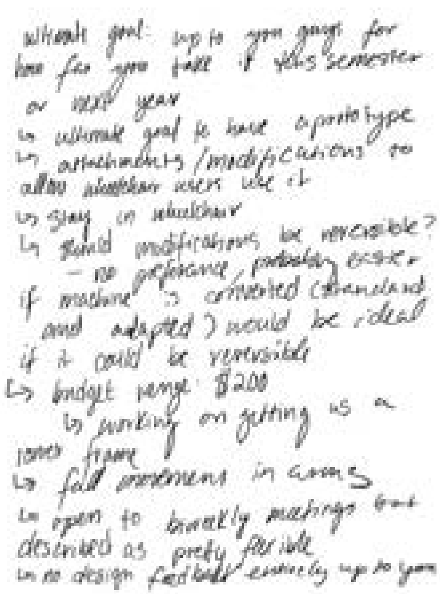
https://adaptederg.commons.bcit.ca/rowing-solutions/

This is a very good resource

Conclusions/action items:

Meet with the client next week and conduct individual research in the week until the next meeting.

Cate Flynn - Feb 04, 2022, 3:23 PM CST



ultimate goal: up to you guys for how far you take it this semester or next year
↳ ultimate goal to have a prototype
↳ attachments / modifications to allow wheelchair users use it
↳ stay in wheelchair
↳ should modifications be reversible?
— no preference, probably easier if machine is converted (standard and adapted) would be ideal if it could be reversible
↳ budget range: $200
↳ working on getting us a rower frame
↳ full movement in arms
↳ open to biweekly meetings but described as pretty flexible
↳ no design feedback entirely up to you

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Client_Meeting_02-04.pdf (972 kB)

Client Meeting 02/04/22

Cate Flynn - Feb 04, 2022, 4:26 PM CST

Title: Client Meeting

Date: 02/04/22

Content by: Cate

Present: Dhruv, Tim, Sam

Goals: Meet with the client for the first time to ask initial questions

Content:

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Conclusions/action items:

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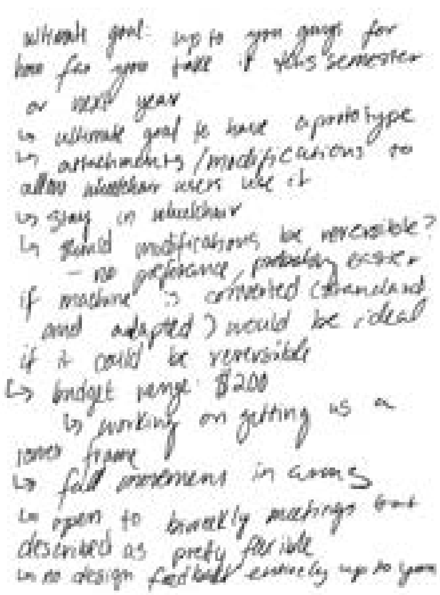
Cate Flynn - Feb 04, 2022, 3:22 PM CST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In Person Tour 02/18/22

Cate Flynn - Feb 18, 2022, 1:12 PM CST

Title: In Person Tour - Johnson Health Tech

Date: 02/18/22

Content by: Cate

Present: Tim, Josh, Sam

Goals: Help assemble the rower and tour the Johnson Health Tech facility

Content:

Most of the team toured the Johnson Health Tech facility today. Staci gave us a thorough tour of the facility where we saw numerous lines of equipment and their motion capture technology. She also showed us multiple testing stations for calibrating and verifying the mechanical and technical components of the equipment. We aided in assembly of the rower, which was pretty simplified, and this helped us to focus our design efforts now that we have a better understanding of the equipment. We are currently thinking of adding multiple pulleys to allow for the wheelchair user to use the equipment more easily.

Josh took pictures of the rower as it was being assembled as well as its inner workings.

Conclusions/action items:

Finish the design matrix for evaluating our designs.

Josh ANDREATTA - Feb 18, 2022, 1:45 PM CST

Title: In Person Tour - Johnson Health Tech

Date: 02/18/22

Content by: Josh

Present: Tim, Josh, Sam, Cate

Goals: Help assemble the rower and tour the Johnson Health Tech facility

Content:

The above image shows the spool that the rope winds around and the black belt that moves the fly wheel to cause the rowing motion. As the handles are pulled back, the rope unwinds and the belt moves the flywheel. As the handles are returned to resting, a bearing in the shaft of the flywheel/spool prevents the wheel from moving, but the spool spins to wind back up the rope. This ensures resistance is only felt when pulling the handles toward ones chest.

The above image shows the pulley that the rope wraps around in the support neck of the rower.

The above image shows the inner mechanism of the magnetic rower, including a flywheel, belt loop, and rope spool.

The above image shows an example of multiple pulleys being used to cause movement in the same direction by pulling on the rope in different directions. We will use this idea to further our design brainstormed ideas.

Conclusions/action items:

Pictures from the visit were added. Next, we will finish the design matrix for evaluating our designs.

2/4/22 Initial Advisor Meeting

SAMUEL SKIRPAN - Feb 04, 2022, 1:31 PM CST

Title: Initial Advisor Meeting

Date: 2/4/22

Content by: Sam

Present: Sam, Cate, Dhruv, Tim

Goals: Meet with Dr. P to discuss initial thoughts on project.

Content:

- Introduced ourselves to Dr. P and told him about career interests
- Ask client about how we can get into JHT for a tour early on
  - They hire a lot of UW Madison BME's
- Ask client:
  - How we can get access to the rower
  - How we can take measurements
  - Take pictures
  - About the target market for this device
    - See how many people you can ultimately help

Conclusions/action items:

Our first meeting with Dr. P involved introducing ourselves to him and telling him about our career interests. We also talked about why we were interested in the project in the first place. He told us some information about our client, Staci. He also mentioned that we should try to see if we can get into JHT for a tour of the facilities.

Action items: Meet with client today at 3 PM. Divide up sections for PDS this weekend.

Advisor Meeting 02/04/22

Cate Flynn - Feb 04, 2022, 4:29 PM CST

Title: Advisor Meeting

Date: 02/04/22

Content by: Cate

Present: Tim, Dhruv, Sam

Goals: This is the first meeting with our advisor for the adapted rower project

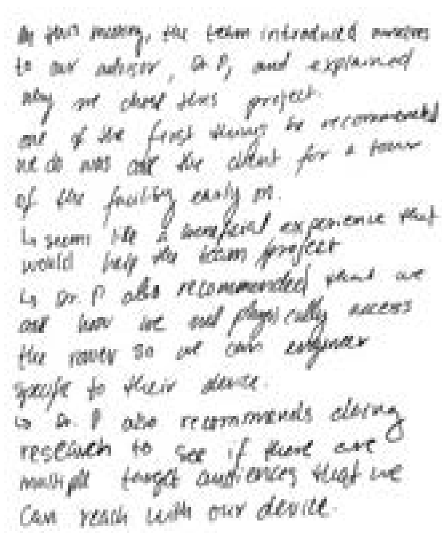
Content:

I have uploaded my notes from the meeting, but the primary takeaways were that we should ask the client for an in person tour and that we should ask questions about the project to get a feel of what concentrated research topics we should look into.

Conclusions/action items:

Meet with the client to ask questions about the project and schedule an in person tour.

Cate Flynn - Feb 04, 2022, 2:17 PM CST



In [illegible] meeting, the team introduced ourselves
to our advisor, Dr. P, and explained
why we chose this project.
one of the first things he recommended
we do was ask the client for a tour
of the facility early on.
↳ seems like a beneficial experience that
would help the team project
↳ Dr. P also recommended that we
ask how we and physically access
the rower so we can engineer
specific to their device.
↳ Dr. P also recommends doing
research to see if there are
multiple target audiences that we
can reach with our device.

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Advisor_Meeting_02-04.pdf (535 kB)

Advisor Meeting 02/11/22

Cate Flynn - Feb 11, 2022, 2:04 PM CST

Title: Advisor Meeting

Date: 02/11/22

Content by: Cate

Present: Tim, Dhruv, Josh, Sam

Goals: Check in with Dr. P

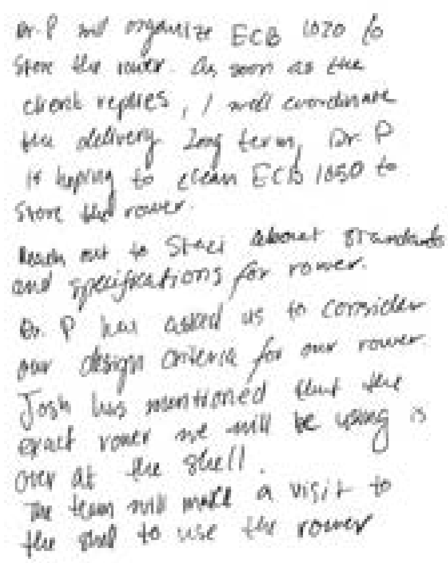
Content:

We discussed the storage situation with Dr. P and have a space to store the rower. Dr. P also suggested that we reach out to Staci about the standards and specifications. The exact rower we will be using is over at the shell so the team can get in and do some measurements. I have included my notes from the meeting.

Conclusions/action items:

Come up with design ideas for the coming Monday design matrix meeting.

Cate Flynn - Feb 11, 2022, 2:04 PM CST


Dr. P will organize ECB 1020 to store the rower. As soon as the check replies, I will coordinate the delivery. Long term, Dr. P is hoping to clean ECB 1050 to store the rower.
Reach out to Staci about standards and specifications for rower.
Dr. P has asked us to consider our design criteria for our rower.
Josh has mentioned that the exact rower we will be using is over at the shell.
The team will make a visit to the shell to use the rower

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Advisor_Meeting_02-11.pdf (536 kB)

Advisor Meeting 02/18/22

Cate Flynn - Feb 18, 2022, 1:30 PM CST

Title: Advisor Meeting

Date: 02/18/22

Content by: Cate

Present: Sam, Dhruv. Tim, Josh

Goals: Present our design criteria to Dr. P to hear his thoughts

Content:

We met with Dr. P and gave him a summary of the tour. He gave us the access code so that we can always get to the rower (ATP). We presented our design criteria to Dr. P and he gave us the go ahead to prep the slides for our upcoming preliminary presentation. He reviewed his comments on our PDS, but we all feel that we will be able to make those corrections now that we have the rower.

Dr. P offered to review the slides for the preliminary presentation as we make them. Sam asked Dr. P what he thought about the overall big picture of the project. Dr. P said that it depended on the scope of our goal and how the project progresses, but he also recommended that we consider dividing and conquering responsibilities. He also recommended considering sourcing materials from Johnson Health Tech itself.

Conclusions/action items:

Begin work on next week's deliverables.

Advisor Meeting 03/04/22

Cate Flynn - Mar 11, 2022, 1:09 PM CST

Title: Advisor Meeting

Date: 03/04/22

Content by: Cate

Present: Tim, Dhruv, Josh, Sam

Goals: Meet with Dr. P in person to look at the machine

Content:

The team met with Dr. P in person in ECB 1070 to look at the rower in person. Dr. P was able to obtain two wheelchairs for the team to use in the design process. Being in person with the machine also enabled us to take some measurements that will be useful in creating the CAD files of the preliminary designs.

Conclusions/action items:

Create CAD files of our preliminary designs.

Advisor Meeting 03/11/22

Cate Flynn - Mar 11, 2022, 1:31 PM CST

Title: Advisor Meeting

Date: 03/11/22

Content by: Cate

Present: Tim, Dhruv, Sam, Josh

Goals: Meet with Dr. P to discuss the state of the project

Content:

The team met with Dr. P to update him on the progress of our project so far. Dr. P suggested that we consider asking our classmates about what materials we should use in the upcoming show and tell. Dr. P was happy with the progress we made in securing the original assembly files from the client and commissioning an additional pulley.

Conclusions/action items:

Prepare for show and tell after break.

Advisor Meeting 03/25/22

Cate Flynn - Apr 06, 2022, 5:05 PM CDT

Title: Advisor Meeting

Date: 03/25/22

Content by: Cate

Present: Tim, Dhruv, Sam, Josh

Goals: Meet with Dr. P to discuss our progress.

Content:

We discussed the changes Josh had made to the original solidworks files with Dr. P. He gave us some recommendations about leaving enough material in the neck in order to prevent bending moments. He also gave us some good recommendations for how to fix the additional pulley to the rower.

Conclusions/action items:

Determine how we will fix the pulleys to the rower and alter the solidworks files.

Advisor Meeting 04/01/22

Cate Flynn - Apr 06, 2022, 5:10 PM CDT

Title: Advisor Meeting

Date: 04/06/22

Content by: Cate

Present: Sam, Josh, Dhruv, Tim

Goals: Meet with Dr. P to discuss the progress of the project

Content:

Dr. P gave us good recommendations for what material to 3D print the pulley from. He also gave us advice about asking JHT to help us machine the part and cut the neck of the rower.

Conclusions/action items:

Reach out to Staci about any help JHT can provide for fabrication.

Advisor Meeting 04/08/22

Cate Flynn - Apr 08, 2022, 1:28 PM CDT

Title: Advisor Meeting

Date: 04/08/22

Content by: Cate

Present: Sam, Josh, Tim, Dhruv

Goals: Update Dr. P with the progress of our project

Content:

We updated Dr. P with our fabrication so far. He reminded us to consider how we will flip the monitor around which we will ask Staci about when we visit JHT. We told him about the stabilization design we have and he liked the idea and suggested that we spray paint it black so that it is aesthetically more pleasing. He also recommended adding a seatbelt strap to the stabilization to keep the user in their chair.

Conclusions/action items:

Continue with the fabrication process and drop off the neck of the rower at JHT.

Advisor Meeting 04/15/22

Cate Flynn - Apr 15, 2022, 1:34 PM CDT

Title: Advisor Meeting

Date: 04/15/22

Content by: Cate

Present: Tim, Dhruv, Sam, Josh

Goals: Update Dr. P with the progress of our project

Content:

We told Dr. P where we're at with fabrication in terms of picking up the neck and the rubber ball (Josh and Sam will pickup this afternoon) and drilling the pilot holes in the stabilization apparatus. The team is still waiting for decent (less windy) weather to spray paint as we must paint outside. Dr. P recommended that we add additional support pieces to the support apparatus. This will be a good way to use up our extra wood. The holes have been drilled in the base board of the support apparatus.

We also updated Dr. P on our plans to make the monitor rotatable. He likes the general idea of our part design, but voiced some concerns about the stability of the design.

He reminded us to weigh our support apparatus as part of our final report.

We asked him our questions about testing: Simulation testing: Dr. P approved of our safety factor simulation testing plan. We modeled with PVC and adjusted the elastic modulus to be as exact as possible. Spring gauge tension plot for maximum tension of both modes: Dr. P recommended a simple pulling back movement to find the tension, but liked the plan otherwise.

He suggested a usability test: make a survey and try not to use your leg muscles at all (could use an EMG to ensure that the tension in the user's legs remains constant throughout the workout). He recommended reaching out to Dr. Nimunker for help developing the EMG circuit for quantitative analysis.

We can recieve feedback if we send our poster by Wednesday the 27th.

Conclusions/action items:

Continue with fabrication and then testing.

Advisor Meeting 04/22/22

Cate Flynn - Apr 22, 2022, 1:46 PM CDT

Title: Advisor Meeting

Date: 04/22/22

Content by: Cate

Present: Sam, Tim, Josh, Dhruv

Goals: Update Dr. P on the status of our project and ask for advice about data presentation

Content:

Dr. P recommended that we add some additional wood supports to our apparatus, ask professors proficient in stats about their recommendations for displaying our data, make the plots larger and possibly include box and whisker plots and averages with trend lines. He also suggested that we add a rubber lining to the cut in the neck to prevent the rope from being frayed. He recommended having our additional printed parts available on the table during our poster session to highlight the work we've done this semester.

Conclusions/action items:

Complete the final deliverables and make appropriate alterations to our data.

Team Testing Meeting

Cate Flynn - Apr 22, 2022, 2:02 PM CDT

Title: Team Testing Meeting

Date: 04/21/22

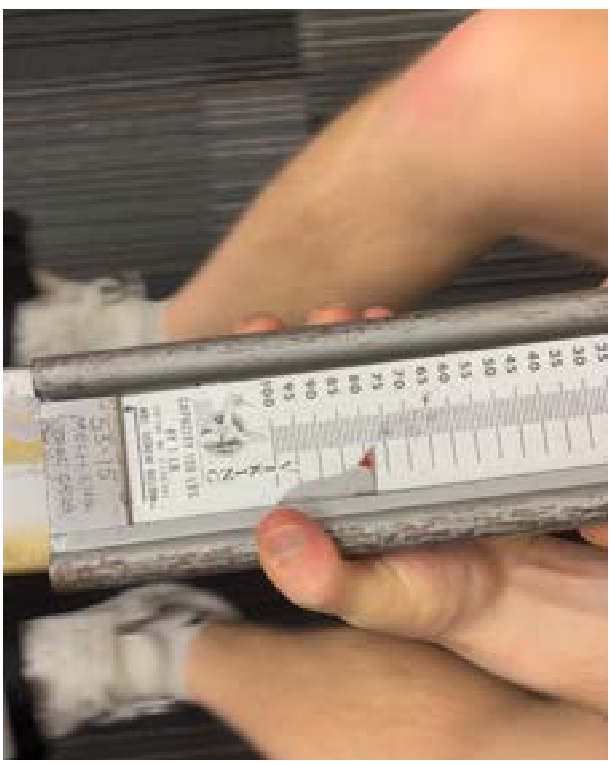
Content by: Cate

Present: Sam, Tim, Dhruv, Josh

Goals: Test the rower

Content:

The team met to test the adapted rower now that construction has been completed. The protocol for testing can be found in the protocol folder. We were going to try to read the fish box live, but found it to be difficult and used a phone to record video of the rower and took the measurements from the video. Images of the testing have been included below:



Conclusions/action items:

Analyze the collected data for final presentation.

Team Poster Meeting

Cate Flynn - Apr 25, 2022, 5:50 PM CDT

Title: Team Poster Meeting

Date: 04/25/22

Content by: Cate

Present: Josh, Sam, Dhruv, Tim

Goals: Finalize our draft of the final poster to send to Dr. P for edits

Content:

The team met for 2 hours to edit our draft of the final poster. We mainly changed things like wording, font size, spacing and finalized the layout of our figures. We will send the poster to Dr. P tomorrow for his feedback.

Conclusions/action items:

Make all edits to the poster suggested by Dr. P before printing.

Team Poster Presentation

Cate Flynn - Apr 30, 2022, 9:18 AM CDT

Title: Team Poster Presentation Practice

Date: 04/28/22

Content by: Cate

Present: Tim, Dhruv, Josh, Sam

Goals: Practice our final presentation

Content:

The team met for about an hour to practice the order and flow of our final presentation for Friday's poster session.

Conclusions/action items:

Present our work tomorrow at final poster session.

Team Final Paper Meeting

Cate Flynn - May 01, 2022, 6:15 PM CDT

Title: Team Final Paper

Date: 05/01/22

Content by: Cate

Present: Tim, Dhruv, Josh, Sam

Goals: Edit the final paper

Content:

The team met for two hours to begin proofing the final paper and notebook to be completed by May 4th.

Conclusions/action items:

Meet again to finish final deliverables.

Team Final Paper Meeting 2

Cate Flynn - May 02, 2022, 8:12 PM CDT

Title: Team Final Paper

Date: 05/02/22

Content by: Cate

Present: Tim, Dhruv, Josh, Sam

Goals: Edit the final paper again

Content:

The team met for four hours to finalize the final paper.

Conclusions/action items:

Turn in final deliverables.

2/9/2022 - Edit Product Design Specifications

Josh ANDREATTA - Feb 09, 2022, 9:44 PM CST

Title: Edit Product Design Specifications

Date: 2/9/2022

Content by: Josh Andreatta

Present: Sam, Cate, Tim, Dhruv, Josh

Goals: Edit and finalize rough draft of PDS

Content:

- We met as a team to edit the PDS and started from the top section and worked our way down through each section.
- At the end, we also wrote a rough draft of the function/problem statement to incorporate into the progress reports.
- Only slight changes to grammar and flow were made during the meeting time.
- The entire document was read through thoroughly again at the end to ensure it covered all the important aspects of the design.

References: n/a

Conclusions:

The PDS has been edited and will continue to be updated throughout the semester as the team gains a better understanding of the goals for this project.

Action items:

- Submit PDS to canvas and website

-Take tour of Johnson Healthtech

-Construct rowing machine set aside for us

-Begin brainstorming design ideas

Team Meeting 02/14/22

Cate Flynn - Feb 14, 2022, 4:55 PM CST

Title: Team Meeting

Date: 02/14/22

Content by: Cate

Present: Josh, Dhruv, Sam, Tim

Goals: Outline the design matrix and present our initial design ideas

Content:

The team met to present our original design ideas for the adapted rower and to create the categories and weights for out design matrix. For the design matrix, we settled on User Stability/Safety at 25%, Ease of Fabrication at 25%, Ease of Use/Ergonomics at 20%, Versatility at 10%, Durability at 10% and Cost at 10%. The team worked together to write the justification for the categories as follows:

User Stability / Safety (25%): The ability of the design to stabilize the user and their wheelchair to the rowing machine. The design must secure the user so that they do not tip over during the course of the repetitive rowing motion. Additionally, no parts of the design should cause harm to the user during use of the rowing machine.

Ease of Fabrication (25%): The device must be easy to fabricate, and components should be available to order/build. Additions made to the existing rowing machine should not involve drastic disassembly of the current rowing machine.

Ease of Use/Ergonomics (20%): The device should be easily accessible for individuals in a wheelchair, and not require outside assistance to use properly. While using the adapted rowing machine, the user should be comfortable and not be at risk for injury due to poor design.

Versatility (10%): The ability of the rowing machine to change between an adaptive and standard erg. The device should minimize the complexity of the interchanging states of the erg. In addition, both the erg states should allow free and full movement from the user during use.

Durability (10%): The lifespan of the device is important as the user should be able to expect the adapted rower to last the same amount of time as a standard rowing machine. If this device were to reach the market, consumers will expect that they will be able to use the device for an extended period of time.

Cost (10%): The device must remain within the $200 budget given for the project. A design that is more cost effective will receive a higher score in this category.

The team then went through and individually pitched the ideas that we came up with. Josh and I all designed ideas along the line of making additions or changes to the standard rower that would allow the user to remain behind the original seat with additional stabilization that would allow the user to pull the handlebar to themselves.

Tim and Sam both came up with ideas that would require structural changes to the rower frame (cutting, screws, etc). Both of these designs would adapt the frame to be more accessible to the user.

Dhruv suggested that we remove some of the additional supports and twist the interface 90 degrees off. The team was really excited about this design as it could be a very simple solution.

The client has invited us out to assemble the rower this coming Friday. The team will wait to complete the final evaluation with the design matrix until after assembly so that we can all determine how feasible each design idea will be.

Conclusions/action items:

Assemble the rower on Friday, complete the final design matrix.

Team Meeting 02/20/22

Cate Flynn - Feb 20, 2022, 12:37 PM CST

Title: Design Matrix Decisions

Date: 02/20/22

Content by: Cate

Present: Sam, Tim, Josh, Dhruv

Goals: Create and fill out the design matrix with our existing design

Content:

The team met to present our second round of designs and to create the design matrix. After presenting our ideas, the team decided to create two matrices. One with three designs for stabilizing the user, the designs being adaptations of a ramp with slots and attachments for stabilization, and the other with two designs regarding an additional pulley system. The "Ramp up Accessibility" design won for the stabilizing feature and the "The 'Pushin' Double P" design won for the pulley designs.

The team currently has only pencil sketches of most designs, so **I** will be creating digital sketches of all of the designs to include in the preliminary presentations. We will now work to complete the slides in time for Wednesday so that we can send them to Dr. P for his edits before Friday.

Conclusions/action items:

Add these matrices to our preliminary presentation and complete the remainder of the slides.

Team Meeting 02/22/22

Cate Flynn - Feb 22, 2022, 8:50 PM CST

Title: Team Meeting

Date: 02/22/22

Content by: Cate

Present: Tim, Dhruv, Josh, Same

Goals: Edit the preliminary presentation slides

Content:

The team met to review our preliminary presentation slides before we send them to Dr. P for his thoughts before our presentation Friday.

Conclusions/action items:

Make any edits recommended by Dr. P and practice our presentation.

Team Meeting 02/24/22

Cate Flynn - Feb 24, 2022, 5:33 PM CST

Title: practice presentation meeting

Date: 02/24/22

Content by: Cate

Present: Dhruv, Tim, Josh, Sam

Goals: Practice our preliminary presentation as a team

Content:

The team met to make the changes to our preliminary presentation slides recommended by Dr. P and to practice our preliminary presentation to time.

Conclusions/action items:

Submit the completed slides to canvas and the project website.

Team Meeting 02/27/22

Cate Flynn - Feb 27, 2022, 4:15 PM CST

Title: Preliminary Presentation Draft Meeting

Date: 02/27/22

Content by: Cate

Present: Tim, Dhruv, Josh, Sam

Goals: Edit the preliminary report draft together

Content:

The team met to edit the preliminary report together for submission later in the week. Now that the preliminary report is written, the team will begin work on the future work outlined in the document.

Conclusions/action items:

Begin sourcing materials and created CAD files of the preliminary designs.

Team Meeting 04/06/22

Cate Flynn - Apr 06, 2022, 4:14 PM CDT

Title: Executive Summary Meeting

Date: 04/06/22

Content by: Cate

Present: Josh, Sam, Dhruv

Goals: Write the executive summary for which design award we will be applying for

Content:

The team has decided to apply for the design excellence award. We feel that this award better suits our project and our team's progress so far this semester because our design is unique. Our design is one of a kind because the rower can still be used in the standard form as well as the adapted form.

Conclusions/action items:

Send executive summary to Dr. P.

Team Meeting 04/07/22

Cate Flynn - Apr 08, 2022, 1:16 PM CDT

Title: Stabilization Apparatus Planning Meeting

Date: 04/07/22

Content by: Cate

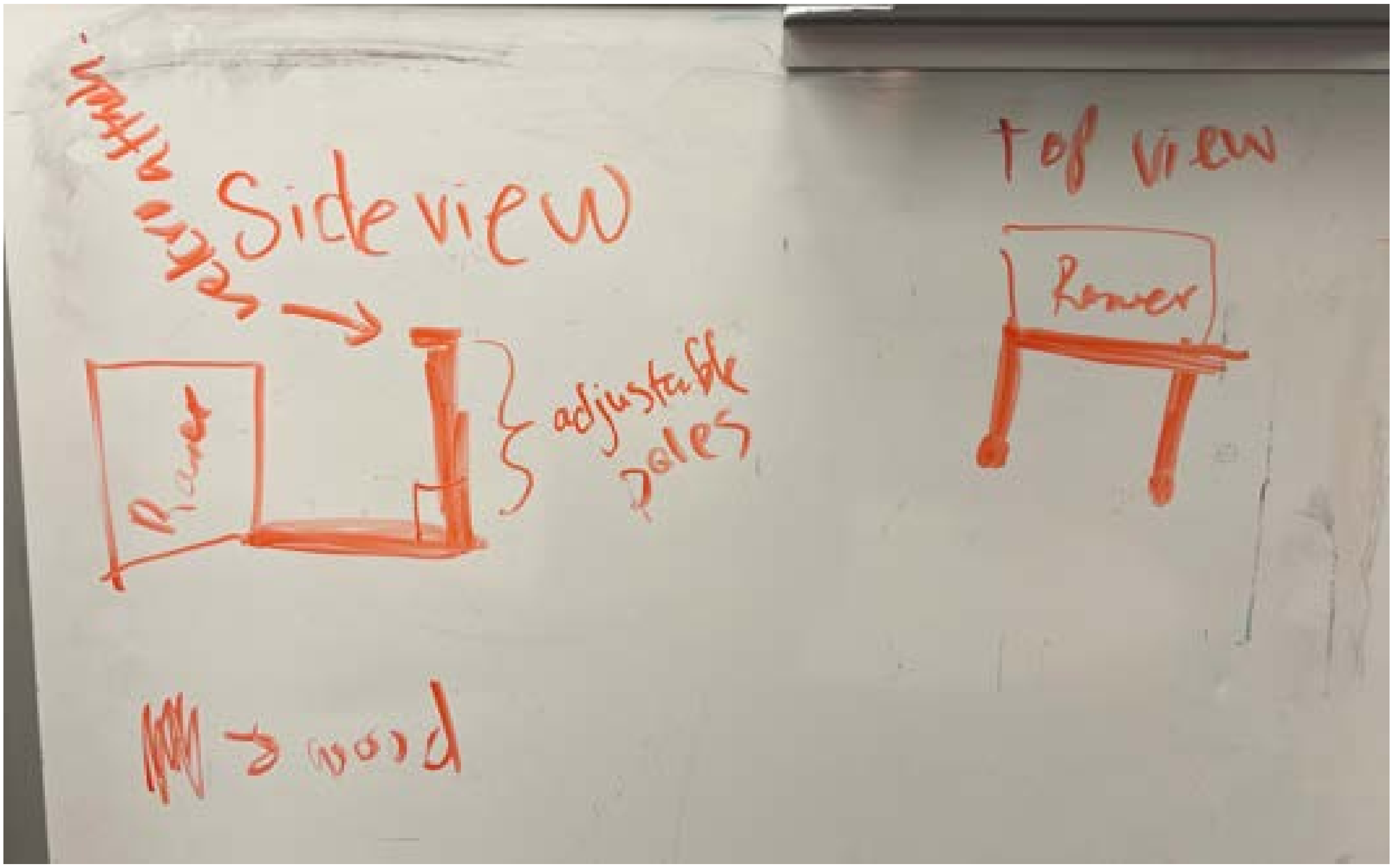
Present: Sam, Tim, Josh

Goals: Take measurements and plan the construction for the stabilization apparatus planning meeting

Content:

Sam, Tim and I met to take measurements and mark the wood to construct the velcro-wood stabilization device. I took some images of the planning and measuring process and Josh came in briefly to test the fit of the pulley support plates with the rower.

We decided that we will connect the apparatus to the rower by cutting slots for the supports to fit into in the board going underneath the rower.



Conclusions/action items:

Return to ECB to cut the wood and fabricate the support apparatus.

Team Meeting 04/08/22

Cate Flynn - Apr 08, 2022, 1:20 PM CDT

Title: JHT Drop Off

Date: 04/08/22

Content by: Cate

Present: Sam, Josh, Tim, Dhruv

Goals: Drop off the neck of the rower at JHT for fabrication

Content:

The team went to JHT to drop off the neck of the rower so that they can execute the cut to enable the second pulley.

Budget question:

Rotating display question:

Conclusions/action items:

Begin fabrication of the support apparatus.

Expenses Table - 4/9/22

Dhruv Biswas - Apr 09, 2022, 3:52 PM CDT

Title: **Team Expenses**

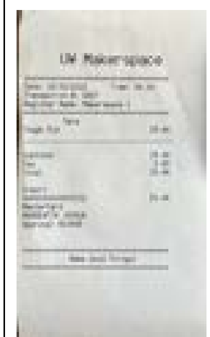
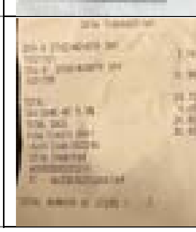
Date: 4/9/22

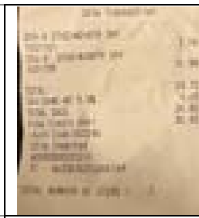
Content by: Dhruv Biswas

Present: Team

Goals: Document all Purchases

Content:

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link	Photos
Modeling Purchases									
Adaptable Pulley Stabalizer 3D-Print - Iteration 1	The initial 3D print of the component that attaches to the rower and stabilizes the second pulley for adaptable use	Makerspace	Transaction Number: 6907	3/30/2022	1	$15.44	$15.44	Printer Link	
Adaptable Pulley Stabilizer 3D-Print - Iteration 2	The second 3D print for the stabilizing component. Adjustments were made to certain dimensions of the model to ensure a proper fit.	Makerspace	Transaction Number: 6948	3/31/2022	1	$15.28	$15.28	Printer Link	
Final Design Components									
Adaptable Pulley Stabilizer 3D-Print - Iteration 2	Same as second entry in "Modeling Purchases"	Makerspace	-	-	0	$0.00	$0.00	Printer Link	
Adaptable Pulley Stabilizer 3D-Print - Iteration 2; Mirrored Side	This print was a similar print to the interation 2 print, but it was for the other side of the rower. Some minor changes are present in this print due to differences present on this specific side of the rower. Basic structure and model is the same.	Makerspace	Transaction Number: 7061	4/6/2022	1	$28.16	$28.16	Printer Link	
Wood for Side Handle Bar - Stabilization	Wood was obtained in order to build the side handle bars which will be used to prevent tipping while using the adaptable rower.	Menards	2x4-8 STUD/#2+BTR SPR 1021101	4/3/2022	1	$7.74	$7.74	2x4-8	

Wood for Side Handle Bar - Stabilization	Wood was obtained in order to build the side handle bars which will be used to prevent tipping while using the adaptable rower.	Menards	2x6-8' STUD/#2&BTR SPF 1021758	4/3/2022	1	$11.99	$11.99	[2x6-8]	
						TOTAL:	**$78.61**		

References: N/A

Conclusions: Purchases have been and will be documented in this table. This table was last updated on 4/9/22

Action items: Continue manufacturing the final design and update the design matrix.

Final Expenses Table - 4/29/22

Dhruv Biswas - Apr 29, 2022, 5:42 PM CDT

Title: Final Expenses Table

Date: 4/29/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document the final expenses table that will be sent to Ms. Staci Quam

Content:

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
Modeling Purchases								
Adaptable Pulley Stabalizer 3D-Print - Iteration 1	The initial 3D print of the component that attaches to the rower and stabilizes the second pulley for adaptable use	Makerspace	Transaction Number: 6907	3/30/2022	1	$15.44	$15.44	Printer Link
Adaptable Pulley Stabilizer 3D-Print - Iteration 2	The second 3D print for the stabilizing component. Adjustments were made to certain dimensions of the model to ensure a proper fit.	Makerspace	Transaction Number: 6948	3/31/2022	1	$15.28	$15.28	Printer Link
Adaptable Pulley Stabilizer 3D-Print - Iteration 3	This print was a similar print to the interation 2 print, but it was for the other side of the rower. Some minor changes are present in this print due to differences present on this specific side of the rower. Basic structure and model is the same.	Makerspace	Transaction Number: 7061	4/6/2022	1	$28.16	$28.16	Printer Link

Swivel Design - Iteration 1	This was the first iteration for the swivel design. However, some dimension issues caused the team to reprint it after making updates. The eventual goal is to use this to control the orientation of the console display.	Makerspace	Transaction Number: 7239	4/18/2021	1	$5.34	$5.34	Printer Link
Swivel Design - Iteration 2	This design was made in order to allow the display on the standard matrix rower to change orientation if needed. Therefore, a user on the adapted and standard side can see the display.	Makerspace	Transaction Number: 7260	4/19/2022	1	$5.52	$5.52	Printer Link
Final Design Components								
Adaptable Pulley Stabilizer 3D-Print - Iteration 3	This print was a similar print to the interation 2 print, but it was for the other side of the rower. Some minor changes are present in this print due to differences present on this specific side of the rower. Basic structure and model is the same. (Same as Above).	Makerspace	Transaction Number: 7061	4/6/2022	1	$0.00	$0.00	Printer Link
Wood for Side Handle Bar - Stabilization	Wood was obtained in order to build the side handle bars which will be used to prevent tipping while using the adaptable rower.	Menards	2x4-8' STUD/#2+B TR SPR 1021101	4/3/2022	1	$7.74	$7.74	2x4-8
Wood for Side Handle Bar - Stabilization	Wood was obtained in order to build the side handle bars which will be used to prevent tipping while using the adaptable rower.	Menards	2x6-8' STUD/#2&B TR SPF 1021758	4/3/2022	1	$11.99	$11.99	2x6-8
Spraypaint for Side Handle Bar	In order to make a streamlined model, spraypaint was bought to paint all wood components black. This matches the rower and wheelchair.	Ace	Part Number: 1396050	4/12/2022	1	$5.99	$5.99	Spraypaint

Screws for Side Handle Bar	Screws were necessary to fabricate the Side Handle Bar design	Ace	Part Number: 5327176; WD PH CS 8x3 50 piece	4/12/2022	1	$7.59	$7.59	Screws
Buckle and Straps - Securing for wood stabilization	These buckles will be used to secure the wheelchair to the wood which will in turn be held in place by the rower.	CooBigo	CS023-25	4/11/2022	1	$8.03	$8.03	Buckle Link
Swivel Design - Iteration 2	This design was made in order to allow the display on the standard matrix rower to change orientation if needed. Therefore, a user on the adapted and standard side can see the display.	Makerspace	Transaction Number: 7260	4/19/2022	1	$0.00	$0.00	Printer Link
						TOTAL:	**$111.08**	

References: N/A

Conclusions: This information will be sent to Staci for reimbursement purposes.

Action items: Fill out proper documents and send to the client.

Dhruv Biswas - May 01, 2022, 7:34 PM CDT

Date: 5/1/2022

The free pulley from Johnson Health Tech was missing

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
Modeling Purchases								
Adaptable Pulley Stabalizer 3D-Print - Iteration 1	The initial 3D print of the component that attaches to the rower and stabilizes the second pulley for adaptable use	Makerspace	Transaction Number: 6907	3/30/2022	1	$15.44	$15.44	Printer Link
Adaptable Pulley Stabilizer 3D-Print - Iteration 2	The second 3D print for the stabilizing component. Adjustments were made to certain dimensions of the model to ensure a proper fit.	Makerspace	Transaction Number: 6948	3/31/2022	1	$15.28	$15.28	Printer Link
Adaptable Pulley Stabilizer 3D-Print - Iteration 3	This print was a similar print to the interation 2 print, but it was for the other side of the rower. Some minor changes are present in this print due to differences present on this specific side of the rower. Basic structure and model is the same.	Makerspace	Transaction Number: 7061	4/6/2022	1	$28.16	$28.16	Printer Link
Swivel Design - Iteration 1	This was the first iteration for the swivel design. However, some dimension issues caused the team to reprint it after making updates. The eventual goal is to use this to control the orientation of the console display.	Makerspace	Transaction Number: 7239	4/18/2021	1	$5.34	$5.34	Printer Link

Swivel Design - Iteration 2	This design was made in order to allow the display on the standard matrix rower to change orientation if needed. Therefore, a user on the adapted and standard side can see the display.	Makerspace	Transaction Number: 7260	4/19/2022	1	$5.52	$5.52	Printer Link
Final Design Components								
Additional Pulley For Adaptive Side	This pulley was used in conjunction with the pulley plates to form the adaptive side of the rower.	Johnson Health Tech	N/A	3/25/2022	1	$0.00	$0.00	N/A
Adaptable Pulley Stabilizer 3D-Print - Iteration 3	This print was a similar print to the interation 2 print, but it was for the other side of the rower. Some minor changes are present in this print due to differences present on this specific side of the rower. Basic structure and model is the same. (Same as Above).	Makerspace	Transaction Number: 7061	4/6/2022	1	$0.00	$0.00	Printer Link
Wood for Side Handle Bar - Stabilization	Wood was obtained in order to build the side handle bars which will be used to prevent tipping while using the adaptable rower.	Menards	2x4-8' STUD/#2+B TR SPR 1021101	4/3/2022	1	$7.74	$7.74	2x4-8
Wood for Side Handle Bar - Stabilization	Wood was obtained in order to build the side handle bars which will be used to prevent tipping while using the adaptable rower.	Menards	2x6-8' STUD/#2&B TR SPF 1021758	4/3/2022	1	$11.99	$11.99	2x6-8
Spraypaint for Side Handle Bar	In order to make a streamlined model, spraypaint was bought to paint all wood components black. This matches the rower and wheelchair.	Ace	Part Number: 1396050	4/12/2022	1	$5.99	$5.99	Spraypaint

Screws for Side Handle Bar	Screws were necessary to fabricate the Side Handle Bar design	Ace	Part Number: 5327176; WD PH CS 8x3 50 piece	4/12/2022	1	$7.59	$7.59	Screws
Buckle and Straps - Securing for wood stabilization	These buckles will be used to secure the wheelchair to the wood which will in turn be held in place by the rower.	CooBigo	CS023-25	4/11/2022	1	$8.03	$8.03	Buckle Link
Swivel Design - Iteration 2	This design was made in order to allow the display on the standard matrix rower to change orientation if needed. Therefore, a user on the adapted and standard side can see the display.	Makerspace	Transaction Number: 7260	4/19/2022	1	$0.00	$0.00	Printer Link
						TOTAL:	**$111.08**	

Pulley Plates - Iteration 1 - 4/29/22

Dhruv Biswas - Apr 29, 2022, 5:45 PM CDT

Title: Pulley Plates - Iteration 1

Date: 4/29/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document the different components

Content:

Iteration one had fraying issues in the smaller cavity region as well as dimension issues. This was the first try at printing this design.

References: N/A

Conclusions: Changes were needed to this iteration.

Action items: Document all materials.

Pulley Plates - Iteration 2 - 4/29/22

Dhruv Biswas - Apr 29, 2022, 5:48 PM CDT

Title: Pulley Plates - Iteration 2

Date: 4/29/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document Materials

Content:

This iteration was nearly correct. However, small issues in the cavity regions needed to be addressed. Therefore, another print was made.

References: N/A

Conclusions: Another print was needed.

Action items: Document all items.

Pulley Plates - Iteration 3 - 4/29/22

Dhruv Biswas - Apr 29, 2022, 5:50 PM CDT

Title: Pulley Plates Iteration 3

Date: 4/29/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document materials

Content:

All dimensions were perfect. They allowed for successful attachment of the second pulley by rest on the support metal arms of the rower.

References: N/A

Conclusions: This is the final pulley plate iteration.

Action items: Document all items

Swivel Design - Iteration 1 - 4/29/22

Dhruv Biswas - Apr 29, 2022, 5:54 PM CDT

Title: Swivel Design - Iteration 1

Date: 4/29/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document all materials

Content:

This design was allowed the display on the matrix to change orientation if needed between the adapted and standard sides. However, the first iteration had dimensional issues which needed to be addressed.

References: N/A

Conclusions: Another iteration was used to complete this component of the design.

Action items: Document materials.

Swivel Design - Iteration 2 - 4/29/22

Dhruv Biswas - Apr 29, 2022, 5:59 PM CDT

Title: Swivel Design - Iteration 2

Date: 4/29/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document materials

Content:

This is the final iteration for the swivel design. Some sanding was needed, but the component effectively allows a user to change the orientation of the display.

References: n/a

Conclusions: This component was used in the final design.

Action items: Document all materials

Wood for Stabilization - 4/29/22

Dhruv Biswas - Apr 29, 2022, 6:02 PM CDT

Title: Wood for stabilization

Date: 4/29/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document all materials

Content:

2x4-8' and 2x6-8' wood boards were bought to complete the stabilization mechanism.

References: N/A

Conclusions: Bought to complete the Side Handlebars.

Action items: Document all materials.

Spray Paint for Stability Mechanism - 4/29/22

Dhruv Biswas - Apr 29, 2022, 6:04 PM CDT

Title: Spray Paint for Stability Mechanism

Date: 4/29/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document all materials.

Content:

As advised by our advisor, the black spray-paint allows for the full design to look streamlined. The majority of the whole design, including existing components, is black.

References: N/A

Conclusions: Black spray-paint was used to make a streamlined final design.

Action items: Document all materials.

Dhruv Biswas - May 01, 2022, 7:20 PM CDT

Link to spray paint: https://www.acehardware.com/departments/paint-and-supplies/spray-paint/hobby-spray-paint/1396050

Picture of Spray paint:

Reference for paint:

[1] "Rust-Oleum Painter's Touch 2X Ultra Cover Flat Black Paint + Primer Spray Paint 12 oz - Ace Hardware." https://www.acehardware.com/departments/paint-and-supplies/spray-paint/hobby-spray-paint/1396050 (accessed May 01, 2022).

Screws for Stability Mechanism - 4/29/22

Dhruv Biswas - Apr 29, 2022, 6:05 PM CDT

Title: Screws for Stability Mechanism

Date: 4/29/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document Materials

Content:

The screws were used in conjunction with the wood to make the stability mechanism.

Conclusions/action items: Screws and wood made the side handlebars.

Action Items: Document all materials

Buckle Straps for Stability Mechanism - 4/29/22

Dhruv Biswas - Apr 29, 2022, 6:08 PM CDT

Title: Buckle Straps for Stability Mechanism

Date: 4/29/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document all materials

Content:

The buckle straps were needed to complete the stability mechanism. Holes were drilled near the arm rests of the wheelchair. The buckle straps went through there and allowed the user to secure themselves into place with them.

References: N/A

Conclusions: Buckle straps were needed for stability mechanism.

Action items: Document all materials.

Dhruv Biswas - May 01, 2022, 7:21 PM CDT

The link to these straps is : https://www.amazon.com/dp/B078P8N2D6?smid=A2292T76OSDPAM&ref_=chk_typ_imgToDp&th=1

Picture:

Reference for straps:

[1] “5 Pack 1" Side Release Buckle Dual Adjustable 5 Yards 1" PP Strap Webbing Outdoor Camping Backpack Sleeping Bag Tent Belt Tied Band Accessories #CS023-25 (Size 1" (5 Buckle + 5 Yards Webbing)) : Arts, Crafts & Sewing.” https://www.amazon.com/dp/B078P8N2D6?smid=A2292T76OSDPAM&ref_=chk_typ_imgToDp&th=1 (accessed May 01, 2022).

Pulley From Johnson Health Tech - 5/1/22

Dhruv Biswas - May 01, 2022, 7:39 PM CDT

Title: Pulley From Johnson Health Tech

Date: 5/1/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document the free pulley that was given to the team from Johnson Health Tech

Content:

The team received a free pulley from Johnson health tech that aided in building the adaptive side of the rower. This pulley was used with the pulley plates that rest on the metal support arms.

References: N/A

Conclusions: The pulley was given by Johnson Health Tech and used in the final adaptable rower design.

Action items: Finish final report.

Team Meeting 04/10/22

Cate Flynn - Apr 10, 2022, 7:11 PM CDT

Title: Fabrication Planning Meeting

Date: 04/10/22

Content by: Cate

Present: Dhruv, Tim, Sam, Josh

Goals: Delegate tasks for fabricating the buckling support apparatus

Content:

The team met to plan out the fabrication of the buckle support apparatus. The team split into two groups, one group to cute the wood and the other to drill it. Today I will be doing preliminary research into where to purchase the support buckles that will be used to secure the wood to the arms of the wheelchair and the rest of the team will be marking the wood to be cut on Monday and then drilled on Thursday.

We found a set of five buckles with adjustable rope for $7 on amazon. We can use this for customizable length in fabrication.

Link:https://www.amazon.com/Adjustable-Backpack-Sleeping-Accessories-CS023-25/dp/B078P8N2D6/ref=sr_1_20?crid=38MBY2PD42JCC&keywords=safety%2Bbuckle%2B1%22&qid=1649635472&sprefix=safety%2Bbuckle%2B1%2B%2Caps%2C72&sr=8-20&th=1

Conclusions/action items:

Order rope and begin fabrication.

Team Meeting 04/11/22

Cate Flynn - Apr 11, 2022, 4:19 PM CDT

Title: Cutting Boards

Date: 04/11/22

Content by: Cate

Present: Sam, Dhruv

Goals: Cut the boards as measured for the buckle stabilization apparatus

Content:

We met to cut the boards according to the pre-measured cuts with a saw in TeamLab. We also asked Henry about his advice for the support and he recommended that we use the drill press.

Conclusions/action items:

Come back within the week to finish drilling the holes for the support.

Team Supply Run

Cate Flynn - Apr 12, 2022, 6:39 PM CDT

Title: Supply Run

Date: 04/12/22

Content by: Cate

Present: Tim

Goals: Pickup items for fabrication

Content:

Tim and I went to ACE hardware to get black spray-paints and screws.

Conclusions/action items:

Use these items to fabricate the stabilizing apparatus tomorrow

Cutting/Drilling Protocol - 4/16/22

Dhruv Biswas - Apr 16, 2022, 2:35 PM CDT

Title: Cutting/Drilling Protocol

Date: 4/16/22

Content by: Dhruv and Sam

Present: Dhruv and Sam

Goals: Document the steps that were taken to make the proper cuts and drills

Content:

- 3 Boards were cut out of the 2" x 6" x 8' board
    - Two 20 in boards
    - One 26 inch board
- 2 boards were cut out of the 2" x 4" x 8' board
    - Both had a length of 29 in

1. Before any cuts or drills were made onto the 2" x 6" x 8', traces of the pegs and metal supports that the base will be resting on were completed
2. A miter saw was used to make the initial length cuts. Two 20 inch cuts were first made to the 2 x 6 board. The miter was lined up to the proper marks and cuts were made.
3. A 26 inch cut was then subsequently made onto the other side of the board were the traces were present
4. Two 29 in cuts were then made onto the 2 x 4 board using the miter saw
5. After completion of the cuts, the base board (26 in. in length) was taken to the drill
6. The drill used a 1.5 inch diameter to create the holes.
7. The two holes for the pegs, three 1.5 inch diameter by 1.5 inch depth cuts were needed. One was done in the middle of the trace, and another two adjacent to that cut. It was ensured that the overall drilling area was constrained within the trace.
8. The two holes for the metal structure then used two cuts using the same drill and same depth (1.5 inch diameter by 1.5 inch depth). The first cut was made at the top of the trace and then a subsequent cut was made just below it to complete the drill for the trace.
9. Finally a singular drill on each 2 x 4, 29 in. length, board was made. 1 inch diameter and 4 inches down from the end of the board. This if for the straps.

References: N/A

Conclusions: This is the protocol followed by Sam and Dhruv on 4/11/22 while cutting at the team lab.

Action items: Finish fabrication and begin testing

Lumber pickup

Tim TRAN - Apr 16, 2022, 4:38 PM CDT

Title: Purchasing wood for stability fabrication

Date: 4/9

Content by: Tim

Present: Tim

Goals: Acquire wood

Content:

I purchased a 2"x4"x8' board and a 2"x6"x8' board to be used for the fabrication of the stability design from Menards.

Conclusions/action items:

Next steps: cut boards to size

4/18/22 Protocol for Making Base Board

SAMUEL SKIRPAN - Apr 18, 2022, 10:47 PM CDT

Title: Protocol for Making Base Board

Date: 4/18/22

Content by: Sam

Present: Sam and Dhruv

Goals: Write fabrication protocol for making the base board that goes under the rowing machine.

Content:

Materials:

- One 8 foot 2x6 board
- Drill (from TEAM Lab)
- 1.5 inch drill bit
- 2 drill clamps (for stabilization of board)
- Miter Saw
- Ruler / Tape Measure
- Pencil

Fabrication Protocol of Base (Resting Under Rower)

1.Measure 26 in (.66 m) from end of 2x6 board and mark with a pencil.

2.Align 2x6 board on Miter saw at the pencil mark made in step 1. Use Miter saw to make 26 inch (.66 m) cut on 2x6 board.

3.Take board that was just cut in step 2 and place under front end of rowing machine. Center the board under the base and supports of the front end of the rowing machine.

4.Use pencil to trace out where the 2 rubber supports and 2 wheels are resting on the wooden board. This will be where the divots are made in the board for the supports to rest in.

5.Attach the 1.5 in drill bit to the drill in the TEAM Lab. Plug in the power cord for the drill. Set the stopper on the drill to .5 in (.0127 m).

6.Place board with traced out supports under the drill. Line up the first support trace under the drill. Use the 2 drill clamps to stabilize the board.

7.Use the drill to make the .5 in (.0127 m) divot in the board. Continue to come down on board with drill bit until the traced out area has been fully excavated.

8.Repeat steps 6-7 for the other traced out spots on the base board.

Fabrication Protocol for Other Boards

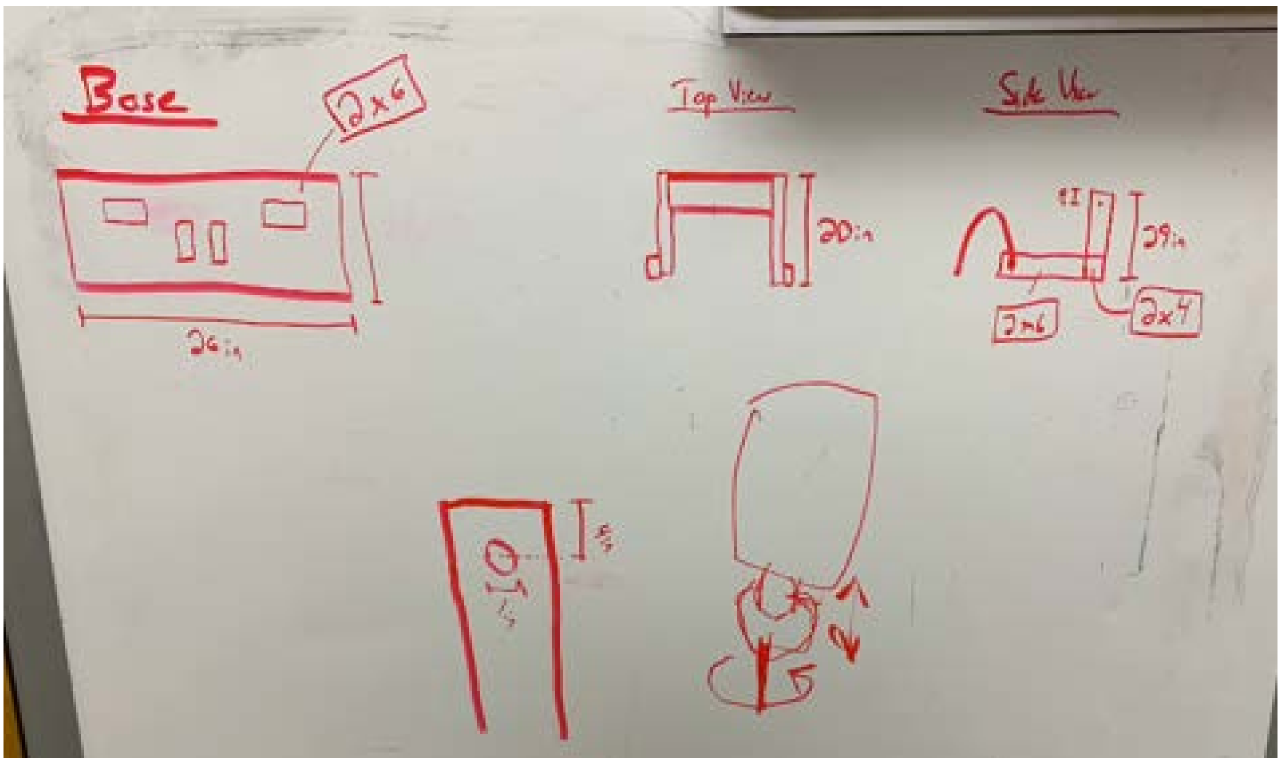
1. Take 2x6 board and mark 20 in (.508 m) down with pencil and tape measure. Make two 20 in (.508 m) measurements along the board.
2. Use the miter saw and line up the 20 in (.508 m) marks and cut the boards here.
3. Take 2x4 board and make marks with pencil at 29 in (.74 m) on the board. Make two 29 in (.74 m) marks along board.
4. Use miter saw and make cuts along the measurements made in step 3.

Fabrication of Holes

1. Take 29 in (.74 m) 2x4 boards and mark 4 in the middle of the board 4 inches (.1 m) from one side.
    1. Make sure this mark is in the middle of the board face (should be 1.75 in (.04 m) from the each side of the board).
2. Use 1 in drill bit and drill in TEAMLab and drill through hole through the board. Use clamps to stabilize the board on the drill surface.

1.

   1. This picture is a demo of what the board should look like. The center of the circle is 4 inches down from one end of the board.



- This picture shows the various measurements along the boards and how long the measurements should be. It also indicates whether each board is a 2x6 or 2x4.

- This picture is of all of the boards that we ended up cutting, except for the base board.

Conclusions/action items:

These are the steps to make the base board for the side arm rest supports. It also includes the rest of the protocol for cutting the boards and the through holes.

Action items: Complete testing for machine.

Assembly Protocol - stability component

Tim TRAN - Apr 23, 2022, 5:41 PM CDT

Title: Assembly of stability component

Date: 4/14

Content by: Tim

Present: Tim

Goals: Document fabrication steps

Content:

- Materials
  - #8x3" screws
  - 1/8 inch drill bit
  - Handheld power drill
- Steps
  - Match up the 20-inch boards cut from the 2x6x8 piece to either side of the baseboard resting under the rower
    - The 20-inch boards are in the vertical orientation - the 2" side comes into contact with the floor
  - Drill 2 pilot holes per board. The holes were 1.5 inches from either end of the baseboard.
    - A 1/8 inch drill bit was used for the pilot holes
    - Pilot holes are the same depth as the screw (3")
  - Screw both boards into the baseboard
  - Match up vertical posts cut from the 2"x4" board to the outside of the end of the 20" boards - end furthest away from the rower
    - one on each side
  - Drill 4 pilot holes per board - 1.5 inches from the edges of the board - same pattern as the four on a dice
  - Spray paint the 3 separate pieces before the final assembly
  - Drill in the remaining 8 screws
  - On the outside edge of both sides
    - Drill rectangular piece angled at 45 degrees connecting the vertical post to the 20-inch vertical board for added front and back stability

Conclusions/action items:

Overall the stability component is rigid. However, there is lateral movement of the post under the strain of rowing. The lateral rigidity could be fixed, but there are concerns that the fix would compromise leg space for the rower.

Next steps: iron out the testing procedure and testing

4/19/2022 - FINAL FBD of FINAL DESIGN

Josh ANDREATTA - Apr 21, 2022, 10:14 PM CDT

Title: FINAL FBD of FINAL DESIGN

Date: 4/19/2022

Content by: Josh Andreatta

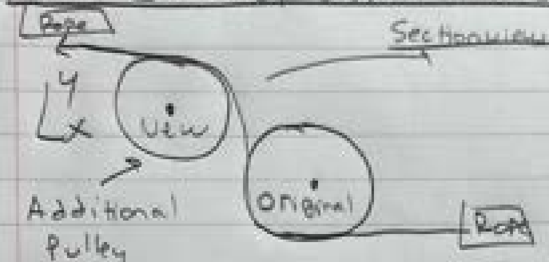
Present: Josh Andreatta

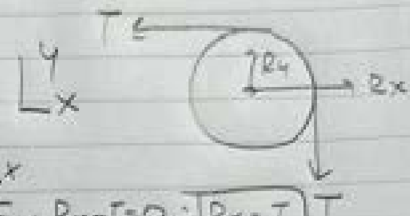
Goals: Show a detailed FBD of the final design

Content:

FBD 1 : Pulley Support Plates

Section view of Additional Pulley :





Neglect small mass of pulley, rope, + support plate compared to max 1050N Load of Rope Tension

$\Sigma F_x: R_x - T = 0 \therefore$ $R_x = T$

$\Sigma F_y: R_y - T = 0 \therefore$ $R_y = T$

∴ Pulley bearing support plates must support max tension developed in rope

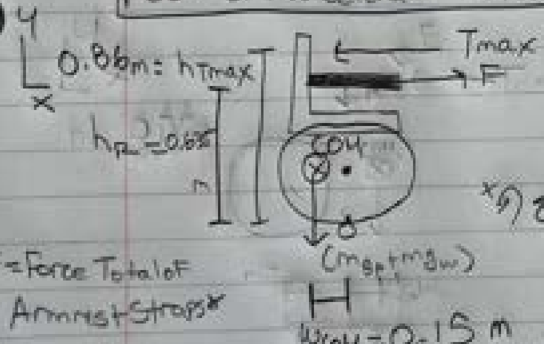
Set $T_{max} = 1050N$. If used properly, $R_x \to 0$ as pulley will spin the x-dir force will not be transmitted to the pulley plate.

In WORST CASE SCENARIO, 1 Pulley Plate recieves T_{max} in y-dir only

↳ modeled in SolidWorks According to equations boxed above

FBD 2 : Wheelchair Stability

Dimensions are from wood structure!



F = Force Total of Armrest Straps

Assume $mg_{person}(mg_p) = 80kg$

Assume $mg_{wheelchair}(mg_w) = 30\ kg$ (max)

Assume $T_{max} = 1050N$, $g = 9.81\ m/s^2$

Find Reaction Force @ Armrest, $\vec{F}$, if $\alpha = 0$:

$\circlearrowleft \Sigma M_o = I\alpha \stackrel{?}{=} (T_{max})(h_{Tmax}) - (F)(h_R) + (mg_p + mg_w)(w_{com})$

$0 = (1050N)(.86m) - (F)(0.635\ m) + (1079.1N)(0.15m)$

∴ $F = 1676.953\ N$

↳ F is Total F ∴ Rxn Force for each of 2 straps is

$F/2 = 838.47N$

∴ If average person sits in the max weight of a typical wheelchair, the armrest straps must apply a downward Force of ≈ 839 N each to prevent the wheelchair from tipping backwards.

Dimensions: h_{Tmax} = 29 inches to armrest + 5 inches to chest = 34 in ≈ 0.86m = h_{Tmax}

h_R = 29 inches to armrest − 4 inches to the hole = 25 in ≈ 0.635 m = h_R

w_{COM} = 6 inches ≈ 0.15m = w_{com} (assume behind center of wheel)

The above image shows the final FBD for the main weight bearing components of the final design: the pulley plates, and the wheelchair stabilizing straps and wooden frame.

References: n/a

Conclusions:

The FBD above was made using some simple assumptions. First, the average weight of a person is around 170-180 Lbs, so I used 80 kg for the weight of the person. The maximum weight of a wheelchair is 60 lbs, which is around 30 kg. The maximum force typically developed while rowing is 1050N (from Sam's prior research). Thus, the max tension and the max wheelchair weight was used to get the maximum force that the arm rest straps would need to apply to prohibit tipping of the wheelchair. Thus, the sum of moments about the center of the wheelchair was taken using the moments generated by the max tension in the rope, the total mass of the user plus the mass of the wheelchair, and the reactive armrest strap force. It was found that under max loading conditions (again, this is max rope tension and max wheelchair weight) that each strap needs to provide around 839N of force to prohibit tipping. The dimensions for the location of the force Tmax, reactive force F, and total mass of person and wheelchair are estimates from our own measurements of the structure.

For the pulley plates, the worst case scenario is if the pulley does not rotate and the max 1050 N rope tension is directed downward onto the pulley bearing. Since this bearing is in contact with the pulley plate "washer" on the bearing, the pulley plates must be able to support this 1050 N load. This is modeled in another entry using SolidWorks Simulation.

Action items:

-Test!

4/16/2022 - Final SolidWorks Design

Josh ANDREATTA - Apr 21, 2022, 10:14 PM CDT

Title: Final SolidWorks Design

Date: 4/16/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show the final SolidWorks design with pulley plates, slit in rower neck, and swivel design

Content:

Our final design consists of the 2 pulley plates to hold and stabilize the additional pulley which is used to redirect the rope and handle bar to the adapted side during use by wheelchair users. The rower neck has a slit cut into that allows for the rope to be easily transferred from the original pulley to the new pulley. The swivel design allows for the display console to be rotated so the user can see the monitor screen. This accomplishes several tasks such as (1) being able to transfer the rope to row from both sides, (2) rotate the console to see display from both sides, (3) make minimal changes to the rower machine itself. Additionally, other members of the team made a stabilization wood frame that holds on to the wheelchair to stabilize it during rowing. Below is a solidworks image of the full design without that wood frame.

The above image is the full final design without the wood frame to stabilize the wheelchair.

References: n/a

Conclusions:

The final design came out great in solidworks and we are excited to test this week. We will test by making a survey to assess comfortability and stability within the wheelchair while using the deivce, show solidworks simulations of the pulley plates to assess strength of material and geometry, and by using a spring gauge to compare forces on the standard and adapted side at 3 arm locations (full extensions, half stroke, and full stroke at chest).

Action items:

-Test!

Josh ANDREATTA - Apr 21, 2022, 10:14 PM CDT

Download

Full_Adapted_Rower.SLDASM (3.5 MB)

4/19/2022 - Show Rower Neck with Cut

Josh ANDREATTA - Apr 21, 2022, 10:16 PM CDT

Title: Show Rower Neck with Cut

Date: 4/19/2022

Content by: Josh Andreatta

Present: Josh Andreatta, Sam Skirpan

Goals: Attach the rower neck with slit back to the rower and row.

Content:

The above image shows sam rowing from the adapted side via the additional pulley and pulley plates and slit through the neck.

The above image shows what the console looks like from the adapted side. Thanks to the swivel bracket, the display console can be positioned to face correctly in both the standard and adaptive states.

The above image is a front view of the full assembly.

The above image is a side view of the swivel bracket with the display attached.

The above image is a back view of the swivel bracket with console attached.

After looking at the second bracket swivel print, it came out much better. The bracket fits tighter within the rower neck to help stabilize it once the screw through it is tightened. Additionally, the pegs fit much better into the bracket, although they needed to be sanded down a little. Putting the rower neck back on was a little challenging due to difficulties in keeping all of the washers in line with the screw through hole. However, after a few attempts, we were able to get it all lined up correctly. For some reason, the rower neck is not as tight as it was before the cut was made in the rower neck. Thus, we believe that removing some material for the neck slit made the material less sturdy at the base which is why it is slightly easier to rotate. We are going to try to tighten the neck even more to get it to be more difficult to rotate. If we are able to do this, the device will work without outside assistance. If the neck cannot be tightened further and it must remain in the position it is in in the images above, the user will require outside assistance to move the rope form the standard to the adapted state. Additionally, we will need to shave down the swivel bracket so it can tip down forward a little bit more. These are small changes that we can easily make. Either way, the design is functional and allows for proper rowing. The pulley support plates remain rigid and held against the outside surface of the rower neck, just as we had planned. There is a slight wiggle due to small errors in the 3D print cavity that sits on the rower neck support arms, but these are not noticeable while rowing, and are so small that they will not damaged the plates or cause them to fail (beyond a little wear and tear of the 3D Tough PLA material). Thus, ideally, these plates would be machined out of metal and welded onto the frame to avoid any of these issues.

Thus, moving forward, we will try to tighten the neck. If we cannot, we will just need outside assistance to move the rope between the standard and adapted states. Slight errors in our fabrication using 3D printed parts would be solved by machining out of metal and welding together components. Our design most definitely shows a proof of concept.

Lastly, tomorrow, sam and I will measure and cut the triangular support bars for the wooden stabilization component to offer it even more stability. Tim will then screw them together so we can test on thursday. Thursday, we will fill out the survey using the machine and use a spring gauge to measure the tension in the rope from the standard and adapted states as described in another entry. Then, we will spray paint the wood black before the poster presentation.

References: n/a

Conclusions:

Overall, the design came together super well. The neck is a little loose right now so we are going to try to tighten it. If this works, nothing else will need to be changed. If we cannot tighten it anymore, then the user will require outside assistance to move the rope and handle bar from the standard to adapted side. Additionally, the swivel socket will need to be sanded down so that it can bend downward a little more. Overall, we are very happy with how the design came out and how it allows for normal rowing motions.

Action items:

-Measure and cut triangular wood supports tomorrow

-Tim to screw in remaining wood pieces tomorrow

-Check testing survey

-Test Design!

4/22/22 Testing Protocol for Spring Gauge Tension

SAMUEL SKIRPAN - Apr 22, 2022, 11:46 AM CDT

Title: Testing Protocol for Spring Gauge Tension

Date: 4/22/22

Content by: Sam

Present: Sam

Goals: Write testing protocol for the spring gauge testing that we completed.

Content:

Tension Testing Protocol:

1. Attach the spring gauge to the middle of the handlebar / rope of the rowing machine.
2. From the traditional side, grab hold of the other side of the spring gauge that is not attached to the handlebar while seated on the rowing machine. Practice rowing motion while holding the spring to get comfortable with the motion.
3. With a resistance level of 1, row on the machine with the spring gauge for 15 reps. The first 5 reps are to calibrate the user to get within the 20-25 spm range. Continuously monitor the console readings to make sure that reps are completed within the 20-25 spm range. The next 10 reps are to be recorded.
    1. While completing the 15 reps, use a phone to record a video of the tension in the spring gauge during the rowing segment. Record the last 10 reps of the segment for data analysis once the segment is complete.
4. Complete step 3 on the standard side for resistance levels of 5 and 10 as well (in addition to resistance level 1).
5. After completing the testing on the standard side, transition the rope and handle to the adapted side. Also, turn the console so that it faces the adapted side.
6. Have the user sit in the wheelchair. Secure the wheelchair using the straps and the arm rest support base. Lock the wheelchair wheel breaks into place as well.
7. Complete steps 3-4 on the adapted side of the rowing machine while in the wheelchair.
8. Use videos from phone to transfer data from both standard and adapted uses to a spreadsheet for data analysis.

Conclusions/action items:

Here is the testing protocol that we used to test the tension during the use of the rowing machine from each side. We chose to complete the segments while maintaining a spm of around 20-25 to standardize the effort for each rep as best as possible. There will be some error associated with this testing protocol since the spm was not always within the range specified.

Action items: Assign report sections along with poster sections.

SAMUEL SKIRPAN - May 01, 2022, 5:59 PM CDT

Date: 5/1/22

By: Sam

Correction: The spm was between 22-25 for this testing protocol, not between 20-25 spm

Testing Protocol for Displacement - 4/22/22

Dhruv Biswas - Apr 22, 2022, 12:34 PM CDT

Title: Testing Protocol for Displacement

Date: 4/22/22

Content by: Dhruv Biswas and Tim Tran

Present: Dhruv Biswas

Goals: Document the testing protocol that was made by Tim and I to quantify the displacement of the wheelchair and side handle bars while a subject is rowing. This was completed using Kinovea.

Content:

1. Obtain colored paper and tape. Use the paper to cut out two 1 inch by 1 inch squares. Tape one of the squares to the one of the handle bars. Should be on the side of it. The other square will be placed on the side handle bars.
2. Set up a camera which captures the entire side handle bar mechanism as well as the subject. Ensure that the two squares can easily be seen in the camera frame.
3. Direct the subject to row using a comfortable resistance setting for 30 seconds.
4. Record the 30 second duration on the camera.
5. Measure the top of the side handle bar so it can be used as a calibration curve for the Kinovea analysis (should be approximately 4 inches)
6. Transfer the video to Kinovea and place two tracking boxes onto the two squares.
7. Move the video frame by frame and ensure the trackers are still over the boxes. If not, readjust them to ensure that they are moving with the squares. Continue until finished with the video.
8. Once finished, play the video to ensure that the tracking is fully complete. A tracking motion should be presented by Kinovea.
9. Make a calibration line using the line tool by using the top of the side handle bar, set it at the appropriate measurement. Use a tape measure to obtain this measurement.
10. Make lines that correspond to the maximum displacement at the sites of the squares (wheelchair and side handle bar) and record these values.
11. Export the tracking data as a excel file and open it in excel.
12. Align each tracker at the top instead of following each other in the same column. Essentially, ensure that time 0 for each tracker is at the same row.
13. Transfer this data to Matlab and plot it.
14. Add legends and make a scale bar that is appropriate using the Kinovea analysis (step 10).

References: N/A

Conclusions: These basic steps were used to complete the displacement portion of the testing. This idea was originally made by Tim Tran, and I helped him to complete it. It resulted in capturing the displacement that takes place while rowing on the adapted side. Both pictures from Kinovea and Matlab were saved.

Action items: Start poster and final paper.

Fray Prevention Protocol

Cate Flynn - May 01, 2022, 7:05 PM CDT

Title: Fray Prevention Protocol

Date: 04/24/22

Content by: Cate

Present: Cate

Goals: Use a lighter to prevent the ends of the adjustable straps from fraying

Content:

Protocol for Fray Prevention:

1. Obtain a lighter and identify the adjustable straps the need prevention from fraying.
2. Take all four ends and hold the lit lighter and a one inch distance from the frayed end.
3. Once the flame is in contact with the fray, move the lighter left and right, careful to only just burn the material.
4. The completed straps are shown in Figure 1.

Figure 1: Strap end after exposed to lighter to prevent fraying

Conclusions/action items:

Complete fabrication of the support apparatus (spray painting) and begin testing.

Spray Paint Protocol

Cate Flynn - May 01, 2022, 6:57 PM CDT

Title: Spray Paint Protocol

Date: 04/24/22

Content by: Cate

Present: Cate

Goals: Spray paint the support apparatus for the adapted side of the rower

Content:

Protocol for Spray Painting:

1. Obtain sanding paper, two trash bags, black matte spray paint and an open grassy area.
2. Cut the trash bags along the long seams, enabling them to be opened to act and a tarp under the support apparatus in the open grassy area (seen under apparatus in Figure 3).
3. Take the sand paper and sand down any rough or jagged portions of wood (seen in Figures 1 and 2).
4. Once sanding is complete, remove the adjustable straps from the wooden arms.
5. Take the wooden apparatus out to the grassy area and place it on the open trash bags (Figure 3).
6. Apply the spray paint 6-10 in from the wood in a consistent, even manner.
7. Once the first coat of paint has dried (20 minutes), rotate the apparatus and apply a second coat of paint (Figure 4).
8. Once the second coat has dried (20 more minutes), transport the frame back inside and reinsert the adjustable straps.
9. Reinstall the support apparatus to the remainder of the rower once complete (Figure 5).

Figure 1: Sanding the top of the wood

Figure 2: Sanding the side of the wood

Figure 3: Initial spray paint on garbage bags in front of Mechanical Engineering

Figure 4: Second coat of spray paint

Figure 5: Completed support apparatus

Conclusions/action items:

Complete testing now that fabrication has been finished.

Rower Testing Survey Protocol

Tim TRAN - Apr 30, 2022, 11:57 PM CDT

Title: Rower testing survey

Date: 4/30

Content by: Tim

Present: Tim

Goals: Present the survey created to quantify the adaptive side rowing experience

Content:

Questions

1. Throughout the duration of the rowing, how much were your legs used for stability? OR Throughout the duration of the exercise, how much did you feel like you required the use of your legs for stability?

2. How stable did the wheelchair / you feel during the rowing? OR How secure did you feel in the wheelchair from tipping backward throughout the duration of the session?

3. How well did the adaptive side emulate the action of rowing? *minus the use of lower body

4. How intuitive was the adaptive side to use?

5. How easy did you find it to transform the rower from regular use to adapted use?

6. How would you compare the upper body workout you received on the adapted rower to the upper body workout you receive during a standard rowing session?

7. Did you experience any discomfort during use? If yes, please describe what you experienced.

8. Do you have any suggestions for the team? (Examples: ergonomics, material use, stability issues, etc.)

Questions 1-5 were answered with a linear scale from 1-5, 5 being the most and 1 being the least.

The survey was created in google forms and was given to users after they used both the standard and adaptive rower.

Conclusions/action items:

The team believes these eight questions will give us a good grasp of how users feel during their experience of adaptive rowing. Additionally, this survey should provide us with valuable information on how the prototype can be improved.

3/1/22 Measurements Of Rower

SAMUEL SKIRPAN - Mar 01, 2022, 9:52 PM CST

Title: Measurements Of Rower

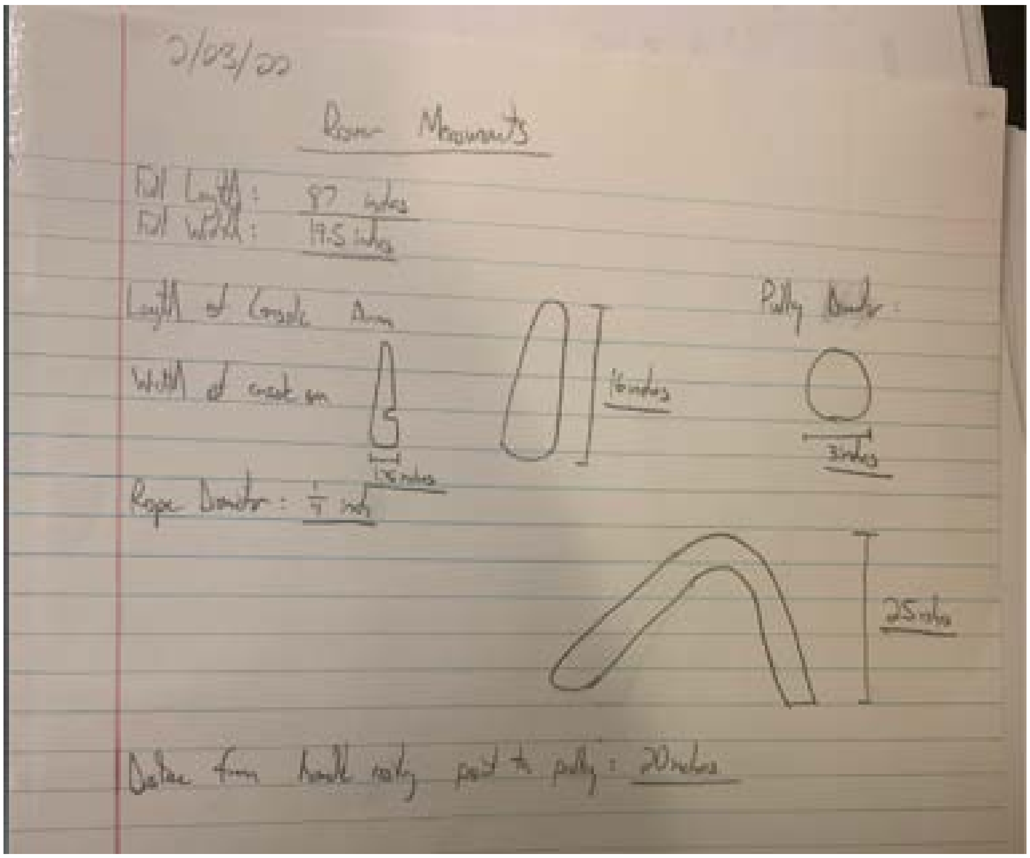
Date: 3/1/22

Content by: Sam

Present: Sam

Goals: Enter measurements of rower into notebook.

Content:

- 
    - This picture is of a couple of the measurements that I took of the rowing machine
- Measurement:
    - Full length: 87 inches
    - Full width: 19.5 inches
    - Console arm
        - Length: 16 inches
        - Width (at bottom): 1.75 inches
    - Pulley diameter: 3 inches
    - Height of support: 25 inches
    - Distance from handle resting point to the pulley: 20 inches
    - Rope diameter: .25 inches

Conclusions/action items:

These are the main measurements that we will need for the rowing machine.

Action items: Work on sourcing materials and begin fabricating.

4/19/2022 - Simulation Testing of Geometry and Strength of Pulley Support Plates

Josh ANDREATTA - Apr 21, 2022, 10:07 PM CDT

Title: Simulation Testing of Geometry and Strength of Pulley Support Plates

Date: 4/19/2022

Content by: Josh Andreatta

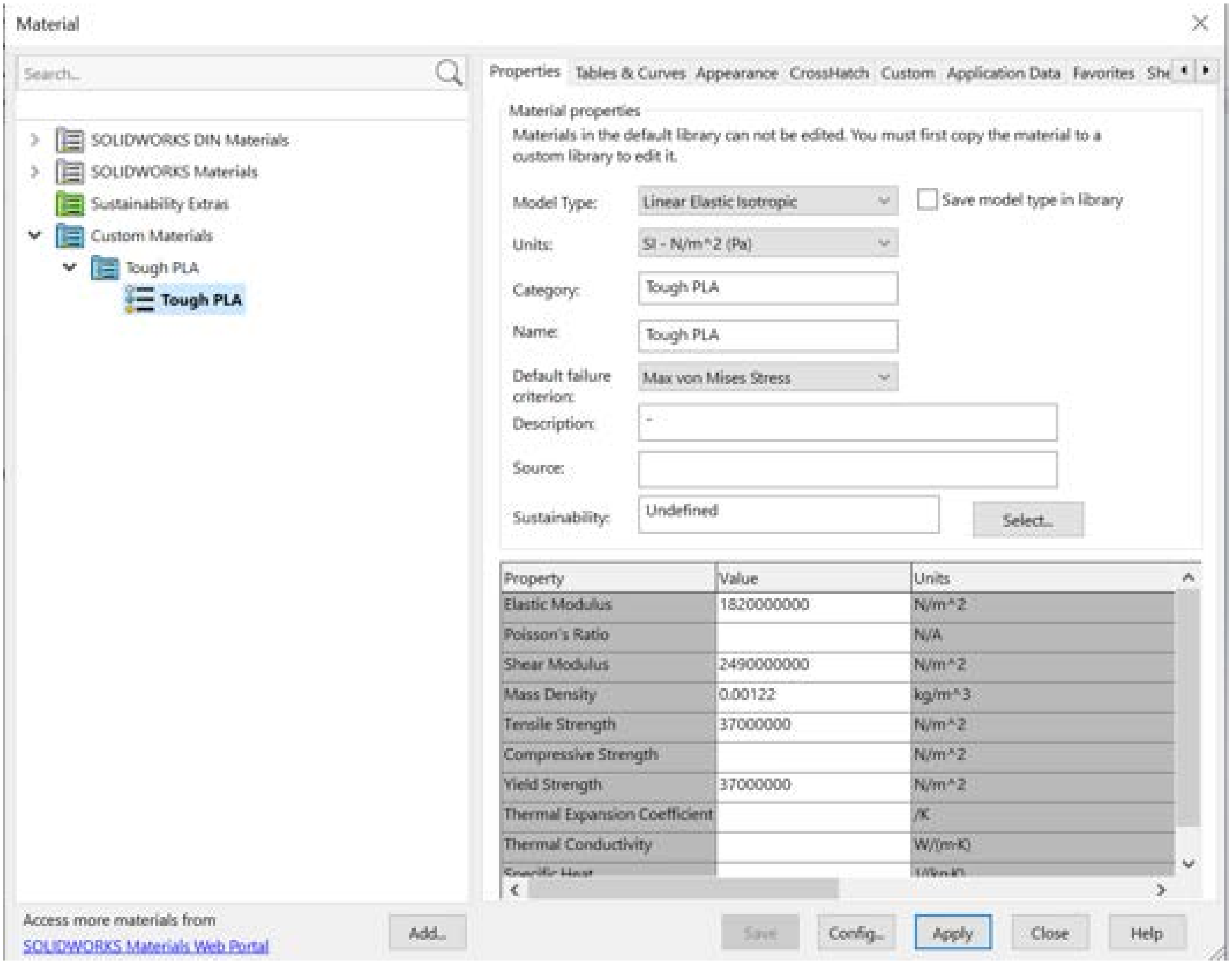
Present: Josh Andreatta

Goals: Show simulation images and describe peak deflections, stresses, and areas of stress concentrations

Content:

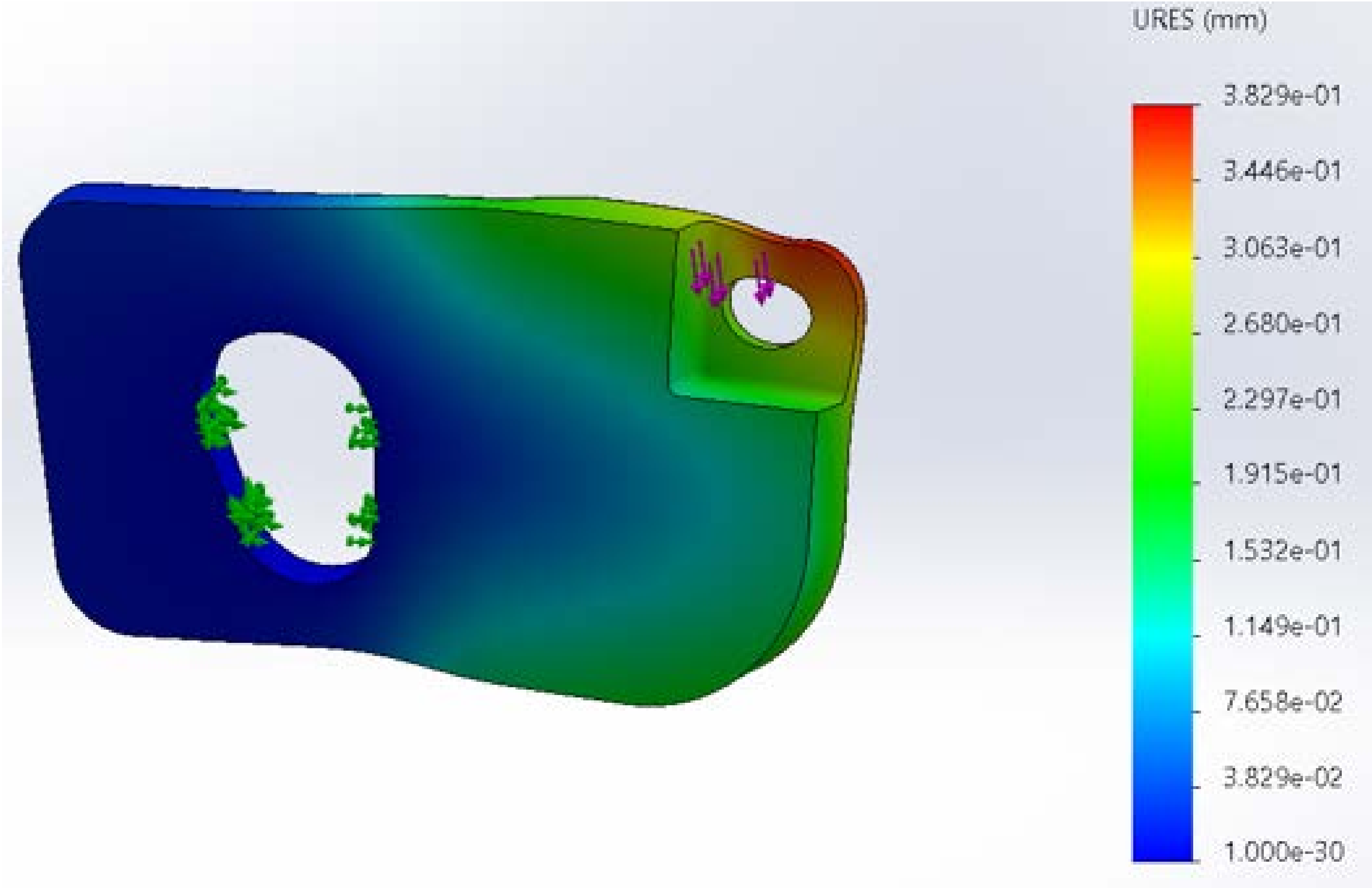
In order to test the strength of material and geometry chosen for the pulley plates, I ran a SolidWorks Simulation force test on each of the pulley support plates. To make sure the material in the simulation was similar to the actual material we used, I used the technical data sheet from Ultimaker (the printer I used) for Tough PLA (the material I used) and made my own SolidWorks material using the mass density (1.22g/cm^3), yield and tensile stress (37MPa each), shear modulus (2490MPa), and tensile modulus (1820MPa). To properly run the simulation to mimic the actual loading on the rowing machine, I fixed the interior cavity surface that slips onto the rower neck support arms, which is denoted by the green arrows below in all the images. To properly assess the force, I ran two different tests. The first I ran was using a safety factor of 2, which placed 1050 N load inside the surface that the plate slips onto the pulley bearing, as this is the location where the directed load form rowing would be applied. From prior research in previous entries, it was found that the maximum force that can be typically generated while rowing is 1050 N. Ideally, this force would be split evenly across the two pulley support plates. However, to asses worst case scenario, I modeled the safety factor test as each pulley plate receiving the total 1050 N load straight down. This wouldn't actually happen because the user will pull the rope parallel to the ground, not perpendicular and straight down towards the ground. Thus, this is the worst case scenario. The second test I ran used the ideal loading conditions where this 1050 N is distributed evenly across the two pulley plates, with each receiving a 525 N load directed downward, again on the surface that sits on the pulley bearing. Below are images of the SolidWorks images of the stresses and displacements developed for each pulley plate under each of these loading conditions, and showing the inside and outside surface of the plate, since they are not geometrically identical.

As shown by the images below, despite very minor deformations occurring at the application site of the force (<1mm), the team is confident that these can be seen as negligible. This is because that inner surface which is being deformed will have a solid metal bearing within it, which will help to absorb some of the applied force and prevent deformation of the Tough PLA plate at that location. Thus, the metal bearing helps reduce the effect of the applied load. A deformation of 1mm is an acceptable amount of deformation because it will not be enough to actually break the plate nor cause it to tip or move while on the rowing machine itself.

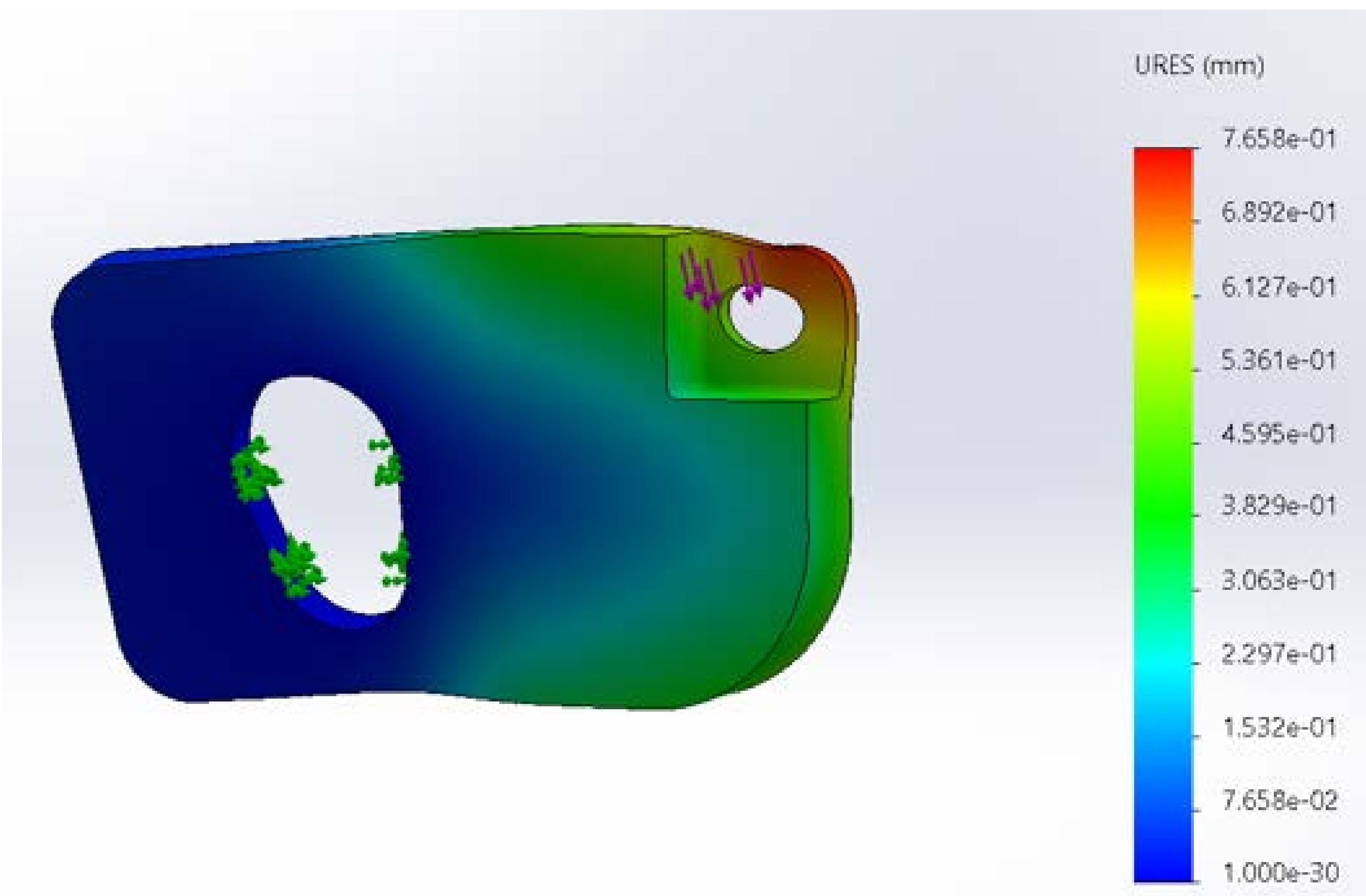


The above image shows the material specifications used to try to mimic Tough PLA according to the Ultimaker Technical Data Sheet for Tough PLA.

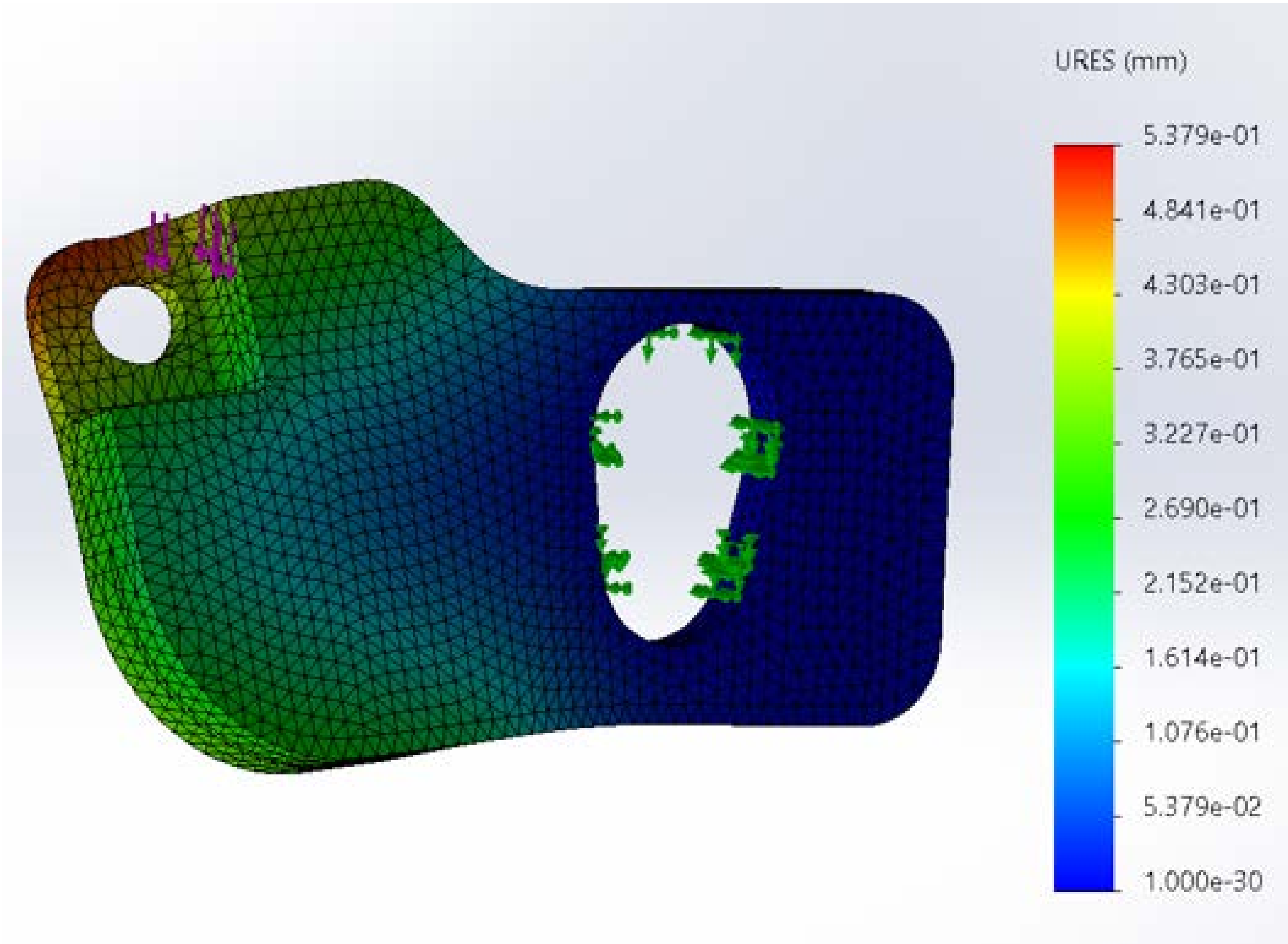
OUTSIDE SURFACE: Defined as the surface facing towards the outside of the rowing machine.



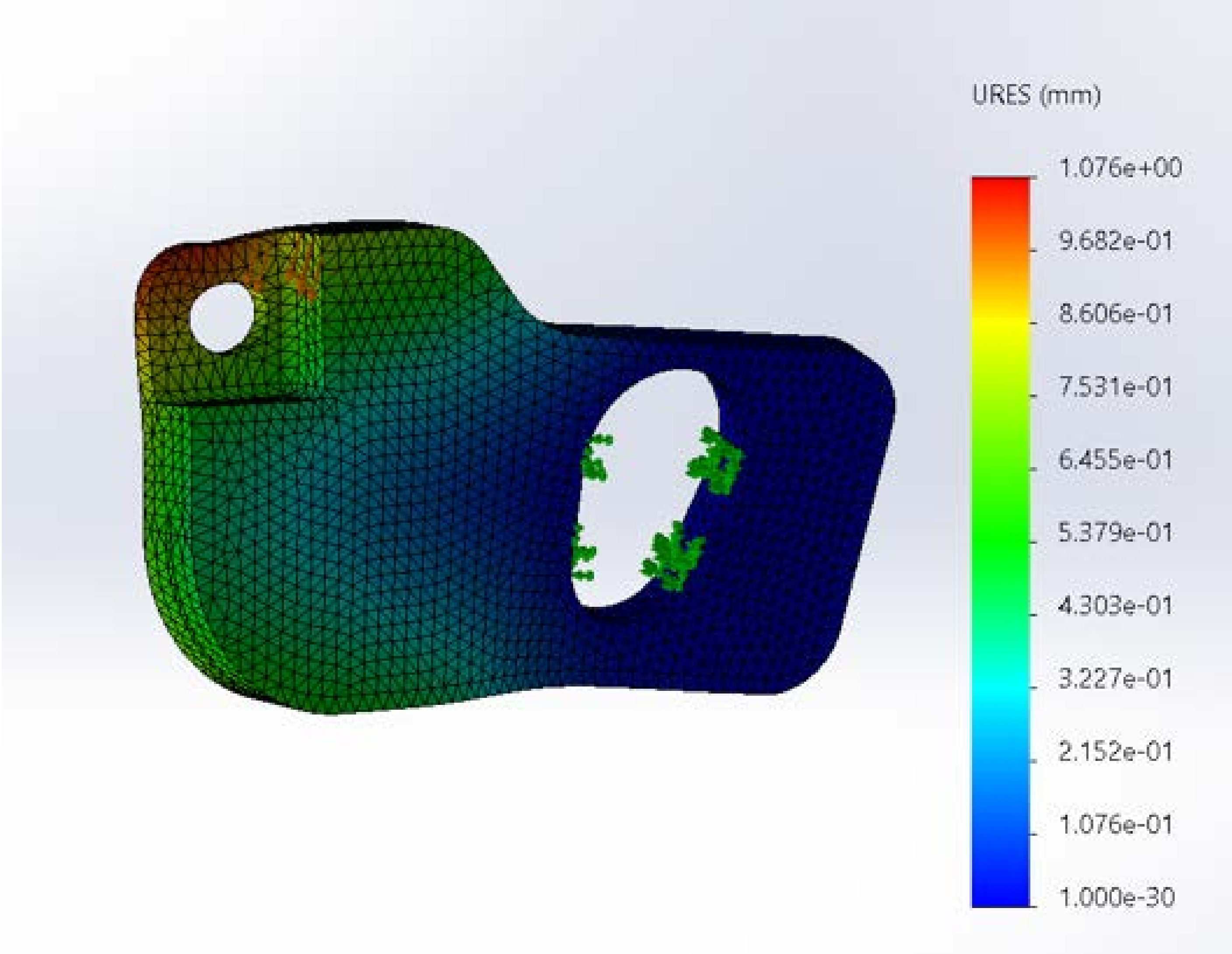
The above image shows the displacement data on the outside of the left pulley plate under ideal 525 N load. The maximum deformation occurred at the site of application of the load and was only 0.3829mm, which is incredibly small.



The above image shows the displacement data on the outside of the left pulley plate under a safety factor of 2 of 1050 N load. The max deformation occurred at the site of application of the load and was only 0.7658mm, which is very small. The proximal portion of the plate undergoes even smaller deformations on the order of 0.4mm, which can be seen as negligible.

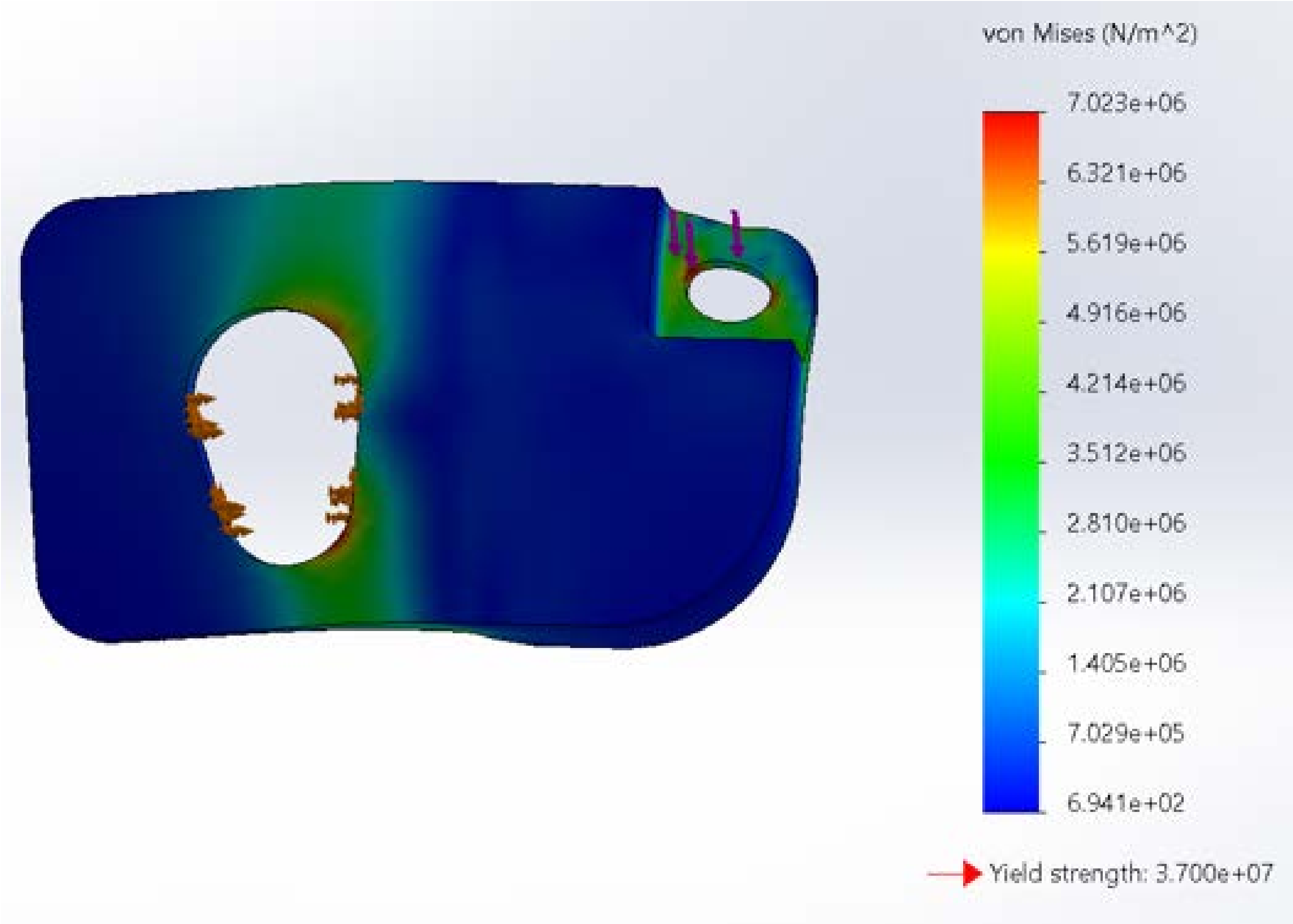


The above image shows the displacement data on the outside of the right pulley plate under ideal 525 N load. The max deformation occurred at the application site of the load and was only 0.5379mm, which is incredibly small.

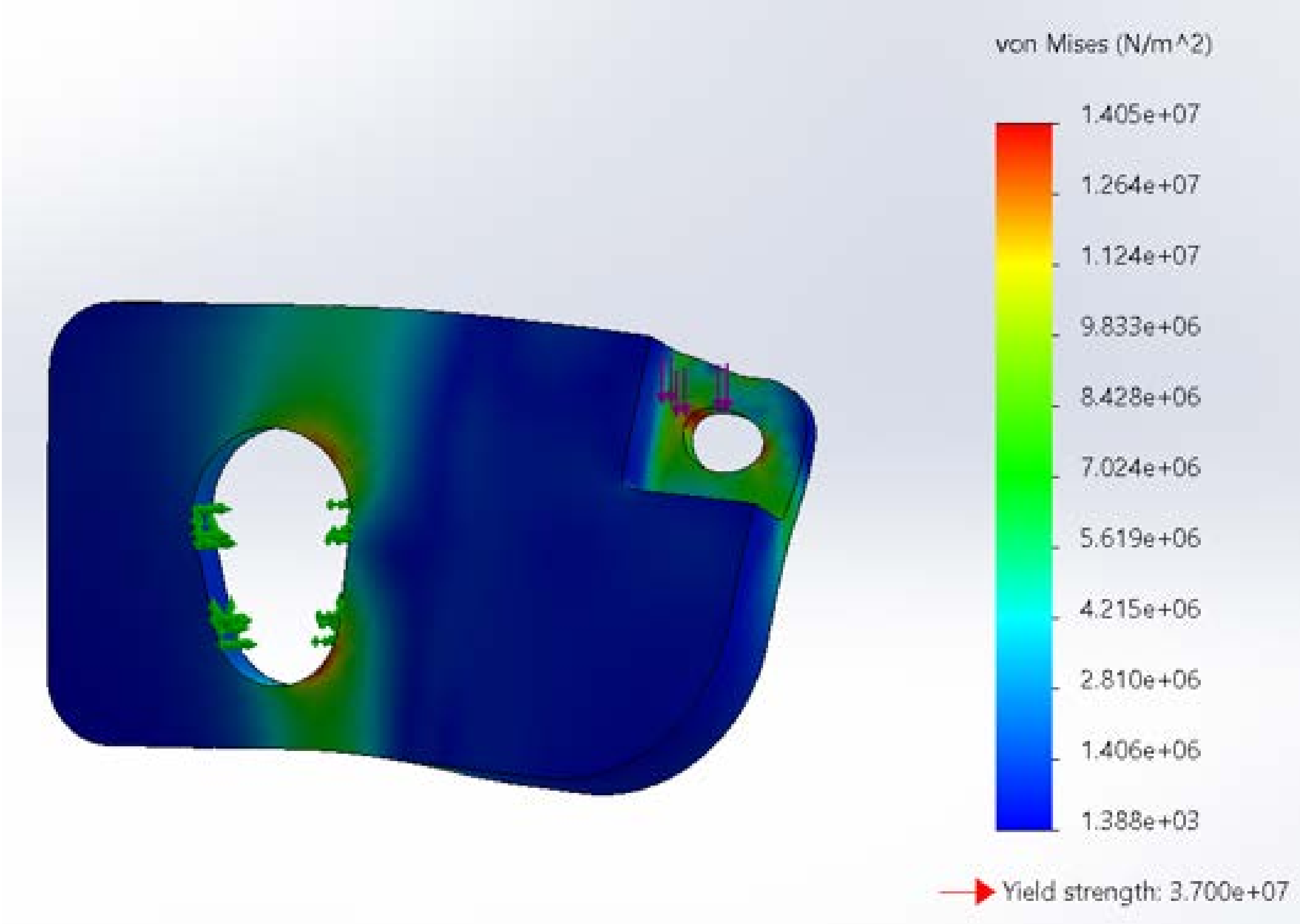


The above image shows the displacement data on the outside of the right pulley plate for a safety factor of 2 of 1050 N load. The max load was developed at the site of application of the load and was 1.076mm, which is the largest deformation between the 2 plates. However, since the metal pulley bearing will be within that cavity, it will help reduce the affect of the loading and thus reduce the observed deformations.

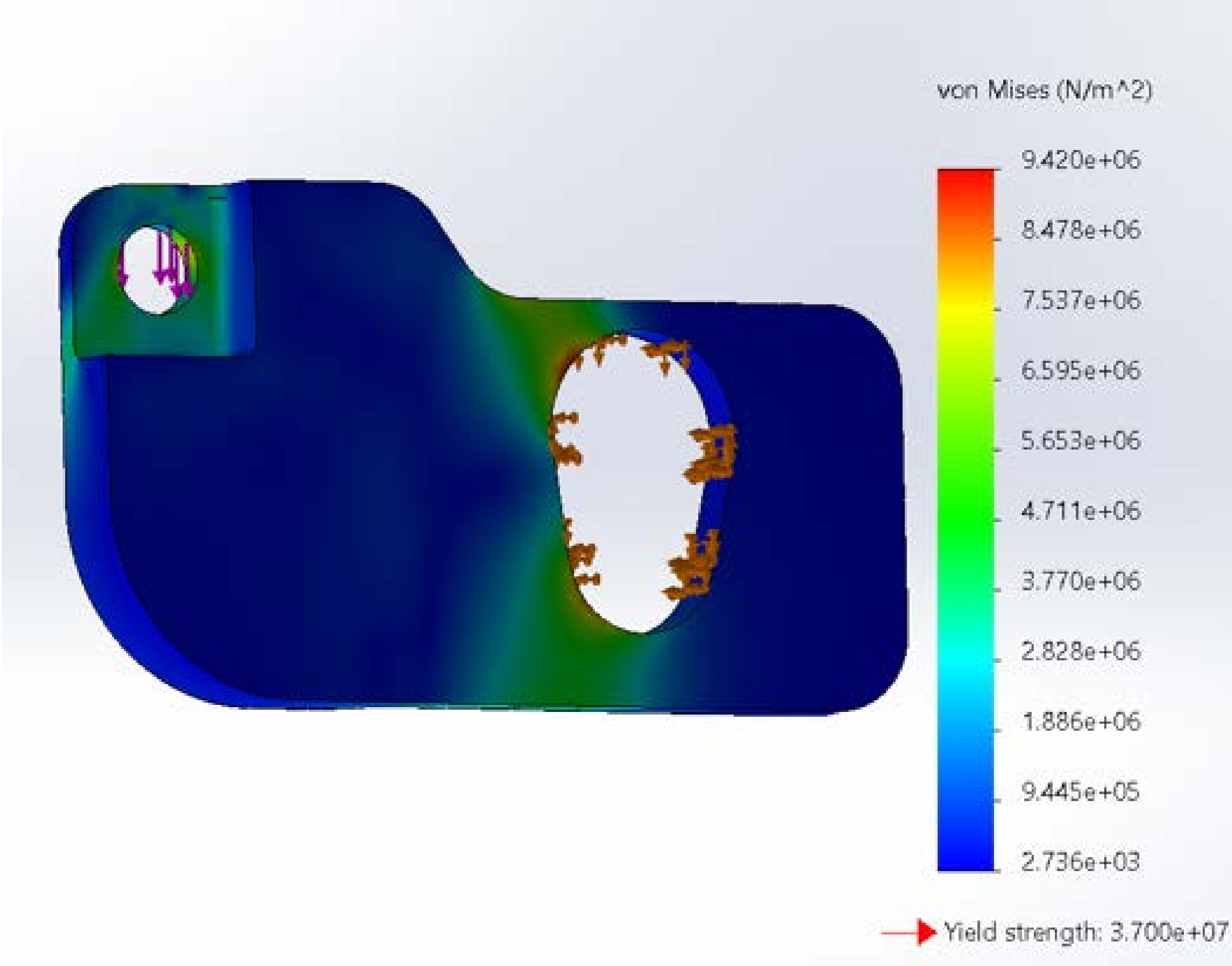
Overall, we can see that the max deformations for each plate under ideal and max loading conditions occurs at the site of application of the force and is less than 1mm of deformation. Thus, the choice to use Tough PLA with this geometry should provide a support plate that is strong enough to withstand the typical loads applied during rowing motions.



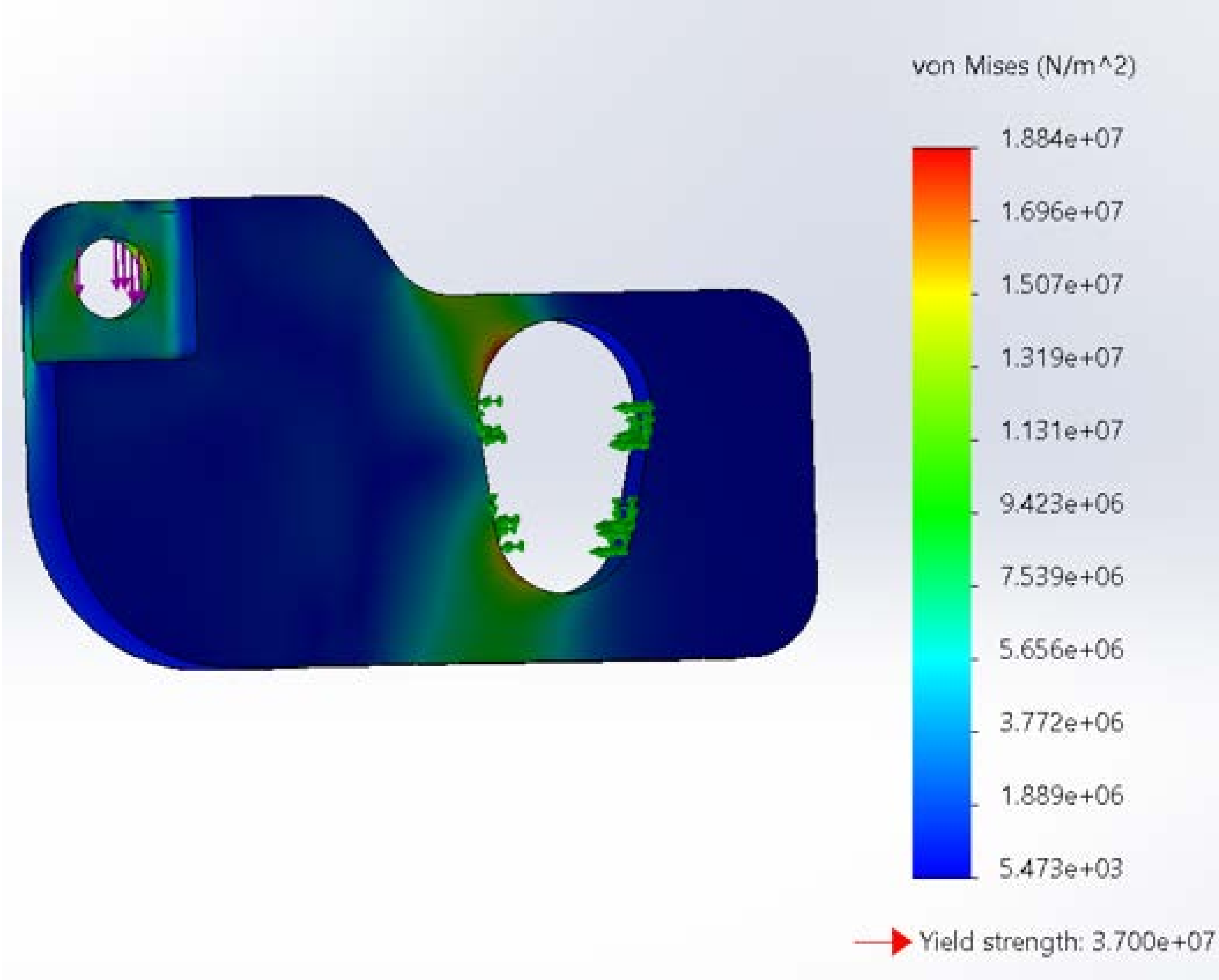
The above image shows the stress on the outside of the left pulley plate for ideal 525 N load.



The above image shows the stress on the outside of the left pulley plate under a safety factor of 2 of 1050 N load.



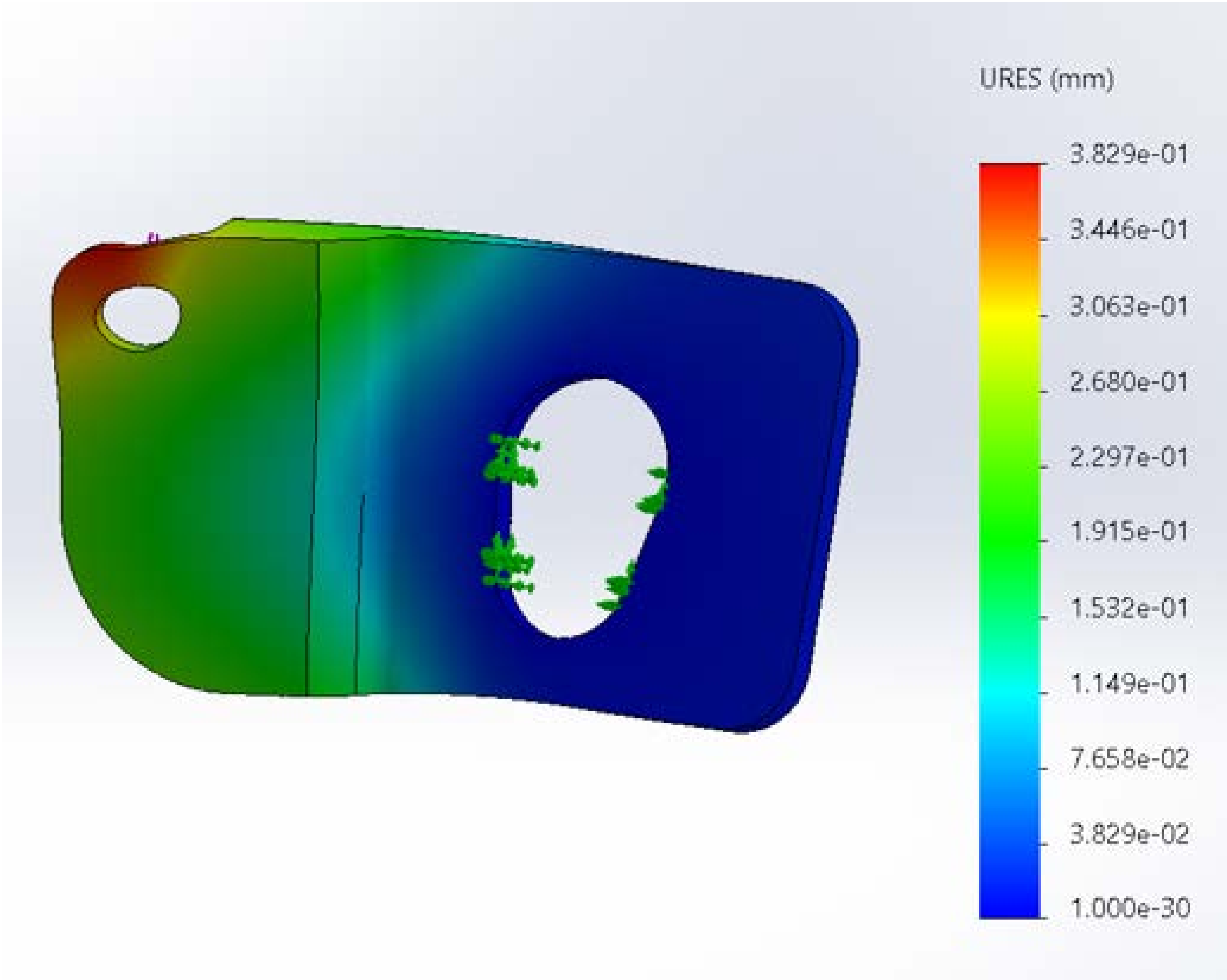
The above image shows the stress on the outside of the right pulley plate for an ideal 525 N load.



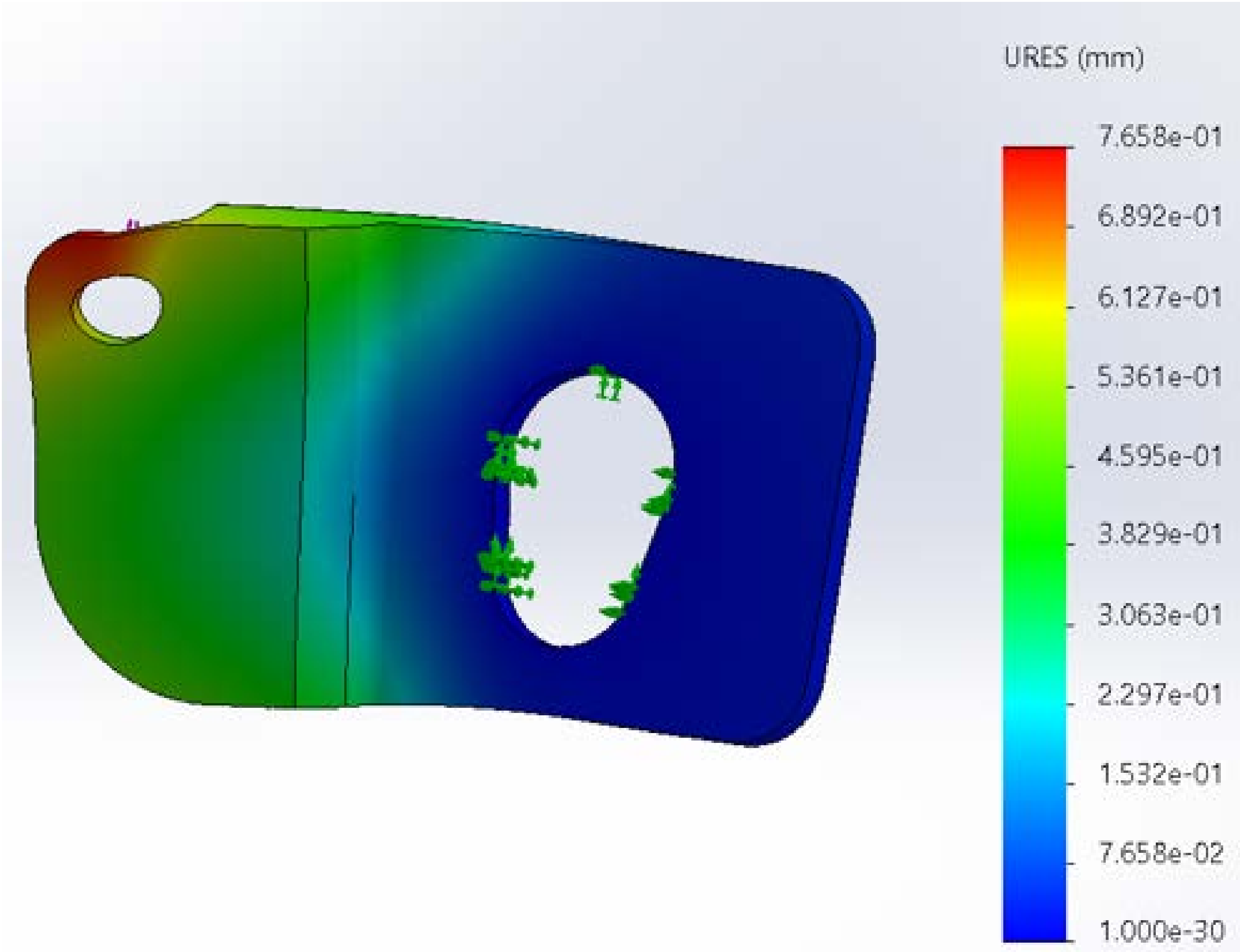
The above image shows the stress on the outside of the right pulley plate under a safety factor of 2 of 1050 N load.

As seen by the previous 4 images above of stress under ideal and max loading conditions, stress concentrations appear both around the application site of the force and around the top edges of where the plate is held fixed. This is because these are the two weakest points in the geometry of the plate and offer the least protection against developed stresses. The maximum stress that was developed was for the right pulley plate under max loading conditions. It makes sense that the right pulley developed more stress, because it has some material removed from the top edge (to allow the user to transition the rope from the standard to adapted side through the slit in the rower neck), which then reduces the structural integrity of the plate. However, despite this, the stress developed was around19MPa, which is 18MPa less than the yield stress. Thus, even under worst case loading conditions, the plate should be expected to remain rigid and not crack or fail.

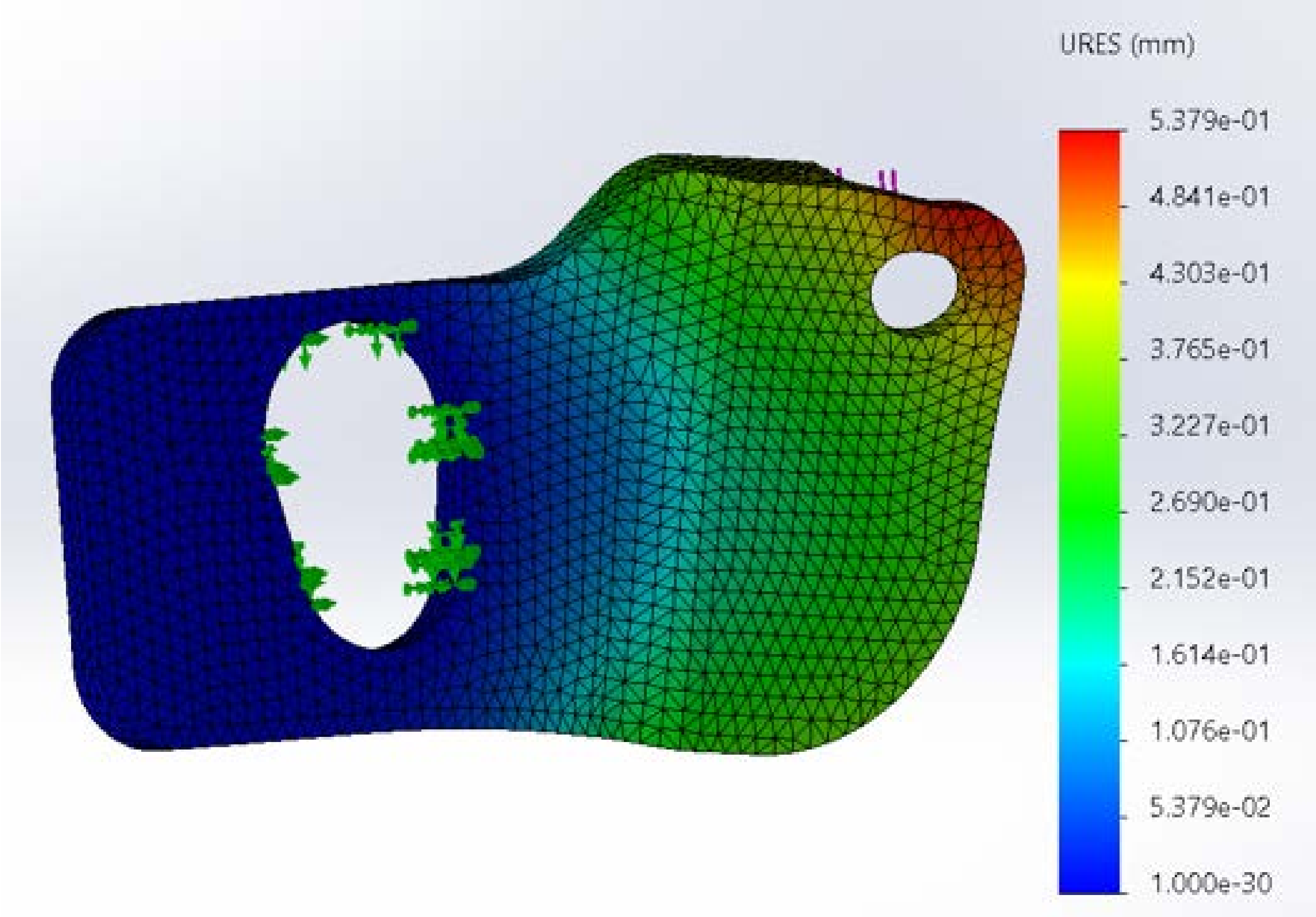
INSIDE SURFACE: Defined as surface facing inward towards the outside surface of the rower neck.



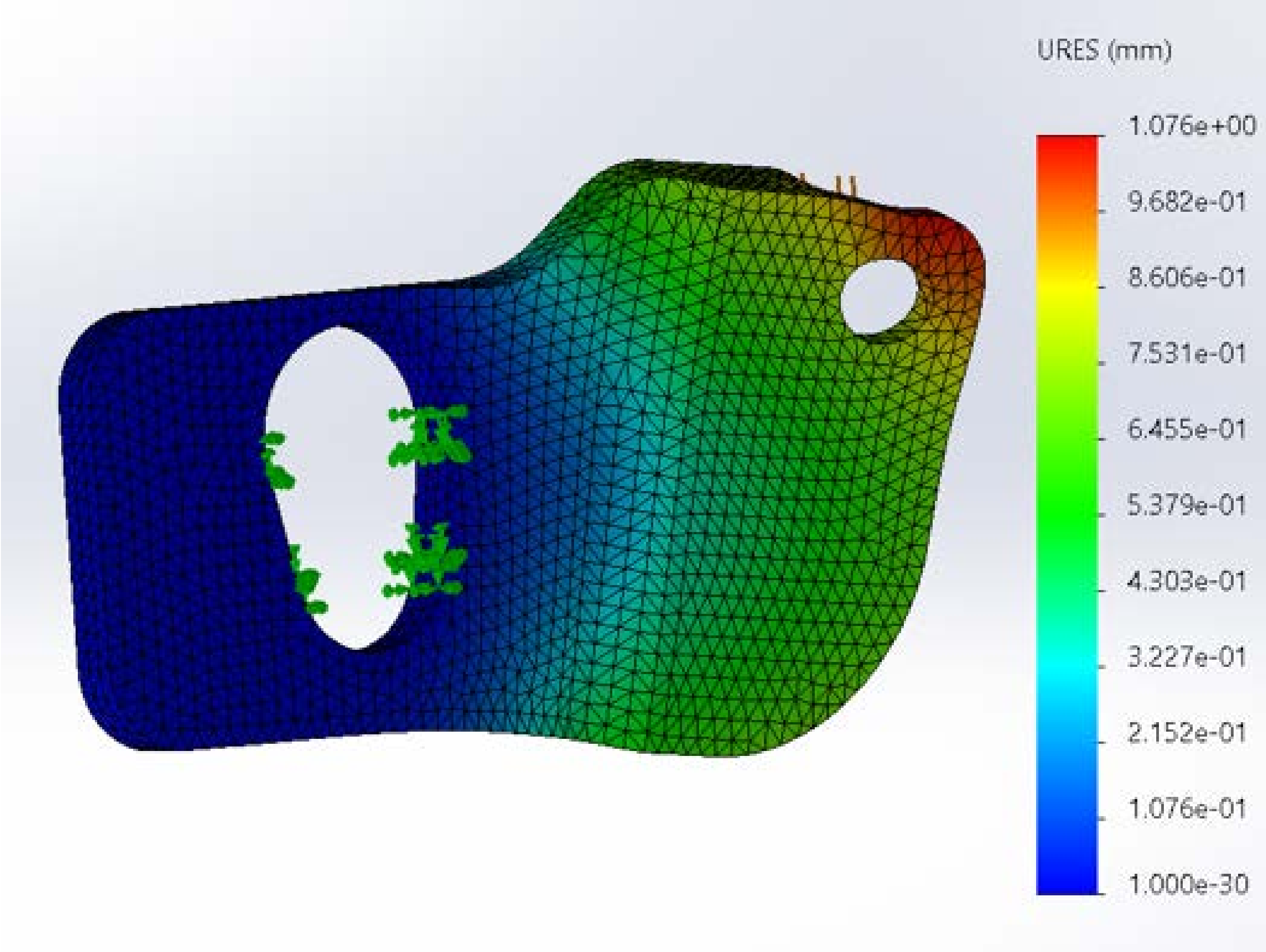
The above image shows the displacement data on the inside of the left pulley plate under ideal 525 N load.



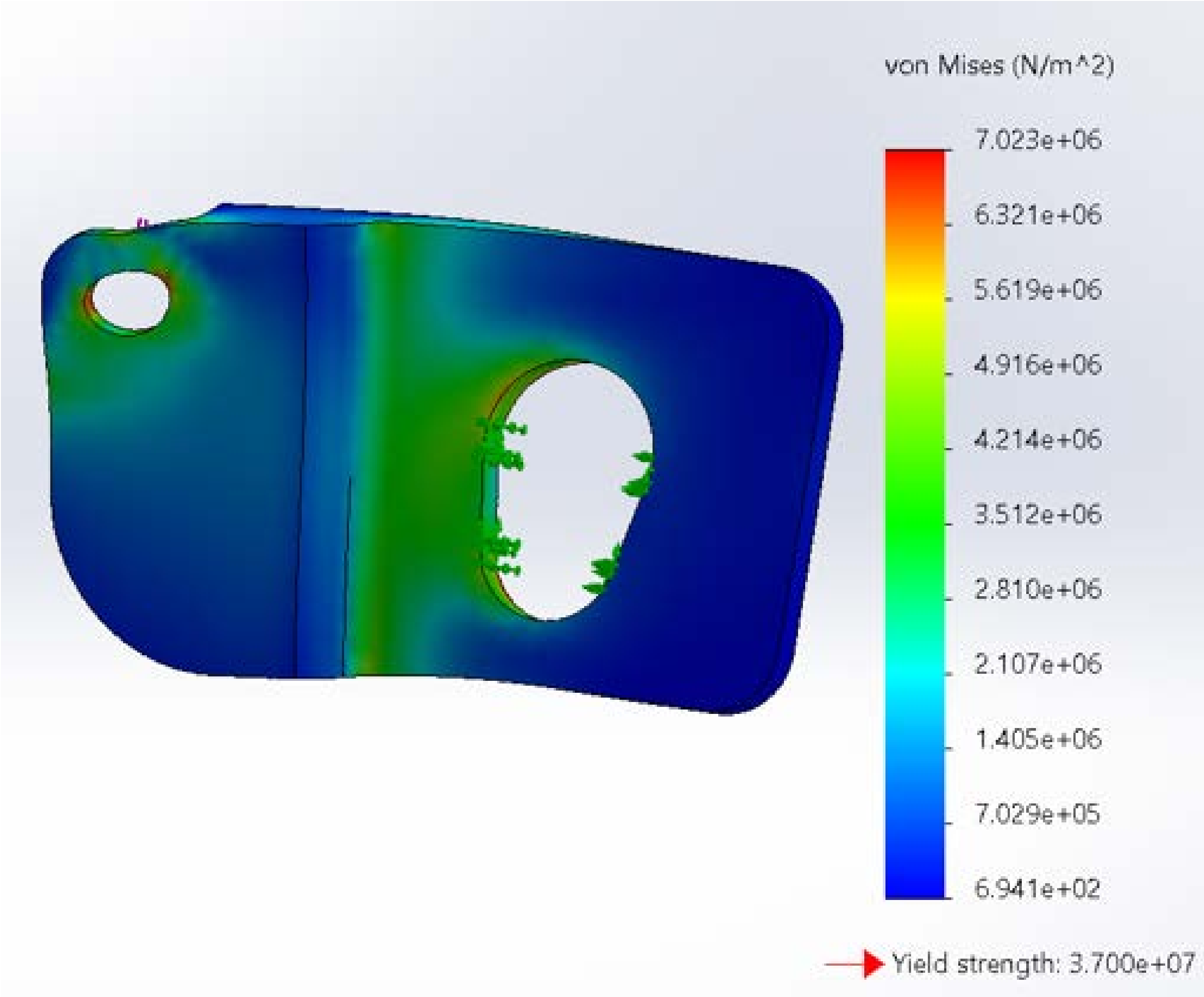
The above image shows the displacement data on the inside of the left pulley plate under a safety factor of 2 of 1050 N load.



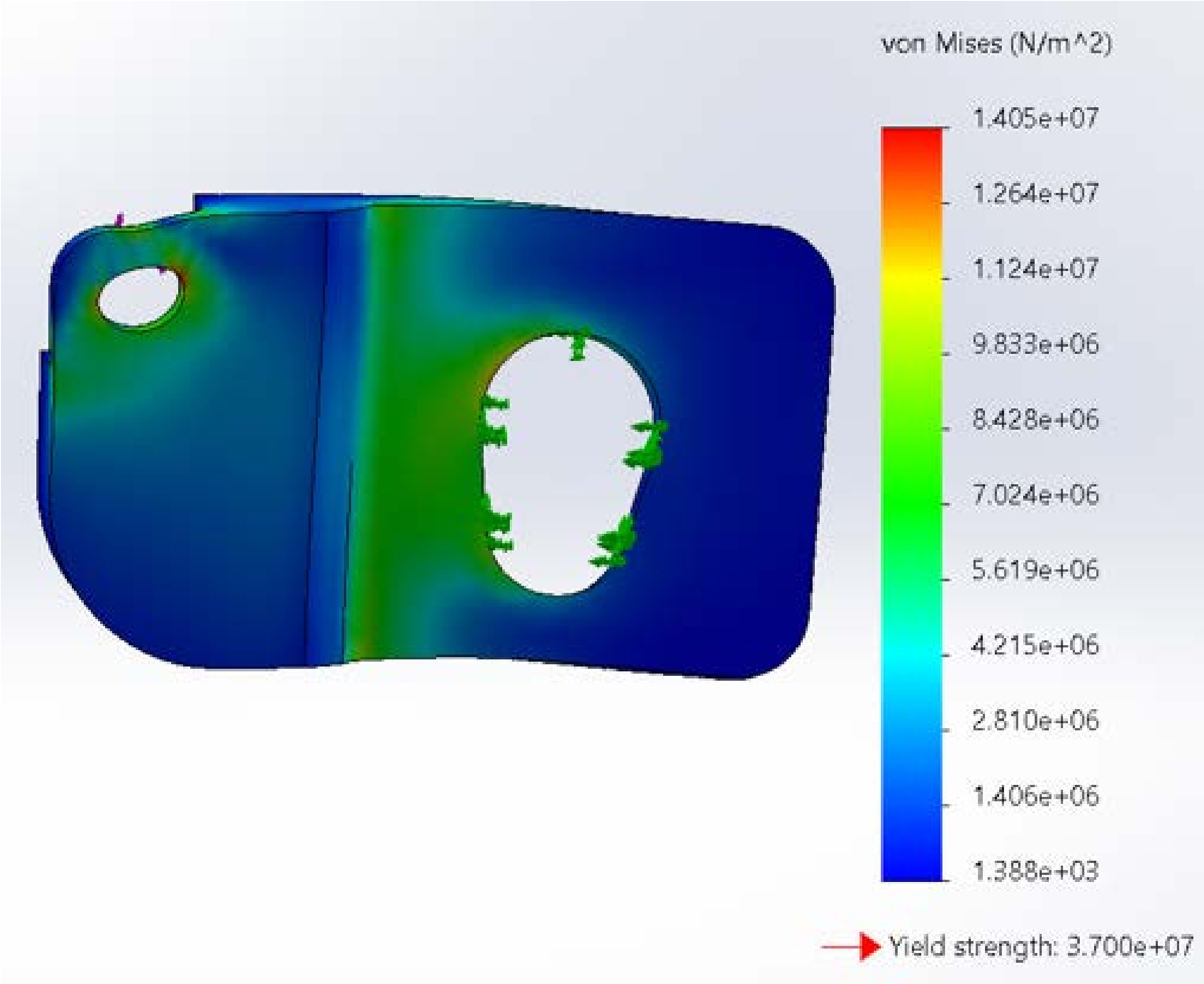
The above image shows the displacement data on the inside of the right pulley plate under ideal 525 N load.



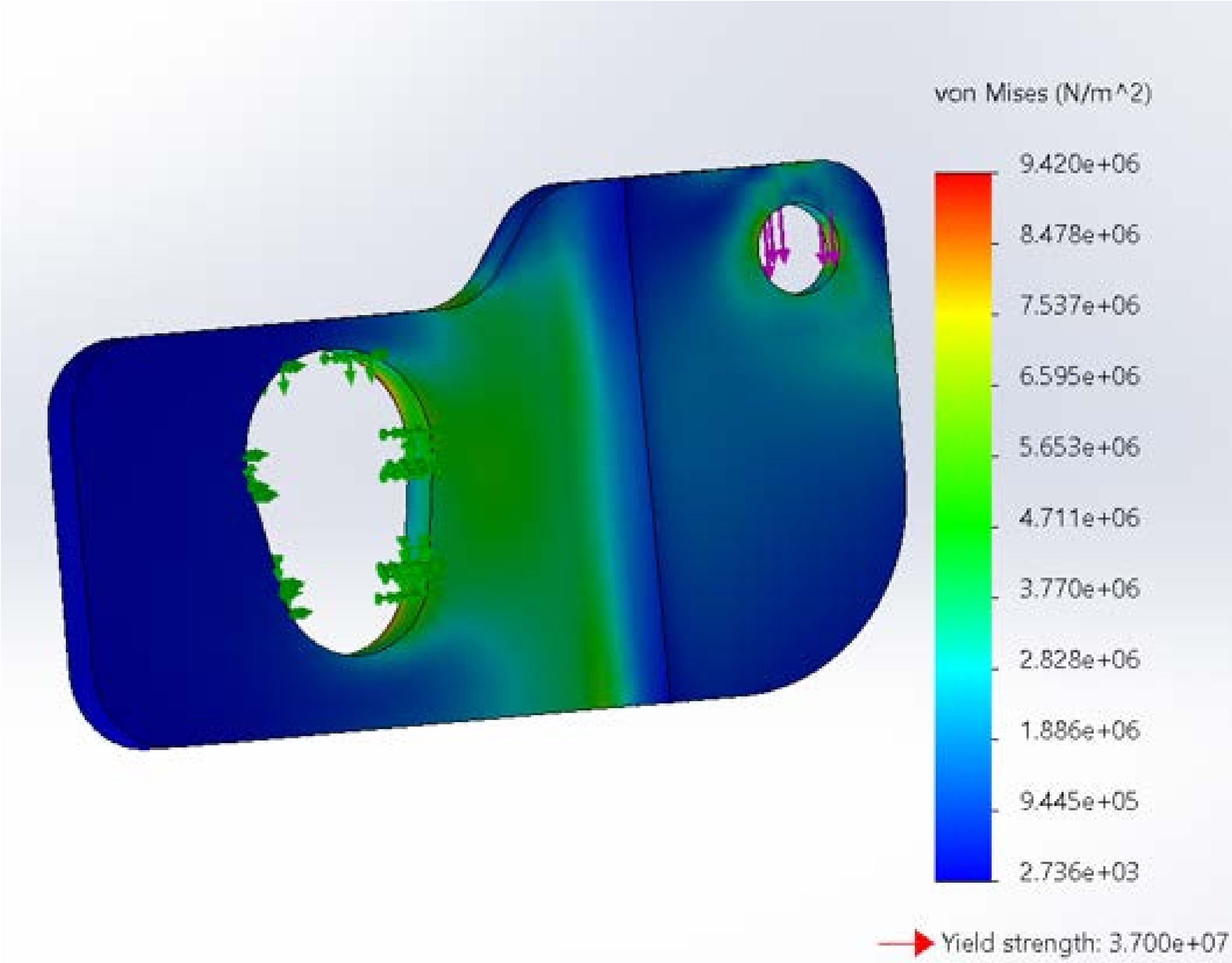
The above image shows the displacement data on the inside of the right pulley plate for a safety factor of 2 of 1050 N load.



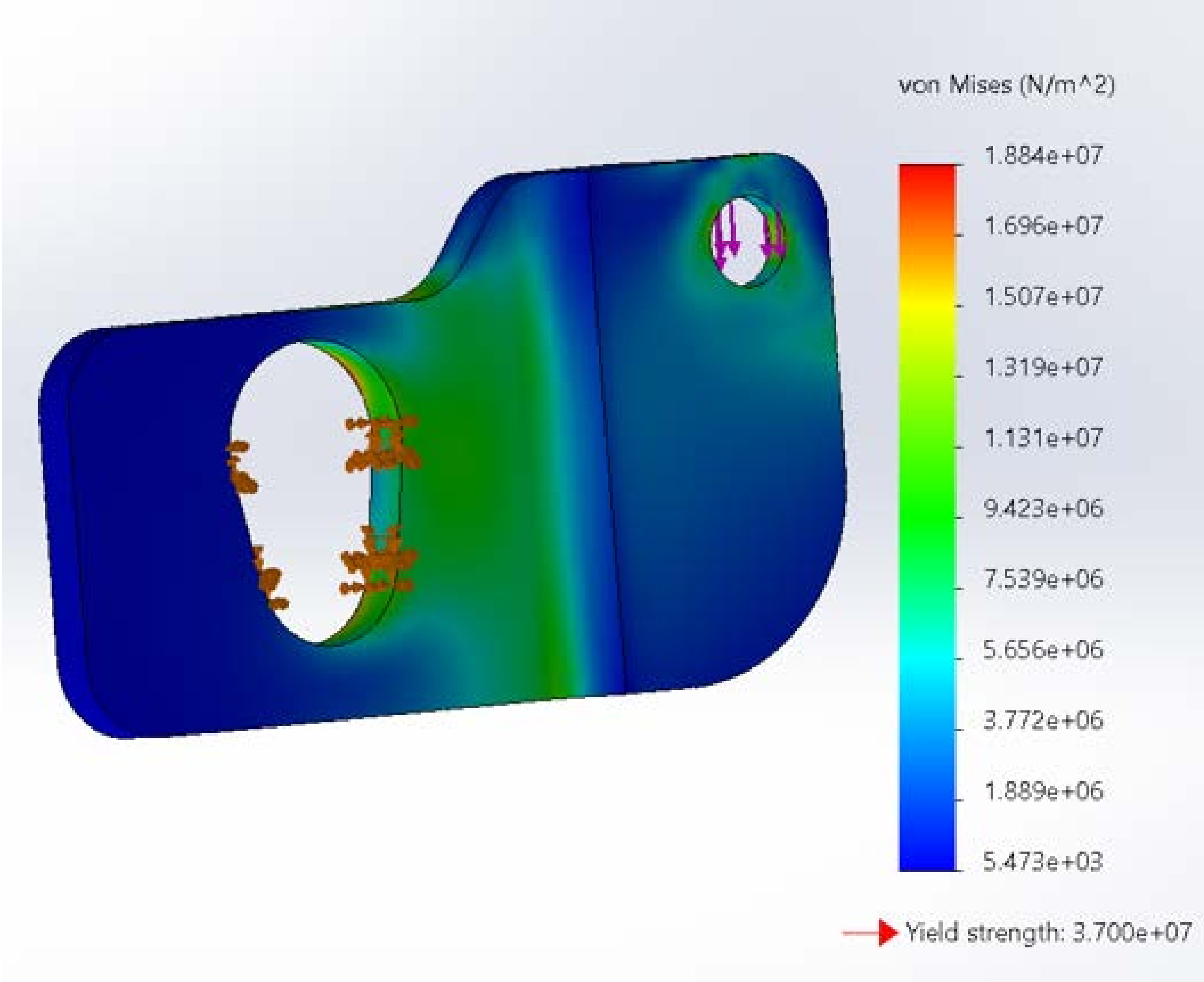
The above image shows the stress on the inside of the left pulley plate for ideal 525 N load.



The above image shows the stress on the inside of the left pulley plate under a safety factor of 2 of 1050 N load.



The above image shows the stress on the inside of the right pulley plate for an ideal 525 N load.



The above image shows the stress on the inside of the right pulley plate under a safety factor of 2 of 1050 N load.

The above images show the same data as previously described, but show the inside surface of the plate. Basically, all this shows is that in the fillet/chamfer where the plate curves inward, some stresses and deformations will develop, but not enough to adversely affect the integrity of the support plates.

To further enhance the rigidity of these plates, when printing, I used a 90% infill so that the plates are almost entirely solid Tough PLA, with little gaps between the layers. This will improve the performance under high loading conditions.

References:

"Ultimaker Tough Pla TDS – Ultimaker Support." [Online]. Available: https://support.ultimaker.com/hc/en-us/articles/360012759599-Ultimaker-Tough-PLA-TDS. [Accessed: 19-Apr-2022].

https://support.ultimaker.com/hc/en-us/articles/360012759599-Ultimaker-Tough-PLA-TDS

Conclusions:

Overall, the SolidWorks Simulation shows that the material of choice and geometry chosen for the pulley support plates are more than equipped to withstand the max load with a safety factor of 2. Thus, we are confident that these plates will be able to endure the stresses and forces transmitted to them on the rower from the rower itself and from the rope during rowing motions.

Action items:

-Print Second Swivel Design tomorrow morning

-Assemble rower tomorrow afternoon

-Make plan for testing

-Test Thursday

-Begin poster on friday and over weekend

Josh ANDREATTA - Apr 21, 2022, 10:07 PM CDT


Simulation of Pulley Support Plate

Table of Contents

Description

No Data

[Download](#)

Right_Pulley_Support_Plate_Safety_Factor.docx (1.5 MB)

Josh ANDREATTA - Apr 21, 2022, 10:07 PM CDT

[Download](#)

Right_Pulley_Support_Plate_Ideal.docx (1.5 MB)

Josh ANDREATTA - Apr 21, 2022, 10:07 PM CDT

[Download](#)

Left_Pulley_Support_Plate_Safety_Factor.docx (1.37 MB)

Josh ANDREATTA - Apr 21, 2022, 10:07 PM CDT


Simulation of Pulley Opposite Support Plate Attempt

Table of Contents

Description

Download

Left_Pulley_Support_Plate_Ideal.docx (1.37 MB)

Josh ANDREATTA - Apr 21, 2022, 10:07 PM CDT


Technical data sheet Tough PLA

Ultimaker

Filament specifications

Color information

Download

TDS_Tough_PLA.pdf (72.3 kB)

4/22/22 Matlab Testing Data Analysis

Cate Flynn - May 01, 2022, 6:49 PM CDT

Title: Matlab Testing Data Analysis

Date: 04/22/22

Content by: Cate

Present: N/A

Goals: Plot the data for rowing force testing

Content:

I analyzed the acquired force versus resistance level data in order to determine the relationship between resistance level and maximum force generated during rowing. I wrote this script in MATLAB to analyze the data by creating arrays of the maximum force generated (in pounds) on each side as well as the resistance level each force was accomplished under. From here, I used the convforce() function to convert the pound force to newtons. Finally, I plotted the x arrays against the newton data for the standard and adapted sides and added titles, colors, markers, and size to each plot as well as axis titles, a legend and a title for the plot. This plot is included below (Figure 1). From here, to establish a clearer trend in the data, I created box plots for each side at each resistance levels (six box plots total). I created these plots by breaking the newton data into three arrays (one for each resistance level) for each side. After this, I used the ' command to invert the combined array and then created the box plots shown in Figure 2. Analysis of these results can be found in the following entry "Implications of Matlab Data".

MATLAB Script:

clear all

close all

x1 = [1 1 1 1 1 1 1 1 1 1 5 5 5 5 5 5 5 5 5 5 10 10 10 10 10 10 10 10 10 10]

adaptedPounds = [35 38 37 38 42 36 39 41 38 42 45 48 46 43 46 47 44 43 46 50 62 58 56 60 57 62 61 57 61 59]

x2 = [1 1 1 1 1 1 1 1 1 1 5 5 5 5 5 5 5 5 5 5 10 10 10 10 10 10 10 10 10 10]

standardPounds = [32 35 39 37 40 39 37 38 41 37 60 56 54 62 63 57 58 55 61 56 78 87 88 76 75 76 74 77 74 74]

adaptedNewtons = convforce(adaptedPounds,'lbf','N')

```
standardNewtons = convforce(standardPounds,'lbf','N')


plot(x1,adaptedNewtons,'DisplayName','Adapted Side', 'Color','r', 'Marker','.', 'LineStyle','none', 'MarkerSize',30)

hold on

plot(x2,standardNewtons,'DisplayName','Standard Side', 'Color','k', 'Marker','.', 'LineStyle','none', 'MarkerSize',30)

hold off


set(gca,"XGrid","off","YGrid","on")

xlabel("Resistance Level", "FontSize",20)

ylabel("Force Generated (N)", "FontSize",20)

title("Force Generated During Rowing ", "FontSize",24)


xlimit = [1 5 10]

set(gca, 'XTick', (xlimit))


legend("show", "FontSize",14)

legend("Position",[0.1479,0.73049,0.32097,0.12805])


aN1 = [adaptedNewtons(1:10)]

aN5 = [adaptedNewtons(11:20)]

aN10 = [adaptedNewtons(21:30)]


sN1 = [standardNewtons(1:10)]

sN5 = [standardNewtons(11:20)]

sN10 = [standardNewtons(21:30)]


x = [aN1; sN1; aN5; sN5; aN10; sN10]

xfinal = x'
```

```
figure

boxplot(xfinal)

set(gca,'XTickLabel',{'Adapted 1','Standard 1','Adapted 5','Standard 5','Adapted 10','Standard 10'}, 'fontsize', 12)

xlabel("Resistance Level", "FontSize",20)

ylabel("Force Generated (N)", "FontSize",20)

title("Force Generated During Rowing ", "FontSize",24)
```

MATLAB Plots)

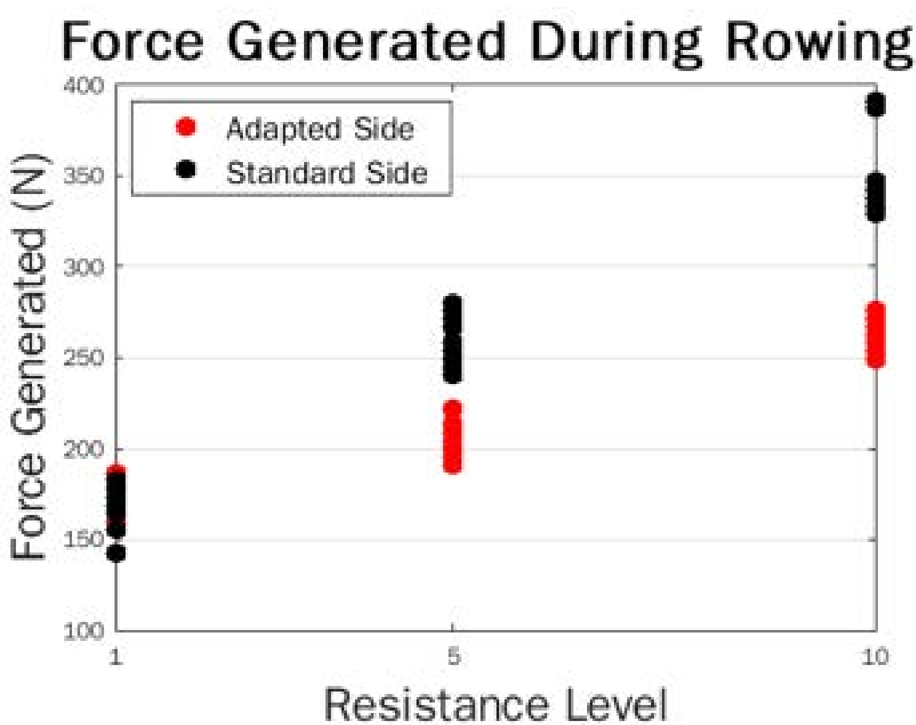


Figure 1: Maximum force generated during rowing for each side for three different resistance levels

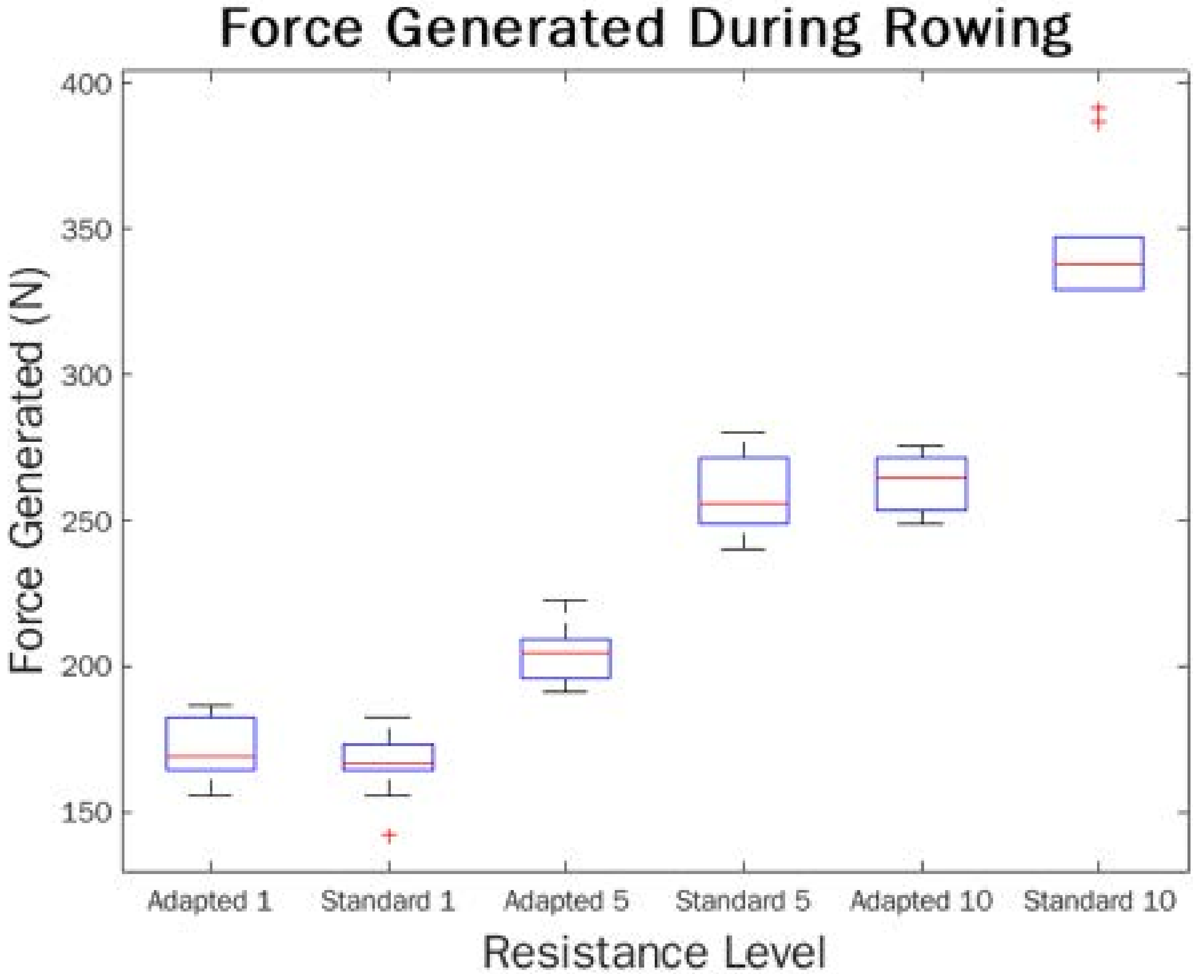


Figure 2: Box plot of maximum force generated during rowing for each side for three different resistance levels

Conclusions/action items:

Include this information in our final poster presentation

Implications of Matlab Data

Cate Flynn - May 01, 2022, 6:51 PM CDT

Title: Implications of MATLAB Data

Date: 05/01/22

Content by: Cate

Present: N/A

Goals: Analyze the implications of the data collected in MATLAB

Content:

In order to evaluate the force developed on the adaptive and standard side while rowing, ten maximum force measurements were taken on each side for three different resistance levels (1, 5, and 10). In order to standardize the maximum force developed, the rower tried to maintain a stroke rate of 22 to 25 strokes per minute during each rowing session. Videos were taken during the rowing in order to slow the footage and accurately capture the maximum force developed per each stroke. The team member rowing held a 45 kg or 100 lb spring gauge to measure the force. The results of this testing were plotted in MATLAB and included in the figure below.

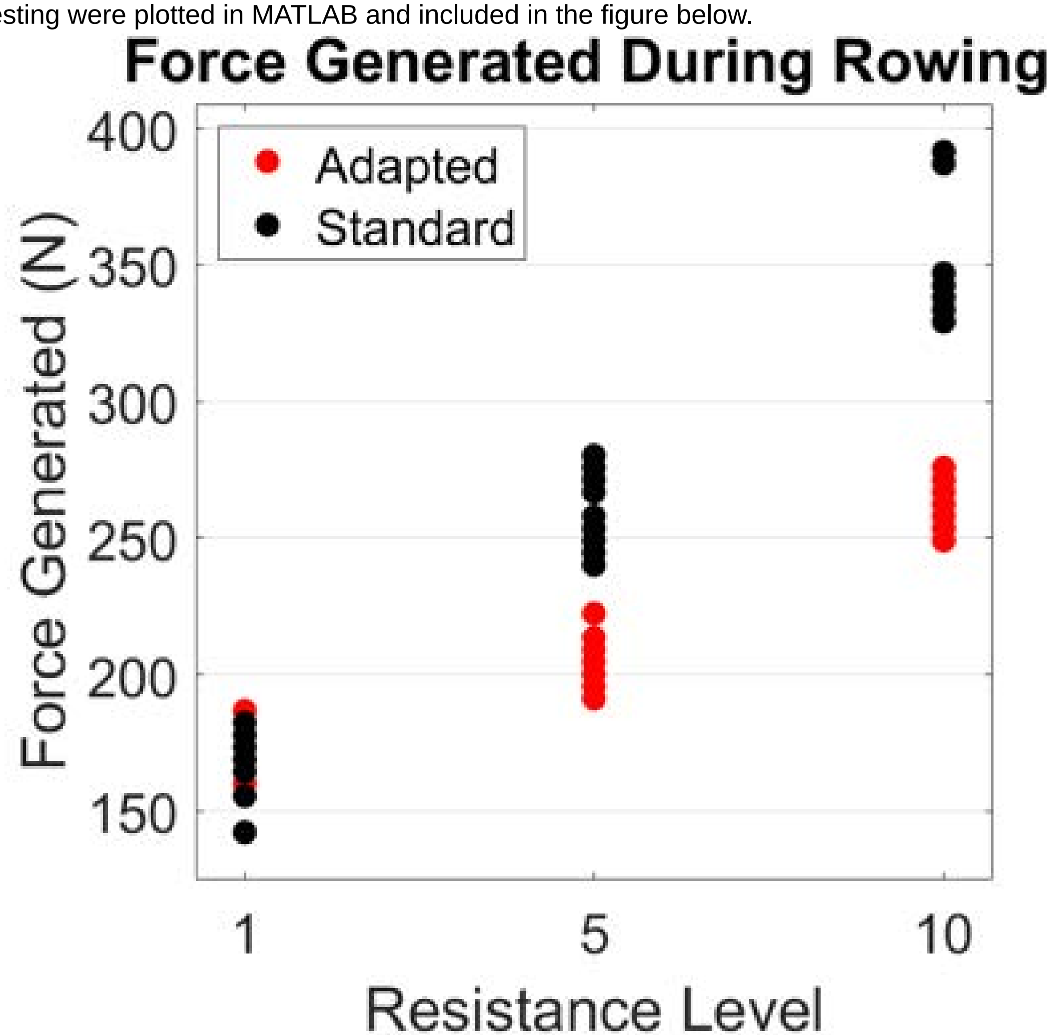


Figure 1) Force Generated During Rowing The force generated during rowing on each side plotted against the resistance level was taken ten times for resistance levels of 1, 5, 10. More force was generated on the standard side, but the overall force generated increased at each resistance level.

The figure shown below demonstrates the general increase in force generated as resistance level increases. Less force is developed on the adapted side as seen in red. This can be explained by the smaller distance generated on the adapted side while rowing. Without the use of their legs, an adapted user can not generate the same amount of tension and therefore force as a standard user. However, the general increase in force generated shows that the workout can be tailored on the adapted side as well as the adapted side by changing the resistance level.

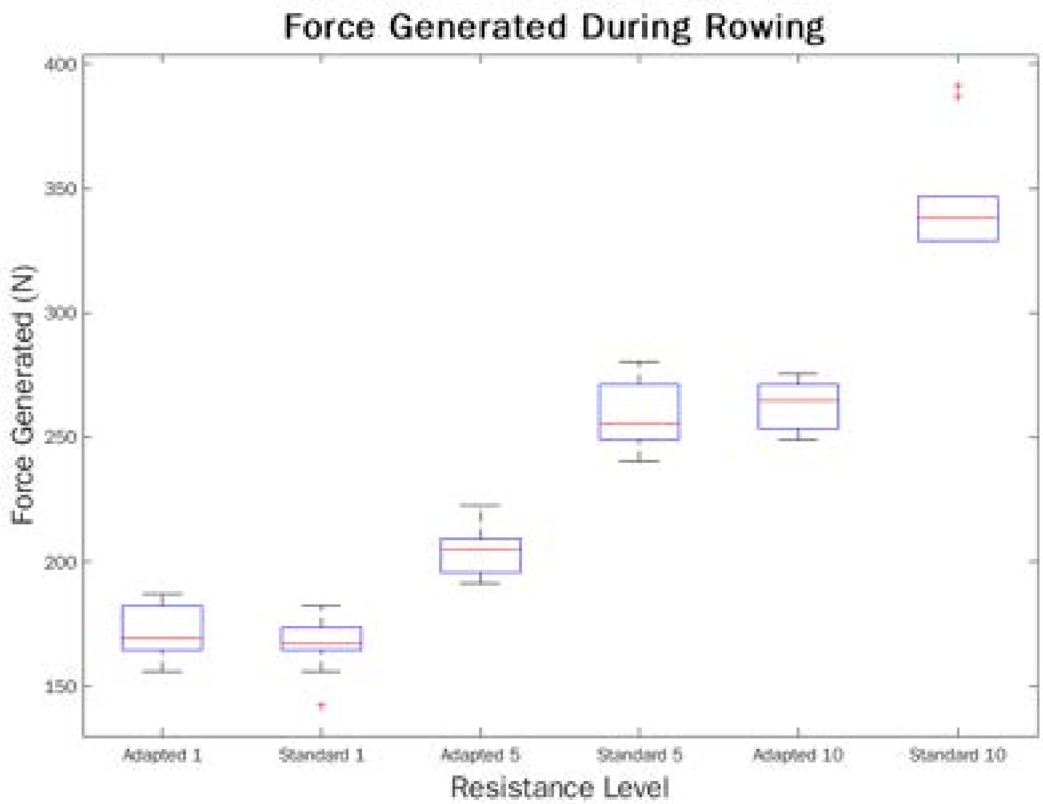


Figure 2) Box Plot of Force Generated During Rowing The box plot for the rowing conducted at resistance levels of 1, 5, 10 demonstrates the general increase in force generated for each resistance level. The red asterisks indicate outliers in the ten data points for each side at each resistance level.

Figure 2 shows the same data in box plot form. The averages for each mode of rowing increase with the resistance level, again demonstrating the capability to tailor the workout on each side. In the future, testing the adapted side with wheelchair users will provide valuable insight into the force an adapted user can create and will ensure the elimination of inaccuracies due to the use of the user's legs. The spring gauge will also be connected directly to the cord when testing in the future in order to make the data collection more accurate.

Dhruv conducted a paired sample t-test of the force generated during rowing. The implications of this data is discussed below.

Paired Sample T-Test)
Resistance 1:

Data Summary			
	A	B	Total
n	10	10	20
ΣX	386	375	761
ΣX^2	14952	14123	29075
SS	52.4	60.5	118.95
mean	38.6	37.5	38.05

Results

$Mean_a - Mean_b$	t	df	P		
				one-tailed	0.1231655
1.1	+1.24	9		two-tailed	0.246331

Resistance 5:

Data Summary			
	A	B	Total
n	10	10	20
ΣX	386	375	761
ΣX^2	14952	14123	29075
SS	52.4	60.5	118.95
mean	38.6	37.5	38.05

Results

$Mean_a - Mean_b$	t	df	P		
				one-tailed	0.1231655
1.1	+1.24	9		two-tailed	0.246331

Resistance 10:

Data Summary			
	A	B	Total
n	10	10	20
ΣX	593	779	1372
ΣX^2	35209	60931	96140
SS	44.1	246.9	2020.8
mean	59.3	77.9	68.6

Results

$Mean_a - Mean_b$	t	df	P		
				one-tailed	<.0001
-18.6	-8.82	9		two-tailed	<.0001

The p value of the t-tests for resistance levels five and ten demonstrate that there is a statistical difference between the force generated on the standard and adapted side. This demonstrates that the greater increase in tension correlates to a greater discrepancy between force developed on the standard and adapted side with more force being generated on the standard side as a result of the increased resistance and tension.

Conclusions/action items:

Include these results and this discussion in the final report.

Rower Testing Survey Results

Tim TRAN - Apr 30, 2022, 11:32 PM CDT

Title: Survey Results

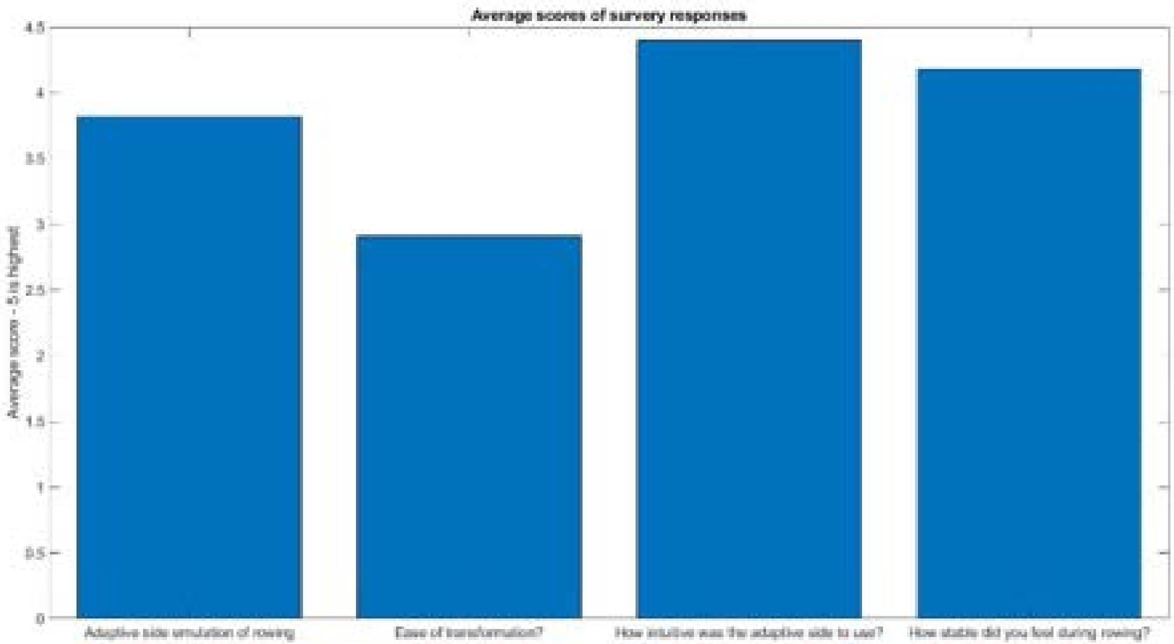
Date: 4/30

Content by: Tim

Present: Tim

Goals: Present the summary of survey responses

Content:



This is the graphical representation of the survey responses for questions 2-5. I did not graph question 1 because I thought the stability question encompassed question 1, so it would be repetitive to graph both.

The feedback was geared towards stability; many testers wanted some sort of chest stability like a seat belt or bar, as they felt like they were being pulled from the wheelchair. Testers thought the adaptive side was intuitive to use, and the adaptive side emulated the rowing motion well.

Conclusions/action items:

The ease of transformation between the adaptive side received the lowest marks from users. Therefore improvements to this aspect of the design as well as the implementation of a chest stability mechanism should be the main focus of the future work.

Statistics and Updated Kinovea (Results) - 4/23/22 (Copied to team notebook on 5/1/22)

Dhruv Biswas - May 01, 2022, 7:12 PM CDT

Title: Statistics and Updated Kinovea

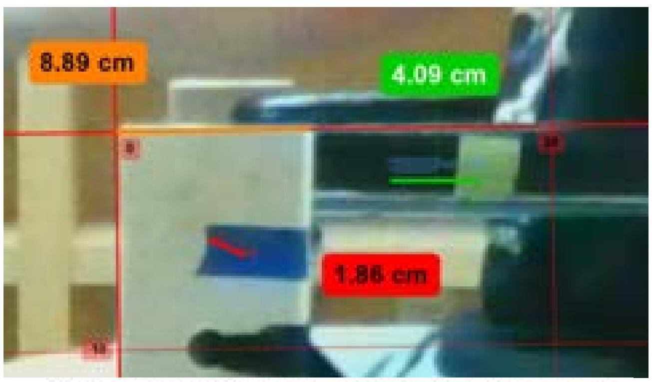
Date: 4/23/22

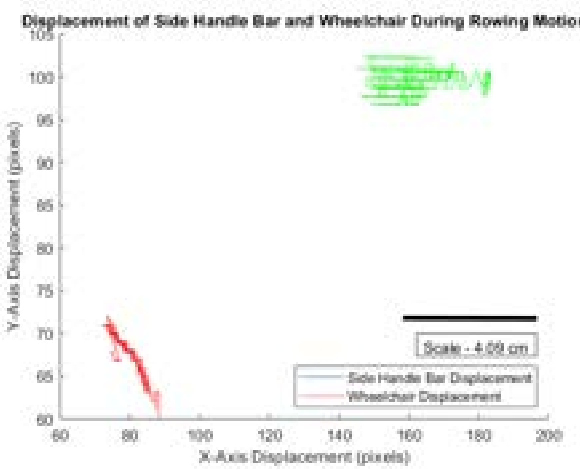
Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document the updates to Kinovea and why I chose the Paired Sample T-Test

Content:

- **Update to Kinovea was needed to an incorrect calibration line. The calibration line was changed from 4 in to 3.5 inches. Additionally all units were changed to SI, therefore the units are now cm for displacement. The final results are below:**
- 



    - **Additionally, Dr. Puccinelli advised that the two images should have some sort of correlation between the similar parts. For example, the two wheelchair displacements should be the same color. The same for the side handlebars. This change has also been made. Arrows might be used in the final report and poster for further clarity.**
- **For the statistics for the Force Tension data, I decided to move forward with a Paired Sample T-Test for the 1, 5, and 10 resistance groups. The standard and adapted sides were compared to see if the mean force necessary to complete rowing machines were the same on both sides under varying resistance groups.**
    - **Paired sample t test because the same subject was used to complete rowing for standard and adapted sides for each resistance groups. Therefore, a correlation could be present and Paired Sample T-Test would be the appropriate test to use.**
- **A p value of 0.05 was used. If the two tailed p value is smaller than 0.05 then the group can reject the null hypothesis and conclude that the mean tension required is significantly different between the adapted and standard side.**

- **A two tailed P-value was used because the mean could be higher or lower between each of the two groups. It would be one tailed if the expected mean was directional (higher or lower). But the team did not want to assume that one side required less or more force because ideally they output equal forces.**
- **Final Results (Done on VassarStats): Significant differences in means for groups 5 and 10, but not for 1.**
- **Resistance 1:**

Data Summary

	A	B	Total
n	10	10	20
$\sum X$	386	375	761
$\sum X^2$	14952	14123	29075
SS	52.4	60.5	118.95
mean	38.6	37.5	38.05

Results

$Mean_a - Mean_b$	t	df	P		
1.1	+1.24	9		one-tailed	0.1231655
				two-tailed	0.246331

- **Resistance 5:**

Data Summary

	A	B	Total
n	10	10	20
$\sum X$	458	582	1040
$\sum X^2$	21020	33960	54980
SS	43.6	87.6	900
mean	45.8	58.2	52

Results

$Mean_a - Mean_b$	t	df	P		
-12.4	-9.12	9		one-tailed	<.0001
				two-tailed	<.0001

- **Resistance 10:**

Data Summary

	A	B	Total
n	10	10	20
$\sum X$	593	779	1372
$\sum X^2$	35209	60931	96140
SS	44.1	246.9	2020.8
mean	59.3	77.9	68.6

Results

$Mean_a - Mean_b$	t	df	P		
-18.6	-8.82	9		one-tailed	<.0001
				two-tailed	<.0001

References: N/A

Conclusions: I have made updates to the kinovea data in order to read them more easily, and to ensure the calibration curve is appropriate. Finally, I ran a Paired Sample T-Test due to the correlation present between the trials (same rower). The results are included above.

Action items: Complete poster and report.

2/18/2022 - PDS

Josh ANDREATTA - Feb 18, 2022, 1:47 PM CST

Title: PDS

Date: 2/18/2022

Content by: Josh Andreatta

Present: Josh, Cate, Sam, Dhruv, Tim

Goals: Upload initial PDS

Content:

The initial PDS was added below. As edits/adjustments are made, newer versions will be uploaded below this original version.

References: n/a

Conclusions:

Update the PDS.

Action items:

Continue brainstorming ideas.

Josh ANDREATTA - Feb 18, 2022, 1:47 PM CST

Johnson Healthtech: Adaptive Indoor Rower for Wheelchair Users

Download

Adapted_Rower_PDS.pdf (7.06 MB)

Josh ANDREATTA - Mar 01, 2022, 8:56 PM CST

Johnson Healthtech: Adaptive Indoor Rower for Wheelchair Users

Download

Adapted_Rower_PDS.pdf (5.2 MB)

2/24/2022 - Preliminary Presentation

Josh ANDREATTA - Feb 24, 2022, 5:17 PM CST

Title: Preliminary Presentation

Date: 2/24/2022

Content by: Josh, Cate, Sam, Tim, Dhruv

Present: Josh, Cate, Sam, Tim, Dhruv

Goals: Attach Preliminary Presentation

Content:

See attached below.

References: n/a

Conclusions:

The team put together a preliminary presentation discussing our design problem and several design ideas to solve this problem.

Action items:

-Begin work on assigned sections of preliminary report

Josh ANDREATTA - Feb 24, 2022, 6:09 PM CST

Download

Adaptive_Rowing_Machine-Preliminary_Presentation.pdf (3.4 MB)

3/1/2022 - Preliminary Report

Josh ANDREATTA - Mar 01, 2022, 9:13 PM CST

Title: Preliminary Report

Date: 3/1/2022

Content by: Josh, Cate, Sam, Tim, Dhruv

Present: Josh, Cate, Sam, Tim, Dhruv

Goals: Attach Preliminary Report

Content:

See attached below.

References: n/a

Conclusions:

The team put together a preliminary report discussing our design problem and several design ideas to solve this problem.

Action items:

-Upload prelim deliverables to Canvas and Website

-Begin work on fabrication

Josh ANDREATTA - Mar 01, 2022, 9:13 PM CST

Adaptive Rowing Machine

Download

Adaptive_Rowing_Machine-Preliminary_Report.pdf (7.02 MB)

4/21/2022 - Design Excellence Award

Josh ANDREATTA - Apr 21, 2022, 10:04 PM CDT

Title: Design Excellence Award

Date: 4/21/2022

Content by: Josh, Sam, Dhruv, Cate, Tim

Present: Josh, Sam, Dhruv, Cate, Tim

Goals: Edit and submit final Design Excellence Award Application

Content: The team edited the document and submitted the below version.

References: n/a

Conclusions:

The team completed and submitted the design excellence application.

Action items:

Make poster!

Josh ANDREATTA - Apr 21, 2022, 10:04 PM CDT

Download

301_-_Excellence_-_2_-_Adaptive_Rower_-_Executive_Summary.pdf (67 kB)

4/27/2022 - Final Poster

Josh ANDREATTA - Apr 27, 2022, 9:37 AM CDT

Title: Final Poster

Date: 4/27/2022

Content by: Josh, Sam, Dhruv, Cate, Tim

Present: Josh, Sam, Dhruv, Cate, Tim

Goals: Show final poster

Content:

The team put together a final poster summarizing our project to build an adaptive rower.

References: n/a

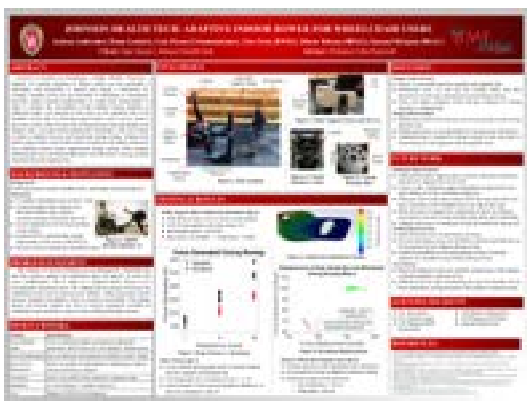
Conclusions:

See below for poster pdf

Action items:

Write Report

Josh ANDREATTA - Apr 27, 2022, 9:37 AM CDT



Download

Adaptive_Rowing_Machine-Final_Presentation.pdf (2.03 MB)

5/2/22 Final PDS

SAMUEL SKIRPAN - May 02, 2022, 9:58 PM CDT

Title: Final PDS

Date: 5/2/22

Content by: All

Present: All

Goals: Enter PDS into notebook.

Content:

See below for attached file of PDS.

Conclusions/action items:

NA

SAMUEL SKIRPAN - May 02, 2022, 9:59 PM CDT

Johnson Healthtech: Adaptive Indoor Rower for Wheelchair Users

Download

PDS__Johnson_Healthtech__Adaptive_Indoor_Rower_for_Wheelchair_Users_.pdf (7.06 MB)

5/3/2022 - Final Report

Josh ANDREATTA - May 03, 2022, 5:19 PM CDT

Title: Final Report

Date: 5/3/2022

Content by: Josh, Sam, Dhruv, Cate, Tim

Present: Josh, Sam, Dhruv, Cate, Tim

Goals: Show final report

Content:

The team put together a final report summarizing our project to build an adaptive rower.

References: n/a

Conclusions:

See below for report pdf

Action items:

Finalize all deliverables

Josh ANDREATTA - May 03, 2022, 5:19 PM CDT

Adaptive Rowing Machine

Download

Adaptive_Rowing_Machine-Final_Report.pdf (15.6 MB)

2/3/2022 - Muscle Groups Worked Using Rowing Machine

Josh ANDREATTA - Feb 03, 2022, 1:32 PM CST

Title: Muscle Groups Worked Using Rowing Machine

Date: 2/3/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Determine the muscle groups worked when using a rowing machine

Content:

Upper Body:

- Deltoids - connect humerus to shoulder blades and collarbone and are activated with each stroke
- Triceps - extend arms and control handles release to return point
- Biceps - help to pull handles toward chest
- Pectoralis Major and Minor - help medial rotating of upper arm and in bringing handles to chest

Lower Body:

- Gluteus Maximus, Medius, Minimus - control posture while sitting on sliding seat and help to maintain engaged hip flexor/extensor muscle groups
- Quadriceps - bend knees to return to starting position
- Hamstrings - extend legs and help push body backwards to pull the handles towards chest
- Gastroc - restrain lower leg movement during bending of the knees - help to stabilize the lower leg

Back Muscles:

- Latissimus Dorsi - controls extension of arms and release of the handles by aiding in medial arm rotation and shoulder extension
- Trapezius - controls shoulder blades to be actively engaged
- Rhomboid Major and Minor - help to support trapezius to maintain and activated back - help with proper posture and shoulder extension upon pulling oars in close to chest

Abdominal Muscles

- Obliques - stabilize body core for proper posture to ensure maximal intake of air during breathing
    - help to lean forward and extend backward during sliding motion

References:

“Main muscle groups used in a rowing machine workout,” *NordicTrack Blog*, 19-Sep-2019. [Online]. Available: https://www.nordictrack.co.uk/learn/main-muscle-groups-used-rowing-machine-workout/. [Accessed: 03-Feb-2022].

Conclusions:

Overall, the rowing machine seems to be an exercise machine that works a majority of the muscle groups in the body and thus gives a holistic workout for the body. This machine is highly acclaimed to be one of the best all around body exercises due to its ability to burn calories and help strengthen muscle groups located all over the body. For individuals in a wheel chair, it is likely that they lose the strengthening of the leg and core muscles, and these are the muscles involved in bending forward or backward to push oneself to pull the oars to the chest. It will be necessary to consider how we can best achieve activation of these muscles for participants who are in a wheel chair. Possibly, if the individual has some mobility in their legs, a low stress system can be designed that would enable them to passively work these muscles by aid of the machine, rather than by individual efforts.

Action items:

- **Continue research on how a rowing machine works and different rowing machines/exercise machines that have been adapted for use while in a wheelchair**
- **Meet with client to learn more about the project**
- **Start generating PDS**

2/3/2022 - How a rowing machine works

Josh ANDREATTA - Feb 03, 2022, 1:51 PM CST

Title: How a rowing machine works

Date: 2/3/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Learn about the mechanism for controlling resistance in a rowing machine

Content:

- There are 4 types of rowing machines that use the resistance mechanism to increase difficulty: Air, Magnetic, Water/fluid, and hydraulic.
- The air and hydraulic machines tend to be noisier than the magnetic or water models
- Hydraulic is usually smallest
- Use a mat beneath machine to dampen noise and vibrations

Air Rowing Machines:

- Produces resistance using air flowing over an internal flywheel
- The flywheel is connected by a chain to the rowing handles so as you pull it spins the flywheel
- The faster you row, the faster the wheel spins through the air and the more resistance is generated
- "Automatic" resistance adjusts to the stroke rate
- Little wear and tear to mechanism

Water Rowing Machines:

- Tend to be smoother and quieter than air rowing machines
- Has a water bath with paddles in it that is spun as the handles are pulled towards you
- The mass of the moving water creates a drag against the paddles in the tank which produces the resistance
- Requires little maintenance

Magnetic Rowing Machines:

- Quietest of all types
- Varies distance between strong magnets and a spinning flywheel attached to the handle by a chain
- Resistance levels are adjusted by using mechanical sliders or a digitally controlled console

Hydraulic Rowing Machines:

- Use pistons attached to handles that allow the user to pull the handles toward their chest
- Doesn't give as smooth of a feel during use
- Users pull against the air or fluid inside the cylinder and adjustments to the level of resistance is made by certain levels or clamps
- Typically cheaper than most other models

References:

"Rowing machine resistance types," *Home Rowing Machine Reviews 2022*. [Online]. Available: https://www.rowingmachine-guide.com/types.html#:~:text=How%20Does%20Air%20Resistance%20Work,thus%20the%20greater%20the%20resistance. [Accessed: 03-Feb-2022].

Conclusions:

There are several different designs to rowing machines that make them produce resistance. The most important aspect of the machine is that a spinning wheel is used to simulate water resistance. For our project, we are likely not adjusting how the resistance is generated, but rather finding a way for people in wheelchairs to comfortably use the device to activate all the proper muscles. This could involve altering how the handles are connect or pulled to the resistance mechanism to accommodate the size of the wheelchair into the overall set up.

Action items:

- **Research competing designs for rowing machines and other exercise machines that have been adapted for use by individuals in a wheel chair**
- **Meet with client**
- **Begin constructing PDS**

4/19/2022 - Activation of Muscle Groups

Josh ANDREATTA - Apr 19, 2022, 12:25 PM CDT

Title: Activation of Muscle Groups

Date: 4/19/2022

Content by: Josh Andreatta

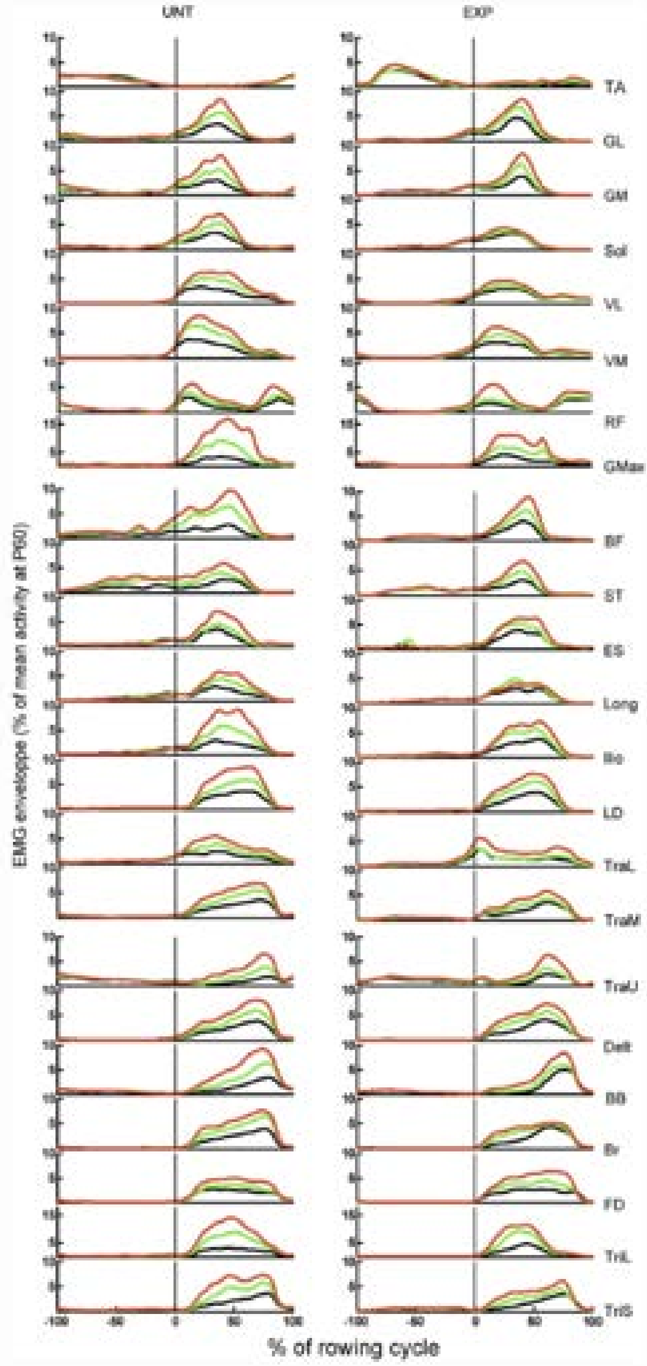
Present: Josh Andreatta

Goals: Address comment to use scientific article to prove which muscles are activated while rowing

Content:

- Strain gauges and EMGs were used to measure the activation of 9 upper limb muscles, 4 back muscles, and 10 lower limb muscles
- The main goal of this article was to asses power output while rowing, and this was done by collecting and assessing the EMG data from 23 different muscles
- If a muscle showed a positive deflection in the EMG curve, this means that it was contracted and excited.
- Overall, each muscle target was contracted at some point in the rowing cycle. Different muscles were contracted during the catch and during the release phases, since this corresponds to arm flexion and extension, respectively.
- Below is a list of the muscles that were recorded
    - Tibialis Anterior (TA), soleus (Sol), gastrocnemius lateralis (GL), gastrocnemius medialis (GM), vastus lateralis (VL), vastus medialis (VM), rectus femoris (RF), biceps femoris (BF), semitendinosus (ST), gluteus maximus (GMax), latissimus dorsi (LD), erector spinae multifidus (ES), trapezius medius (TraM), biceps brachii (BB) and brachioradialis (Br), longissimus (Long), illiocostallis (Ilio), multifidus (ES), latissimus dorsi (LD), deltoideus posterior (Delt), trapezius upper (TraU), trapezius medius (TraM), trapezius lower (TraL), triceps brachii (long head—TriL), triceps brachii (short head—TriS), biceps brachii (BB), brachioradialis (Br) and flexor digitorum superficialis (FD).

Fig. 3



The above image shows the individual EMG data for the 23 targeted muscles used during one cycle of rowing. The graph compares untrained rowers vs experienced rowers, and doing an ANOVA statistical analysis, found that when 22 of the 23 muscles (excluding TA) where activated, that they lead to an increase in power output. On the x-axis, -100% to 0% refers to the recovery phase, while 0% to 100% refers to the drive phase. Thus, the black vertical line shows the transition between these two phases in the rowing cycle. As can be seen above, muscles are not actively used a lot during the recovery phase, while during the drive phase a majority of the muscles are used in the legs, arms, and upper body to contract and pull the handle bar towards the chest. Thus, this article confirms the article in a previous entry in identifying muscle groups that are used while rowing, as shown by EMG output data.

References:

N. A. Turpin, A. Guével, S. Durand, and F. Hug, “Effect of power output on muscle coordination during rowing,” *European Journal of Applied Physiology*, vol. 111, no. 12, pp. 3017–3029, 2011.

Conclusions:

The main use of muscles are the arm flexors and core muscles during the drive phase. Since wheelchair users cannot utilize their legs to extend and push themselves backward, our device must be able to hold them stable so that they do not tip over when using their arms to complete the drive phase. This is what our wood stabilization component will be used for (essentially taking the place of the legs during the standard rowing motions).

Action items:

-Complete impact research

-Update FBD

Josh ANDREATTA - Apr 19, 2022, 12:26 PM CDT

Effect of power output on muscle coordination during rowing

Download

Turpin2011_Article_EffectOfPowerOutputOnMuscleCoo.pdf (2.13 MB)

2/3/2022 - Wheelchair for Sport Rowing

Josh ANDREATTA - Feb 03, 2022, 2:30 PM CST

Title: Wheelchair for Sport Rowing

Date: 2/3/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Observe the FBDs and KDs of a currently used wheelchair for sporting activities such as rowing

Content:

- Upper limb injuries appear to be more common for people in wheelchairs during exercise because the legs are not used
- Must start out with a pulling movement in the arms to obtain proper movement forward
- Rowing is divided into two phases: the traction phase (user provides power and pulls handles toward chest) and the recovery phase (user goes back to initial position)
- When the user pulls on the cables, they apply a torque to two pulleys to the two wheels of the wheel chair. A power spring connects the pulley to the wheelchair. The angular speed of the pulley and wheel are equal.
- During recovery, the user stops pulling and the spring that was loaded now unloads and rotates the pulleys in the opposite direction. The cables then wrap around each pulley so the traction phase can start again.
- This technique could be used in wheelchair racing, where the wheels are replaced by these two pulleys
- The Hanwheelchair.q02 has two configurations: one for normal use with foldable links folded down, and one for sport where the foldable links are folded up
- The hub is adjacent to the pulley which has the power spring placed behind it. This allows the wheel to still function as a normal wheel, and the pulley can rotate over the axle just as the hub of the wheel can
- When the links are folded up, the wheel connects to the pulley. As the users pulls the cable, it applies a torque to the pulley and thus to the wheel to generate movement
- A set of dynamic equations are provided to estimate the power and force generated during one pull of the cables while seated in the chair.

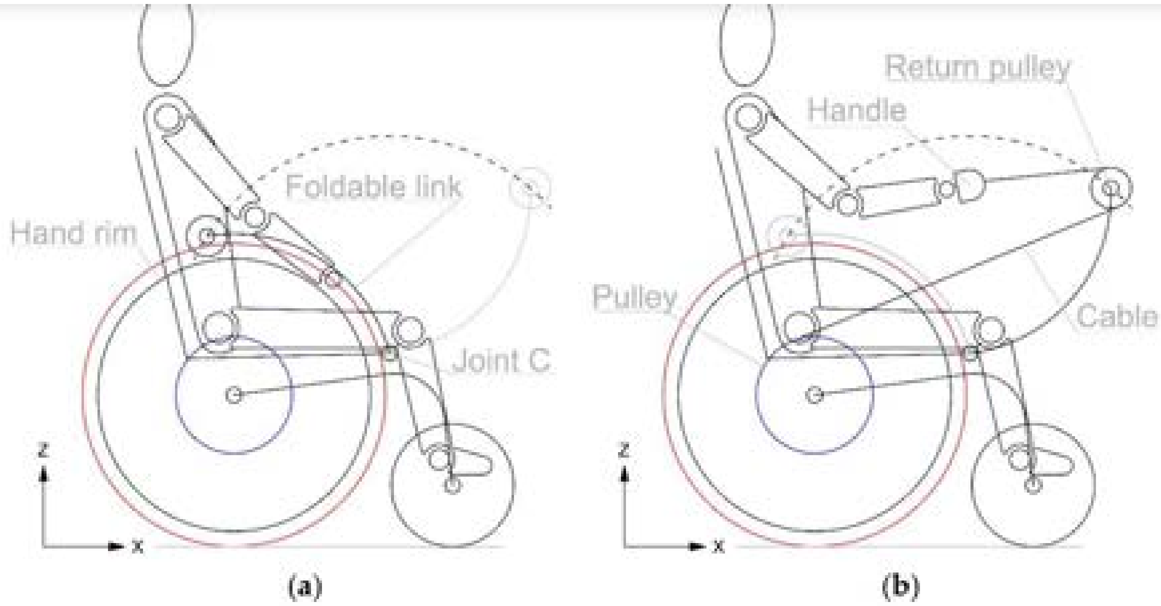
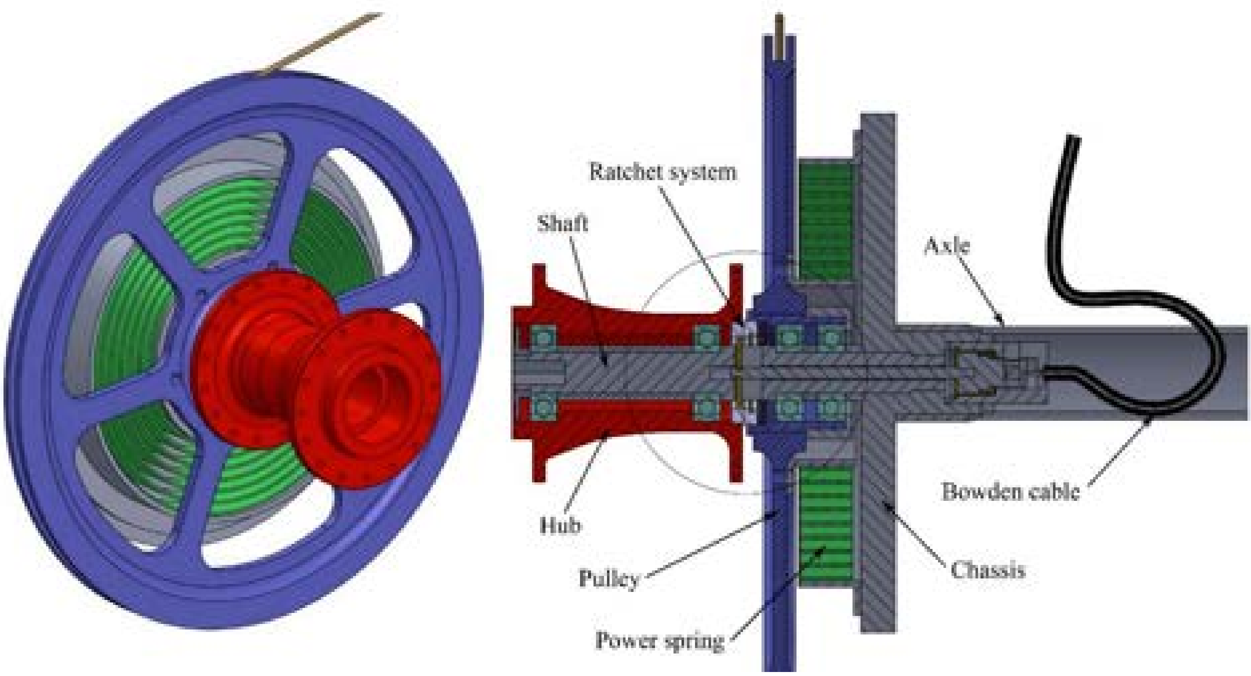


Figure 6. (**a**) Handwheelchair.q02 indoor configuration; (**b**) Handwheelchair.q02 outdoor configuration.

Figure 7 show the components that enable the use of the wheelchair in the innovative configuration. The red component is the hub of the wheel and the blue one is the pulley around which the cable is wrapped. The green one is the power spring that connects the pulley with the chassis of the wheelchair, in grey. In the first configuration, the mechanism of transmission of motion allows the user to use the wheelchair as a common wheelchair. In fact, the hub of the wheel rotates around the shaft as in the classic wheelchair, as sketched in Figure 8a.



The above image shows the break down of the design used in the sport wheelchair. In this image, one can see how the wheel is connected to the pulley via a ratchet and power spring.

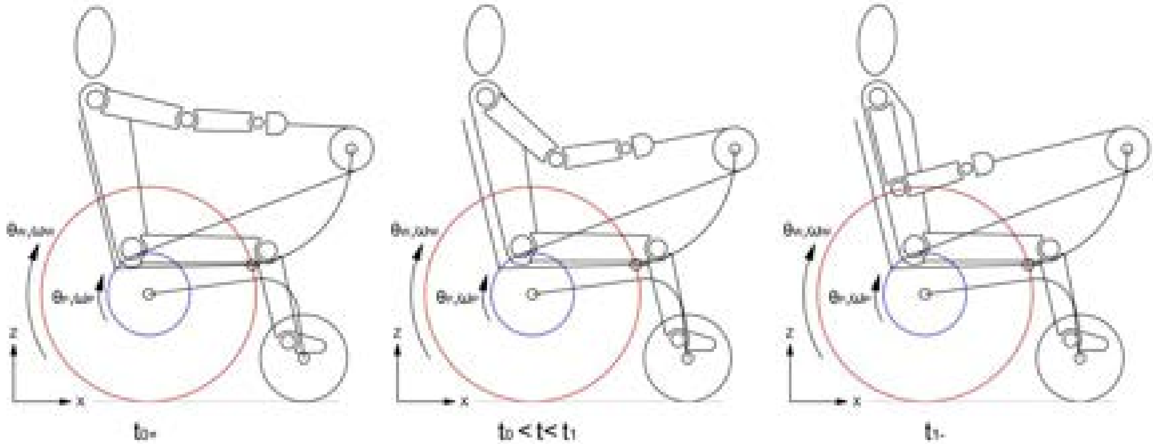


Figure 1. Rowing gesture during the traction phase.

During the recovery phase shown in Figure 2, the user stops pulling and the power spring, previously loaded, rotates the pulleys in the opposite direction ($\omega_W > 0$, $\omega_P < 0$). The cables are wrapped around each pulley and the user can start another traction phase.

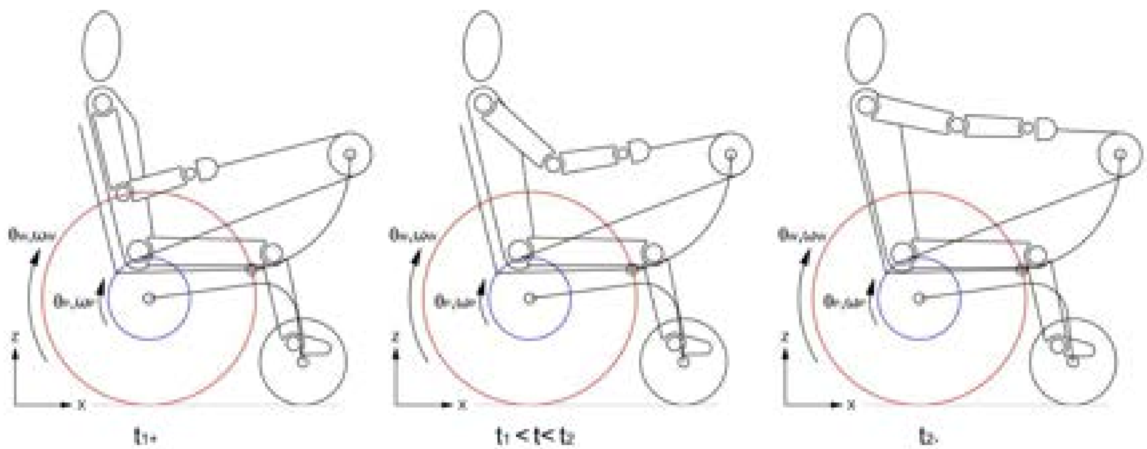


Figure 2. Rowing gesture during the recovery phase.

The above image shows the FBD of the wheelchair design during traction and recovery phases of rowing. More detailed FBDs of the different components of the wheelchair itself can be found in the attached article pdf.

References:

G. Quaglia, E. Bonisoli, and P. Cavallone, "The design of a new manual wheelchair for Sport," *Machines*, vol. 7, no. 2, p. 31, 2019.

Conclusions:

Its possible we can use the dynamic equations to assess our final design or use them as a starting point for figuring out how to develop proper FBDs and KDs. This design shows several FBDs of the design which effectively used the rowing motion to propel a wheelchair forward. For our design, we could manipulate this design so that the wheels rotate backwards upon release of the cables rather than forward. This would allow the individual to have the wheel chair move in a rowing motion. This article shows a proper way to tackle the equations of motion for the different components of the design. It will be important also to assess the degree of possibility of injury when using a complicated system as this to different muscles and joints within the body.

Action items:

- **Continue background research**
- **Meet with client**

- **Start PDS**

Josh ANDREATTA - Feb 03, 2022, 2:07 PM CST


machines

Article

The Design of a New Manual Wheelchair for Sport

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The_Design_of_a_New_Manual_Wheelchair_for_Sport.pdf (7.62 MB)

2/14/2022 - Summary of Cate's Standards Research

Josh ANDREATTA - Feb 14, 2022, 12:55 PM CST

Title: Summary of Cate's Standards Research

Date: 2/14/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Learn about the standards available for adapted rowing machines

Content:

The adapted rowing machine will not require FDA approval because it does not fall under the umbrella that the FDA covers, such as medical devices, pharmaceuticals, or food products.

There is a standard from the International Organization for Standardization (ISO) that stipulates the proper safety requirements needed for regular rowing machines. It can be assumed that these safety requirements, if not more, would be applicable to an adapted rowing machine. Specifically, entry 20957-1 address the requirements for accessories that are added to existing rowing machines.

References:

First paragraph: "Does My Product Require FDA Approval? FDA Pre-Approval Requirements," August 6, 2019. https://www.onlinegmptraining.com/does-my-product-require-fda-approval/.

Second Paragraph: 14:00-17:00. "ISO 20957-7:2005." ISO. Accessed February 9, 2022. https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/03/99/39908.html.

Conclusions:

The rowing machine is not heavily documented. It was found that it does not require FDA approval.

Action items:

-Create brainstormed ideas and draw preliminary designs

-Create Design Matrix with Team

4/19/2022 - Adapt2Row

Josh ANDREATTA - Apr 19, 2022, 11:47 AM CDT

Title: Adapt2Row

Date: 4/19/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Complete background research on a popular competing product

Content:

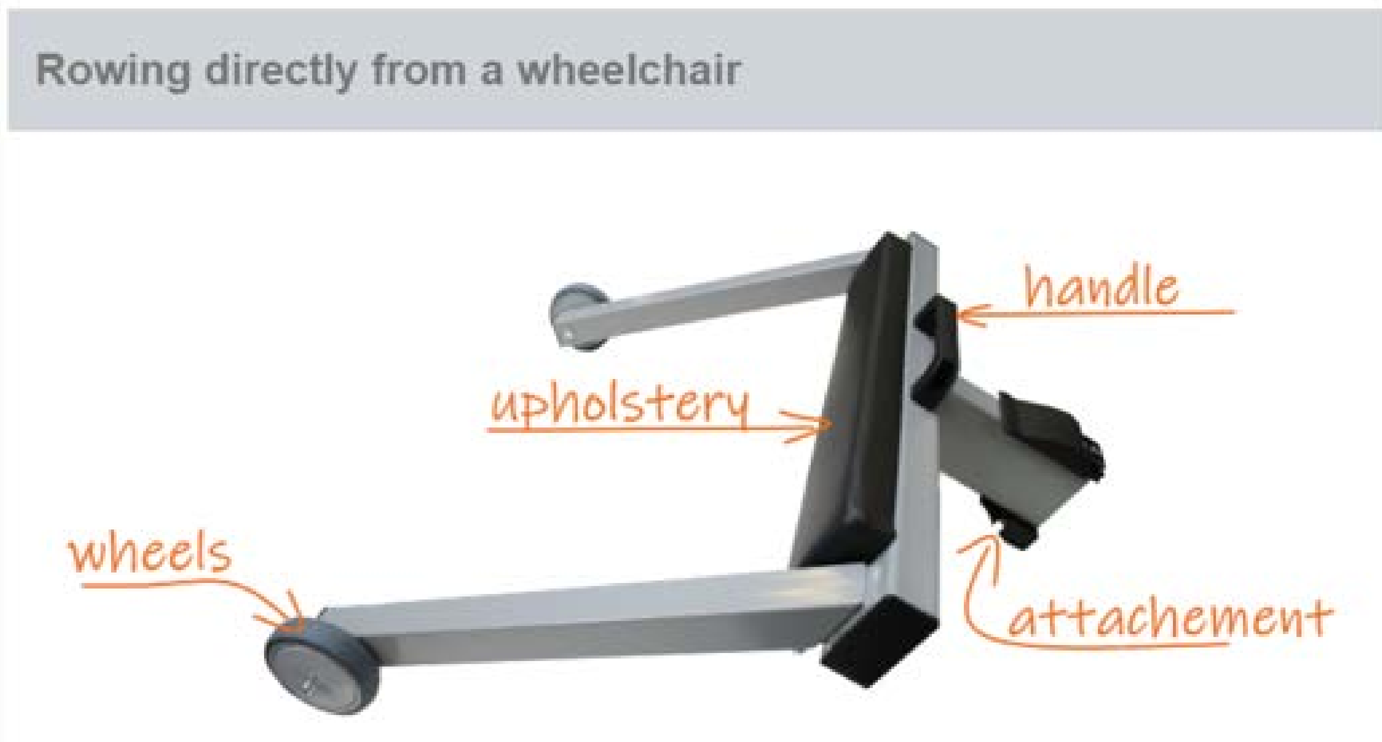
I know that other team members have researched this product, but I wanted to conduct my own research with regards to the Adapt2Row to gain my own better understanding of how it functions.

- Uses wheels on the ground to allow for easy positioning of the adaptive component for people with different sized wheelchairs and different length legs
- An upholstery pad is placed against the anterior surface of the lower leg to cushion the leg during rowing.
- A handle is added to allow for easy movement of this adaptive piece when placing it on the Concept2 rowing machine. This attachment is made via a specially made attachment piece that connects to the Concept2 itself.
- The article says that connecting this adaptive piece can be done by the wheelchair user and takes less than a minute to complete
- The user can only use this adaptive piece on the Concept 2 model C or model D rowing machines, which may limit the use of this on other rowing machines, such as those made by Matrix

Specs Adapt2row

box size	81x36x36 (LxBxH)
weight	+/- 20kg
Oppervlakte toestel	81x50cm
surface device	200x100cm (including rower)
Material	steel
color	grey
upholstery	black Boltaflex
practicing directly from the wheelchair	yes, no transfer needed
power connection	no
warranty	1 year on construction
deliverytime	2-5 week

The above image shows the device specifications. Of not is that no power connection is needed to use the adaptive piece and that the wheelchair user themselves can install this piece to the rowing machine.



The above image shows the different components of the designed adaptive piece.

References:

"Adapt2Row: Rowing on a concept2 rowing machine from your wheelchair," *GeroFitness*. [Online]. Available: https://gerofitness.nl/export/406-adapt2row.html. [Accessed: 19-Apr-2022].

Conclusions:

Overall, this design allows for the user to attach the adaptive piece themselves and complete normal rowing motions. The cushion on the legs is a nice touch so that resistance is offered to their body, which prevents them from launching themselves forward. This is a good baseline model for a typical adaptive mechanism to a rowing machine.

Action items:

-Complete research on the impact of our device

-Update FBD of final design

4/19/2022 - AROW/ARM

Josh ANDREATTA - Apr 19, 2022, 12:01 PM CDT

Title: AROW/ARM

Date: 4/19/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Conduct background research on competing designs for adaptive rowing machines

Content:

Other team members have already researched this product, but I wanted to read about it myself and conduct my own individual research on this device.

- The original sliding seat and bar of the original rowing machine is removed.
- The device consists of a cushioned support arm that connects to the front side of the original rowing machine
- This arm is extendable to accommodate being at different lengths from the rowing machine front edge
- This arm has a cushioned chest piece that offers resistance to the user to prevent them form throwing themselves out of their wheelchair during rowing motions
- A lap support bar also helps the user stay properly seated in their wheelchair. This is important because depending on the level of injury or disability that the user has, they may not have the core/leg strength to hold themselves "rigid" in their seat
- Users who have good hand functionality can be expected to put together the adaptive pieces themselves, but if their injury is too severe, outside assistance will be necessary
- From user feedback, users liked the fact that they were doing an exercise that has them pull back on an object. During normal wheelchair use, users are typically pushing their wheels forward to move. So, being able to sit up straight and pull back worked different

muscles and helped them exercise different parts of the arms and upper body

Adapted Rowing Machine designed for Trevor.

- The above image shows the ARM adaptive rowing machine with chest and lap pad.

References:

Spinal Cord Injury BC, “Adapted Rowing Machines for fitness and health,” *Spinal Cord Injury BC*, 01-Sep-2020. [Online]. Available: https://sci-bc.ca/adapted-rowing-machines/. [Accessed: 19-Apr-2022].

Conclusions:

The ARM adaptive mechanism is very similar to the Concept2 adaptive piece in the previous entry. Both of these designs hook onto the front of the rowing machine and completely replace the sliding seat and bar used during standard rowing. Thus, although these devices can technically still be used in both manners to row normally and adaptively, our team wanted to keep the ability to do this without having to assemble and reassemble the machine. Thus, placing the user on the backside of the rowing machine and adding a swivel to the console display will allow wheelchair users to row from the back/adaptive side, and allow typical users to row from the standard side. All that needs to be done is swivel the console display, and loop the rope through the slit that we made in the rower neck. Our design straps in the wheelchair using loop brackets, rather than adding a cushion pad onto the user themself.

Action items:

-Conduct impact research

-Update FBD

4/19/2022 - Quantifying Number of Wheelchair Users and Reason for Needing Them

Josh ANDREATTA - Apr 19, 2022, 12:48 PM CDT

Title: Quantifying Number of Wheelchair Users and Reason for Needing Them

Date: 4/19/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Quantify Number of Wheelchair users in US who could use our device

Content:

Citation:

A. J. Roberts and O. published: O. 22, "Wheelchair and power mobility for adults," *PM&R KnowledgeNow*, 13-Oct-2021. [Online]. Available: https://now.aapmr.org/wheelchair-and-power-mobility/#:~:text=Background%3A,uses%20a%20wheelchair%20for%20mobility. [Accessed: 19-Apr-2022].

Link: https://now.aapmr.org/wheelchair-and-power-mobility/#:~:text=Background%3A,uses%20a%20wheelchair%20for%20mobility.

- According the Article above, it is estimated that around 5.5 million people in the united states require a wheelchair to perform daily tasks and mobilize themselves
- Adults older than 65 are 4 times as likely to require a wheelchair, as opposed to if you are younger than 65
- The article recognizes that individuals who have the ability to walk and are mobile receive more low stress exercise on a daily basis. Thus, for users who do not have independent mobility, the risk is greater to develop health complications unless the wheelchair is made specifically for the user.
    - This would mean that the seat, cushions, and all other dimensions are tailored exactly to the user so that they do not develop chronic muscle pain from remaining static in a position that is harming the muscles for too long

Citation:

A. M. Koontz, D. Ding, Y.-K. Jan, S. de Groot, and A. Hansen, "Wheeled mobility," *BioMed Research International*, vol. 2015, pp. 1–2, 2015.

Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4397418/

- According to the above article, it is estimated that there are 2.7 million wheelchair users in the united states
- Although prosthetics, powered orthotics, and exoskeletons are rising in popularity, wheelchairs are still the most common form of assisted mobility
- Due to increased life spans and the baby boomer generation and an ever growing population, it is estimated that this number will exponentially increase in the future as more people require the need for additional mobility assistance

References: above

Conclusions:

Based off of the two articles above, we can estimate the total number of wheelchair users in the united states is between 3 and 4 million people. This can be used to help justify the impact of our device, because all of these people are put at a risk for developing muscle fatigue or other health concerns because they cannot exercise or mvoe around like a typical individual.

Action items:

-Research 1 more impact article

-Update FBD

4/19/2022 - Assessment of Wheelchair User Exercise Levels

Josh ANDREATTA - Apr 19, 2022, 1:07 PM CDT

Title: Assessment of Wheelchair User Exercise Levels

Date: 4/19/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show that users in wheelchairs have less exercise as a way to justify the need for our device to make exercise more approachable

Content:

- 50 wheelchair users wore an activity monitor for 7 days and filled out a record of their activity over those 7 days
- After the week of collection, each individual filled out a survey asking for their stage of exercise and other demographic questions
- The most recent federal recommendations for the proper amount of exercise for a typical healthy adult is 150minutes/week or 20 minutes of strenuous activity at least 3 days each week. Muscle strengthening and endurance activities are recommended to be done at least twice a week
- The study found that a smaller proportion of people with physical disabilities (such as restricted to a wheelchair) engaged in 30 minutes of activity 5 times per week (23% with disabilities, 33% without disabilities)
- Exercise is extremely important, even for individuals with physical disabilities. This is because an extended period of time without exercise can lead to muscle atrophy, slowing of the metabolic rate, loss of bone density, and decreased control over blood pressure. Thus, it is very important that individuals who cannot actively engage in traditional forms of exercise such as walking, hiking, swimming, ect receive some sort of physical engagement that can increase their heart rate and strengthen muscle groups.
- The article states that even for people with disabilities, moderate weekly exercise can contribute to improvements in overall strength, stamina, posture, weight, and circulation and immune function. Additionally, low stress exercise can further reduce the risk of developing depression or anxiety
- Approximately 2.2 million people use wheelchairs in the united states, and people with these mobility impairments report a greater number of adverse conditions associated with their disability
- This article suggests that if wheelchair users can engage in 150minutes of exercise/week, that they will lower the risk of developing adverse health concerns.

References:

C. A. Warms, J. A. D. Whitney, and B. Belza, “Measurement and description of physical activity in adult manual wheelchair users,” *Disability and Health Journal*, vol. 1, no. 4, pp. 236–244, 2008.

https://www.sciencedirect.com/science/article/pii/S1936657408000733?casa_token=uIV7MS3loD0AAAAA:-uucqz_89ECdYTSfENwFcJbzJmGxbrsQjHEugYxEtNv_ACmhYV1K0rm5yfKsHn-bJ8uJm8_4tw

Conclusions:

The value of exercise for immobilized individuals is extremely important as described above. Thus, our rowing machine offers a non-intimidating form of exercise that wheelchair users can use to increase their heart rate, and strengthen their arm and upper body muscles. It is extremely important that our adapted device be easy to use for these users, because even just rowing on a low resistance level will give them more exercise than they normally receive by pushing themselves in the wheelchair, which will ultimately lead to less adverse health concerns, and hopefully a longer lifespan.

Action items:

-Update FBD

Josh ANDREATTA - Apr 19, 2022, 12:52 PM CDT

Download

Exercise_Assessment.pdf (221 kB)

2/14/2022 - Initial Design Ideas

Josh ANDREATTA - Feb 14, 2022, 1:43 PM CST

Title: Initial Design Ideas

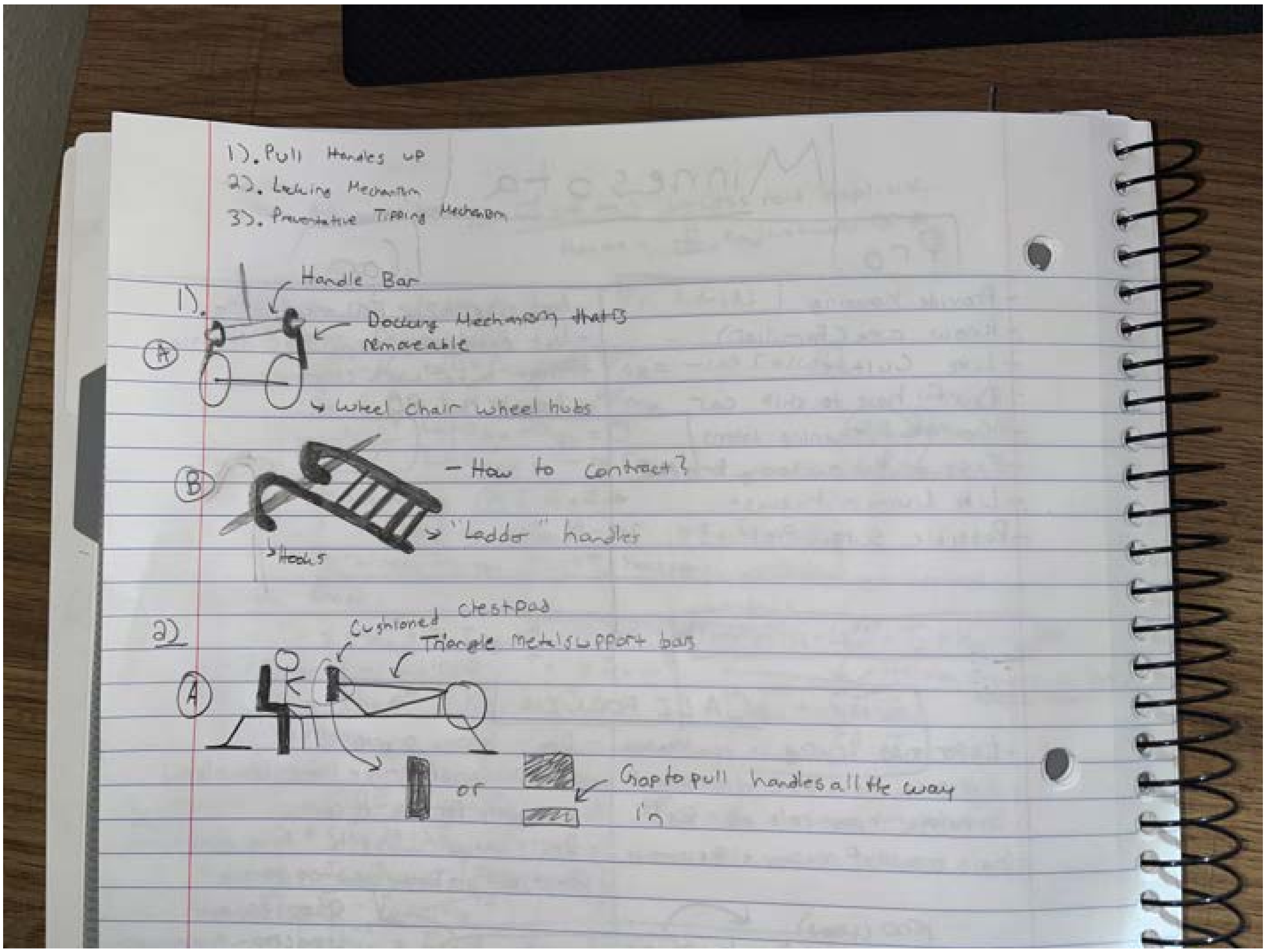
Date: 2/14/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Brainstorm mechanisms to lock the wheelchair in place, bring handles to user, and prevent tipping (any of these)

Content:



The above image shows my quick sketches of some initial designs. Once the team decides on a solid concept and design idea, I will construct it in SolidWorks.

Above, my first idea (1A) is a mechanism for the user to pull the handle bars towards themselves without outside assistance. This idea involves two removable "Train Track Piston Hooks" that slide onto the handle and connect to the hub of the wheel. Once the user connects this, they simply wheel backwards until they have reached their set point, and then lift the handle bars up, and remove the hooks. The bars would need to be extendible or an already predetermined length so that they can connect across the varying height from original placement to the users lap without straining the hooks or the wheels of the wheelchair.

My second idea (1B) is a similar mechanism to that of 1A. It still utilizes a hook to grab the handle bar. However, the hooks are connected via "ladder steps" so that the user can "horizontally climb the ladder" while stationary in the wheelchair to pull the handles toward themselves. For this to work, the individual would need to already be at their set point, and the hooks would need to be long enough stretch to reach the handles. One disadvantage is that the ladder steps might start to dig into the users chest once they begin "climbing." If the bars can shrink as the person "climbs," then I think this idea would be manageable,

My third idea (2A) is a locking mechanism for the user in the wheelchair. Rather than having to wheel back to a set point and lock the wheels in place, which could cause some instability for the user and the wheelchair, the machine would have an attachable cushioned chest pad that the user would roll up against and stop their forward movement. This is similar to the chest pad on a stationary row free weight machine. I also was thinking that if we design the metal structure supporting the cushion properly, it could be essentially 2 cushions with a space in between, which would allow for the user to pull the handle bar all the way into their chest to complete the rowing movement.

I still need to brainstorm a way to prevent the wheels on the wheelchair from tipping during use of the machine.

References: n/a

Conclusions:

I developed 2 ideas for initially grabbing the handle bars, and 1 idea for stopping forward movement during machine use. I think that all of these ideas would be feasible to accomplish in an overall design during the semester. The team will meet tonight to discuss everyones ideas and see what the best combination of designs is. Then, we will construct our design matrix with appropriate criteria.

Action items:

-Discuss design ideas with group and develop design matrix.

2/20/2022 - Design Ideas after Seeing Rower

Josh ANDREATTA - Feb 20, 2022, 9:24 AM CST

Title: Design Ideas after Seeing Rower

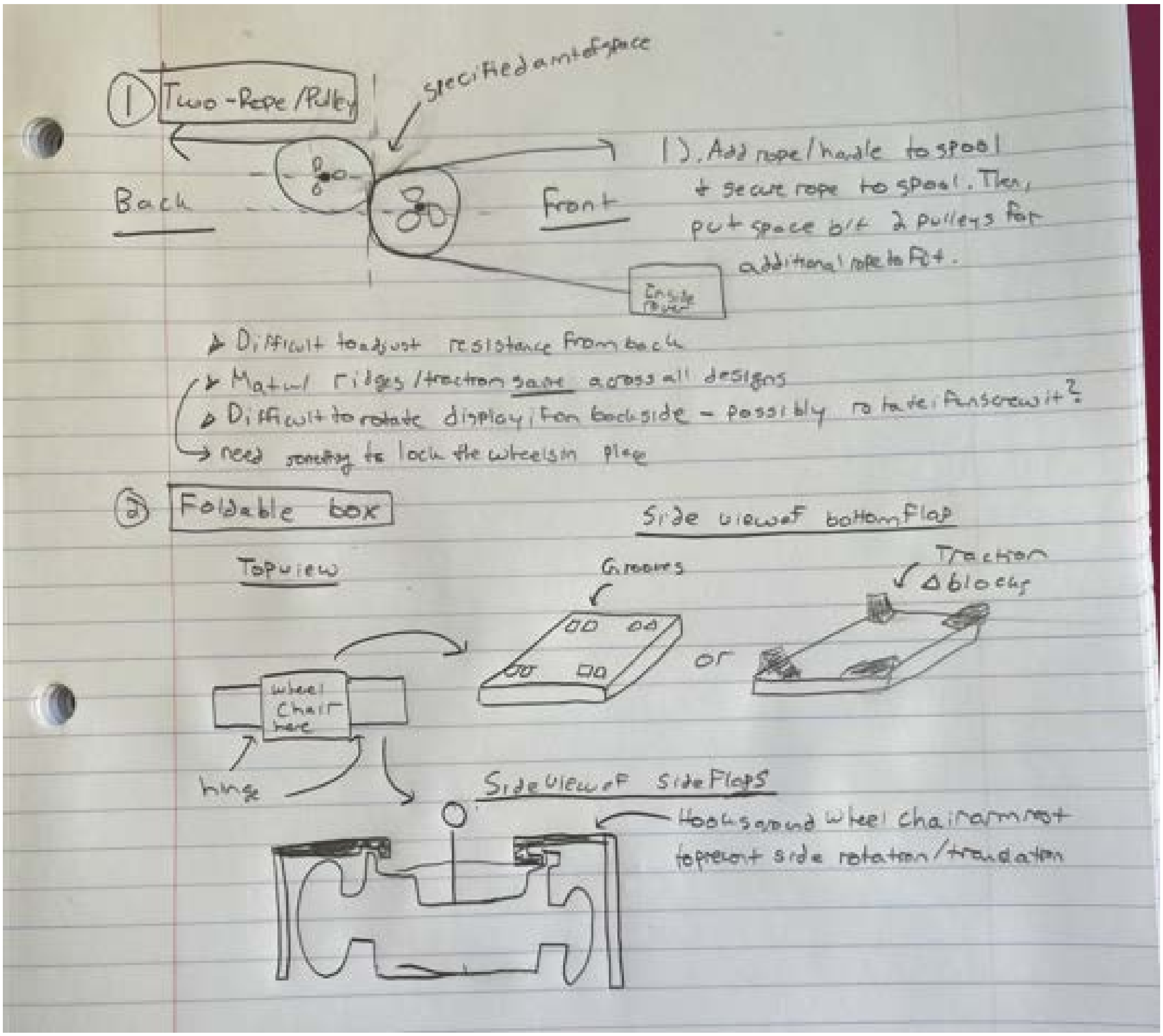
Date: 2/20/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show my further developed design ideas after seeing the rowing machine

Content:



The picture above shows the two designs I came up with after visiting Johnson Healthtech and seeing the rowing machine we are going to be using this semester. My first idea, the Two-Rope/Pulley Design, would have the individual in a wheelchair seated 180 degrees from the slide seat bar (behind the machine). Another pulley would be added to the support bars of the neck of the console and a second rope/handle would be added to

the machine. Within the inner mechanism, the rope wraps around a big spool, and the spool has some more room, so, the new rope would be secured to this spool and wrapped around the second pulley. This would allow the user to pull on the new rope/handle, but still have the flywheel rotate in the same direction as if using it normally. Also, this design would retain the ability to be used normally because no modifications would be made to the front side of the machine. However, the individual would require some assistance in changing the resistance of the machine because this cannot be moved to the back without completely revamping the inner mechanism.

My second idea, the Foldable Box, is a design to stabilize the wheelchair during use of the machine. When visiting Johnson Healthtech, we saw two machines that used a floor mat to stabilize the wheelchair. So the Foldable Box above would consist of a floor mat with either ridges, or elevated traction blocks to prevent forward and backward motion. Then to stabilize the sides of the wheelchair from tipping, side flaps would be attached to the base flap via a hinge mechanism and would have hooked arms that hold on to the arm rests on the wheelchair. Thus, it stays out of the users way while using the machine, and keeps the user safe.

References: n/a

Conclusions:

My ideas are feasible to be completed in a semester and would accomplish our project goals for preventing translation/rotation of the individual in a wheelchair while using the machine.

Action items:

-Meet with team to discuss final designs and make design matrix

-Assign and completed assigned prelim presentation sections

2/26/2022 - FBD of Final Design

Josh ANDREATTA - Feb 26, 2022, 9:57 AM CST

Title: FBD of Final Design

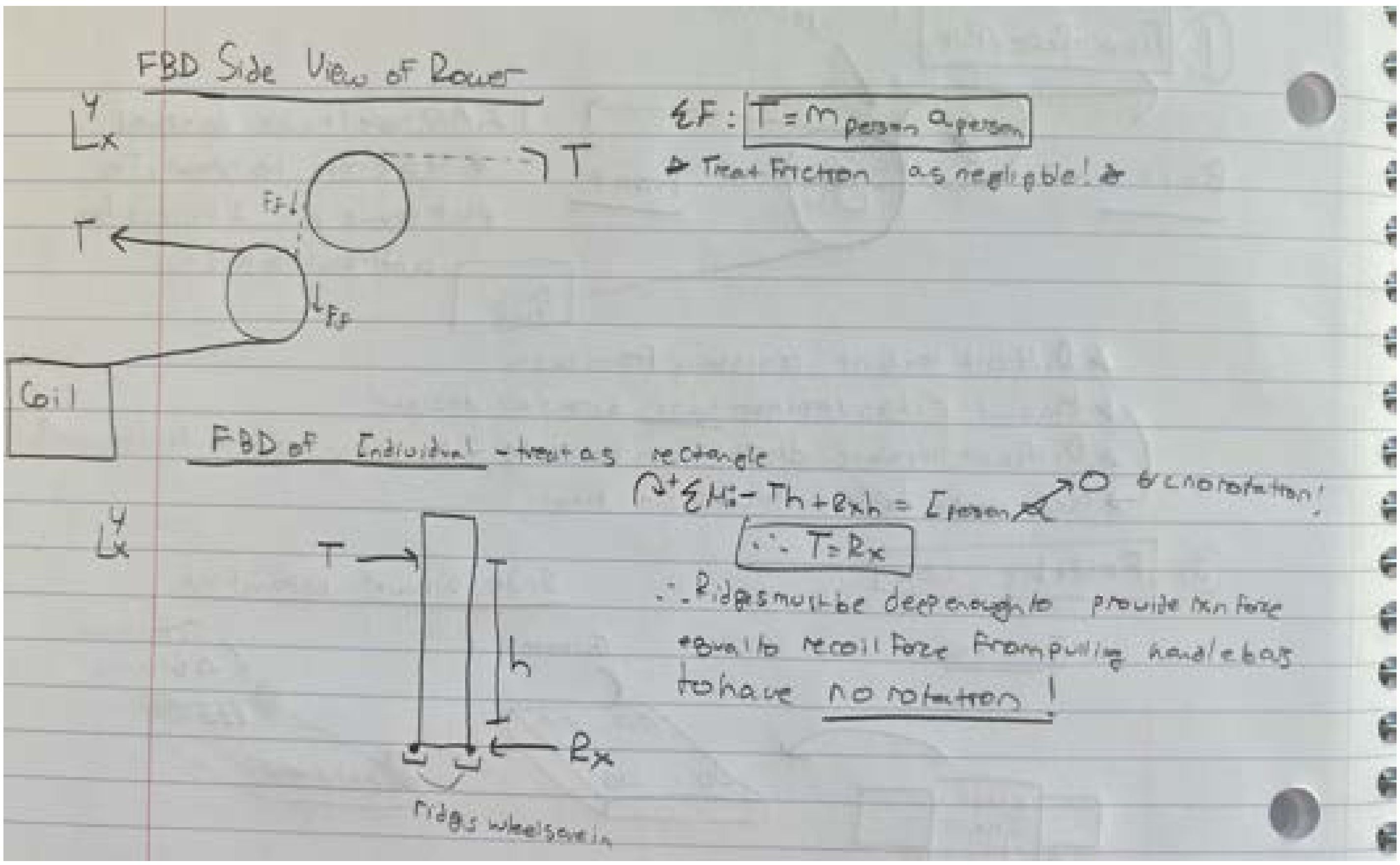
Date: 2/26/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Provide an FBD of all forces acting on all aspects of our final design.

Content:



The above image shows an FBD of the 2 pulley mechanism as well as an FBD for the user in a wheelchair on top of the Highway Ridges platform.

As shown in the top FBD, the tension that is applied to the rope is equal to the force that the person pulls on the rope with. This will hold true whether the rower is in the standard form or the adaptive form (shown by the dotted line). There is a slight belt frictional force between the rope and the pulley, but this will be treated as negligible for the sake of simplifying the understanding of this design. Then, as seen in the bottom FBD, the amount of force that the user pulls back on the rope with will equal the force that is essentially applied to the user in the wheelchair, since ehy are directing this force backwards by pulling on the handlebar and rope. If the person in the wheelchair is treated as a rectangle, we can see that to prevent tipping (meaning angular acceleration goes to zero) the total reaction force provided by the ridges on the wheels of the wheelchair must equal this applied force to the rope. Although this model is simplified, it still captures the equivalent forces

acting on our system. In reality, the two wheels of the wheelchair would each have an inertia and angular acceleration (although they would be zero if the wheels are stationary), and the center of mass of the wheelchair-person complex would be in a different place. Thus, there would be a system inertia, and the applied force would be working to rotate that entire inertia.

References: n/a

Conclusions:

The team will use these FBDs to help guide us in properly designing our final design so that the user is safe.

Action items:

-Make SolidWorks Models of final design

4/19/2022 - FINAL FBD of FINAL DESIGN

Josh ANDREATTA - Apr 19, 2022, 1:55 PM CDT

Title: FINAL FBD of FINAL DESIGN

Date: 4/19/2022

Content by: Josh Andreatta

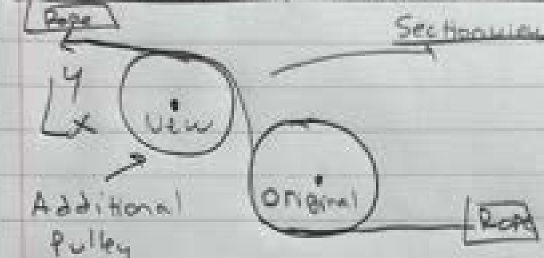
Present: Josh Andreatta

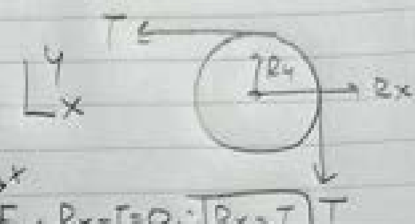
Goals: Show a detailed FBD of the final design

Content:

FBD 1: Pulley Support Plates

Section view of Additional Pulley:





* Neglect small mass of pulley, rope, + support plate compared to max 1050N Load of Rope Tension*

$\xrightarrow{+} \Sigma F_x: R_x - T = 0 \therefore$ **$R_x = T$**

$+\uparrow \Sigma F_y: R_y - T = 0 \therefore$ **$R_y = T$**

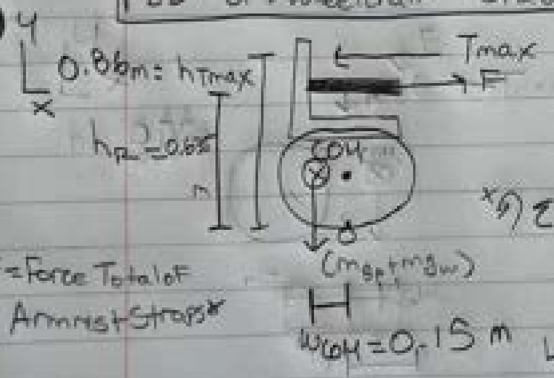
∴ Pulley bearing support plates must support max tension developed in rope

Set $T_{max} = 1050N$. If used properly, $R_x \to 0$ as pulley will spin + the x-dir force will not be transmitted to the pulley plate.

In WORST CASE SCENARIO, 1 Pulley Plate recieves T_{max} in @-dir only

↳ modeled in SolidWorks According to equations boxed above

FBD 2: Wheelchair Stability



F = Force Total of Armrest Straps

* Dimensions are from wood structure!*

Assume $m g_{person} (mg_P) = 80kg$

Assume $m g_{wheelchair} (mg_w) = 30\ kg$ (max)

Assume $T_{max} = 1050N$, $g = 9.81\ m/s^2$

Find Reaction Force @ Armrest, $\vec{F}$, if $\alpha = 0$:

$\curvearrowleft \Sigma M_O = I\alpha^{0}: (T_{max})(h_{T}) - (F)(h_{R}) + (mg_P + mg_w)(w_{com})$

$0 = (1050N)(0.86m) - (F)(0.635\ m) + (1079.1N)(0.15m)$

∴ **$F = 1676.953\ N$**

↳ F is Total F ∴ Rxn Force for each of 2 straps is

$F/2 = 838.48N$

* ∴ If average person sits in the max weight of a typical wheelchair, the armrest straps must apply a downward Force of ≈839 N each to prevent the wheelchair from tipping backwards.*

Dimensions: $h_{T_{max}}$ = 29 inches to armrest + 5 inches to chest = 34 in ≈ 0.86m = $h_{T_{max}}$

h_R = 29 inches to armrest − 4 inches to the hole = 25 in = 0.635 m = h_R

w_{COM} = 6 inches ≈ 0.15 m = w_{COM} (assume behind center of wheel)

The above image shows the final FBD for the main weight bearing components of the final design: the pulley plates, and the wheelchair stabilizing straps and wooden frame.

References: n/a

Conclusions:

The FBD above was made using some simple assumptions. First, the average weight of a person is around 170-180 Lbs, so I used 80 kg for the weight of the person. The maximum weight of a wheelchair is 60 lbs, which is around 30 kg. The maximum force typically developed while rowing is 1050N (from Sam's prior research). Thus, the max tension and the max wheelchair weight was used to get the maximum force that the arm rest straps would need to apply to prohibit tipping of the wheelchair. Thus, the sum of moments about the center of the wheelchair was taken using the moments generated by the max tension in the rope, the total mass of the user plus the mass of the wheelchair, and the reactive armrest strap force. It was found that under max loading conditions (again, this is max rope tension and max wheelchair weight) that each strap needs to provide around 839N of force to prohibit tipping. The dimensions for the location of the force Tmax, reactive force F, and total mass of person and wheelchair are estimates from our own measurements of the structure.

For the pulley plates, the worst case scenario is if the pulley does not rotate and the max 1050 N rope tension is directed downward onto the pulley bearing. Since this bearing is in contact with the pulley plate "washer" on the bearing, the pulley plates must be able to support this 1050 N load. This is modeled in another entry using SolidWorks Simulation.

Action items:

-Test!

2/23/2022 - Prelim Presentation Work

Josh ANDREATTA - Feb 23, 2022, 5:30 PM CST

Title: Prelim Presentation Work

Date: 2/23/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Explain what slides I made and show my script

Content:

I worked on slides 14-18, which encompassed discussing the 3 wheelchair stability designs, their design criteria, and their design matrix. These slides can be found in the entry with the Prelim Presentation uploaded as an attachment. Below is my script:

"Thanks Sam! For our second portion of the overall design, we needed to have a way to stabilize the wheelchair during the action of rowing. Our first idea is the Highway ridges design, which is based off of current designs at Johnson Healthtech. This design incorporates a platform with cut-in-ridges that the wheels of the wheelchair rest in during use. The platform has an incline down to the floor so the user can simply roll into place. This design is the easiest of all to fabricate, but may not be sufficient in preventing forward or backward tipping.

The second design is the traction blocks design. The blocks have a semicircle groove cut down the middle which is larger than the wheelchair wheel width. If the user rolls too far backward during the rowing motion, they will roll up and into the block which will slow them down and prevent tipping. The surfaces of the blocks will be covered in a traction material similar to blocks used in track meets to reduce the users velocity. This design is slightly more complex to fabricate and would require outside assistance for someone to insert the blocks behind the wheels once the user rolls onto the platform.

The final design is essentially a combined version of the previous two designs, incorporating traction blocks and wheel ridges. Thus, this is the most stable of all the designs, but has possible redundancy in preventing tipping which may not be necessary.

The design criteria are similar to that for the pulley mechanisms, however, versatility was removed and the percentages of Durability and Cost were each raised to 15%. The most important factor among the designs is again the safety it provides to the user and how easy it will be to fabricate and use.

After comparing the 3 designs, it was determined the the Highway ridges design was the most likely to accomplish our stability goals. This design, having the easiest fabrication process and the least cost while still remaining safe and user friendly, was the clear choice to proceed forward with. If during testing, we notice a lack of stability in preventing tipping, the team will aim to incorporate a mechanism similar to the traction block design. Next, Cate will discuss our final designs and our future work. "

References: n/a

Conclusions:

I rehearsed my script for the presentation and am ready to practice with the team.

Action items:

-Practice Presentation Thursday at 4:30 in ECB with team

-Assign Report Sections

-Write report Sections and edit

-Turn in notebook, report, evals

2/26/2022 - Prelim Report Work

Josh ANDREATTA - Feb 26, 2022, 9:21 AM CST

Title: Prelim Report Work

Date: 2/26/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Explain what I wrote for the Prelim Report

Content:

I was assigned the section for describing the 3 stability designs (Highway Ridges, Traction Blocks, and Combined Design) as well as the Armrest Hooks Design. I wrote the section describing the Design Matrix criteria for the pulley mechanism designs and the stability designs. I put in the design matrix for the stability designs and wrote the section explaining this design matrix. I made theses same slides in the preliminary presentation, so I was able to use my images and knowledge from creating those slides to help me in writing my sections of the preliminary report.

References: n/a

Conclusions:

I wrote my assigned sections for the prelim report and am ready to edit the entire document, along with the PDS, with the team.

Action items:

-Edit Prelim report

-Edit PDS

-Submit Prelim Report and Notebook to Website & Canvas

-Email Evals

2/26/2022 - Personal Thoughts Prior to Spring Break

Josh ANDREATTA - Feb 26, 2022, 9:34 AM CST

Title: Personal Thoughts Prior to Spring Break

Date: 2/26/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Express how I feel the project has been coming along so far.

Content:

I think that we have had a very successful semester so far working on this design project. This project is the most interesting project to me I have done so far in design so it has been very fun to work on. I think that our team dynamic works very well together and this has allowed us to have productive meetings and always create great work together, whether it be on deliverables or just talking through brainstorming. I feel that we completed a thorough amount of research on competing designs of currently adapted rowing machines, and after visiting Johnson Healthtech, I believe that our designs we created are original and likely to be very successful. I think visiting Johnson Healthtech was a very cool experience, getting to see all of the work they do on designing and improving gym equipment.

I think that our preliminary presentation went very well and that we executed it the best we had ever done it before. I also thought that we answered all the questions we got very well and showed that we know a lot about the details of our project. I also think that we have written and very good report that correctly explains our design process, starting with our extensive background research, and ending with our 2 design matrices. Again, I am very pleased with how well everyone on our team works together. People are never shy to ask questions and are always willing to take any part of work that is assigned or needs help, and this makes for a successful team.

With regard to our actual designs, I am happy with them moving forward. I definitely agree with the teams decision to choose the 2 pulley with slit option to transform the standard rower into an adaptive rower. Due to the complex coiling mechanism within the machine itself, I think that it is safest and smartest to only use the same rope and handle bar that is already attached to the inner workings of the machine. After talking through this design, I am confident that we can execute it and have it come to life. For the stability designs, I believe that the Highway ridges design will work. At first, I was a little hesitant, but after visiting Johnson Healthtech and seeing a very similar design used on one of their products, I became more confident that if we design the ridges properly, it should be sufficient to prevent the user from rolling out and off the platform. In addition, I think that the side handle bars attaching to the armrest will help to account for any rotation that is not already stopped by the platform ridges. So, I believe that the team came up with several unique designs that accomplish the goals we set forth for this project. I look forward to trying to make these goals come to life after spring break.

References: n/a

Conclusions:

Overall, I feel that the team has worked very well together and this has made the design process more enjoyable. I think that we put together a very well written report and had a good prelim presentation. I am very proud of our designs for being simple, yet achieving all of our goals outlined in the PDS. I think that our diligence and work thus far has set us up for a successful rest of the semester once we return from spring break.

Action items:

-Begin making SolidWorks Models of Designs

-Begin Sourcing Materials

4/24/2022 - Final Report Work

Josh ANDREATTA - Apr 24, 2022, 5:25 PM CDT

Title: Final Report Work

Date: 4/24/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Discuss final report work

Content:

For the final report, I was assigned the portions of the fabrication methods, testing methods, and results that all pertain to solidworks. Thus, I discussed my process on designing the pulley plates, swivel bracket, and rower neck slit cut in solidworks. I talked about why certain features were added in certain places. For testing, I talked about the process behind applying the 1050 N maximum load to the portion of the plate that is directly in contact with the additional pulley bearing. In the results section, I talked about the maximum displacements and stresses seen on both the right and left plates, since they were different. I only talked about this max loading, rather than the ideal loading I did. This is because the plates proved that they would perform well even under the safety factor loading. Thus, talking about ideal loading and specific displacements and stresses would clutter up the report, as this can be assumed by the plates performing well under max loadings (stresses and displacements are less in the ideal loading because there is less applied force). This, however, is mentioned in the report that the plates would thus perform well under typical loadings which are less than the 1050 N.

References: n/a

Conclusions:

I will meet with the team to edit the report and fix the comments from the prelim report after we have presented our poster.

Action items:

Edit Report

4/23/2022 - Final Poster Work

Josh ANDREATTA - Apr 23, 2022, 10:54 AM CDT

Title: Final Poster Work

Date: 4/23/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Discuss final poster work

Content:

DISCUSSION

- Design Achievements
  - Rower is convertible between standard and adapted sides
  - Wheelchair users can roll into the wooden frame and lock themselves in with only minimal movement during rowing
  - Users can adjust resistance levels and get workouts of varying intensity on adapted side
- Design Shortcomings
  - Stabilization frame lifts up and forward slightly during strong rowing motion
  - Stabilization frame is not adjustable for varying sized wheelchairs / people
  - Additional help is required to release tension in the rope prior to transitioning it to the opposite side through the neck
  - Adapted side needs a component to hold the handle bar during rest

The above image shows my work writing the discussion section of the final poster. I talked about the main achievements and shortcomings of our design.

TESTING & RESULTS

Pulley Support Plates Solidworks Simulation:

- Cavity around support arms fixed
- 1050 N load with safety factor of 2 applied on inner surface of pulley bearing cavity
- Max Displacement: 1.076 mm
- Max Stress: 18.84 MPa < Yield Stress Tough PLA: 37 MPa

Figure x,x: Solidworks Simulation Testing

The above shows my work writing the results section for the solidworks testing. I described where the load is applied and the maximum displacement and stress relative to the yield stress of the chosen material (Tough PLA).

References: n/a

Conclusions:

The team will meet to edit the poster on Monday from 4-6pm.

Action items:

-Edit Poster

-Write Report

4/27/2022 - Final Poster Presentation Script

Josh ANDREATTA - Apr 27, 2022, 9:58 AM CDT

Title: Final Poster Presentation Script

Date: 4/27/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show the script I will use for the final poster presentation

Content:

Thanks Cate. We decided to separate our testing into four chunks to analyze four different components of our design. First, we ran a simulation in solidworks on the two pulley support plates to test the strength of the geometry and the chosen material, Tough PLA. From literature, it was found that the maximum tension that is developed during rowing is 1050N. So, to model a worst case scenario, the simulation applied this 1050N load to each plate where the plate is contact with the pulley bearing, thus giving it a safety factor of two since ideally this load would be distributed equally between the two plates. The plates were held fixed at the same location that they will be fixed on the rower around two metal support arms. It was found that the maximum displacement was only around 1 mm and the max stress developed was around 19MPa, which is just above half of the yield stress. Thus, the plates should perform well under loads below this safety factor, which are the loads that are typical during normal rowing.

Next, we compared the tension developed during rowing on both the standard and adaptive sides. We used a 100 pound spring gauge to record the max tension that developed during 10 consecutive rowing pulls at the lowest, middle, and highest resistance levels. To standardize this method, we did our best to maintain a stroke rate of 22-25 strokes per minute, that way any change in tension was due to the increasing resistance level, and not due to extra user effort. During this rowing, the user lifted their legs off of the ground so they could not use them to propel themselves backward, as wheelchair users can only use their upper body to row. Although the exact values did not match, there was still an increase in the force required to row at higher resistances on the adaptive side as well as the standard side, proving the ability to achieve varying workout intensities from the adaptive side.

Thirdly, we used Kinovea Motion Capture to track the movement of the wheelchair and its stabilization frame during rowing. Trackers were placed on the wheelchair itself and on the vertical support post of the wooden frame and motion was recorded during 30 seconds of rowing at level 10. We saw that the wheelchair slightly moves back and forth on the ground, but does not tip. We also saw that the wooden frame tends to move up and forward off of the ground, which could be solved by constructing it out of metal, as sam will touch on later. However, these slight movements do not impede the ability to row from the adaptive side.

Lastly, we had 6 people use the device and fill out a survey based on their experience. From their feedback, the common complaint was that it was difficult to not use their legs as the room to lift them off of the ground was limited. However, each participant did feel that transitioning the rope from the standard to adaptive side was intuitive and easy to do, and that the rowing motion itself mimicked that of a normal motion. Next, dhruv will talk about the implication of our results.

References: n/a

Conclusions:

I will memorize and be comfortable saying this script in 2 minutes.

Action items:

-Print Poster

-Practice Script

-Edit Report

-Finalize lab archives and final report

4/30/2022 - Personal Thoughts on entire semester

Josh ANDREATTA - Apr 30, 2022, 9:56 AM CDT

Title: Personal thoughts on entire semester

Date: 4/30/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Discuss personal thoughts on entire semester

Content:

This semester, our team was tasked with developing a device that can transform a standard Matrix Rowing machine into a rowing machine that is accessible to individuals who require the use of wheelchairs. During the first part of the semester, we conducted background research on the target population, reasons for the need of such a device, and any competing designs that currently existed. We wanted to develop a unique device that not only let wheelchair users use the rowing machine, but also kept the ability to row from the standard side. Thus, we designed the two pulley with slit design that allowed for this simple conversion and extension of functionality. Before we spring break, we developed the general ideas for this design and got to work fabricating after spring break.

After we got back from spring break, we split up tasks for fabrication. Since i had the most experience with solidworks, I handled all of the modeling and 3D printing of components. This included modeling the cut in the neck, and then modeling and repeatedly printing the 2 pulley support plates and console swivel mechanism. This ended up being a lot of work due to the time it took to properly design the plate geometry and run simulations on it, and in thinking of how best we could rotate the display to be visible from both the standard and adaptive sides. However, once it was completed, I was glad I spent the time on developing these designs as they actually functioned how we wanted. Tim, Sam, and Dhruv were responsible for buying, measuring, and fabricating the wood support frame. They also helped to develop the testing plans for tracking the motion of the wheelchair and its stabilizing frame in Kinovea. Cate helped with developing the testing protocol for the rope tension testing and in analyzing this data in MATLAB. She also spray painted the final support structure black to match the color of the rower. Overall, the team split up work according to everyones strengths, which I think was a good way to go about it, that way we ensured that we would get the best quality work for each component of the design. Fabrication went smoothly and we were able to get pulley plates that properly fit onto the rower without slipping off or becoming damaged, and we were able to get the console to swivel which was a great additional feature. The wheelchair also had its wood stabilization frame and this enabled us to begin our testing.

I think that our testing was very complete. Running a solidworks simulation on the pulley support plates was the best way to analyze the strength of the material and geometry. I also think our method for comparing the rope tension on the standard and adaptive sides was well thought out and proved our main goal of being able to achieve workouts of varying intensity from the adaptive side. The kinovea motion capture was a great bonus in testing that allowed us to quantify the stabilizing effects of the wood frame on the wheelchair while rowing. Thus, I believe that our testing was very well thought out and executed and displayed a great proof of concept that our design actually works.

Overall, I am very happy with the final design. I still believe that adding the second pulley and making a cut in the rower neck was the easiest way to allow for rowing from both the standard and adaptive sides. I also think that the wood stabilization frame was the best way to stabilize the wheelchair, given our time and resources. I am very happy with the progress I made in my skill improvements, and very proud of the final work that our team did to create a product that has such a high likelihood of success on the actual market. This was a very fun and interesting project to work on, and I think it really helped me figure out more the things I like and don't like when it comes to the finding a passion with BME. If this project were continued in the future, I definitely think we would want to just make the stabilizing frame out of metal and make it adjustable, like regular workout equipment at the gyms. This would extend its use to people of varying sizes and wheelchairs of varying shapes and sizes. Additionally, smaller improvements could be made to ensure that rowing is as close to rowing on the standard side. This would include making the pulley support plates out of metal and welding them to the rower, and adding a mechanism to take tension off of the rope to transition it from one side to the other. This would make the device able to be easily used by a user without any outside assistance. Finally, we would want to create a robotic arm that can change the resistance level from the adaptive side, that way absolutely no outside assistance is needed. Thus, there is still room for great improvement of our design, but the progress we made this semester was fantastic and shows that the device can actually be used and works as intended, which is a great feeling. Overall, this was a great semester of team building, great designing, and great execution of fabrication of a design and testing it, while recognizing the possibilities it has to be improved on in the future.

References: n/a

Conclusions:

This semester we successfully fabricated a device that allows for the conversion of a standard rowing machine into that of an adaptive rowing machine that is accessible by wheelchair users. This device is different than any other on the market because it retains the ability to still be used as a normal rowing machine. I am very proud of the work that our group did and the fact that we were actually able to run lots of testing and prove that our design works was a great feeling. I grew alot in my solidworks and fabrication skills and definitely feel that this was my favorite semester in BME design so far.

Action items:

-Edit report

-Turn in final report, notebook, and peer and client evals

9/15/2021 - Chemical and Biosafety Trainings

Josh ANDREATTA - Sep 15, 2021, 1:21 PM CDT

Title: Chemical and Biosafety Trainings

Date: 9/15/2021

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Complete Chemical and Biosafety Trainings

Content:

Below is an attachment of the Chemical and Biosafety Trainings that were to be completed.

Conclusions/action items:

I completed the Chemical and Biosafety Trainings.

Josh ANDREATTA - Mar 08, 2021, 11:56 AM CST

Download

Trainings.pdf (139 kB)

2/3/2022 - Red/Green Pass Permits

Josh ANDREATTA - Feb 03, 2022, 2:05 PM CST

Title: Red/Green Pass Permits

Date: 2/3/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show documentation for my red and green pass permits

Content:

You have the following permits and upgrades:

Name	Date
Green Permit	01/25/2022
Red Permit	02/11/2020
Laser 1	02/18/2020

References: n/a

Conclusions:

I can use all equipment designated by the red and green pass.

Action items:

Meet with client and start PDS.

3/7/2022 -WARF Lecture Notes

Josh ANDREATTA - Mar 07, 2022, 5:58 PM CST

Title: WARF Lecture Notes

Date: 3/7/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Learn how WARF could apply to my project

Content:

- WARF been around for patenting for a long time
- Non-profit, fully separate from UW-Madison
- Cycle of Innovation: UW Research/discovery, IP Protection (patents), Licensing and Startups, Funding to support further research and discovery
    - File in US; no global patents
- Try to return some money to us
- Protection: Patents, Trademarks, Copyrights
- Prior Art: "references" created before a specific date
    - 1 year grace period until have to file for patent
- Requirements for Patenting: Eligible, Useful, Novel, Non-Obvious
- Takes a LONG time to get a patent
- Try to market device while patent still getting confirmed
- First to file system in US, rather than first to invent
- After getting a patent, have to go through the licensing process which will also take time
- License is a contract where company agrees to use device and commercialize it for us
- Timeline depends on technology and makret readiness
- WARF provides milestone based validation funding to speed promising technologies to a commercial license
- Lots of resources on campus to help us find funding and guidance for entrepreneurship

References: Justin Anderson / Jeanine Burmania / WARF staff

Conclusions:

Our adaptable rowing machine would benefit greatly from a patent because it is a novel device that would reach a large population of individuals in wheelchairs and thus extra commercialization and funding would greatly help with its development. Because it is a new device, we believe it would not find pushback during the patent approval process because there shouldn't be any competing devices that are exactly like it. For licensing, Johnson Healthtech via Matrix could take on the product to further develop.

Action items:

-Begin modeling concepts in SolidWorks and work on fabrication plan

3/30/2022 - Initial Pulley Plate Print

Josh ANDREATTA - Mar 30, 2022, 10:52 AM CDT

Title: Initial Pulley Plate Print

Date: 3/30/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Model a support plate to stabilize the additional pulley

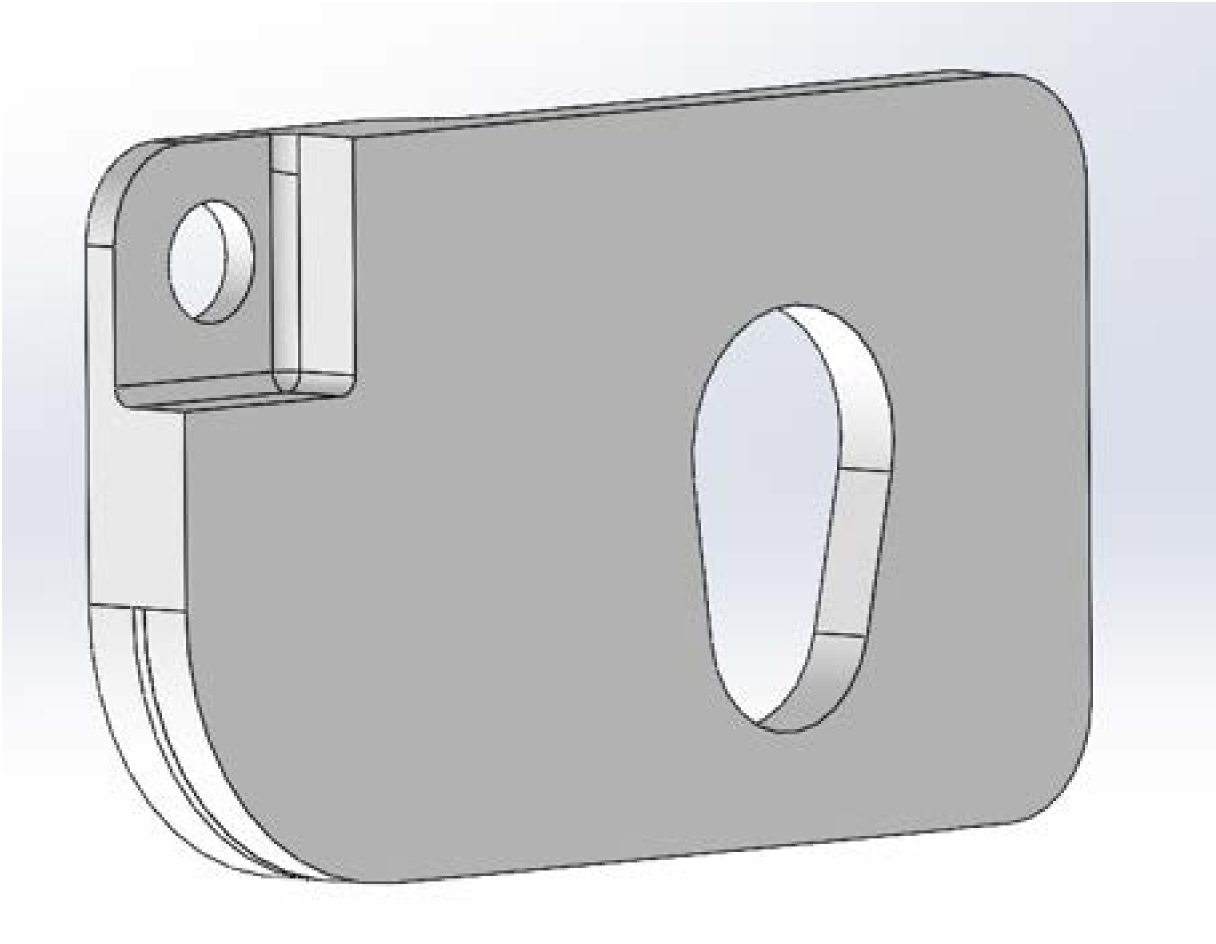
Content:

I wanted to design a support structure that would hold the pulley in place. Our intended course of action is to remove the two lower bolts on the rower neck that restrict how far the neck can be rotated. We are going to remove these so that the neck can be rotated to be completely perpendicular with the floor/ground. Then, as per our prelim pulley design, we want the pulley to be statically held in place at one location. Thus, all the user would need to do is rotate the neck of the rower up and utilizing the cut that will be made in the rower neck, transfer the rope and handle bar to be slotted around the additional pulley.

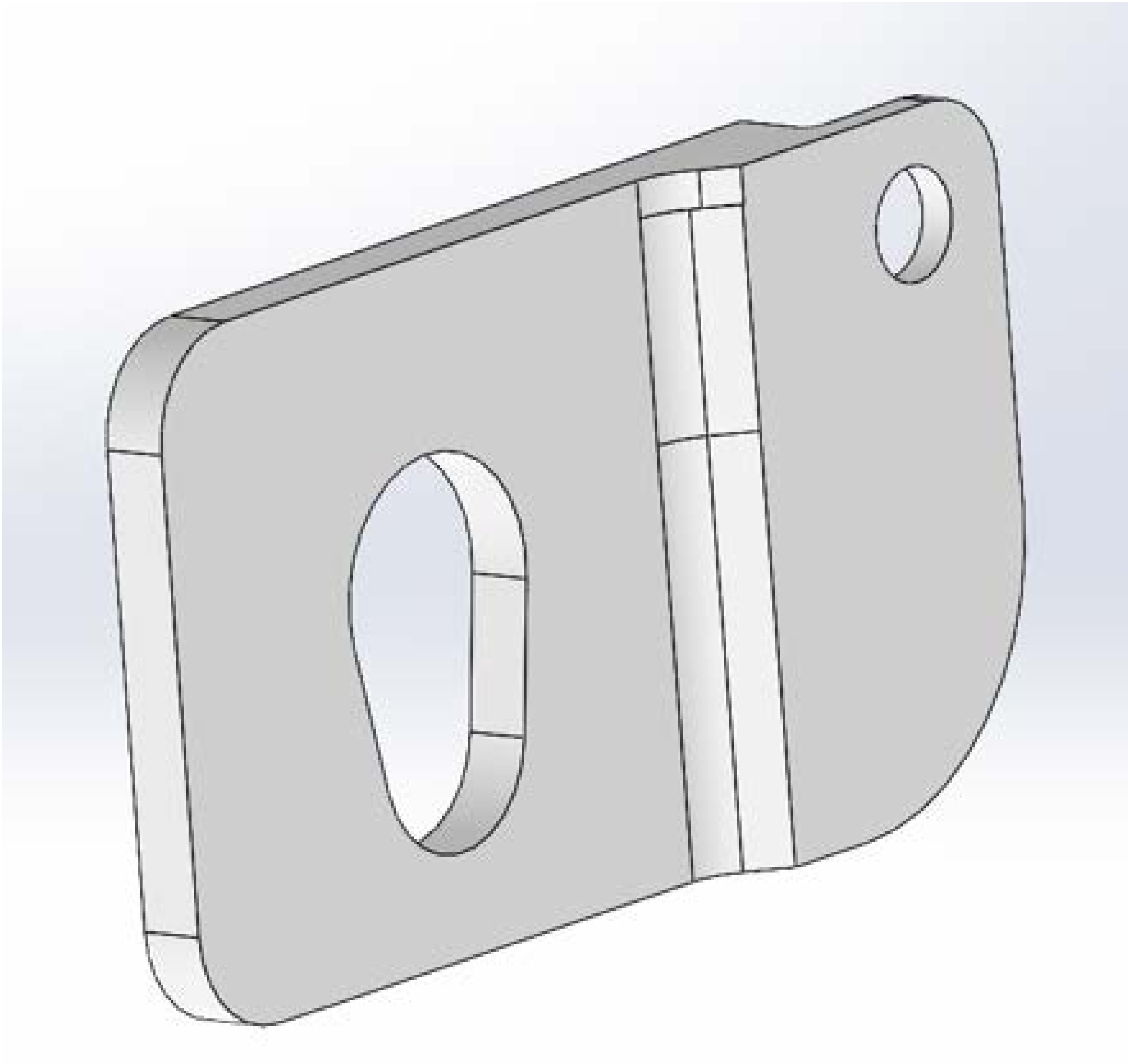
Initially, we wanted to make a clamp in the shape of the Greek Letter Ohm, that would have two mating parts attached via screws However, prior to modeling this, the team realized that this would likely not offer enough support material to be strong enough to bear the weight of the pulley, and any additional force that may be applied to it during the action of rowing. Thus, when modeling, I wanted to maximize the surface area and volume of the support structure, so that any applied forces and stresses could be dissipated throughout the material. I also removed any sharp corners by adding chamfers/fillets to remove stress concentrations. Below is the final design I came up with. This is a plate that has an extruded cavity of the welded support bars that support the rower neck. In order to insert, the neck of the rower would be removed and this plate would slide on and fit snuggly over the flat portion of the two support arms. Then, at the other end of the plate is a hole that would slip onto the additional pulley that we will be attaching. The diameter and thickness of the hole is enough to latch onto the bearing, and still have room to add 1-2 smaller washers, as in the regular pulley.

I printed this at the makerspace in White Tough PLA, with a 0.2mm layer thickness and a 90% infill, as recommended by the student helping me, because they said this would offer the strongest part possible. I tried to model this material in SolidWorks, but it did not have Tough PLA, so I used PVC, which had a fairly similar elastic modulus and tensile strength. The Elastic Modulus of PVC in SolidWorks is around 2400MPa, and the Elastic Modulus of the Tough PLA is around 1800MPa, however the high infill % should further increase rigidity. During modeling, I made the cavity that fits around the 2 support arms rigid/fixed, because during use of the machine, these would be tightly held around the 2 support arms. As per prior research, I then applied 1050N load on to the inner surface of the hole that is wrapped around the pulley bearing. This is because as force is pushed down onto the pulley, the center bearing will transfer this force to the contact surface of the plate. This is really a large over estimate of the true force that would be applied. This is because the tension generated during rowing of 1050N would ideally be directed parallel to the ground. Thus, modeling it as perpendicular to the ground transfers all of this force directly into the support plate. After looking at the displacement, it was determined that it would only be displaced maximally by 0.7234mm at the hole around the pulley bearing. I am confident that this will not break, because the pulley bearing is made of sturdy metal and will offer a resistance to any potential bending in the part. This is essentially no displacement at all, so I am confident that given the % infill I printed with, the piece will be more than capable to withstand excessive loads. Further more, this 1050N would ideally be transferred equally between the two plates, with each plate receiving 525N. Thus, this is a large overestimate of force and ensures a large safety factor in the stability of the support plate. Below are images of the part, and the deformation simulation.

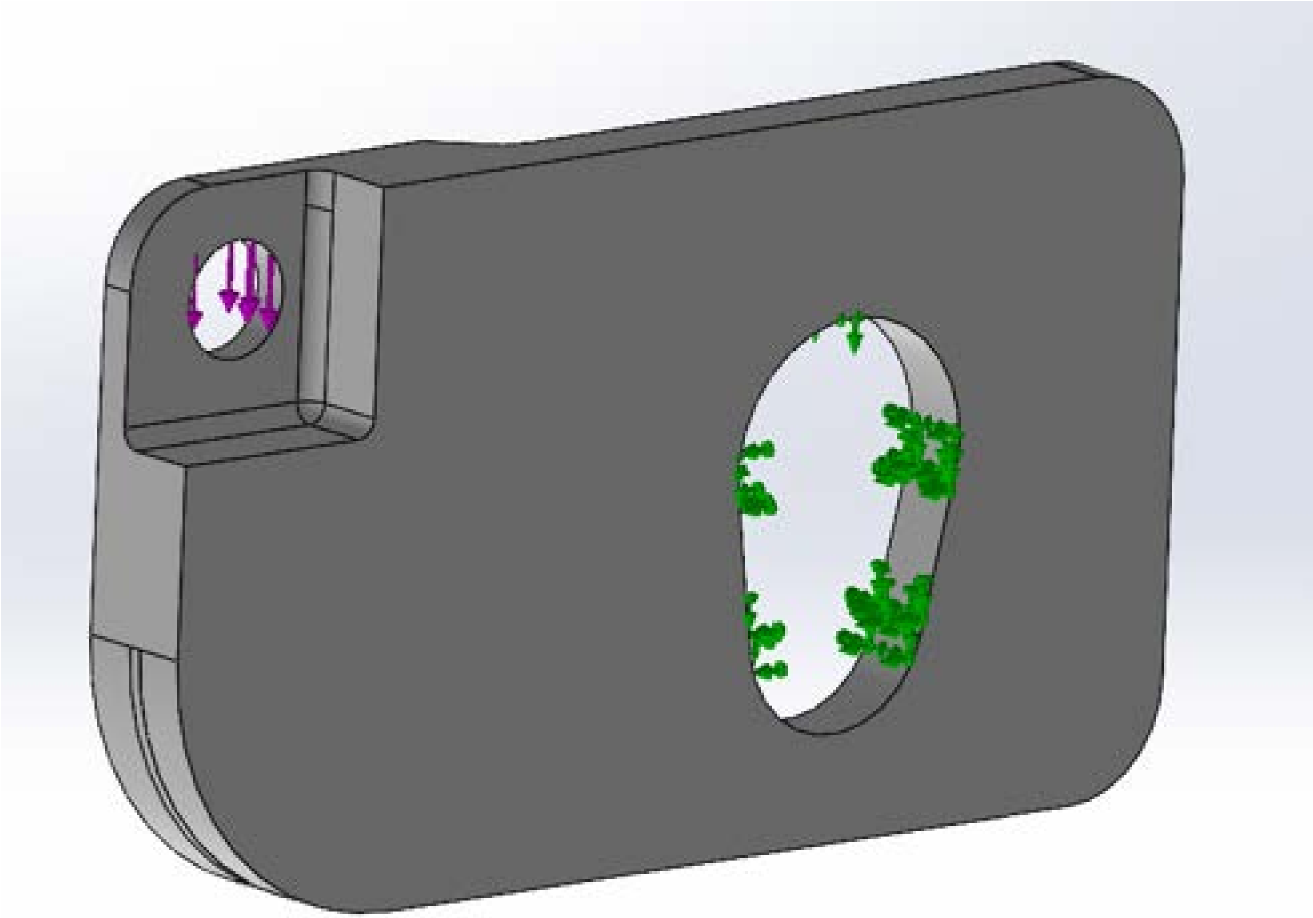
Attached Below are the SolidWorks Files of the entire rower assembly with the plate, and a separate file of just the support plate.



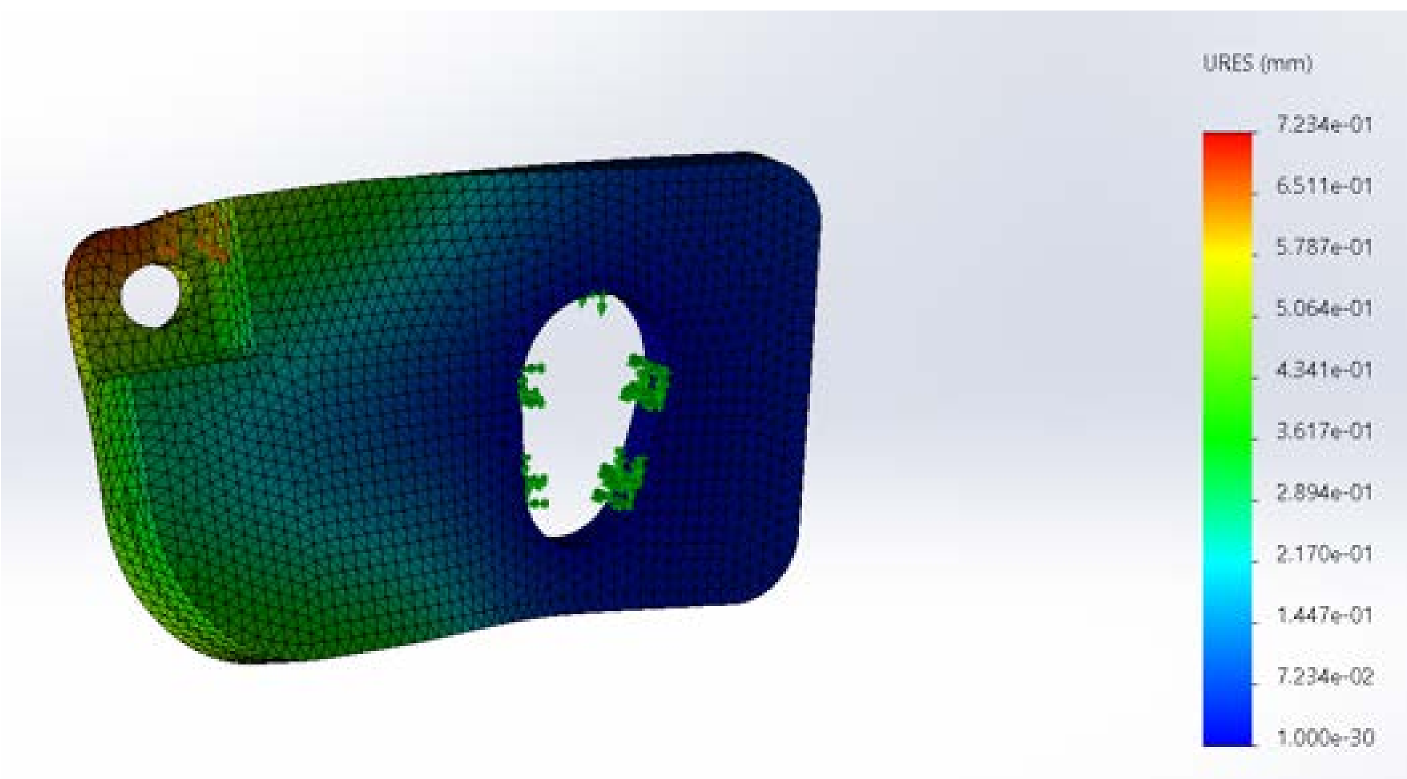
The above image shows the front of the pulley plate with a hole for the pulley bearing (top left) and a cavity to slip onto the support bars (lower right).



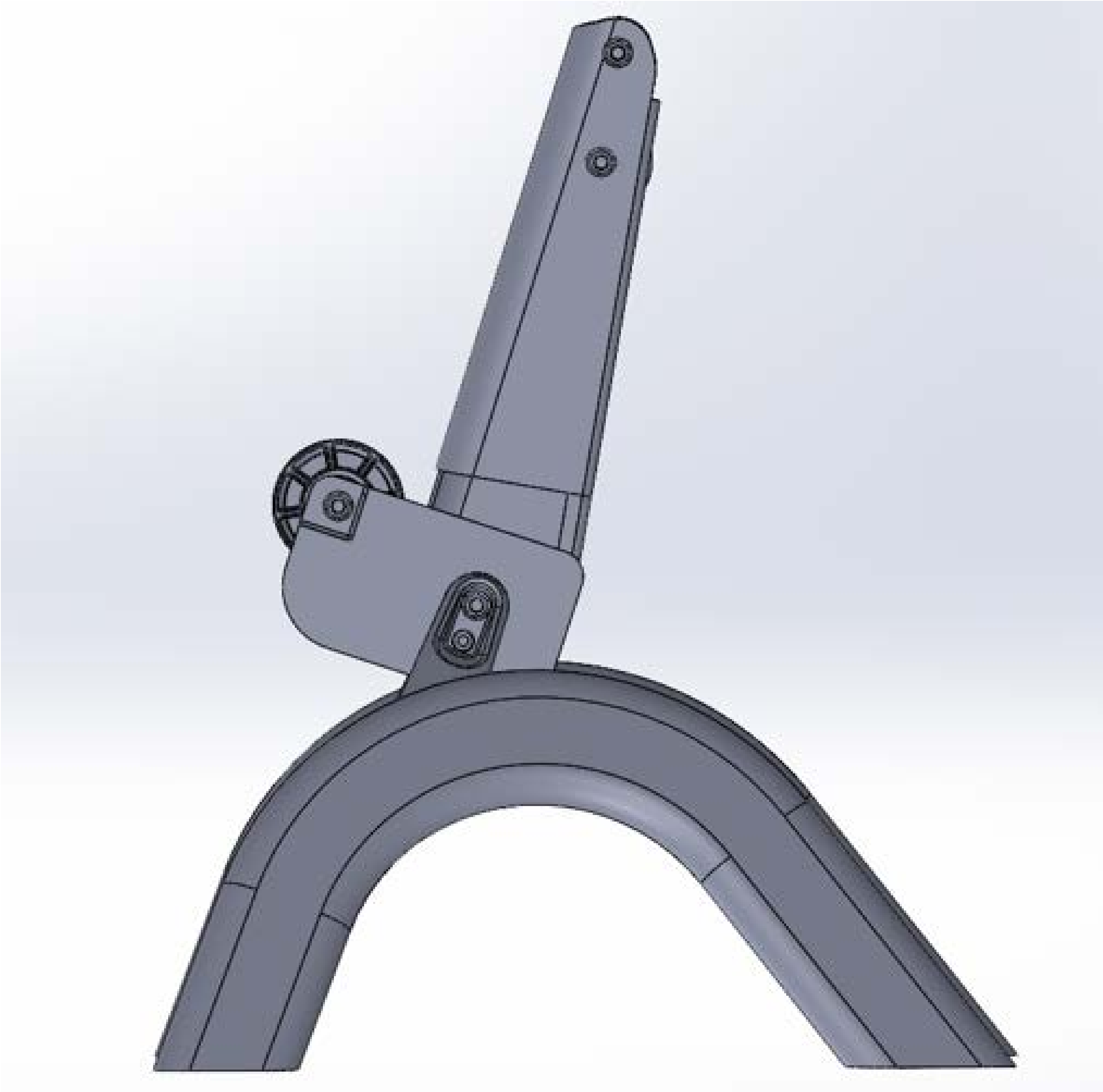
The above image shows the back view of the support plate.



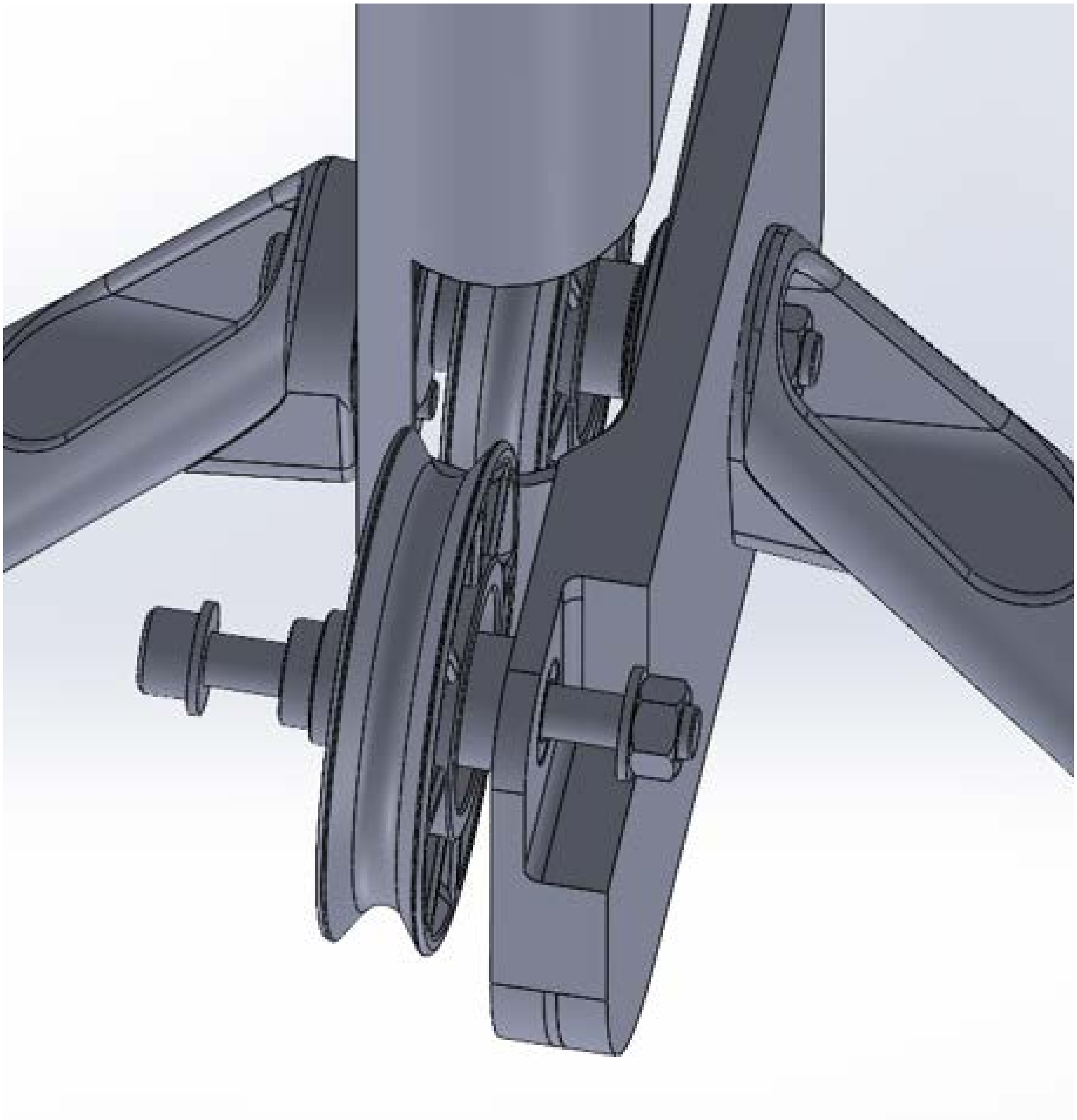
The above image shows the application of forces for deformation testing. The green arrows represent that the part is held in place rigidly around the 2 support arms. The purple arrows are the application of 1050N, which is the maximum force we expect to be transferred to the part via the pulley bearing, which is why it is applied in that hole surface.



The above image shows the deformation of the plate under 1050N.



The above image shows the plate with the rest of the rower structure,



The above image shows a zoomed in view of the plate wrapping around the pulley bearing, and around the support arms of the rower neck.

References: n/a

Conclusions:

After the print finishes printing in 15 hours, I will take it to the rower and ensure that it fits correctly. If any adjustments need to be made, I will make these and then print this part, and the plate for the other side of the pulley, again, hopefully for the final time. Then all that remains for fabrication is cutting the slit through the rower neck, and making the floor support to hold the wheelchair in place.

Action items:

-Analyze print of first plate and see if it fits on the rower. Make any necessary adjustments to sizing in the model

-Once fits correctly, make the opposite side support plate and print both as final print

Josh ANDREATTA - Mar 30, 2022, 10:53 AM CDT

Download

Matrix_Rower_with_Separated_Assemblies.SLDASM (2.27 MB)

Josh ANDREATTA - Mar 30, 2022, 10:53 AM CDT

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Matrix_Rower.SLDASM (2.17 MB)

Josh ANDREATTA - Mar 30, 2022, 10:53 AM CDT

Download

Pulley_Support_Plate.STL (47.5 kB)

Josh ANDREATTA - Mar 30, 2022, 10:53 AM CDT

Download

Pulley.SLDPRT (542 kB)

3/30/2022 - Visualization of Additional Pulley Placement

Josh ANDREATTA - Mar 30, 2022, 10:59 AM CDT

Title: Visualization of Additional Pulley Placement

Date: 3/30/2022

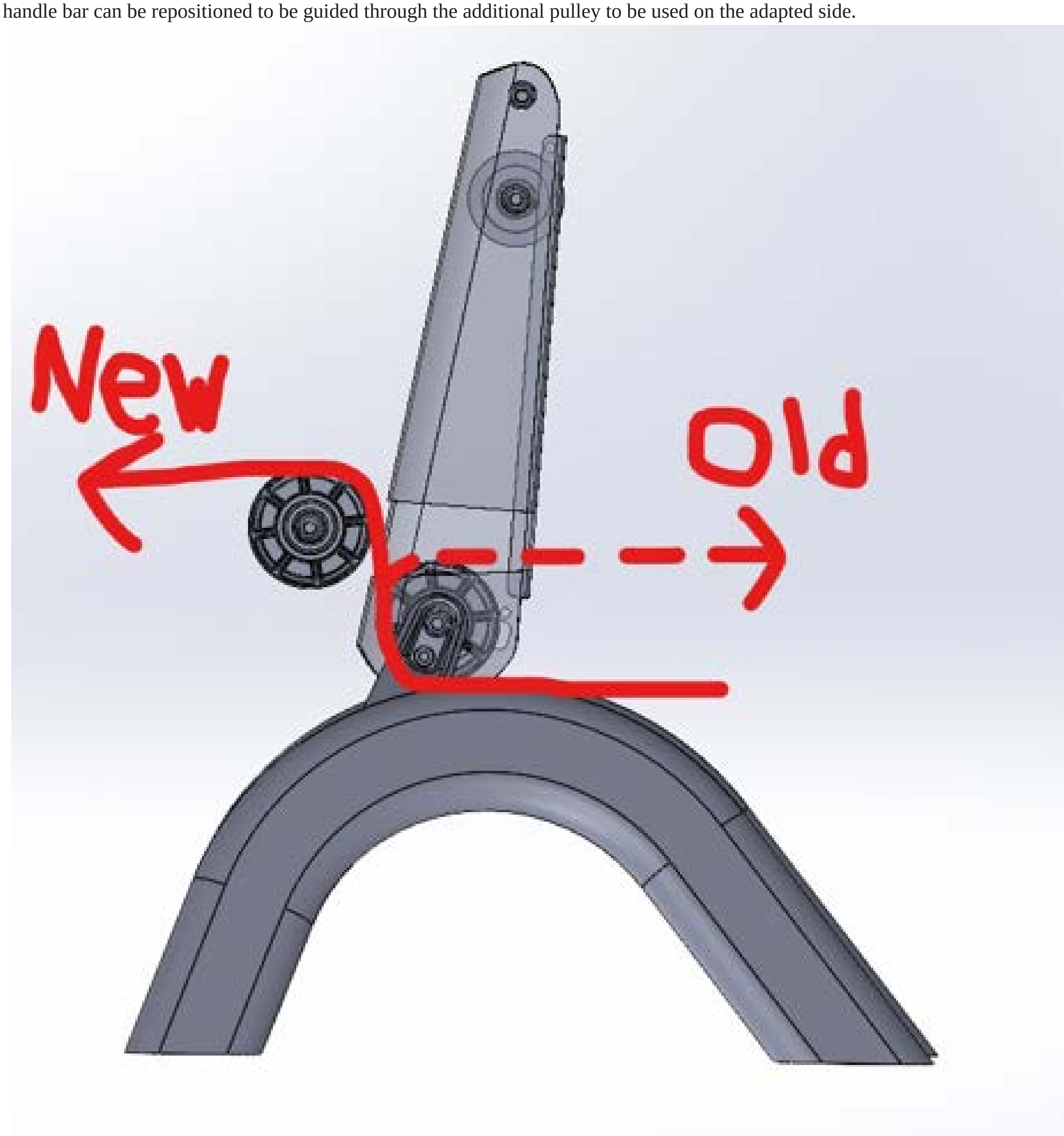
Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show the cut made in the rower neck and how it allows the use of the additional pulley.

Content:

Below is an image of the rower showing the cut made in the rower neck, which allows for the transferring of the rope and handle to the adapted side, view an additional pulley. The cut is made so that when the neck of the rower is rotated to be almost perpendicular with the ground, the rope and handle bar can be repositioned to be guided through the additional pulley to be used on the adapted side.



The above image shows in a red line how the rope would be guided in the adapted form. The dashed line is in standard form.

References: n/a

Conclusions:

The cut will need to be machined out of the rower neck.

Action items:

-Fabricate above cut

3/31/2022 - First Pulley Plate Print & Adjustments

Josh ANDREATTA - Mar 31, 2022, 12:40 PM CDT

Title: First Pulley Plate Print & Adjustments

Date: 3/31/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show first print and explain adjustments to be made

Content:

After printing the first time, the part came out very rigid and solid. When I went to fit it on the rower, the edges were just touching the edges of the rower. So, around the cavity that sits on the rower neck supporting arms, and in the hole that slips around the additional pulley bearing, I added a 0.05 in clearance to ensure that it will slip over more easily. I then sent this off to be printed at the makerspace, again using Tough White PLA on an Ultimaker printer.

The above image shows the back view of the printed plate.

The above image shows a front view of the printed plate.

References: n/a

Conclusions: I will print this today and pick it up tomorrow morning. Hopefully, it will fit around the rower snuggly. If so, I will then print the opposite side plate to complete pulley stabilization fabrication.

Action items:

-Print next iteration with 0.05 in clearance

-See if it fits better

-Print opposite side pulley plate

4/1/2022 - Second Pulley Plate Print & Next Steps

Josh ANDREATTA - Apr 01, 2022, 2:19 PM CDT

Title: Second Pulley Plate Print & Next Steps

Date: 4/1/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show how pulley plate fits onto rowing machine and explain next steps

Content:

After printing the pulley plate a second time by adding the 0.05in clearance, I was able to fit it onto both the rower and the pulley. There is still a little wiggle room around the cavity that attaches to the rower neck support arms, so I will consider adding back 0.02in worth of material to make that fit more snug. First, we emailed our client Staci Quam to ask her if she wants us to 3D print the final versions here on campus, or if she would like to have someone at Johnson Healthtech, or at one of their manufacturing sites, machine the 2 pulley support plates out of metal. We also asked her if she wants us to fabricate the cut in the rower neck on campus or at one of their sites. Based on her response, we will proceed forward with fabrication either on campus or with Johnson Healthtech's help. For now, the proof of concept of the pulley plate is confirmed that it works. Below are several pictures showing it attached to the pulley and the rower separately.

The above image shows the back view of the pulley on the pulley plate.

The above image shows the side view of the pulley on the pulley plate.

The above images shows the left view of the pulley plate on the rower.

The above image shows the right view of the pulley plate on the rower.

The above image shows the top view of the pulley plate on the rower.

The above image shows the back view of the pulley plate on the rower.

References: n/a

Conclusions:

I will wait to see what Staci says about machining the 3D printed pulley plate at Johnson Healthtech. I will also wait to see if I should take any CNC training for cutting the slit out of the neck of the rower, or if Staci will do this at Johnson Healthtech. I will see if I can help with fabrication of the wooden platform that will stabilize the wheels of the wheelchair.

Action items:

-Wait for staci's response regarding pulley plate and neck slit final fabrication steps

-Help team with modeling/fabrication of wooden floor support

Josh ANDREATTA - Apr 01, 2022, 2:20 PM CDT

Download

Pulley_Support_Plate.STL (47.3 kB)

Josh ANDREATTA - Apr 01, 2022, 2:20 PM CDT

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Pulley_Support_Plate.SLDPRT (461 kB)

Josh ANDREATTA - Apr 01, 2022, 2:20 PM CDT

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Pulley_Opposite_Support_Plate_Attempt.SLDPRT (182 kB)

Josh ANDREATTA - Apr 01, 2022, 2:20 PM CDT

Download

Matrix_Rower_with_Separated_Assemblies.SLDASM (2.29 MB)

4/5/2022 - Update on Fabrication at Johnson Healthtech

Josh ANDREATTA - Apr 05, 2022, 7:32 PM CDT

Title: Update on Fabrication at Johnson Healthtech

Date: 4/5/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Update on fabrication of neck and pulley support plates.

Content:

I added a little material back to the slit in the neck so it could have more support against bending moments, as recommended by Staci Quam. I also removed a little material from the top of the right pulley support plate so that it wasn't blocking the more narrowed slit. Attached below are the solidworks files for these updated parts.

Staci said they can cut the slit into the neck of the rower and is still waiting on word for fabrication of the pulley plates into metal.

References: Staci Quam

Conclusions:

Fabrication should begin shortly once Staci gives us the final word of when to drop off parts to her.

Action items:

-Fabricate neck at johnson healthtech

-Possibly fabricate support plates at johnson healthech, if not then 3D print

-Sam and Tim will start fabrication of wheelchair support soon with the wood Tim bought this weekend

Josh ANDREATTA - Apr 05, 2022, 7:32 PM CDT

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Pulley_Support_Plate.SLDPRT (496 kB)

Josh ANDREATTA - Apr 05, 2022, 7:32 PM CDT

Download

Pulley_Opposite_Support_Plate_Attempt.SLDPRT (192 kB)

Josh ANDREATTA - Apr 05, 2022, 7:32 PM CDT

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Matrix_Rower_with_Separated_Assemblies.SLDASM (2.29 MB)

4/7/2022 - Final Pulley Plate Print

Josh ANDREATTA - Apr 07, 2022, 7:03 PM CDT

Title: Final Pulley Plate Print

Date: 4/7/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show final pulley plate print

Content:

The final pulley prints look very good. They are definitely strong enough to withstand the action of rowing. Each plate fits well on the pulley and can be easily tightened with the washers and nuts. The plates fit snuggly onto the rower. However, due to slight curvatures on the rower neck support arms, if the rope is pulled very hard, the plates will wobble slightly. They will not fall off as they would need to be pushed inward to cause this, and no rowing motion will push inward on the plates - only downward. If additional stabilization of the plates is needed, we will stick material between the rower neck and the inside surface of the plates to prevent wobbling, or add a rod between them to push them out and hold them apart steadily. For now, they fit well and function well. Once the neck has the cut, we will attach it all together and assess future steps.

The above image shows both pulley plates on the pulley.

The above image shows the left pulley plate on the pulley.

The above image is the right pulley plate on the pulley. The loss of material on the top surface is to allow for the user to pull the rope out and reposition it on this additional pulley.

The above image is the pulley plates on the rower. In this, you can see the slight gap between pulley plate and rower neck support arms which need to be pushed against each other.

The above image is the left pulley plate on the rower.


Fall 2021
BME 400

The above image shows the right pulley plate on the rower.

References: n/a

Conclusions:

The pulley prints fit the pulley very well, and fit very snuggly on the rower. If additional parts are needed to make sure there is no slipping of the plate on the rower, then material will either be placed in between the rower neck and the plates, or a tight fixed row will be placed perpendicularly between the plates pushing them and holding them apart.

Action items:

-Drop off rower neck at Johnson Healthtech tomorrow to be cut

-Finish fabrication of wooden wheelchair stabilization component

Josh ANDREATTA - Apr 07, 2022, 7:04 PM CDT

Download

Pulley_Support_Plate.SLDPRT (495 kB)

Josh ANDREATTA - Apr 07, 2022, 7:04 PM CDT

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Pulley_Opposite_Support_Plate_Attempt.SLDPRT (193 kB)

Josh ANDREATTA - Apr 07, 2022, 7:04 PM CDT

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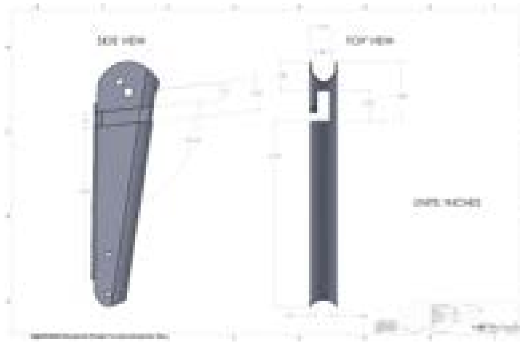
Matrix_Rower_26.SLDPRT (309 kB)

Josh ANDREATTA - Apr 07, 2022, 7:04 PM CDT

Download

Rower_Neck_Drawing.SLDDRW (229 kB)

Josh ANDREATTA - Apr 07, 2022, 7:04 PM CDT



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Rower_Neck_Drawing.pdf (226 kB)

Josh ANDREATTA - Apr 07, 2022, 7:04 PM CDT

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Pulley_Right_Support_Plate.STL (50.4 kB)

Josh ANDREATTA - Apr 07, 2022, 7:04 PM CDT

Download

Pulley_Left_Support_Plate.STL (43.7 kB)

Josh ANDREATTA - Apr 07, 2022, 7:04 PM CDT

Download

Matrix_Rower_with_Separated_Assemblies.SLDASM (2.29 MB)

4/16/2022 - Final Swivel Design for Rotating the Display Console

Josh ANDREATTA - Apr 16, 2022, 11:46 AM CDT

Title: Final Swivel Design for Rotating the Display Console

Date: 4/16/2022

Content by: Josh Andreatta

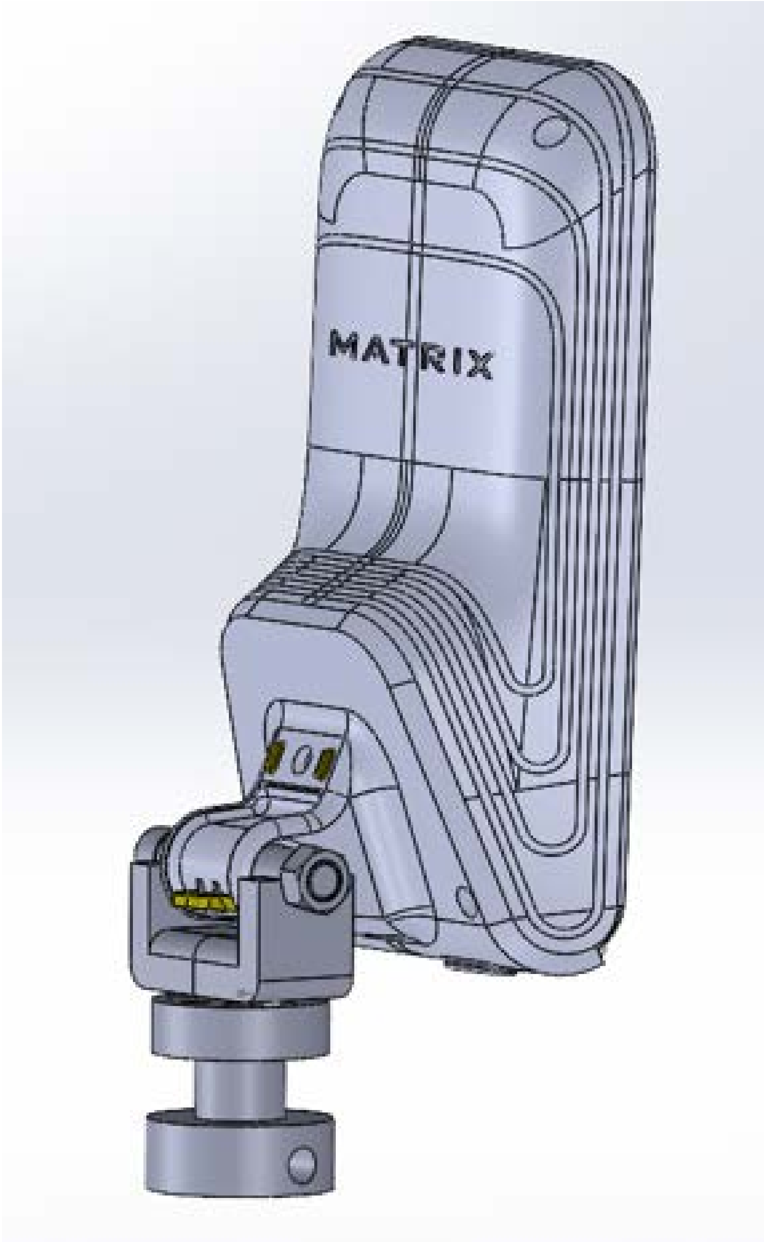
Present: Josh Andreatta

Goals: Show my design for the swivel to rotate the display console

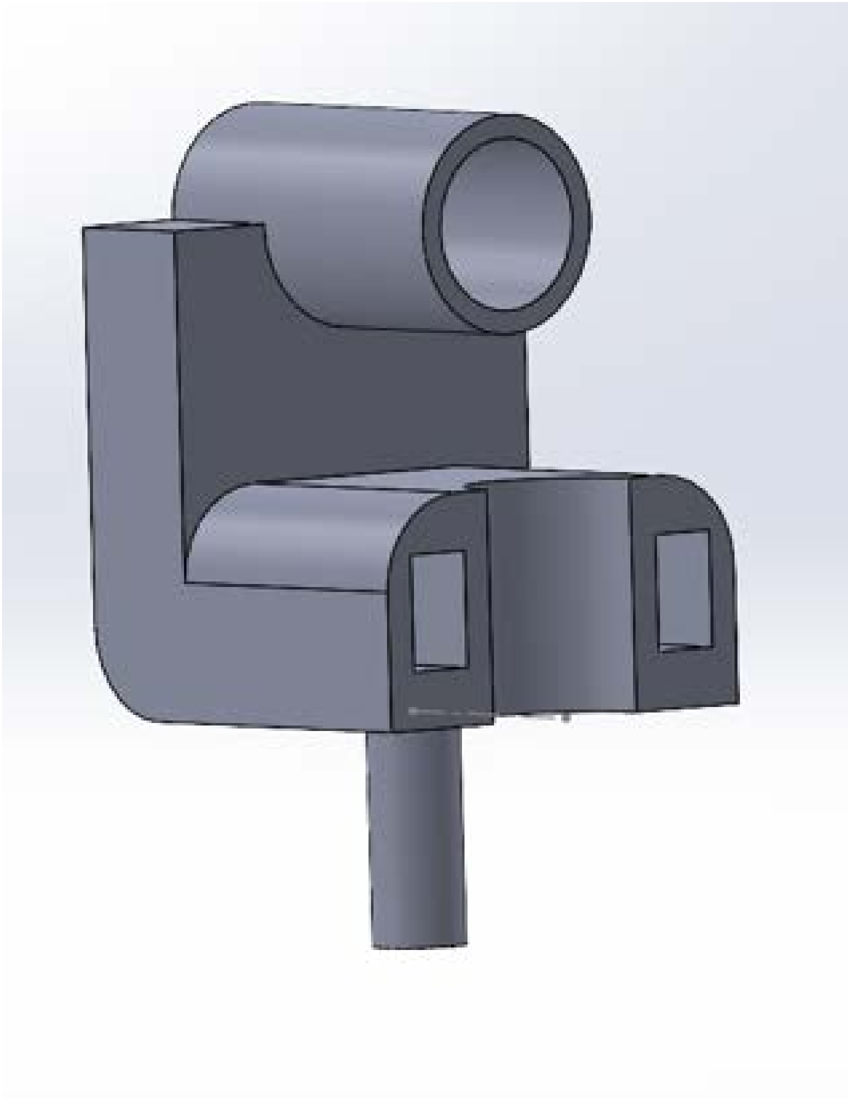
Content:

The last component to our design was to make the display console rotate 180 degrees so that the wheelchair user could still see the monitor. To do this, I took a similar approach to that while making the pulley plates. The design consists of 3 components: a Left and Right Male/Female Mating components that make up a field goal post, and a swivel component that the field goal sits into. Essentially, we wanted to keep the ability for the display to rotate about the screw in the rower neck, but also have it rotate perpendicular to the floor to face the wheelchair user. To do this, a male and female mating piece were made that slip into the through hole in the display console back. The right piece has a semicircular indent that accepts a post on the left piece. The right piece also two block extruded cuts that accept two block boss extrudes in the left piece. These act as a way to hold the two field goal units together when rotating. If necessary, once put together, these two components can be taped or glued together to ensure that they do not come apart when picking up the console and rotating it. The main field goal post then comes down and sits in a cavity in the swivel bracket. This is what allows rotation of the display console. The right field goal piece also has a small peg that comes down and fits into one of 5 holes in the swivel bracket. This acts as a locking mechanism for the console once rotated to a certain position. Since these peg accepting holes are only on half of the upper surface of the swivel, the console can only lock and sit into place for 180 degrees of rotation. However, the console when lifted out will still be able to turn 360 degrees, it just wont be able to lock into place. The user will be instructed to only turn it 180 degrees to avoid over stretching the cord that runs into the console. Ideally, we would want a way to prohibits any rotation greater than 180 degrees, but for now, we will just instruct the user properly how to use the swivel bracket.

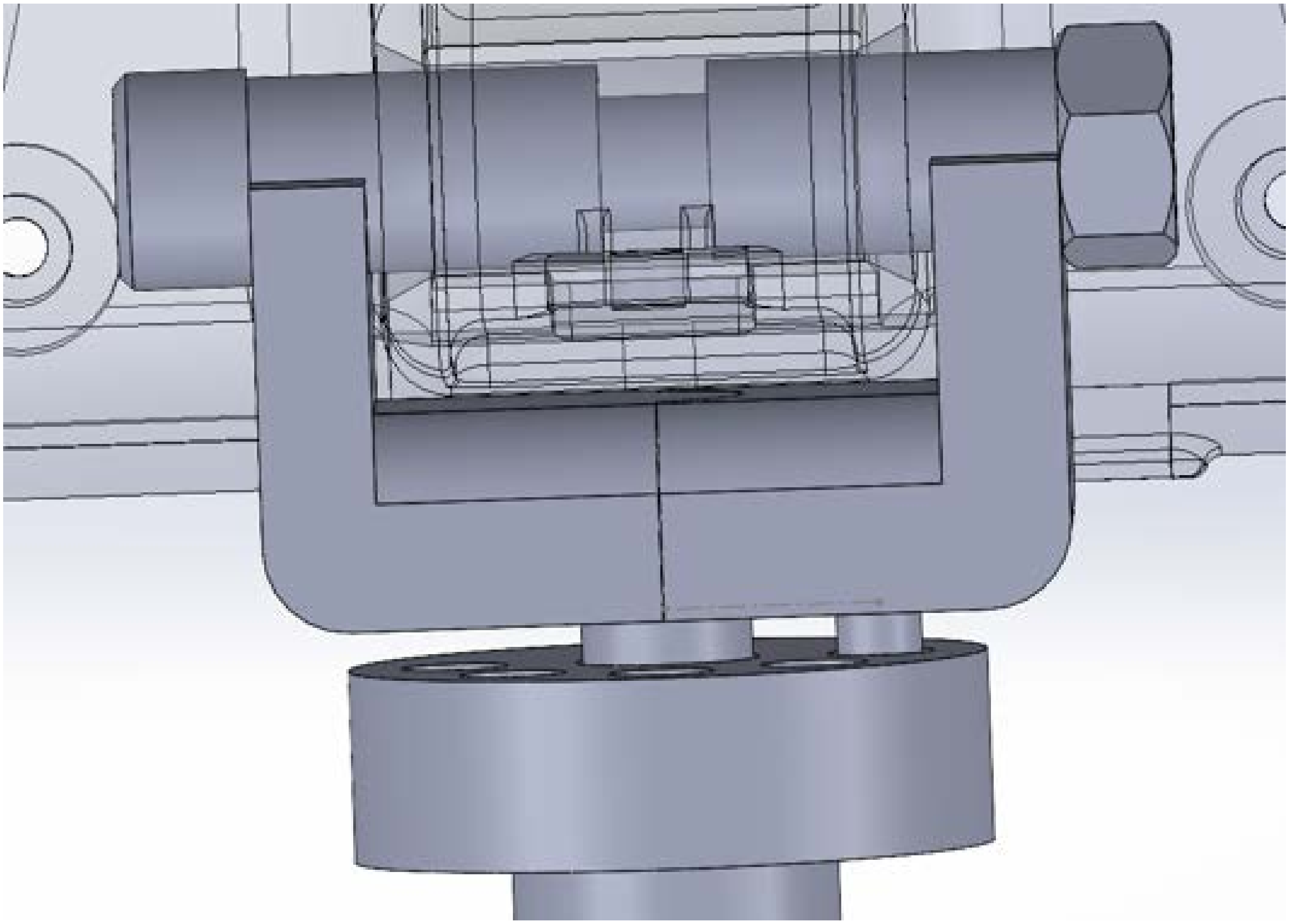
Below the screw that initially held the display console in place in the rower neck is a wheel with an identical screw. Since we are not sure (and neither is our client) what the wheels purpose is, we are going to remove it and use this screw to attach the swivel design to the rower neck. The screw will be moved to where the original position of the display console in the neck was, since the console with swivel design will now be placed slightly above the neck head to allow for rotation. We could not come up with a great way to stabilize the design within the rower neck. For now, we decided to give it a tight fit both around the screw shaft and between the inner walls of the rower neck so that when the screw is tightened, it will push on the outside of the swivel bracket and hold it in place with this contact force. If this doesnt work, we will add material or use glue/tape to hold it in place for now, since a more succinct design could not be brainstormed before we had to test. Below are images of the swivel design.



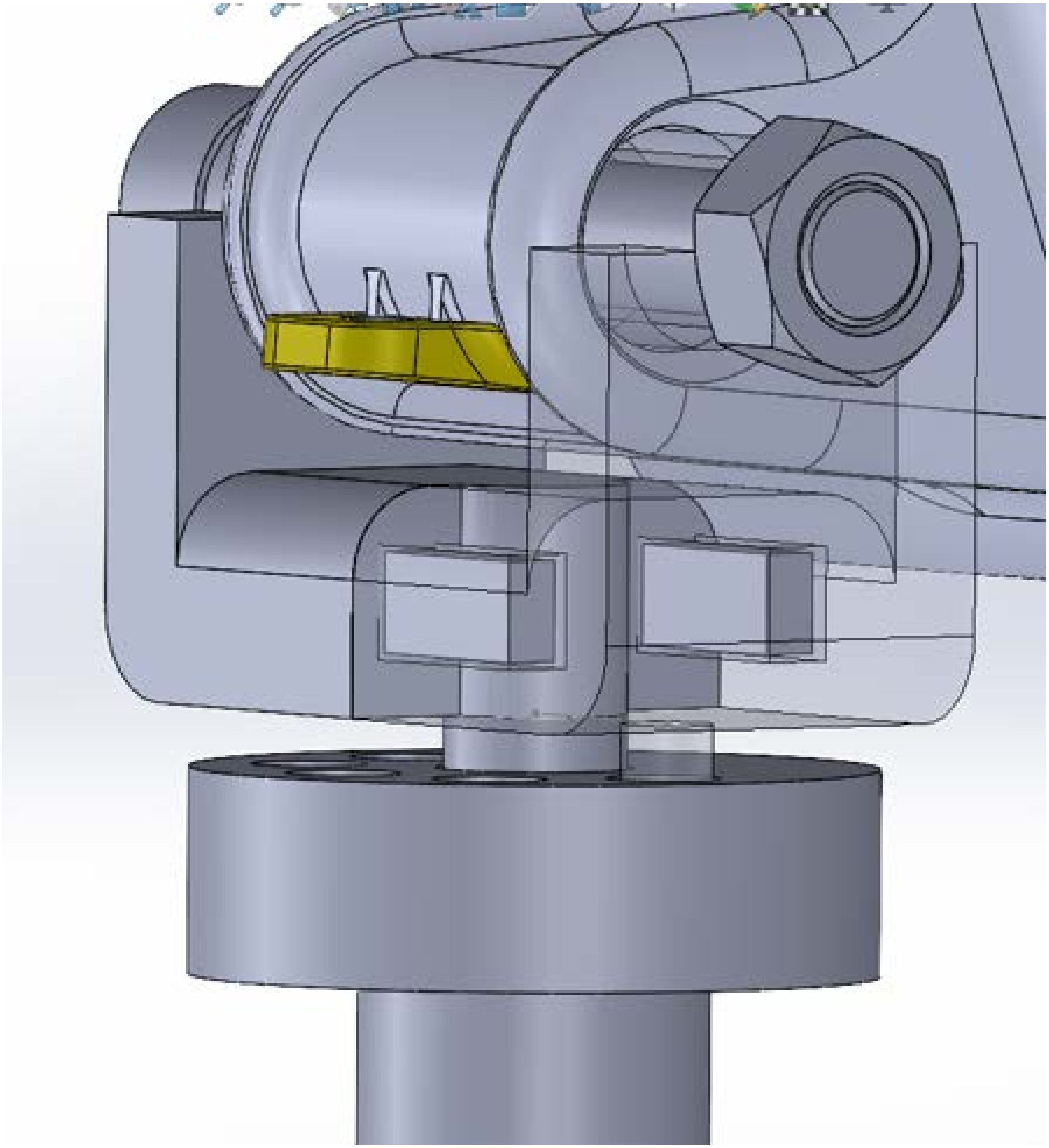
The above image shows the display console with the swivel design. The bottom hole is what the screw in the rower neck will go through with a tight fit.



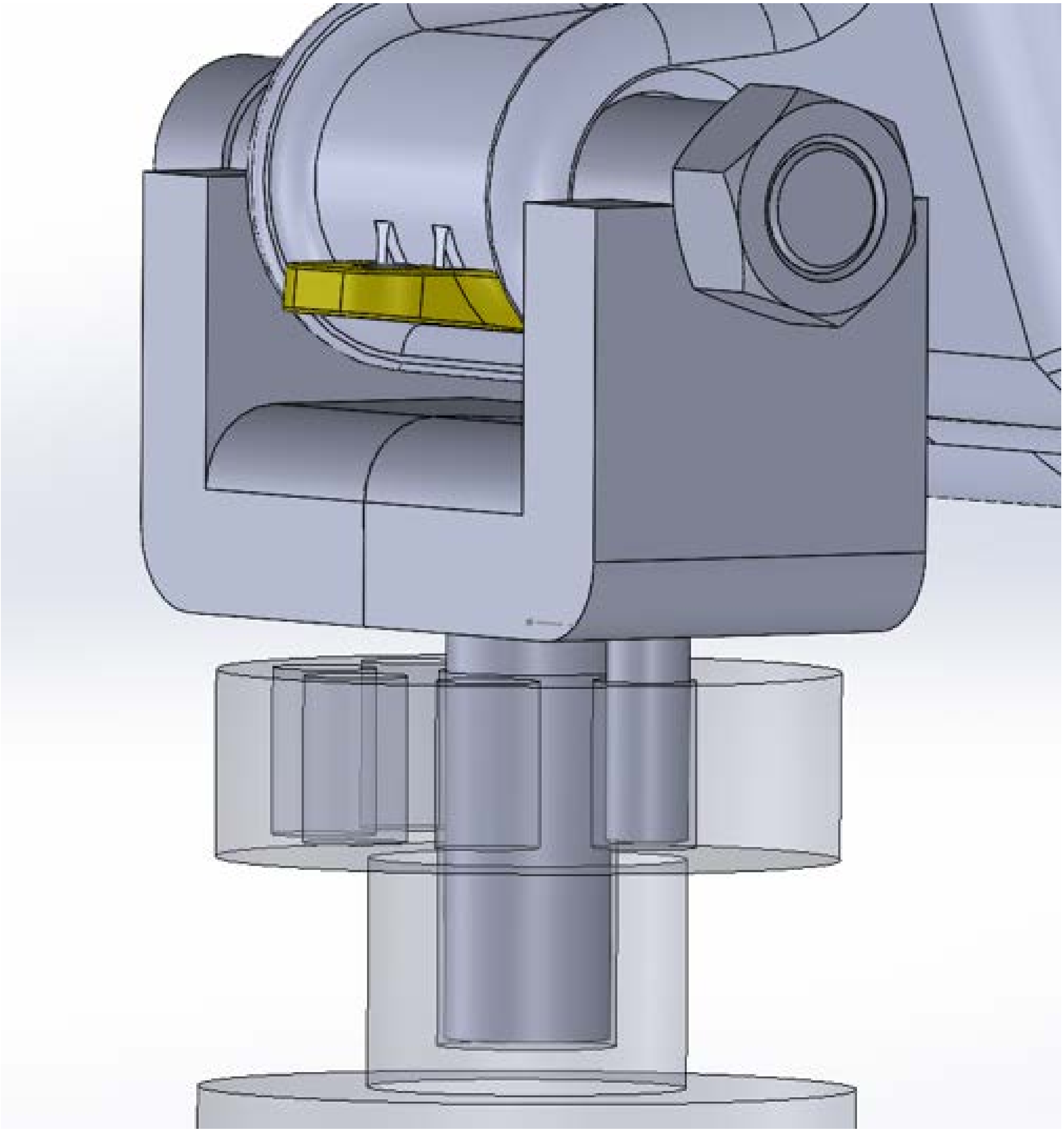
The above image is the right field goal female piece with post cavity, locking block cavities, and the locking rotating peg.



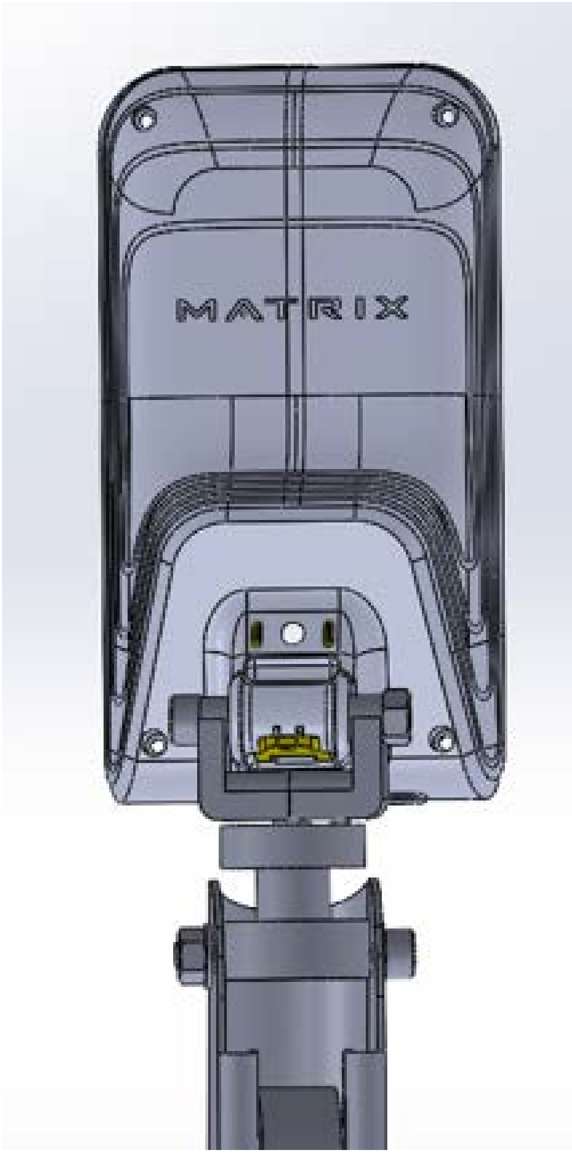
The above image shows how the field goal posts slide into the screw through hole in the back of the display console while leaving room for the screw itself.



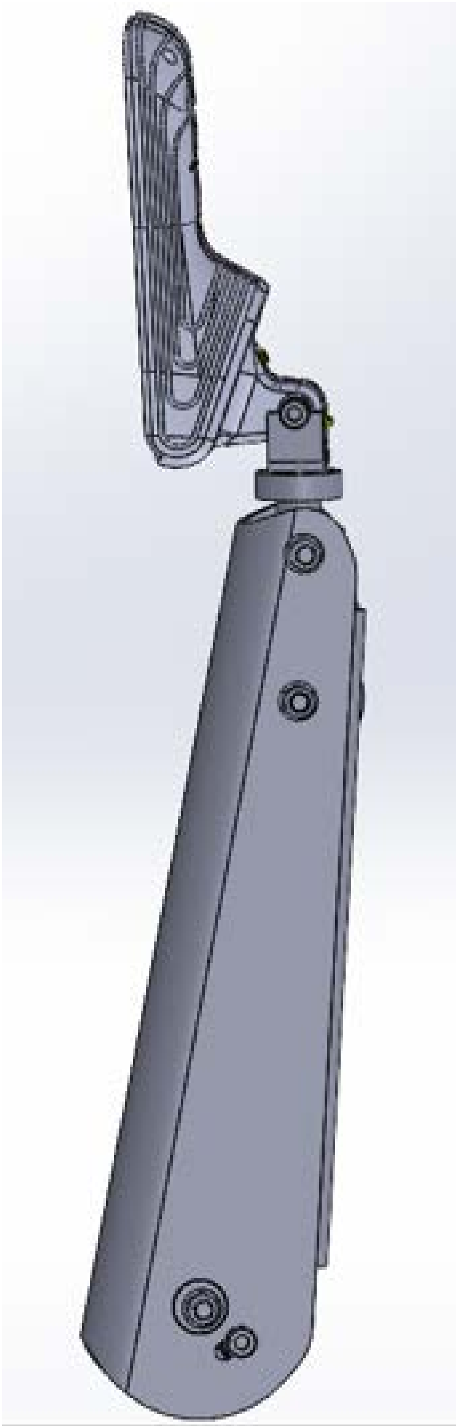
The above image shows how the male and female field goal posts mate.



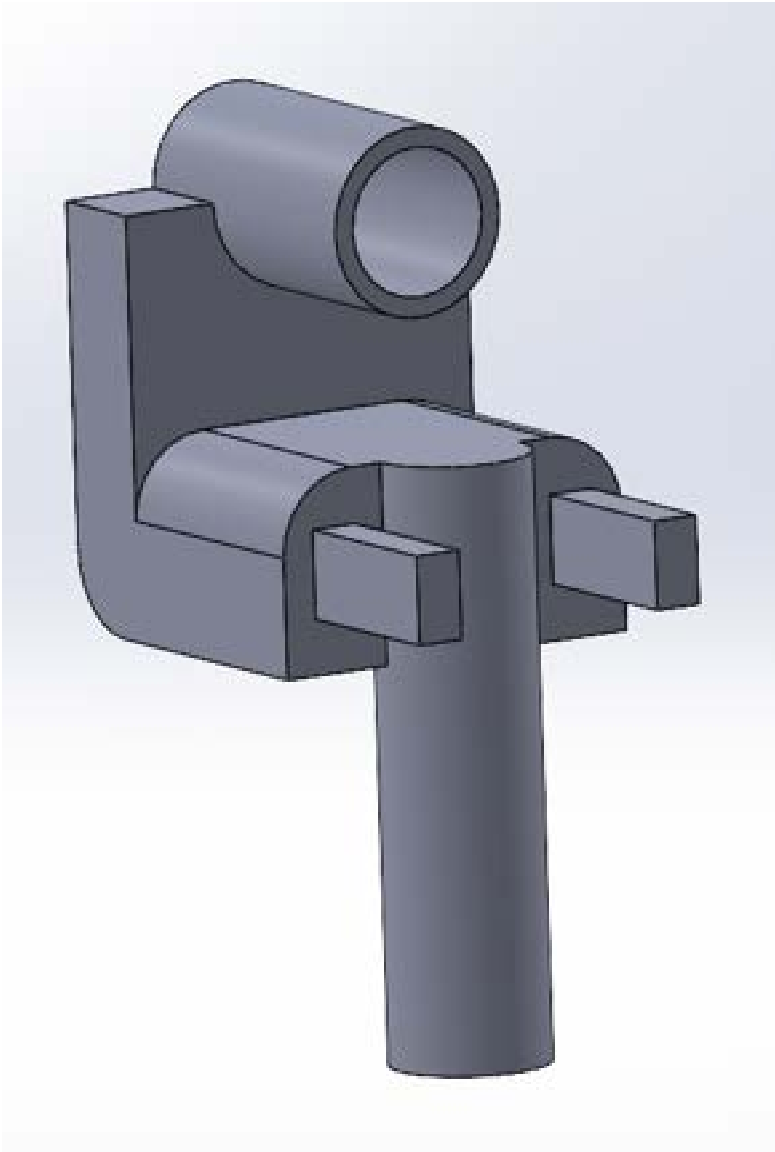
The above image shows how the field goal post and the locking peg sit in the swivel bracket. When you lift the console up to remove the locking peg, the main field goal post will still be in its cavity to allow for rotation to the next peg.



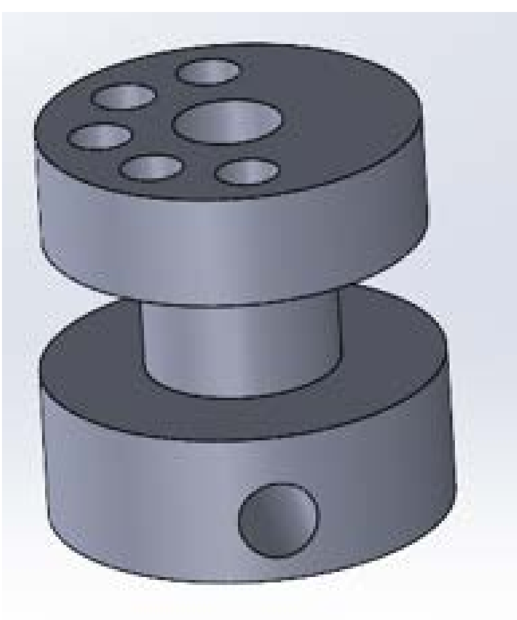
The above image shows the full assembly from the back side.



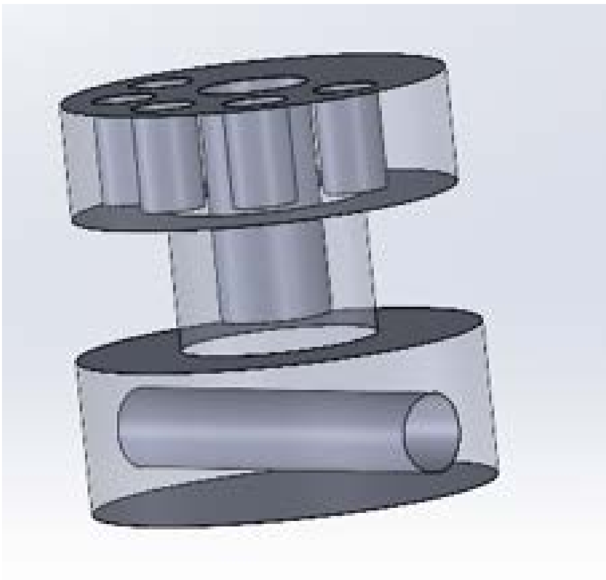
The above image shows the full assembly from a side view.



The above image shows the left male field goal most with block locks and main field goal post.



The above image shows the swivel bracket with holes on top for the main field goal post and locking peg, and through hole on the bottom for the screw in the rower neck.



The above image shows the swivel bracket transparent to see the cavities that are made within it,

References: n/a

Conclusions:

The swivel design should be fairly easy to print and hopefully should allow for proper rotation of the display console. Downsides to this design are that we weren't able to fully prevent 360 degrees of rotation beyond just telling the user not to turn it that much. It also was difficult to design a good way to hold the entire design in place in the rower neck. We decided to make it have a tight fit with no clearance within the rower neck to hold it in place, and will use glue/tape if this isn't enough. I will print this at the makerspace on Monday morning.

Action items:

-Go to ECB with Sam today to Put on the New Rower Neck and see how it fits with the pulley plates while rowing

-Print the above swivel design on Monday

-See how swivel design fits. If necessary, make minor adjustments to print again or add extra material to stabilize

Josh ANDREATTA - Apr 16, 2022, 11:46 AM CDT

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Swivel_for_Display_Console_Assembly.SLDASM (1.39 MB)

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Download

Full_Swivel_Assembly.SLDASM (1.41 MB)

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Download

FINAL_SWIVEL_ASSEMBLY.SLDASM (2.72 MB)

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Field_Goal_for_Console_Display_Right_Part.SLDPRT (133 kB)

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Field_Goal_for_Console_Display_LEFTLEFT_Part.SLDPRT (125 kB)

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Console_Back.SLDASM (1.35 MB)

Josh ANDREATTA - Apr 16, 2022, 11:46 AM CDT

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Bearing_Socket_for_Console_Display.SLDPRT (127 kB)

4/16/2022 - Final SolidWorks Design

Josh ANDREATTA - Apr 16, 2022, 11:52 AM CDT

Title: Final SolidWorks Design

Date: 4/16/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show the final SolidWorks design with pulley plates, slit in rower neck, and swivel design

Content:

Our final design consists of the 2 pulley plates to hold and stabilize the additional pulley which is used to redirect the rope and handle bar to the adapted side during use by wheelchair users. The rower neck has a slit cut into that allows for the rope to be easily transferred from the original pulley to the new pulley. The swivel design allows for the display console to be rotated so the user can see the monitor screen. This accomplishes several tasks such as (1) being able to transfer the rope to row from both sides, (2) rotate the console to see display from both sides, (3) make minimal changes to the rower machine itself. Additionally, other members of the team made a stabilization wood frame that holds on to the wheelchair to stabilize it during rowing. Below is a solidworks image of the full design without that wood frame.

The above image is the full final design without the wood frame to stabilize the wheelchair.

References: n/a

Conclusions:

The final design came out great in solidworks and we are excited to test this week. We will test by making a survey to assess comfortability and stability within the wheelchair while using the deivce, show solidworks simulations of the pulley plates to assess strength of material and geometry, and by using a spring gauge to compare forces on the standard and adapted side at 3 arm locations (full extensions, half stroke, and full stroke at chest).

Action items:

-Test!

Josh ANDREATTA - Apr 16, 2022, 3:51 PM CDT

Download

Full_Adapted_Rower.SLDASM (3.5 MB)

4/19/2022 - Show Rower Neck with Cut

Josh ANDREATTA - Apr 19, 2022, 7:34 PM CDT

Title: Show Rower Neck with Cut

Date: 4/19/2022

Content by: Josh Andreatta

Present: Josh Andreatta, Sam Skirpan

Goals: Attach the rower neck with slit back to the rower and row.

Content:

The above image shows sam rowing from the adapted side via the additional pulley and pulley plates and slit through the neck.

The above image shows what the console looks like from the adapted side. Thanks to the swivel bracket, the display console can be positioned to face correctly in both the standard and adaptive states.

The above image is a front view of the full assembly.

The above image is a side view of the swivel bracket with the display attached.

The above image is a back view of the swivel bracket with console attached.

After looking at the second bracket swivel print, it came out much better. The bracket fits tighter within the rower neck to help stabilize it once the screw through it is tightened. Additionally, the pegs fit much better into the bracket, although they needed to be sanded down a little. Putting the rower neck back on was a little challenging due to difficulties in keeping all of the washers in line with the screw through hole. However, after a few attempts, we were able to get it all lined up correctly. For some reason, the rower neck is not as tight as it was before the cut was made in the rower neck. Thus, we believe that removing some material for the neck slit made the material less sturdy at the base which is why it is slightly easier to rotate. We are going to try to tighten the neck even more to get it to be more difficult to rotate. If we are able to do this, the device will work without outside assistance. If the neck cannot be tightened further and it must remain in the position it is in in the images above, the user will require outside assistance to move the rope form the standard to the adapted state. Additionally, we will need to shave down the swivel bracket so it can tip down forward a little bit more. These are small changes that we can easily make. Either way, the design is functional and allows for proper rowing. The pulley support plates remain rigid and held against the outside surface of the rower neck, just as we had planned. There is a slight wiggle due to small errors in the 3D print cavity that sits on the rower neck support arms, but these are not noticeable while rowing, and are so small that they will not damaged the plates or cause them to fail (beyond a little wear and tear of the 3D Tough PLA material). Thus, ideally, these plates would be machined out of metal and welded onto the frame to avoid any of these issues.

Thus, moving forward, we will try to tighten the neck. If we cannot, we will just need outside assistance to move the rope between the standard and adapted states. Slight errors in our fabrication using 3D printed parts would be solved by machining out of metal and welding together components. Our design most definitely shows a proof of concept.

Lastly, tomorrow, sam and I will measure and cut the triangular support bars for the wooden stabilization component to offer it even more stability. Tim will then screw them together so we can test on thursday. Thursday, we will fill out the survey using the machine and use a spring gauge to measure the tension in the rope from the standard and adapted states as described in another entry. Then, we will spray paint the wood black before the poster presentation.

References: n/a

Conclusions:

Overall, the design came together super well. The neck is a little loose right now so we are going to try to tighten it. If this works, nothing else will need to be changed. If we cannot tighten it anymore, then the user will require outside assistance to move the rope and handle bar from the standard to adapted side. Additionally, the swivel socket will need to be sanded down so that it can bend downward a little more. Overall, we are very happy with how the design came out and how it allows for normal rowing motions.

Action items:

-Measure and cut triangular wood supports tomorrow

-Tim to screw in remaining wood pieces tomorrow

-Check testing survey

-Test Design!

4/18/2022 - Show first Swivel Print

Josh ANDREATTA - Apr 18, 2022, 9:37 PM CDT

Title: Show first Swivel Print

Date: 4/18/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show first swivel print

Content:

I printed the swivel design in Tough Black PLA to match the color of the rower. The print used a 80% infill and 0.2mm layer height, which were all good parameters. After putting together the 3 pieces (swivel socket, and 2 field goal post mating pieces) I realized that I needed to add a little bit more clearance in some areas. First, the part of the field goal posts that go into the through hole in the console itself were too lose, so I made them 0.49 inches in diameter rather than 0.46 inches. Next, the female extruded cuts for the male extruded bosses on the field goal posts needed to be a little wider, so I made them 0.27x0.17 inches for the 0.22x0.12 mating posts. I made the bottom extruded boss of the swivel bracket 1.60inches instead of 1.58 inches to make it a little more snug within the rower neck itself. I also made the hole for the screw in the rower neck 0.35 inches in diameter, because before it was 0.31inches which was too small and the screw would not fit in. Lastly, I made the large field goal posts smaller, shrinking it to 0.36 inches form 0.40 inches, because it was just too large and would not allow the two mating field goal pieces to fit together properly. Thus, with these changes, I believe the pieces should fit together much better and result in a better functioning swivel bearing. Below are images of this print.

The above image shows the female field goal piece.

The above image shows the male field goal posts (posts are ripped off because they got stuck in the female piece).

The above image shows the socket that the field goal posts sit in.

The above image shows the full assembly. The field goal cannot sit properly in the swivel socket because the field goals wont close together all the way.

References: n/a

Conclusions:

The initial swivel design proved that the design does work and that the infill and layering chosen for the print was good. Tomorrow I will print with the adjustments I made which should hopefully fix the clearance issues we had in this first print.

We will assign Tim/Dhruv to make the survey for assessing stability, and then test thursday. We will all use the full device and rate it according to the survey. We will also use a strain gauge to measure and compare the forces in the rope (tension) at full arm extension, half flexion, and full flexion from both the standard and adapted side to show similarity in force developed during rowing. We would like to test thursday to get graphs made and ready for friday. This way, we can work on the poster over this weekend. This will conclude testing and fabrication. The wood will be spray painted black prior to the poster presentation.

Action items:

-Print final swivel on morning of 4/19/2022

-Assembly rower neck, pulley plates, and swivel design onto rower on afternoon of 4/19/2022

-Sam to measure triangular wood piece and me to cut on Wednesday

-Test on Thursday and make graphs to show on Friday

Josh ANDREATTA - Apr 18, 2022, 9:38 PM CDT

Download

Swivel_for_Display_Console_Assembly.SLDASM (1.39 MB)

Josh ANDREATTA - Apr 18, 2022, 9:38 PM CDT

Download

Full_Swivel_Assembly.SLDASM (1.41 MB)

Josh ANDREATTA - Apr 18, 2022, 9:38 PM CDT

Download

FINAL_SWIVEL_ASSEMBLY.SLDASM (2.77 MB)

Josh ANDREATTA - Apr 18, 2022, 9:38 PM CDT

Download

Field_Goal_for_Console_Display_Right_Part.STL (109 kB)

Josh ANDREATTA - Apr 18, 2022, 9:38 PM CDT

Download

Field_Goal_for_Console_Display_Right_Part.SLDPRT (181 kB)

Josh ANDREATTA - Apr 18, 2022, 9:38 PM CDT

Download

Field_Goal_for_Console_Display_LEFTLEFT_Part.STL (102 kB)

Josh ANDREATTA - Apr 18, 2022, 9:38 PM CDT

Download

Field_Goal_for_Console_Display_LEFTLEFT_Part.SLDPRT (169 kB)

Josh ANDREATTA - Apr 18, 2022, 9:38 PM CDT

Download

Bearing_Socket_for_Console_Display.STL (88.1 kB)

Josh ANDREATTA - Apr 18, 2022, 9:38 PM CDT

Download

Bearing_Socket_for_Console_Display.SLDPRT (129 kB)

4/20/2022 - Cut wood supports

Josh ANDREATTA - Apr 20, 2022, 6:43 PM CDT

Title: Cut Wood Supports

Date: 4/20/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Cut wood supports

Content:

Today I went to the Makerspace and cut wood supports for the wood stabilization frame. I slightly mis calculated where the cut at 45degrees should be placed, but there should still be enough contact and room to screw them in to the other wood pieces. Additionally, sam was able to fully tighten the rower neck. The key tightening device Staci gave us does not fit or work on the rope. Thus, in order to move from the adapted to standard side, someone must hold the rope near where it comes out of the base of the rower to remove the tension. Ideally, a locking mechanism would choke down on the rope.

Additionally, for testing we secured a fish hook. We are going to test and see what the static force is in the rope on both sides of the rower. Additionally, we are going to set the resistance to level 1, 5, and 10 and measure the max force developed during one rowing stroke to the chest. We will do this 5 times on each resistance level on each of the standard and adaptive sides of the rower to compare.

The above image shows the wood I cut. Ideally, the angled cut should have gone all the way to the corner.

The above image shows the neck holding itself in place because it is tight.

References: n/a

Conclusions:

Tim will finish screwing in the wood tonight and we will meet to complete all testing tomorrow.

Action items:

-Test tomorrow

5/3/2022 - Final Swivel Print Quick Discussion

Josh ANDREATTA - May 03, 2022, 1:46 PM CDT

Title: Final Swivel Print Quick Discussion

Date: 5/3/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Discuss final swivel print

Content:

The second iteration of the swivel print worked very well. Although not picture here, the parts look identical to those in the entry describing the first print - just with slightly larger clearances which can't be seen well with the naked eye. We sanded down the two pegs on the field goal post a little bit, but after this, the field goal components fit very easily into the swivel bearing. The swivel bearing also easily fit into the rower neck and was easily tightened in place by the screw that goes between it and the rower neck. Thus, the swivel design allowed for us to easily transition the display to be seen when rowing on both the standard and adapted side. The cord just needs to be pulled out of the way so it isn't pinched. To improve this swivel design, we would want to make it so that the console cannot be completely lifted out of the swivel bearing, and make it a continuous rotation, rather than discrete positions. Overall, it worked great for our device!

References: n/a

Conclusions:

The second iteration of the swivel worked well for our device and can still be improved.

Action items:

-Turn in all final deliverables

4/19/2022 - Simulation Testing of Geometry and Strength of Pulley Support Plates

Josh ANDREATTA - Apr 19, 2022, 12:07 AM CDT

Title: Simulation Testing of Geometry and Strength of Pulley Support Plates

Date: 4/19/2022

Content by: Josh Andreatta

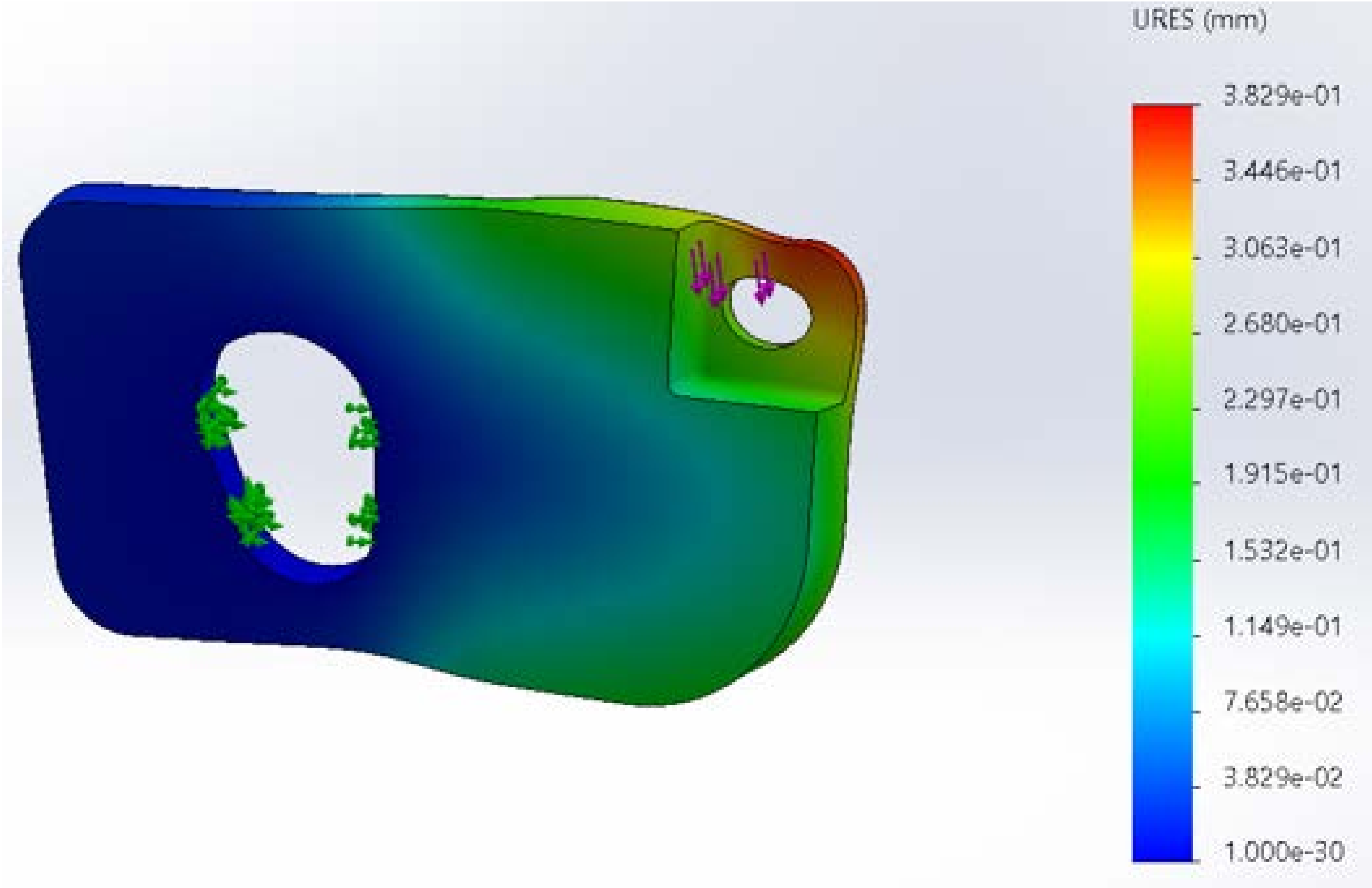
Present: Josh Andreatta

Goals: Show simulation images and describe peak deflections, stresses, and areas of stress concentrations

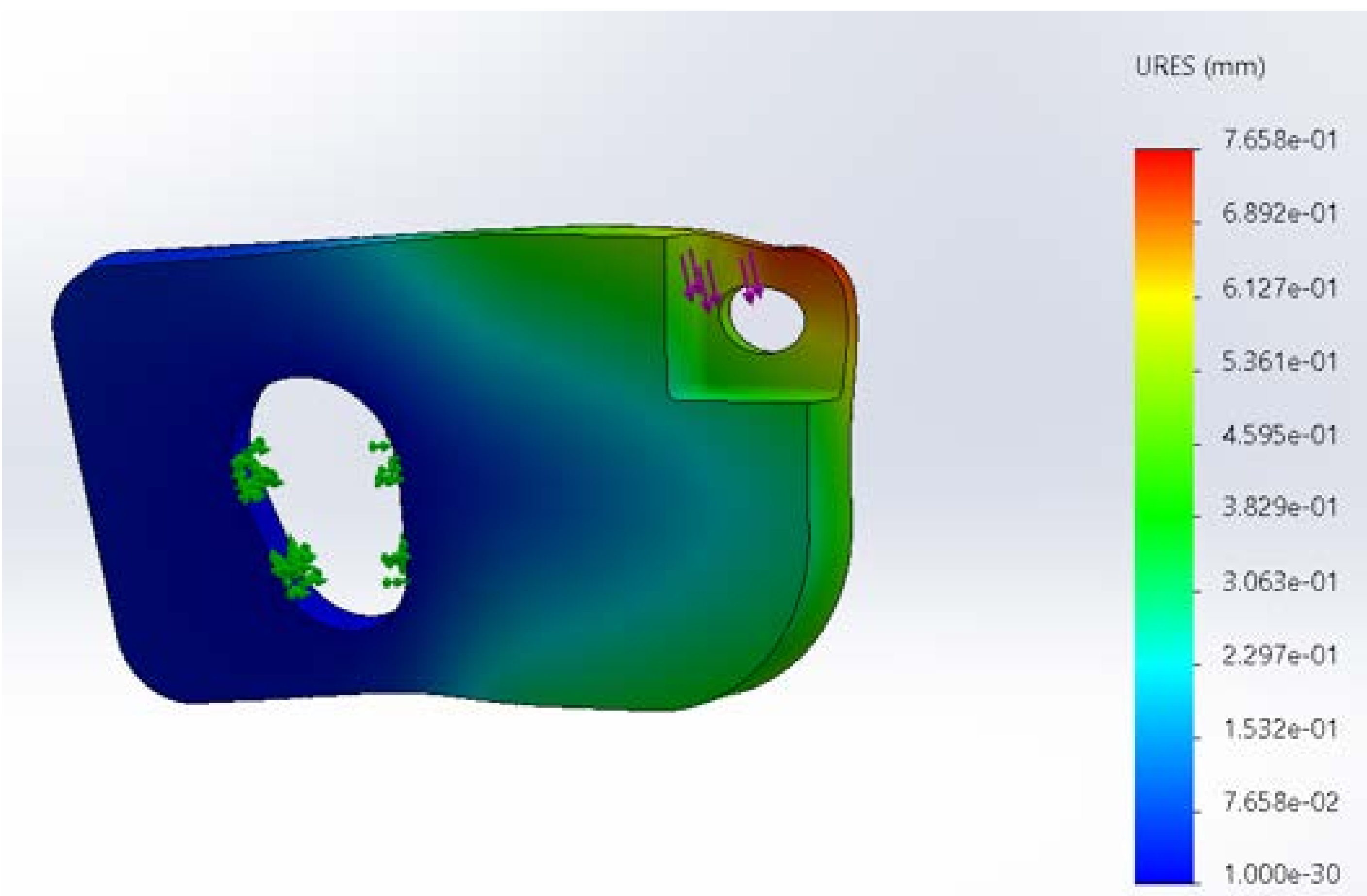
Content:

In order to test the strength of material and geometry chosen for the pulley plates, I ran a SolidWorks Simulation force test on each of the pulley support plates. To make sure the material in the simulation was similar to the actual material we used, I used the technical data sheet from Ultimaker (the printer I used) for Tough PLA (the material I used) and made my own SolidWorks material using the mass density (1.22g/cm^3), yield and tensile stress (37MPa each), shear modulus (2490MPa), and tensile modulus (1820MPa). To properly run the simulation to mimic the actual loading on the rowing machine, I fixed the interior cavity surface that slips onto the rower neck support arms, which is denoted by the green arrows below in all the images. To properly assess the force, I ran two different tests. The first I ran was using a safety factor of 2, which placed 1050 N load inside the surface that the plate slips onto the pulley bearing, as this is the location where the directed load form rowing would be applied. From prior research in previous entries, it was found that the maximum force that can be typically generated while rowing is 1050 N. Ideally, this force would be split evenly across the two pulley support plates. However, to asses worst case scenario, I modeled the safety factor test as each pulley plate receiving the total 1050 N load straight down. This wouldn't actually happen because the user will pull the rope parallel to the ground, not perpendicular and straight down towards the ground. Thus, this is the worst case scenario. The second test I ran used the ideal loading conditions where this 1050 N is distributed evenly across the two pulley plates, with each receiving a 525 N load directed downward, again on the surface that sits on the pulley bearing. Below are images of the SolidWorks images of the stresses and displacements developed for each pulley plate under each of these loading conditions, and showing the inside and outside surface of the plate, since they are not geometrically identical.

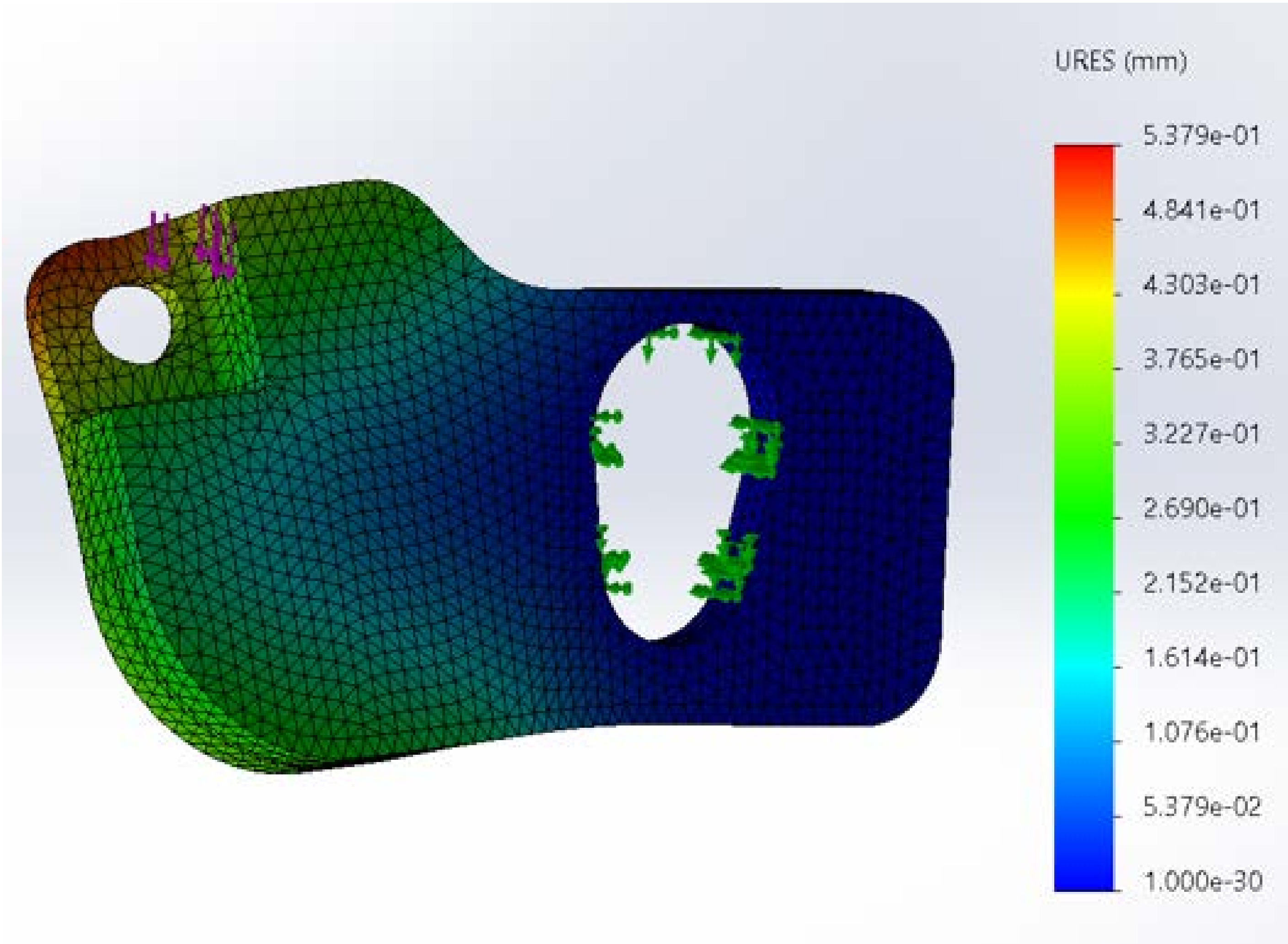
As shown by the images below, despite very minor deformations occurring at the application site of the force (<1mm), the team is confident that these can be seen as negligible. This is because that inner surface which is being deformed will have a solid metal bearing within it, which will help to absorb some of the applied force and prevent deformation of the Tough PLA plate at that location. Thus, the metal bearing helps reduce the effect of the applied load. A deformation of 1mm is an acceptable amount of deformation because it will not be enough to actually break the plate nor cause it to tip or move while on the rowing machine itself.



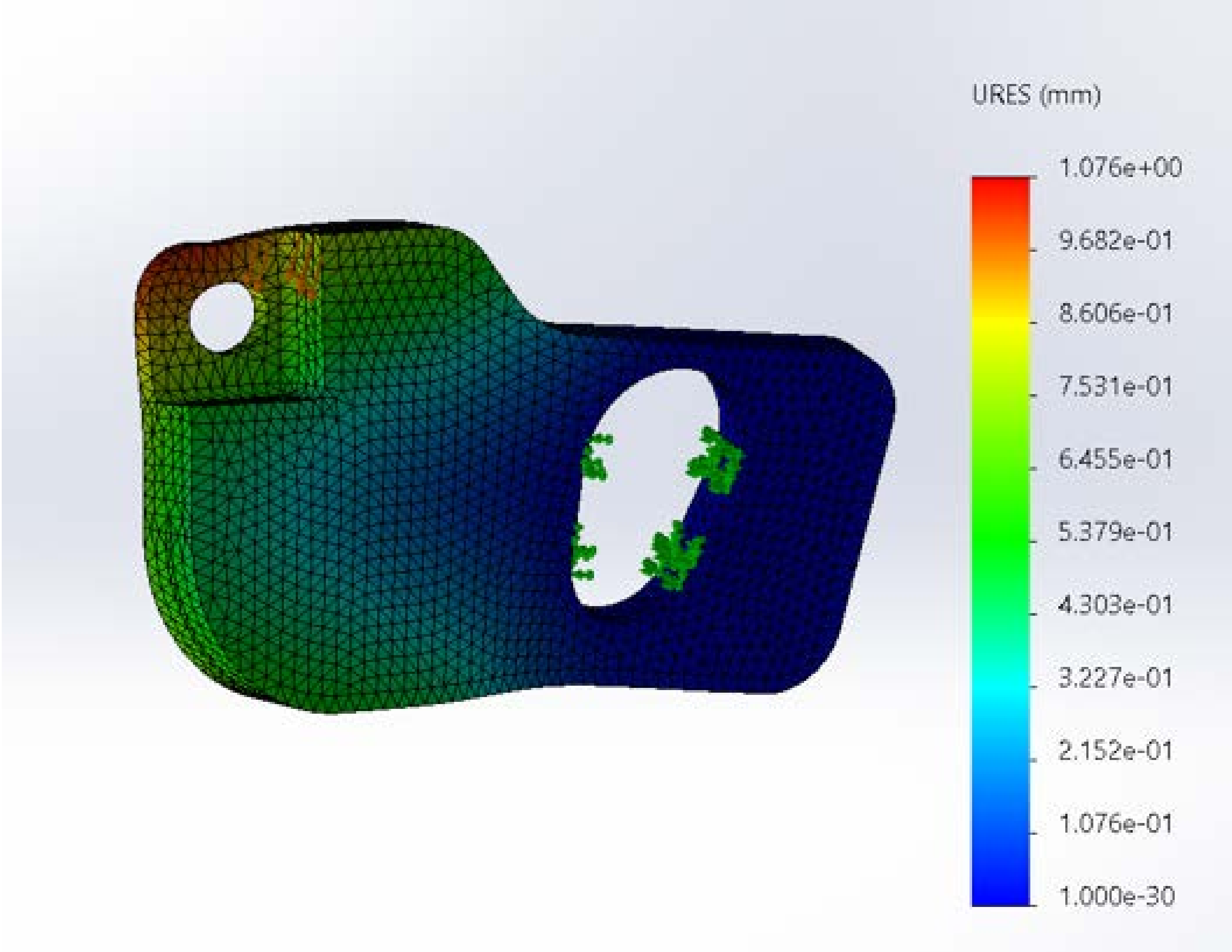
The above image shows the displacement data on the outside of the left pulley plate under ideal 525 N load. The maximum deformation occurred at the site of application of the load and was only 0.3829mm, which is incredibly small.



The above image shows the displacement data on the outside of the left pulley plate under a safety factor of 2 of 1050 N load. The max deformation occurred at the site of application of the load and was only 0.7658mm, which is very small. The proximal portion of the plate undergoes even smaller deformations on the order of 0.4mm, which can be seen as negligible.

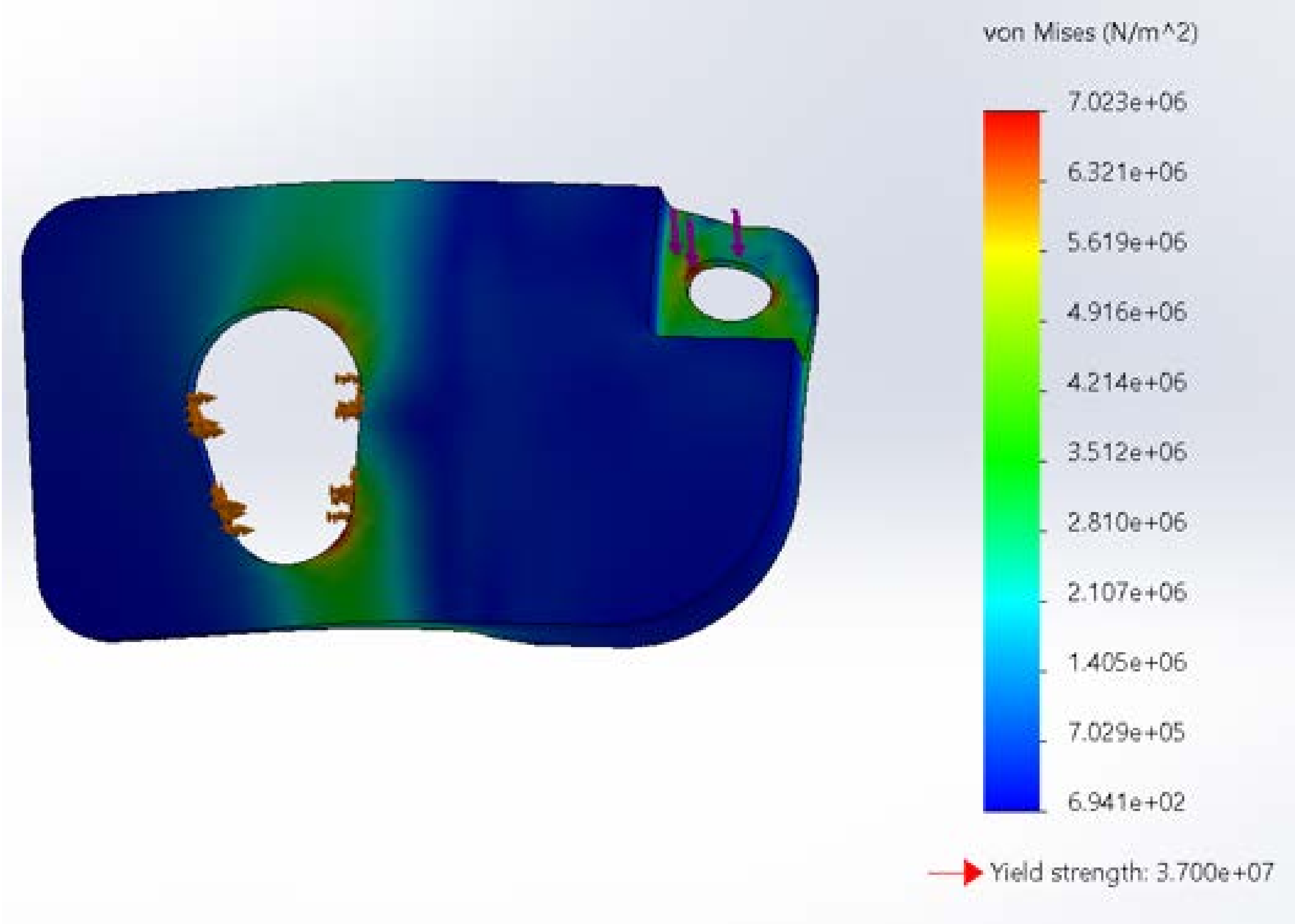


The above image shows the displacement data on the outside of the right pulley plate under ideal 525 N load. The max deformation occurred at the application site of the load and was only 0.5379mm, which is incredibly small.

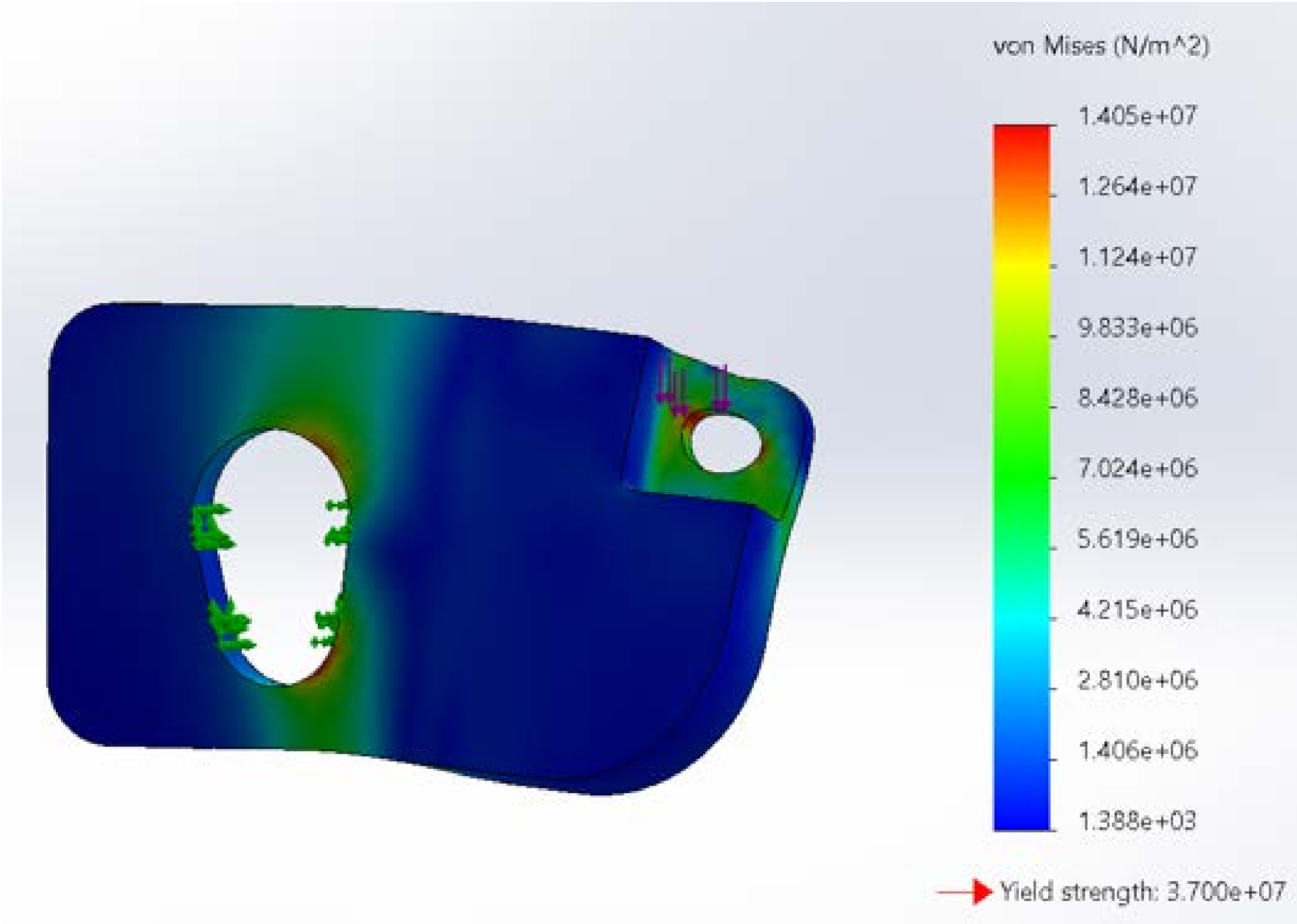


The above image shows the displacement data on the outside of the right pulley plate for a safety factor of 2 of 1050 N load. The max load was developed at the site of application of the load and was 1.076mm, which is the largest deformation between the 2 plates. However, since the metal pulley bearing will be within that cavity, it will help reduce the affect of the loading and thus reduce the observed deformations.

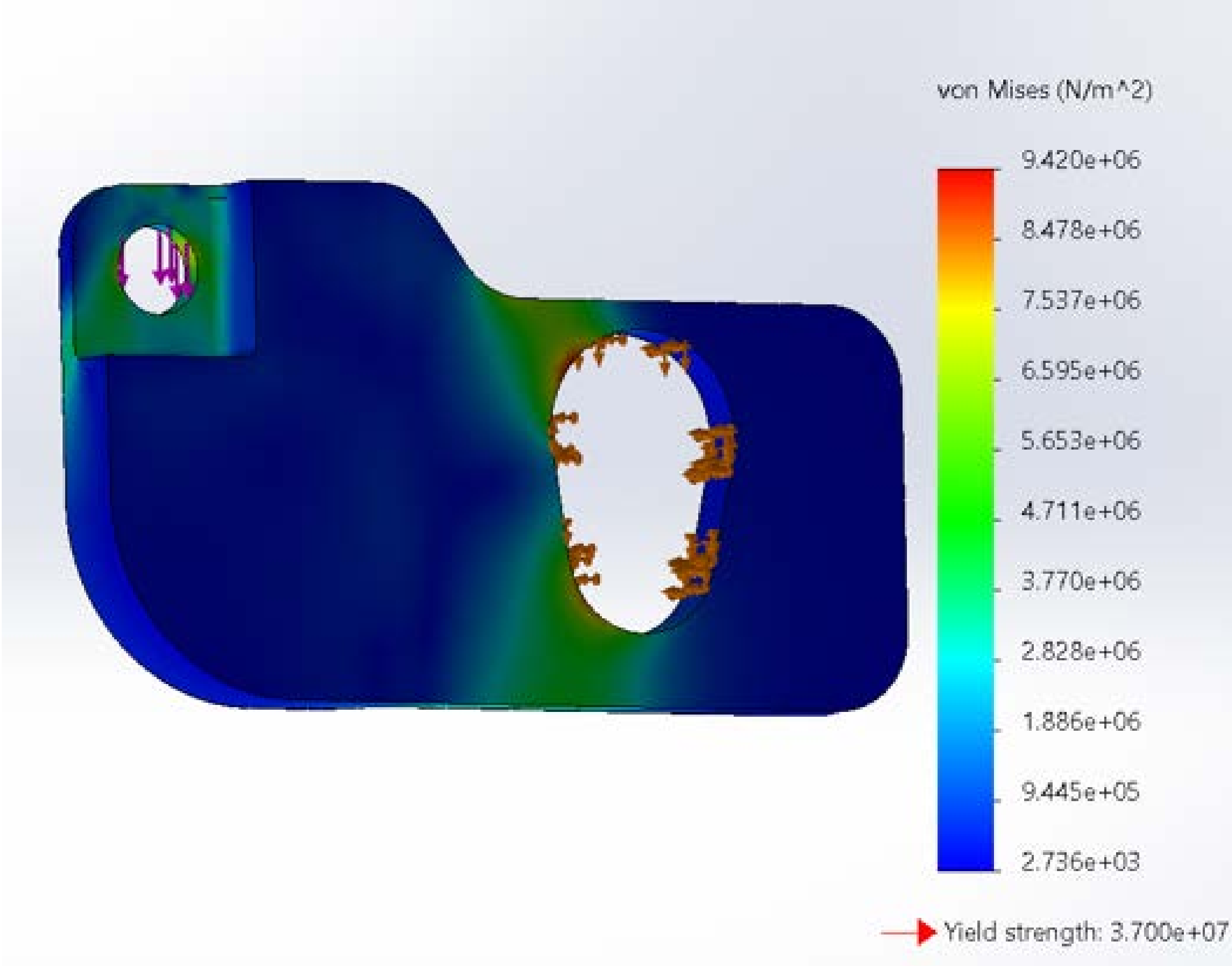
Overall, we can see that the max deformations for each plate under ideal and max loading conditions occurs at the site of application of the force and is less than 1mm of deformation. Thus, the choice to use Tough PLA with this geometry should provide a support plate that is strong enough to withstand the typical loads applied during rowing motions.



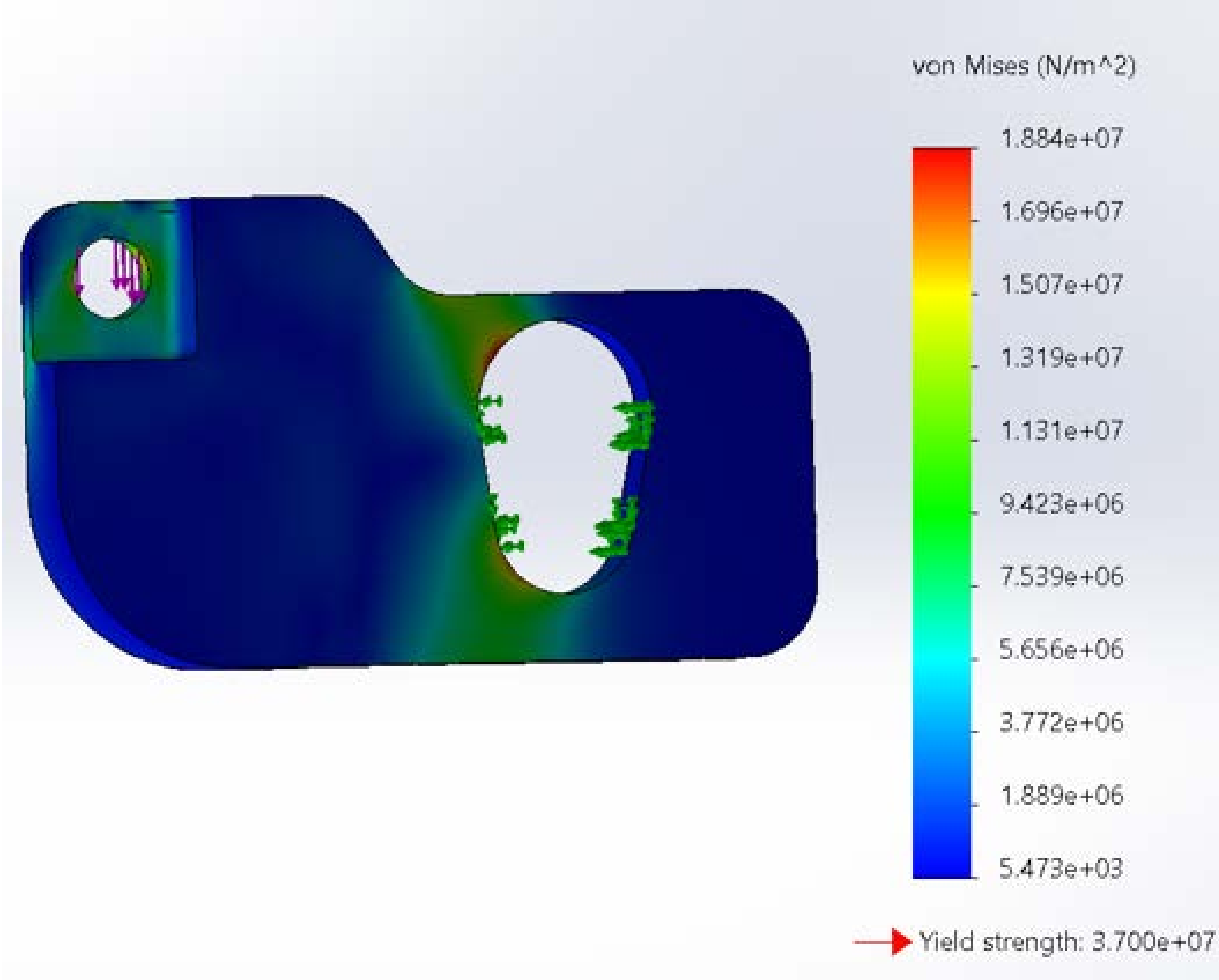
The above image shows the stress on the outside of the left pulley plate for ideal 525 N load.



The above image shows the stress on the outside of the left pulley plate under a safety factor of 2 of 1050 N load.



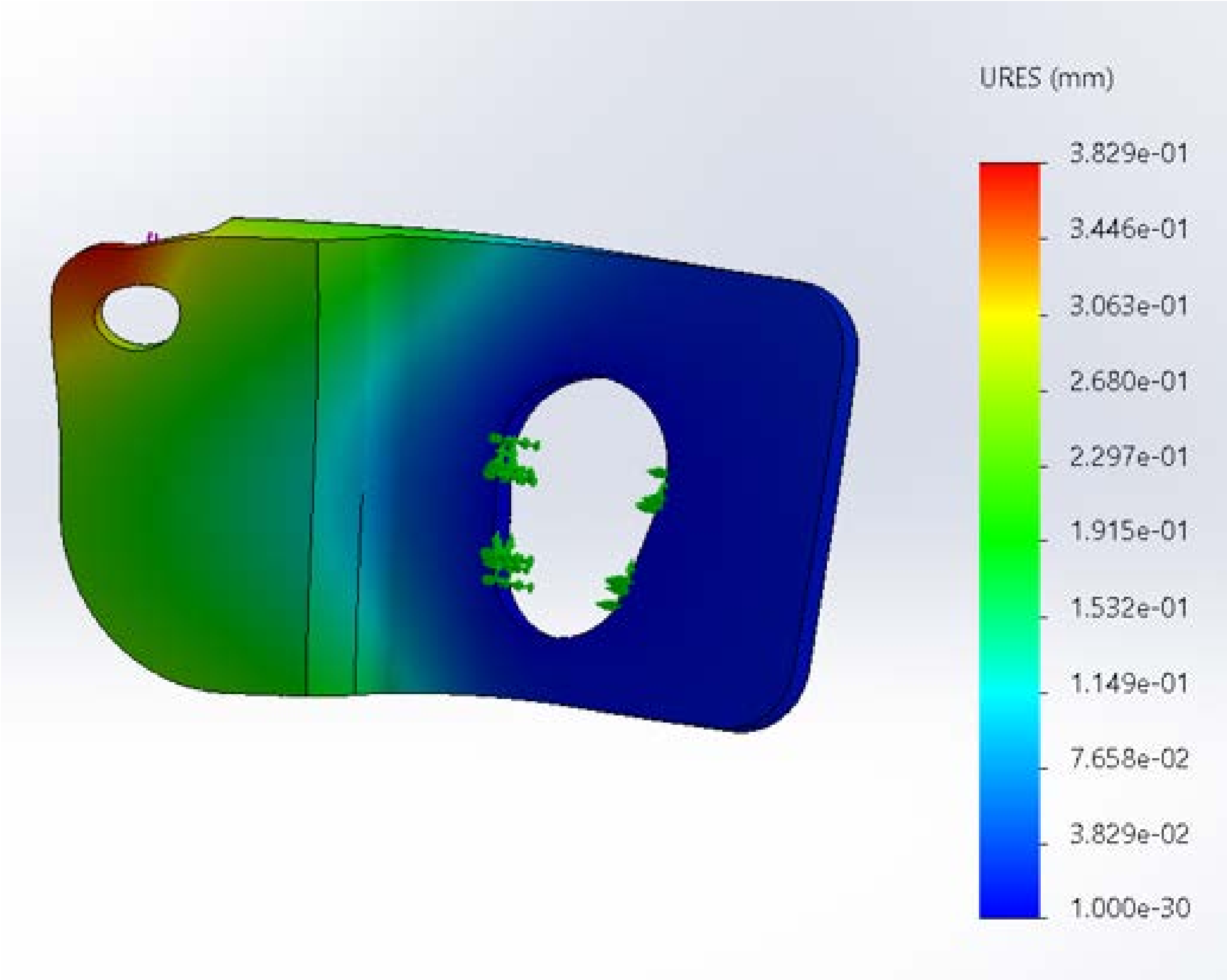
The above image shows the stress on the outside of the right pulley plate for an ideal 525 N load.



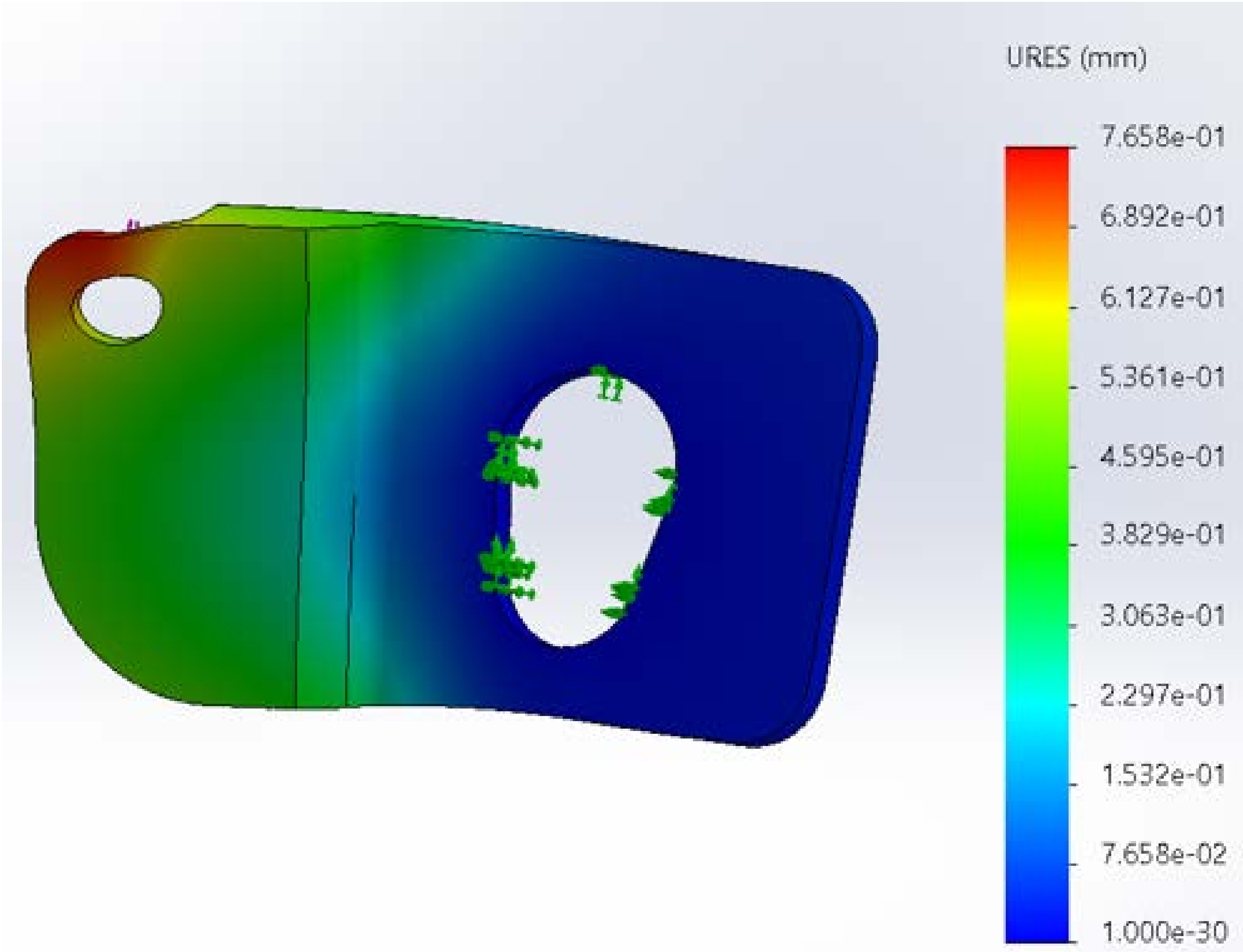
The above image shows the stress on the outside of the right pulley plate under a safety factor of 2 of 1050 N load.

As seen by the previous 4 images above of stress under ideal and max loading conditions, stress concentrations appear both around the application site of the force and around the top edges of where the plate is held fixed. This is because these are the two weakest points in the geometry of the plate and offer the least protection against developed stresses. The maximum stress that was developed was for the right pulley plate under max loading conditions. It makes sense that the right pulley developed more stress, because it has some material removed from the top edge (to allow the user to transition the rope from the standard to adapted side through the slit in the rower neck), which then reduces the structural integrity of the plate. However, despite this, the stress developed was around19MPa, which is 18MPa less than the yield stress. Thus, even under worst case loading conditions, the plate should be expected to remain rigid and not crack or fail.

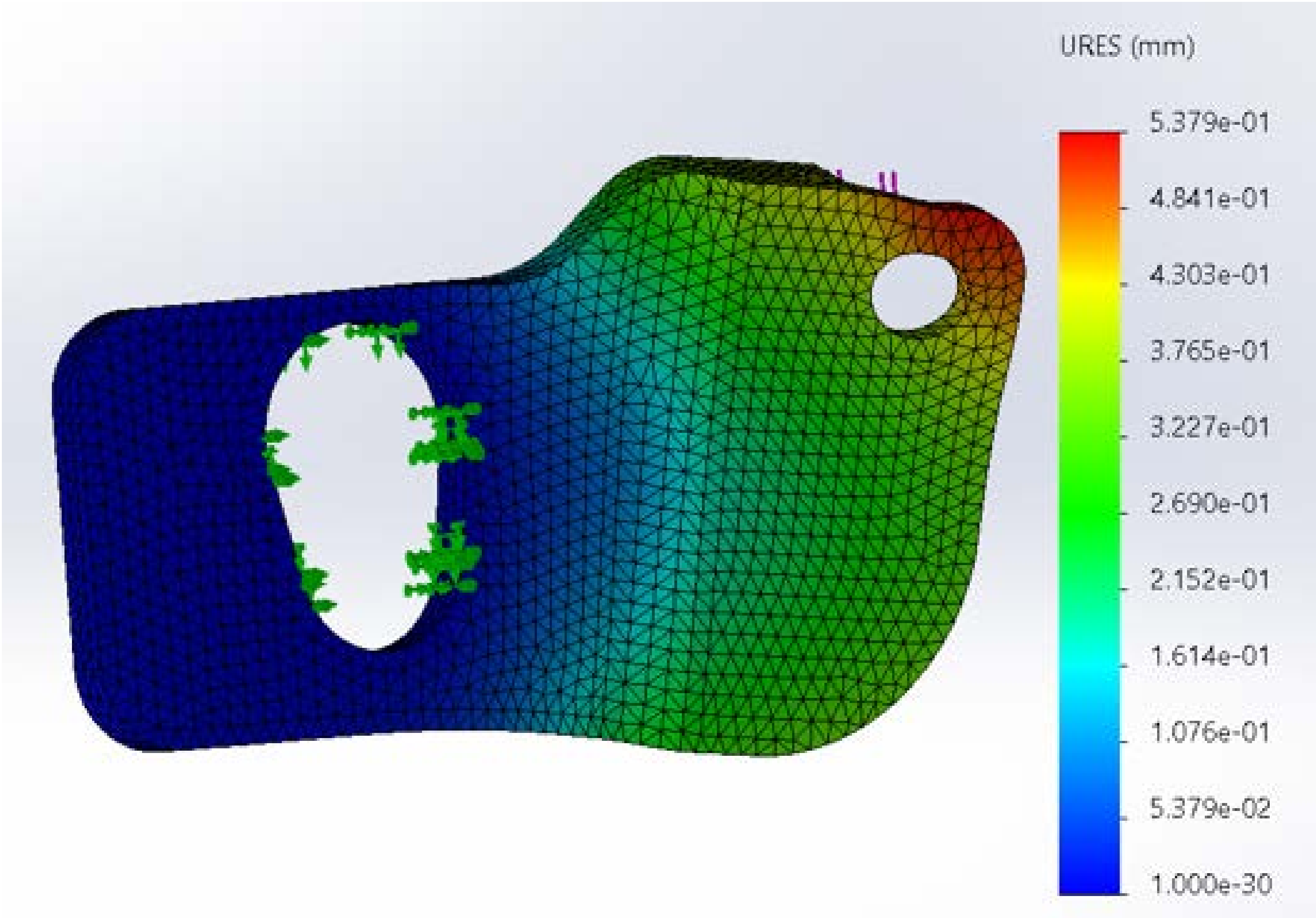
INSIDE SURFACE: Defined as surface facing inward towards the outside surface of the rower neck.



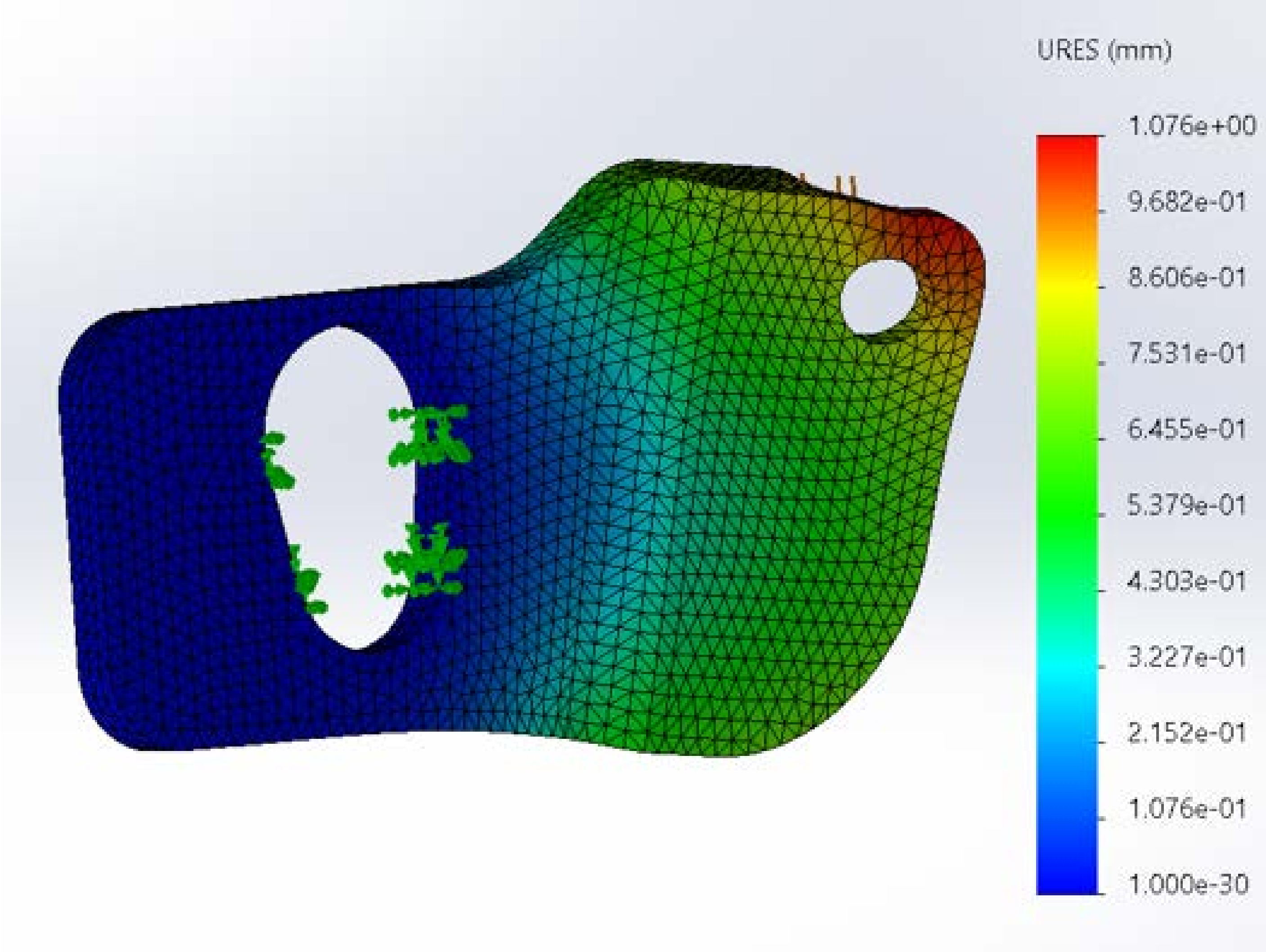
The above image shows the displacement data on the inside of the left pulley plate under ideal 525 N load.



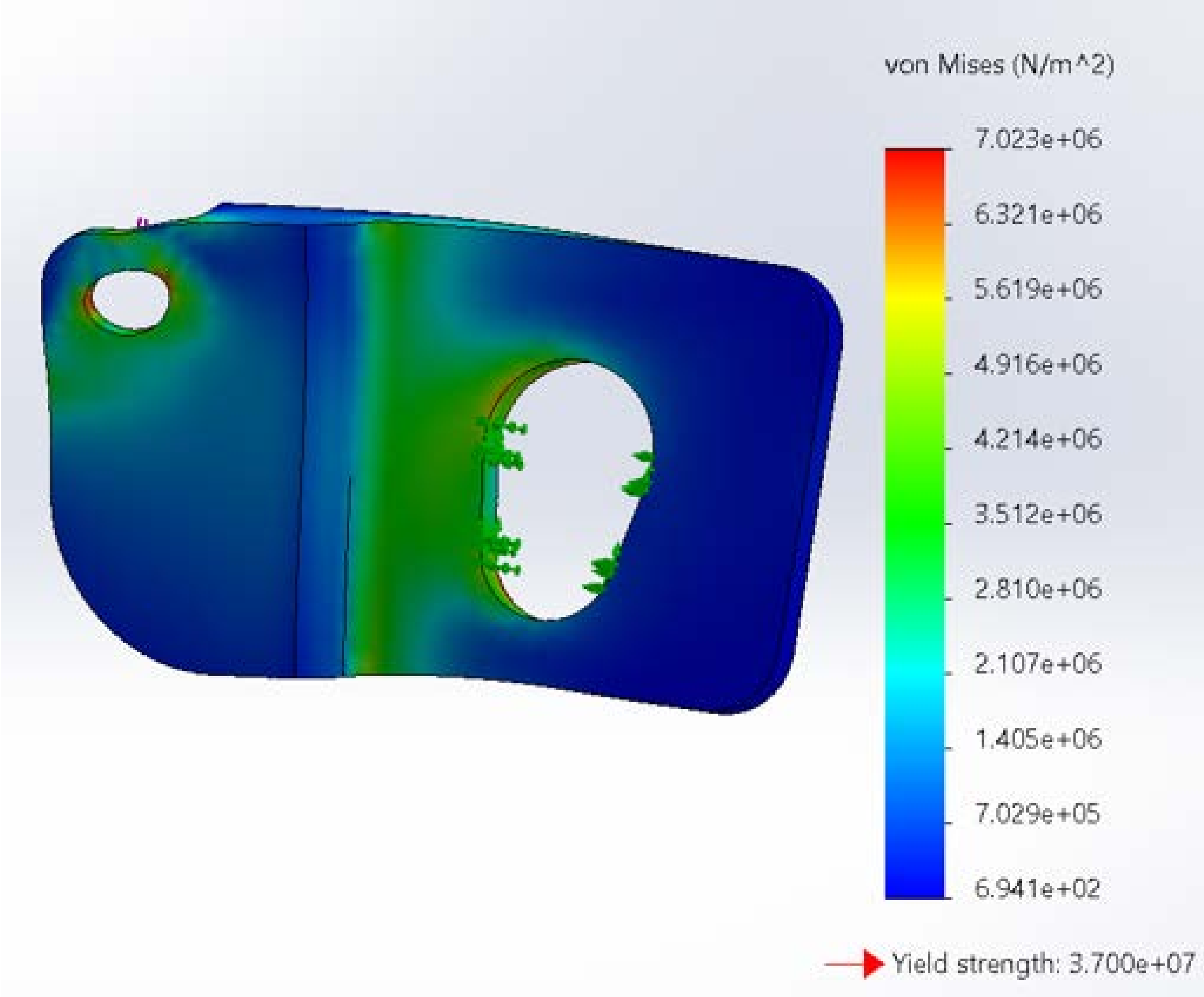
The above image shows the displacement data on the inside of the left pulley plate under a safety factor of 2 of 1050 N load.



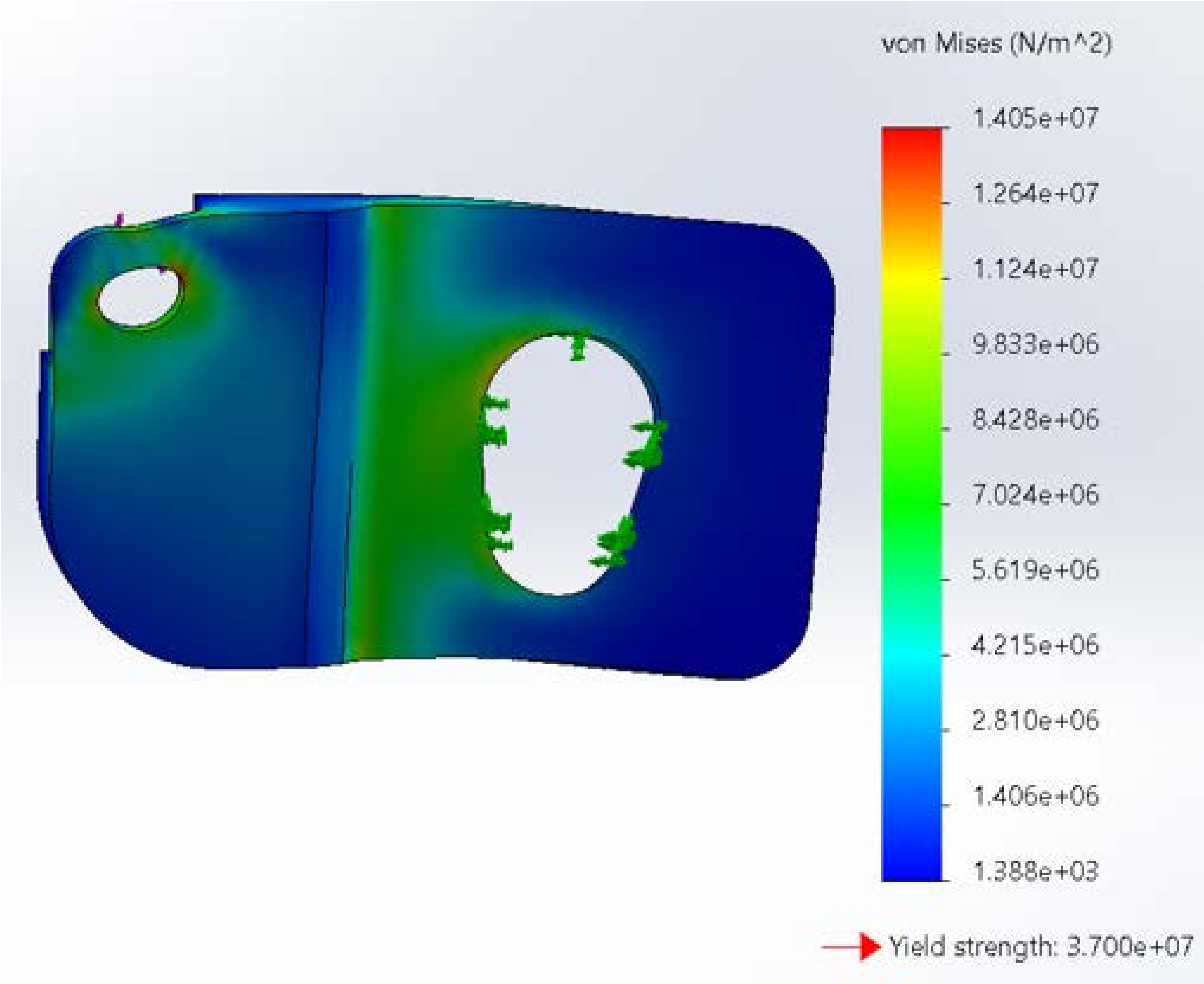
The above image shows the displacement data on the inside of the right pulley plate under ideal 525 N load.



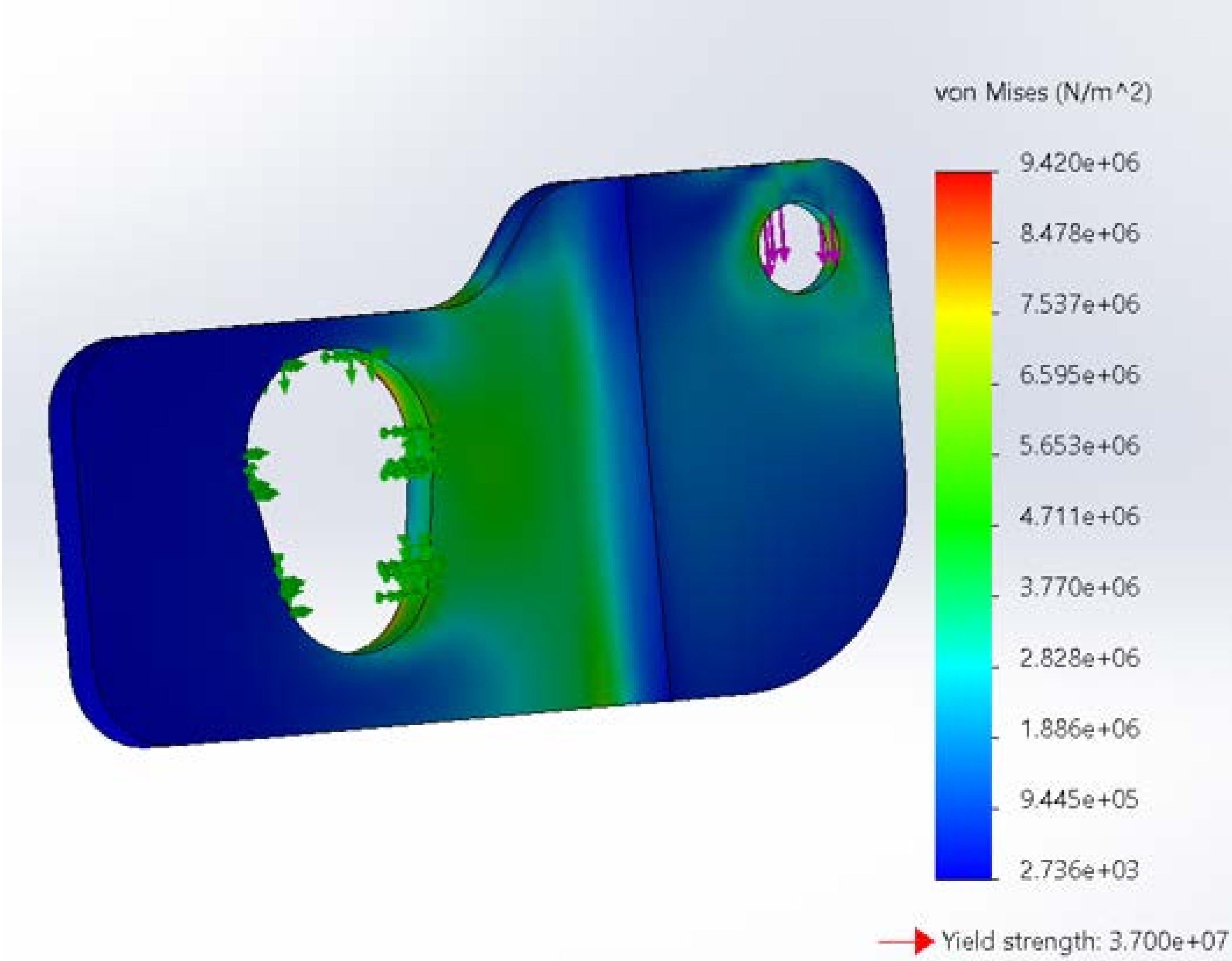
The above image shows the displacement data on the inside of the right pulley plate for a safety factor of 2 of 1050 N load.



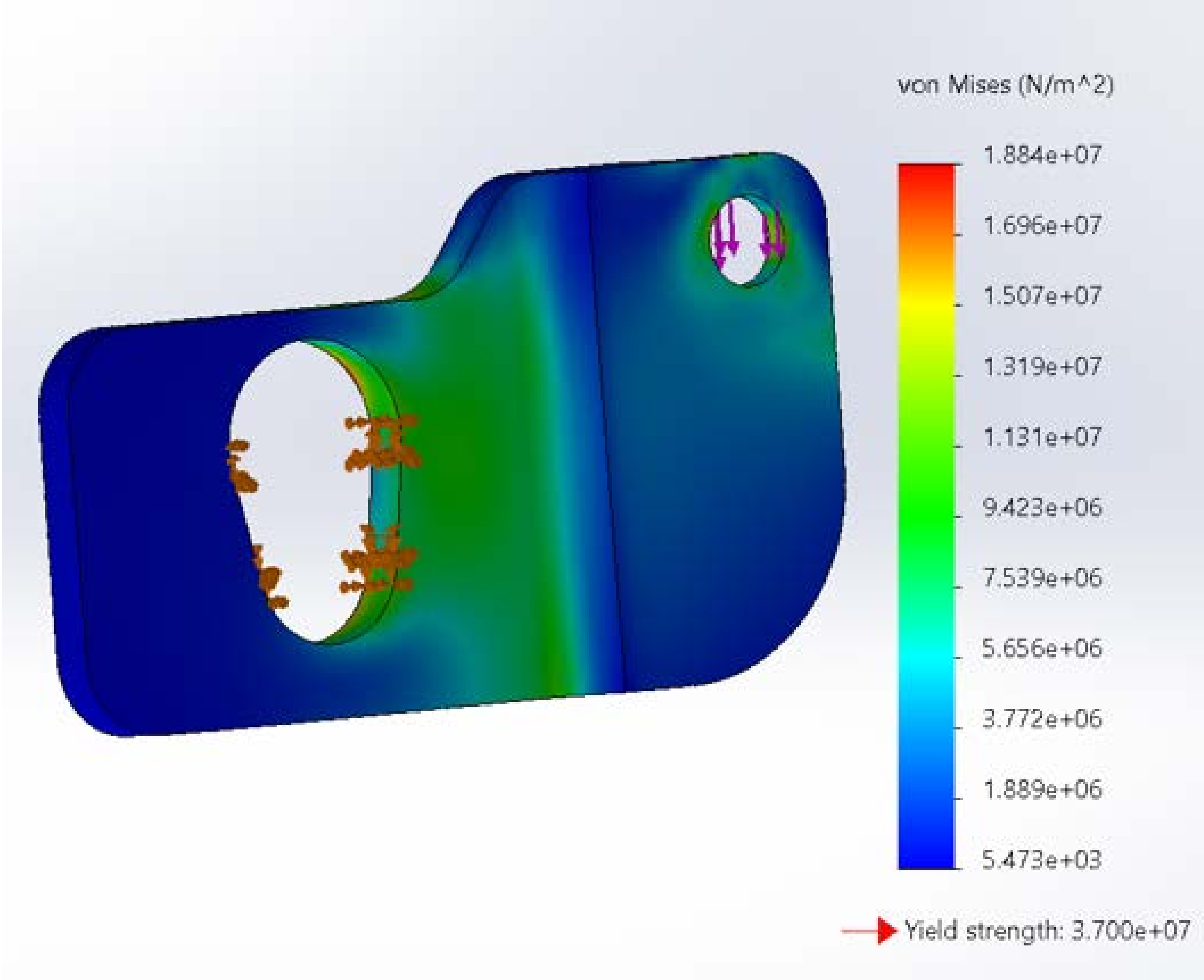
The above image shows the stress on the inside of the left pulley plate for ideal 525 N load.



The above image shows the stress on the inside of the left pulley plate under a safety factor of 2 of 1050 N load.



The above image shows the stress on the inside of the right pulley plate for an ideal 525 N load.



The above image shows the stress on the inside of the right pulley plate under a safety factor of 2 of 1050 N load.

The above images show the same data as previously described, but show the inside surface of the plate. Basically, all this shows is that in the fillet/chamfer where the plate curves inward, some stresses and deformations will develop, but not enough to adversely affect the integrity of the support plates.

To further enhance the rigidity of these plates, when printing, I used a 90% infill so that the plates are almost entirely solid Tough PLA, with little gaps between the layers. This will improve the performance under high loading conditions.

References:

“Ultimaker Tough Pla TDS – Ultimaker Support.” [Online]. Available: https://support.ultimaker.com/hc/en-us/articles/360012759599-Ultimaker-Tough-PLA-TDS. [Accessed: 19-Apr-2022].

https://support.ultimaker.com/hc/en-us/articles/360012759599-Ultimaker-Tough-PLA-TDS

Conclusions:

Overall, the SolidWorks Simulation shows that the material of choice and geometry chosen for the pulley support plates are more than equipped to withstand the max load with a safety factor of 2. Thus, we are confident that these plates will be able to endure the stresses and forces transmitted to them on the rower from the rower itself and from the rope during rowing motions.

Action items:

-Print Second Swivel Design tomorrow morning

-Assemble rower tomorrow afternoon

-Make plan for testing

-Test Thursday

-Begin poster on friday and over weekend

Josh ANDREATTA - Apr 18, 2022, 11:35 PM CDT

Download

Right_Pulley_Support_Plate_Safety_Factor.docx (1.49 MB)

Josh ANDREATTA - Apr 18, 2022, 11:35 PM CDT

Download

Right_Pulley_Support_Plate_Ideal.docx (1.49 MB)

Josh ANDREATTA - Apr 18, 2022, 11:35 PM CDT

Download

Left_Pulley_Support_Plate_Safety_Factor.docx (1.37 MB)

Josh ANDREATTA - Apr 18, 2022, 11:35 PM CDT

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Left_Pulley_Support_Plate_Ideal.docx (1.37 MB)

Josh ANDREATTA - Apr 18, 2022, 11:40 PM CDT

Download

TDS_Tough_PLA.pdf (72.3 kB)

Preferred Template

Josh ANDREATTA - Sep 14, 2021, 9:45 AM CDT

Title:

Date:

Content by:

Present:

Goals:

Content:

References:

Conclusions:

Action items:

Importance of Exercise for Wheelchair Users

Cate Flynn - Mar 01, 2022, 10:44 AM CST

Title: Importance of Exercise for Wheelchair Users

Date: 03/01/22

Content by: Cate

Present: N/A

Goals: Investigate the importance of upper body exercise for wheelchair users

Content:

Wheelchair users were exposed to 12 weeks of home upper body workouts under the hypothesis that the participants would lessen their shoulder pain and increase their mobility as a result of the exercise.

As a final result of the study, "pain was reduced and function improved after the intervention".

Citation:

Van Straaten, Meegan G., Beth A. Cloud, Melissa M. Morrow, Paula M. Ludewig, and Kristin D. Zhao. “Effectiveness of Home Exercise on Pain, Function, and Strength of Manual Wheelchair Users with Spinal Cord Injury: A High-Dose Shoulder Program with Telerehabilitation.” *Archives of Physical Medicine and Rehabilitation* 95, no. 10 (October 2014): 1810-1817.e2. https://doi.org/10.1016/j.apmr.2014.05.004.

Conclusions/action items:

Continue with the design of this rower.

Health Benefits and Constraints of Exercise Therapy for Wheelchair Users

Cate Flynn - May 02, 2022, 7:34 PM CDT

Title: Health Benefits and Constraints of Exercise Therapy for Wheelchair Users

Date: 05/01/22

Content by: Cate

Present: N/A

Goals: Characterize the impact of this design project for millions of wheelchair users in America

Content:

Summary of Findings:

It has been found that approximately 1 billion people in the world have a chronic limb disability which often results in reliance on a wheelchair. This staggering statistic demonstrates how many rely on wheelchairs for day to day life. Cardiometabolic and neuromuscular risk profiles are used to evaluate the overall health and condition of wheelchair users. Consistent exercise has been found to improve these profiles over time. This source is a review paper documenting the state of health for wheelchair users in terms of benefits and constraints of exercise therapy for wheelchair users. Only 25 papers total were accepted into this review. These papers generally found that this lack of exercise leads to a lower quality of life, highlighted by low self esteem, social isolation, and depression. Unfortunately, the primary mode of exercise for wheelchair users is upper body exercise which does not lower their risk profiles and can contribute to chronic overuse conditions. Poor chair setup and poor cardiovascular health contribute to upper limb injuries.

Readily available workout equipment could help to improve these overall risk profiles by increasing cardiovascular ability and contributing positively to self esteem. This review highlights the importance of adaptations to existing workout equipment to make it more accessible to all.

Citation:

Ellapen, Terry J., Henriëtte V. Hammill, Mariette Swanepoel, and Gert L. Strydom. “The Health Benefits and Constraints of Exercise Therapy for Wheelchair Users: A Clinical Commentary.” *African Journal of Disability* 6 (2017). https://doi.org/10.4102/ajod.v6i0.337.

Conclusions/action items:

Complete final deliverables for this design project with these implications in mind.

Exercise Therapy for Muscle and Lower Motor Neuron Diseases

Cate Flynn - May 03, 2022, 11:57 AM CDT

Title: Exercise Therapy for Muscle and Lower Motor Neuron Diseases

Date: 05/01/22

Content by: Cate

Present: N/A

Goals: Learn more about the benefits of exercise for wheelchair bound individuals

Content:

Findings:

Impeded lower muscle function is a characteristic of both muscle and lower motor neuron diseases. This is generally due to wasting and weakness of the muscles in these extremities. This wasting can have adverse effects on the quality of life of these individuals including restricted mobility and even respiratory difficulty. These diseases remain incurable, however this review article aimed to characterize the impact of exercise for the individual. The review found that moderate intensity aerobic exercise (such as rowing) and strength training is beneficial for wheelchair bound users with muscle diseases without causing any harmful damage to muscles. Unfortunately, users with motor neuron diseases did not recieve the same positive benefits from exercise. High-intensity training (HIT) is now being investigated as a potential mode of exercise that could be more beneficial for those with motor neuron disease.

This project could have a positive impact on wheelchair users with muscle diseases by providing a more accessible means of exercise. However, of the 5.5 million wheelchair users in the US, those with lower motor neuron diseases will not benefit from this device as these patients do not benefit specifically from repeat aerobic exercise. Hopefully, in the future, we will be able to develop therapies helpful to all wheelchair users, regardless of the disease or condition they have.

Citation:

Sheikh, Aisha Munawar, and John Vissing. “Exercise Therapy for Muscle and Lower Motor Neuron Diseases.” *Acta Myologica: Myopathies and Cardiomyopathies: Official Journal of the Mediterranean Society of Myology* 38, no. 4 (December 2019): 215–32.

Conclusions/action items:

Continue forward with finalizing the concluding deliverables with these implications in mind.

Standards and Specifications

Cate Flynn - Feb 09, 2022, 5:22 PM CST

Title: Standards and Specifications

Date: 02/09/22

Content by: Cate

Present: N/A

Goals: Research the standards and specifications for the PDS

Content:

The International Organization for Standardization (ISO) entry 20957-7:2005 stipulates the specific safety requirements for rowing machines, specifically rowing machines within classes S and H and class A for accuracy. Entry 20957-1 stipulates the general safety requirements for stationary workout equipment. Entry 20957-1 covers the safety requirements for any additionally provided accessories to be used in conjunction with the rowing machine [1].

This product does not require FDA approval as it does not fall under any of the FDA regulated products such as pharmaceuticals, medical devices, medical biologics, food, products that contain tobacco, supplements, cosmetics or electronic products that emit radiation [2].

[1] 14:00-17:00. “ISO 20957-7:2005.” ISO. Accessed February 9, 2022. https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/03/99/39908.html.

[2] “Does My Product Require FDA Approval? FDA Pre-Approval Requirements,” August 6, 2019. https://www.onlinegmptraining.com/does-my-product-require-fda-approval/.

Conclusions/action items:
Work with the team to edit the PDS before the final deadline.

Competition

Cate Flynn - Feb 09, 2022, 5:21 PM CST

Title: Competing Designs

Date: 02/09/22

Content by: Cate

Present: N/A

Goals: Research the competing designs for the adapted rowing machine for the PDS

Content:

There are currently a plethora of adapted rowing options for wheelchair users available on the market. One of these options is an adapted rowing machine seat that is easy to switch with a standard seat and is more accessible to get in and out of for paralyzed users [1].

Adapted rowing machines such as the AROW (Adapted Rowing Machine) by BCIT REDLab utilize an adapter and a stabilizer to isolate the rowing motion to the upper body of the user while keeping their chair in place [2].

There are also existing patents for adapted rowing machines, including patents specific to wheelchair users. One such patent describes a machine that includes a unit for fixing the upper half of a user's body to the machine, straps to keep the user's legs stabilized, and a pulley system to create the rowing motion for the upper body [3]. Many of these patents appear to require the use of a secondary person to assist the user onto the machine or the user to move themselves from their chair to the machine, both scenarios that have been deemed undesirable for this project by the client.

There appears to be a gap in the market for a rower that can be converted between an adapted and standard model. This interconvertibility is something that the client expressed interest in and could be a unique deliverable for this project.

[1] The Accessible Planet. "Wheelchair Rowing Equipment." Accessed February 9, 2022. https://www.theaccessibleplanet.com/fitness/wheelchair-rowing-equipment/.

[2] "Rowing Solutions – Adapted Rowing Machine (AROW)." Accessed February 7, 2022. https://adaptederg.commons.bcit.ca/rowing-solutions/.

[3] 박대성, 김민, 정다운, and 이범석. Rowing machine for paraplegic patient. World Intellectual Property Organization WO2012008664A1, filed December 22, 2010, and issued January 19, 2012. https://patents.google.com/patent/WO2012008664A1/en.

Conclusions/action items:

Work with the team to edit the PDS before the final deadline.

Mechanism for Pulling Handlebar

Cate Flynn - Feb 14, 2022, 12:23 PM CST

Title: Mechanism for Pulling Handlebar

Date: 02/14/22

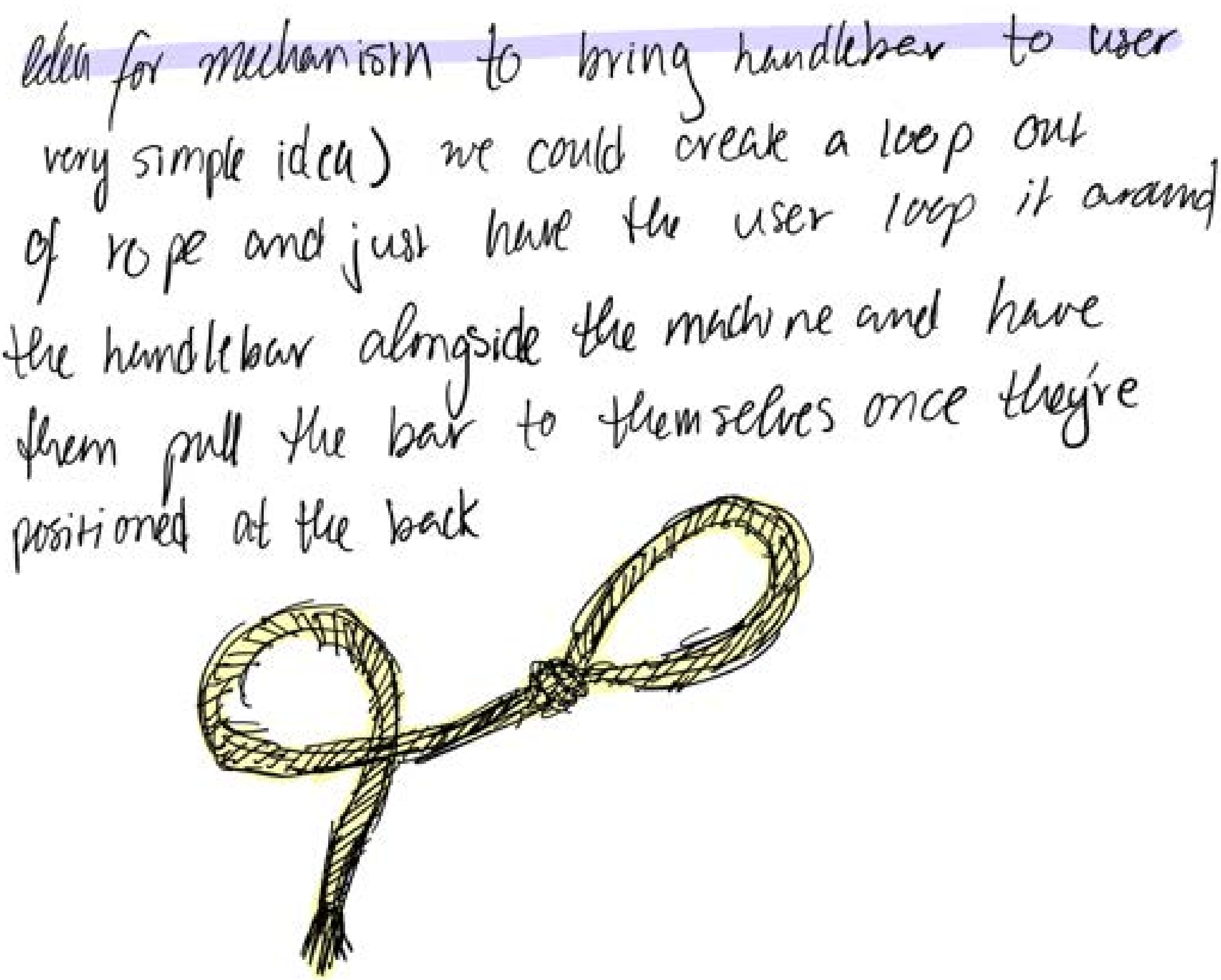
Content by: Cate

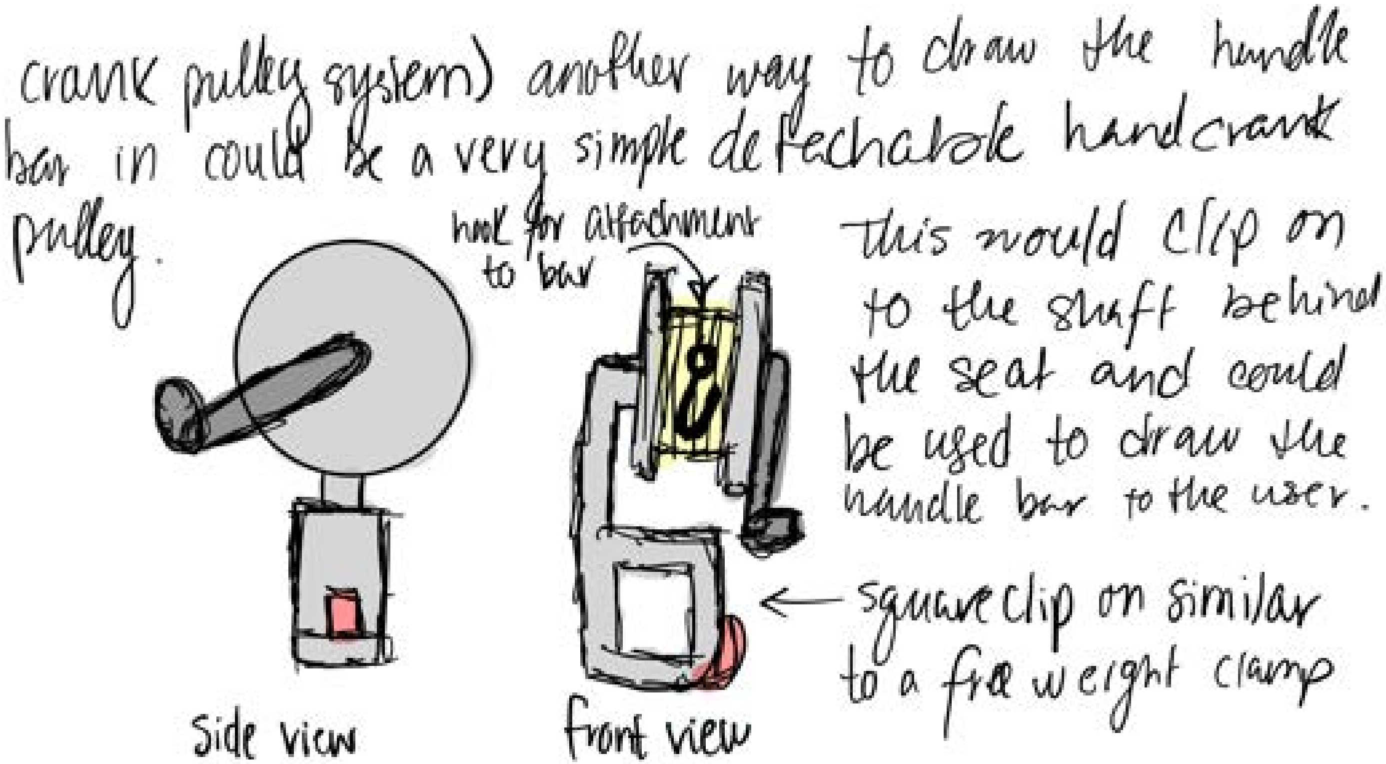
Present: N/A

Goals: Outline design ideas for pulling the handlebar to the user

Content:

One simple way to pull the handlebar to the user could be to place a rope around the bar and have the user pull it to themselves. While cost efficient and simple, this method is not the most developed and would also create an excess of loose rope that the use would have to navigate. A more complex approach would be to attach a crank pulley to a lead with a hook and attach that to a free weight clip that will attach to the shaft behind the conventional seat. I have included my preliminary notes and sketches below.





Conclusions/action items:

Present these ideas to the team for discussion at the coming design matrix meeting.

Locking Mechanism

Cate Flynn - Feb 14, 2022, 12:29 PM CST

Title: Mechanism for Locking the User in Place

Date: 02/14/22

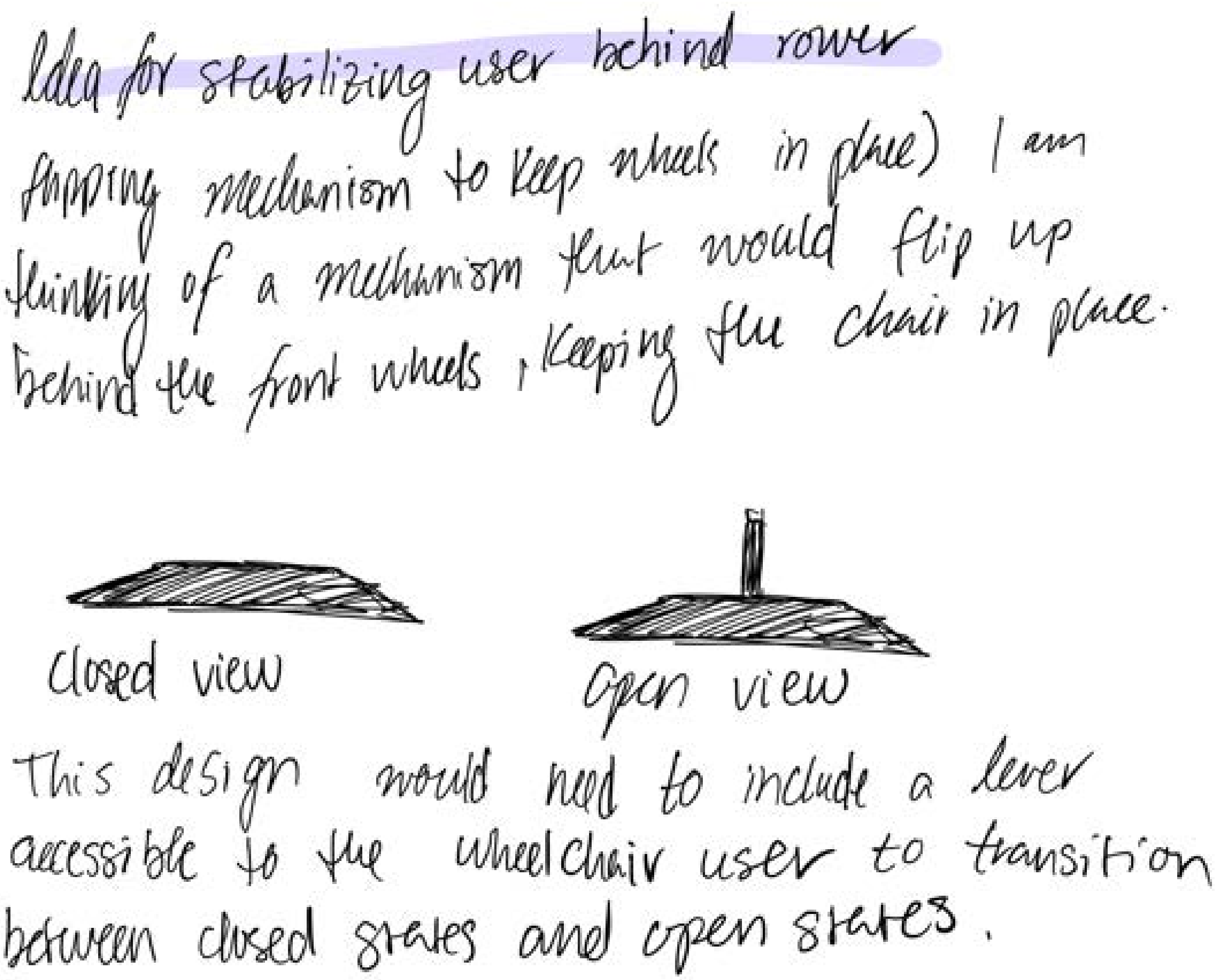
Content by: Cate

Present: N/A

Goals: Outline a preliminary design idea for keeping the user in place

Content:

The idea here would be to create a mechanism that flips up at the pull of a lever that would keep the wheelchair in place while the user is rowing. The flipped up part would go behind the front wheel, keeping them stationary.



Conclusions/action items:

Present this preliminary idea for discussion at the design matrix meeting.

Ramp and Hook Design

Cate Flynn - Feb 20, 2022, 11:32 AM CST

Title: Ramp and Hook Design

Date: 02/20/22

Content by: Cate

Present: N/A

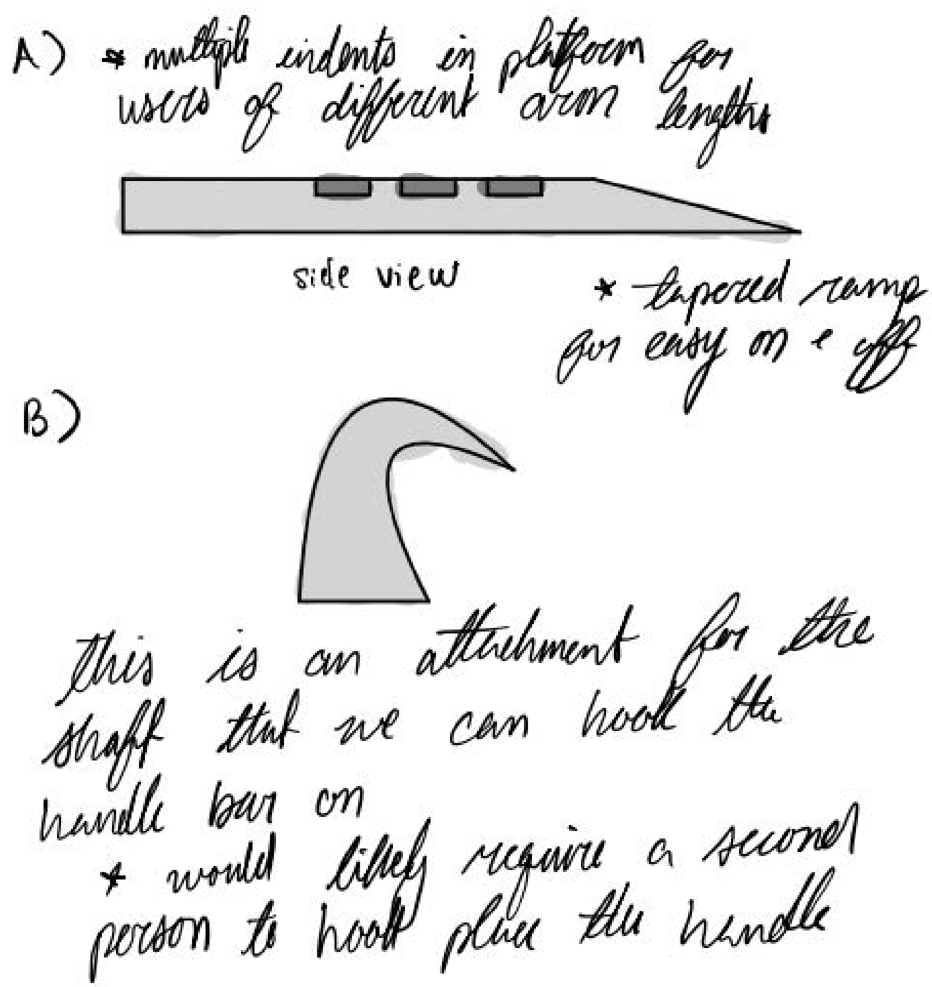
Goals: Outline my design idea for the second design matrix meeting

Content:

After the Johnson Health Tech tour, I designed an adapted ramp with slotted grooves to keep the user in place. This would also make it possible to place differently spaced slots in the ramp so that users of different arm lengths can work out at a comfortable distance. I also thought that we might be able to add a hook to the shaft to hold the handle in place for easy accessibility for the user. I have attached both drawings below.

A) Ramp up accessibility

B) Handle Hook



Conclusions/action items:

Add my ramp design to the design matrix for team deliberation.

Design Redraw

Cate Flynn - Feb 22, 2022, 8:57 PM CST

Title: Preliminary Design Redraw

Date: 02/22/22

Content by: Cate

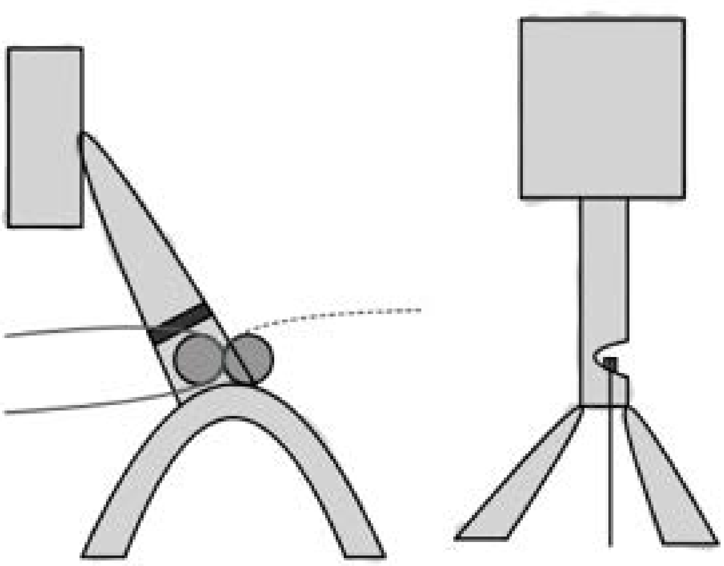
Present: N/A

Goals: Document the redrawing I did of all preliminary designs for the preliminary presentation

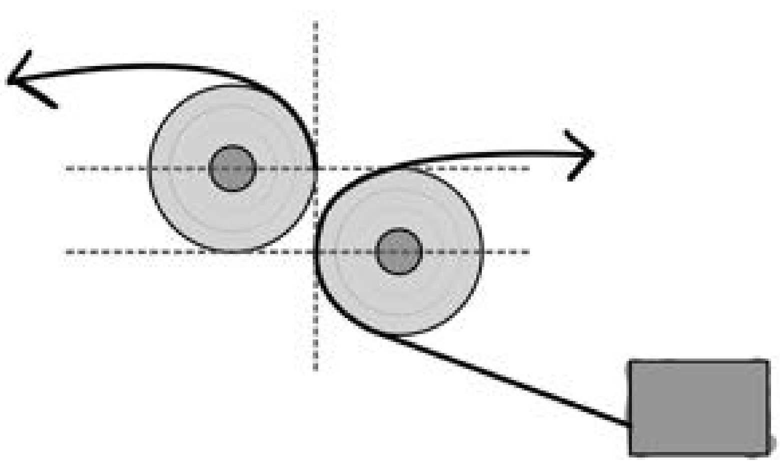
Content:

Pulley Designs:

2 Pulleys with Slit

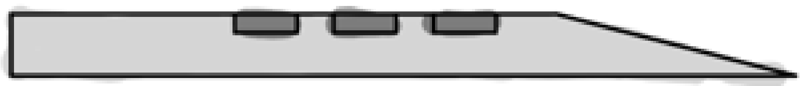


2 Pulleys With 2 Ropes

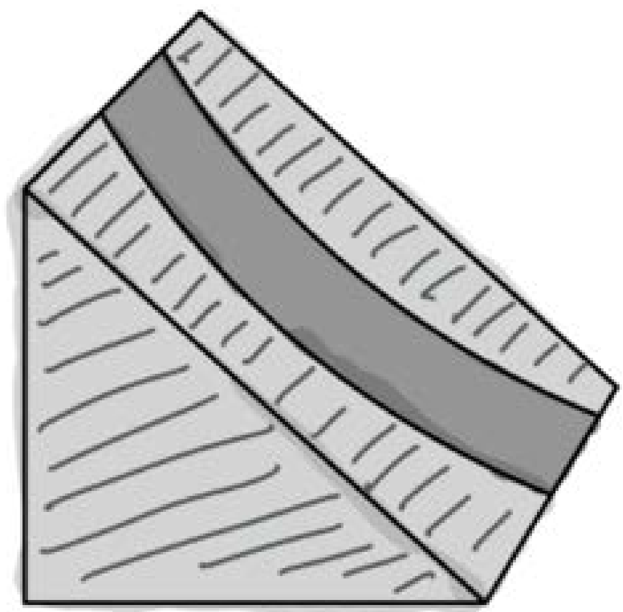


Stability Designs:

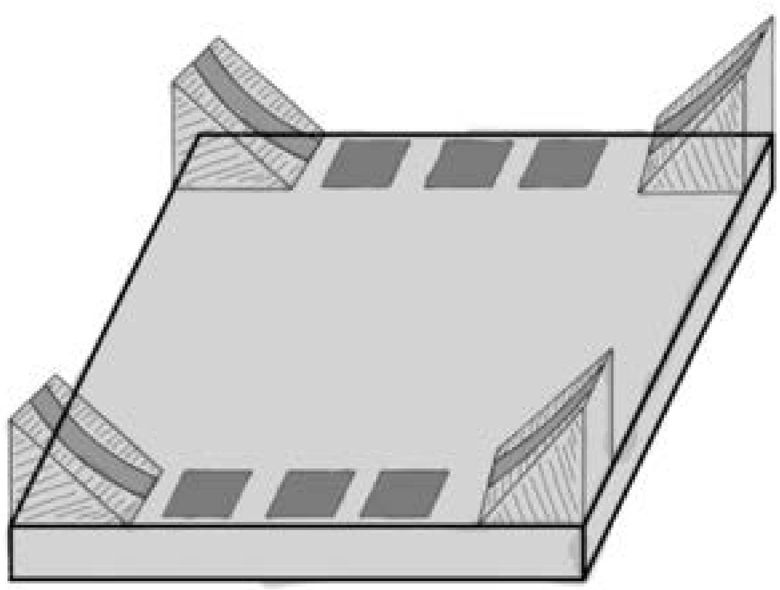
Highway Ridges



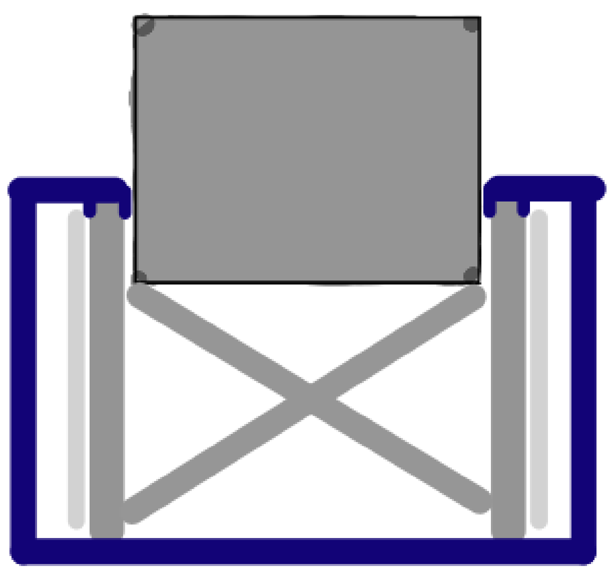
Traction Blocks



Combined Design



Side Handle Bars



Conclusions/action items:

Implement these drawings in our preliminary presentation.

FBDs for Final Preliminary Design

Cate Flynn - Mar 01, 2022, 10:31 AM CST

Title: FBDs for Final Preliminary Design

Date: 03/01/22

Content by: Cate

Present: N/A

Goals: Document the FBDs I drew for each of the preliminary designs

Content:

Below I have included the FBDs for the Highway Ridges design (Figure 1) and the 2 Pulleys 1 Slit design (Figure 2).

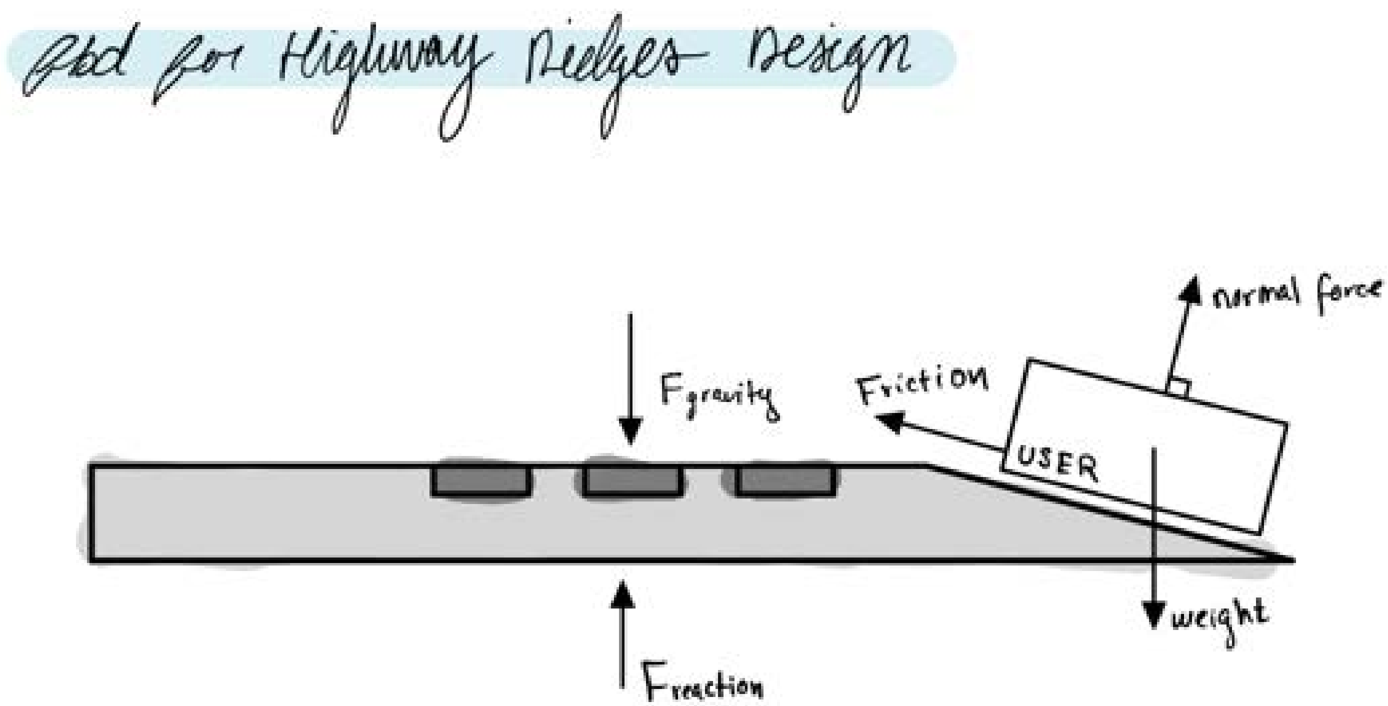


Figure 1: Highway Ridges FBD

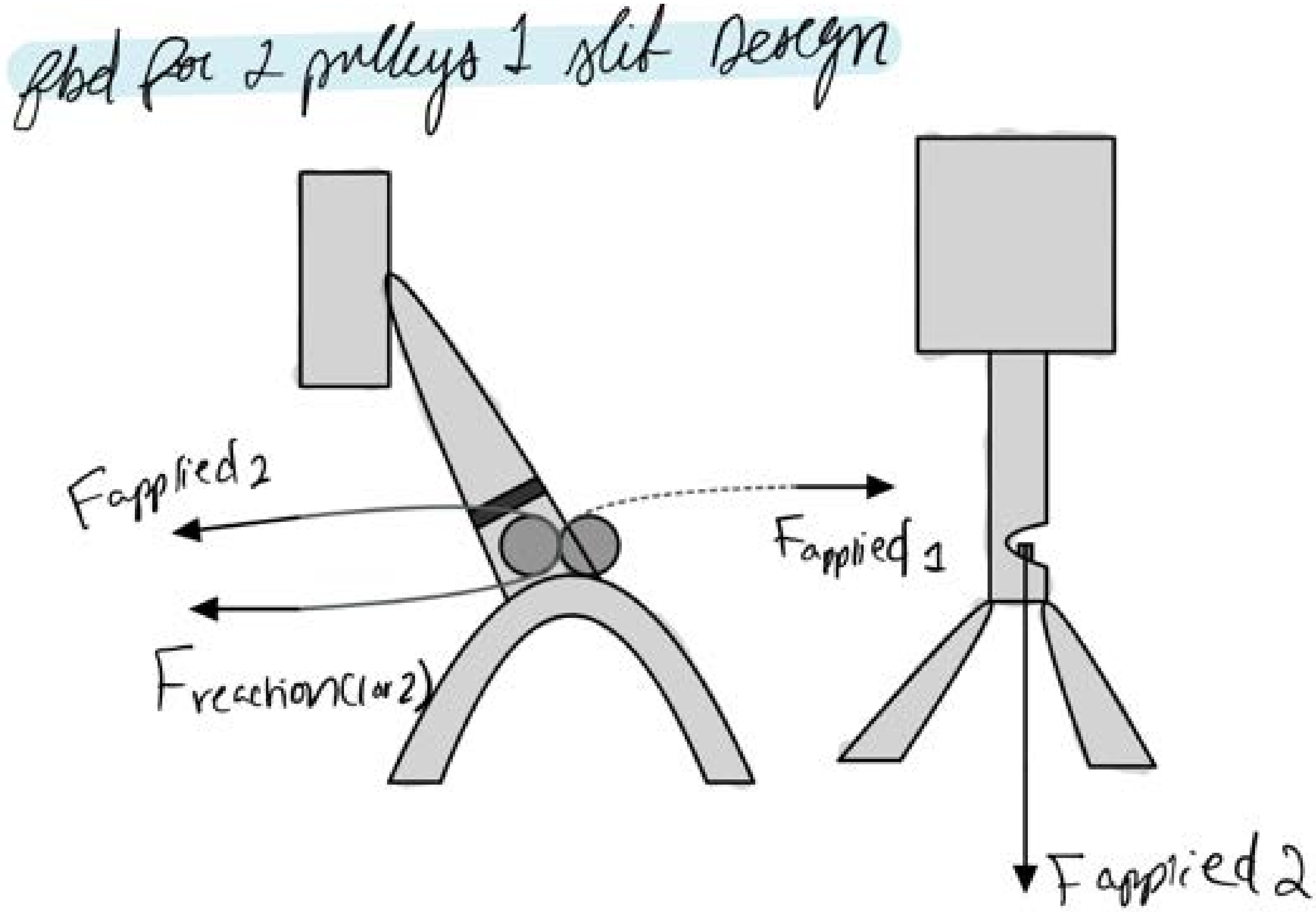


Figure 2: 2 Pulleys 1 Slit FBD

Conclusions/action items:

Convert these Force Body Diagrams into CAD files.

Velcro-Wood Stabilization

Cate Flynn - Apr 08, 2022, 1:09 PM CDT

Title: Velcro-Wood Stabilization

Date: 04/07/22

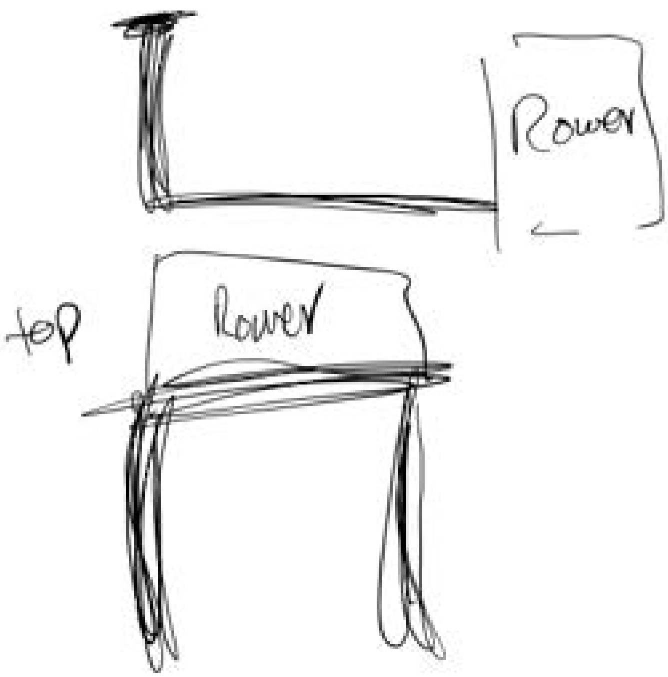
Content by: Cate

Present: N/A

Goals: document my idea for a stabilization device constructed from wood and Velcro

Content:

I drew a rough sketch of my idea during our last team meeting. Essentially, the frame would be made out of wood and would take the shape of a mostly completed square. The wood would go up at a 90 degree angle from the two beams going back from the rower. Some sort of velcro or buckling mechanism would attach to the top of the wood to secure the structure to the frame of the rower.



Conclusions/action items:

Go into ECB to take measurements of the rower and wheelchair to construct the stabilization device.

Rotating Display Sketch

Cate Flynn - Apr 11, 2022, 4:14 PM CDT

Title: Rotating Display Sketch

Date: 04/10/22

Content by: Cate

Present: Josh, Sam, Tim, Dhruv

Goals: Document the sketch I made for a part that would enable the display to rotate

Content:

I drew this sketch on the whiteboard during our team planning meeting today. The idea is to add a mechanism to the rotating part so that the display will de able to rotate 180 degrees in the clockwise and counterclockwise directions. I have also emailed Staci to ask if she has any thoughts as well as for the solidworks file of the display.

Conclusions/action items:

Distribute Staci's response to the team and continue the design process.

FBD for Stabilization Apparatus

Cate Flynn - May 01, 2022, 7:50 PM CDT

Title: FBD for Stabilization Apparatus

Date: 04/24/22

Content by: Cate

Present: N/A

Goals: Document the FBD I created for the wooden support apparatus

Content:

I have created FBDs for the support apparatus I designed previously in the "Velcro-Wood Stabilization" entry. In my original design, the apparatus was constructed from retractable steel tubes to enable users in different wheelchairs to comfortably use the machine. I have drawn the FBD for the wooden construction because it is accurate to the materials and the construction we have for the semester. Figure 1 is the side view of the apparatus with an applied force from the user which creates a distributed reaction force throughout the frame. There are also equal and opposite normal and gravitational forces. Figure 2 shows the same forces from the front view.

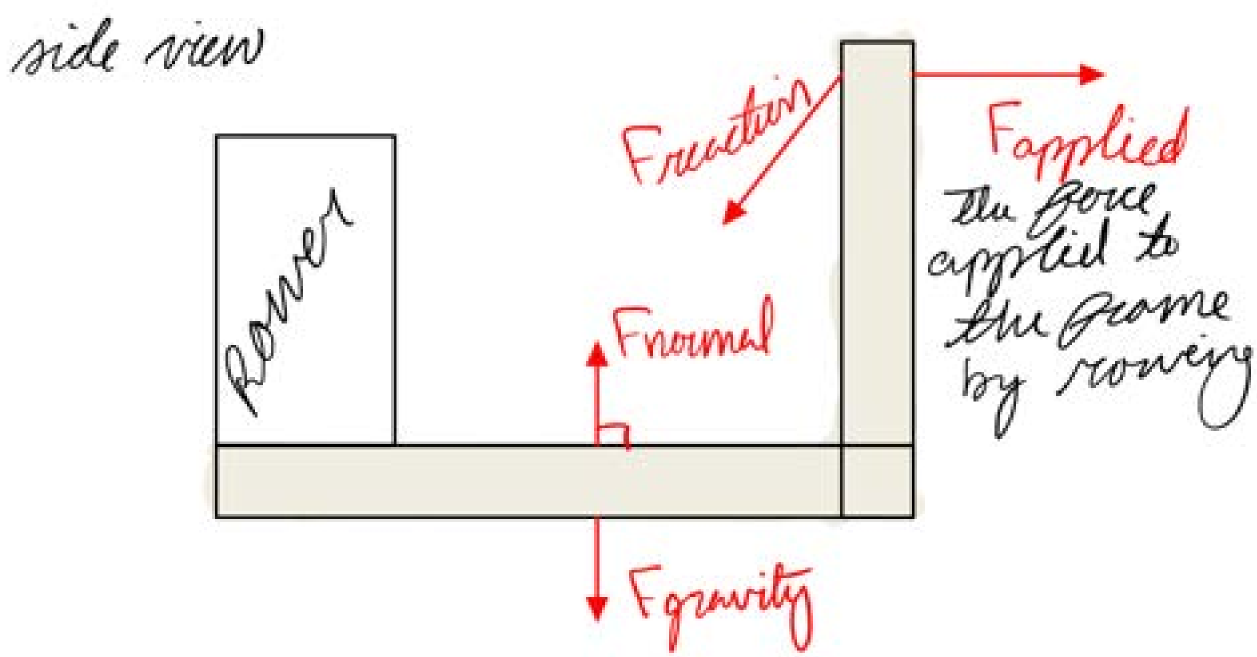


Figure 1: Side view of apparatus

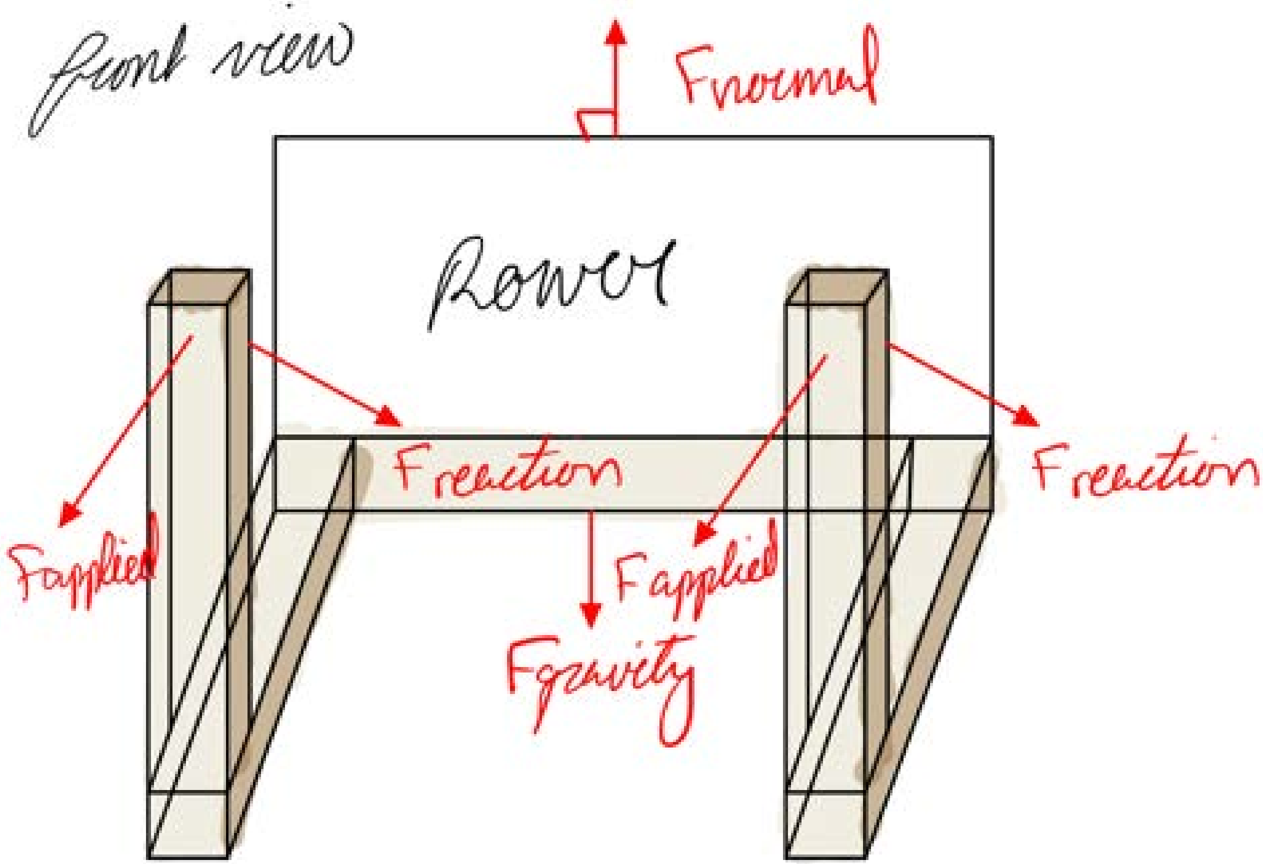


Figure 2: Front view of apparatus

Conclusions/action items:

Finish construction and testing of the support apparatus.

MATLAB Force Data Analysis

Cate Flynn - May 01, 2022, 7:11 PM CDT

Title: Matlab Testing Data Analysis

Date: 04/22/22

Content by: Cate

Present: N/A

Goals: Plot the data for rowing force testing

Content:

I analyzed the acquired force versus resistance level data in order to determine the relationship between resistance level and maximum force generated during rowing. I wrote this script in MATLAB to analyze the data by creating arrays of the maximum force generated (in pounds) on each side as well as the resistance level each force was accomplished under. From here, I used the convforce() function to convert the pound force to newtons. Finally, I plotted the x arrays against the newton data for the standard and adapted sides and added titles, colors, markers, and size to each plot as well as axis titles, a legend and a title for the plot. This plot is included below (Figure 1). From here, to establish a clearer trend in the data, I created box plots for each side at each resistance levels (six box plots total). I created these plots by breaking the newton data into three arrays (one for each resistance level) for each side. After this, I used the ' command to invert the combined array and then created the box plots shown in Figure 2. Analysis of these results can be found in the following entry "Implications of Matlab Data".

MATLAB Script:

```
clear all
close all
x1 = [1 1 1 1 1 1 1 1 1 1 5 5 5 5 5 5 5 5 5 5 10 10 10 10 10 10 10 10 10 10]
adaptedPounds = [35 38 37 38 42 36 39 41 38 42 45 48 46 43 46 47 44 43 46 50 62 58 56 60 57 62 61 57 61 59]

x2 = [1 1 1 1 1 1 1 1 1 1 5 5 5 5 5 5 5 5 5 5 10 10 10 10 10 10 10 10 10 10]
standardPounds = [32 35 39 37 40 39 37 38 41 37 60 56 54 62 63 57 58 55 61 56 78 87 88 76 75 76 74 77 74 74]

adaptedNewtons = convforce(adaptedPounds,'lbf','N')
standardNewtons = convforce(standardPounds,'lbf','N')

plot(x1,adaptedNewtons,'DisplayName','Adapted Side', 'Color','r', 'Marker','.', 'LineStyle','none', 'MarkerSize',30)
hold on
plot(x2,standardNewtons,'DisplayName','Standard Side', 'Color','k', 'Marker','.', 'LineStyle','none', 'MarkerSize',30)
hold off

set(gca,"XGrid","off","YGrid","on")
xlabel("Resistance Level", "FontSize",20)
ylabel("Force Generated (N)", "FontSize",20)
title("Force Generated During Rowing ", "FontSize",24)
```

```
xlimit = [1 5 10]
set(gca, 'XTick', (xlimit))

legend("show", "FontSize",14)
legend("Position",[0.1479,0.73049,0.32097,0.12805])

aN1 = [adaptedNewtons(1:10)]
aN5 = [adaptedNewtons(11:20)]
aN10 = [adaptedNewtons(21:30)]

sN1 = [standardNewtons(1:10)]
sN5 = [standardNewtons(11:20)]
sN10 = [standardNewtons(21:30)]

x = [aN1; sN1; aN5; sN5; aN10; sN10]
xfinal = x'

figure
boxplot(xfinal)
set(gca,'XTickLabel',{'Adapted 1','Standard 1','Adapted 5','Standard 5','Adapted 10','Standard 10'}, 'fontsize', 12)
xlabel("Resistance Level", "FontSize",20)
ylabel("Force Generated (N)", "FontSize",20)
title("Force Generated During Rowing ", "FontSize",24)
```

MATLAB Plots)

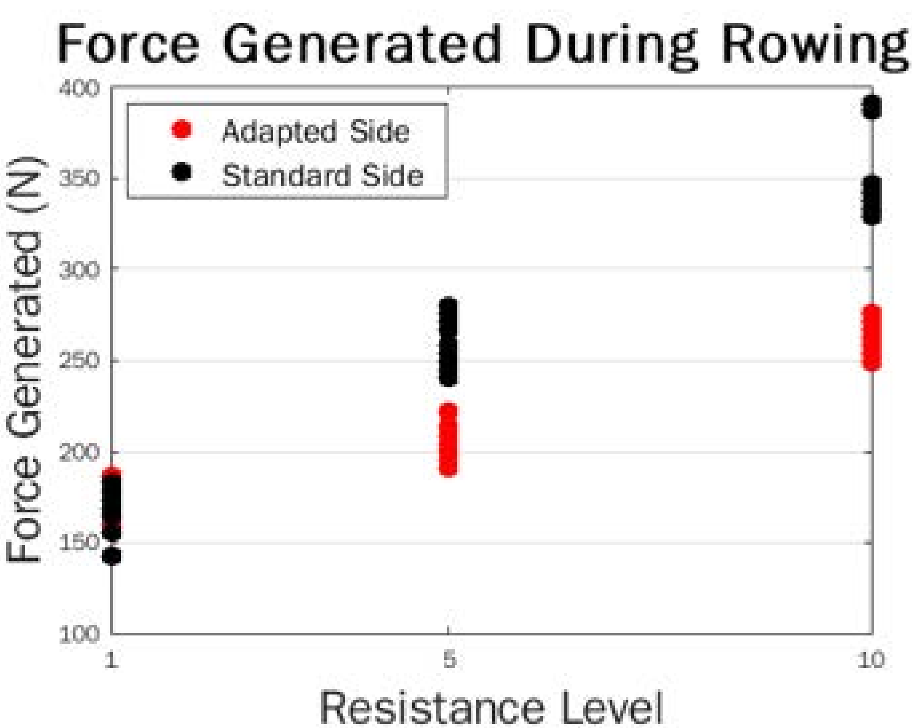


Figure 1: Maximum force generated during rowing for each side for three different resistance levels

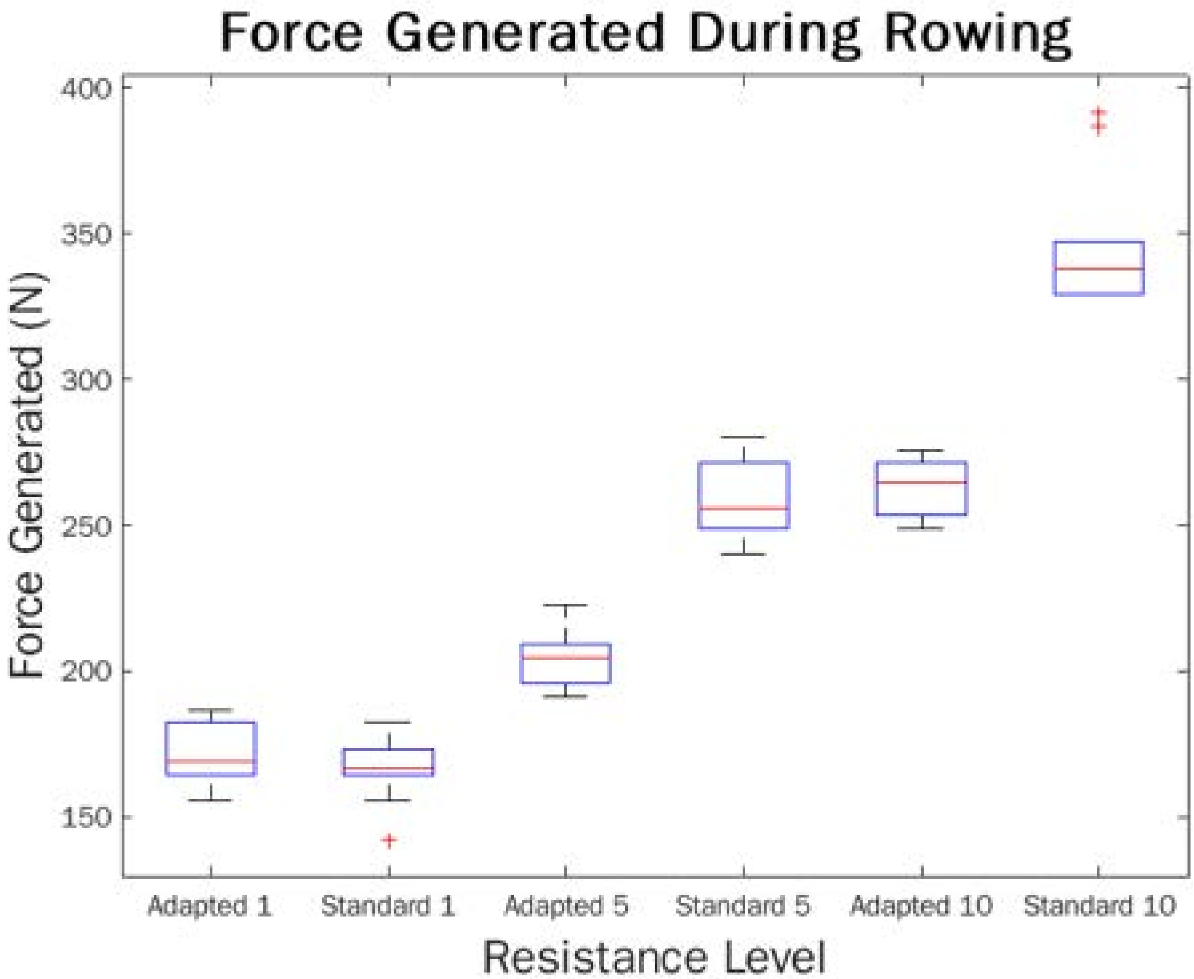


Figure 2: Box plot of maximum force generated during rowing for each side for three different resistance levels

Conclusions/action items:

Include this information in our final poster presentation

Implications of MATLAB Data

Cate Flynn - May 01, 2022, 7:56 PM CDT

Title: Implications of MATLAB Data

Date: 05/01/22

Content by: Cate

Present: N/A

Goals: Analyze the implications of the data collected in MATLAB

Content:

In order to evaluate the force developed on the adaptive and standard side while rowing, ten maximum force measurements were taken on each side for three different resistance levels (1, 5, and 10). In order to standardize the maximum force developed, the rower tried to maintain a stroke rate of 22 to 25 strokes per minute during each rowing session. Videos were taken during the rowing in order to slow the footage and accurately capture the maximum force developed per each stroke. The team member rowing held a 45 kg or 100 lb spring gauge to measure the force. The results of this testing were plotted in MATLAB and included in the figure below.

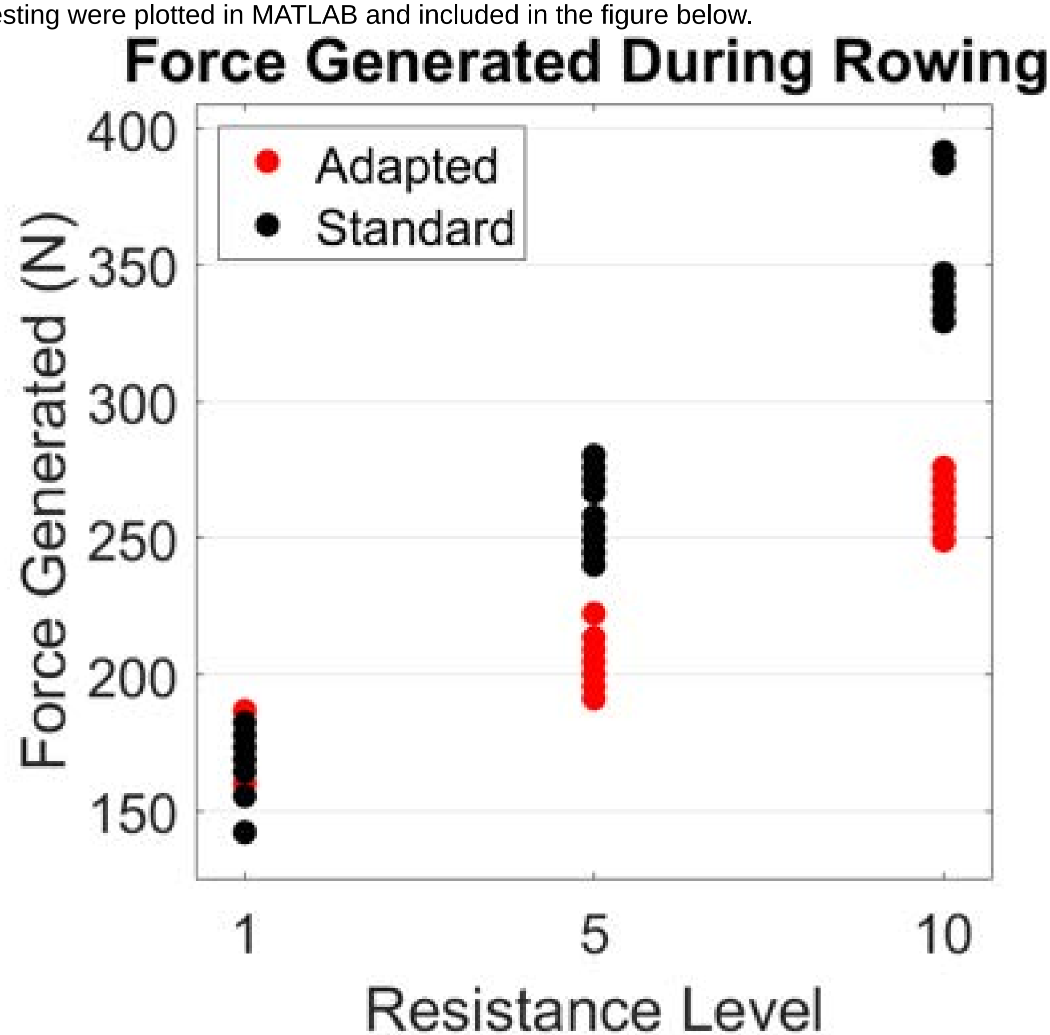


Figure 1) Force Generated During Rowing The force generated during rowing on each side plotted against the resistance level was taken ten times for resistance levels of 1, 5, 10. More force was generated on the standard side, but the overall force generated increased at each resistance level.

The figure shown below demonstrates the general increase in force generated as resistance level increases. Less force is developed on the adapted side as seen in red. This can be explained by the smaller distance generated on the adapted side while rowing. Without the use of their legs, an adapted user can not generate the same amount of tension and therefore force as a standard user. However, the general increase in force generated shows that the workout can be tailored on the adapted side as well as the adapted side by changing the resistance level.

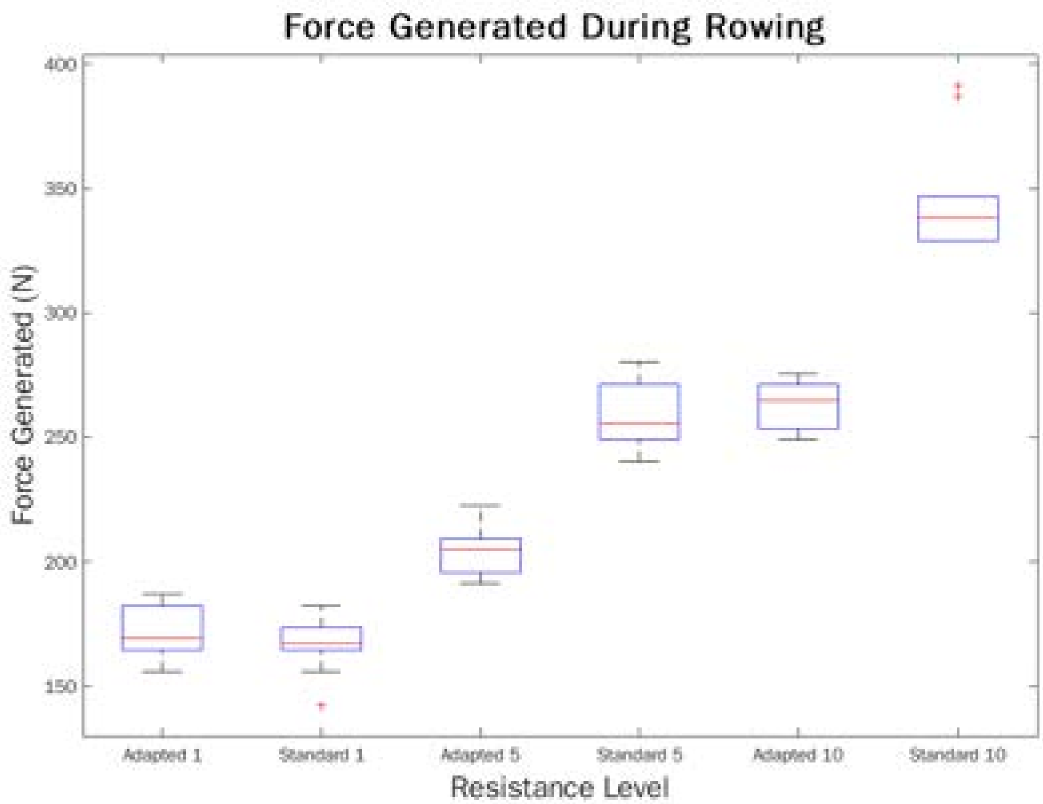


Figure 2) Box Plot of Force Generated During Rowing The box plot for the rowing conducted at resistance levels of 1, 5, 10 demonstrates the general increase in force generated for each resistance level. The red asterisks indicate outliers in the ten data points for each side at each resistance level.

Figure 2 shows the same data in box plot form. The averages for each mode of rowing increase with the resistance level, again demonstrating the capability to tailor the workout on each side. In the future, testing the adapted side with wheelchair users will provide valuable insight into the force an adapted user can create and will ensure the elimination of inaccuracies due to the use of the user's legs. The spring gauge will also be connected directly to the cord when testing in the future in order to make the data collection more accurate.

Conclusions/action items:

Include these results and this discussion in the final report.

Intellectual Property Lecture

Cate Flynn - Mar 21, 2022, 3:27 PM CDT

Title: Intellectual Property Lecture

Date: 03/19/22

Content by: Cate

Present: N/A

Goals: Record my completion of the viewing and notes for the intellectual property lecture

Content:

I think that our project may have intellectual property that could be disclosed to WARF. From what we have seen so far, there isn't currently a rower on the market that can convert between the standard and adapted rowing modes in the way that our design intends to. I think that whether we disclose or not may depend on the success and progression of our design. I also don't know how working with a commercial company like Johnson Health Tech. impacts our ability to disclose intellectual property.

Conclusions/action items:

Ask Dr. P about the impact of working with JHT on our ability to disclose intellectual property.

Cate Flynn - Mar 21, 2022, 3:23 PM CDT

Download

Intellectual_Property_Lecture_.pdf (2.26 MB) Notes and reflection for Intellectual Property Lecture

2/4/22 Muscles Used While Rowing

SAMUEL SKIRPAN - Feb 04, 2022, 9:51 AM CST

Title: Muscles Used While Rowing

Date: 2/4/22

Content by: Sam

Present: Sam

Goals: Complete prelim research on muscles used while rowing.

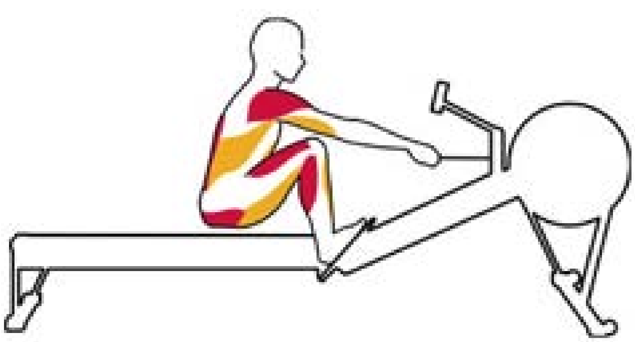
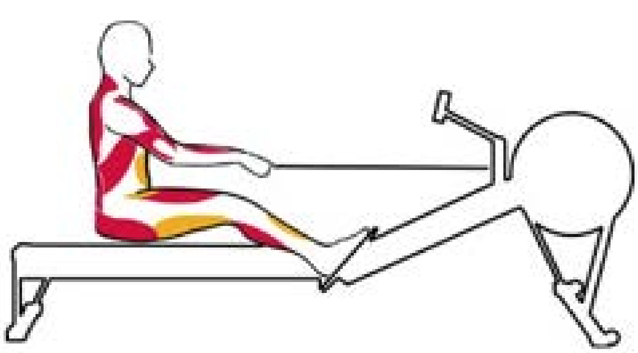
Content:

Article: Rowing and Your Muscles

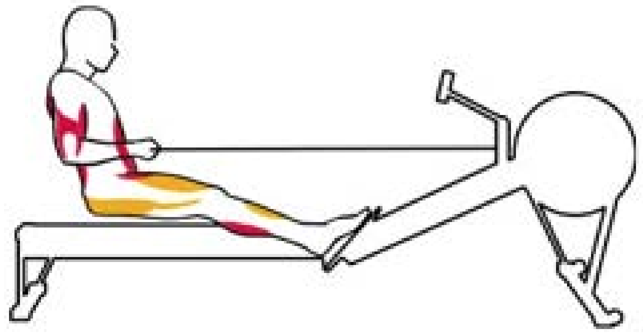
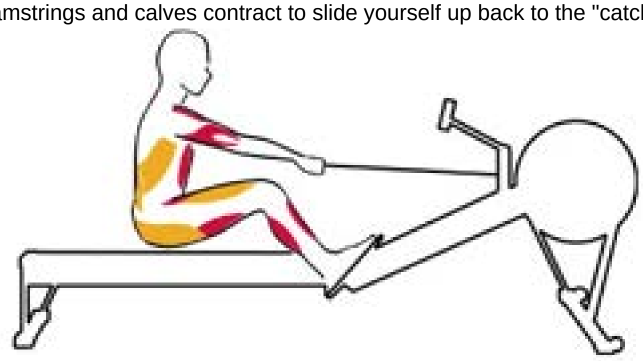
Website: https://www.concept2.com/indoor-rowers/training/muscles-used

Citation: David, "Muscles used," *Concept2*, 26-Jul-2021. [Online]. Available: https://www.concept2.com/indoor-rowers/training/muscles-used. [Accessed: 04-Feb-2022].

Notes:

- There are 4 different main movements made during each repetition completed while on a rowing machine
  - 1. The catch
  - 2. The Drive
  - 3. The finish
  - 4. The recovery
- The Catch:
  - Your triceps work to extend your arms and the flexor muscles of your fingers and thumbs grip the handle
  - Abdominals are flexing your torso forward
  - 
    - This picture shows the "catch" movement. The muscles in yellow are relaxed and the muscles in red are engaged.
- The Drive
  - Initiated by your quads, glutes, and calves
  - Biceps engage to pull the handle toward your abs
  - Back muscles work as your torso swings to open
  - Hamstrings contract at the end to swing your hips
  - 

    - This picture shows the "drive" motion. A lot of muscle groups are activated here as shown in red. The yellow groups indicate muscles that are barely / not used.

- The Finish
  - The abs stabilize the body
  - The biceps are contracting to help keep the torso in the finish position
  - Lower back is working for stabilization purposes
  - 
    - This picture represents the "finish" movement. The muscles here in red are activated and the muscles in yellow are relaxed.
- The Recovery
  - Triceps engage to push the arms forward and away from the body
  - Abs flex the torso forward
  - Hamstrings and calves contract to slide yourself up back to the "catch" position
  - 
    - This picture shows the "recovery" movement. The muscles in red are activated and the muscles in yellow are relaxed at this point.

Conclusions/action items:

For a typical rowing stroke, there are 4 core movements that are involved. These movements include the catch, the drive, the finish, and the recovery. Each of these movements uses different core muscle groups throughout the body. However, overall, the typical rowing stroke uses every major muscle group throughout the body and provides a terrific cardio workout for the user. These pictures in this entry are terrific visualization tools for seeing which muscles are used at a given moment.

Action items: Meet with client to ask questions. Continue on with prelim research. Consider competing designs.

2/8/22 Forces on Rowing Machine

SAMUEL SKIRPAN - Feb 08, 2022, 8:48 PM CST

Title: Forces on Rowing Machine

Date: 2/8/22

Content by: Sam

Present: Sam

Goals: Determine typical forces created by person on rowing machine.

Content:

Article: Forces applied on rowing Ergometer Concept2

Citation: N. Découfour, F. Barbier, P. Pudlo, and P. Gorce, “Forces applied on rowing ergometer Concept2®: A kinetic approach for development (P94),” *The Engineering of Sport 7*, pp. 483–490.

Notes:

- Max force developed by rower is around 1050 N (backwards)
  - Components must resist this pulling force
- Forces vary through different phases of rowing cycle
- Seat must also support heavy pressure at end of propulsive phase
  - Note: not super important for us since we will not be using the seat

Conclusions/action items:

For this research, the maximum force an "average" person exerts while pulling back on the rowing machine is around 1050 N. Our device (the attachments parts to the wheel chair) should be able to resist this force without breaking or bending. This is the main thing we will need to account for with our modifications for attachment to the wheelchair.

Action items: edit PDS.

2/17/22 Concept2 Adapt2Row Rower Design

SAMUEL SKIRPAN - Feb 17, 2022, 11:23 A

Title: Concept2 Adapt2Row Rower Design

Date: 2/17/22

Content by: Sam

Present: Sam

Goals: Complete research on the Concept2 Adaptive Rower Design.

Content:

Article: Adapt2Row

Link: https://gerofitness.nl/export/406-adapt2row.html

Notes:

- Adapt2Row makes rowing on a Concept2 rowing machine accessible for people in wheelchairs
- The device is connected to an existing Concept2 machine
- Doesn't require any tools to connect the Adapt2Row
- Takes 1 minute to switch from one normal to the Adapt2Row
    - Allows for switching back from adaptive to normal, vice versa
- It uses the adapter from the Concept2 rowing machine

-
    -
        - This picture shows someone attaching the Adapt2Row attachment to the base of the Concept2 Erg. As can be seen in the picture, the conept2 has a detachable rail for the seat, which allows for easy switching back and forth.

-
    - This picture shows the main components of the Adapt2Row attachment. The person in the wheelchair scoots up into the upholstery and in between the two bars with wheels.

box size	81x36x36 (LxBxH)
weight	+/- 20kg
Oppervlakte toestel	81x50cm
surface device	200x100cm (including rower)
Material	steel
color	grey
upholstery	black Boltaflex
practicing directly from the wheelchair	yes, no transfer needed
power connection	no
warranty	1 year on construction
deliverytime	2-5 week

-
    - This picture shows some of the specs of the Adapt2Row. Most importantly, the device weighs about 20 kg.

Conclusions/action items:

This Adapt2Row is an attachment to the Concept2 rowing machine which allows for easily accessible wheel chair use. It attaches on the same attachment point where the seat shaft would usu rest. This design allows for the Concept2 to be converted back and forth between a regular rower and an adaptive rower. It weighs about 20 kg and the conversion time between adaptive and use takes about 1 minute. It also doesn't require any outside tools to attach. Our team could use the 20 kg weight as a benchmark for our design.

Action Items: Meet with team to build the rowing machine. Start working on Prelim Presentation slides.

4/18/22 Research on ARM Competing Design

SAMUEL SKIRPAN - Apr 18, 2022, 11:08 PM CDT

Title: Research on ARM Competing Design

Date: 4/18/22

Content by: Sam

Present: Sam

Goals: Research this adaptive rowing machine competing design and define important characteristics of ARM.

Content:

Article: Using Adapted Rowing Machines for Fitness and Health

Link: https://sci-bc.ca/adapted-rowing-machines/

Citation: Spinal Cord Injury BC, "Adapted Rowing Machines for fitness and health," *Spinal Cord Injury BC*, 01-Sep-2020. [Online]. Available: https://sci-bc.ca/adapted-rowing-machines/. [Accessed: 18-Apr-2022].

Notes:

- NOTE: I belIeve Tim may have originally found this article, but I wanted to do my own research on it
- Dr. Carolyn Sparrey wanted to create an exercise machine for stationary rowing
- Adapted Rowing Machine = ARM
- The machine consists of a support arm that connects to the front end of an existing rowing ergometer
- The arm provides adjustable chest and lap support to accommodate users with a range of injury levels
- ARM was designed to make sure that it would not be very expensive and so that it would encourage gyms and other facilities to be able to provide an alternative accessible exercise option
- The chest pad in the design is there if users have limited or no trunk strength, so it supports them during the rowing motion
- The ARM allows for an arms-only exercise
- The fabrication plans for ARM are open source
- 

Adapted Rowing Machine designed for Trevor.
    - Here is a picture of the of the ARM with a user strapped in.

Conclusions/action items:

The ARM is an adaptation that can be made to an existing rowing machine to allow for wheelchair users to use the rowing machine. It allows for the user to get a great upper body and upper back exercise in while remaining safe on the machine. There is a bar that reaches out and supports the user to keep them in place. Our design does not quite include a bar, but it does include a strap that will hold the user in place. Right now, the ARM plans are open source. Our device would be more of something that would be pre-built and sold along with the rowing machine.

Action items: Meet with team to discuss / complete testing.

2/26/22 Review of Cate's Research on Standards

SAMUEL SKIRPAN - Feb 26, 2022, 2:08 PM CST

Title: Review of Cate's Research on Standards

Date: 2/26/22

Content by: Sam

Present: Sam

Goals: Complete a review of the standards that Cate found in her research.

Content:

- For this entry, I am going to review one of Cate's entries when she did research on standards so that I am fully aware of what she found
- For the first standard: International Organization for Standardization (ISO) entry 20957-7:2005
  - Talks about the safety requirements for rowing machines and the accuracy accompanying that safety
  - There are general safety requirements for stationary workout equipment in general
  - Also, if additional attachments are added to the rowing machine, there are safety requirements for those accessories covered by entry 20957-1
  - Citation: 14:00-17:00. “ISO 20957-7:2005.” ISO. Accessed February 9, 2022. https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/03/99/39908.html.
- Also, our project / product would not require any FDA approval since it is not a pharmaceutical, medical device, medical biologics, food, products that contain tobacco, supplements, cosmetics or electronic products that emit radiation
  - citation: “Does My Product Require FDA Approval? FDA Pre-Approval Requirements,” August 6, 2019. https://www.onlinegmptraining.com/does-my-product-require-fda-approval/.

Conclusions/action items:

It is good to know that we will not need FDA approval for our project since it does not fall under any of the items in the list above. Additionally, there are general safety requirements for exercise equipment under ISO entry 20957-7:2005.

Action items: Meet with team to complete preliminary report.

2/2/22 - Initial Research on How a Rowing Machine Works

SAMUEL SKIRPAN - Feb 04, 2022, 9:20 AM CST

Title: Initial Research on How a Rowing Machine Works

Date: 2/2/22-2/4/22

Content by: Sam

Present: Sam

Goals: Start initial research on how a rowing machine works. Find out the fundamental parts of the rowing machine.

Content:

Article: Types of Rowing Machine;

Website: https://www.rowingmachine-guide.com/types.html#:~:text=How%20Does%20Air%20Resistance%20Work,thus%20the%20greater%20the%20resistance.

Citation: “Rowing machine resistance types,” *Home Rowing Machine Reviews 2022*. [Online]. Available: https://www.rowingmachine-guide.com/types.html#:~:text=How%20Does%20Air%20Resistance%20Work,thus%20the%20greater%20the%20resistance. [Accessed: 02-Feb-2022].

Notes:

- Four main types of rowing machines which are classified by types of resistances used:
  - Air
  - Magnetic
  - Water/fluid
  - Hydraulic
- To exercise your muscles, you need to work against an opposing force that provides some resistance (would be applied by water in real boat)
- Air rowing machines
  - Most popular type
  - Have an internal flywheel that is connected by a chain to the rowing handle, which is pulled by the person on the rower
  - The faster you row, the faster the flywheel spins through the air, thus the greater the resistance
    - NOTE: possibly wouldn't have to add adjustable resistor then
  - Possible disadvantage: could be noisy for indoor use
- Water Rowing machines
  - Newer innovation
  - Use water paddles to create resistance
  - The faster you row, the greater the resistance
  - Have a very smooth, consistent resistance through the stroke
  - Disadvantage: tend to be a little bit bigger; would require a water tank
- Magnetic Rowing Machines
  - More popular for use in a home
  - Resistance mechanism makes them the most quiet and they are more compact
- Hydraulic Rowing Machines
  - Smaller and quieter than flywheel rowers
  - Don't have a smooth, flowing feel of a flywheel machine
  - Require regular maintenance

Conclusions/action items:

The four different types of rowing machines are categorized by their types of resistance. They include air, water, magnetic, and hydraulic rowing machines. Currently, Air rowing machines appear to be the most popular and widely used type of rowing machine. They contain an internal flywheel that provides the resistive force for the person who is rowing. For our project, we will likely incorporate a flywheel into our rower to provide the resistance for the user.

Action items: Go to BSAC meeting. Meet with client today (Friday) at 3 PM to ask questions. Continue with background research.

2/8/22 Lifetime of Rowing Machine

SAMUEL SKIRPAN - Feb 08, 2022, 9:13 PM CST

Title: Lifetime of Rowing Machine

Date: 2/8/22

Content by: Sam

Present: Sam

Goals: Determine the lifetime of a rowing machine.

Content:

Article:

Citation: “How long will a concept 2 rowing machine last?,” *Rowing Machine 101*, 16-Oct-2020. [Online]. Available: http://rowingmachine101.com/concept-2-rowing-machine-lifespan/. [Accessed: 09-Feb-2022].

Notes:

- Rowing machines are categorized for duration either by number of years or number of meters rowed
- Rowing machines can last from 10-25 years or around 8 million meters rowed
    - There have been people who have hit 40 million meters rowed
- Magnetic machines typically last longer than air resistance machines

Conclusions/action items:

Rowing machines last a long time (almost 10-25 years). For our device, our adjustments should last just as long as the rowing machine does. Since there is not a standard for how many meters are rowed in a year, we will probably use the 10 year mark for our PDS.

Action items: edit PDS.

4/10/22 Research on Wheelchair User Population

SAMUEL SKIRPAN - Apr 10, 2022, 12:47 PM CDT

Title: Research on Wheelchair User Population

Date: 4/10/22

Content by: Sam

Present: Sam

Goals: Research and quantify the number of wheelchair users in the US to help determine the impact of our product.

Content:

Article: Wheeled Mobility

Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4397418/#:~:text=There%20are%20currently%20about%202.7,and%20increasing%20longevity%20%5B3%5D.

Citation: A. M. Koontz, D. Ding, Y.-K. Jan, S. de Groot, and A. Hansen, “Wheeled mobility,” *BioMed research international*, 01-Apr-2015. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4397418/#:~:text=There%20are%20currently%20about%202.7,and%20increasing%20longevity%20%5B3%5D. [Accessed: 10-Apr-2022].

Notes:

- Independence in mobility is a huge determinant of quality of life for individuals with disabilities
- Currently 2.7 million wheelchair users in the US
  - NOTE: can use this to quantify population
- The powered and manual mobility market is expected to grow globally at an exponential rate due to aging baby boomers and increasing longevity

Article: North America Wheelchair Market Report 2021

Link: https://www.businesswire.com/news/home/20210813005309/en/North-America-Wheelchair-Market-Report-2021---ResearchAndMarkets.com

Citation: “North America Wheelchair market report 2021 - researchandmarkets.com,” *Business Wire*, 13-Aug-2021. [Online]. Available: https://www.businesswire.com/news/home/20210813005309/en/North-America-Wheelchair-Market-Report-2021---ResearchAndMarkets.com. [Accessed: 10-Apr-2022].

Notes:

- This article said that as of 2016, there were 3.3 million wheelchair users in the US
- Around 1.825 million of these users are 65 years of age or older

Conclusions/action items:

With the research I completed, we can estimate the population of wheelchair users in the US to be around 2.7 to 3.3 million people. The number in 2022 is likely greater than 3.3 million since the market for wheelchair users is apparently growing every year. We can use these numbers for our project to help show the impact of our product for users and show how important our product will be since the number of wheelchair users is increasing every year.

Action items: meet with team to discuss fabrication of base.

4/10/22 Need for Upper Body Exercise for Wheelchair Users Research

SAMUEL SKIRPAN - Apr 10, 2022, 1:10 PM CDT

Title: Need for Upper Body Exercise for Wheelchair Users Research

Date: 4/10/22

Content by: Sam

Present: Sam

Goals: Determine why our product is needed by wheelchair users and how it will help them with their upper body strength. Complete research to determine impact our product could have on upper body musculature.

Content:

Article: The Health Benefits and Constraints of Exercise Therapy for Wheelchair Users

Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5594262/

Citation: T. J. Ellapen, H. V. Hammill, M. Swanepoel, and G. L. Strydom, “The health benefits and constraints of exercise therapy for wheelchair users: A clinical commentary,” *African journal of disability*, 08-Sep-2017. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5594262/. [Accessed: 10-Apr-2022].

Notes:

- Wheelchair users can have poor cardiometabolic risk profiles because of a lack of physical activity, limiting their quality of life, characterized by low self-esteem, social isolation, and depression
- They can sustain upper limb overuse injuries
    - The primary cause of these injuries is attributed to poor wheelchair propulsion related to incorrect chair setup and poor cardiorespiratory fitness
        - BIG: our product could help improve their cardiorespiratory fitness since we are now making it easy for them to use a rowing machine
- Wheelchairs limit the users' involvement in physical activity and exercise
- It is difficult for wheelchair users to maintain their body fat and body mass index levels within normative values
    - These are usually elevated compared to normal levels
    - These elevated levels lead to increased chances of having obesity, diabetes mellitus, hypertension, osteoporosis and osteoarthritis
- The physically inactive lifestyle of wheelchair users decreases their basal metabolic rate, and increase their insulin resistance as well as their glucose sensitivity
- By engaging in a physically active lifestyle, wheelchair users can increase their energy expenditure, thereby decreasing body fat and BME, which will positively influence their cardiometabolic profile
- Also, regular exercise and physcial activity can diminish muscular and neuropathic pain, thereby improving quality of life

Conclusions/action items:

This article was fantastic in terms of talking about how our device could make such a positive impact on the lives of wheelchair users. Many times, wheelchair users can sustain upper body overuse injuries because they are not used to having to use their upper limbs all the time to move around. Our device could help them with this by allowing them to train their upper body muscles so that they are more prepared for the continual use. Additionally, the lifestyle of wheelchair users is typically not as healthy as non-wheelchair users. They tend to have increased fat levels and BMI's and be at an increased risk for many diseases and problems. However, if they were more physically active, they could reduce their risk for developing a number of problems. BIG: Our device could help remove a barrier for them to exercise since our device makes exercise equipment more accessible!

Action items: meet with team to discuss fabrication of base.

2/14/22 Foldable Concept

SAMUEL SKIRPAN - Feb 14, 2022, 1:21 PM CST

Title: Foldable Concept

Date: 2/14/22

Content by: Sam

Present: Sam

Goals: Enter foldable concept idea into notebook

Content:

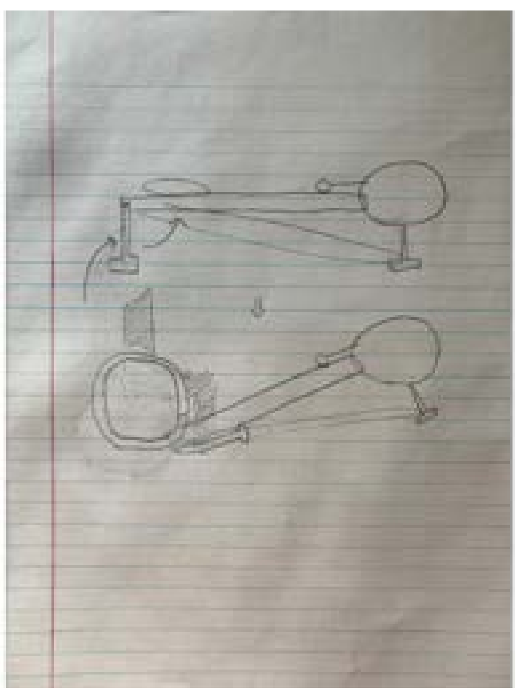
- Note: the pdf of the idea is attached to this entry
- This idea takes the base model for the rower and makes the hind support foldable
    - This would allow for the seat shaft to be folded downward, allowing for the wheel chair user to wheel their chair up "into" the rower
- In the picture, the back support folds forward, which allows for the shaft to bend downward and rest against the floor
- The handle is still in the same position, so this idea doesn't solve that problem
- Main benefit: allows wheelchair to get closer the handle and not just be resting behind the base model
- This idea would also allow for the rower to be interchangeable between normal rowing and rowing for something in a wheel chair

Conclusions/action items:

I came up with an idea that would allow for the wheelchair to be easily scooted up right behind the rower. It features a collapsable hind support that folds inwards so that the seat shaft could bend downwards and make room for the wheelchair to get closer to the handle.

Action items: Share this idea with the team today. Complete design matrix. Continue brainstorming ideas.

SAMUEL SKIRPAN - Feb 14, 2022, 1:22 PM CST



Download

Foldable_idea.pdf (18.3 MB)

2/20/22 Double P Idea

SAMUEL SKIRPAN - Feb 20, 2022, 9:59 AM CST

Title: Double P Idea

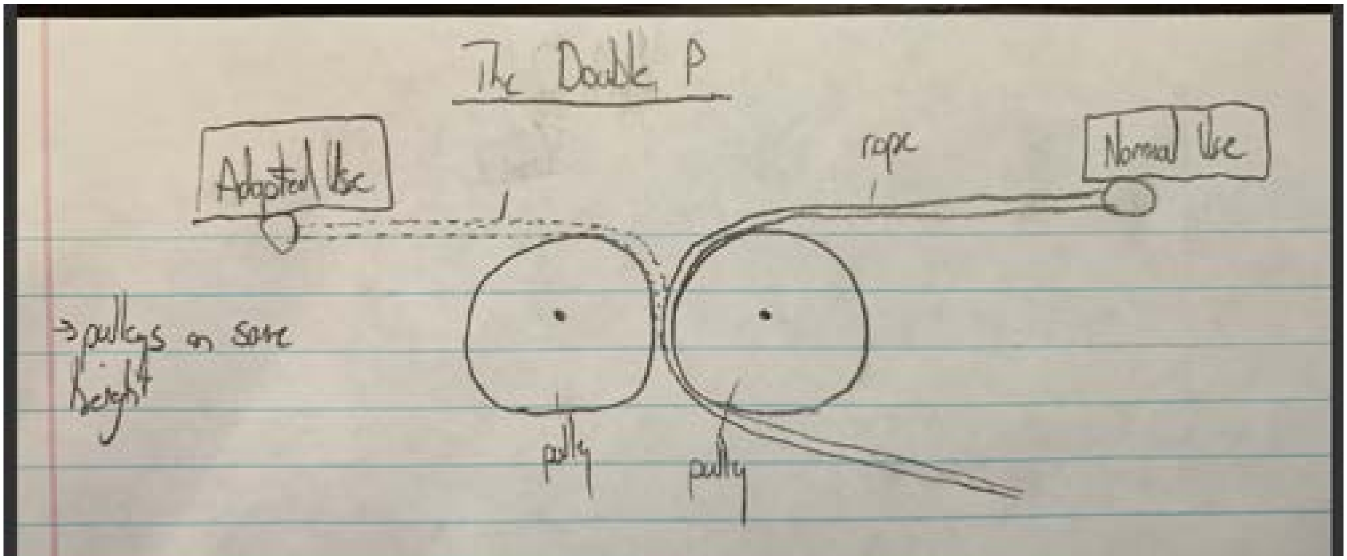
Date: 2/20/22

Content by: Sam

Present: Sam

Goals: Put Double P design idea into notebook.

Content:

- 

    - This is a picture of the Double P design idea
- This design consists of a two pulley system that allows for the rope attached to the handle to be used on both sides of the rowing machine
    - If the wheelchair user is scooted up behind the rower and secured 180 degrees to the original seat bar, they will now be able to use the handle from that side since the rope will be guided by the second pulley over to them
        - This will prevent the rope from rubbing on the other materials and parts of the frame of the rower
- This two pulley concept is similar to what they use for many lifting machines and it allows for certain machines to be used in opposite directions (pulling from opposite sides but still getting resistance activation)
- The pulleys would be placed on the same height

Conclusions/action items:

This is the Double P design and it focused on redirecting the rope over to the 180 degree side of the machine. The pulleys will be placed on the same level and will redirect the forces of the rope from one side to the next, which allows for both regular and adaptive use of the rower. This concept is very similar to what many weight lifting machines use to redirect cables in opposite directions. Our team plans to use some sort of 2 pulley design, but this is the concept that I came up with.

Action items: Divide up sections of the presentation. Meeting to talk over designs and design matrix.

2/20/22 Console Arm Cut

SAMUEL SKIRPAN - Feb 20, 2022, 10:06 AM CST

Title: Console Arm Cut

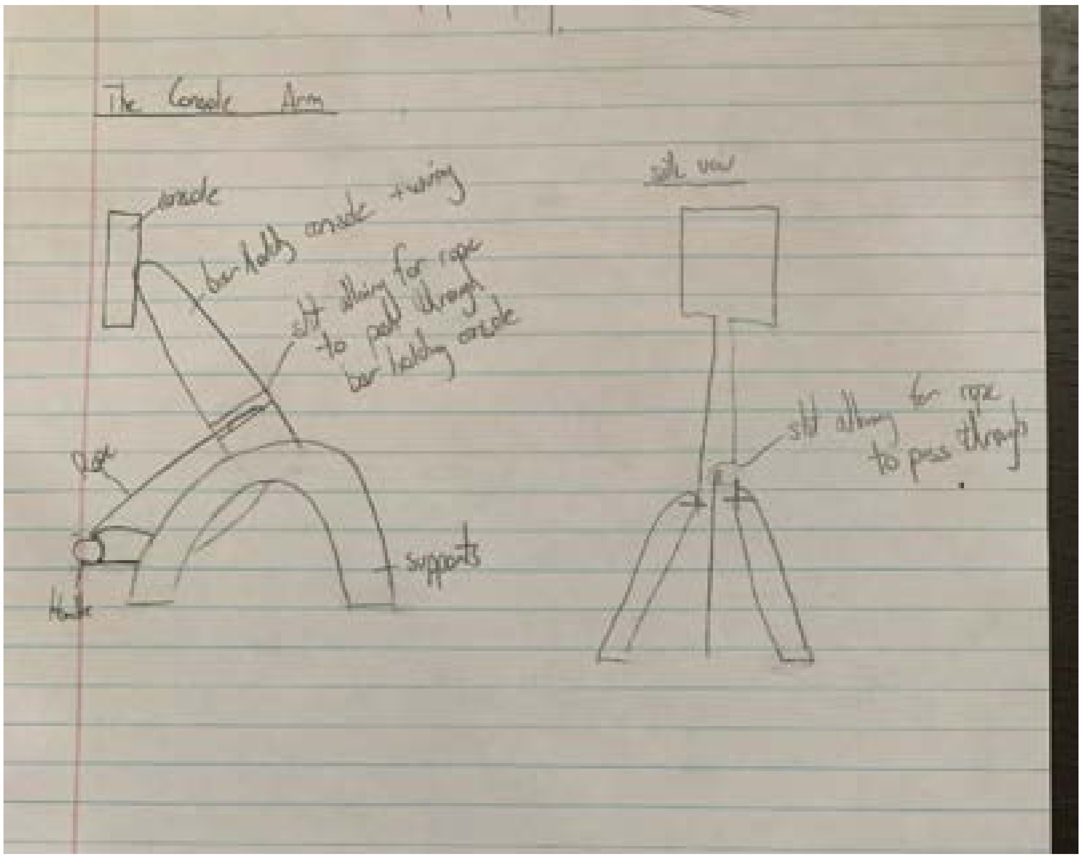
Date: 2/20/22

Content by: Sam

Present: Sam

Goals: Put Console Arm Cut Idea into the notebook.

Content:

- 

    - This is a picture of the console arm cut idea
- The main concept for this design is that we would make a small sliver cut in the console arm of the rowing machine in order to allow for the rope to be switched from its normal position to a position that is on the opposite side of the rower
    - The sliver cut in the arm would allow for the rope to pass from one side to the next
- Note: This is just a singular idea that I had (we aren't going to make a design matrix for this because we are all expecting it to happen)
- This cut still makes the console arm structurally sound to hold the console, but we are taking away one side of the arm now in order to feed the rope through

Conclusions/action items:

The Console Arm Cut idea will allow for the rope to switch from one side of the rower to the other side. Originally, we would not have been able to pass the rope from one side to the next without making a cut, so this will allow for that (and thus all of our other ideas). We need to make sure that the structural integrity of the console arm is not modified too drastically such that it would possibly fail.

Action items: Meet with team to do design matrix. Split up sections for preliminary presentation.

2/20/22 Wheel Chair Locker / Bike Rack Locker

SAMUEL SKIRPAN - Feb 20, 2022, 10:33 AM CST

Title: Wheel Chair Locker / Bike Rack Locker

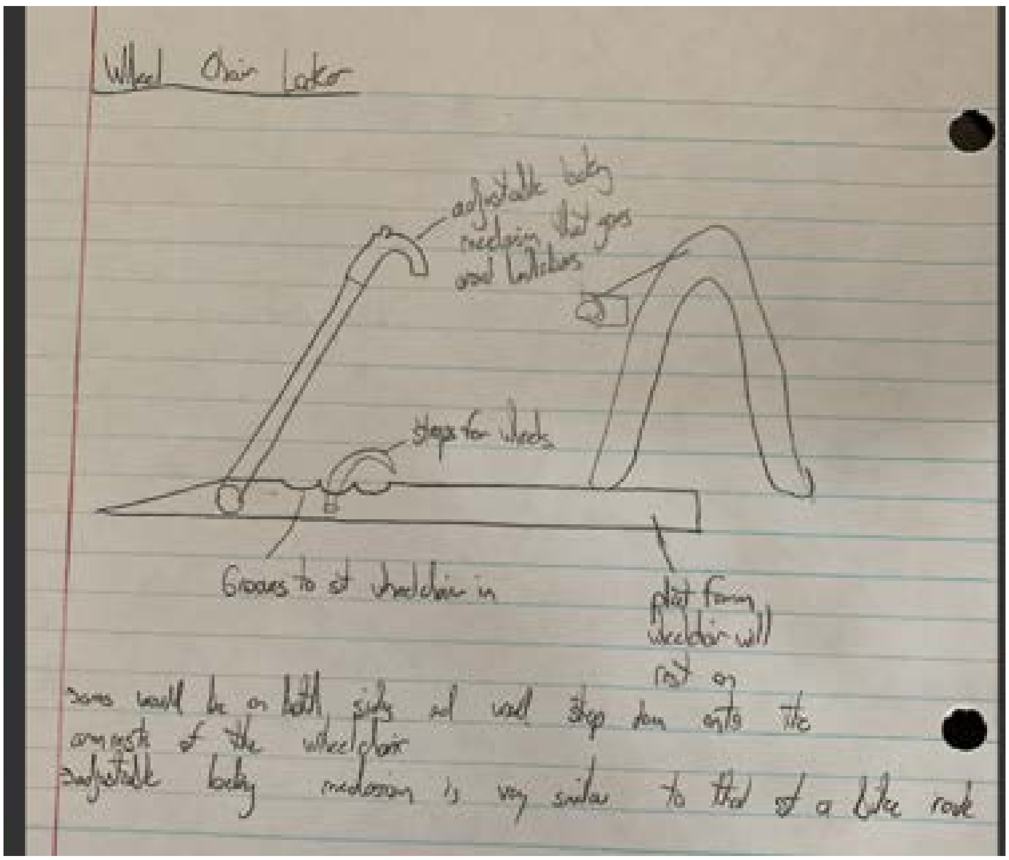
Date: 2/20/22

Content by: Sam

Present: Sam

Goals: Enter wheelchair locker idea into notebook.

Content:

- 

    - This is a picture of the wheel chair locker design idea
- The main concept behind this idea is that you have two arms on each side of the platform the wheelchair will be wheeled up onto that will lock on to the arm rests of the wheel chair
    - These arms will stop the wheelchair from going backwards and from tipping over backwards
- The mechanism of adjustment for these arms is very similar to how a bike rack works on the back of a car
    - The arms are adjustable and can be secured down onto the arms of the wheelchair by the user
- There also would be straps on the platform that lock the wheels into place so that they cannot rotate

Conclusions/action items:

The wheel chair locker idea would prevent the wheelchair from tipping over backwards or rolling backwards. There would be two arms, one on each side of the platform, that would attach to the arm rests of the wheelchair and would lock it in place from rolling backwards. There would also be straps on the platform that would lock the wheels in place.

Action items: Share this design with the team. Make the design matrix. Work on Prelim Presentation.

5/2/22 Review of Josh's FBD

SAMUEL SKIRPAN - May 02, 2022, 9:40 PM CDT

Title: Review of Josh's FBD

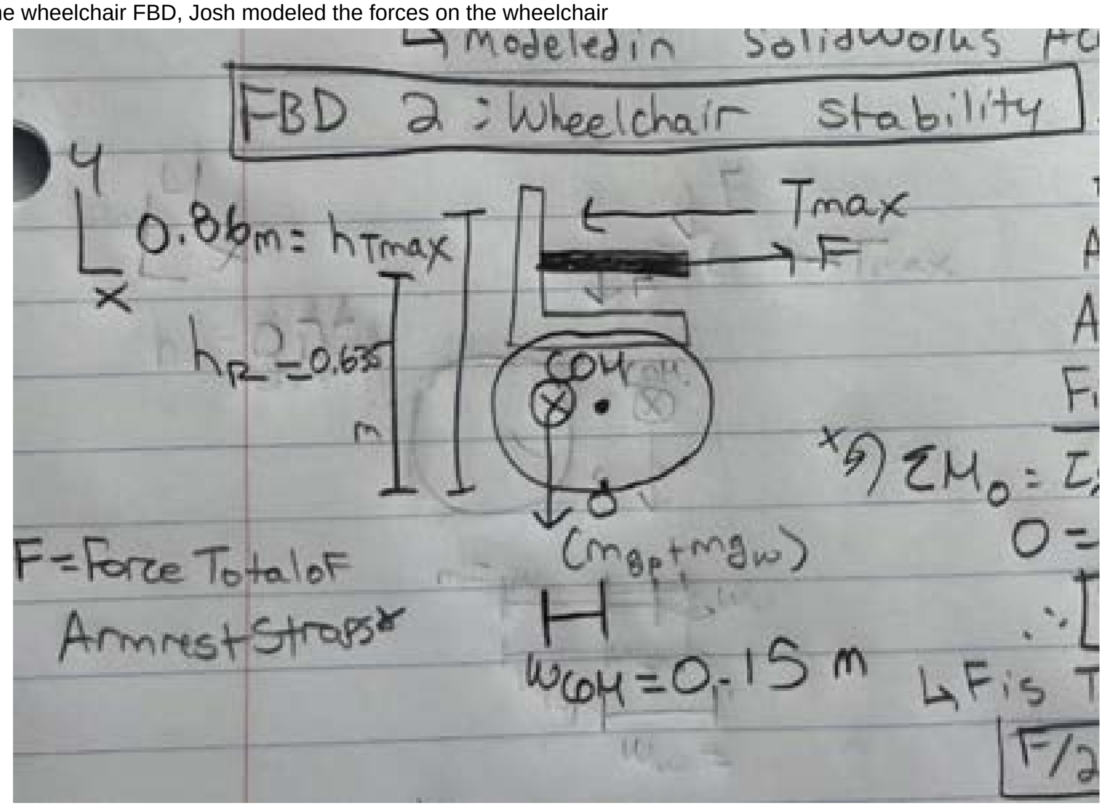
Date: 5/2/22

Content by: Sam - Review of Josh

Present: Sam

Goals: Review Josh's final FBD.

Content:

- Josh created an FBD of the pulley system to see what the reactions would be in the pulley support plates under worst scenario of 1050 N tension in the rope
    - The vertical and horizontal reaction forces would be equal to the 1050 N force, which means that the pulley bearing support plates must be able to support the max tension developed in the rope
- For the wheelchair FBD, Josh modeled the forces on the wheelchair
    - 

        - This is the picture of Josh's FBD that he made for the wheelchair
    - With a max tension force of 1050 N backwards
    - This FBD assumes that the user is 80 kg and that the wheelchair would be 30 kg max
    - With zero tipping, the rotational acceleration would be equal to zero
    - With the solving of the moment equation, we find out that the straps would need to give a total forward reaction force of 1676 N, so each strap would need to support 840 N at the worst case scenario
        - This means that we will need to test to see if the straps will be able to support this force

Conclusions/action items:

The FBD of the pulley indicates how strong the material needs to be to support the max 1050 N load for tension. The testing will determine whether or not the tough PLA is strong enough for this use. Additionally, for the wheelchair FBD, the straps need to be able to support a load of 840 N, which will be tested.

2021/03/9 Biosafety Training Documentation

SAMUEL SKIRPAN - Mar 09, 2021, 9:31 AM CST

Title: Biosafety Training Documentation

Date: 3/9/21

Content by: Sam

Present: Self

Goals: Place Biosafety Training documentation in lab notebook.

Content:

See pdf attached below for Biosafety Training documentation.

Conclusions/action items:

I took the Biosafety training course and passes. This document (attached below) will give me access to working in the lab with Bio-hazardous materials in the future if need be for a design project. I will need to get re-certified every 5 years for this training.

SAMUEL SKIRPAN - Mar 09, 2021, 9:31 AM CST


University of Wisconsin-Madison

Download

PDF_OF_BIO_SAFETY_TRAINING_VERIFICATION.pdf (78.3 kB)

2021/03/9 Chemical Safety Training Documentation

SAMUEL SKIRPAN - Mar 09, 2021, 12:38 PM CST

Title: Chemical Safety Training Documentation

Date: 3/9/21

Content by: Sam

Present: Self

Goals: Place Chemical Safety Training documentation in lab notebook.

Content:

See pdf attached below for Chemical Safety Training documentation.

Conclusions/action items:

I took the Chemical Safety training course and passes. This document (attached below) will give me access to working in the lab with different types of chemicals in a safe way in the future if need be for a design project.

SAMUEL SKIRPAN - Mar 09, 2021, 12:39 PM CST

University of Wisconsin-Madison

Download

CHEMICAL_SAFETY_TRAINING_VERIFICATION.pdf (84.7 kB)

3/19/2022 WARF Lecture

SAMUEL SKIRPAN - Mar 19, 2022, 4:13 PM CDT

Title: WARF Lecture

Date: 3/19/22

Content by: Sam

Present: Sam

Goals: Take notes on WARF lecture.

Content:

Notes:

- WARF created to manage intellectual property
- Mission: support scientific research within the UW-Madison community by providing financial support, actively managing assets, and moving innovation
- Cycle of innovation:
    - UW Research and discovery, then IP protection, then licensing and startups, then funding to support research and discovery, then start over
- Annual grant: $85 million in 2018, over $3 billion cumulative to UW
- Protecting Innovation:
    - Patents: machines and devices, compounds, processes and methods, improvement
    - Trademarks: words and phrases, colors, pictures or logos, sound
    - Copyrights: literary works, webpages, software programs
- Prior art:
    - Defn: "references" created before a specific date
        - By the inventor: greater than 1 year before the filing date of the patent application
        - By another: before the filing date of the patent application
    - The novelty and non-obviousness are evaluated based on the prior art
    - Internationally, absolute novelty is typically required
- Examples of typical public disclosures of an invention
    - Journal publication (often available online before printing)
    - Talk or poster at conference / professional meeting
        - NOTE: This is what ours would be like for our project
    - Non-confidential department seminar
- Requirements for Patentability:
    - Is it new, is it obvious, and is it eligible for patenting?
    - Has to be non-obvious
- It takes around 3-5 years for patent to actually be processed
- Patent Process:
    - Invent / discover / fill out invention disclosure report
    - Disclosure committee meets to review new disclosures
    - Patent application drafting, filing, and prosecution
    - Technology marketing
    - Licensing
- A license is a contract that you enter into within a company allowing them to use your project
- WARF's Accelerator Program
    - Milestone-based validation funding to speed promising technologies to a commercial license
- Finding a licensee
    - Very common for inventor to have contacts
- Factors to consider for a startup
    - Technology, market, management, and capital requirements

Conclusions/action items:

Our design may have intellectual property / be non-obvious due to the fact that we place the wheelchair and user on the opposite side of the rower rather than on the traditional side. Most of the existing inventions on the market today include the user being on the same side as the seat bar, so our design may be eligible for patenting due to this "unique" factor.

2/23/22 Work On Prelim Presentation

SAMUEL SKIRPAN - Feb 23, 2022, 10:02 AM CST

Title: Work On Prelim Presentation

Date: 2/23/22

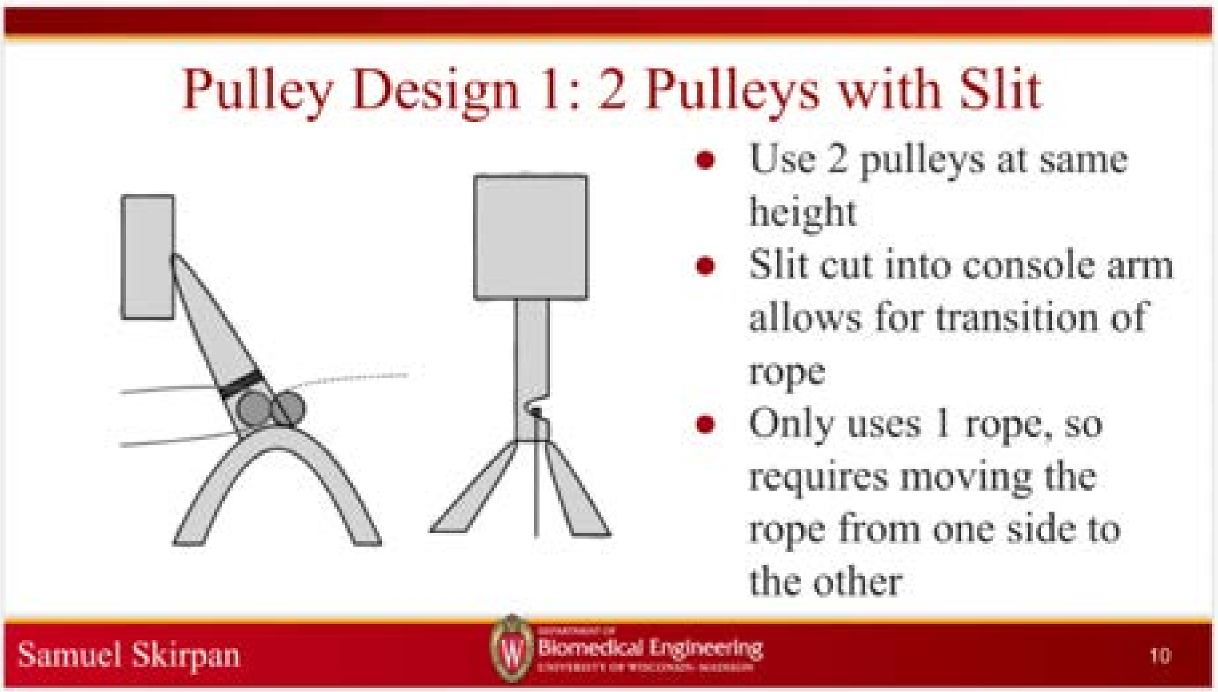
Content by: Sam

Present: Sam

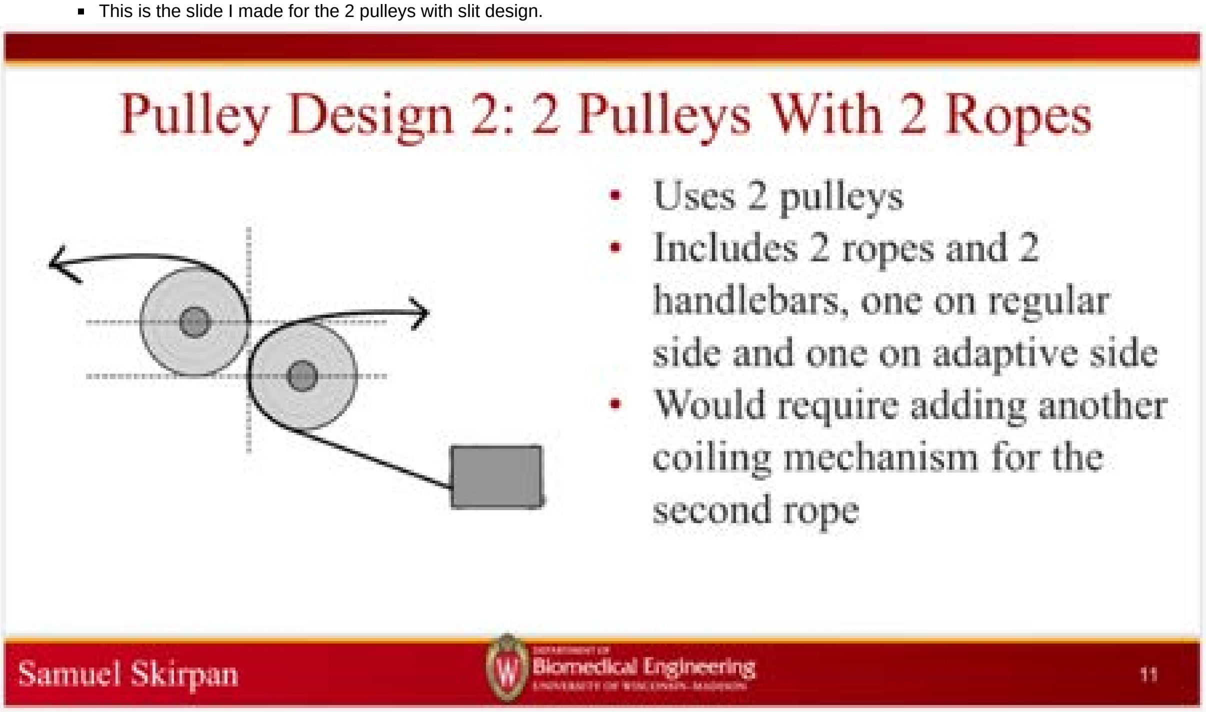
Goals: Enter my work from prelim presentation into notebook.

Content:

- I worked on 4 slides for the preliminary presentation:
  - 1 about each design (2)
  - 1 for design criteria
  - 1 for design matrix for pulleys
- First design



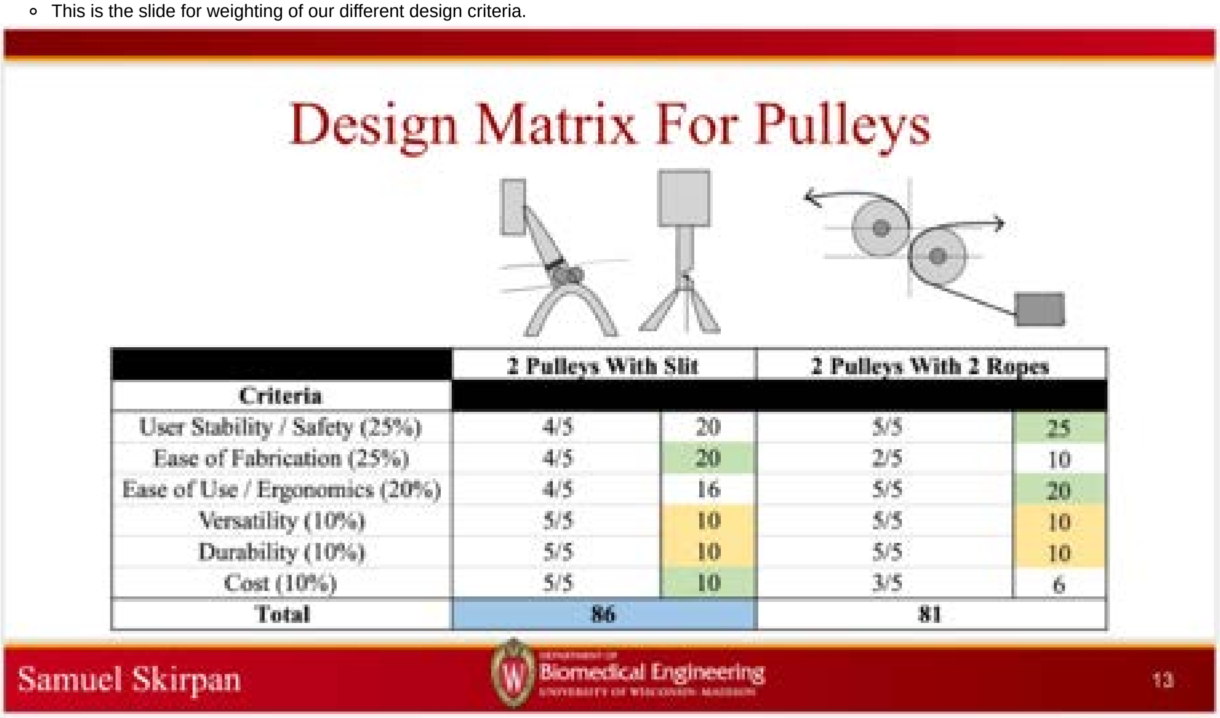
  - This is the slide I made for the 2 pulleys with slit design.



-

- This is the slide I made for the 2 pulleys 2 ropes design.

- This is the slide for weighting of our different design criteria.



Criteria	2 Pulleys With Slit		2 Pulleys With 2 Ropes	
User Stability / Safety (25%)	4/5	20	5/5	25
Ease of Fabrication (25%)	4/5	20	2/5	10
Ease of Use / Ergonomics (20%)	4/5	16	5/5	20
Versatility (10%)	5/5	10	5/5	10
Durability (10%)	5/5	10	5/5	10
Cost (10%)	5/5	10	3/5	6
Total	86		81	

- Finally, this is the slide for the design matrix and comparing both pulley designs.
- Script:
  - I also wrote out a little blurb on what I plan to say for the design presentation.
  - Thanks Tim. Getting into our design ideas, we first compared the pulley mechanisms we will use for our project and then the stability mechanism we will use. Another note: we have already decided to have the wheelchair user be aligned 180 degrees to the where the traditional sliding seat bar is, so all of our designs are based on that concept. Our first pulley design is called the 2 pulleys with slit. The main idea behind this design is that it adds on an additional pulley to the existing machine that would allow for the rope and handle to be transitioned from the normal rowing position to the adaptive position. For this design, a slit cut would need to be made on the console arm to allow for the rope to be moved from one side to the other. The key concept behind this idea is that it uses the original rope and handle from the rower.

    The second pulley mechanism is called the 2 pulleys with 2 ropes. Just like the other design, it also uses 2 pulleys. The key difference is that this design would involve adding in an additional rope and handle on the adaptive side of the rowing machine so that the handle would not need to be transitioned from one side to the other while switching from traditional to adaptive use. The downside of this concept is that adding another rope would be more complicated due to having to also attach another coiling mechanism for the second rope.

As for criteria for comparing both pulley ideas, we have user stability and safety weighted highest along with ease of fabrication, then ease of use and ergonomics, versatility meaning how easy it is to stitch from traditional to adaptive form, durability, and cost with the lowest weighting.

We then compared and scored the designs based on these criteria. Both designs ended up scoring very similarly in most categories, but the large differentiator came in for ease of fabrication. Even though the additional rope for the 2 pulleys with 2 ropes design would make the ease of use higher, it would be a lot more difficult to fabricate since we would have to create an additional recoiling system for the new rope and figure out a way to keep the other rope from unraveling during use of the opposite side. Overall, the 2 pulleys with slit design totaled the highest score, so we plan on moving forward with this concept.

Now I will pass it off to josh to talk about our stability designs.

Conclusions/action items:

I completed 4 slides for the prelim presentation for this Friday. They were mainly on the pulley mechanism we plan to use for our design. I also wrote out a little script/blurb on the general ideas I want to convey for the presentation.

Action items: meet with team to practice presentation. Present on Friday!

2/26/22 FBDs for Forces and Moments on Final Prelim Design

SAMUEL SKIRPAN - Feb 26, 2022, 1:42 PM CST

Title: FBDs for Forces and Moments on Final Prelim Design

Date: 2/26/22

Content by: Sam

Present: Sam

Goals: Enter FBDs for prelim design into notebook.

Content:

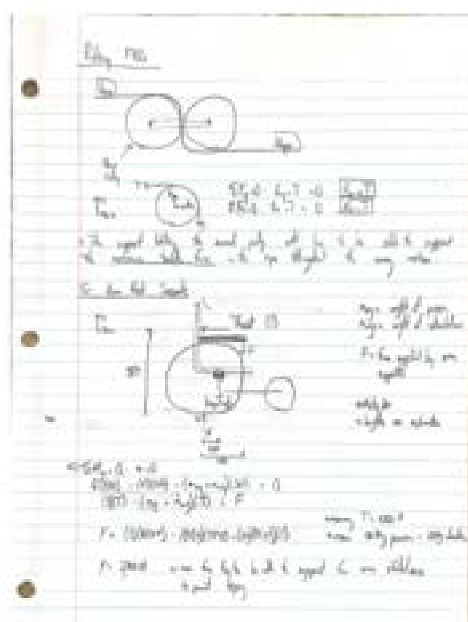
- In order to see what forces and moments would be required by our design to be feasible, I created some FBDs to calculate forces
- We need to check to see what force would be applied to the bar holding the second pulley and the force needed for the arm support bars to stop tipping
- My calculations are in the PDF below and they show my work.
- Summary:
    - The force in the support for the pulley would be as high as the maximum tensile force in the rope during the rowing motion
        - We must choose a material that would be able to hold a tensile force of 1050 N
    - The force that the arm support bar at the base would need to support would be a 2700 N tensile force
        - This would prevent tipping from occurring

Conclusions/action items:

I created some FBDs to see the maximum forces that would be instilled in the pulley support bar and the arm support stabilizer at the base of our design. With these calculations I came up with, we need to choose materials that would support these physical characteristics.

Action items: I will check these calculations with the team and see what they got. Work on preliminary report with team and edit it.

SAMUEL SKIRPAN - Feb 26, 2022, 1:43 PM CST



Download

FBDs_for_301_Notebook.pdf (459 kB)

2/28/22 Thoughts on Preliminary Design

SAMUEL SKIRPAN - Feb 28, 2022, 9:38 AM CST

Title: Thoughts on Preliminary Design

Date: 2/28/22

Content by: Sam

Present: Sam

Goals: Enter my thoughts about preliminary design into notebook.

Content:

- After completing preliminary presentations and finally choosing our preliminary design, I am confident in the designs we hav chosen to move forward with
    - The 2 Pulleys with Slit design will be an easy was of allowing for the rope and handle to transition from one side to the other with use of little outside assistance
        - The only hard part of this design will be cutting a slit in the console arm
        - We also need to consider the metal we will use to actually attach the pulley and the actual location of the pulley in comparison to the console arm
    - We also will need to consider a way to hold the handle on the other side of the rowing machine from the sliding seat bar
    - The Highway Ridges design in tandem with the armrest supports will keep the wheelchair from tipping over during use on the rower
        - The mat will keep the wheelchair from translating backwards and the arm bars will keep rotation from occurring
        - The fabrication plan for the mat/base will either include buying a large chunk of metal and cutting away an incline and some ridges or welding together smaller parts to make the base
        - The arm bars will be attached to the base and will likely be made out of steel and something adjustable on the top to accommodate different sized wheelchairs
        - I am confident that we may be able to start fabricating the base after spring break if we are able to complete some CAD files in Solidworks

Conclusions/action items:

The preliminary designs that we have right now need to be designed into CAD files. Once that occurs, we can start fabricating the designs and incorporating them into the adaptive rowing machine. It shouldn't be very difficult to create the pulley design, but the base design may take a little bit more work and be more intensive. My work with this team has been very smooth so far. I have really enjoyed working with everyone and the attitudes of everyone on this team.

Action items: Turn in report and notebook to canvas.

4/7/22 Taking off Console Arm

SAMUEL SKIRPAN - Apr 07, 2022, 10:07 AM CDT

Title: Taking off Console Arm

Date: 4/7/22

Content by: Sam

Present: Sam

Goals: Take the console arm off of the rowing machine so that we can send the part to Staci to be machined.

Content:

Yesterday, I went over to ECB to remove the console arm from the rowing machine.

The process took about 20 minutes because I had to remove many screws and take apart the monitor to remove the electrical cord first.

This picture above is one that I took of the rowing machine after removing the console arm. The rope is just resting along one side of the structure currently.

Conclusions/action items:

Yesterday, as Josh was 3D printing the two plates to hold the additional pulley, I went over to ECB to remove the console arm. This Friday, we are going to travel to JHT to give the part to Staci to be machined.

Action items: Meet to discuss fabrication of base / arms.

4/7/22 Work on Design of Base

SAMUEL SKIRPAN - Apr 07, 2022, 9:50 PM CDT

Title: Work on Design of Base

Date: 4/7/22

Content by: Sam

Present: Sam, Cate, Tim

Goals: Plan out how base of project will be fabricated.

Content:

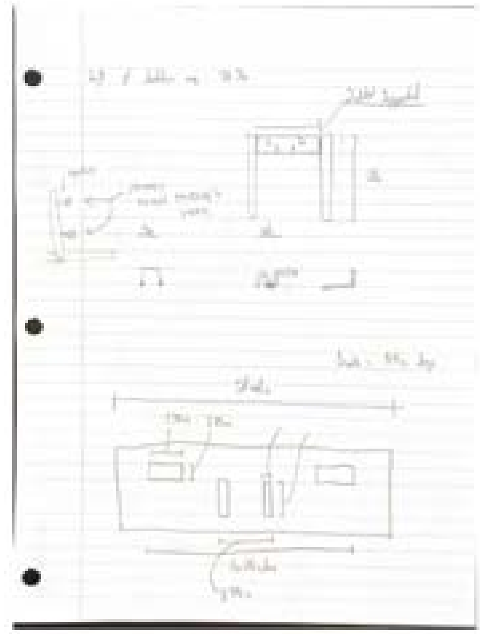
- Today, Cate, Tim, and I met to discuss the specifics of how we are going to fabricate the base of the adaptation to the rower
    - We made a big decision that we are no longer going to be creating a ramp, but instead just arm bars that secure the wheelchair a certain distance from the rowing machine
- We will be fabricating these arm supports out of wood
    - We have an 8 foot 2x4 and an 8 foot 2x6
- Today, we drew up some plans and took measurements for how we will cut up the wood to make the device
    - The picture of the plans are in the attached document
    - The plans are not drawn perfectly, but they give a good idea of how the device will look
- Plans:
    - Will have rower sitting in divots of wooden 2x6x26 in base
        - The supports of the rower will be in grooves, which will lock the base board in place and prevent it from moving
    - There will then be 2x6x20 inch boards that come out towards the wheelchair user that are perpendicular to one another that attach to the base board
    - Then, vertically, 2x4 planks will reach upwards and will be right at the outside of the arm rest of the wheel chair being used
    - Velcro will then be attached to the top of these upright 2x4 pieces that will attach to the arm rest of the wheelchair

Conclusions/action items:

Tim, Cate, and I were able to do some successful planning of how we will create the base today in ECB. Eventually, we will need to use a saw and cut the pieces of wood where we measured them and marked them. The goal is by next week to have the base fabricated, so that we can test in just under 2 weeks time.

Action items: meet this weekend to begin cutting and fabricating the base board arm rest plans.

SAMUEL SKIRPAN - Apr 07, 2022, 9:46 PM CDT



Download

Picture_of_Arm_Rest_Plan.pdf (474 kB)

4/10/22 Final Measurements of Wood

SAMUEL SKIRPAN - Apr 11, 2022, 10:31 PM CDT

Title: Final Measurements of Wood

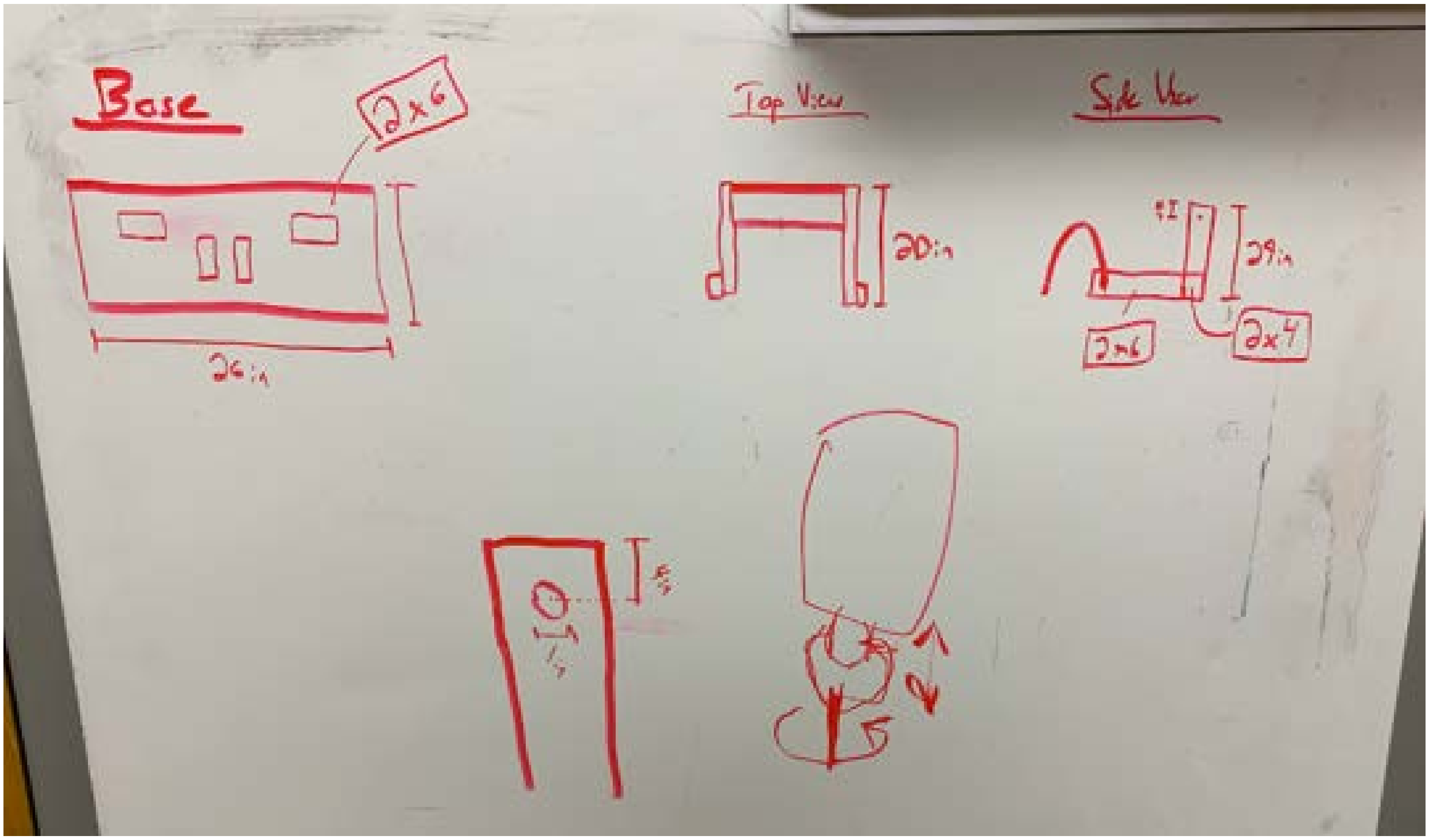
Date: 4/10/22

Content by: Sam

Present: Everyone

Goals: Make final measurements of wood and create plan for when we would meet to fabricate.

Content:



- These are the final dimensions of the wood we will be cutting on Monday (Dhruv and me)
- We will be making a 1 inch diameter hole to hold the straps and buckles that will attach to the wheelchair.
- For the Base in the top left, the divots / cuts on the inside would be between .25-.5 inches deep.

Conclusions/action items:

I double checked these measurements depicted in the picture on Sunday while the team was present. Dhruv and I will / did meet on Monday to make all of the cuts and the divots in the wood.

Action items: determine way for rotation of console.

4/11/22 Cutting of Wood and Drilling of Indentations

SAMUEL SKIRPAN - Ap

Title: Cutting of Wood and Drilling of Indentations

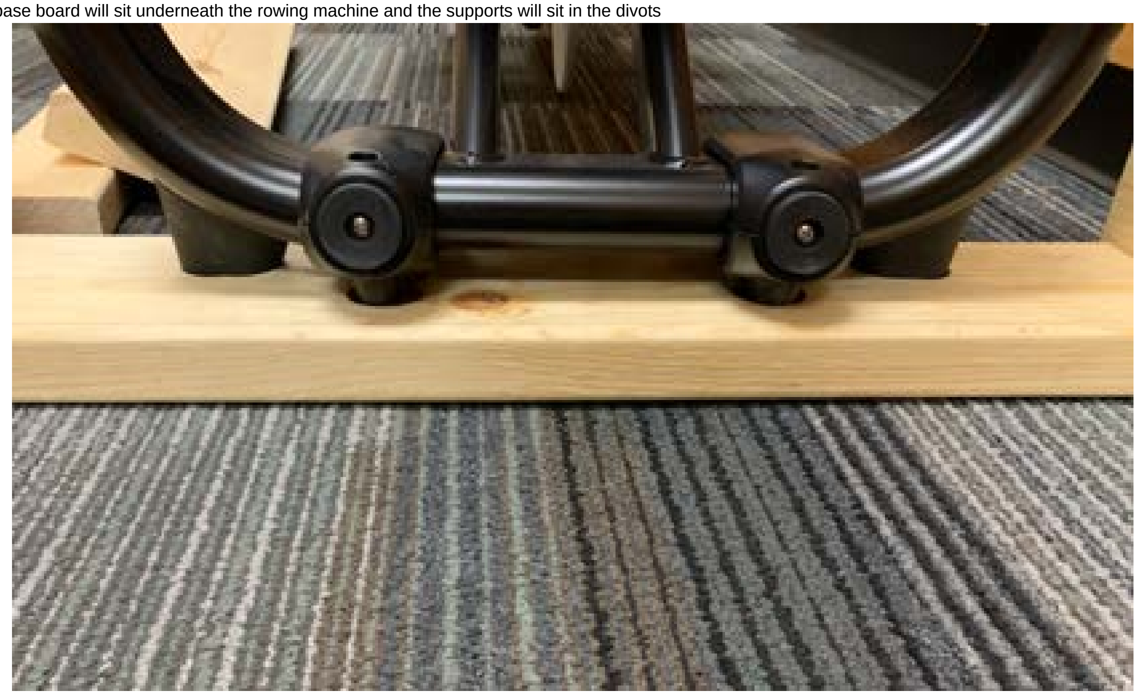
Date: 4/11/22

Content by: Sam

Present: Sam, Dhruv, Cate

Goals: Cut all of the wood pieces where we measured and also drill the divots for where the rower would be sitting.

Content:

- Today, Dhruv and I met and Cate watched for a little as we went to the TEAM lab to cut all of our pieces of wood
- We ended up using a very nice miter saw to cut our wood
    - All of the cuts we ended up making were very clean and smooth
- We also used a drill to make the divots in the base board
    - 
        - This is a picture of the wood lined up on the drill using clamps
            - The base board will sit underneath the rowing machine and the supports will sit in the divots
                - 
                    - This picture shows the supported resting in the indentations that Dhruv and I drilled out of the wooden base board
- Lastly, once we finished cutting, we lined a few of the boards up to see how they would fit and they ended up looking very nice and how we planned

- 
  - This picture is just of the base board and the two side boards that will stick out, but they lined up nicely and how we planned

Conclusions/action items:

Dhruv and I were able to make some nice progress today with the base by cutting all of the boards. I still need to go back on Wednesday to drill 2 more holes to allow for the straps to go throu too difficult. Additionally, Dhruv and I got a lot more comfortable working in the team lab and using the saw and drill, which was very nice. Cate and Tim will now meet later this week to actually and spray paint them.

4/18/22 Writing of Fabrication Protocol for Cutting the Boards

SAMUEL SKIRPAN - Apr 18, 2022, 10:50 PM CDT

Title: Writing of Fabrication Protocol for Cutting the Boards

Date: 4/18/22

Content by: Sam

Present: Sam

Goals: Write the fabrication protocol for the cutting of the boards and the drilling of the holes.

Content:

I spent the last 30-45 minutes writing a detailed fabrication protocol for the base board, the rest of the board cutting, and the making of the drill hole. I entered this into the team lab notebook under the fabrication section. There are some pictures that go along with the steps to show different measurements, etc.

Conclusions/action items:

Check Fabrication section of Team Activities for detailed fabrication steps of the cutting of the boards and the base board. Dhruv helped me out with this fabrication, but I wrote the detailed steps of the fabrication.

Action items: Meet with team to discuss testing and complete the testing.

4/19/2022 Putting Console Arm, Console, And Second Pulley on Rower

SAMUEL SKIRPAN - Apr 19, 2022, 9:09 PM CDT

Title: Putting Console Arm, Console, And Second Pulley on Rower

Date: 4/19/22

Content by: Sam

Present: Josh and Sam

Goals: Put the console, console arm, second pulley, and original pulley back on the rower.

Content:

- I met with Josh today at the rowing machine and we spent around 2 hours putting the console arm, pulley, second pulley, and console back onto the rower
- It took a long time because we wanted to make sure that we put all of the washers and screws in their correct places
    - It was also very difficult to put the console arm back on when we added the plates that hold on to the second pulley
    - There was one set of washers in particular that were very difficult to put into the right place, but we eventually were able to do it after many tries and using a pair of needle nose pliers
- We also sat in the wheelchair and made sure that the distance from the rower was the proper distance
    - It felt like a comfortable distance to row from
- Below are some pictures that I took of our work today:
    - 
        - This is a picture of how the rowing machine looks with the second pulley and console arm reattached. The base arm rest support boards are also lined up, but not all of them are connected.

- 
  - THIS PICTURE IS VERY EXCITING! We were able to get the console to turn around so that the person in the wheelchair is able to see the console while they are rowing. This picture also shows how the two plates align with the second pulley.

Conclusions/action items:

Overall, even though it took Josh and me a while to put the adaptations together, we were VERY EXCITED to see the progress that we made. I also tried rowing on the adapted form a couple of times, and it felt quite comfortable. We worked very hard to get to this point and we are excited to see what we have accomplished.

Action items: Address console arm and trying to make it tighter so that it doesn't swivel as much. Meet with team to discuss testing.

4/20/22 Cutting of Diagonal Supports and Making Console Arm Tighter

SAMUEL SKIRPAN - Apr 20, 2022, 5:59 PM CDT

Title: Cutting of Diagonal Supports and Making Console Arm Tighter

Date: 4/20/22

Content by: Sam

Present: Josh and Sam

Goals: Josh: Cut the diagonal wooden pieces down in the team lab. Sam: Use the drill to make the screw tighter that is holding the console arm in place.

Content:

- Today, Josh and I just met at ECB at the rowing machine to complete two tasks
- As Josh was down in the TEAMlab cutting and measuring the 45 degree angle cuts on the wooden supports, I use the drill that he checked out to make the screw for the console arm and pulley tighter
- After tightening the screw, the console arm now is much more resistive to move, which is a GOOD thing
    - It now will not flop to one side or the other, but now can remain at a fixed position unless otherwise moved
    - This is also similar to the way it was able to move originally, which is good.

Conclusions/action items:

Josh and I met today at the rowing machine to cut the last pieces of wood (Josh) and to tighten the rotation of the console arm (Sam). We were successful with our efforts and time and were very pleased with the results.

Action items: Tim will now attach the support piece to the side arm rest base with screws. We will meet as a team tomorrow to complete the testing.

4/22/22 Ideas for Testing and Thoughts on Testing

SAMUEL SKIRPAN - Apr 22, 2022, 9:48 AM CDT

Title: Ideas for Testing and Thoughts on Testing

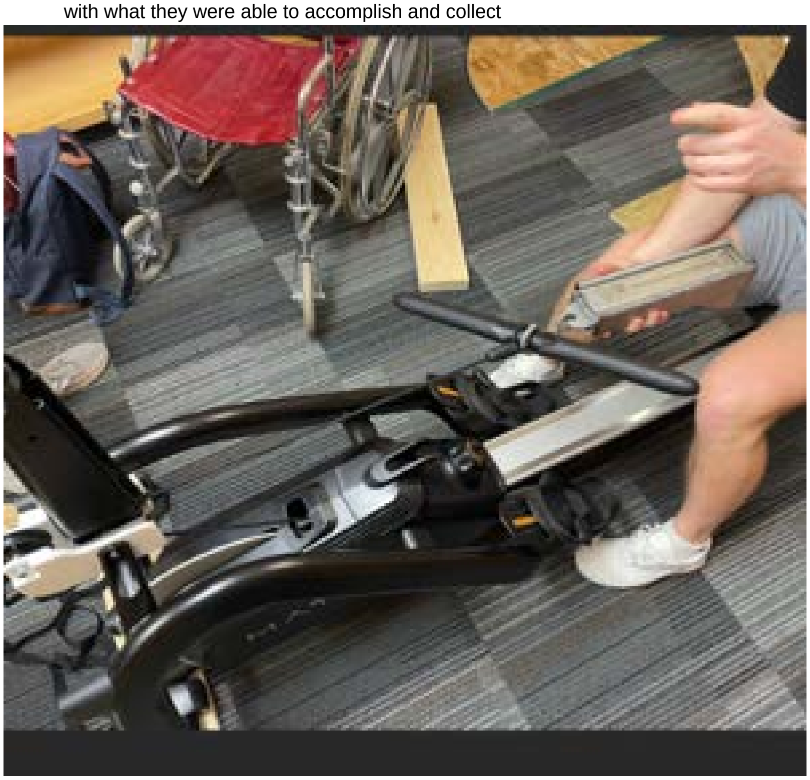
Date: 4/22/22

Content by: Sam

Present: Everyone

Goals: Record my ideas for testing into notebook. Also, talk about how I thought the testing process went.

Content:

- My ideas for testing:
  - Use the spring gauge and complete the rowing motion and record the maximum force encountered while doing the rowing motion
    - Complete this process on each side
  - Do this for resistance levels of 1, 5, and 10
  - To make sure that the same effort is being given for each repetition, try to keep the strokes per minute in the 20-25 range
    - This way, we have some consistency between trials and on both sides
- Thoughts on how testing process went:
  - I was really excited that we were able to be efficient and finish all of our testing in one day
  - I was the subject that our team used to complete the testing reps, so I also was able to get a little bit of a workout in yesterday when we tested
  - The holding of the spring gauge was a little awkward, but we figured out a way to make sure it was similar on both sides
  - When on the standard side, I was able to use my legs
    - This was not the case on the adapted side, so I was not able to output as much force on the adapted side
  - While testing on the adapted side, I held my legs up off of the ground so that I minimized the amount of contribution that I made with my leg muscles for stability and balance
  - Tim and Dhruv mainly were in charge of the stability testing and the use of Kinovea, but it seems like they were successful and pleased with what they were able to accomplish and collect
- 
  - This picture is showing the setup that we had with the spring gauge
    - It was attached to the middle of the handlebar with the hook on one end
    - I then held the other side and pulled that back during the rowing motion

- 
  - This is a fun team picture that we took when we were testing the stability of the arm rest supports.

Conclusions/action items:

Overall, I think testing went really well. We are now able to compare on each side the magnitudes of forces endured by the pulley system and see how the forces change from standard to adapted side. Also, we were able to see that the supports kept the wheelchair from tipping backwards, which is great since that was a client requirement.

Action items: Meet with Dr. P to show him our results. Start writing poster sections.

4/24/22 Work on Final Poster

SAMUEL SKIRPAN - Apr 24, 2022, 12:58 PM CDT

Title: Work on Final Poster

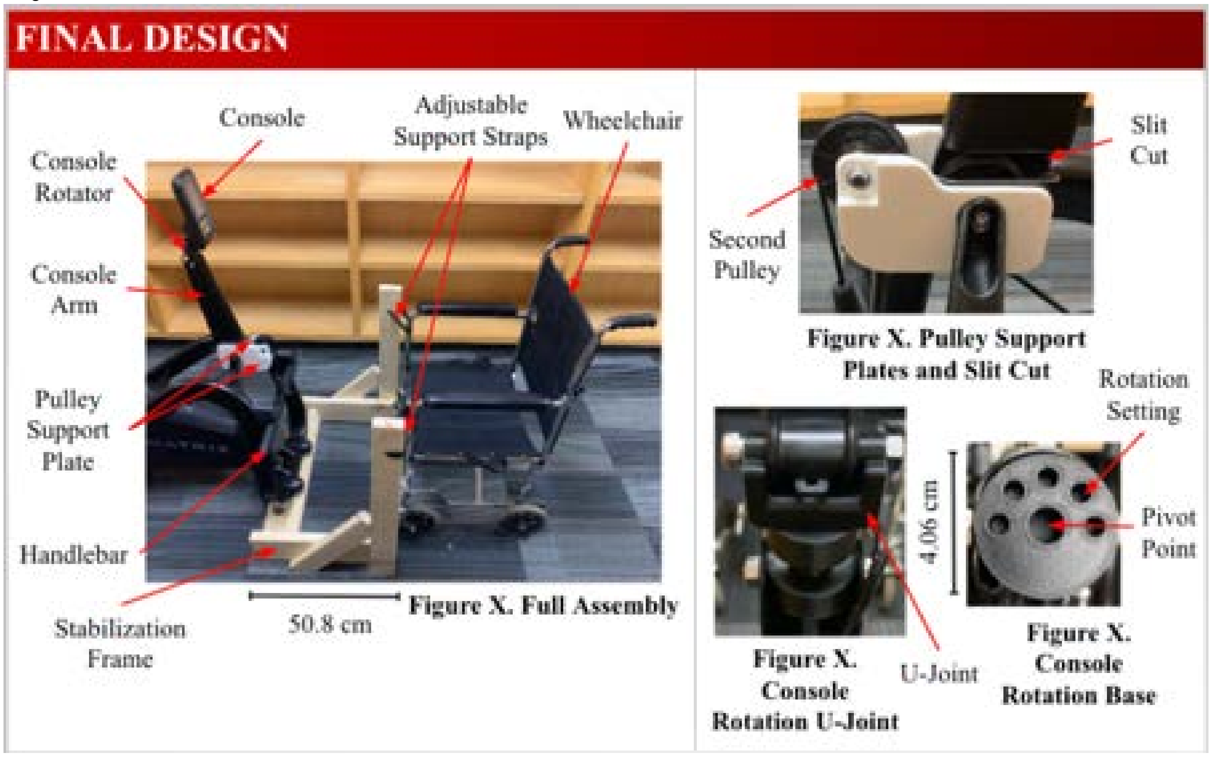
Date: 4/24/22

Content by: Sam

Present: Sam

Goals: Enter my work on final poster to lab notebook.

Content:

- For the poster, I was assigned the final design and future work sections
- Final Design:
    - 

        - This picture is the the slide/portion that I created for the final design section
            - I put a full assembly picture in and labeled the following:
                - Wheelchair
                - Console
                - Console Arm
                - Stabilization Frame
                - Handlebar
                - Pulley Support Plates
                - Console rotator
                - Adjustable support straps
                - I also put in a 50.8 cm scale to mark one of the base boards of the arm support base
            - I also thought it would be a good idea to see a little bit closer to the u-joint and the console rotation base
                - Put a 4.06 cm scale on this picture
            - Then one picture of the pulley plates and the slit cut
- Future work slide:

- Prototype Improvements
  - Fabricate the pulley support plates, console rotational mechanism, and arm rest support base out of steel.
  - Create a chest / abdomen support mechanism to prevent the user from sliding out of the wheelchair during use.
  - Fabricate a device that takes tension off of the rope and allows for easier transition of the handlebar from one side to the other.
  - Make the arm rest support base adjustable to allow for different sized users to use the rowing machine both safely and comfortably.
- Testing Improvements
  - Find wheelchair users to participate in testing.
  - For non-wheelchair users, use an EMG to monitor and limit the use of leg muscles by test subjects during the rowing experience.
  - Attach the handlebar to the strain gauge to most accurately replicate the standard rowing motion during testing.

- This picture is of the information I wrote for what we would plan to do in the future with this project. Read the specs of the picture for the information regarding prototype improvements and testing improvements.

Conclusions/action items:

For the poster, I was assigned the sections of final design and future work. For final design, I put in 4 total pictures and focused on the full assembly, the pulley support plates, and the console rotation device. I put arrows pointing to various parts of the design. For the future work section, I talked about testing improvements and prototype improvements. For the prototype, we would want to make our design adjustable for people of all different sizes and eventually make our device out of metal. For testing, we ideally would want to use wheelchair users to get the best data and possibly use an EMG for people that do have use of their lower extremities.

Action items: Meet with team to edit the poster. Present the poster next Friday. Start working on final report.

4/27/22 Script for Final Poster Future Work

SAMUEL SKIRPAN - Apr 27, 2022, 1:00 PM CDT

Title: Script for Final Poster Future Work

Date: 4/27/22

Content by: Sam

Present: Sam

Goals: Write script and thoughts I want to mention when we present our poster

Content:

- I was assigned the future work section for the poster, so I will speak on that section during presentations.
-
  Prototype Improvements:
  - Fabricate the pulley support plates, console rotational mechanism, and arm rest support base out of steel
  - Create a chest / abdomen support mechanism to prevent the user from sliding out of the wheelchair during use
  - Fabricate a device that takes tension off of the rope and allows for easier transition of the handlebar from one side to the other
  - Make the arm rest support base adjustable to allow for different sized users to use the rowing machine both safely and comfortably
  - Adapted side needs a component to hold the handle bar during rest

  Testing Improvements:
  - Find wheelchair users to participate in testing
  - For non-wheelchair users, use an EMG to monitor and limit the use of leg muscles by test subjects during rowing
  - Attach the handlebar to the spring gauge to more accurately replicate the standard rowing motion during testing

  User Survey:
  - Received feedback on the user stability, intuitiveness of the design, workout mechanics, and ease of use
  - Difficult to not use legs; transitioning the rope was feasible, but not from wheelchair; rowing mechanics felt similar to normal rowing

  - Here is a screenshot of what I will be talking about on the poster
- Script:
  - Thanks Dhruv! For future work, we will first start off with prototype improvements. Our main goal would be to fabricate the entire design out of steel to make every component more sturdy and durable. Additionally, to help support the user, we would plan on adding a chest support mechanism to the device to further stabilize the user during rowing. Since it can be a little tricky to transition the rope from one side to the other, we would plan on adding a device that takes the tension off of the rope, which will make it easier to move the handle from the standard side to the adapted side. To allow for our design to be more universal for users of varying sizes, we would plan on making the arm rest support base adjustable to fit different sized wheelchairs. Although the handle is able to rest on these supports on the adapted side, we would plan on making a mechanism that comes a little further out so that the handle is more secure on the rower when no one is using it.
  - In terms of testing improvements, it would be very ideal for us to have actual wheelchair users try out our design and give us feedback. Whenever users that are not physically impaired try using the device, it is very difficult to restrain from using your legs to balance and help with the rowing motion. Because of this, we would plan on using an EMG to track leg muscle activity for these users to limit their leg usage during testing. The last testing improvement we would plan on making would involve attaching the handlebar to the spring gauge during testing to most accurately replicate the motion of rowing.

- As part of our testing, we conducted a user survey for the participants that tried out our adapted rower. The survey focused on the stability, ergonomics, and intuitiveness of our design. The results showed that users thought the adapted rowing motion was similar to normal rowing and that they felt stable during the process. However, the majority of users agreed that it was slightly difficult to transition the rope from standard to adapted side along with not using their legs during the testing. With our testing and prototype improvements, these thoughts will be addressed in the future.
- Lastly, I would like to give a special thanks to Ms. Staci Quam, Johnson health tech, Dr. P, the TEAM lab, the Makerspace, and the entire UW Madison BME department for their guidance and help during this process.

Conclusions/action items:

This entry just has my script for what I plan on saying during the poster presentation. Right now, it looks pretty long, but I will be able to cut it down and get it under 2 minutes. I will be speaking on both the future work and acknowledgements.

Action items: meet with team to practice poster presentation.

4/30/22 Figures for Fabrication of Wooden Base

SAMUEL SKIRPAN - Apr 30, 2022, 12:30 PM

Title: Figures for Fabrication of Wooden Base

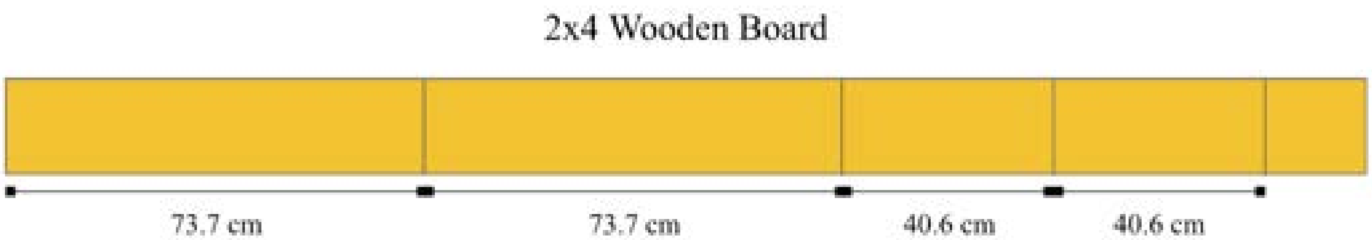
Date: 4/30/22

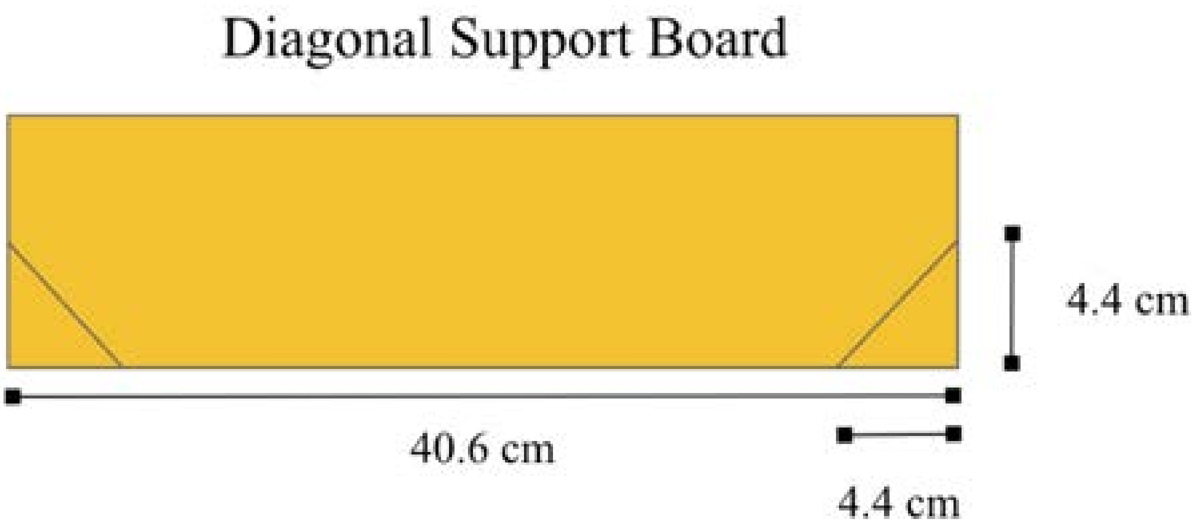
Content by: Sam

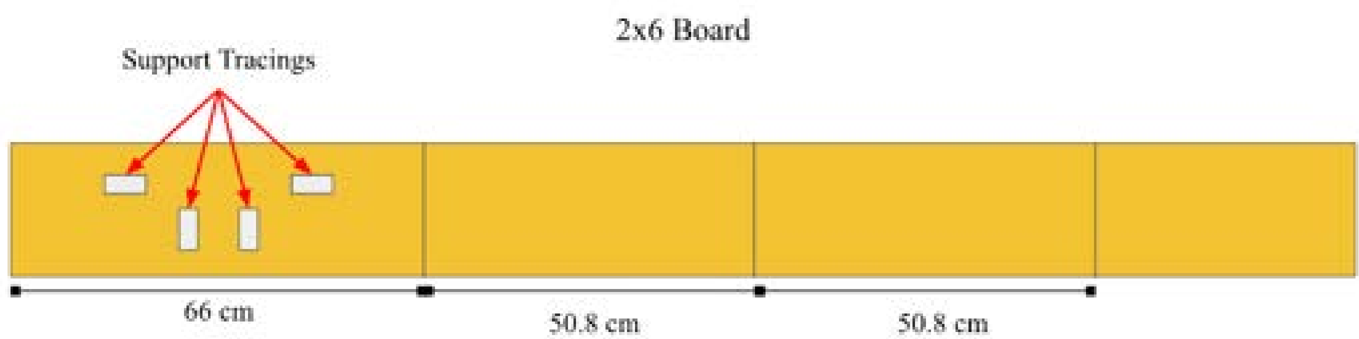
Present: Sam

Goals: Enter figures that I made for the wooden support base into notebook.

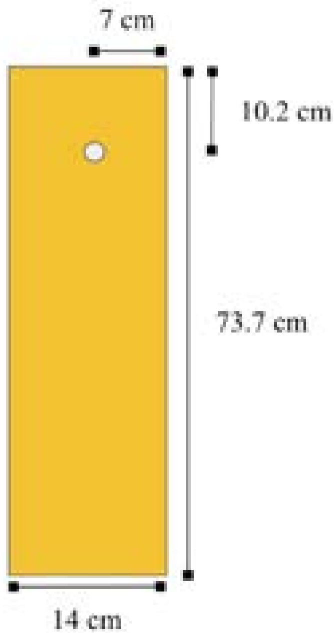
Content:

- 

    - This figure was to show the cuts that were made on the 2x4 board
- 

    - This figure shows the markings and cuts on the diagonal support boards.
- 

    - This figures shows the cuts that were made to the 2x6 board. Additionally, the base board had the tracings of the rowing machine supports.



-
    - This figures shows where the holes were marked on the vertical supports

Conclusions/action items:

For the final report fabrication section, I wanted to make sure it was clear where we were making the markings and cuts, so I decided to make these figures. These figures make it very clear ar are very easy to interpret.

Action items: edit final report with team.

4/30/22 Work on Final Report

SAMUEL SKIRPAN - Apr 30, 2022, 12:51 PM CDT

Title: Work on Final Report

Date: 4/30/22

Content by: Sam

Present: Sam

Goals: Enter work that I did on the final report into lab notebook.

Content:

- For the final report, I was tasked with writing the fabrication protocol for the wooden support base in addition to writing the testing protocol for the tension section.
- For the fabrication protocol of the wooden support:
    - I first talked about how we used a 2x4, 2x6, screws, and adjustable straps to make the wooden base
    - Then I talked about how we measured the vertical supports and diagonal supports on the 2x4, then the horizontal supports and base board on the 2x6, and the supports of the rowing machine on the base board
    - After measuring the wood, I talked about cutting the wood using the miter saw in addition to drilling out the divots and holes using the drill
    - Then we attached all the pieces of wood together using a hand drill and screws
    - Lastly, we put the straps on
- Testing protocol for tension section:
    - I talked about using the spring gauge on the standard side with resistance levels of 1, 5, and 10, then doing the same on the adapted side
    - We used a phone to video the tension in the gauge and then recorded these values
    - On the adapted side, the participant was not allowed to use their legs
- I also ended up going through and making all of our old pictures in metric units for the scales.

Conclusions/action items:

I was tasked with writing the testing protocol for the tension section of the final report as well as the fabrication of the wooden support base. In addition to this, I took it upon myself to recreate all of the scales in metric units for our old figures.

Action items: get lab notebook in order and edit report with team.

5/2/22 Thoughts on Semester

SAMUEL SKIRPAN - May 02, 2022, 9:30 PM CDT

Title: Thoughts on Semester

Date: 5/2/22

Content by: Sam

Present: Sam

Goals: Enter thoughts on semester into notebook.

Content:

Today, we met for the last time as a team to edit the final report. Josh and I are going to go back through one time to make sure we have everything that we need. I am very excited that we are nearing the end of the semester and have completed so much excellent work. Our design is something to be very proud of and I think that we could possibly get a patent for it if we wanted to.

I think that it is very neat that we created a design that not only makes exercise machines more accessible for wheelchair users, but also allows for traditional use. This will make the machine more attractive for prospective gyms to buy. Also, it is really cool that we were able to get the console of the rowing machine to rotate so that you can see it on the adaptive side. I am very passionate about exercising and living a healthy lifestyle, so this project was very enjoyable for me. I hope to get the chance to work on an exercise project once again before I graduate.

I played a key part in coming up with the ideas for the slit cut and the support base, so those were my biggest contributions. I feel like I was a very supportive teammate this semester and was always willing to put in extra time and effort to edit deliverables. I also helped out writing a lot of the testing protocols and fabrication protocols along with checking to make sure we have all the required material for the lab notebook, final report, and poster.

In terms of team MVP, Josh has been very helpful this semester with all of his work with Solidworks and editing the reports and deliverables. We could not have done all that we did for this project without his help.

Our client, Staci, has also been very helpful. The fact that JHT was able to make the cut on the console arm for us was very helpful and made things a lot easier for us. None of us have our metalworking passes, so we wouldn't have been able to do this. Staci also gave us some great ideas for making the rotating console part.

Lastly, Dr. P has been very helpful and given us great advice this semester. Even though I always get scared whenever we get our preliminary deliverable grades back, I always feel confident that if we correct those comments and listen to his advice, we will end up doing well with final deliverables.

Conclusions/action items:

This semester has been a great semester for the adaptive rowing project. I hope I get the chance to work on an exercise project in the future as well.

Action items: turn in final deliverables.

3/25/22 Base Model 2x4

SAMUEL SKIRPAN - Mar :

Title: Base Model 2x4

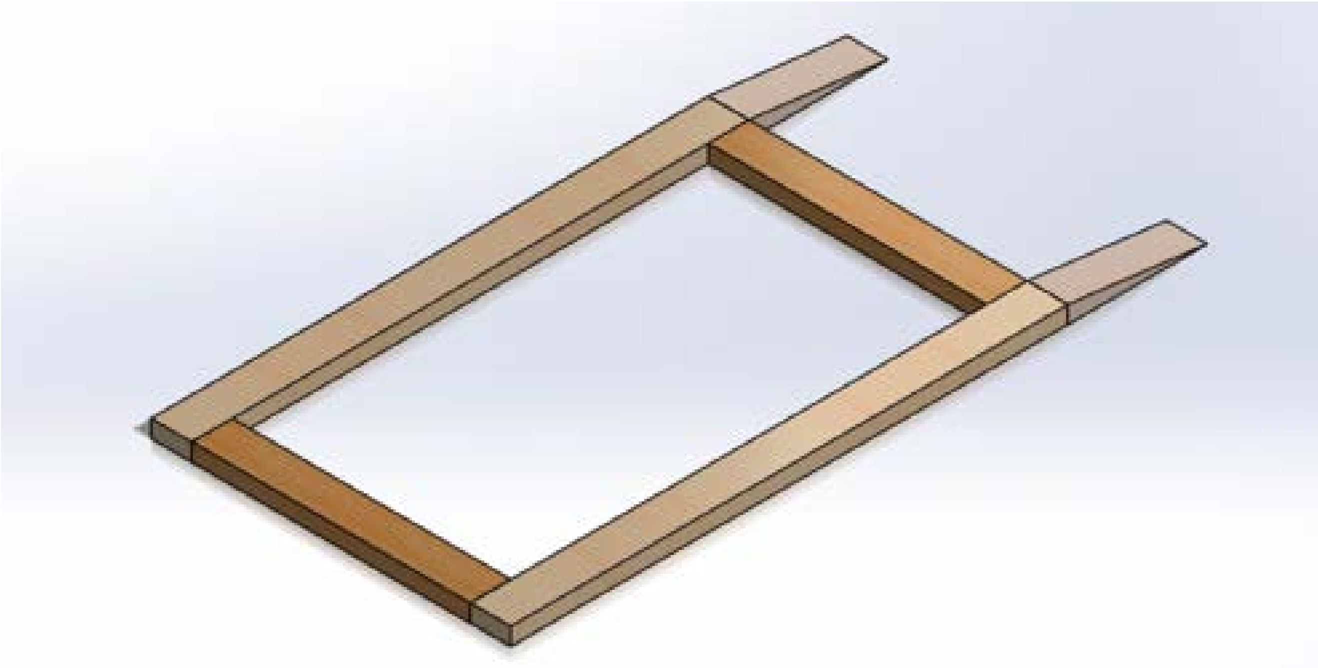
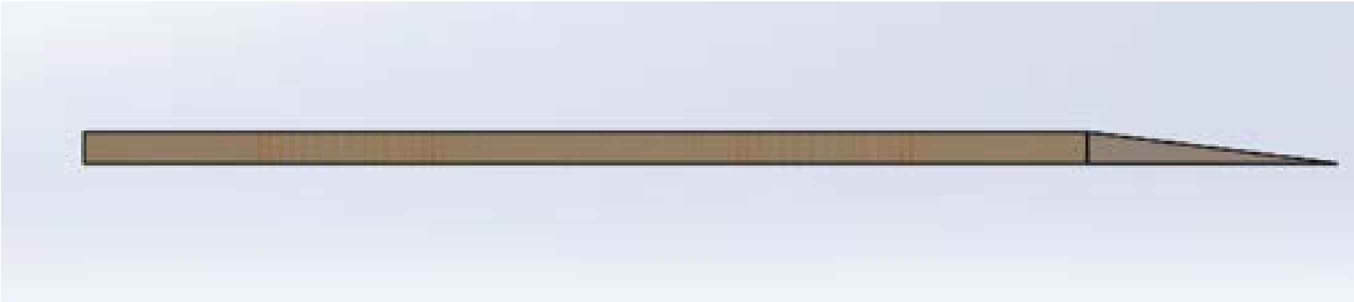
Date: 3/25/22

Content by: Sam

Present: Sam

Goals: Enter solidworks progress into notebook.

Content:

- I used solidworks to create a 2x4 model of what our base will look like that the wheelchair will rest in
- I still have to add the grooves to the model, but this is what the general base will look like
    - 
        - This is a main view of the base I created. Each piece of wood is a 2x4.
            - The darker wood is 2x4x24in
            - The lighter wood is 2x4x48 in
            - The ramps is 2x4x12 in
    - 
        - This is a side view of the ramp

Conclusions/action items:

I was excited to be able to create the base in SOLIDWORKs. We originally thought that we were going to use a solid piece of metal for the base, but now we will just plan on making a skeletor other material would be unnecessary.

Action Items: Add grooves to the model for the wheelchair to rest in.

Rowing machine research - biomechanics

Tim TRAN - Feb 04, 2022, 1:39 PM CST

Title: Biomechanics of rowing machine

Date: 2/4

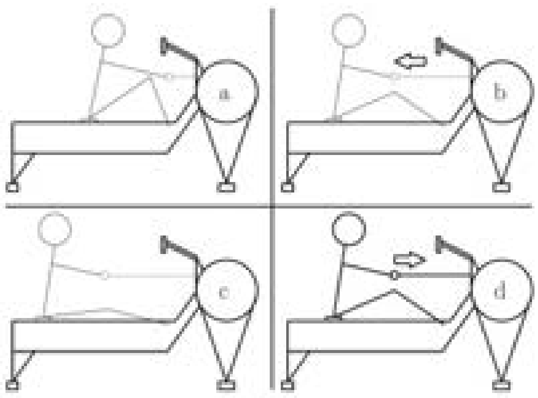
Content by: Tim

Present: Tim

Goals: Gain familiarity with rowing machine design and intended muscle groups.

Content:

- 4 main movements of rowing pattern
  - Catch
    - relaxed lower back - truck flexion
    - flexed knees
    - ankles dorsified
    - arms extended
    - **The catch will have to be modified for a wheelchair user**
      - **How to design initial motion to brace against wheel of wheelchair**
  - Drive
    - leg emphasis
      - *extending leg and plantarflexion against foot pads*
    - body drive emphasis
      - pulling handle towards upper body - contracting shoulder muscles
      - knees full extension --> hips extend --> back extension
    - arm pull through emphasis
      - elbow flexion
  - Finish
    - knees and ankles maintain extension and plantarflexion respectively
    - muscles of back and upper arms contracting
  - Recover
    - back to initial postion
    - arms extend
    - hips flex
    - ankles dorsiflexed



https://www.sciencedirect.com/science/article/pii/S2590093519300086

Conclusions/action items:

Research adapted rowing machine designs

AROW

Tim TRAN - Feb 17, 2022, 9:34 PM CST

Title: AROW (adapted rowing machine)

Date: 2/4/22

Content by: Tim

Present: Tim

Goals: Detail the design of the adapted rowing machine (AROW)

Content:

The AROW was created specifically for the Concept 2 rowing ergometer.

There are currently two ways to row on an Ergometer without adaptations

- **Splitting the rowing ergometer**
  - This method simply removes the sliding track of Concept 2, allowing the wheelchair user to gain access to the handle and control panel.
  - An abdominal binder or harness is used for additional support
  - Users do not need to leave their wheelchair
  - cons
    - ergometer could move during intensive rowing
    - abdominal binder provides limited trunk stability
- **Rowing on a fixed seat**
  - This method requires the user to transfer themselves from their wheelchair to the rowing machine
  - The sliding chair is replaced with a fixed seat which clamps down on the rails
    - the setup is similar to rowing a boat
  - cons
    - seat is out of reach of control panel and handle

- AROW
  - This adaptation splits the erogmeter
  - this adaptation attaches a main support bar to the frame of the ergometer. This bar has cushioning at the end to support the user's trunk.
  - The main bar has slots for a smaller bar that supports the upper body if needed.
  - The main bar also has a clip near the end of it to hold the handle, for easy access
  - Additional supports were placed at the bottom of the machine to prevent tipping and sliding

Conclusions/action items:

The AROW provides good ideas to work off when designing our own adaptations for the Matrix ergometer. The next steps would be to assemble the matrix ergometer and take measurements

Standards research

Tim TRAN - Feb 25, 2022, 8:34 PM CST

Title: Standards regarding rowing machines

Date: 2/25

Content by: Tim

Present: Cate

Goals: Be aware of the standards in place regarding rowing/exercise machines

Content:

I have read through Cate's research on standards and specifications.

There is a standard on the safety of rowing machines, which is encompassed by standards on safety specifications for stationary exercise machines. Additionally, there are standards for any additional accessories used in conjunction with the rowing machine, which our adaptions will fall under.

The rowing machine and any adaptions we make will not need to be approved by the FDA

Conclusions/action items:

There seem to be very few standards our product will be held under. This will give us leeway in our designs. The most important thing is maintaining the safety of the user.

Impact

Tim TRAN - Apr 30, 2022, 9:46 PM CDT

Title: Impact of increasing accessibility to adaptive fitness equipment

Date: 4/30

Content by: Tim

Present: Tim

Goals: Present motivation for adapting a rowing machine

Content:

This information is compiled from Josh's, Sam's, and Dhruv's impact research

- There is an estimated 5.5 million wheelchair users in the United States alone.
- Upper body/shoulder pain is a common complaint amongst wheelchair users
  - This pain can be alleviated with consistent upper body simulation
- Low exercise leads to decreased metabolism, increased resistance to insulin, increased body fat, and overall quality of life
- The main fitness equipment manufacturers do not offer adapted versions of their machines
  - very few fitness options for wheelchair users

Conclusions/action items:

Wheelchairs have a big presence in the world, and being wheelchair leads to additional health complications if regular exercise cannot be achieved. Therefore, it is of utmost importance that adaptive fitness options are made easily accessible.

Design idea 1

Tim TRAN - Feb 25, 2022, 8:18 PM CST

Title: Design ideas before Johnson Health Tech tour - inspired by AROW

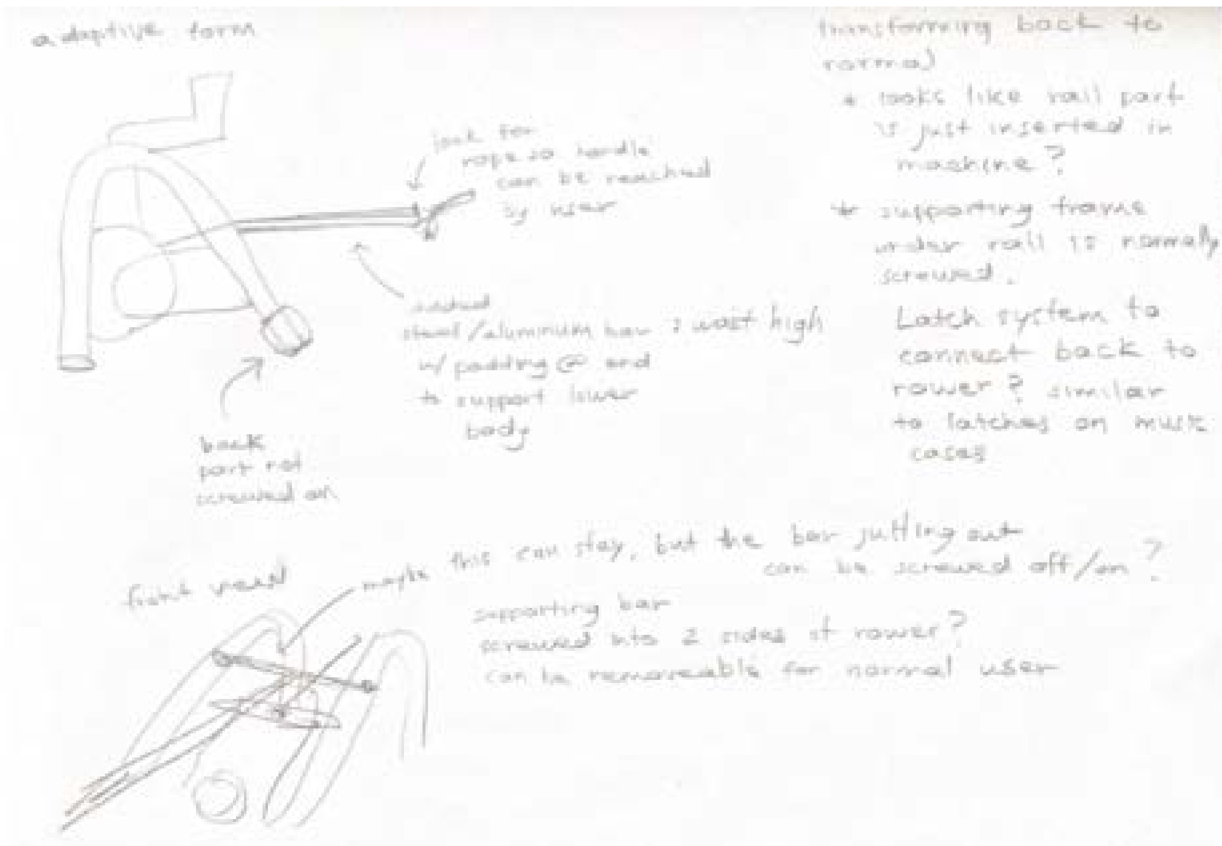
Date: 2/14

Content by: Tim

Present: Tim

Goals: Brainstorm adaption ideas

Content:



Conclusions/action items:

This design employs similar a similar supporting bar as the AROW. After seeing the rower in person, I think the best place to attach the bar would be in the same spot the console arm is attached to the rower. The bar will hold the rowing handlebar, as well as support the user's upper and lower body. This design, however, does not allow a seamless transition between adaptive and normal use.

Design idea 2

Tim TRAN - Feb 25, 2022, 8:23 PM CST

Title: AROW inspired design - after tour

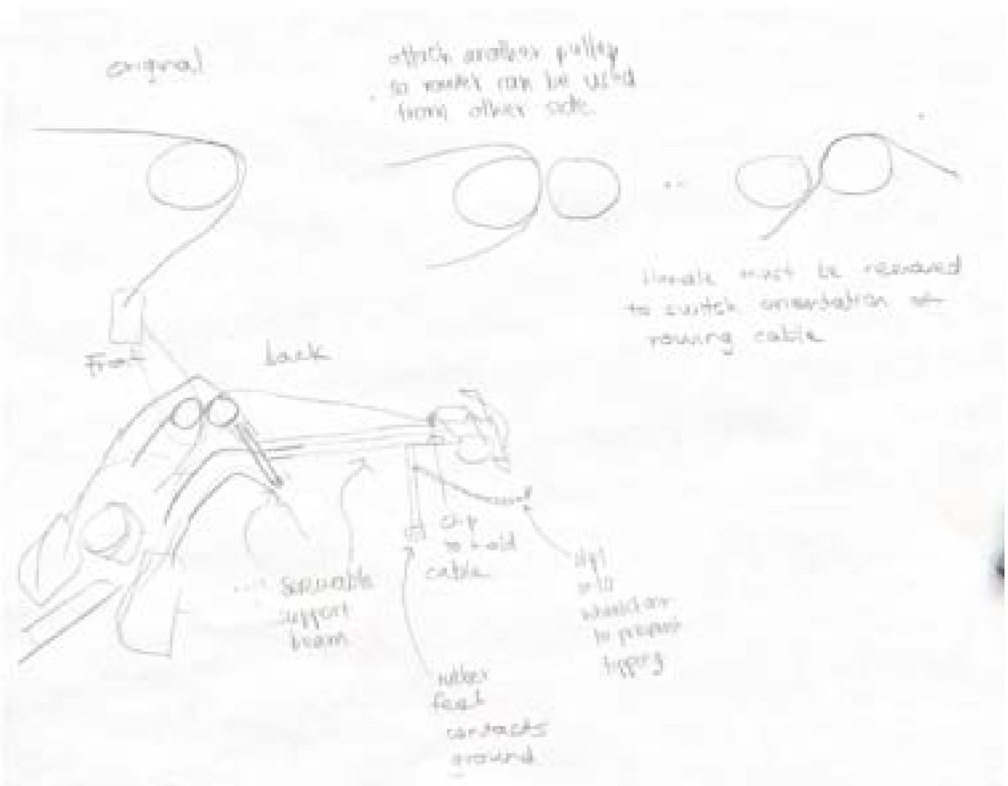
Date: 2/20

Content by: Tim

Present: Tim

Goals: Present more adaptation ideas to the rower

Content:



Conclusions/action items:

After seeing the matrix rower in person, the team has observed that the addition of an extra pulley will allow rowing to take place on both sides of the machine. This way there is minimal setup required for adaptive or nonadaptive rowing.

The support bar will be attached in the same slot as the console arm and will be easily removable to conserve space if needed.

FBD of final design

Tim TRAN - Mar 01, 2022, 11:58 AM CST

Title: Tim

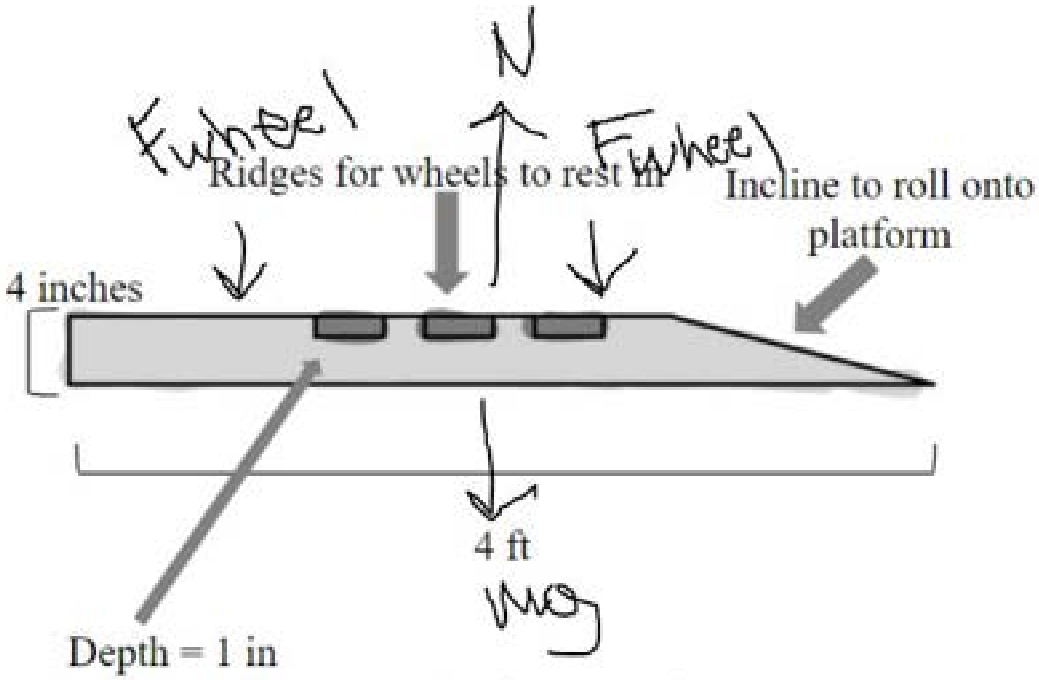
Date: 3/1

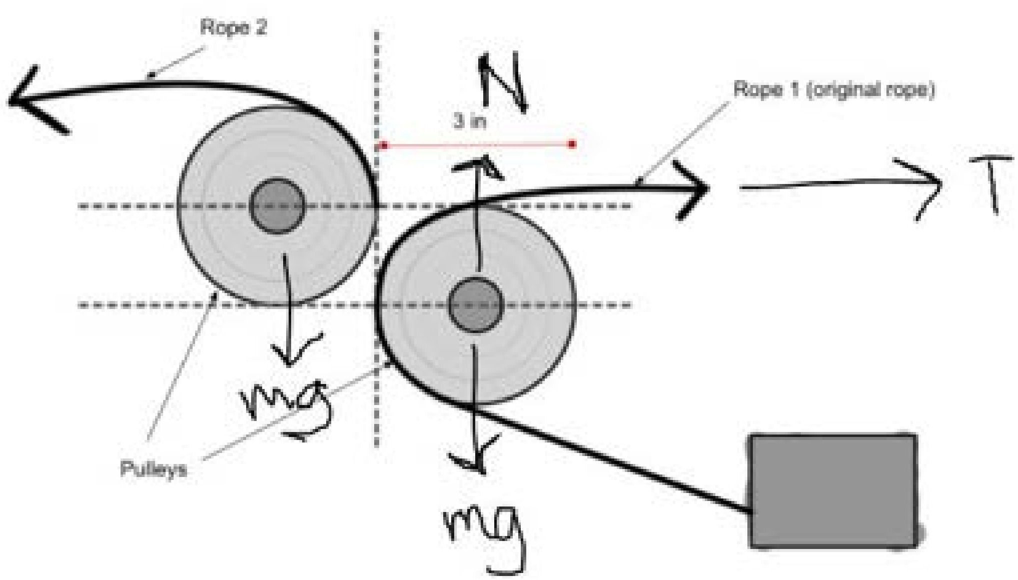
Content by: Tim

Present: Tim

Goals: Present full-body diagrams of pulley and stability designs to analyze forces present and potential points of failure

Content:





Conclusions/action items:

I used the 2 ropes with 2 pulleys design drawing because it depicted the 2 pulleys more clearly, however, the final pulley design that was decided on was the 2 pulley, 1 rope design.

The next steps to take will be client approval, fabrication, and testing.

WARF Presentation

Tim TRAN - Mar 11, 2022, 5:34 PM CST

Title: WARF presentation notes

Date: 3/11/22

Content by: Tim

Present: Tim

Goals: Learn about WARF and the patent process

Content:

Beginnings of WARF

- Created in 1925 - to manage the intellectual property of Dr. Steenbock
- nonprofit
- Governed by an independent board of UW-Madison alumni

WARF's mission: support scientific research within the UW-Madison community

- Provides financial support
- Managing assets
- moving innovations to marketplace - for global impact and financial return

Cycle of Innovation

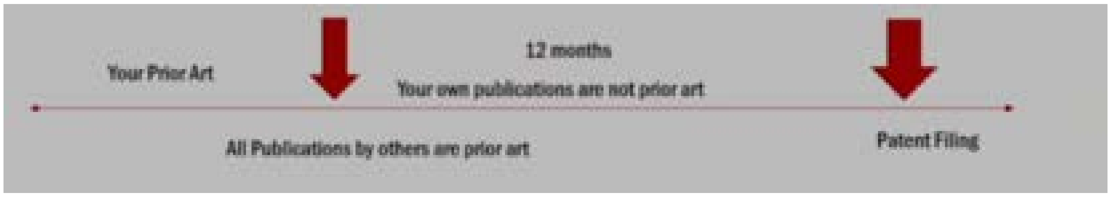
- 6th overall in research funding
  - annual grant: $85 million
  - $3 billion cumulative to UW
- 300-400 invention disclosures each year
- 2000 issued U.S patents
  - 700 pending patents
- 125 faculty start-ups
- UW research and discovery --> IP protection --> licensing and startups --> funding to support research and discovery --> repeats

Protecting innovation

- Patents
  - machines and devices
  - compounds
  - processes and methods
  - improvements
- Trademarks
  - Words and phrases
  - Colors
  - Pictures or logos
  - Sound
- Copyrights
  - Literary works
  - Webpages
  - Software programs

Prior Art

- references created before a specific date
  - By the inventor: >1 year before the filing date of the patent application
  - By another: before the filing date of the patent application
- Novelty and non-obviousness are evaluated based on prior art
  - internationally - absolute novelty require. cannot be prior art from another



- Public disclosure
  - Journal publications
  - Talk / conference / meeting
  - non-confidental seminar
  - open thesis defense
  - dissertation
  - description on the internet

Requirements for patentability

- Eligible
- Useful
- Enabled
- Described
- Novel
- Non-obvious
- Examination = assessment of invention
  - Based on statutory requirements and application of prior art

WARF's IP management process

- Disclosure of invention to WARF
- Disclosure committee meets monthly to review new disclosures
- Patent application drafting, filing, and prosecution
- technology marketing
- Licensing

Licensing considerations

- Chance of licensing
- Timeline for licensing
- Licensing strategy
- Plan for the next year
- Revenue project

Licensing innovation

- WARF provides
  - exclusive or non-exclusive rights to make, use, sell, or import
- Licensee provides
  - develop and commercialize
  - Reasonable fees: upfront, royalties, milestones, etc
  - Fulfill obligations under Bayh-Dole
- Timeline
  - Varies from months to years
  - Depends on technology and market readiness

WARF's Accelerator Program

- Goal: accelerate commercialization prospects for WARF IP
- Catalyst: Expert consultants with significant business experience
- Five sectors
  - comp sci and engineering
  - Medical devices and health care
  - CleanTech
  - Food and agriculture
  - Research tools
- Results
  - 28 licenses / 6 paid options
  - 13 startups

- $5.5M in COE

Finding a license

- Internal
  - inventor contacts
  - meetings
  - sponsored research
- External
  - Technology descriptions on website
  - Publication
  - Technology portals
  - Targeted outreach

Starting a company

- Technology
  - incremental or revoluntary?
  - how much is technology used in final product
  - how much development is needed
  - government approval?
- Market
  - sizable market?
  - competitors / competing products?
  - good margins?
- Management
  - Role in startup?
  - raising capital

Start-up resources

- D2P to product, campus-wide resource for entrepreneurship
- Entrepreneurons
- Innovation Roadmap Series
- UpStart Program for minority and Women's Entrepreneurship
- Law and Business Entrepreneurship Clinics

Conclusions/action items:

In regards to our project, The two pulley mechanisms along with the side handlebars for stability could potentially be considered for a patent.

Rower provided by client - 2/7/22

Dhruv Biswas - Feb 07, 2022, 5:40 PM CST

Title: Rower provided by client

Date: 2/7/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document the type of rower the team will be adapting. This will include its basic specifications.

Content:

- Includes aluminum flywheel, 10 magnetic resistance levels, adjustable backlit console, program quick keys, seat with a lock, reinforced handle, reinforced aluminum rail, low maintenance cord.
- Dimension: 223 x 55 x 97 cm
- Weight: 59 kg/130 lbs
- max user weight 158.76 kg/350 lbs
- Seems to be a one piece system, no breaking points that can be disassembled. Wheels near the flywheel allow for easy storage
- A lightweight handle is used in the current product to "row"
- A combination of a cord and aluminum rail with stainless steel strips makes up the area where the seat slides.
- 

- Has a generator powered LCD display. Has a memory battery within it.

References:

[1] "Rower | Matrix Fitness - United States." https://matrixfitness.com/us/eng/group-training/cardio/rower (accessed Feb. 07, 2022).

Conclusions: This entry documents the rower system that will be provided by the client. Basic facts about the device have been recorded and will be included along with the PDS. The team was interested in making two parts of the system so reassembly into the original product would be easy. However, that might be tough with this model.

Action items: The team will look to include this information into the PDS.

Barriers and Facilitators - 2/10/22

Dhruv Biswas - Feb 10, 2022, 9:18 PM CST

Title: Barriers and Facilitators

Date: 2/10/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document barriers that disabled individuals face during physical activity

Content:

- Sessions were tape recorded in this study and the content was analyzed.
- 178 barriers were revealed as well as 130 facilitators. The themes included...
    - Barriers and facilitators related to the built and natural environment
    - Economic issues
    - Emotional and psychological barriers
        - Barriers
            - Perception that fitness centers have an unfriendly environment.
                - Based off of experience often.
            - They feel self conscious
            - Fear of unknown
            - Concern about needing and requesting assistance
        - Facilitators
            - Offer a more friendly environment
            - Offer free trials which allow users to test the facility
    - Equipment barriers
        - Barriers:
            - Not enough space between equipment for wheelchair access
            - Poor equipment maintenance
            - Lack of adaptive and/or accessible equipment
        - Facilitators
            - Some other things that were wanted include: Velcro straps to allow individuals with disabilities to grip exercise equipment, and strength equipment.
                - Ideally while not transferring from the wheelchair to use the machine
            - They wanted facilities to seek input from persons with disabilities regarding exercise equipment purchases
                - Might be a smart idea to interview a subject that uses a wheelchair while working out for the project at hand
    - Barriers related to the use and interpretation of guidelines, codes, regulations, and law
    - Information related barriers

    - Professional knowledge, education, and training professions
    - Policies and procedures both at the facility and community level
    - Availability of resources
- Historically, accessibility to public spaces has limited the opportunity for people with disabilities to engage in social and recreational activities.
- Focus groups were conducted to obtain feedback
    - 4 of them...
        - People with disabilities
        - architects
        - fitness/recreation professionals
        - city planners and park district managers
- Four types of fitness/recreation venues were analyzed by the participants...
    - Fitness centers
    - Swimming pools
    - Parks
    - Trails

References:

[1] J. H. Rimmer, B. Riley, E. Wang, A. Rauworth, and J. Jurkowski, “Physical activity participation among persons with disabilities: Barriers and facilitators,” *American Journal of Preventive Medicine*, vol. 26, no. 5, pp. 419–425, Jun. 2004, doi: 10.1016/j.amepre.2004.02.002.

Conclusions:

Having direct input from someone that experiences the barriers of a disabled individual will be valuable for the team. While research will educate the team on how to properly design an adaptive rower, direct input from someone that could potentially use it would be helpful. In addition Velcro straps should be implemented into the design. It was a common suggestion in this study.

Action items: Continue research and begin making design ideas.

Shoulder Complaints in Wheelchair Athletes - 2/12/22

Dhruv Biswas - Feb 12, 2022, 2:43 PM CST

Title: Shoulder Complaints in Wheelchair Athletes

Date: 2/12/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Identify why wheelchair athletes obtain shoulder pain

Content:

- External mechanical loading may lead to shoulder issues
- Pain in the shoulder is a common complaint from wheelchair athletes
- Cause of shoulder problems is not known.
    - Increased years of disability, age, and BMI can affect risk
    - A balance strength regimen may decrease risk
- In wheelchair users, upper body and shoulder complex are used in almost all sports and daily related activities
- Increased load placed onto the shoulder could cause issues with shoulder
    - Intensity, frequency, duration.
        - If any of the factors sway too far form their optimal value, or the combination of the submaximal values from the three factors is increased, the risk of complaints is by default also increased.
    - Larger loads to the scapula-humero-thoracic musculature could affect shoulder pain
- Increases weight and age are factors to consider with shoulder pain
- Other common issues with wheelchair athletes includes...
    - rotator cuff impingement, rotator cuff tear, acromia-clavicular pathology, bicep tendon pathology, subacromial and subdeltoid effusion, non specific shoulder (and upper arm) injury, and shoulder pain.
- Shoulder complaints in wheelchair athletes ranged from 21%-79% in various studies
- Cause of the pain is multifactorial.
    - Overuse
    - Weakness in shoulder adduction
    - Internal and external rotation
    - Decrease of trunk control
    - Poor driving posture in wheelchair
- Overall athletic activity protects the wheelchair athlete from shoulder complaints

References:

[1] O. W. Heyward, R. J. K. Vegter, S. de Groot, and L. H. V. van der Woude, “Shoulder complaints in wheelchair athletes: A systematic review,” *PLOS ONE*, vol. 12, no. 11, p. e0188410, Nov. 2017, doi: 10.1371/journal.pone.0188410.

Conclusions:

This article was a literature review regarding shoulder pain in wheelchair athletes. There does not seem to be a clear cause to it and concrete preventititve actions an athlete can take. Proper technique and well developed shoulder muscles can prevent shoulder pain. This knowledge will help the team create a device that will not induce improper technique from the user.

Action items:

Make design ideas and continue researching

Propulsive Mechanisms in Rowing - 2/13/22

Dhruv Biswas - Feb 13, 2022, 12:00 PM CST

Title: Propulsive Mechanisms in Rowing

Date: 2/13/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Identify the proper upper mechanics of rowing and ensure that the eventual design does not impede the motions documented.

Content:

- Cyclical event
    - The catch
        - rowers legs are flexed, arms extended.
            - hands are lifted.
    - Drive
        - Extension of legs, arms pulling on the oar towards chest.
            - Hands lowered to raise the oar blade from the water at finish.
    - Finish
        - Timing of finish is crucial. Water strike back can slower the boat.
    - Recovery
        - Hands pushed away from the body and, as they pass the knees, the knees begin to flex too.
- Oar blades themselves help with the propulsion of the boat and to maximize the velocity of the boat.
- Using the proper techniques above, and a proper oar, can lead to maximum boat velocity.

References:

[1] N. Caplan, A. Coppel, and T. Gardner, "A review of propulsive mechanisms in rowing," *Proceedings of The Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology*, vol. 224, pp. 1–8, Mar. 2010, doi: 10.1243/17543371JSET38.

Conclusions:

This entry highlights the basic mechanics needed from rowing. It is important to note that this is for rowing in actual water. The mechanics might alter slightly using an erg. Regardless, the team will ensure that any modification added to the rower will not impede on the four core motions in rowing.

Action items:

Continue researching and make three preliminary designs.

Adapted Rowing Machine by BCIT REDlab - 2/7/22

Dhruv Biswas - Feb 07, 2022, 6:07 PM CST

Title: Adapted Rowing Machine by BCIT REDLab

Date: 2/7/22

Content by: Dhruv Biswas; Original article found by Tim Tran

Present: Dhruv Biswas

Goals: Analyze and document this solution provided by BCIT REDLab

Content:

- Multiple different methods have been provided by this lab. A concept 2 rower must be used in order to successfully complete these changes
- First option: split the rowing ergometer and use the AROW
    - The chest pad can be used if wanted
    - Essentially the slider portion of the rower can be removed and the chest pad is used to provide support to the user.
        - pad can also relieve neck strain
    - An adapter is used to stabilize the user while they row.
    - This option can also work with a regular chair.
    - Stick or cane can be used to adjust the tension of the machine
    - 

- Second option: "split" the rowing ergometer (no ergometer adapter)
    - If ergometer adapter is not present this option could be a great option.
    - Allows user to remain in the wheelchair. An abdominal binder or harness can be used for additional support.
    - Essentially only the front half of the machine is used, and the user uses only their hands to row.

        - Stability is provided by harnesses

    -

- Option three: rowing on the fixed seat
    - This option works for users that can transfer to and from the rowing machine.
        - Would not apply to the team's project
    - Essentially the seat done not slide.

References:

[1] "Rowing Solutions – Adapted Rowing Machine (AROW)." https://adaptederg.commons.bcit.ca/rowing-solutions/ (accessed Feb. 07, 2022).

Conclusions: The team can use these basic ideas to draw inspiration for how an adaptive mechanism could look like. The rower that is provided by the client does not disassemble as readily as the concept 2 rower. This will present more challenges to the team, but ideas like the harness or fixed seat could be applied to the project. Ideas like this will be implemented into preliminary designs.

Action items: Finish PDS and begin making preliminary designs

Review of Standards From Cate Flynn - 2/27/22

Dhruv Biswas - Feb 27, 2022, 5:16 PM CST

Title: Review of Standards From Cate Flynn

Date: 2/27/22

Content by: Dhruv Biswas; Original Standards research completed by Cate Flynn

Present: Dhruv Biswas

Goals: Document the standards that were found by Cate

Content:

- Entry 20957-7-2005 explains the requirements needed in order to make a safe rower for standard use.
    - It is important to note that this standard only has specifications for a normal rower. No specifications have been made for an adapted ergometer, this might be due to the lack of adapted rowers on the market.
    - It specifies classes S, H, and A for accuracy
- Entry 20957-1 goes through the safety measures regarding stationary workout equipment. In addition, rules for adding accessories to machines
    - These standards should be followed by the team. While the team is adapting as standard rower, the adapted version is still stationary.
    - In addition, the team will actively be removing and adding components to the rower. So, all additions should follow standard 20957-1 [1]
- Lastly, Cate recognized that the product being made by the team does not fall under FDA regulation [2]

Cate has helped the team to find the standards that will be applied to the project. No specific standard has been found for adapted rowers specifically. The team will look to ensure safety for the user during the designing process.

References:

[1] 14:00-17:00. “ISO 20957-7:2005.” ISO. Accessed February 9, 2022. https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/03/99/39908.html.

[2] “Does My Product Require FDA Approval? FDA Pre-Approval Requirements,” August 6, 2019. https://www.onlinegmptraining.com/does-my-product-require-fda-approval/.

Note: Both references were found by Cate Flynn

Conclusions: The team does not have a set of guidelines from a standard to follow specifically. However, the standards mentioned in this entry will act as a guideline for the designing process. The users safety is of utmost importance and will be ensured through the PDS that has been formulated. Regardless, the standards will help to reinforce the safety guidelines that the group has created.

Action items: Finish preliminary report and update lab archives

Initial Design Ideas - 2/13/22

Dhruv Biswas - Feb 13, 2022, 12:38 PM CST

Title: Initial Design Ideas

Date: 2/13/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document initial design ideas

Content:

- **Idea 1**
  - **The top portion of the rower contains the rowing bar and the console. Therefore, if this piece is placed slightly lowered and allowed to rotate, then an adaptive rower could successfully be made.**
  - **This will require the removal of two bolts, an addition of a rotating component, a lock between various position of rotation, and stabilizing mechanisms for the user in the wheelchair.**
- **Idea 2**
  - **A cut is made right where the leg rests are so the wheelchair user can pull up and lock themselves in for use.**
  - **The portion that is cut off can be reattached for standard use.**

References:

N/A

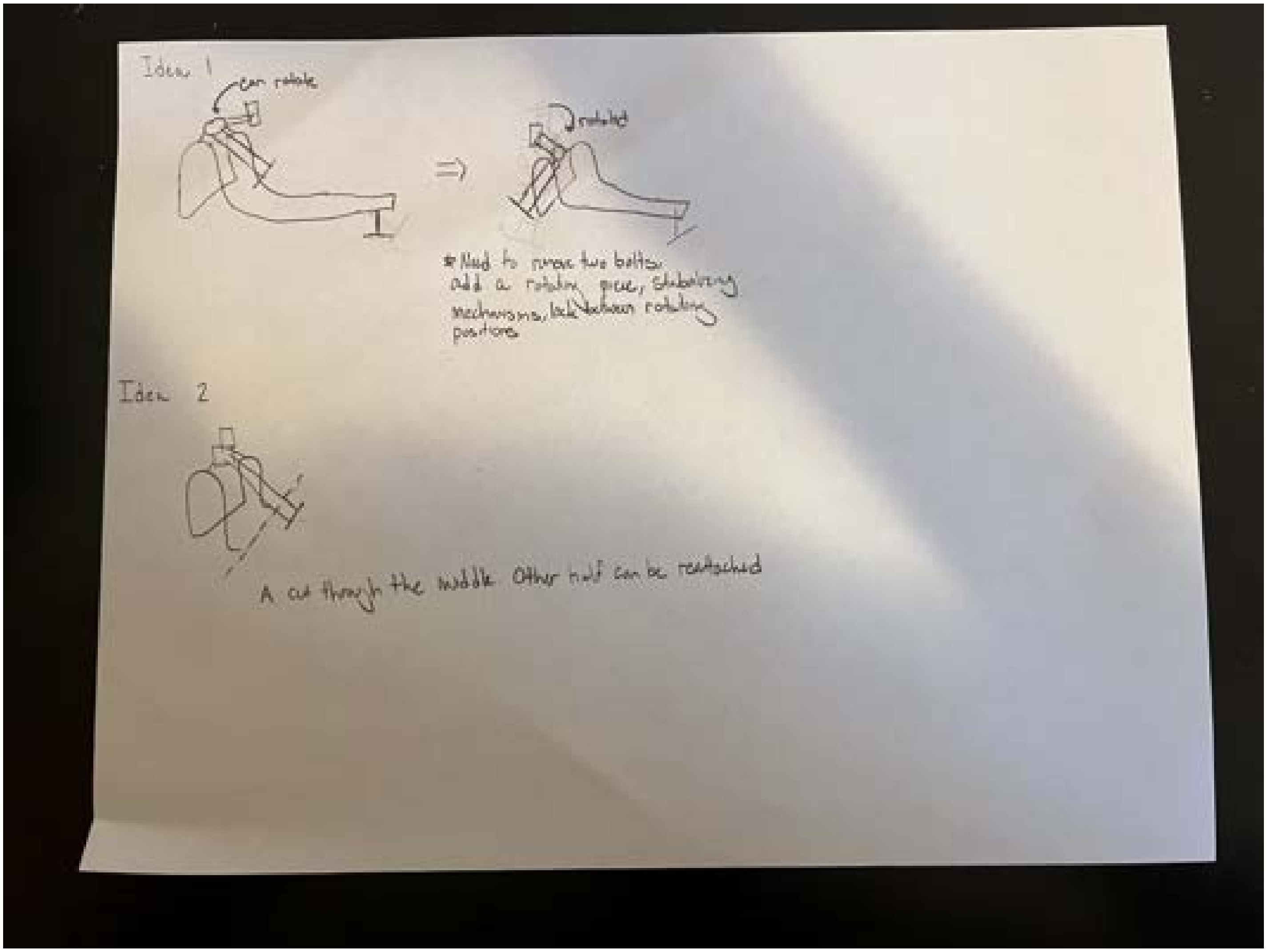
Conclusions:

These are the initial ideas that I have come up with. The first idea seems plausible and will require only a few extra components. The second idea requires more than disassembling the machine. Cuts might need to be made. These ideas will be presented to the whole team.

Action items:

Continue research and begin the design matrix

Dhruv Biswas - Feb 21, 2022, 12:52 PM CST



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Design Matrix Review - 2/27/22

Dhruv Biswas - Feb 27, 2022, 8:06 PM CST

Title: Design Matrix

Date: 2/27/22

Content by: Dhruv Biswas; Work completed by the team

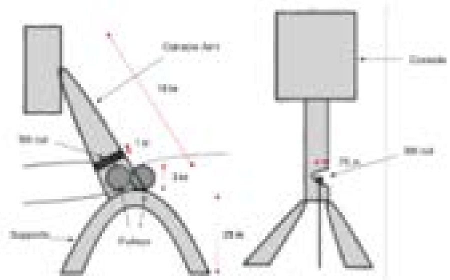
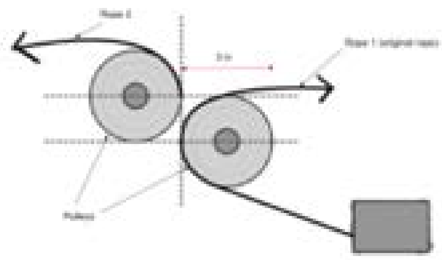
Present: Dhruv Biswas

Goals: Review and highlight the design matrix

Content:

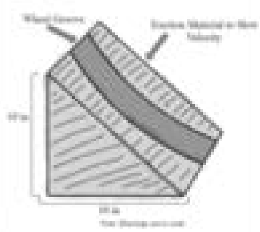
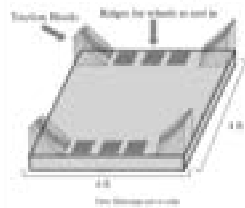
- Two design matrixes were made in order to analyze the designs for two different components of the final adaption that will be completed.
  - Pulley and stabilizers. They are included below:

Pulley:

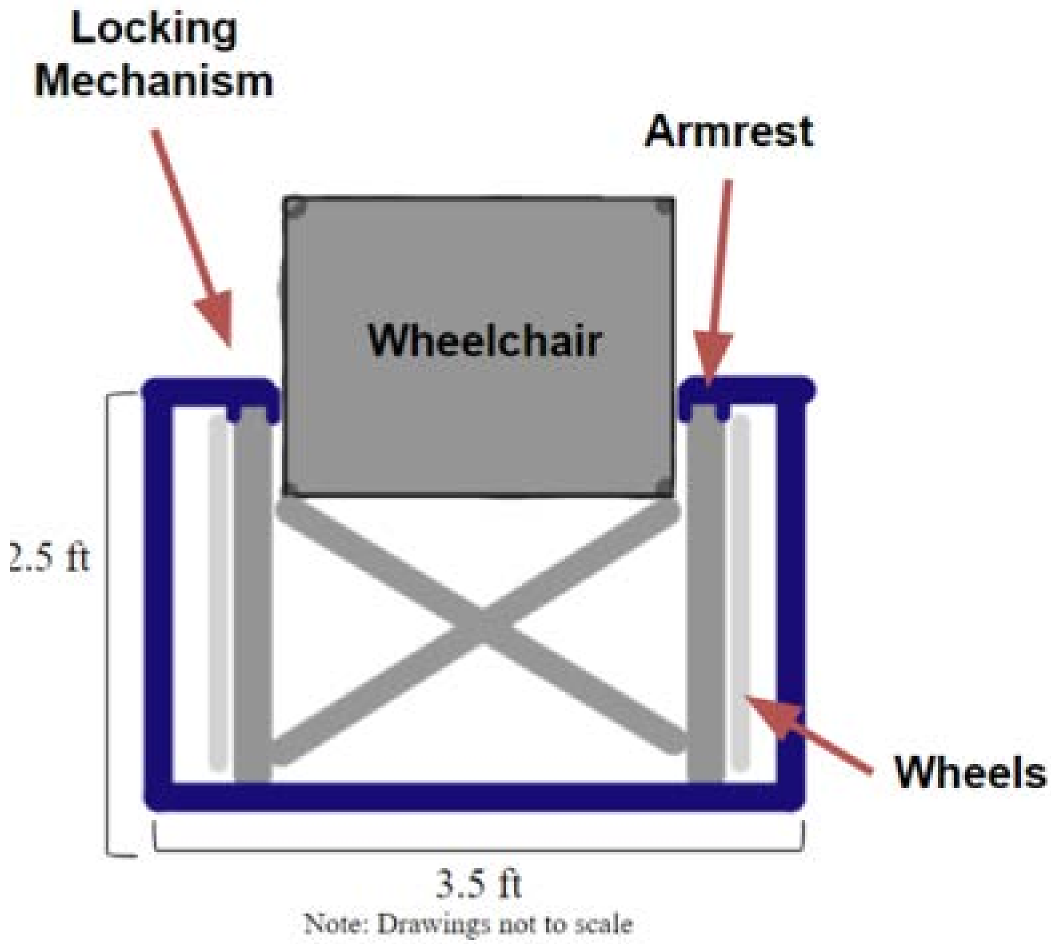
Design	**2 Pulleys with Slit** 		**2 Pulleys with 2 Ropes** 	
User Stability / Safety (25%)	4/5	20	5/5	25
Ease of Fabrication (25%)	4/5	20	2/5	10
Ease of Use / Ergonomics (20%)	4/5	16	5/5	20
Versatility (10%)	5/5	10	5/5	10
Durability (10%)	5/5	10	5/5	10
Cost (10%)	5/5	10	3/5	6
Total for each design:	**86**		**81**	

- 2 pulleys received a higher score for safety due to no transfer of cable being needed
- Fabricating two pulley would require uncoiling of flywheel among other issues. Slit design allows use of cables and ropes that are already built in. Only another pulley is required
- 2 pulleys is easier to use due to no transfer needed
- Would cost more for 2 pulley design due to new cable and pulleys needed. Slit only needs one new pulley

Stabilizers:

Design	Highway Ridges 		Traction Blocks 		Combined Design 	
User Stability / Safety (25%)	4/5	20	4/5	20	5/5	25
Ease of Fabrication (25%)	5/5	25	4/5	20	3/5	15
Ease of Use / Ergonomics (20%)	5/5	20	3/5	12	3/5	12
Durability (15%)	5/5	15	4/5	12	4/5	12
Cost (15%)	5/5	15	4/5	12	3/5	9
Total for each design:	**95**		**76**		**73**	

- Maximum stability is provided by a combination of highway and traction designs
- Fabrication of the highway ridge design is simple due to only grooves needing to be made
- Ridges only requires the user to drive themselves in
    - No external assistance needed
- Normal wear and tear will be minimal for all designs
- Cheapest to make highway ridges due to least amount of materials needed
- In addition, a set stabilizer for lateral movement was chosen regardless of the choice from the design matrixes above. The design hooks onto the arm rests to prevent tipping in the lateral direction. The design is included below:



References: N/A

Conclusions:

The team has chosen the slit pulley design and the highway ridges as the final design. In addition the armrest hooks will be made for extra stability. I believe all of these choices were the correct ones and allows the team to manufacture a product that will be successful and ready in time. In addition, they all work together to ensure safety of the user.

Action items: Complete preliminary report and update lab archives

Preliminary Report Review - 2/27/22

Dhruv Biswas - Feb 27, 2022, 9:11 PM CST

Title: Preliminary Report Review

Date: 2/27/22

Content by: Dhruv Biswas; Report and Presentation by group

Present: Dhruv Biswas

Goals: Briefly discuss preliminary report and its content

Content:

- **The Preliminary presentation went well and I was happy with how smooth it went. I thought every member spoke with confidence and the questions were fielded well.**
- **I was assigned the motivation and physiological background sections. Overall, the main ideas from the presentation were placed into the report. It was explained in greater detail in writing. Editing was done as a group and then the conclusion and abstract were written. The PDS still needs to be edited with the recommendations provided by Dr. Puccinelli**
- **Testing was a new section that was considered. Testing the resistance between the adapted and normal mode will be essential. In addition, testing of the motions, solidworks stress and strain testing, and experience testing. Experience testing includes each member using the machine in the adapted form in order to find any issues with the design.**

References: N/A

Conclusions: The preliminary report has nearly been finished with the exception of the PDS. Final designs are included, as well as testing, and background information. Additionally, the preliminary presentation was successful.

Action items: Finish editing PDS

FBD of Final Designs - 2/28/22

Dhruv Biswas - Feb 28, 2022, 12:54 PM CST

Title: FBD of Final Designs

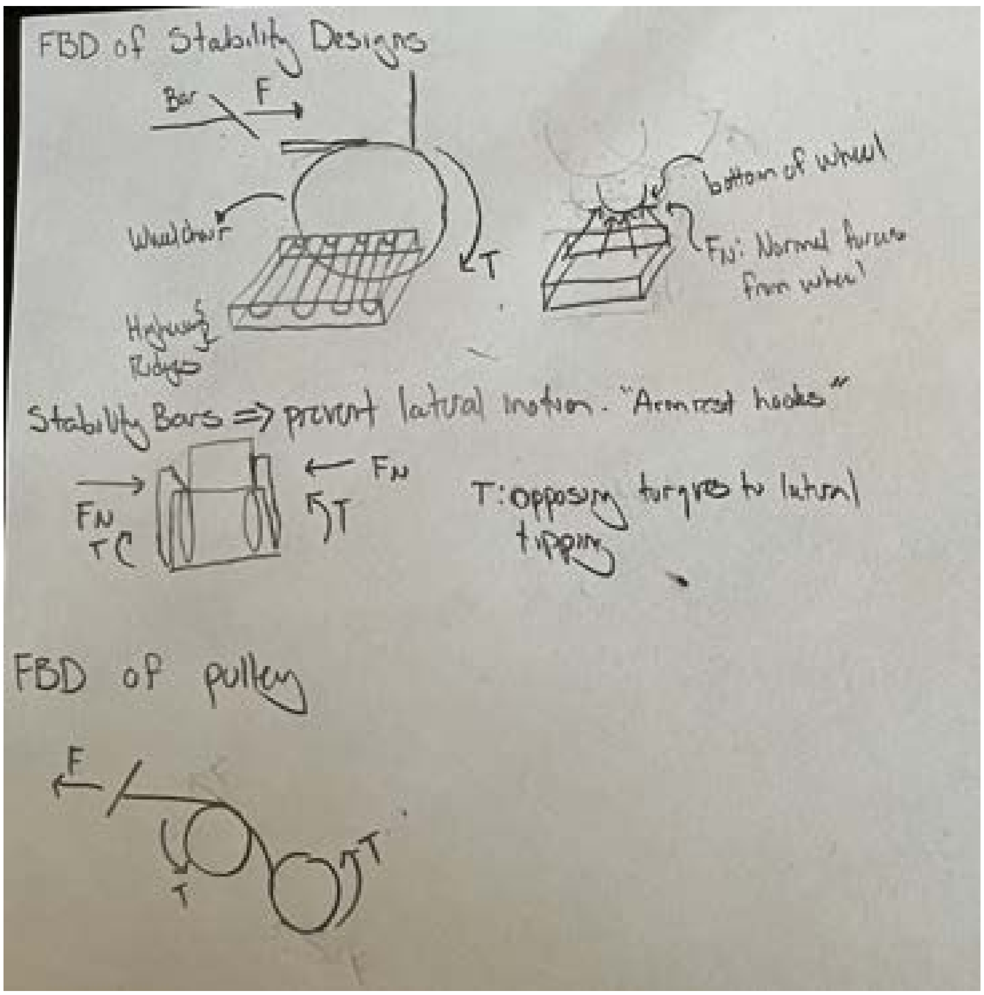
Date: 2/28/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document potential forces and torques that could be present when using the final designs

Content:



- **The highway ridges should provide normal forces to the wheel. In addition, the torque from the arm movements of the user should be counteracted by the ridges as well.**
  - **However, the hook arms will aid with this.**
- **The armrest hooks prevent lateral, backward, and forward movement. This is done through two normal forces acting on the arm rests as well as providing a counteracting torque in the lateral direction.**
- **Lastly, the force applied by the user on the arm bar will lead to torques on the pulley. If they act as they should, the torques of both pulleys should be rotating the same direction (counter-clockwise).**

References: N/A

Conclusions: Finalized designs have been made and analysis of external forces acting on the wheelchair and the stability devices have been documented here. This acts as a documentation of my thought process of potential forces acting on the devices. Further testing through solidworks and through trials will determine the true forces.

Action items: Begin modeling on solidworks

WARF Lecture - 3/10/22

Dhruv Biswas - Mar 11, 2022, 5:18 PM CST

Title: WARF Lecture

Date: 3/10/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document notes from WARF lecture

Content:

- Created in 1925 to manage intellectual property
    - For Dr. Harry Steenbock
- Nonprofit
- Proceeds support research at UW-Madison
- Governed by an independent board of UW-Madison alumni with expertise in a variety of fields
- Fully separate from the university
- Vision: Enable University of Wisconsin - Madison research to solve world's problems
- Mission: to support scientific research within UW-Madison community by providing financial support, actively managing assets, and moving innovations to the marketplace for a financial return and global impact.
- Cycle of innovation...
    - UW Research and Discovery
    - IP Protection
        - Patents
    - Licensing and Startups
    - Funding to Support Research and Discovery
    - Protecting Innovation
        - Patents
            - Machines and devices
            - Compounds
            - Processes and methods
            - Improvements
        - Trademarks
            - Words and phrases
            - Colors
            - Pictures or logos
            - Sound

        - Copyrights
            - Literary works
            - Webpages
            - Software programs
        - Tradesecret
            - Weakest protection. Once not secret, cannot protect
            - Not part of WARF
- Prior Art
    - Definition: "references" created before a specific date
        - By the inventor: > 1 year before the filling date of the patent application
        - By another: before the filing date of the patent application
        - Novelty and non-obviousness are evaluated based on the prior art
- Public Disclosure and Prior Art
    - Journal Publication
        - Often available online before printing
    - Talk or poster at a conference/professional meeting
        - Abstracts sometimes published in advance
    - Non-confidential department seminar
    - Open thesis defense
    - Cataloged dissertation
    - Some funded grant abstracts
    - Description on an internet site
- Requirements for Patentability
    - Eligible
    - Useful
    - Enabled
    - Described
    - Novel
    - Non-obvious
        - If a combination of inventions makes yours, its non-obvious.
    - Examination = Assessment of the invention
    - Based on statutory requirements and application of prior art
- Costs 10,000 or more to get a patent
- WARF's IP Management Process
    - Disclose your invention to Warf
        - 6-8 weeks. Moved to first to invent to first to file.
    - Disclosure committee meets monthly to review new disclosures
    - Patent application drafting, filing, and prosecution
        - Within 2 months
    - Technology Marketing

        - 15 percent goes to you
    - Licensing
- Licensing Considerations For New Disclosures
    - Chance of licensing
        - Potential applications, technology benefits and impact, state of the market, WARFs history licensing
    - Timeline for Licensing
        - Stage of the technology, patent status, position in WARF's portfolio
    - Licensing strategy
        - Companies (existing or start-up), exclusive vs non, field limitations
    - Plan for the next year
        - Further technology development, proactive marketing, marketing materials
    - Revenue projections
        - Early revenue, patent reimbursement, lifetime royalty projections
- Licensing Innovation
    - WARF Provides
        - Exclusive or non-exclusive rights to make, use, sell, or import
    - Licensee Provides
        - Develop and commercialize
        - Reasonable Fees: Upfront, royalties, milestones, etc.
        - Fulfill obligations under Bayh-Dole
    - Timeline
        - Varies from months to years
        - Depends on technology and market readiness
- WARF's Accelerator Program
    - Milestone-based validation funding to speed promising technologies to a commercial license
        - Goal: accelerate commercialization for WARF IP
        - Catalysts: Expert consultants with significant business experience
        - Five Sectors
            - Computer Science and Engineering
            - Medical Devices and Healthcare
            - CleanTech
            - Food and Agriculture
            - Research Tools
    - Results
        - 28 licenses/ 6 paid options
        - 13 startups
        - $5.5 M (45% of funding) in COE
- Finding a Licensee
    - Internal
        - Inventor contacts
        - Meetings
        - Sponsored Research
    - External
        - Technology descriptions on website
        - Publications
        - Technology portals
        - Targeted outreach
    - Inventor Startup
- Factors to Consider in Starting a Company
    - Technology
        - Is is incremental or revolutionary; is it a platform technology?
        - How is the technology used in the final product?
        - How much development is needed?
        - Are government approvals needed?

        - Market
            - Is there a sizeable market with a need?
            - Who are the competitors and the competitive products?
            - Are the margins attractive for a product?
        - Management
            - What should be your role subsequent to start up phase?
            - Is team experienced in raising investment capital and successful exits?
        - Capital Requirements
- Start up resources
    - Discovery to product, a campus wide resource for entrepreneurship
        - Technology innovation funding
        - Seed Funding
    - Entrepreneurs - Seminar Series
    - Innovation Roadmap Series
    - UpStart Program for Minority and Women's Entrepreneurship
    - Law and Business Entrepreneurship Clinics

References: N/A

Conclusions: The second pulley that is being added could potentially be patented. The mechanism of adapting from a standard form and then using the second pulley to enable the adapted form is novel. Currently an erg can only be adapted and not reverted back to the standard form. Additionally, the side handle bars could be patented as there seems to be no other product like it. More research would be needed for this. A worry would be the non-obviousness component of the patent review.

Action items: Work on solidworks for the final design

Review of Pulley for Adaptation Support - 4/14/22

Dhruv Biswas - Apr 15, 2022, 10:45 PM CDT

Title: Review for Pulley for Adaptation Support

Date: 4/14/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document updates to the pulley system and highlight the design Josh made in his entry "3/30/2022 - Initial Pulley Plate Print." It shows the key details for the final design that the team will be using.

Content:

- **Before show and tell the team thought a clamping system in the shape of an ohm would be an effective way to support the second pulley that would allow for the adaptable function.**
- **However, after input from a colleague, Josh was able to come up with the idea that is presented in his entry mentioned above.**
- **This design is sleek, simple, and effectively holds the pulley in place without adding excessive weight or material to the machine.**
- **Initial simulation tests run by Josh provides the team with confidence that the part will not fail under normal distress.**
    - **This normal distress is defined as 1050 N. This is the maximum load that the machine can withstand as determined by previous research.**
    - **He found that with 1050 N placed perpendicularly onto the inner loop of the piece that a deflection of 0.7234 mm. The reason it was modeled perpendicular was due to the reaction forces that would be present from the metal pulley.**
    - **It is important to note that there are two stability components so they would split the 1050 N, but the test placed all 1050 N onto one piece. Due to this, the team believes there will be minimal to no deflection seen in the plastic components.**
    - **Josh used PVC to run these tests, but they had similar mechanical properties to PLA, and josh strengthened the final component with filling.**

References: N/A

Conclusions: The team has placed the two supports onto the rower. The final rowing arm, that contain the cut, has been picked up today. Within the next four days the full design will be completed.

Action items: Finish the last few steps of fabrication, begin brainstorming testing protocols

Update for Stability Component - 4/14/22

Dhruv Biswas - Apr 15, 2022, 11:23 PM CDT

Title: Update for Stability Component

Date: 4/14/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document the change of plans that occurred during the fabrication process for the stability component of the design.

Content:

- **The team was planning to continue with the groove patterned board that would minimize movement along the ground while using the machine. However, after realizing that wheelchairs commonly have breaks, this design seemed to be useless [1]. This is especially the case because it had minimal effects on preventing tipping motion. It is true the ridges would allow some angular movement in relation with the ground, but any moderate movement would lead to the user to falling. There are no reactive forces present that would prevent the tipping motion.**
- **To combat tipping motion, it was determined that a focus on the side handle bar designs, one of the final designs, would be the sole stability component fabricated. It was always planned to fabricate this, but more time was taken to fabricate this component due to the removal of the platform.**
- **The side handle bars is as follows...**
    - **One base wooden component that contains divots where the rubber pegs of the rowing machine (at the front) enter into the base. This piece is parallel to the ground and therefore lays below the rower and uses its weight to hold the stability component in place. (1st Component)**
        - **Made of a 2'' x 6'' board. Divots will be made as the same dimensions as the pegs to ensure proper fitting and no external movements.**
            - **Length cut was 26 in**
    - **Two wooden pieces perpendicular to the base component, but parallel and on the ground, will come in an outward direction from the rowing machine. (2nd Component)**
        - **Length was 20 in.**
        - **Also made out of 2'' x 6'' boards.**
    - **Lastly, two additional wooden pieces are placed perpendicularly, parallel to a human while standing, and at the end of the previous components. (#rd Component)**
        - **Length was 29 in**
        - **Made out of 2'' x 4'' boards.**
    - **Straps will be added at the end of the 3rd component for adjustability of wheelchair height. Holes will be drilled for this.**

References:

[1] "Wheelchair with Brakes," *Karman® Wheelchairs*. https://www.karmanhealthcare.com/wheelchair-with-brakes/ (accessed Apr. 15, 2022).

Conclusions: Documents the stability design chosen. 3 main parts make up the design and will prevent tipping of the user. Manufacturing is nearly completed. Painting needs to be done, straps need to be attached.

Action items: Finish fabrication and begin testing

Explanation of Cost Matrix - 4/16/22

Dhruv Biswas - Apr 16, 2022, 12:56 PM CDT

Title: Explanation of Cost Matrix

Date: 4/16/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document why each purchase was made and how exactly it was used.

Content:

Current Table Version (few additional prints and purchases will be made in the coming weeks but nothing substantial, these will be documented and added in the team activities section):

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
Modeling Purchases								
Adaptable Pulley Stabalizer 3D-Print - Iteration 1	The initial 3D print of the component that attaches to the rower and stabilizes the second pulley for adaptable use	Makerspace	Transaction Number: 6907	3/30/2022	1	$15.44	$15.44	Printer Link
Adaptable Pulley Stabilizer 3D-Print - Iteration 2	The second 3D print for the stabilizing component. Adjustments were made to certain dimensions of the model to ensure a proper fit.	Makerspace	Transaction Number: 6948	3/31/2022	1	$15.28	$15.28	Printer Link
Final Design Components								
Adaptable Pulley Stabilizer 3D-Print - Iteration 2	Same as second entry in "Modeling Purchases"	Makerspace	-	-	0	$0.00	$0.00	Printer Link
Adaptable Pulley Stabilizer 3D-Print - Iteration 2; Mirrored Side	This print was a similar print to the interation 2 print, but it was for the other side of the rower. Some minor changes are present in this print due to differences present on this specific side of the rower. Basic structure and model is the same.	Makerspace	Transaction Number: 7061	4/6/2022	1	$28.16	$28.16	Printer Link

Wood for Side Handle Bar - Stabilization	Wood was obtained in order to build the side handle bars which will be used to prevent tipping while using the adaptable rower.	Menards	2x4-8 STUD/#2+B TR SPR 1021101	4/3/2022	1	$7.74	$7.74	2x4-8
Wood for Side Handle Bar - Stabilization	Wood was obtained in order to build the side handle bars which will be used to prevent tipping while using the adaptable rower.	Menards	2x6-8' STUD/#2&B TR SPF 1021758	4/3/2022	1	$11.99	$11.99	2x6-8
Buckle and Straps - Securing for wood stabilization	These buckles will be used to secure the wheelchair to the wood which will in turn be held in place by the rower.	CooBigo	CS023-25	4/11/2022	1	$8.03	$8.03	Buckle Link
						TOTAL:	**$86.64**	

- The Modeling Purchases represent purchases that required numerous iterations in order to reach the final component. This could be due to dimension errors between fitting parts, faulty prints, or any other printing related issues.
  - So far the team has two prints under this category, with the second iteration of the Adaptable Pulley Stabilizer acting as the final component.
  - A swiveling mechanism for the console has also been made by Josh on solidworks, this will be printed and its initial iterations will be placed within the Modeling Purchases category.
- The Final Design Components represent all the components that make up the final design. Note: some components will show up in Modeling Purchases and Final Design Components. However, the cost will be $0 in the Final Design Components section.
  - Two prints of the Adaptable Pulley Stabilizer were printed for each side of the rower. These will both be used to stabilize the additional pulley that will be attached for the adaptable side of the rower.
  - All wood went towards the side handle bars. Left over wood is still present. If time permits, it will be used to make additional support beams as advised by Dr. Puccinelli.
  - The Buckle and Straps were purchased to allow for wheel chair height variability during the strap in process for the side handle bar apparatus. They strap came in a 5 yard length coil which can be customized by the team. No length has been determined by the team as of right now.
- Future Purchases
  - Pivoting 3D part for console
  - Rubber stopper if the client is unable to find one

References: N/A

Conclusions: A brief description of how the BPAG table was setup by me. Most purchases have been completing, a few more prints will be made.

Action items: Finish fabrication, begin testing.

Team Lab Wood Drilling and Cuts - 4/16/22

Dhruv Biswas - Apr 16, 2022, 1:22 PM CDT

Title: Team Lab Wood Drilling and Cuts

Date: 4/16/22

Content by: Dhruv Biswas

Present: Dhruv and Sam

Goals: Cut wood into the dimensions need, make appropriate divots into the lumber

Content:

- **Note: This process took place on 4/11/22**



- **Sam and I had the opportunity to use the Team Lab to begin the fabrication process. The picture to the far right has the final cuts made by the team and some leftover wood. The bottom two components in that picture and the two middle ones were used for the side handle bars. The picture on the left and in the middle document the base of the side handle bar and how the divots were made for that component. The divots allowed the rower pegs to sit right into them and help stabilize the overall structure once fully fabricated.**
- **To create the cuts a miter saw was used. A drill was used, with a stopper for the appropriate depth, for the divots. It is important to note that the divot dimensions were either drawn (from the rower directly) or written onto the board. However, it was not possible for Sam and I to create perfect dimensions with a circular drill, so precision was limited to our eyesight, but after placing it onto the machine, the board fit in a snug manner. The dimensions and drawings on the board were followed closely.**

References: N/A

Conclusions: Sam and I went into the team lab and made the cuts needed for the side handle bar design. These cuts will be placed together to form the final design. Sam and I forgot to make the hole for the straps, but Sam and Josh completed that on 4/13/22.

Action items: Finish fabrication, begin testing

Testing Protocol Ideas - 4/16/22

Dhruv Biswas - Apr 16, 2022, 1:46 PM CDT

Title: Testing Protocol Ideas

Date: 4/16/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document how a testing protocol would look like for the 3 tests that will be conducted by the team

Content:

- **using a spring gauge measure both sides, survey, simulation**
- **Solidworks Simulation for Stresses and Deformation:**
    - **This was already completed. Entries "3/30/22 - Initial Pulley Plate Print" and "Review of Pulley for Adaptation Support - 4/14/22" by Josh and Dhruv respectively documents and reviews it.**
- **Spring Gauge Tests:**
    - **Before testing, use a team member to find standard distances between catch, drive, and recovery. These distances will be used as the three distances for both sides of the rower (standard and adapted).**
    - **Remove the handle bar from the rower while maintaining the loop that holds it. After removal, place the spring gauge into loop and tighten.**
    - **Use one team member to reach each distance with spring gauge and hold for 5 seconds, after 5 seconds record force value.**
    - **A total of 6 values should be present - 3 for each side.**
    - **Repeat 4 more times and take the average value and find standard deviation**
- **Survey**
    - **Make a survey with the following: Ease of use (Without use of legs), comfortability, Comparison with standard side, comments from subject**
    - **Subjects will be friends of the team members.**

References: N/A

Conclusions: Completion of these tests will occur within the next week. The spring gauge test will be the most important one as it should result in equal tensions on both sides of the rower. If not, a calibration curve needs to made or adjustments to the pulley.

Action items: Finish fabrication and begin testing

Final Testing - 4/22/22

Dhruv Biswas - Apr 22, 2022, 12:50 PM CDT

Title: Final Testing

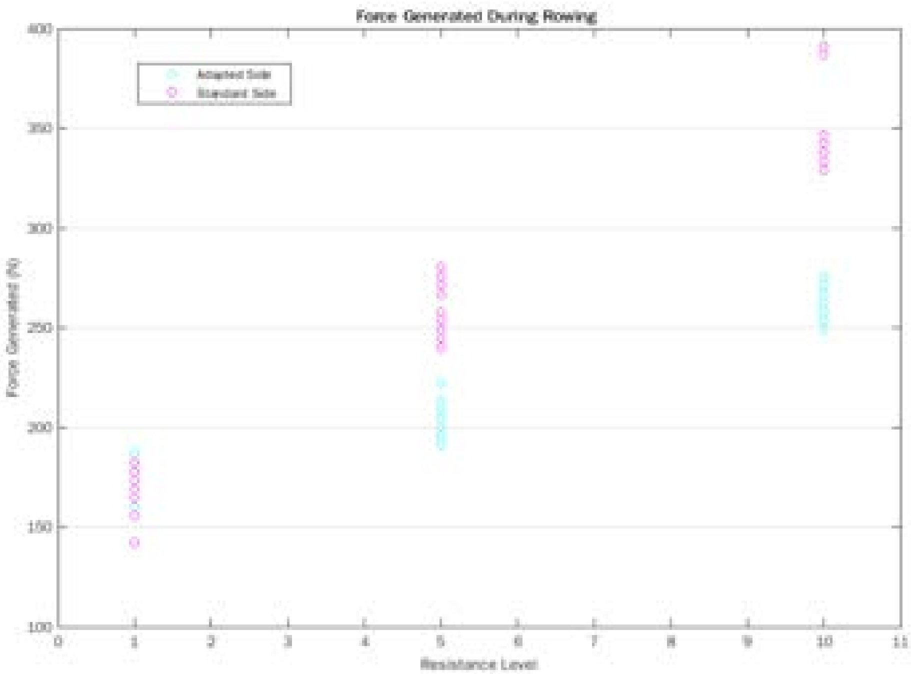
Date: 4/22/22

Content by: Dhruv Biswas

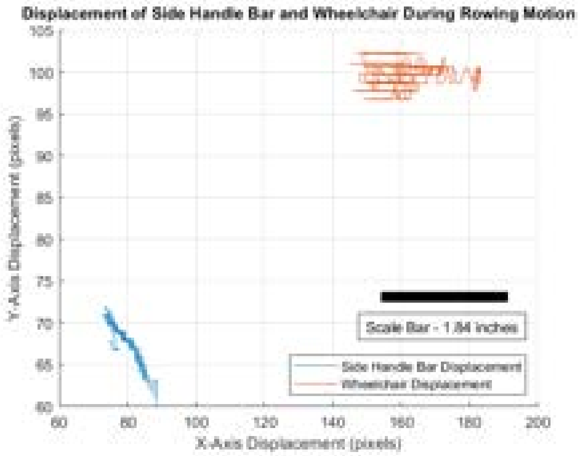
Present: During Testing: Tim, Cate, Sam, Josh

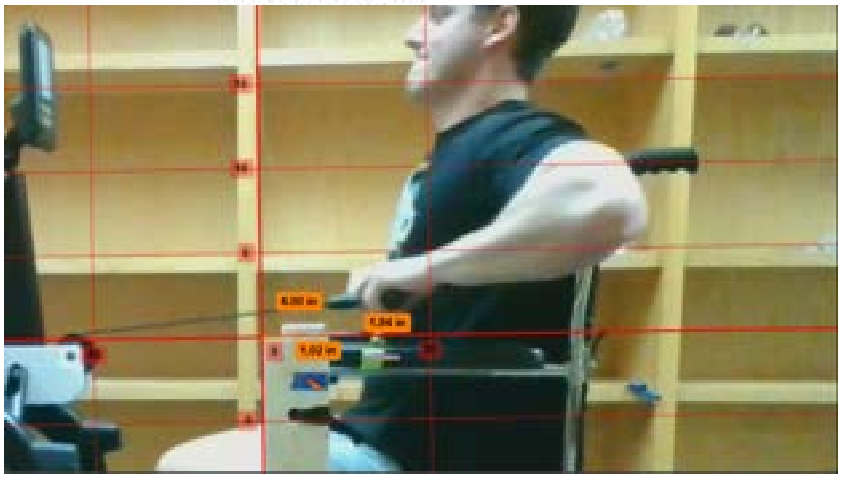
Goals: Document the testing process that was completed by the team yesterday

Content:

- **The team began with spring gauge testing of the two sides of the rower - adapted and standard.**
    - **This was completed to compare the force required to complete a standard rowing motion on the adapted versus standard side.**
    - **It was found that, in general, the adapted side output less force when compared to the standard side (occurred for resistance 5 and 10). However, this was not the case for resistance 1. Statistical tests can be run to see if there is a statistically significant difference.**
    - **The graph is below:**
    - 

- **A displacement test was run by Tim and I. This was done to analyze what the maximum displacement would be for the wheelchair and side handle bars during rowing. The analysis was completed on Kinovea and Matlab. Minimal displacement was seen. At the time of writing this, I realized that I should obtain a more accurate measurement for the 4" calibration line that I used for the displacements. Even though the wood is marketed as 4"x6", I remember my teammate Sam telling me that the actual dimensions are always 0.5" smaller than what is advertised. I will make the appropriate changes in the future. As of right now there was a displacement of 1.84 inches horizontally in the wheelchair and 1.02 inches in a northwest direction from the side handle bars.**
    - **Note: The subject was rowing at the maximum resistance during this trial (10).**
    - **Here are the final images and graphs from the analysis:**



- 

References: N/A

Conclusions: The displacements are most probably overestimated as of right now. Appropriate changes will be made within the next week. However, testing regarding force generation and displacement of components were conducted. The data from these tests were recorded and then analyzed. The analyzed data is included above.

Action items: Fix calibration line. Run a T-test for force tests.

Final Design Documentation - 4/23/22

Dhruv Biswas - Apr 23, 2022, 2:24 PM CDT

Title: Final Design Documentation

Date: 4/23/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document images of the final design

Content:

- 
    - **This image highlights the support plates for the pulley that was added by the team. The pulley plates attach to the metal support arms and extend outwards and away from the machine. The pulley is attached in between the two plates. The rope can be passed from the standard side to the adapted side through a slit that was made by Johnson Health Tech (using a solidworks file made by Josh).**
- 
    - **This swivel design was made by Josh on solidworks. Essentially it allows a user to turn the display on the rower in a direction that is desired. A peg and hole mechanism is used, therefore the whole display can be removed. The wiring is still intact and has been kept together using a zip tie.**

-  
    - **These last two images show the final design. It contains two support plates, a pulley, wood for the stability apparatus and straps to complete the stability portion. It is important to note, that brakes on the wheelchair should be used when completing a workout on the adapted side.**
    - **There is flexion in the inward direction (towards the users body), but minimal movement in a front and backwards direction relative to the user.**
        - **This is quantified in testing entries.**

References: N/A

Conclusions: The team has completed the final design. After woodworking, drilling, sanding, painting, 3D printing/designing, and a few bloody fingers, the team has made a final product. Minimal movement in the forward and backward direction has been promising. There is an inward torque in the direction that the user will not fall in. The only worry is that it might cause failure in the stability portion of the design, but will not cause the user to tip. Once this component is made out of metal, more stability should be seen.

Action items: Complete poster and paper.

Statistics and Updated Kinovea - 4/23/22

Dhruv Biswas - Apr 23, 2022, 2:40 PM CDT

Title: Statistics and Updated Kinovea

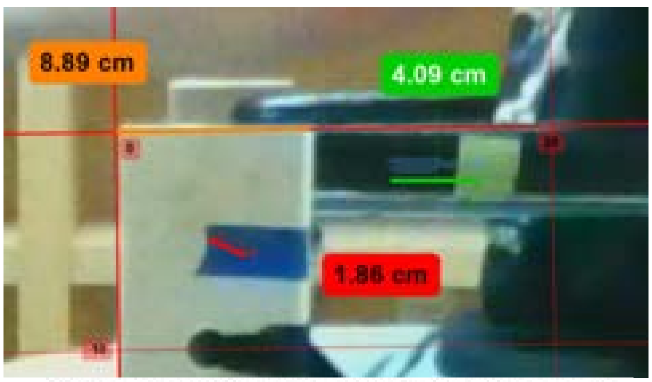
Date: 4/23/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document the updates to Kinovea and why I chose the Paired Sample T-Test

Content:

- **Update to Kinovea was needed to an incorrect calibration line. The calibration line was changed from 4 in to 3.5 inches. Additionally all units were changed to SI, therefore the units are now cm for displacement. The final results are below:**
- 

    - **Additionally, Dr. Puccinelli advised that the two images should have some sort of correlation between the similar parts. For example, the two wheelchair displacements should be the same color. The same for the side handlebars. This change has also been made. Arrows might be used in the final report and poster for further clarity.**
- **For the statistics for the Force Tension data, I decided to move forward with a Paired Sample T-Test for the 1, 5, and 10 resistance groups. The standard and adapted sides were compared to see if the mean force necessary to complete rowing machines were the same on both sides under varying resistance groups.**
    - **Paired sample t test because the same subject was used to complete rowing for standard and adapted sides for each resistance groups. Therefore, a correlation could be present and Paired Sample T-Test would be the appropriate test to use.**
- **A p value of 0.05 was used. If the two tailed p value is smaller than 0.05 then the group can reject the null hypothesis and conclude that the mean tension required is significantly different between the adapted and standard side.**

- **A two tailed P-value was used because the mean could be higher or lower between each of the two groups. It would be one tailed if the expected mean was directional (higher or lower). But the team did not want to assume that one side required less or more force because ideally they output equal forces.**
- **Final Results (Done on VassarStats): Significant differences in means for groups 5 and 10, but not for 1.**
- **Resistance 1:**

Data Summary

	A	B	Total
n	10	10	20
$\sum X$	386	375	761
$\sum X^2$	14952	14123	29075
SS	52.4	60.5	118.95
mean	38.6	37.5	38.05

Results

$Mean_a - Mean_b$	t	df	P		
				one-tailed	0.1231655
1.1	+1.24	9		two-tailed	0.246331

- **Resistance 5:**

Data Summary

	A	B	Total
n	10	10	20
$\sum X$	458	582	1040
$\sum X^2$	21020	33960	54980
SS	43.6	87.6	900
mean	45.8	58.2	52

Results

$Mean_a - Mean_b$	t	df	P		
				one-tailed	<.0001
-12.4	-9.12	9		two-tailed	<.0001

- **Resistance 10:**

Data Summary

	A	B	Total
n	10	10	20
$\sum X$	593	779	1372
$\sum X^2$	35209	60931	96140
SS	44.1	246.9	2020.8
mean	59.3	77.9	68.6

Results

$Mean_a - Mean_b$	t	df	P		
				one-tailed	<.0001
-18.6	-8.82	9		two-tailed	<.0001

References: N/A

Conclusions: I have made updates to the kinovea data in order to read them more easily, and to ensure the calibration curve is appropriate. Finally, I ran a Paired Sample T-Test due to the correlation present between the trials (same rower). The results are included above.

Action items: Complete poster and report.

Final FBD for Design Components - 4/23/22

Dhruv Biswas - Apr 23, 2022, 3:12 PM CDT

Title: Final FBD for Design Components

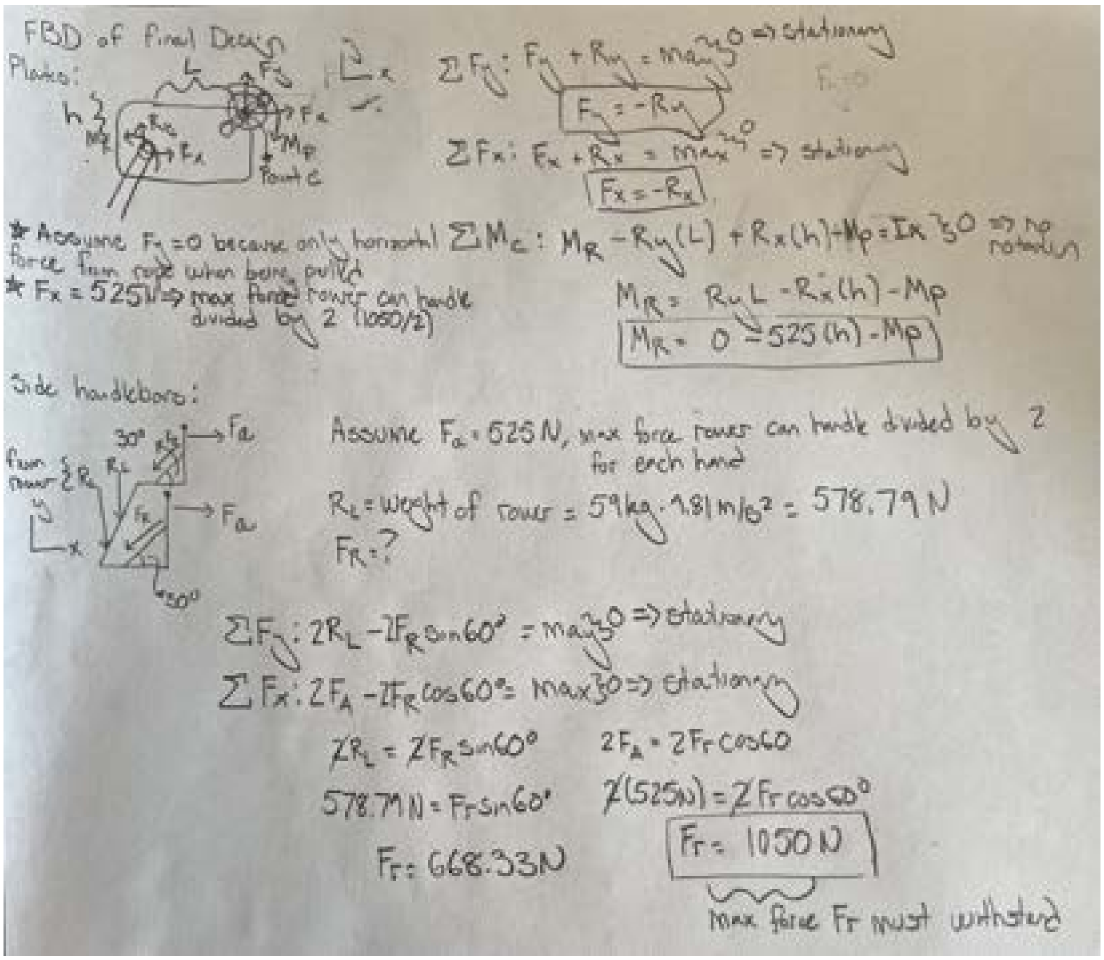
Date: 4/23/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Apply numbers and update FBD

Content:

- **Calculations:**
  - 
    - **Some numbers from the PDS and official specification document for the matrix document were included for my calculations above [1]. the added diagonal piece for the side handlebars should withstand up to 1050 N. Although this is extreme, and would probably not be attainable by most users. For the plates there were too many unknowns to calculate the moments.**

References:

[1] "Rower | Matrix Fitness - United States." https://matrixfitness.com/us/eng/group-training/cardio/rower (accessed Feb. 07, 2022).

Conclusions: A basic FBD was constructed for each component of the final design. It was found that the maximum force that the new diagonal piece of the side handle bar should be able to withstand 1050N of force. The calculations are included above.

Action items: Complete final poster and report

Impact and Final Design Thoughts - 5/3/22

Dhruv Biswas - May 03, 2022, 7:28 PM CDT

Title: Impact and Final Design Thoughts

Date: 5/3/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Document the number of people impacted by the design that was made by the team and final thoughts on the design,

Content:

- **Sam documented that there are 2.7 million wheelchair users in the U.S.**
- **It is essential to offer this demographic viable options for exercise equipment. Their disability should not limit their ability to stay fit.**
- **To address this, a standard rower (provided by Matrix/Johnson Health Tech) was adapted for wheelchair use.**
- **Not only does the design offer adaptive use, but still maintains the functionality of the standard rower. Therefore, the wheelchair community and the standard users can use this machine.**
- **I am proud of how the final design turned out. The team addressed all of the concerns that were covered in the PDS. In addition, the design is sleek (all black) and is simple to use once given instructions.**
- **Changing the material of the stability mechanism to metal will enhance the stability that is provided by the apparatus. Currently there is some displacement seen in the wheelchair and vertical bar of the stability device.**
- **The swivel device needs to be changed so that the user does not need to lift and place back the console in order to change the orientation. Instead it should be a smooth turning motion.**
- **Further testing will be needed with wheelchair users to garner feedback about the design.**
- **Overall, the design came out well and a few simple modifications need to be made in order to enhance the design further.**

References: N/A

Conclusions:

An effective design was completed and delivered to the client. My teammates and I are excited to hear her feedback and thoughts.

Action items: Submit Lab Archives to Canvas

2/3/22 - Questions for Client

Dhruv Biswas - Feb 03, 2022, 10:46 PM CST

Title: Dhruv Biswas

Date: 2/3/22

Content by: Dhruv Biswas

Present: Dhruv Biswas

Goals: Create questions for the client

Content:

Questions for the Client:

- Of the 4 rowing machine types, which one will the team be making modifications on? (Water, Air, Magnetic, Hydraulic)
- What is the overall goal of the project?
    - Are there specific requirements that you want the team to follow?
    - Will the user be capable of using their legs in any capacity?
- Should the user remain in the wheelchair, or would they ideally be placed into the adapted rower?
- Who is the target group for this machine?
    - Rehab patients?
    - Permanently disabled patients?
    - Athletes?
    - Age group?
    - Experience with rowing machines?
- Should the modification made by the team be reversible, so other users can use it in its standard form?
    - Are certain modifications off limits?
- Material preferences or constraints?
- Should the overall changes allow the patient to use the machine on their own?
    - Or is help allowed?
- What are the most important safety concerns?
- What is the budget?

References: N/A

Conclusions: These questions will be asked at the upcoming client meeting. The team would like to clarify the project and understand the exact criteria wanted by the client. After this is complete research will be done followed by design ideas. This work will be done in the upcoming weeks.

Action items: Begin research about rowing machines and the body mechanics needed to properly use the machine.

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

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

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items: