BME Design-Fall 2022 - ANNABEL FRAKE
Complete Notebook

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Table of Contents

Team contact Information

ANNABEL FRAKE - Sep 09, 2022, 2:32 PM CDT

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Project description

ANNABEL FRAKE - Sep 09, 2022, 2:35 PM CDT

Course Number:

BME 400, Lab 307

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.

12SEP2022 Initial Client Meeting

ANNABEL FRAKE - Sep 12, 2022, 2:06 PM CDT

Title: 12SEP2022 Initial Client Meeting

Date: 12SEP2022

Content by: Annabel Frake

Present: Annabel, Sam, Josh, Roxi, Tim, Ruby, Staci Quam

Goals: Talk to the client about expectations for the upcoming semester

Content:

- Ruby is now working part-time for JHT
- introductions to client
- Are there strengths/weaknesses from the previous design that you would like to point out?
    - think about material strength, had to adjust on neck piece the put width (if you remove too much, it becomes too flimsy)
    - likes how handle bar sits on back feet of rower when in adaptive position
- What are you hoping for this year?
    - if there is a different design path we want to go down, we can always get another arm
    - rotation up in console, is there a way to move it down by the base of the neck?
        - that would help with the rope tension issue
- support system for the wheelchair
    - make adjustable
    - make out of sturdier material
    - If we came up with a design for base, would JHT be able to fabricate out of same material used to make rowing machine?
        - metal is possible
        - the exact tubes will be harder because they are metric, not readily available
        - square or rectangular tube are easy to get
        - if we have lab where we can do the weld, that would be great experience
        - they have to give it to shop people there
        - try for at least 1 piece and then come back to them if we can't do it
        - before any cutting or welding, meet with Staci to do a design review
    - needs to be adjustable in width, heigh, and length
    - Josh's idea is to use a peg system
    - build structure out of 8020
    - she doesn't recommend final design for 8020, but they have 8020 that we can maybe do an initial design of
    - what needs to be adjustable and what doesn't
    - one of our gyms have matrix products, so go to get ideas
    - use them as inspiration

    - look at seat adjustments for sliding designs
    - want pin and hole type design since weight bearing
    - there are some clamp adjustments with frictional force, but more susceptible to false engagement
- budget for this year?
    - she will have to look it up, same as last year
    - this can be flexible, she can get approval for more money
- Improvements that we as a team want to make
    - improve bracket that twists display console
    - aided by electronics to include bioinstrumentation and make it more user friendly
    - mechanism to remove tension in rope
    - wheelchair base - accessible, adjustable, project worthy
    - being able to adjust resistance level from adaptive side
        - linkage system between the dial on adaptive side and standard side
    - chest support?
    - pulley plates rest on smaller arms, has strange geometry where it doesn't fit snuggly in SolidWorks
        - Instead of using SolidWorks to make cavity, can we do a forming thing?
        - Use mold to make sure it fits better
        - they don't have any official tools there and she isn't sure how we would do that
        - maybe use foam insulation to make mold
        - tricky getting it out of mold without breaking it
        - then use plaster?
        - seems like we are abandoning this and just making it work better in SolidWorks or have it rotate in a different area
        - Can remove whole base without removing tension in rope itself?
        - Intermediate hold while you move the handle? Just twist in the pulley?
- Does she want frequent meetings? Or as things come up?
    - try to do every other week
    - send her an email with availability

References: Stacy Quam and Ruby

Conclusions:

Based on the progress made last semester, the client suggested that we think about material choice again. She also said that we could switch to a new design and obtain a new arm piece if that is necessary. JHT may be able to help us with fabrication of metal components, but the client would prefer if we try to fabricate on our own first. The budget for this semester is the same as before, but is flexible if she can gain approval for more than that. We talked about the improvements we were considering making for the upcoming semester, and the biggest ones seem to be removing the tension in the rope, making the wheelchair support adjustable steel, and changing the console design to potentially be automatic. We currently plan on meeting with her every other week, but that can change as the semester progresses.

Action items:

1. update the client requirements within the PDS based on this meeting's content
2. start brainstorming how to implement the improvements

3. send the client time options for a meeting every other week

30SEPT2022 Client Meeting

Roxi Reuter - Sep 30, 2022, 8:19 PM CDT

Title: Client Meeting

Date: 09/30/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Talk through design matrices and address any of Staci's questions about the designs

Content:

- Staci wanted a design explanation of the rower antlers, so Josh explained the design idea to her and was able to show where they would be located on the rowing machine
- Staci wanted to know if there was any way the console could be centered
    - As a team, we were not able to come up with a design that does this without excess material and a bulky design
- Staci wanted to challenge us with the following:
    - Move the button to the adapted side for accessibility
        - Annabel suggested methods for one button or two buttons
    - Hinge design for stabilization design?
        - Hinge for lap bar could trigger the turning of the console
            - Limit switch could help this
- Staci offered 80/20 material if we needed to experiment with it
    - Might be easier to go straight to the metal
- Tim asked about materials for changing the design of the diagonal bar for the bar-in-bar stabilization
    - Staci will review products at JHT for this, but we might need to buy or fabricate some yourself
- Staci will be sending us a presentation of ideas on locking mechanisms from current JHT equipment

Conclusions/action items:

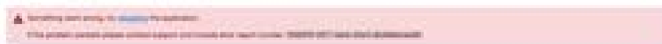
Staci gave us some great ideas for our designs, and she will be sending us information on locking mechanism ideas that she mentioned (common to other JHT products). The team will be moving forward with the design concepts chosen in the design matrices and will work on the preliminary presentation over the next several days, as it will take place in one week.

14OCT2022 Client Meeting

ANNABEL FRAKE - Oct 15, 2022, 2:44 PM CDT

This entry was uploaded the day after the meeting because I was having issues with LabArchives. It would not load the notebook in my browser. The issue is resolved now.

ANNABEL FRAKE - Oct 15, 2022, 2:41 PM CDT



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ANNABEL FRAKE - Oct 15, 2022, 2:41 PM CDT

Title: 14OCT2022 Client Meeting

Date: 14OCT2022

Content by: Annabel Frake

Present: Annabel, Josh, Sam, Roxi, Tim, Staci Quam

Goals: touch base about the design status

Content:

- we answered her questions about the prelim design
- she agrees with us about the resting position of the lab pad, but she thinks it would be best to have it upright
- i asked about ensuring that users return it to upright so that the limit switch works
- she said people are more likely to leave it like they found it and we could add a sign
- she suggested that we may not need a horizontal bar adjustment because the rotation of the bar would cover height and distance from the machine
- we expressed concern that it may not offer enough adjustment
- she said to get people of various sizes to test it out
- i explained that I wrote the coding flowchart assuming polling with stepper motors, but we could change it
- i may do testing with both polling and interrupting and see if we could put the Arduino in sleep mode to save on power consumption
- Sam asked about the prototyping process
- when they are ready, let her know in the progress report and they can setup a time to go to JHT
- we are going to make a proof of concept prototype, then one that looks better, and then hand off to JHT for final design and fabrication

References: none

Conclusions:

We discussed our answers to her questions. The lap bar will rest upright in an unused position. We are going to test whether we need a horizontal adjustment. We will explore polling vs interrupting. We will contact her when we are ready to fabricate at JHT.

Action items:

1. contact Staci when ready to go to JHT

28OCT2022 Client Meeting

Roxi Reuter - Oct 28, 2022, 3:18 PM CDT

Title: Client Meeting

Date: 10/28/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Update Staci on project progress
- Confirm a meeting date at JHT

Content:

- Meeting date at JHT: next Friday 11/4 after show and tell (around 3-4:30PM)
  - Can do a little tour of the facility
- Josh showed Staci the pulley plate design and asked about printing at higher infill out of tough PLA instead of welding with metal due to complex design
  - Staci can talk to model shop guys to see if we could fabricate it with plastic (milling it with plastic)
  - Staci suggested changing the geometry slightly of the antler arm (diagonal member instead of L-shaped design)
- Josh also explained and showed the motor housing on SolidWorks
  - Staci didn’t think that a fan would be necessary
  - Overheating issue: 12V power supply may be causing this (Staci suggested maybe looking to make sure we aren’t supplying too much power in terms of volts and amperage)
- Tim has a document with estimated bar lengths, so Staci will be going through the materials at JHT to streamline our time there a little bit
- Staci also has limit switches which we can use, and she will be showing those to us when we go to JHT on Friday 11/04.

Conclusions/action items:

During the client meeting, the team updated Staci on the project progress and money that has been spent this far. The team will be going to JHT next week (Friday 11/04) following show and tell to tour the JHT facility in Cottage Grove and to start fabricating the stabilization frame.

18NOV2022 Client Meeting

Roxi Reuter - Nov 18, 2022, 2:01 PM CST

Title: Advisor Meeting

Date: 11/18/2022

Content by: Roxi Reuter

Present: Tim, Josh, Annabel, and Roxi

Goals:

- Discuss project progress
- Ask about stabilization materials and fabrication

Content:

- Josh showed Staci the new SolidWorks pulley plate design (moved up the location of the added pulley so the stabilization frame can fit)
  - Josh is printing the final models today out of tough PLA at 100% (or highest possible) infill
- Annabel showed Staci her circuit updates
  - Added solder board
- Stabilization frames:
  - Feedback from Staci on Sam's SolidWorks stabilization design (roller coaster edition) - the thickness of the bar may need to be increased
  - Screws and bolts dimensions - we can use the size that we used at JHT or we can drill out the holes to be bigger if needed
    - JHT pretty much has all sizes that we will need for bolts (M6, M8 is best bet but could probably go up to M10)
  - Lap pad from JHT - all one piece
  - Width of bars used for stabilization frame - Staci can give us feedback on what widths we decide on
    - Staci suggested FEA (this will help narrow down the size options)
  - Angle adjustment - not standard pieces. We will need to design this angle adjustment mechanism and design it at the fabrication shop at JHT.
  - Materials list - usually does not take too long to get materials (usually within a day or two after signature from Staci's boss if needed
    - Gas assist - for future semester
    - Can make drawings for materials (page with picture of bars and dimensions)

Conclusions/action items:

During this client meeting, we gave Staci a quick project update. Tim will be sending Staci the materials list and drawings. Since there will be a time delay for obtaining materials (approval and cutting) and next week is a short week due to Thanksgiving, we told Staci we would like to pick up the materials by the Monday after Thanksgiving (11/28).

9SEP2022 Initial Advisor Meeting

ANNABEL FRAKE - Sep 09, 2022, 2:46 PM CDT

Title: 9SEP2022 Initial Advisor Meeting

Date: 9SEP2022

Content by: Annabel Frake

Present: Annabel, Sam, Roxi, Josh, Tim, Professor Tracy Puccinelli, BME design

Goals:

-meet with advisor

Content:

- Meetings with Tracy for the next 2 weeks will be virtual
- Then we will have the outreach meeting in person
- We will have 30 min advisor meetings weekly - have communicator email her time options (list as many as possible)
- We will have weekly participation grades for notebooks - SO KEEP UP

References: none

Conclusions:

During the initial advisor meeting, we met with Tracy briefly and she talked about her expectations for the semester. We will have weekly notebook checks, which is a new development for the team. After that, we had a team meeting to discuss first day activities (see "9SEP2022 Initial Team Meeting" in the Team Meetings Folder).

Action items:

1. have communicator send Tracy options for weekly meeting times on Fridays

16SEP2022 Advisor Meeting

Roxi Reuter - Sep 16, 2022, 2:08 PM CDT

Title: Advisor Meeting

Date: 09/15/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss project goals with our advisor, Tracy
- Explain the previous semester's progress and get general feedback on design ideas
- Talk about grading changes (notebook checks)

Content:

- Josh started off by giving a brief overview of the progress last semester
- Then, we discussed budget with Tracy
  - As of now, Staci gave us a $200 budget that is flexible
  - If we need further funds (other than the $200 provided), Tracy recommended sending the funding request form to our client
- Tracy mentioned possibly having a specific person interested in this device. If so, we should gear the design towards their specific wheelchair dimensions.
- Most people with disabilities use powered wheelchairs?
  - Look into research on this since it may affect the adjustable frame dimensions
- We went through notebooks with Tracy and discussed future meeting plans
  - Weekly Friday meeting sat 1 PM either on Zoom, in-person, or alternating
- Next week: BME Outreach Meeting from 12:05 to 1:30 PM, with short advising meeting (about 10 minutes) to follow.
  - Possibly going to ECB with Tracy to view the rower

Conclusions/action items:

During this advisor meeting, we introduced the project to Tracy and discussed progress that was made last semester. Areas of improvement were also mentioned, and client budget was a topic included in this discussion. If a larger budget is needed, BME offers a funding request form which can be sent to the client. Each team member went through their individual notebook and presented their progress from this week and last.

For the coming week, Tracy suggested each team member do individual brainstorming and document the design ideas in LabArchives before meeting as a team to discuss these ideas so that everyone can contribute. The BME outreach meeting is happening next Friday (09/23) and conflicts with normal advising meeting times. We will meet with Tracy following the meeting (approximately 20 minutes afterwards) for 10 minutes and possibly walk over to ECB to see the rower in-person. Additionally, the PDS is due next Friday, so that is something the team should be working on, as well.

23SEP2022 Advisor Meeting

ANNABEL FRAKE - Sep 23, 2022, 2:53 PM CDT

Title: 23SEP2022 Advisor Meeting

Date: 23SEP2022

Content by: Annabel Frake

Present: Annabel, Josh, Tim, Sam, Roxi, Prof Tracy Puccinelli

Goals: update our advisor on our brainstorming process, discuss design matrices

Content:

- she will look at notebook on Monday
- expect to see research in areas that we are planning to change
- she needs to see how we contributed to the PDS (our team notes indicate who was in charge of updating which sections and then we uploaded the PDS to the project files in LabArchives)
- we should each have our own design ideas in addition to the group brainstorming
- told her about the antler design
- we didn't have time to show her the rower in person, but I had pictures of the rower for her to look at
- we need to make sure the angle at which you we rowing represents the rowing motion (client concern)
- when we meet with the client next week, we should present our ideas as if it is the prelim design so we can get feedback and get going
- during preliminary designs, make sure we tell them it is a continuing project and give context
- we explained our design matrices to her and she said that we didn't need to create one for the linear actuator vs antler design
- because it is an improvement to the current design, we just have to give context and explain what we plan to do
- therefore, we are doing a design matrix for the console and stabilization frame only
- we need to let her know if we prefer an in person or virtual meeting for next week

References: Prof Tracy Puccinelli

Conclusions:

We explained the antler design idea to tracy using sketches and pictures of the current rower. She suggested that we don't need to create a design matrix for the linear actuator vs antler design choice because we already made the decision. I wasn't sure if we still needed to document that decision using the matrix, but it is discussed in our meeting entries and the choice is pretty straight forward. She told us to provide context during the preliminary presentation so that our audience knows this is a continuing design. She also suggested that we present our ideas to the client as if it were preliminary presentations when we meet with her next week. This way, we can get immediate feedback and start going.

Action items:

1. discuss whether we want an in-person or virtual meeting next week and relay that information to Prof Tracy Puccinelli

2. work on the design matrices

30SEPT2022 Advisor Meeting

Roxi Reuter - Sep 30, 2022, 8:19 PM CDT

Title: Advisor Meeting

Date: 09/30/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss design matrices and the preliminary design

Content:

- We discussed the design matrices with Tracy
    - For the design sketches on the console, manipulate the images since it's a little difficult to tell the difference between them
    - Stabilization design matrix
- Up to us if we want to include the design matrices
    - Don't need to include stabilization design matrix for improvements
- Next week: electronics workshop in the Makerspace on motors
    - In general, work with the Makerspace to determine motor requirements
- PDS feedback next week
- Tracy is offering an office hour next week 2-3PM if we want any feedback on our presentations
- On report
    - Summary paragraph for previous work and reference it as needed
    - Focus on what we're doing this semester in the report
- Preliminary design presentations in the Tong lecture hall

Conclusions/action items:

During this meeting, the team explained design ideas to Tracy and asked questions about the preliminary presentation. The team has a better understanding of how to format the preliminary presentation since this is a continuing project and not all the same requirements apply to the project. The team will be working on the prelim presentation through next week and present it on Friday. Additionally, we will be receiving PDS feedback early next week, which the team will be using to improve the document before preliminary deliverables are due.

14OCT2022 Advisor Meeting

ANNABEL FRAKE - Oct 15, 2022, 2:44 PM CDT

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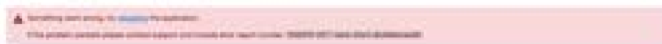
ANNABEL FRAKE - Oct 15, 2022, 2:42 PM CDT



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ANNABEL FRAKE - Oct 15, 2022, 2:42 PM CDT

Title: 14OCT2022 Advisor Meeting

Date: 14OCT2022

Content by: Annabel Frake

Present: Annabel, Josh, Sam, Roxi, Tim, Dr. Tracy Puccinelli

Goals: touch base about the design status

Content:

- she showed us the rubric for our prelim presentation and told us good job
- we shared our notebook entries for the week
- we discussed what we are going to do next
- she usually recommends small scale prototypes first, but because we are so far along, we could probably just jump right in
- she asked about purchasing materials
- she lives next to JHT, so she told us that she could pick up materials if we needed her to
- if we go to JHT for a tour, we should let her know
- we gave some feedback on the new peer eval system - don't require people to list a con

References: none

Conclusions:

We did a great job on our prelim presentation. We shared our notebooks and discussed next steps.

Action items:

1. ask Staci about materials
2. start building a prototype

28OCT2022 Advisor Meeting

Roxi Reuter - Oct 28, 2022, 3:18 PM CDT

Title: Advisor Meeting

Date: 10/28/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss project progress and show and tell

Content:

- Show and tell next Friday in Tong lecture hall
- Think of questions for show and tell
- Run elevator pitch by Tracy if we would like
    - Put BME 400 as subject for email (with space)
- A few comments on preliminary report, so take a look at that
- Testing plans (preliminary):
    - SolidWorks - tensile testing to identify the weakest points (and if possible do this in person, otherwise we will do it next semester if we don't get to it this semester)
    - Stabilization frame - making sure pad prevents from falling forward or tipping backwards, ensuring brakes from wheelchair are sufficient to prevent backward motion of wheelchair
        - Use motion sensors but may need to be careful with human subjects for testing (look into IRB - institutional review board)
            - Start this process now!! Need to make sure this process is exempt before we can proceed
            - Can be a tedious process so might be good to start over winter break
            - Tracy will help us with this (she's our PI in this case)

Conclusions/action items:

During this advisor meeting, the team discussed show and tell, as well as a bit on the preliminary report. Additionally, the team updated Tracy on design progress and prints.

11NOV2022 Advisor Meeting

ANNABEL FRAKE - Nov 11, 2022, 5:41 PM CST

Title: 11NOV2022 Advisor Meeting

Date: 11NOV2022

Content by: Annabel Frake

Present: Annabel, Roxi, Josh, Sam, Tim, Dr. Tracy Puccinelli

Goals: touch base about design progress

Content:

- Stabilization frame
  - built prototype
  - model in CAD
  - Sam has initial layout, still need to add bar that rotates down
  - next Friday, send model to Staci, they will cut the bars
  - thing to consider, not interfere with rowing motion
  - can we test with PVC or cardboard first?
  - have Staci cut both designs and try both? (Sam to ask her)
  - can have Dr. Tracy Puccinelli send her email saying she wants us to try both (or use materials at the MakerSpace)
  - lap pads from JHT
- CAD (Antlers and electronics box)
  - update goal posts for D shaft
  - updates to electronics box
  - chopped off top of antlers
  - semi-final version printed next Tuesday
  - then final print
  - Staci can't mill because wastes too much
  - simulation tests this semester: where pulley sits and at first joint from handle
  - next semester: MTS machine, let it fly
- Electronics
  - updated motor controller
  - make code more efficient
  - vibration
- IRB
  - start as soon as possible
  - list Dr. Tracy Puccinelli as PI
  - have to include protocol
  - then hopefully they would say exempt
  - not clinical trial
  - low-risk
  - need to identify any potential risk
    - electronics, pinch points, if they drop it on themselves
    - how to ensure that it won't happen
    - what you are going to say to them

References: none

Conclusions:

During our advisor meeting, we updated Dr. Tracy Puccinelli on our progress the past two weeks (since we didn't meet last week - Show and tell). We told her about our visit to JHT, and she recommended that we mock up our stabilization frame design using cardboard or PVC to get a better understanding of how things will be spaced. She supports our preference for testing both a roller coast like design and a design where the bar comes down from the top.

Action items:

1. meeting next week will be in person unless she tells us otherwise

2. keep making progress on the design

3. think about mocking up the stabilization frame with cardboard or PVC

18NOV2022 Advisor Meeting

Roxi Reuter - Nov 18, 2022, 1:32 PM CST

Title: Advisor Meeting

Date: 11/18/2022

Content by: Roxi Reuter

Present: Tim, Josh, Annabel, and Roxi

Goals:

- Talk about design progress and updates
- Ask about outreach activity

Content:

- Tracy encouraged us to explore the rollercoaster design for the stabilization frame
- Josh showed Tracy the new SolidWorks pulley design (the second pulley is moved up)
  - He informed her that he will be doing final prints at 100% infill
- Annabel talked about the motor vibration issues; however, this is not present anymore since we purchased the new D-shaft motor
- Activity guide: what we're thinking about
  - Middle schoolers
  - Potato/battery activity
  - Turn in activity guide template explaining
- I updated Tracy on the IRB ARROW application
  - I plan on slowly working through that throughout the remainder of the semester, and we will do the bulk of it over winter break
  - Tracy said if anything comes up, I can
- In terms of testing, we can focus on what we changed this semester. Testing data from last semester is still valid for tension testing.
  - We will focus on testing the frame and the circuit design.
- Tracy recommended taking a look at preliminary report comments again because the final report will be due soon

Conclusions/action items:

Tracy received project updates from the team. She told us to reach out for help if we need anything in terms of testing as we continue working on that after Thanksgiving break.

02DEC2022 Advisor Meeting

Roxi Reuter - Dec 02, 2022, 4:26 PM CST

Title: Advisor Meeting

Date: 12/02/2022

Content by: Roxi Reuter

Present: Sam, Roxi, Josh

Goals:

- Look over outreach activity outline
- Show Tracy the rower and demonstrate how it works
- Discuss testing that we performed (verify that we tested all the necessary resistance testing cases)

Content:

- Outreach activity is good to go
  - Turn in with final deliverables this semester
- We described our integration and testing process to Tracy
- Then, we visited the rower in the green room
- Josh demonstrated rowing from the adaptive side and the turning of the console
- We confirmed with Tracy that we did motion capture testing for all the necessary cases (extreme resistances: 1 and 10), and since there was no significant movement in either case, Tracy said we do not need to test any middle cases
- Tracy will be available Wednesday (12/07) to give feedback on the poster via Zoom
  - As many team members should attend this as possible

Conclusions/action items:

The team has a working design and carried out testing this week! Tracy loved the design. The team plans on working on the poster over the weekend and meeting on Monday (12/05) to edit the poster. Practice for the final poster presentation will take place on Thursday (12/08).

7DEC2022 Poster Feedback

ANNABEL FRAKE - Dec 07, 2022, 6:12 PM CST

Title: 7DEC2022 Poster Feedback

Date: 7DEC2022

Content by: Annabel Frake

Present: Annabel, Josh, Roxi, Tim, Sam, Dr. Tracy Puccinelli

Goals: receive feedback on final poster

Content:

Here is a list of her suggestions (Notes taken by Roxi and sent to the group chat):

- No abstract
- Choose more descriptive titles for background and motivation
- Need dimensions to scale rower in image
- Put in CAD of the design since we are taking about the abstract (bottom left of the poster)
- On testing pictures, add in force with arrow
- Introduce graph very well during presentation (place in a picture of wheelchair with coordinate system so it is more intuitive); it is telling you location within the software
- "Design Shortcomings" —> "Areas for Improvement"
- Maybe add in a flowchart for testing??
- Future work is a little wordy (delete some fluff and leave a little space to separate future design iterations and future testing)

References: none

Conclusions:

We met with Dr. Tracy Puccinelli today to get her feedback on our poster before printing it.

Action items:

1. make the edits

9SEP2022 Initial Team Meeting

ANNABEL FRAKE - Sep 09, 2022, 2:47 PM CDT

Title: 9SEP2022 Initial Team Meeting

Date: 9SEP2022

Content by: Annabel Frake

Present: Annabel, Sam, Roxi, Josh, Tim

Goals:

-assign team roles

-complete first day tasks

-discuss upcoming week events

Content:

- Team Roles:
    - Josh - communicator (has existing rapport with Stacy)
    - Roxi - BPAG
    - Tim - BWIG
    - Annabel - Team Leader
    - Sam - BSAC
- We discussed briefly everyone's individual role tasks for first day activities
- Josh sent Tracy an email about advisor meeting times for Friday (during 12-2pm time frame)
- We are planning on holding weekly team meetings either before or after the advisor meeting (TBD) for general updates, etc.
- Josh also emailed the client about an initial meeting for next Monday (Sep 12th) anytime after 12 pm
- We are meeting next Wednesday (Sep 14th) to begin the onboarding process for Roxi and I (everyone else on the team had this project last semester). We are meeting in ECB from 2:15-3:15 pm
- After the teams meeting, Sam showed Roxi and I the current design in ECB (onboarding will be continued next Wed)

References: none

Conclusions:

After our initial advisor meeting (see "9SEP2022 Initial Advisor Meeting" in the Advisor Meetings Folder), we had a team meeting to discuss first day activities. We assigned team roles and talked about setting up meetings for the upcoming week. We will each work on our individual tasks and prepare for the meetings next week. Roxi and I will also start the onboarding process by reviewing the previous notebook, reading research articles, etc. since we are the two members who are new to the project.

Action items:

Upcoming meetings:

1. Monday Sep 12th (afternoon TBD) on zoom/teams - meet with Stacy
2. Wednesday Sep 15th (2:15-3:15 pm) in ECB - Team meeting to discuss current design
3. Friday Sep 17th (TBD) on zoom/teams - advisor meeting

To Do:

1. Swap enrollment

2. Complete individual role tasks for first day activities
3. Upload photo of yourself to google drive for Tim
4. Update google drive for design improvement ideas
5. Annabel and Roxi: onboarding (ie look at previous notebook, read articles, etc.)

14SEP2022 - Discuss Semester Goals and Plans

Josh ANDREATTA - Sep 14, 2022, 7:21 PM CDT

Title: 14SEP2022 - Discuss Semester Goals and Plans

Date: 14SEP2022

Content by: Josh Andreatta

Present: Annabel, Sam, Roxi, Josh, Tim

Goals:

-meet and look at rower to brainstorm design options for goals we have for the semester

Content:

- Wheelchair support frame
    - Want to make out of metal pipes that are adjustable
    - Mimic adjusting pins from other Matrix Equipment
    - If we conceptualize this well, we can just fabricate it without needed to model it in SolidWorks, unless the nice image of a solid model is necessary for the report
    - Need to be adjustable in width, length, and height
    - Need to improve strapping mechanism to attach the wheelchair to the frame itself
    - Sam and Tim to try to get to welding pass to weld any metal components together
- Josh to work on improving pulley plate design and updating display console so that it just has one peg and spins in its center hole
    - May want to trim neck down and screw display console into lower hole to have console at same height as in traditional rower
- Removing Tension from rope
    - Create a mechanical structure to hold a linear actuator
    - Use mechanical clamp to grasp the rope to remove tension, and use linear actuator to move the rope up to give it slack so it can easily be transitioned to the other side
    - Will need to move handle resting location on traditional side closer to pulley so that the user does not have to lean very far forward when grabbing the rope to move from one side to the other
- If time permits, work on mechanical structure to change resistance level, but first focus on making a fully adjustable wheelchair frame, adding the mechanism for removing the tension, and updating the display console swivel bracket and pulley plates (includes making all components out of metal to be finished product worthy)
- Will split into two teams (2 and 3 member) to tackle the wheelchair frame and removing tension in rope to be efficient

References: none

Conclusions:

We met and looked at the rower to brainstorm what design changes we want to accomplish. We decided it would be best if we split into two teams to tackle the two large goals of the project and work together as a group to still make sure we are all on the same page for next steps.

Action items:

Upcoming meetings:

1. Friday Sep 17th (12:30-1) on teams - assign PDS sections and set time to edit PDS
2. Friday Sep 17th (TBD) on zoom/teams - advisor meeting

To Do:

1. Complete preliminary research
2. Begin brainstorm design ideas

16SEP2022 Team Meeting

Roxi Reuter - Sep 16, 2022, 1:53 PM CDT

Title: Team Meeting

Date: 09/16/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Schedule meeting to review PDS
- Check in on brainstorming ideas and research found this past week
- Set up meetings for brainstorming next week

Content:

- We decided to schedule a meeting for Wednesday (09/21) to go over the PDS from 2:15-3:15 PM
    - Everyone should come with their portion of the PDS completed
- We went through the PDS and noted areas that need to be updated
- PDS assignments:
    - Roxi - Performance requirements
    - Sam - Materials / Aesthetics
    - Annabel - Safety
    - Josh - Client Requirements
    - Tim - Ergonomics
- A brainstorming meeting is planned for Monday afternoon, either virtually or in person
    - Do individual brainstorming sessions before then and document it in LabArchives
    - Waiting on scheduling a specific time because Sam may have a conflict

Conclusions/action items:

This short team meeting allowed us to touch base with each other and look at upcoming project deadlines. The PDS is due next Friday (09/23), and we discussed a plan of action to complete that assignment: individually assigning components after reviewing the PDS as a team, and we will meet next Wednesday (09/21) to edit the document before turning it in.

Additionally, we want to get straight into designing and completing necessary research so that our design is finished and in the hands of the client by the end of BME 402. We scheduled a brainstorming meeting for Monday afternoon; however, each member should brainstorm ideas individually before then.

19SEP2022 Design Brainstorming Meeting

Roxi Reuter - Sep 19, 2022, 3:04 PM CDT

Title: Brainstorming Meeting

Date: 09/19/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss ideas that we brainstormed for the adapted rower design
- Talk about response from Staci (meeting times and budget)

Content:

- Staci emailed us back this morning to let us know that she was approved for a $500 budget
  - Josh will be emailing her back to clarify if that budget is for the year or just the semester
    - Update: $500 for the whole year; however, Staci can get approved for further funding if needed
- Meeting times with Staci will be bi-weekly to start from 1:30-2PM
  - We will begin meeting next Friday (09/30)
- Annabel’s tension removal idea:
  - Placing the handle just above the pulley, with an antler-like design that is open in the middle. This way, the hand bar is in a neutral position and doesn’t require any slack when using the rower on the normal or adapted side.
  - Possible issue: console placement (not centered), but we can slightly offset the console so that it is still easy to view and access, and it pivots to be viewed from either side. The current console support bar would be removed
- Other ideas:
  - From Roxi: Just using a lap pad / lap support instead of an entire adjustable frame (inspiration from AROW competing design)
    - An adjustable frame may be hard to manipulate by the wheelchair user alone and can get heavy
    - A lap bar would allow for more variation in size of wheelchairs and prevents tipping

Conclusions/action items:

The team took time to discuss design ideas which would work towards meeting our client’s wants and needs, while also brainstorming new ideas while viewing the rowing machine. The team will be meeting Wednesday virtually to conclude the PDS edits and begin working on design matrices. Before then, each member should dedicate time to additional brainstorming and sketching some of the concepts talked about today.

21SEP2022 Team Meeting

ANNABEL FRAKE - Sep 21, 2022, 11:00 PM CDT

Title: 21SEP2022 Team Meeting

Date: 21SEP2022

Content by: Annabel Frake

Present: Annabel, Josh, Sam, Roxi, Tim

Goals: review the PDS for submission and discuss the design matrices

Content:

- we met on Teams to review the updates everyone made individually to the PDS
- we noticed that we had dimensions in the ergonomics section and didn't have a size section
- after checking the PDS specifications rubric, we realized that the PDS from last semester was missing that section
- we created a size section and moved the dimensional information there
- I had noticed that the standard they cited was withdrawn, so we updated it to the new standard
- we are going to use Zotero as a citation manager
- Sam created a working folder for this class and shared it with everyone
- Tim is going to demonstrate how to use Zotero at one of our upcoming in person meetings
- we ran out of time and were unable to discuss the design matrices, so we will do that before/after the outreach seminar and advisor meeting on Friday
- Please see the PDS entry under the Project Files folder

References: none

Conclusions:

During today's meeting, we edited and reviewed the PDS document for submission. We are going to use the citation manager Zotero and Tim offered to demonstrate how to use it at an upcoming meeting. We have the outreach seminar and an advisor meeting this Friday. Before/after the meeting, we will discuss the design matrices and schedule meetings for next week.

Action items:

1. Josh to email the PDS to the client and advisor
2. Tim to upload the PDS to the website
3. fill out the progress report for this week
4. attend the outreach seminar on Friday, as well as our advisor meeting
5. discuss design matrices on Friday

23SEP2022 Team Meeting

ANNABEL FRAKE - Sep 23, 2022, 4:38 PM CDT

Title: 23SEP2022 Team Meeting

Date: 23SEP2022

Content by: Annabel Frake

Present: Annabel, Josh, Sam, Roxi, Tim

Goals: discuss the plan for the upcoming week, split up work for the design matrices

Content:

- Design Matrices
  - Console
    - 2 pivot points (like dentist arm)
    - horizontal pin (based on current design)
    - use stepper motor
  - Ease of Transition
    - Antlers
    - Linear Actuator
  - Stabilization Frame
    - adjustable frame (based on current design)
    - lap bar
- Break out groups
  - ease of transition: Josh, Roxi, Annabel
  - stabilization frame: Sam, Tim
- rate designs all together so that we can get an "outsider's" opinion
- virtual meeting to rate designs: Tuesday, Sep 27th (4-5:30ish pm)
- meeting with my sub-group: Sunday, Sep 25th (2-3pm) virtual
- Drawings for my sub-group:
  - Annabel: alter Roxi's antler drawing to include a stepper motor
  - Josh: change console rotation mechanism in SolidWorks to have channel and horizontal pin
  - Roxi: changing general format of image so handle bars come off of the pulley plate; from that, generate the 1 pivot point and 2 pivot points design sketches
- after our advisor meeting, we re-grouped to confirm that we aren't creating a design matrix for the linear actuator vs antler design

References: none

Conclusions:

During the first part of the meeting, we created a plan for 3 design matrices: linear actuator vs antler design, 1 pivot vs 2 pivots vs stepper motor for the console rotation, and adjustable frame vs lap bar. We confirmed our sub-groups to be Roxi, Josh and I for the console and ease of transitioning projects and Sam and Tim for the stabilization project. We met with Prof Tracy Puccinelli in the middle of our group meeting. After speaking with her (see "23SEP2022 Advisor Meeting"), we decided not to do a design matrix for the linear actuator vs antlers design because we had already chosen to pursue the antler design. We will phrase it as updates to the existing pulley plate design in our preliminary presentation.

Action items:

1. Add entries to labArchives, make sure you have design ideas and research relevant to the design updates (Tracy will look at the notebook on Monday).
2. Coordinate with your sub-group to create the matrix criteria and professional drawings. I made two templates for the design matrices in the google drive.
3. Meet to rank the designs virtually on Tuesday, Sep 27th 4-5:25pm.
4. Keep the outreach project in the back of your mind - think about what you might want to do.

25SEPT2022 Console Design Subgroup Meeting

Roxi Reuter - Sep 25, 2022, 3:31 PM CDT

Title: Console Design Subgroup Meeting

Date: 09/25/2022

Content by: Roxi Reuter

Present: Josh, Annabel, Roxi

Goals:

- Share design sketches for the design matrix and give feedback on them
    - Make modifications if necessary
- Create the criteria, descriptions, and weights of the tension removal design matrix
- Write design descriptions and add figures for each design and

Content:

- We modified the design matrix criteria to accurately reflect the design characteristics for our console design
- We debated on design weights (see the attachment)
- Josh updated the CAD model for the swivel mechanism
- We each went through the design matrix document and wrote out descriptions for the design criteria. Then, we edited those definitions together.
- Following design criteria definitions, Annabel and I added our design sketches to the design matrix, and Josh showed us his modifications to the CAD in SolidWorks for the console rotation mechanism
- We wrote descriptions for each design in consideration and ended the meeting by reviewing them
- **Please see attached design matrix outline for further details on meeting work

Conclusions/action items:

This was a very productive meeting for the tension subgroup. Together, we completed our design matrix (excluding the scoring of the designs, which will occur at our meeting on 09/27). This included reviewing design sketches, changing design criteria, defining and weighting the design criteria, writing design descriptions, and editing the document as a team.

Moving forward, I will think about how I would score these designs such that on Tuesday (09/27), I have already put some thought into the criteria and designs as a whole while discussing this as a team.

On Tuesday, we will meet to score the criteria for each design and write the final design paragraph.

Roxi Reuter - Sep 25, 2022, 3:32 PM CDT

[Download](#)

Console_Design_Matrix.pdf (1.07 MB)

27SEP2022 Team Meeting

ANNABEL FRAKE - Sep 27, 2022, 11:37 PM CDT

Title: 27SEP2022 Team Meeting

Date: 27SEP2022

Content by: Annabel Frake

Present: Annabel, Roxi, Josh, Sam, Tim

Goals: rank designs using the design matrices, write the final design paragraph

Content:

- we started with the console rotational mechanism
- we had Sam and Tim read through our design criteria and give feedback
- they were concerned that "ease of use/ergonomics" and "position/orientation" were too similar and we were artificially scoring the distance of the console from the midline twice
- we moved the position into the "ease of use/ergonomics" criteria and renamed it to just be "ergonomics"
- we also defined a new criteria for "ease of rotation" (how easy it is for the user to transition the console from standard to adaptive and back) instead of "versatility" since all designs were able to transition, but the ease of transitioning varied
- we readjusted the percentages
- we ranked the designs in the design matrix
- Design 3: Motor won the design matrix
- we then moved onto the stabilization frame
- they initially had 3 designs, one of which was a preliminary sketch Roxi made
- however, no one had developed the idea and it was basically the same as Sam and Tim's design, so we removed Roxi's initial sketch from the design matrix
- we read through the design criteria and gave feedback
- we added an "ease of use criteria" for how easy it is to attach / detach the user from the stabilization frame
- we also changed the ease of installation and removal criteria to be "integration into environment" so that we could describe the size of the device and how easily it fit into gyms
- the idea being, that if the stabilization frame took up a lot of room, the gym may need to store it during certain times
- if it takes up less space, they are more likely to simply leave it out
- we adjusted percentage and scored the designs using the criteria
- the bar-in-bar pad support won the design matrix
- each sub-group will write the justification for the chosen design before we send out the design matrix with the PR on Thursday
- I reminded everyone to fill out the PR before Thursday

References: none

Conclusions:

During this meeting, our two design sub-groups came together to edit and improve our design criteria for the console rotational mechanism and the stabilization frame. The sub-group that did not write the criteria were able to offer an "outside" perspective on the work and help to fix any errors in logic. After we revised the criteria for each design matrix, we ranked the designs and determined the winning ones to be: the motor design for console rotation and the bar-in-bar pad support for the stabilization frame. Each sub-group will write a justification for the preliminary designs before we send out the progress report on Thursday.

Action items:

1. fill out PR before Thursday
2. write justification for chosen design within sub-groups
3. submit design matrices and upload them to the projects folder in our notebook

ANNABEL FRAKE - Sep 27, 2022, 11:23 PM CDT

Download

Console_Design_Matrix.pdf (1.07 MB)

ANNABEL FRAKE - Sep 27, 2022, 11:37 PM CDT

Design Matrix Criteria

Safety / Security [illegible]

Adjustability [illegible]

Ease of Fabrication [illegible]

Ease of Use [illegible]

Cost [illegible]

Integration in Environment [illegible]

Download

Stablization_Design_Matrix.pdf (998 kB)

28SEP2022 Antler Sub-group Meeting

ANNABEL FRAKE - Sep 28, 2022, 10:30 AM CDT

Title: 28SEP2022 Antler Sub-group Meeting

Date: 28SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: write the justification for the console rotational mechanism design matrix

Content:

- we wrote the justification for the console rotational mechanism design 3: Motor
- we explained why each design received the scoring it did for each criteria
- we talked about rough estimates for the dimensions of the design
- please see the "Design Matrices" entry in the Project Files folder

References: none

Conclusions:

During today's meeting, we focused on writing the justification for the Motor Design in the design matrix. We explained why it scored the highest in the design matrix overall and pointed out both its advantages and its issues. Namely, it scored highest in "ease of rotation" and "durability" because the user only has to press a button to complete the transition between standard and adaptive sides and the chosen motor will be durable. It also scored well in "ergonomics", "ease of fabrication", and "cost". The mechanism will be easy to use and reach, however, not as easy as the 2 pivot design because it will be fixed in one location. I have worked with servo and stepper motors before, so I believe that the fabrication of the electronics will not be too complex. The 1 pivot design would be easier to fabricate because it only has one point of rotation and no electronics. The addition of the electronics will increase the cost of the design, but it will have less material than the 2 pivot point design in terms of the arm extension on which the motor will rest. The lowest scoring category was safety because adding electronics to a design brings in more potential sources of harm, such as electrocution or fire hazards. Overall, I think we made the correct choice in choosing the Motor Design because it will make things easier for the user. At the end of the meeting, we came up with rough estimates of the required dimensions.

Action items:

1. Roxi will add the dimensions to the design sketches and put the updated images in the design matrix
2. send out the design matrix with our progress report (Josh)

30SEPT2022 Team Meeting

Roxi Reuter - Sep 30, 2022, 8:19 PM CDT

Title: Team Meeting

Date: 09/30/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss preliminary presentation and report

Content:

- We have questions for Tracy about the structure of our preliminary report since we are on a continuing project
- Need slides for:
    - Design matrices
    - Explanation slide for each design
        - Three console designs
        - Two stabilization designs
    - Summary of last year's work
    - Antler design explanation
    - Update PDS slide
- Splits:
    - 1st person: intro, client, problem statement, motivation, physiology (slides 1-7)
        - Tim
    - 2nd: competing design, last semester, PDS (slides 8-10)
        - Josh
    - 3rd: antler design, console design matrix (slides 11-16)
        - Roxi
    - 4th: stabilization design matrix (slides 17-20)
        - Sam
    - 5th: testing, prelim design, future work (slides 21-24)
        - Annabel
- Have slides done by: Wednesday (meeting on Teams from 2:15-3:15PM to edit it)
- Meeting on Thursday to practice (from 4-5PM in ECB)
- After our advisor and client meetings, the team decided to take a slightly different approach to preliminary design presentation: explaining last semester's design in detail and giving an explanation of areas of weakness, how we will be improving the design.

Conclusions/action items:

The team took this meeting time to further develop design ideas (such as the points of adjustment for the lap pad) and structure the preliminary presentation. Each individual, in addition to necessary project research, has assigned slides which must be finished for the Wednesday meeting for presentation edits.

Next week, the team will be meeting Wednesday (10/05) from 2:15-3:15PM on Teams to edit preliminary slides and Thursday from 4-5PM in ECB for presentation practice.

5OCT2022 Team Meeting

Roxi Reuter - Oct 05, 2022, 3:32 PM CDT

Title: Team Meeting

Date: 10/04/2022

Content by: Roxi Reuter

Present: Sam, Roxi, Annabel, and Josh

Goals:

- Edit the preliminary presentation as a team
- Discuss the preliminary report due next week

Content:

- We went through the presentation slide-by-slide
- We also talked about the PDS comments and updated the suggestions from Tracy based on her feedback
- As the team continued editing, Sam got feedback from Tracy during her office hours, so we revisited the slides with her suggestions and made edits
    - Mainly more quantitative additions or modifications to the design slides
- Look at BME 402 evaluation form for better idea of grading

Conclusions/action items:

Make necessary modifications to the presentation slides and look at the BME 402 evaluations forms in preparation for the presentation on Friday (10/07). Fill out the progress report by tomorrow (10/06) and attend the team meeting in-person tomorrow (10/06) from 4-5PM in ECB to practice the presentation.

6OCT2022 Team Meeting

ANNABEL FRAKE - Oct 06, 2022, 7:26 PM CDT

Title: 6OCT2022 Team Meeting

Date: 6OCT2022

Content by: Annabel Frake

Present: Annabel, Josh, Sam, Tim, Roxi

Goals: practice presenting for prelims, assign sections for the report, discuss updating the PDS

Content:

- the Tong lecture hall was open, so we were able to practice in the room we will actual present in
- we went through the presentation once and then gave feedback to each member on their content and delivery
- we were over 10 minutes
- we continued to run through the presentation until we met the time limit
- we will need to point to pieces on the rower during the actual presentation
- we made some minor edits to the slides based on formatting issues we noticed on the big screen
- Josh turned the presentation slides in on canvas
- Please see the project files folder for the pdf version of the presentation
- we then created an outline for the preliminary report and assigned sections:

New report outline:

Abstract - update - Everyone

Introduction and Background (already have) - just update problem statement (see PDS) - Sam

Previous semester summary - Josh

Preliminary design section

stabilization frame - Sam

Antler design - Roxi

Console - Annabel

Fabrication plan

Stabilization frame - Tim

Antler + Console Support - Roxi

Console Electronics - Annabel

Testing plan - Josh

Results - line that says we don't have any yet

Discussion - (Use from previous prelim) Everyone

Conclusion - (Use from previous prelim) Everyone

Future work - Tim

Appendices - add all previous report sections not in current report

- Sam is going to make the updates to the PDS since he is making the same edits in the prelim report

- we are going to have our sections done by Sunday night so that everyone can read and edit the report before our meeting on Monday (2:30-3:30 pm on Teams)
- I suggested that we plan a contingency meeting on Tuesday (3:00-3:30 pm on Teams) in case there are last minute things we need to wrap up
- we are all going to meet 15 min early tomorrow to transport the rower to the Tong lecture hall

References: none

Conclusions:

During the first part of the meeting, we practiced our preliminary presentation as a team. After a few run throughs, we were within the time limit. We will meet 15 minutes before class tomorrow to transport the rower to the Tong Lecture Hall. For the last portion of the meeting, we created a general outline for the preliminary report and assigned sections. Everyone will have their written section done by Sunday night so that everyone can read and edit the report for our meeting next Monday. I also suggested that we have a contingency meeting on Tuesday in case everything is not finished. This meeting will most likely be canceled.

Action items:

1. meet team 15 min before class starts tomorrow to transport the rower to the Tong
2. present prelims tomorrow
3. work on assigned report sections (done by Sunday night)
4. edit and review the report before our meeting to edit on Monday (2:30-4:30 pm on Teams)
5. Contingency meeting next Tuesday (3:00-3:30 pm on Teams) in case we don't finish on Monday (will cancel if done on Monday)

10OCT2022 Team Meeting

ANNABEL FRAKE - Oct 10, 2022, 6:01 PM CDT

Title: 10OCT2022 Team Meeting

Date: 10OCT2022

Content by: Annabel Frake

Present: Annabel, Josh, Roxi, Sam, Tim

Goals: write the discussion, conclusion, and abstract sections of the prelim report; address any editing comments made previous to the meeting; general formatting

Content:

- before the meeting, everyone was tasked with reading each other's sections, making edits for small things, and leaving comments for things that needed to be discussed
- we started the meeting by going through comments people left on each other's sections
- we updated the discussion section from the previous semester's report
- Tim gave a tutorial of how to use Zotero and then needed to leave for work
- the rest of us wrote/updated the conclusion and abstract
- we fixed the figure, table, and references numbers within the document
- we then looked at the appendix for previous design work
- we updated the section, figure, table, and references numbers here too (restarting the count because it is viewed as a separate document)
- we updated the Table of Contents
- I discussed the plans for the week (please see action items for a detailed list of what was decided)
- we will meet before our advisor meeting on Friday to plan the upcoming week
- The contingency meeting planned for tomorrow is canceled because we stayed later today to finish our work
- Please see the Project Files folder for a pdf of the prelim report

References: references in the prelim report

Conclusions:

During today's meeting, we finished writing and editing the preliminary report in its entirety. We will each do a final read through before tomorrow night and consult each other if we believe any changes need to be made. Before the deadline, Tim will upload it to the website and we will also upload it to canvas. Tim will update the PDS on the website. The preliminary notebook will be downloaded by Josh at dinnertime tomorrow and submitted to canvas. Everyone should fill out the progress report before Thursday and complete peer evals for Friday. Upcoming meetings are listed in action items.

Action items:

1. Final read through of the prelim report before tomorrow night and text in the group chat when you are done. If a change needs to be made, text the chat and we will decide together if the change should be made (may mess up Table of Contents, etc).
2. Once the final read through is done, we need to upload it to the website (Tim) and canvas.
3. Tim: update the PDS on canvas to the new version Sam made
4. The prelim notebook is due on Wednesday as well. Please have your notebook in shape by tomorrow at dinner time. Josh will download it and upload to canvas.
5. Fill out the PR for Thursday
6. Peer evals are due on Friday, make sure to follow the instructions in Pucc’s email

<u>Upcoming Meetings:</u>

-Friday Team Meeting to discuss upcoming week (12:30-1:30pm) wherever we are meeting Tracy (Josh will email her to ask where)

-Friday Advisor Meeting (1:05-1:35pm)

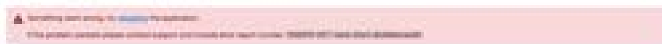
- Friday Client Meeting (1:35-2:05 pm) on Teams

14OCT2022 Team Meeting

ANNABEL FRAKE - Oct 15, 2022, 2:44 PM CDT

This entry was uploaded the day after the meeting because I was having issues with LabArchives. It would not load the notebook in my browser. The issue is resolved now.

ANNABEL FRAKE - Oct 15, 2022, 2:43 PM CDT



Download

LabArchives_Error.jpg (182 kB)

ANNABEL FRAKE - Oct 15, 2022, 2:42 PM CDT

Title: 14OCT2022 Team Meeting

Date: 14OCT2022

Content by: Annabel Frake

Present: Annabel, Josh, Sam, Roxi, Tim

Goals: touch base about the design status, discuss Staci's Questions

Content:

- I asked Josh about Staci's request to know when our next presentation was; he said he would tell her today
- first question from Staci:
  - bring down bar to 1 level above where you would lock it, adjust horizontal bar length, finish adjusting height
  - when will console turn around?
  - have an override button to turn? add later if needed
- second question from Staci:
  - have the arm go straight up in the air
- third question from Staci:
  - have Arduino in sleep mode and then use interrupts so battery consumption is good
  - we need the second conditional statement because we can't keep rotating in the same direction (wire would get wound up)
- after our client and advisor meetings, we touched base on the upcoming week in our sub groups
- josh is going to work on the CAD
- i am going to work on the motor selection and code
- roxi asked to meet with me to help with that
- i asked about our outreach project and everyone is going to keep thinking about it
- Tim and Sam want to flush out their dimensions so that we can visit JHT Oct 28th

References: none

Conclusions:

Today, we discussed Staci's questions about our designs based on our preliminary report. We agreed that the lap bar should rest straight up or out when not in use. Tim and Sam think that the order of operation for adjustment could be done multiple ways. The code may need the second conditional block if we use polling and stepper motors. In the upcoming week, we don't have any set meeting times, but may meet in subgroups to make progress on fabrication plans.

Action items:

1. Keep thinking about the outreach project
2. work with your subgroups to make progress on design fabrication planning
3. fill out peer evaluation reflections

19OCT2022 Console Motor Meeting

Roxi Reuter - Oct 19, 2022, 1:17 PM CDT

Title: Servo/Stepper Motor Meeting

Date: 10/19/2022

Content by: Roxi Reuter

Present: Annabel and Roxi

Goals:

- Discuss servo vs. stepper motor and look at coding

Content:

- Annabel demonstrated her servo and stepper motor circuits that she has been working on
  - The code is working with polling and interrupts are a work in progress
- She went to the MakerSpace on Friday (10/14) for recommendations on which motor would be best for our application, but she received mixed feedback
- We believe that either motor would probably work, so we estimated the weight of the console and used a similarly-weighted object to test with the stepper motor
  - This method worked with the stepper motor, so we believe that the stepper motor would be a good option for the console swivel mechanism
  - It also worked with the servo motor (did not expect this)
- We have proof of concept of both motors
- We plan on showing everyone else on Friday what they think
  - We are inclined to believe that the servo motor would wear down faster than the stepper motor since it is smaller and the shaft is much smaller and weaker than that of the stepper
- Another thing to think about: server operates on 5V and stepper operates on 12V
  - Size and cost will be a factor
- Ask Staci at the client meeting; Should we be worried about battery longevity? Will the power for the console swiveling be incorporated into the rower's power?
  - Does she just want proof of concept of the idea?
- Factors to consider:
  - Shaft **-** we think the servo is better in terms of notches, but the stepper is better in terms of dimensions and durability
    - Which connection point is the most sturdy?
  - Battery **-** servo only needs 9V which also powers Arduino (may need to be switched sooner); stepper we need 12V and 9V (cost and size difference)
  - Size of the motors **-** servo is smaller in stepper but both feasible
  - Cost of the circuit **-** servo requires fewer components than stepper circuit (motor controller and 12V added)
  - Motor longevity **-** it appears that servo will wear down faster than stepper
- Annabel thinks the stepper is more accurate in terms of position
- We are thinking of testing these motors with the actual console. To do so, we need an external 12V power supply for the stepper motor.

  - This is an option that my group used last year to power our stepper motor: https://www.amazon.com/gp/product/B07GFFG1BQ/ref=ppx_yo_dt_b_asin_title_o08_s00?ie=UTF8&th=1
- In terms of securing both motors, the stepper might be able to be screwed into the lid of the housing. The servo has a case which it can sit in.
  - We also figured out that the stepper motor has bolts which can be removed, so we can attach supports straight through it if needed.

Please see attached videos and photos for the functionality testing we did using an object similar in weight to the console.

Conclusions/action items:

Discuss the topics of today's meeting with the team and plan on testing the stepper and servo with the actual console soon. In Friday's team meeting, we will try to make a final decision on which motor to use so that we can have a discussion with Staci and purchase the correct components for our project.

We will be meeting from 12-1PM on Friday as a team.

Personally, I plan on trying to look into any of the following areas before Friday:

- Testing plans
- Stepper motor integration from previous project
- Outreach project.

Roxi Reuter - Oct 19, 2022, 1:22 PM CDT

Download

Untitled_Message.zip (31.4 MB) Servo and stepper motor testing pictures and videos 10/19/2022

21OCT2022 Team Meeting

ANNABEL FRAKE - Oct 21, 2022, 2:13 PM CDT

Title: 21OCT2022 Team Meeting

Date: 21OCT2022

Content by: Annabel Frake

Present: Annabel, Roxi, Sam, Josh, Tim

Goals: talk about motor selection

Content:

-
- Josh showed us the 3D printed prototype of the antler and talked about the changes that he intends to make
  - make it taller to give more room for the console
  - make the diameter of the handle holder larger and make it filleted so that the handle is easier to pull out
  - give more clearance for the standoffs connecting the pulley plates (they don't fit right now)
- Josh had a great idea for the placement of the console
  - he realized that the console is actually in front on the pivot point
  - because of this, when the pivot point rotates (because of the motor), the console will essentially swing around the antler to the other side of the machine
  - this means that the antler bar doesn't have to be as tall, which is a good thing because the printers at the MakerSpace are limited to a foot of printing space, so we would have had to print 2 pieces and connect them if it needed to be taller
- we talked about the ease with which someone could remove the handle from the holders
  - it can be done from the wheelchair side, but not really from the standard side if your feet are strapped in
  - we decided that the standard user would move the handle to the original handle bar holder on the Matrix machine as an intermediate step, then they would strap their feet in and begin rowing
  - I expressed concern that it would be tempting to leave the handlebar there instead of putting it back where a wheelchair user could reach it, but we would need to use signs just like with putting the lap bar all the way back up so the limit switch is properly engaged
- Roxi and I then shared our pros and cons list for the servo vs stepper motor with the team
  - we went through each of the differences and similarities
  - Roxi and I both think that the stepper motor is better because the shaft is sturdier and the connection to the console would be more robust
  - after hearing our thoughts, we got feedback from Josh, Sam, and Tim
  - Josh and Tim both thought that the stepper motor would be better
  - Sam said that his gut reaction would have been to go with the servo motors because he has seen ones that are bigger and there are actually extensions of the shaft that you can buy and then potentially glue on
  - Sam's major concern was the added complexity of the stepper motor, but since I already have the code mostly figured out, he was on board with using the stepper motor too

  - Conclusion: we are using a stepper motor
- In Staci's email for this week, she mentioned using limit switches at the console to determined which direction the console is facing
  - I didn't think that this would be necessary for a servo motor because you tell it what degree to rotate to
  - It would be useful for the stepper motor since you are trusting the code to know where the console is at, but have not way of actually confirming that if something gets out of whack
  - after deciding on the stepper motor, I asked the team if we should use the limit switches at the console
  - Staci had only suggested one, but I think we would need two (one for each position and then you would essentially tell the motor to rotate until it hit the next switch)
  - the team thinks it would be best to use the limit switches to make sure that the console is where it should be, and I agree with them
- We talked about the arm that will extend from the antler design to hold the motor and electronics
  - Josh is going to work on developing that this upcoming week once I send him the information for the motor, etc. so that he can model it all in CAD
  - we need to be careful that the box doesn't run into the welded braces on the Matrix machine
- Tim and Sam gave an update on the stabilization frame
  - Sam updated the drawings so that the structure goes straight up and then out instead of the angle we had it at initially
  - he also added support extensions to counteract the moment of the lap bar when it is lowered from its vertical position
  - we are going to ask Staci if we can visit JHT next Friday to build a prototype using the parts she has
  - Sam also got his welding pass
- We talked about the Gantt chart
  - people are going to fill in the sections that they are working on
  - Roxi is going to fill in the parts for our sub-group based on info Josh and I will send to her about when we plan to have certain things done

References: none

Conclusions:

The meeting today was extremely productive! Josh shared his progress on the antler design, and it seems like the changes he is making will be sufficient for the final design. He will wait to 3D print the new version until we ask Staci if 3D printing is sufficient or she still wants it to be made of metal. He thinks that the tough PLA would be sufficient, but wants to double check with her. Roxi and I shared our pros and cons list for the servo vs stepper motor decision. After discussing the list, we decided to move forward with the stepper motor. I will start to purchase the components and keep developing the code using my person electronic until then. Tim and Sam updated us on the progress of the stabilization frame. We plan to visit JHT next Friday to begin fabricating the prototype for it; Josh will email her to ask if that date works for her schedule. At the end of the meeting, we went around the room and shared our next steps so that we are all on the same page about the progress for this project.

Action items:

Group:

1. fill out Ganht chart
2. Josh: email Staci about going to JHT next Friday
3. continue to develop the design in our sub-groups
4. Roxi: look into outreach stuff if time

Me:

1. Purchase the motor, motor controller, 12V power supply, and 9V power supply
2. send Josh the specs for the purchased items so he can find CAD models for them and develop the electronics box in CAD
3. send Roxi the relevant info for the electronic design development
4. continue to develop the code

25OCT2022 Electronics Box Meeting

ANNABEL FRAKE - Oct 25, 2022, 9:32 PM CDT

Title: 25OCT2022 Electronics Box Meeting

Date: 25OCT2022

Content by: Annabel Frake

Present: Annabel, Josh

Goals: to discuss placement of electronic components within the 3D print that supports them

Content:

- Josh asked if meet to discuss the placement of the electronics components within the housing box
- He showed me the placement of the motor on the CAD model (positioned so that the console can rotate 180 deg without hitting the antlers)
- he found models for the Arduino Uno and NEMA stepper motor
- I reminded him that there would also be a motor controller
- I don't think we will need a breadboard
- I did ask for clearance around the motor controller board for wires to stick out a bit (when they come out of the headers)
- The motor controller can be on the bottom, top, or side of the box because the wires are screwed into terminals
- but the Arduino Uno should probably remain upright since the wires won't be screwed into terminals for that and we don't want to risk them coming out
- I also asked for a hole where the USB plug could be inserted into the board without having to open the box up
- we agreed that the 9V should be attached externally so it's easier to swap out when the battery dies (so we will need an opening for that too)
- we discussed briefly how the extension would attach to the pulley plate
- Josh was thinking screws
- I suggested we just print as part of the pulley plate (would have to be careful of printing orientation / layering - we may have to drill out holes)
- we are going to print it separate as a prototype and then print it together when we print the final pulley plate / antler

References: none

Conclusions:

Josh and I met tonight to talk about the platform that supports the console and houses the electronics. He asked questions about how the circuit would look and what orientation would be most beneficial for wiring. We discussed different features of the box and ways to attach it to the pulley plate. Josh will make a prototype of the design we talked about and then we can improve it from there.

Action items:

1. Josh will work on a prototype and we will make edits to that before printing

ANNABEL FRAKE - Oct 25, 2022, 10:24 PM CDT

Title: 25OCT2022 Electronics Box Meeting

Date: 25OCT2022

Content by: Annabel Frake

Present: Annabel, Josh

Content:

- Josh and I did another quick Teams call so I could give feedback on his first iteration
- I suggested that he make the wire clearance on the inside of the box instead of having windows for the wires to leave the box
- we talked about where the motor wires should come out (on the side with the motor controller)
- he will add tolerances at the end
- hope to print sometime next week (probably by Tuesday)
- this gives us time to get feedback from the rest of the team
- I also want to have the circuit operational to make sure I'm not missing anything that would impact the design of the box

28OCT2022 Team Meeting

Roxi Reuter - Oct 28, 2022, 3:19 PM CDT

Title: Team Meeting

Date: 10/28/2022

Content by: Roxi Reuter

Present: Entire Team

Goals:

- Discuss plans for the show and tell next week
- Talk about design progress

Content:

- We discussed the show and tell
  - Possible questions to ask other groups:
    - Suggestions for changing the resistance of the rowing machine from the adaptive side
    - Any better methods to attach the stabilization frame
  - What will we be showing at the show and tell?
    - Have rower with us
    - Show 3D prints
    - Paper sketch of stabilization frame and photos of materials if possible
- For the 3D print of the motor housing, Annabel suggested adding venting (such as a fan, slits, or both) to the design
  - Might be able to place the fan underneath the motor since we have more room in that direction; however, placing it on the side is optimal (although we don't have as much room there)
  - Also - 12V will be able to power both Arduino and stepper motor, so the 9V battery is no longer needed
- Research possible fans that could be used to motor ventilation
  - Motor heats up even when not rotating (just based on when Annabel has been playing around with it, but will this still occur when the motor is used in
- Box for housing estimated under $10 to print
  - Current project cost is around $94
  - Should only have to do one to two more prints with the pulley plate - still need to approve the 3D print (instead of metal) idea with Staci
- Josh estimated approximately $60 for the printing of both pulley plates out of tough PLA and high density
- We will plan on adding slits for ventilation as of now and not using the fan at the moment

Conclusions/action items:

The team will continue working on the design and testing plans. Josh will be modifying the current CAD designs, and the team will prepare for show and tell next Friday (11/04).

31OCT2022 Electronics Box Meeting

ANNABEL FRAKE - Oct 31, 2022, 7:13 PM CDT

Title: 31OCT2022 Electronics Box Meeting

Date: 31OCT2022

Content by: Annabel Frake

Present: Annabel, Josh

Goals: update Josh on the need for the relay, check in about the design for the box before Josh prints it this week

Content:

- Josh showed me the updated box with venting
- I suggested that he could reduce the window size for the USB and 5V power plug to be just the USB plug since we can power the Arduino with the 12V power supply
- he also added screw holes to attach to the pulley plates
- I proposed that we could move the window for the power supply wires since they aren't directly going to the L298N anymore (go to relay and then L298N and ground)
    - We aren't sure where to put them instead
    - I had suggested the floor of the box, but there isn't much space there
    - we will wait until we print the prototype and see where the most location would be to have the wires go through
- I explained the relay and what it was doing in the circuit
- while I was talking to him, I realized that we may have an issue
    - since the motor turns off once the console gets to where it needs to be, it is possible to rotate the motor with your hand
    - there is still resistance to rotating the shaft, but it is possible that someone could rotate the console if they touch it
    - the weight of the console would help prevent this somewhat, but I would want to test this
    - we could also maybe use a timer to keep the motor on for x amount of time after the console reaches the intended spot (ex: 1 minute to press the console screen and adjust things and then most likely don't touch console again) and then turn off the relay
    - we will have to mess around with that and see
- Josh added a flag to the console holder
    - we may need to adjust the size, height, etc once we have the lid and limit switches
- Josh is going to print 5 pieces
    - 2 parts of the console
    - box
    - curved part of antler (since he changed the antler to have a diagonal like Staci suggested)
    - part of pulley plate that interfaces with weld so Josh can make sure that the pulley plate will fit snugly on the other side (we tried the one side, but they are not symmetrical, so we want to make sure for the other side as well)

- once Josh prints the items and they are done, he will hand the relevant pieces off to me and I will remake the circuit within the box for show and tell

References: none

Conclusions:

Josh requested that we meet to discuss the updates he made to the electronics box. The grating looks great, but hopefully we won't really need it with the relay added to the circuit (ie the motor shouldn't heat up). He made some changes during the meeting: 1. added the flag and 2. changed the window size to fit the USB port only. We are going to print the first prototype and then see where the best place is to feed the power wires in. Josh will print the 5 pieces listed in the content section and then I will remake the circuit in the box and with the flag for show and tell on Friday.

Something to think about: since the motor isn't on / holding the console in place once it reaches its intended destination, is is possible that the console could be knocked out of place. The code should correct the position of the console if this happens, but it would be annoying, so I will need to test if this happens and how often. I could possibly add a timer for how long the relay should be on after a state change to give the user time to touch the console while it is held in place. Then, after some amount of time, the relay would turn off, preventing the motor from heating up.

Action items:

1. Annabel: continue to work on the circuit / code
2. Josh: print 5 components

11/4/2022 - Show & Tell Feedback

Josh ANDREATTA - Nov 04, 2022, 7:33 PM CDT

Title: 11/4/2022 - Show & Tell Feedback

Date: 11/4/2022

Content by: Josh, Annabel, Roxi, Tim, Sam

Present: Josh, Annabel, Roxi, Tim, Sam

Goals: Receive feedback from peers regarding

Content:

1. Relay/turning issue:
    a. Use a D-shaped shaft and add some sort of catching mechanism to hold the shaft in place when in the correct orientation (standard side or adaptive side).
    b. In addition to the current design, add a pin which slides up and locks the console in place while it is in the correct position. The pin would return to the original position (lower) and "unlock" the console to allow rotation when the console must change position.
    c. Add another piece or mechanism that holds the motor shaft in place once the relay is on (prevents rotation of the shaft).
    d. Add an arm which locks the console into place when the relay is turned on.
    e. Add a geometric lock or some sort of second locking mechanism.
2. Adjusting resistance from adaptive side:
    a. Could rewire and create a mechanism to use from each side
    b. Use a remote to change the resistance of the rower
    c. Take the rower apart and look at the resistance mechanism inside in order to move forward.

Corey: what kind of motor controller did you use and did it have heating problems?

Sam and Josh

- Relay and turning issue:
    - Split the voltage
        - Cut the voltage in half so that it doesn't
    - Use a timed interval to calibrate the turning
        - When they open the bar, it would then turn back on the limit switch
    - Adding in a locking mechanism whenever one of the switches is compressed to not have the console rotate
    - Add in a cooling system
    - Split up the code between two arduinos
        - The two limits are working on a different motor
    - Print a piece that sits above motor that provides resistance
        - Silicon ring
    - Adding in a button that would correct if there console wasn't in correc tspot
    - Adding in a gear that has the motor lock when it is not in use
        - May be a different type of motor
- Adjusting resistance from adaptive side: didn't have time to ask about this

References: n/a

Conclusions:

Several people mentioned using a button to turn the console rather than a limit switch, but this does not solve our problem of the motor over-heating and needing to be cooled down. We will talk to the makerspace again next week to see what they recommend for us to do to keep it cool while still holding shaft rotation resistance.

Action items: Visit JHT!

11/4/22 - Fabrication at JHT for Stabilization Frame

SAMUEL SKIRPAN - Nov 05, 2022, 9:43 AM CDT

Title: Fabrication at JHT for Stabilization Frame

Date: 11/4/22

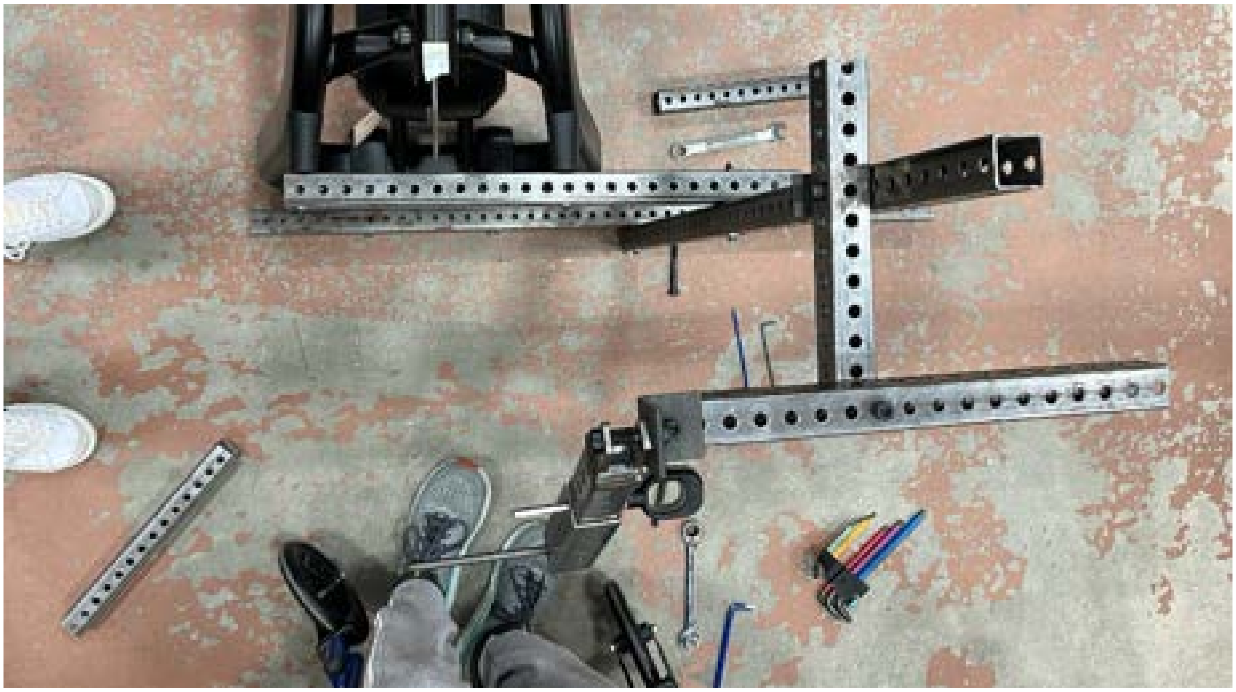
Content by: Sam

Present: Sam, Roxi, Annabel, Josh (Tim was unable to attend due to sickness)

Goals: Fabricate stabilization frame prototype at JHT and take tour.

Content:

- We went to JHT to take both a tour and start to build our stabilization frame using some of the perforated bars that they had within their shop
- We spent about 2 hours total at JHT
- With the fabrication of the stabilization frame:
    - We utilized the screw attachment points on the back of the rowing machine
        - Staci showed us a way that we could attach two horizontal attachment bars to secure the stabilization frame
    - We then used a series of perforated bars and screws to build out our prototype
    - Our preliminary fabrication was an iterative process and we put the design together multiple times, then took it apart multiple times after thinking of various shortcomings
    - Shortcomings/problems to consider:
        - Not having the stabilization mechanism arm run into one of the arms of the wheelchair
        - Having the horizontal bar with the pad on come down onto the user for leverage advantages
        - Making sure the stabilization frame doesn't get in the way of the rowing motion or grabbing of the handle bar
    - While we were fabricating, Staci gave us a lot of fabrication tips and suggestions to point us in the right direction
- The following are a few pictures of our design:
    - 

- 
- 
- These pictures show the various angles of the design that we created at JHT

Conclusions/action items:

Yesterday, we had a very successful preliminary fabrication of our stabilization mechanism. We were able to figure out some of the main problems we might face in terms of the actual design of the mechanism. Staci also gave us a lot of great fabrication tips along the way.

Action items: Model the stabilization design in SolidWorks to see how the moving parts work together. Get dimensions for each of the bars we want to use.

11NOV2022 Team Meeting

ANNABEL FRAKE - Nov 11, 2022, 6:09 PM CST

Title: 11NOV2022 Team Meeting

Date: 11NOV2022

Content by: Annabel Frake

Present: Annabel, Roxi, Josh, Sam, Tim

Goals: touch base about design progress, plan for upcoming week

Content:

- Before our advisor meeting, we shared our sub-group progress with the team
    - Sam: started modeling the bars in SolidWorks
    - Josh: updated the CAD
    - Annabel: new circuit with DRV8825
    - Roxi: sketches for stabilization frame and IRB research
    - Tim: IRB research
- After our advisor meeting, we put the console on the stepper motor using the newly printed goalposts
- it did not fit very well, but we were able to force it on somewhat for testing
- we got the console to rotate (manually pressing the limit switches because the flag didn't reach the limit switches)
- see attached videos
- the vibrations were not dampened, but actually worse
- we tried placing the motor on the wooden shelf and holding it down, but the vibrations were still present
- I will ask someone at the MakerSpace about this
- Sam said we could remove the console cable so that I could take the console with me for testing, so we did that
- Josh also measured the electronics components for his tolerance updates
    - I suggested making the hole for the 12V power supply cable fit around the connection piece so that it plugs in and nothing else is exposed by the hole
    - I also suggested moving that to the bottom of the box from the side
    - I suggested that we start thinking about the limit switch placement and how the screws for holding them in place will fit into the design
- we talked about looking into a roller-coaster stabilization frame like our initial design because we think this will prevent a hinderance of the rowing motion
- I also suggested that we move the 2nd pulley up so that the rope comes out entirely horizontal to the floor instead of the user pulling it at an upward angle
    - this will give more space underneath for the stabilization frame to work without interfering with the pulley and rope
    - it will require some rework for Josh, but he said that he was willing to try it
- at the end of the meeting, I asked the team about our timeline
    - have the CAD for the stabilization frame done for the client meeting next Friday
    - Josh will print the semi-final version of the CAD next week and then the final versions after that
    - once he has the final box, I will cut the wires to length and solder
    - we will integrate everything around Thanksgiving and then test
        - only screw together the stabilization frame and wait to weld until next semester?
    - We need to keep thinking about the outreach project - Tim will reach out to the school he has ties with to see if we could work with them

References: none

Conclusions:

Today, we updated everyone on sub-group progress and planned the rest of the semester (see action items). We connected the console to the stepper motor and showed that it could move as intended (see attached videos). The console vibrates because the motor shaft vibrates. I will look into this more in the upcoming week.

Action items:

1. Sam will send the CAD file to Josh and then he will send it back once updated. Sam can send this file to Tim and Roxi if they want to try their hand at the modeling.
2. Tim: reach out to your school contact to gauge their willingness to work with us for an outreach project
3. Sam and Tim: Model the stabilization frame using CAD, cardboard/PVC, etc. for our client meeting next Friday
4. Josh: update the antler design and electronics box. Print the semi-final version early next week.
5. Annabel: look into the vibrations more. Once I have the final electronics box, cut wires to length and solder.
6. Roxi: make sketches for the stabilization frame

Semester Plan:

- Stabilization frame design finalized for client meeting and then we will fabricate it
- Test SolidWorks simulations and code before Thanksgiving
- Integration around Thanksgiving
- Testing with the whole setup
- Final poster and report

ANNABEL FRAKE - Nov 11, 2022, 6:14 PM CST

Download

IMG_2633.MOV (13.3 MB) Video of the circuit rotating the console. Part 1

ANNABEL FRAKE - Nov 11, 2022, 6:14 PM CST

Download

IMG_2634.MOV (11.6 MB) Video of the circuit rotating the console. Part 2

14NOV2022 Electronics Box Meeting

ANNABEL FRAKE - Nov 16, 2022, 8:36 PM CST

Title: 14NOV2022 Electronics Box Meeting

Date: 14NOV2022

Content by: Annabel Frake

Present: Annabel, Josh

Goals: finalize dimensions for the electronics box

Content:

- Josh and I met so that he could measure the Arduino and circuit board with a caliper before printing the next iteration of the box
- he took measurements and updated his CAD
- we will need to cut down a larger solder board to fit into the space we have in the box
  - we will only secure this solder board with 2 screws
  - we will most likely need stand offs
- I suggested that he make the lid so that we could figure out screw placements for connecting it to the box
- we talked about the placement of the limit switches

References: none

Conclusions:

Josh and I met briefly to discuss the electronics box and lid. He took measurements and made updates to his SolidWorks files. We discussed the placement of the electronic components and the upcoming print jobs.

Action items:

1. create the lid
2. make updates to the electronics box
3. print the electronics box, lid, and goalposts

18NOV2022 Team Meeting

Roxi Reuter - Nov 18, 2022, 2:09 PM CST

Title: Team Meeting

Date: 11/18/2022

Content by: Roxi Reuter

Present: Josh, Tim, Annabel, and Roxi

Goals:

- Update each other on project progress
- Plan integration and activities before/after Thanksgiving

Content:

- Josh and Annabel shared their 3D printing updates on the console/motor housing designs
- Tim and I discussed the stabilization frame
    - As of now we are giving Staci bar dimensions for the stabilization frame which sits in the middle of the rower
    - Next week, we are planning on fabricating the stabilization frame
- In terms of outreach, I will be planning the outreach activity outline
    - We will ask Tracy when she will have time to meet for the outreach activity
- As for the IRB application, I will continue working on that and
- Josh will be printing all the final 3D prints today and will have the testing simulations done over Thanksgiving break
- After Thanksgiving, we will be integrating the console and 3D printed components with the rower and the stabilization frame
- Next week, the team will try to meet to fabricate the stabilization frame.
    - No welding will be done by the team initially
- No meeting next week
- Following Thanksgiving break, we will be keeping our schedules open and flexible to pick up materials and fabricate the stabilization frame.
    - Following stabilization frame fabrication, we will be carrying out testing and working on final deliverables.

Conclusions/action items:

The team has made great progress so far with the project this semester. Josh will be printing final prints today, and Tim is planning on sending Staci drawings of the materials which we need from JHT. I will be dedicating time to the IRB exemption application and the outreach activity planning. When we get back from Thanksgiving break, we will be picking up materials from JHT and begin fabricating the stabilization frame, integrating project components, complete testing, and start final deliverables.

11/29/22 Motor Box and Pulley Plate Assembly

SAMUEL SKIRPAN - Nov 28, 2022, 4:39 PM CST

Title: Motor Box and Pulley Plate Assembly

Date: 11/29/22

Content by: Sam

Present: Sam, Annabel, Josh

Goals: Attach motor box and pulley plates to the rowing machine.

Content:

- The 3D printed motor box and pulley plates were picked up from the MakerSpace earlier
- Annabel and Josh attached the pulley plates and motor box to the rowing machine
  - This requires purchasing some screws from the Team Lab that fit within the holes of the 3D printed materials
  - We completed some trial and error with finding the right screws sizes and lengths for the 3D printed materials
- Josh tapped all of the holes in the 3D printed items at the Team Lab
- Annabel and Sam discussed how to include the limit switch within the stabilization frame
  - Talked about adding in a physical stop where the horizontal bar will not be able to rotate past
    - This is where the limit switch will be placed so that it is depressed enough to work but not too much such that it breaks
  - Plan is to create a working model this semester that can be tested, but a more professional design will be created next semester
    - The model next semester will have the physical limit included in the angle adjustability mechanism
- There are a few things we discussed / problems that may need to be addressed next semester:
  - Adjust the placement of holes within the motor box and electronic box cover
  - Adjust hole placement for the pulley play small support block
  - Determine way to permanently secure limit switches on top of motor box
- The following are pictures of the incorporation of the 3D printed parts to the rowing machine:
  - 

- 
- 

- 

Conclusions/action items:

Josh, Annabel, and Sam met at ECB to attach the 3D printed materials to the rowing machine. Screws were purchased from the Team Lab to be able to screw the motor box and pulley plates in place. Josh tapped all of the holes within the 3D printed materials.

Action items: Incorporate stabilization frame with electronics. Complete testing.

01DEC2022 Design Integration and Testing

Roxi Reuter - Dec 01, 2022, 6:20 PM CST

Title: Testing and Design Integration

Date: 12/01/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Integrate all design components with each other and the rower
- Perform testing
- Divide up the final presentation and report

Content:

- The team met in ECB to work on integration and testing
- Some areas of improvement for next semester include:
  - Redesign the lid for the circuit and motor box so that the screws do not impede movement of the console
  - Add a flat piece instead of a bolt as the backstop (we can also glue or somehow attach the limit switch on this so it is better attached)
  - Implement pin-angle adjustment instead of tightening a bolt
  - Add in the gas assist
  - Get a smaller lap pad (in width) to accommodate the standard range of wheelchair widths - or cut the current lap pad
  - We also need to increase the height of the antlers because the console is just barely running into the handle bar.
  - Add wedges or some sort of support to prevent the rower from rocking when used on the adaptive side
- Divisions for the final poster presentation (editing):
  - Abstract - Roxi
  - Background and motivation - Roxi
  - Problem statement (alter slightly) - Roxi
  - Design criteria - Tim
  - Final design - Annabel (electronics) & Sam (rest of the design)
  - Testing and results
    - Motor and pulley plate simulation - Josh
    - Stabilization frame - Tim
  - Discussion - Sam
  - Future work - Annabel & Josh
  - Acknowledgements - All
- Divisions for the final poster presentation (presenting):
  - Abstract - Not presented
  - Background and motivation - Tim
  - Problem statement - Tim
  - Design criteria - Annabel
  - Final design - Annabel
  - Testing and results - Josh

    - Discussion - Roxi
    - Future work - Sam
    - Acknowledgements - Sam
- We ran into slight issues with the console turning back to the adaptive side once it reached the standard side (unnecessary turning); however this was fixed with wire placement
- Meeting to edit poster on Monday 12/05 (virtually) at 7:30PM
    - 45-ish minute meeting
    - Try to have parts done by Sunday night and look over poster before team meeting
    - Assign report sections if time during this meeting
- Printing poster on Wednesday (12/07)
- Practicing on Thursday for final poster presentation next Friday (12/09)

Conclusions/action items:

The team successfully completed integration of the different design components with each other and with the rower. Testing of the displacement of both the wheelchair and the stabilization frame were carried out with motion capture on Kinovea in the extreme cases (resistance of 1- lowest resistance - and resistance of 10 - highest resistance). The team will analyze these results and work on the final deliverables.

05DEC2022 Team Poster Editing

Roxi Reuter - Dec 05, 2022, 9:17 PM CST

Title: Team Poster Editing

Date: 12/05/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Edit the team poster

Content:

- The team took a look at the poster which each member worked on over the weekend
- Questions for Tracy's office hours on Wednesday:
  - Font size of abstract section? Is it OK that it is not the same as the other sections?
  - Any other quantitative data that should be included?
- The team made the design specifications and future work more quantitative to sound less vague and give a better idea of what we actually intend(ed) to do with our design
- We added a table to clean up the data in the testing results for the Kinovea testing
- Josh is emailing Tracy about meeting at 2PM to go over the poster
- Plan for 4PM on Thursday to practice the poster presentation
  - Sam is going to try to reserve a room
- We will plan on meeting slightly before the presentation on Friday to set everything up
- We also assigned report sections
  - I have…
    - 1. Adding sources to the introduction (statistic from today of 81%..., competing design from Annabel, etc.)
      - Competing design from Annabel: "Adapt2Row: rowing on a Concept2 rowing machine from your wheelchair," *Gerofitness*. https://gerofitness.nl/export/406-adapt2row.html (accessed Sep. 26, 2022).
    - Discussion
- We are planning on meeting both Sunday and Monday (1 hour each day) to edit the report
  - 7:30PM on Monday (1-1.5 hours)
  - 4PM on Sunday (2 hours)

Conclusions/action items:

The team spent this meeting editing and discussing the poster content together. We have a busy couple weeks finishing up the design semester but have planned out how we will successfully tackle the end of the semester.

7DEC2022 Team Poster Editing

ANNABEL FRAKE - Dec 07, 2022, 6:15 PM CST

Title: 7DEC2022 Team Poster Editing

Date: 7DEC2022

Content by: Annabel Frake

Present: Annabel, Josh, Roxi, Sam, Tim

Goals: make edits to the final poster based on our advisor's feedback

Content:

- see attached pdf

References: none

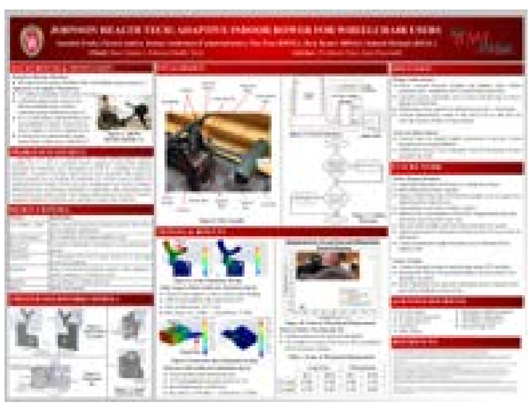
Conclusions:

After meeting with Dr. Tracy Puccinelli for poster feedback, we met as a team to make the necessary edits. We then each looked over the poster one final time and gave the go-ahead to print. Josh will print the poster.

Action items:

1. print the poster (Josh)

ANNABEL FRAKE - Dec 07, 2022, 6:15 PM CST



Download

Final_Poster_-_Adaptive_Rower_Fall_2022.pdf (2.1 MB)

8DEC2022 Practice Poster Presentation

ANNABEL FRAKE - Dec 08, 2022, 6:22 PM CST

Title: 8DEC2022 Practice Poster Presentation

Date: 8DEC2022

Content by: Annabel Frake

Present: Annabel, Josh, Sam, Roxi, Tim

Goals: practice the final poster presentation

Content:

- we practiced the final presentation 3 times and gave feedback on everyone's scripts
- I went through the team folder in the notebook with the team to make sure we had all of the appropriate entires
    - we removed the design process folder since that is covered by the team meetings folder
- we checked the distance from our table position to the nearest outlet and determined that we will need an extension cable
- Sam got an extension cable from TeamLab
- we put the old goalposts back on the console since the new ones Josh printed were worse
- we tested the console rotation to make sure it still works for tomorrow - it does
- we plan to meet at 11:30 am tomorrow to set everything up before the poster session starts

References: none

Conclusions:

We prepared for the final poster presentation.

Action items:

1. present at poster presentations tomorrow

11DEC2022 Report Editing I

Roxi Reuter - Dec 11, 2022, 7:03 PM CST

Title: Report Editing I

Date: 12/11/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Start editing report (address comments from individual editing, as well as preliminary report)
- Write conclusion and abstract together

Content:

- The team addressed both comments from team members from individual editing and from our advisor, Tracy, in the preliminary report
- Final meeting with Tracy:
  - Monday or Tuesday (12/19 or 12/20) during the morning

Conclusions/action items:

During this long meeting, the team spent time editing the final report together. Although the team did not completely finish edits, a final editing meeting will take place tomorrow (12/12) from 7:30-9PM on Teams. A copy of the final report after edits will be added to the team notebook.

12DEC2022 Report Editing II

ANNABEL FRAKE - Dec 12, 2022, 9:23 PM CST

Title: 12DEC2022 Report Editing II

Date: 12DEC2022

Content by: Annabel Frake

Present: Annabel, Josh, Sam, Tim, Roxi

Goals: finish going through the comments on the final report; fix appendices, figures, references, tables, etc.; fill out the client eval form

Content:

- we finished going through the comments on the discussion and future work sections
- we wrote the conclusion
- we filled out the client eval form and Josh will send that out later
- we fixed references, tables, figures, and appendices numbering

References: none

Conclusions:

During tonight's meeting, we finished going through the comments made when individually editing the document. Then, we wrote the conclusion and updated the formatting of the report. Lastly, we completed the client evaluation form.

Action items:

1. look over the report one last time individually and then submit the report
2. Josh to email Dr. Tracy Puccinelli the client eval form

Expense Spreadsheet

Josh ANDREATTA - Dec 12, 2022, 10:03 PM CST

Download

BPAG_Expense_Spreadsheet_Updated_12_07.xlsx (43.5 kB)

Receipts

Roxi Reuter - Oct 27, 2022, 11:14 AM CDT

Download

Initial3DPrint_Receipt.jpg (3.69 MB)

Roxi Reuter - Oct 27, 2022, 11:14 AM CDT

Download

Motor_Controller_12V_Power_Supply_and_Arduino_Uno_Receipt.pdf (51.4 kB)

Roxi Reuter - Oct 27, 2022, 11:14 AM CDT

Download

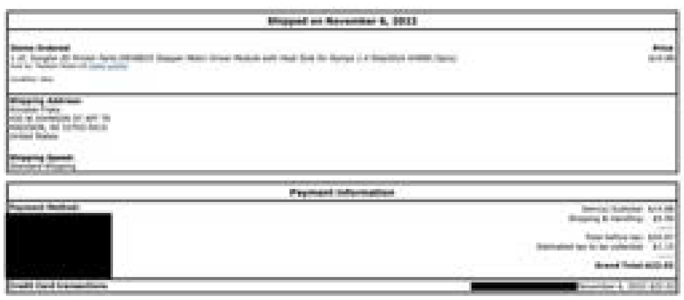
Stepper_Motor_Receipt.pdf (83.2 kB)

Roxi Reuter - Nov 09, 2022, 10:05 PM CST

Download

PreliminaryPrints_11012022.heic (2.69 MB)

Roxi Reuter - Nov 09, 2022, 10:06 PM CST



Items Ordered

Shipping Address

Shipping Speed

Payment Information

Payment Method

[redacted]

Credit Card transactions [redacted]

Download

NewMotorController_11062022.jpeg (256 kB)

Roxi Reuter - Nov 10, 2022, 9:37 AM CST

Download

3DPrint_Dshaftconsoleposts.jpg (4.21 MB)

Roxi Reuter - Nov 10, 2022, 9:40 AM CST

Download

Relay_Receipt.heic (2.27 MB)

Roxi Reuter - Nov 14, 2022, 4:35 PM CST

Download

Dshaftmotor.jpeg (252 kB)

Roxi Reuter - Nov 16, 2022, 6:10 PM CST

Download

14.heic (2.68 MB)

Roxi Reuter - Nov 29, 2022, 5:28 PM CST

Download

Reprint_FieldgoalPosts.HEIC (2.56 MB)

Roxi Reuter - Nov 29, 2022, 5:30 PM CST

Download

FinalPrints1.heic (2.46 MB)

Roxi Reuter - Nov 29, 2022, 5:30 PM CST

Download

FinalPrints2.heic (2.49 MB)

Roxi Reuter - Nov 29, 2022, 5:31 PM CST

Download

FinalCircuitComponents.heic (2.74 MB)

Roxi Reuter - Dec 01, 2022, 9:40 AM CST

Download

Fieldgoalpost_reprint_final.HEIC (3.49 MB)

Roxi Reuter - Dec 07, 2022, 12:29 PM CST

Download

Reprinted_FieldgoalPosts.HEIC (2.58 MB)

Individual Reimbursements

Roxi Reuter - Dec 07, 2022, 12:30 PM CST

Download

Individual_Reimbursements_12_07.xlsx (59.5 kB)

Materials for Stabilization Frame 11/30/22

SAMUEL SKIRPAN - Nov 30, 2022, 10:04 PM CST

Title: Materials and Tools Used for Stabilization Frame Fabrication

Date: 11/30/22

Content by: Sam

Present: Sam and Tim

Goals: Enter materials used for stabilization frame into notebook.

Content:

- Materials:
  - Screws:
    - M 10 (10 mm) socket head cap bolts
      - 7 – 50 mm screws
      - 4 – 80 mm screws
      - 1 – 90 mm screw
    - M 5 (5 mm) socket head cap bolts
      - 4 – 50 mm
  - Nuts
    - 12 M 10 (10 mm) nuts
  - Perforated Bars
    - Smaller gauge:
      - 2 - 40 cm long
      - 1 - 30 cm long
      - 1 - 68 cm long
    - Larger gauge:
      - 1 - 40 cm long
  - 2 triangle braces
  - 1 L bracket
  - Washers
    - 6 – M 6 washers
  - JHT semi-circular pad
  - Matrix rowing machine
- Tools Used
  - Hexagonal wrenches
    - 10 mm wrench
    - 5 mm wrench

Conclusions/action items:

Above are the materials and tools that were utilized to fabricate the stabilization frame.

Final Schematic

ANNABEL FRAKE - Nov 27, 2022, 11:26 PM CST

Note: Please navigate to "Annabel => Design Ideas => Motor Design for Console Rotation" for a full accounting of the circuit design process.

ANNABEL FRAKE - Nov 19, 2022, 9:10 PM CST

Title: 19NOV2022 Final Schematic

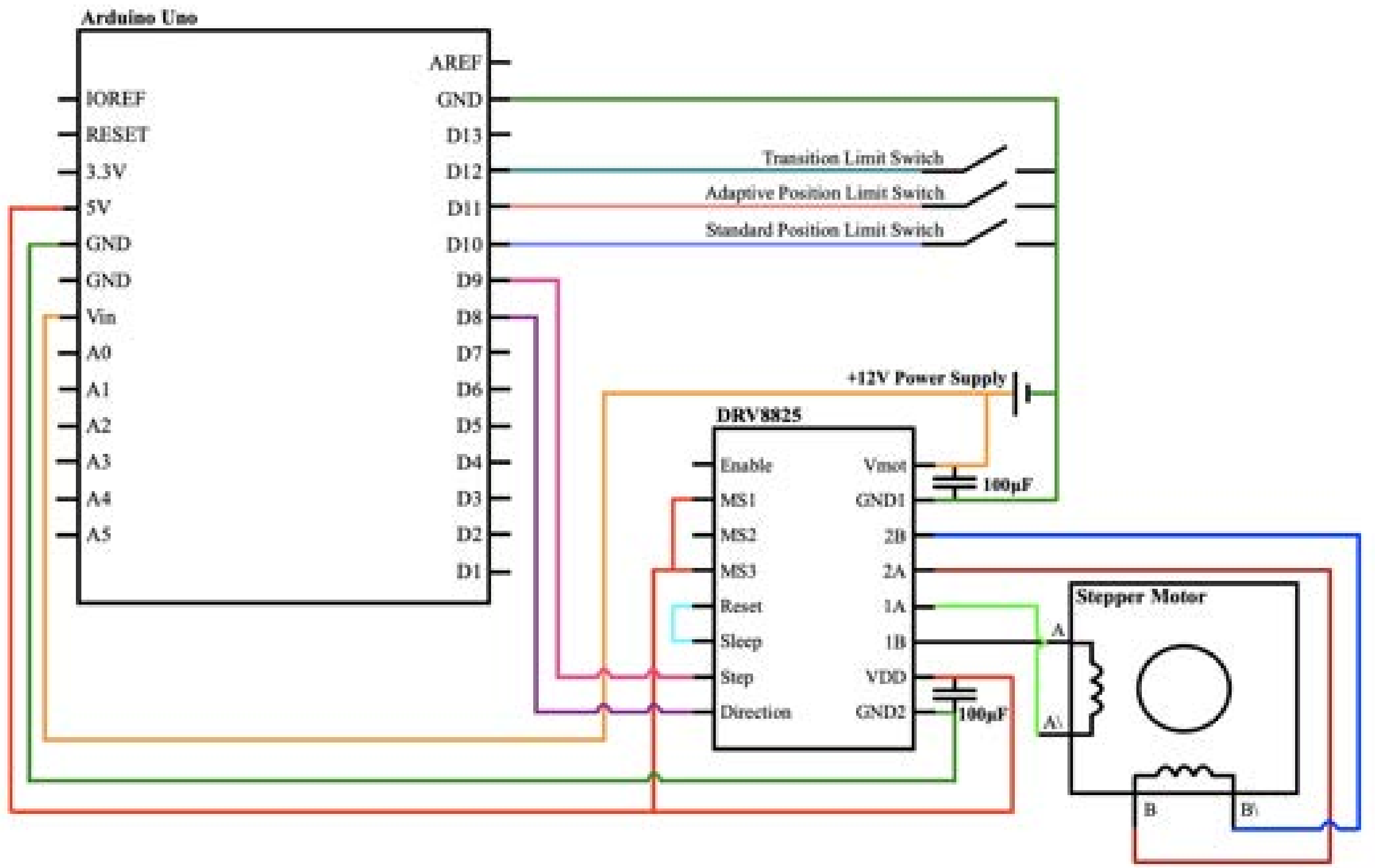
Date: 19NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: create a final schematic of the circuit

Content:



References: none

Conclusions:

I created a final circuit diagram schematic using shapes within Pages (apple Word equivalent). I couldn't get the lines to match up perfectly because the resolution of placement wasn't small enough, but I got it as close as possible.

Action items:

1. include this in the final fabrication plan

ANNABEL FRAKE - Nov 19, 2022, 9:10 PM CST

Download

Schematic.pages (165 kB)

Final Coding Flowchart

ANNABEL FRAKE - Nov 27, 2022, 11:26 PM CST

Note: Please navigate to "Annabel => Design Ideas => Motor Design for Console Rotation" for a full accounting of the coding design process.

ANNABEL FRAKE - Nov 27, 2022, 11:48 PM CST

Title: 27NOV2022 Final Coding Flowchart

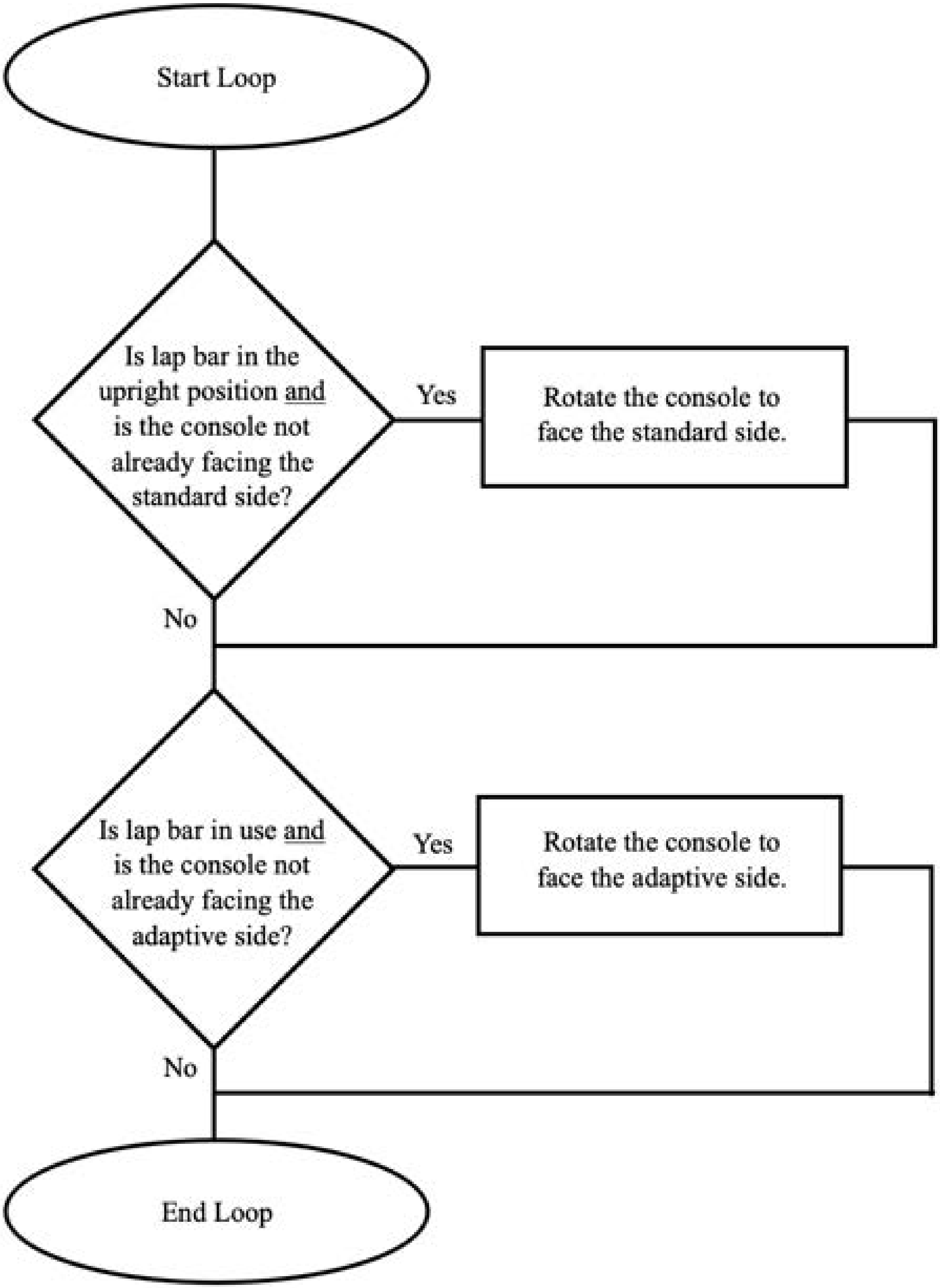
Date: 27NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: create the finalized flowchart

Content:



-

References: none

Conclusions:

I created a final coding flowchart using the Pages software.

Action items:

1. test the code using the edge case protocol after integration

2. include this in the final fabrication plan

ANNABEL FRAKE - Nov 27, 2022, 11:49 PM CST

Download

Final_Coding_Flowchart.pages (152 kB)

Final Circuit Fabrication

ANNABEL FRAKE - Dec 01, 2022, 6:45 PM CST

Title: Final Circuit Fabrication

Date: 19NOV2022 (initial fabrication), 1DEC2022 (finalized fabrication after transition limit switch cut to length)

Content by: Annabel Frake

Present: Annabel Frake

Goals: describe the final circuit fabrication

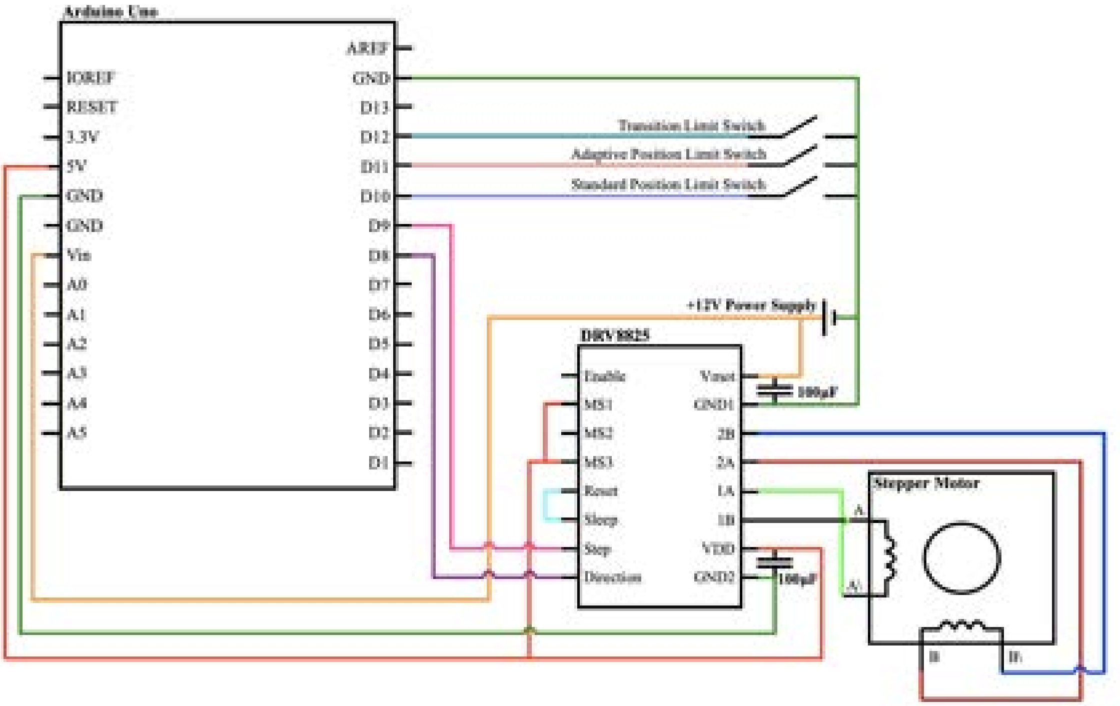
Content:

- Materials:

    1. Arduino Uno (https://www.amazon.com/dp/B01EWOE0UU?psc=1&ref=ppx_yo2ov_dt_b_product_details)
    2. DRV8825 (https://www.amazon.com/dp/B07XF2LYC8?psc=1&ref=ppx_yo2ov_dt_b_product_details)
    3. NEMA 17 stepper motor (https://www.amazon.com/gp/product/B00PNEQI7W/ref=ppx_yo_dt_b_asin_title_o00_s00?ie=UTF8&psc=1)
    4. +12V power supply (https://www.amazon.com/gp/product/B07GFFG1BQ/ref=ppx_yo_dt_b_asin_title_o00_s00?ie=UTF8&psc=1)
    5. three NO limit switches (sourced from client)
    6. two 100 µFarad capacitors (sourced from BME spare materials room)
    7. solder board (sourced from BME spare materials room)
    8. wires (sourced from MakerSpace)
    9. solder (sourced MakerSpace)
    10. heat shrink (sourced MakerSpace)

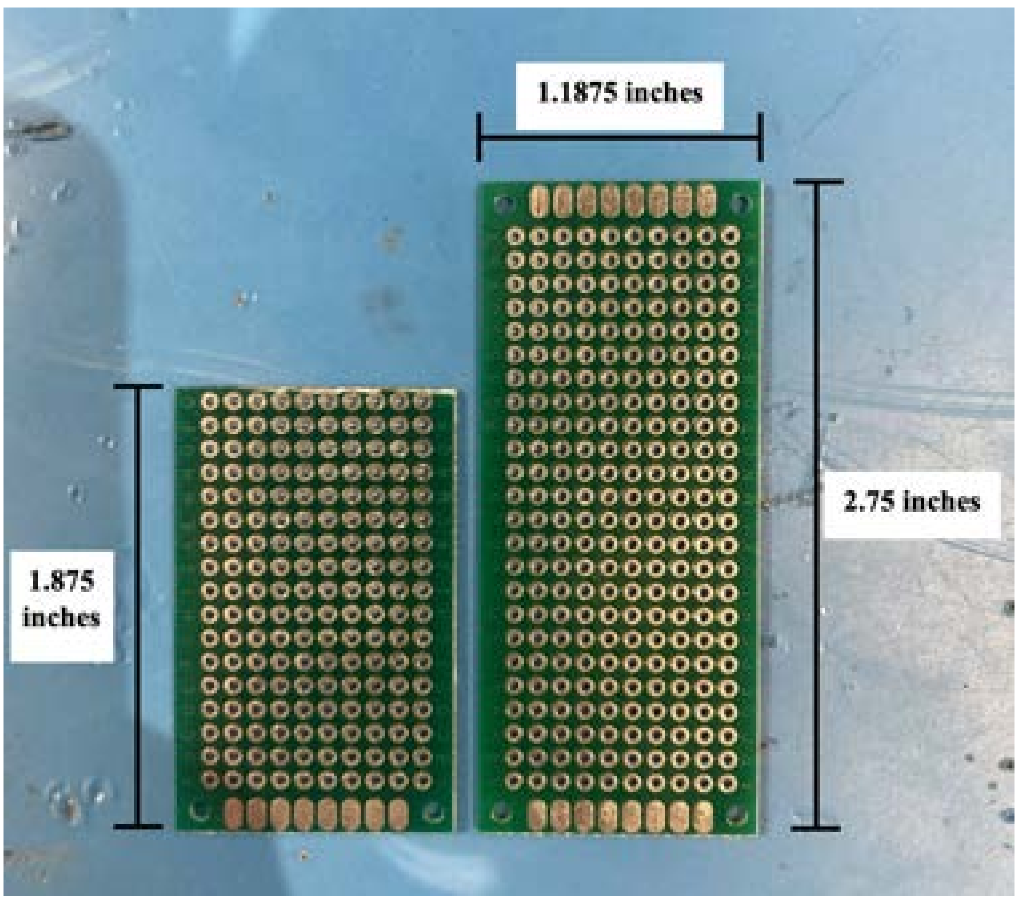
- Tools:
    - Soldering iron
    - heat gun
    - wire strippers / cutters
    - small screw driver (flathead or Philips)
    - bandsaw (could be substituted with handsaw)
    - USB cable

- Schematic:



- Procedure:

1. Cut a 2.75" x 1.1875" solder board down from 2.75" to a length of roughly 1.875".



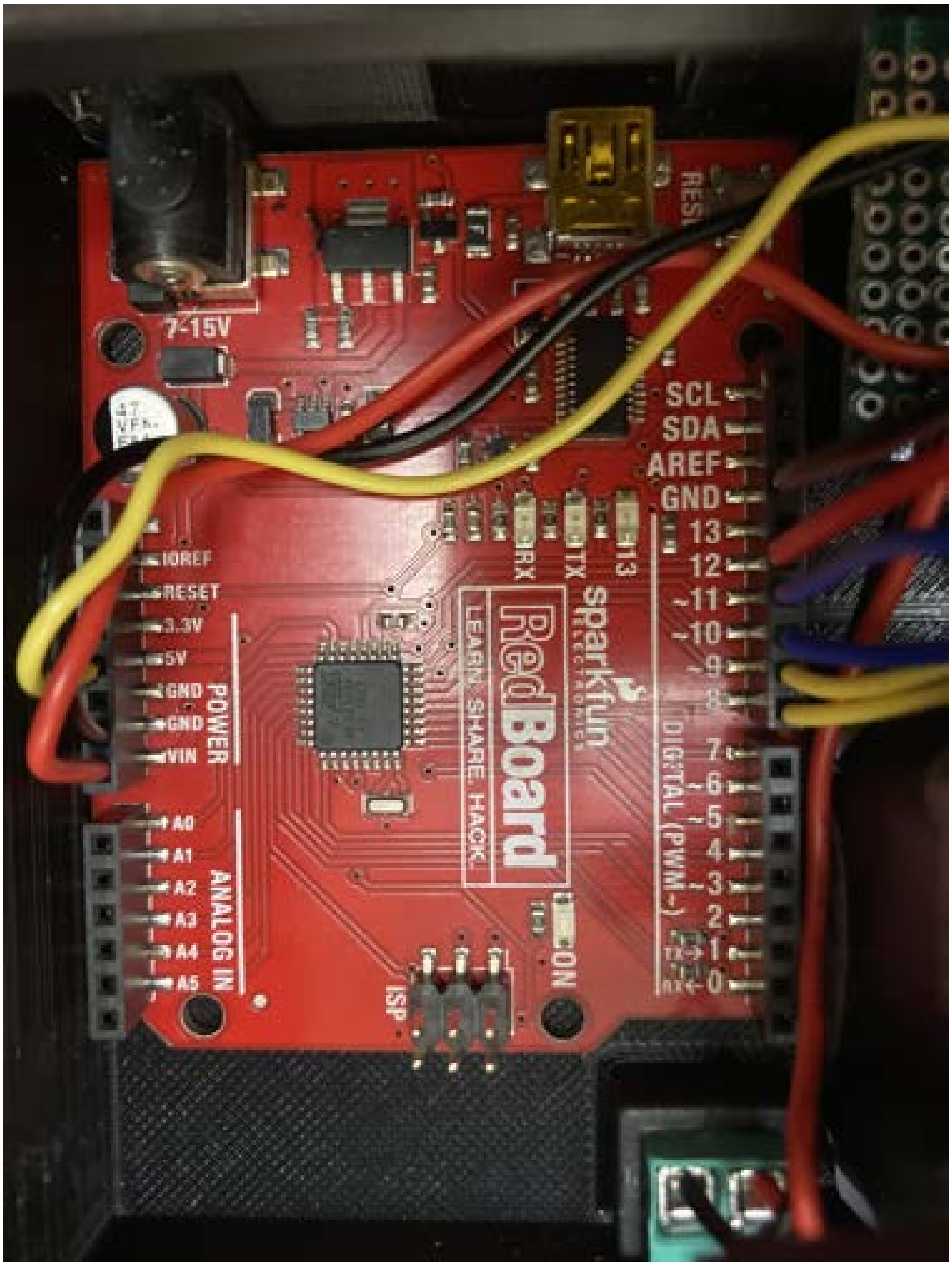
2. Cut two wires to a length of approximately 8". Solder these wires to the standard position limit switch. The GND wire should connect to the terminal labeled "C" and the digital pin wire should connect to the terminal labeled "NO". Cover the exposed metal with heat shrink.

- 

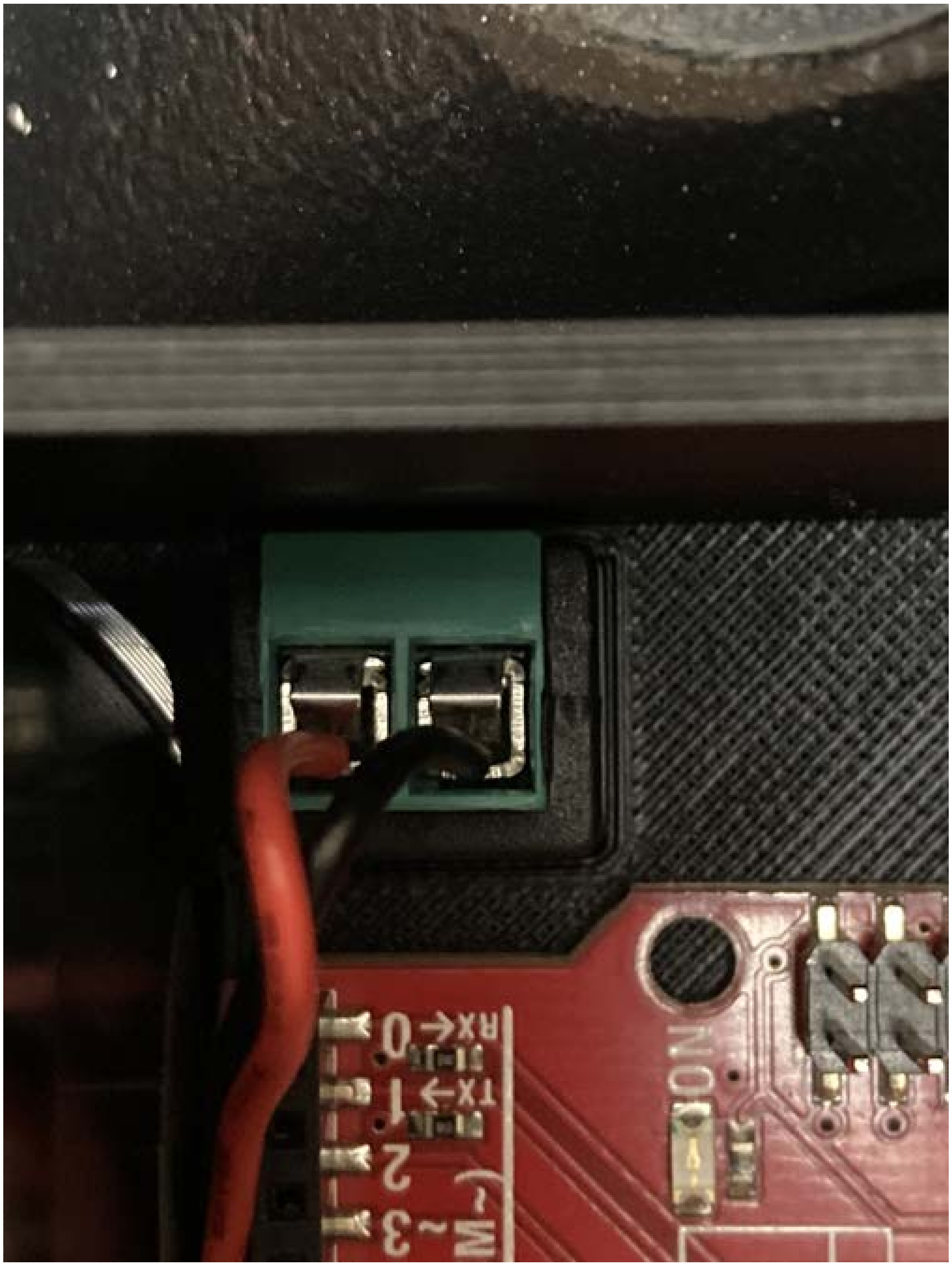
3. Repeat step 3 for the adaptive position limit switch.
4. Cut two wires to a length of approximately 3'. Solder these wires to the transition limit switch that goes to the lap bar on the stabilization frame. The GND wire should connect to the terminal labeled "C" and the digital pin wire should connect to the terminal labeled "NO". Cover the exposed metal with heat shrink.

- 

5. Populate the solder board with the DRV8825 and two 100 µFarad capacitors. Cut the stepper motor wires to approximately 2" in length. Solder the stepper motor wires, standard and adaptive position limit switch ground wires (Note, the transition limit switch ground wire is not soldered to the board. This will happen next semester after the stabilization frame is finalized to ensure proper wire length, etc.), and Arduino connection wires to the solder board. Reference the schematic provided above.

- 

6. Connect the wires from the solder board (GND and Vin) to the +12V power supply. Reference the schematic above.

- 

7. Upload the final Arduino code to the board using a USB cable. See attached Arduino file.
8. Connect the circuit to power via the +12 power supply.
9. Adjust the current potentiometer on the DRV8825 such that the current is enough to rotate the motor, but as low as possible to limit noise and vibration.

References: please go to "Annabel Frake > Design Ideas > Motor Design for Console Rotation" for an account of the entire circuit design process

Conclusions:

This entry describes the fabrication process for the final circuitry. For a detailed review of the design process, please navigate through the following folders: "Annabel Frake > Design Ideas > Motor Design for Console Rotation".

Action items:

1. integrate the electronics with the rest of the design
2. conduct final circuit testing

ANNABEL FRAKE - Nov 27, 2022, 11:17 PM CST

Download

streamlined_final_code_fall_2022_bme_400.ino (4.21 kB)

Fabrication of Stabilization Frame 11/30/22

SAMUEL SKIRPAN - Nov 30, 2022, 5:58 PM CST

Title: Fabrication of Stabilization Frame

Date: 11/30/22

Content by: Sam

Present: Sam and Tim

Goals: Fabricate stabilization frame at JHT with help of Staci.

Content:

- NOTE: refer to fabrication protocol page in notebook for exact protocol
- Tim and Sam traveled to JHT to fabricate the stabilization frame with the help of Staci
- First, we worked to solve the problem of attaching the pad to the metal bars
    - We utilized the triangular braces to attach the pad to the smaller horizontal bar with the use of some additional nuts and bolts
- Then, we took the support bars that Staci cut for us and attached them to the rowing machine
- We then attached the vertical bar to both of the support bars
- Next, we attached the larger horizontal bar to the top of the vertical bar and allowed it to rotate
    - We utilized an L bracket to allow for the larger horizontal bar to rotate
    - A long bolt was used to serve as a physical stop for the rotating horizontal bar
- The smaller horizontal bar with the pad on the end was then attached to the larger horizontal bar
- The following are a few pictures of the stabilization frame we fabricated:
    - 

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MATRIX
MATRIX
MATRIX

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Conclusions/action items:

Tim and I went to JHT to fabricate the stabilization frame with Staci's help. We were able to put everything together and make sure that it worked properly. We then took it off of the JHT rower and will place it on the rower we have at ECB.

Action items: create specific fabrication plan for the stabilization frame / update current fabrication plan.

Fabrication Protocol For Stabilization Frame 11/30/22

SAMUEL SKIRPAN - Nov 30, 2022, 10:00 PM CST

Title: Fabrication Protocol For Stabilization Frame

Date: 11/30/22

Content by: Sam

Present: Sam

Goals: Create fabrication protocol for stabilization frame.

Content:

See Sam's notebook entry in Sam's Fabrication Folder titled "Final Stabilization Frame Protocol for Assembly at JHT 11/30/22" for fabrication protocol.

Conclusions/action items:

See mentioned notebook page for protocol.

Fabrication Protocol For All 3D Printed Components 12/11/22

Josh ANDREATTA - Dec 11, 2022, 1:17 PM CST

Title: Fabrication Protocol For All 3D Printed Components

Date: 12/11/22

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Create fabrication protocol for all 3D printed components

Content:

See Josh's notebook entries in Josh's Fabrication Folder for explanations of each 3D print iteration and the overall fabrication (just screwing together).

Conclusions/action items:

See mentioned notebook page for protocol.

Circuit & Code Functionality Testing Protocol

ANNABEL FRAKE - Nov 19, 2022, 11:05 PM CST

Title: Circuit & Code Functionality Testing Protocol

Date: 19NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: create a protocol to test the functionality of the circuit and code after integration

Content:

- To test the functionality of the circuit and code, induce the following edge cases and record the rotation (or lack thereof) of the console. Record pass if the circuit operates according to the expected outcome. Otherwise, record fail.
  - Edge Case 1:
    - before power application: position the console in no-man's land (not facing the standard or adaptive sides), lower the lap bar such that the transition limit switch is not pressed
    - expected outcome: console rotates to adaptive side
    - recorded observation:
    - Pass/Fail:
  - Edge Case 2:
    - before power application: position the console in no-man's land (not facing the standard or adaptive sides), raise the lap bar such that the transition limit switch is pressed
    - expected outcome: console rotates to standard side
    - recorded observation:
    - Pass/Fail:
  - Edge Case 3:
    - before power application: position the console on the adaptive side such that the adaptive limit switch is suppressed, lower the lap bar such that the transition limit switch is not pressed
    - expected outcome: console remains stationary until lap bar is raised such that the transition limit switch is suppressed, then console rotates to standard side
    - recorded observation:
    - Pass/Fail:
  - Edge Case 4:
    - before power application: position the console on the standard side such that the standard limit switch is suppressed, raise the lap bar such that the transition limit switch is pressed
    - expected outcome: console remains stationary until lap bar is lowered such that the transition limit switch is no longer suppressed, then console rotates to adaptive side
    - recorded observation:
    - Pass/Fail:
  - Edge Case 5:
    - before power application: position the console on the adaptive side such that the adaptive limit switch is suppressed, raise the lap bar such that the transition limit switch is pressed
    - expected outcome: console rotates to standard side
    - recorded observation:
    - Pass/Fail:
  - Edge Case 6:

    - before power application: position the console on the standard side such that the standard limit switch is suppressed, lower the lap bar such that the transition limit switch is not pressed
    - expected outcome: console rotates to adaptive side
    - recorded observation:
    - Pass/Fail:
  - Edge Case 7:
    - after power application: disconnect the power supply while the console is rotating between the standard and adaptive sides (or vice versa), supply the circuit with power
    - expected outcome: the console rotates to the appropriate side of the rowing machine in accordance with the state of the transition limit switch when power is reconnected
    - recorded observation:
    - Pass/Fail:

References: none

Conclusions:

Tonight, I wrote a formal version of the edge case testing protocol I conducted previously. This version is specifically intended for the integrated design (ie motor, antlers, and stabilization frame all in one).

Action items:

1. after integration, complete the testing protocol

ANNABEL FRAKE - Dec 01, 2022, 6:31 PM CST

Title: Circuit & Code Functionality Testing Protocol

Date: 1DEC2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: add an additional edge case and specify number of test iterations

Content:

- To test the functionality of the circuit and code, induce the following edge cases and record the rotation (or lack thereof) of the console. Record pass if the circuit operates according to the expected outcome. Otherwise, record fail. Repeat each edge case 3 times.
    - Edge Case 1:
        - Before power application: Position the console in no-man's land (not facing the standard or adaptive sides). Lower the lap bar such that the transition limit switch is not pressed.
        - Apply power.
        - Expected outcome: The console rotates to adaptive side.
        - Recorded observation:
        - Pass/Fail:
    - Edge Case 2:
        - Before power application: Position the console in no-man's land (not facing the standard or adaptive sides). Raise the lap bar such that the transition limit switch is pressed.
        - Apply power.
        - Expected outcome: The console rotates to standard side.
        - Recorded observation:
        - Pass/Fail:
    - Edge Case 3:
        - Before power application: Position the console on the adaptive side such that the adaptive limit switch is suppressed. Lower the lap bar such that the transition limit switch is not pressed.
        - Apply power.
        - Expected outcome: The console remains stationary until the lap bar is raised such that the transition limit switch is suppressed. Then the console rotates to standard side.
        - recorded observation:
        - Pass/Fail:
    - Edge Case 4:
        - Before power application: Position the console on the standard side such that the standard limit switch is suppressed. Raise the lap bar such that the transition limit switch is pressed.
        - Apply power.
        - Expected outcome: The console remains stationary until the lap bar is lowered such that the transition limit switch is no longer suppressed. Then the console rotates to adaptive side.
        - Recorded observation:
        - Pass/Fail:
    - Edge Case 5:
        - Before power application: Position the console on the adaptive side such that the adaptive limit switch is suppressed. Raise the lap bar such that the transition limit switch is pressed.
        - Expected outcome: The console rotates to standard side.
        - Recorded observation:
        - Pass/Fail:
    - Edge Case 6:

    - Before power application: Position the console on the standard side such that the standard limit switch is suppressed. Lower the lap bar such that the transition limit switch is not pressed.
    - Expected outcome: The console rotates to adaptive side.
    - Recorded observation:
    - Pass/Fail:
  - Edge Case 7:
    - Apply power.
    - After power application: Disconnect the power supply while the console is rotating between the standard and adaptive sides (or vice versa). Supply the circuit with power.
    - Expected outcome: The console rotates to the appropriate side of the rowing machine in accordance with the state of the transition limit switch when power is reconnected.
    - Recorded observation:
    - Pass/Fail:
  - Edge Case 8:
    - Apply power.
    - After power application: Induce rotation of the console. Raise and lower the lap bar multiple times (such that the transition limit switch is pressed and released multiple times) during the rotation from one side of the machine to the other (either adaptive to standard or standard to adaptive, the choice is arbitrary). Before the console finishes rotating, either raise or lower the lap bar and keep it there.
    - Expected outcome: After the console finishes rotating to the position to which it was originally traveling, the console either stays there or rotates to the opposite side in accordance with the state of the transition limit switch.
    - Recorded observation:
    - Pass/Fail:

References: none

Conclusions:

I added another edge case to the protocol (edge case 8) and specified that each edge case should be tested 3 times. Also fixed the wording on the rest of the edge cases to be more clear.

Action items:

1. after integration, complete the testing protocol

Testing Protocol for Displacement - 12/1/22

SAMUEL SKIRPAN - Dec 01, 2022, 1:50 PM CST

Title: Testing Protocol for Displacement

Date: 12/1/22

Content by: Dhruv Biswas and Tim Tran

Present: Tim, Sam, Annabel, Josh, and Roxi

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

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 Dhruv Biswas helped him to write the protocol. 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.

1DEC2022 Circuit & Code Functionality Testing

ANNABEL FRAKE - Dec 01, 2022, 6:43 PM CST

Title: 1DEC2022 Circuit & Code Functionality Testing

Date: 1DEC2022

Content by: Annabel Frake

Present: Annabel, Roxi, Sam, Tim

Goals: test the circuit & code functionality according to the circuit & code functionality test protocol

Content:

- To test the functionality of the circuit and code, induce the following edge cases and record the rotation (or lack thereof) of the console. Record pass if the circuit operates according to the expected outcome. Otherwise, record fail. Repeat each edge case 3 times.
    - Edge Case 1:
        - Before power application: Position the console in no-man's land (not facing the standard or adaptive sides). Lower the lap bar such that the transition limit switch is not pressed.
        - Apply power.
        - Expected outcome: The console rotates to adaptive side.
        - Recorded observation: The console rotated to adaptive side.
        - Pass/Fail: Pass, Pass, Pass
    - Edge Case 2:
        - Before power application: Position the console in no-man's land (not facing the standard or adaptive sides). Raise the lap bar such that the transition limit switch is pressed.
        - Apply power.
        - Expected outcome: The console rotates to standard side.
        - Recorded observation: The console rotated to standard side.
        - Pass/Fail: Pass, Pass, Pass
    - Edge Case 3:
        - Before power application: Position the console on the adaptive side such that the adaptive limit switch is suppressed. Lower the lap bar such that the transition limit switch is not pressed.
        - Apply power.
        - Expected outcome: The console remains stationary until the lap bar is raised such that the transition limit switch is suppressed. Then the console rotates to standard side.
        - recorded observation: The console remained stationary.
        - Pass/Fail: Pass, Pass, Pass
    - Edge Case 4:
        - Before power application: Position the console on the standard side such that the standard limit switch is suppressed. Raise the lap bar such that the transition limit switch is pressed.
        - Apply power.
        - Expected outcome: The console remains stationary until the lap bar is lowered such that the transition limit switch is no longer suppressed. Then the console rotates to adaptive side.
        - Recorded observation: The console remained stationary.
        - Pass/Fail: Pass, Pass, Pass
    - Edge Case 5:
        - Before power application: Position the console on the adaptive side such that the adaptive limit switch is suppressed. Raise the lap bar such that the transition limit switch is pressed.
        - Expected outcome: The console rotates to standard side.

    - Recorded observation: The console rotated to standard side.
    - Pass/Fail: Pass, Pass, Pass
  - Edge Case 6:
    - Before power application: Position the console on the standard side such that the standard limit switch is suppressed. Lower the lap bar such that the transition limit switch is not pressed.
    - Expected outcome: The console rotates to adaptive side.
    - Recorded observation: The console rotated to adaptive side.
    - Pass/Fail: Pass, Pass, Pass
  - Edge Case 7:
    - Apply power.
    - After power application: Disconnect the power supply while the console is rotating between the standard and adaptive sides (or vice versa). Supply the circuit with power.
    - Expected outcome: The console rotates to the appropriate side of the rowing machine in accordance with the state of the transition limit switch when power is reconnected.
    - Recorded observation: The console rotated to the appropriate side of the rowing machine in accordance with the state of the transition limit switch when power was reconnected.
    - Pass/Fail: Pass, Pass, Pass
  - Edge Case 8:
    - Apply power.
    - After power application: Induce rotation of the console. Raise and lower the lap bar multiple times (such that the transition limit switch is pressed and released multiple times) during the rotation from one side of the machine to the other (either adaptive to standard or standard to adaptive, the choice is arbitrary). Before the console finishes rotating, either raise or lower the lap bar and keep it there.
    - Expected outcome: After the console finishes rotating to the position to which it was originally traveling, the console either stays there or rotates to the opposite side in accordance with the state of the transition limit switch.
    - Recorded observation: After the console finished rotating to the position to which it was originally traveling, the console either stayed there or rotated to the opposite side in accordance with the state of the transition limit switch (we tried both situations).
      - *Note: Because the lap bar didn't move up and down smoothly and kind of got stuck, we couldn't press and release the transition limit switch fast enough during the console rotation. Therefore, we completed this test by manually pressing and releasing the switch with a finger.*
    - Pass/Fail: Pass, Pass, Pass

References: none

Conclusions:

The circuit and code passed all 8 edge cases, 3 times each. Because things are duct taped together and the fit isn't perfect (will be fixed next semester), the motor stalled a handful of times during rotation (i.e. caught on a tape edge, etc.). To combat this, we raised the console up on the shaft of the motor so it had more clearance. This fit is a bit loose, so we wrapped tape around the shaft to make it a bit thicker. Josh will reprint it for the final poster presentation. Despite the rare stalling (which was eliminated by raising the console 3D print on the motor shaft to give more clearance), the console always rotated the way it was intended to rotate.

Action items:

1. include the data in the final report

ANNABEL FRAKE - Dec 01, 2022, 6:44 PM CST

Download

IMG_6379.MOV (19.1 MB) Video of the console rotating based on feedback from the limit switches. Not any particular edge case.

11/19/2022 - Pulley Plate, Antler, and Motor Box Simulation Testing

Josh ANDREATTA - Dec 03, 2022, 11:59 AM CST

Title: 11/19/2022 - Pulley Plate, Antler, and Motor Box Simulation Testing

Date: 11/19/2022

Content by: Josh Andreatta

Present: Josh Andreatta

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

Content:

A solidworks simulation was conducted to analyze the stresses and displacements acquired due to a maximum, worst case load. In order to properly test the strength and geometry of the pulley support plates, the plates were modeled as Tough PLA in SolidWorks. This was done by creating a new material and altering the mechanical properties as shown in **Figure #**. This ensured that the stress and displacement data that was acquired was representative of the material that the plates were printed in. To test the strength of the pulley support plates, a maximum load of 1050 N was applied to the inner circular cavity on each plate where the pulley is connected to the plates. According to the PDS in **Appendix #**, this would be the maximum load applied to the additional pulley under maximum rowing effort. Ideally, this load would be transmitted equally to each pulley plate. Thus, this load has a safety factor of two, and represents the maximum loading of the plates [source from zotero]. To model a worst case scenario, the load was applied directly downward onto this cavity. This is where the plate sits on the additional pulley bearing. Thus, if any force were directed onto the pulley plates, it would be transmitted to this inner cavity surface. During a typical rowing motion, tension in the rope follows along a path parallel to the floor. Thus, the worst case scenario was modeled as the maximum load placed on the plates perpendicular to the floor. The cavity that sits on the rower neck support arms and the two faces in which the front and back separator blocks are rigidly screwed into the pulley plates were held fixed during the simulation to model the plates when sitting on these support arms and being pushed apart by the separator blocks, as they should not move. Testing of the stresses and displacements that develop revealed the strength and rigidity of the chosen material and geometry of the support plates, which in turn revealed how well the plates stabilized the additional pulley under typical rowing conditions.

Next, another solidworks simulation was conducted to analyze the stresses and displacements acquired due to a maximum, worst case load on the new antlers added to the pulley plates. To simulate this worst case loading, the same 1050N load (with a safety factor of two) was applied to two locations. First, this load was applied to the slanted edge of the inner surface of the handlebar cavity on the standard side of the rower directed towards the standard side of the rower. Next, the load was applied to the slanted edge of the inner surface of the handlebar cavity on the adaptive side of the rower directed towards the adaptive side of the rower. The plates were again held rigidly fixed at the two faces in which the plates contact the separator blocks and the cavity where the plate sits on the rower neck support arm. This loading simulates the worst case scenario of a user pulling directly on the handlebar while it is still sitting within the antler handlebar cavity. By placing the loads on either side of this cavity and directing the load to either the standard or adaptive side, this simulation will predict how the antlers will react to an excessive load being applied from either the standard or adaptive side of the rower.

Lastly, a final solidworks simulation was conducted to analyze the stresses and displacements due to a maximum, worst case load on the motor box. To simulate this worst case loading, a 50N force was directed downward on the bottom surface of the motor box. This simulates any weight from the electronics, console, or the user slightly pressing down on the box to be directed directly down on the box. The box was held rigidly fixed where it is screwed into the two pulley plates. A 50N force was arbitrarily chosen because the motor box is not expected to experience more than 5lbs of weight being placed on it at any time. Thus, by applying a 50N force (11.24 lbs), the box was tested with a safety factor of 2.25 to ensure its strength and rigidity under both normal and extreme loads. The box was also modeled as Tough PLA to mimic the actual material properties of the material it will be 3D printed out of.

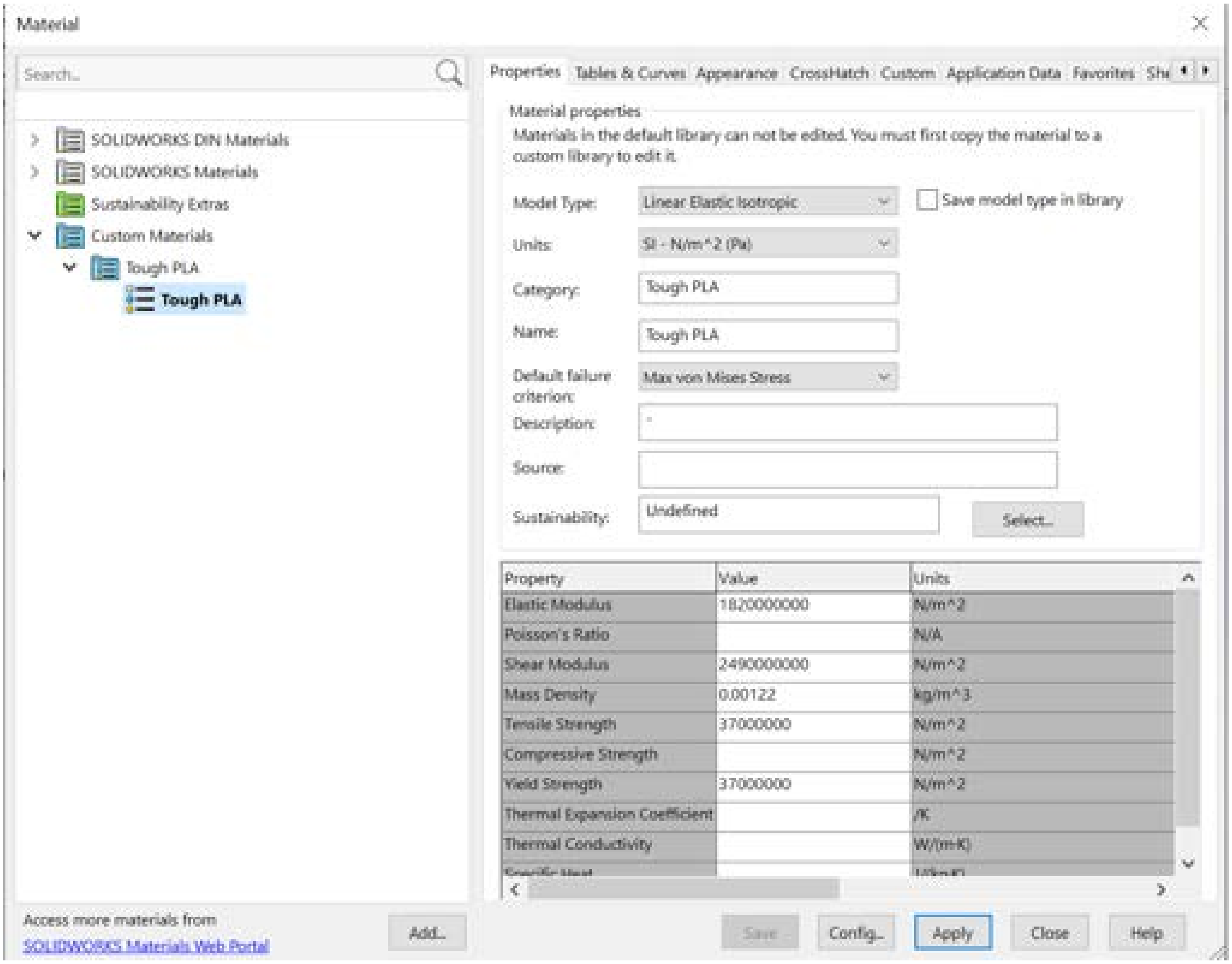


Figure #. Tough PLA. The above image shows the material specifications used to try to mimic Tough PLA according to the Ultimaker Technical Data Sheet for Tough PLA.

To further enhance the rigidity of these plates, when printing, I will use a 100% infill so that the plates are entirely solid Tough PLA, with little gaps between the layers. This will improve the performance under high loading conditions, and greatly reduce the deformations predicted by the solidworks simulations.

Simulation testing for the pulley plates was only conducted on the Left Pulley Plate because the left and right plates are exact mirror images of each other and will thus perform identically. After completing the SolidWorks simulation testing on the pulley plates, the resulting stresses and displacements were analyzed to determine the strength of the Tough PLA material and the designed geometries. After applying a 1050 N load to the inner bearing surface of the pulley plates, a maximum displacement of 1.757 mm occurred at the top of the antler handlebar cavity (**Figure #**). This was expected because the region in which the load was applied is thin. However, since this cavity is supported by a thick base of Tough PLA material below it, the cavity itself did not deflect excessively. Rather, the less supported antler deflected more because it has the least amount of structural integrity, and this is why the tips of the handlebar cavity deflected the most. This displacement is incredibly small, and will likely be even less during actual load bearing, due to the metal pulley bearing being inserted into this cavity and accepting some of the applied load. Throughout the rest of the plate, displacements were also less than 1.757 mm, proving that the geometry for both plates will be strong enough to withstand typical rowing loads. Additionally, the maximum stress that developed under this maximum load was only 18.36 MPa (**Figure #**). This is much less than the yield strength of Tough PLA of 37 MPa [12]. This maximum stress developed along the inner surface of the bearing cavity where the load was directly applied. This was expected because when the load is applied, the cavity would want to fold in on itself. Loading with a safety factor of two shows that both pulley support plates will be able to withstand loads well under this maximum, like the loads experienced during typical rowing, and thus should hold the additional pulley stable.

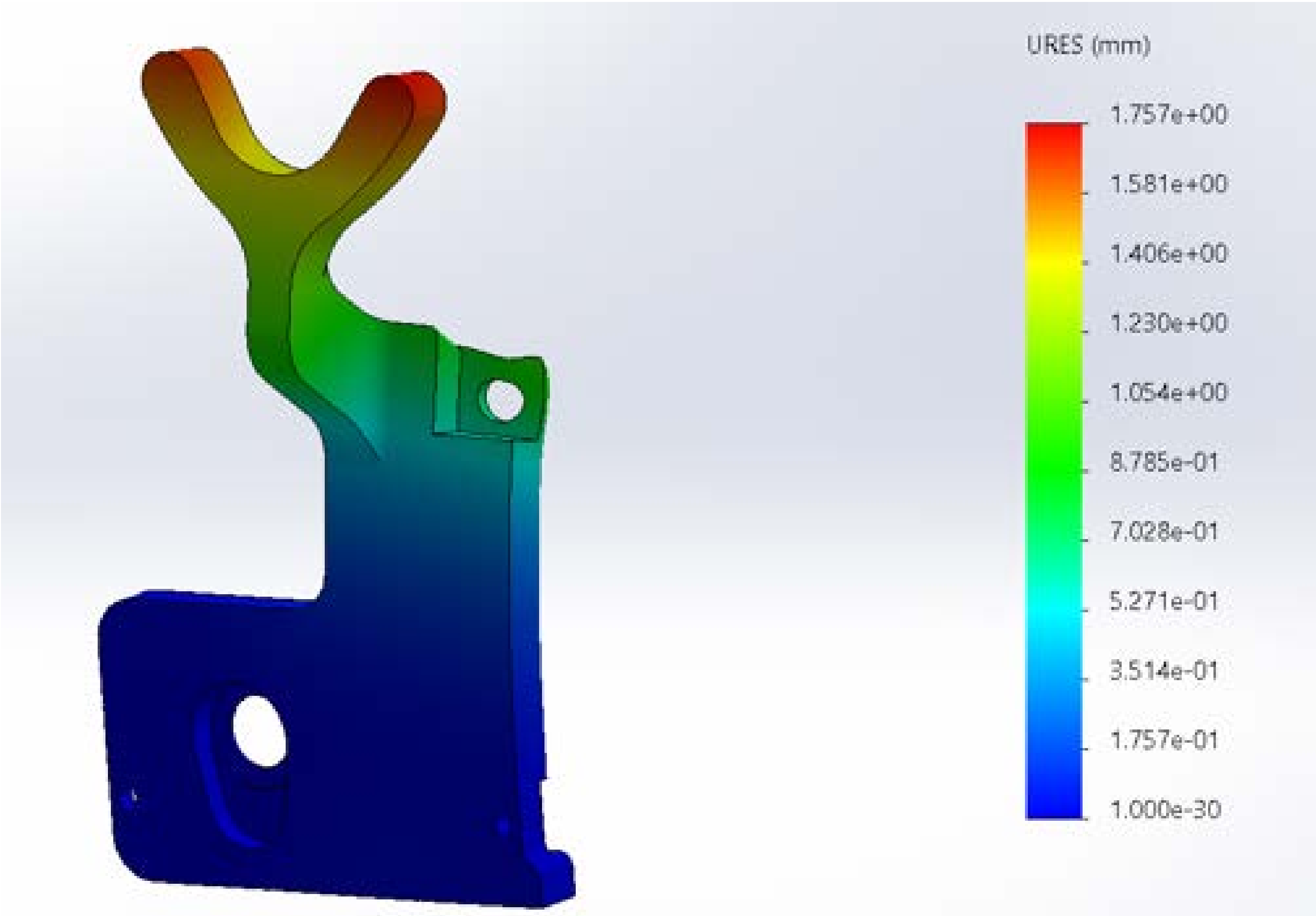


Figure #. Pulley Plate Deformation. The pulley plate deforms the most at the tips of the antler handlebar cavity due to having the least amount of structural integrity.

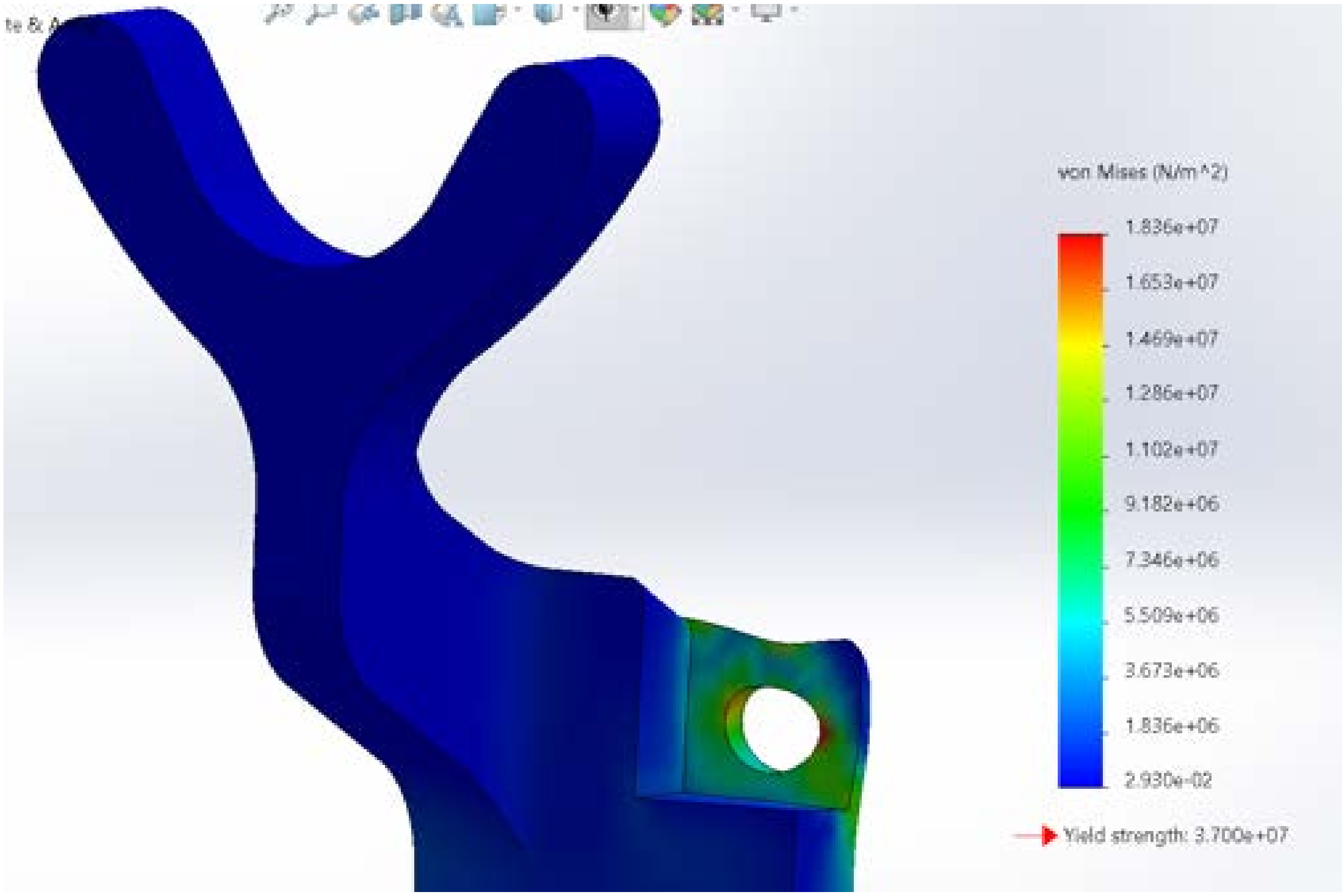


Figure #. Pulley Plate Stress. The pulley plate develops the largest stress concentration at the outer edge of the center of the cavity in which the load was applied due to the cavity wanting to fold in on itself.

After completing the SolidWorks simulation testing on the antlers, the resulting stresses and displacements were analyzed to determine the strength of the Tough PLA material and the designed geometries. After applying a 1050 N load to the slanted edge of the inner surface of the handlebar cavity on the standard side of the rower directed towards the standard side of the rower, a maximum displacement of 29.46 mm occurred at the top of the antler handlebar cavity (**Figure #**). This was expected because the region in which the load was applied has a relatively weak structural integrity when compared with the rest of the pulley plate. Thus, when an excessive load such as 1050N is applied, this region will be likely to fail. Throughout the rest of the antler, displacements were greater than 6mm. However, since the antler will be printed out of a completely solid Tough PLA structure, the actual deformation of the handlebar cavity is likely to be much less than predicted. Additionally, the maximum stress that developed under this maximum load was 110.7 MPa (**Figure #**). This is much greater than the yield strength of Tough PLA of 37 MPa [zotero]. This maximum stress developed along the slanted surface of the antler which supports the handlebar cavity. This was expected because when the load is applied, the antler arm would want to bend away from the plate and fracture.

After applying a 1050 N load to the slanted edge of the inner surface of the handlebar cavity on the adaptive side of the rower directed towards the adaptive side of the rower, a maximum displacement of 29.57 mm occurred at the top of the antler handlebar cavity (**Figure #**). This was expected because the region in which the load was applied has a relatively weak structural integrity when compared with the rest of the pulley plate. Thus, when an excessive load such as 1050N is applied, this region will be likely to fail. Throughout the rest of the antler, displacements were greater than 6mm. However, since the antler will be printed out of a completely solid Tough PLA structure, the actual deformation of the handlebar cavity is likely to be much less than predicted. Additionally, the maximum stress that developed under this maximum load was 111.5 MPa (**Figure #**). This is much greater than the yield strength of Tough PLA of 37 MPa [zotero]. This maximum stress developed along the slanted surface of the antler which supports the handlebar cavity. This was expected because when the load is applied, the antler arm would want to bend away from the plate and fracture.

Thus, the predicted stresses and loadings for both loading conditions of the antlers are very similar to one another. Despite the excessive deformations and stresses that the simulation predicts, the antlers are likely to actually experience a much smaller magnitude of force, which would greatly reduce their deformations and stresses. This is because users are not likely to being rowing with the handlebar still placed in the cavity. Rather, users are more likely to pull strongly on the handlebar by accident, which would be a force much less tha 1050N. Finally, the antlers will be made out of a 100% infill structure of Tough PLA. This extra infill will greatly increase the structures rigidity and therefore reduce the experienced deformations and stress concentrations. The antlers are predicted and likely to perform as intended under typical loading conditions, but are likely to fail under very extreme loading scenarios. Due to the limitations of simulating worst case loadings and accurately representing material properties, future testing will include physical failure tests to record the actual failure force required to fracture the antlers.

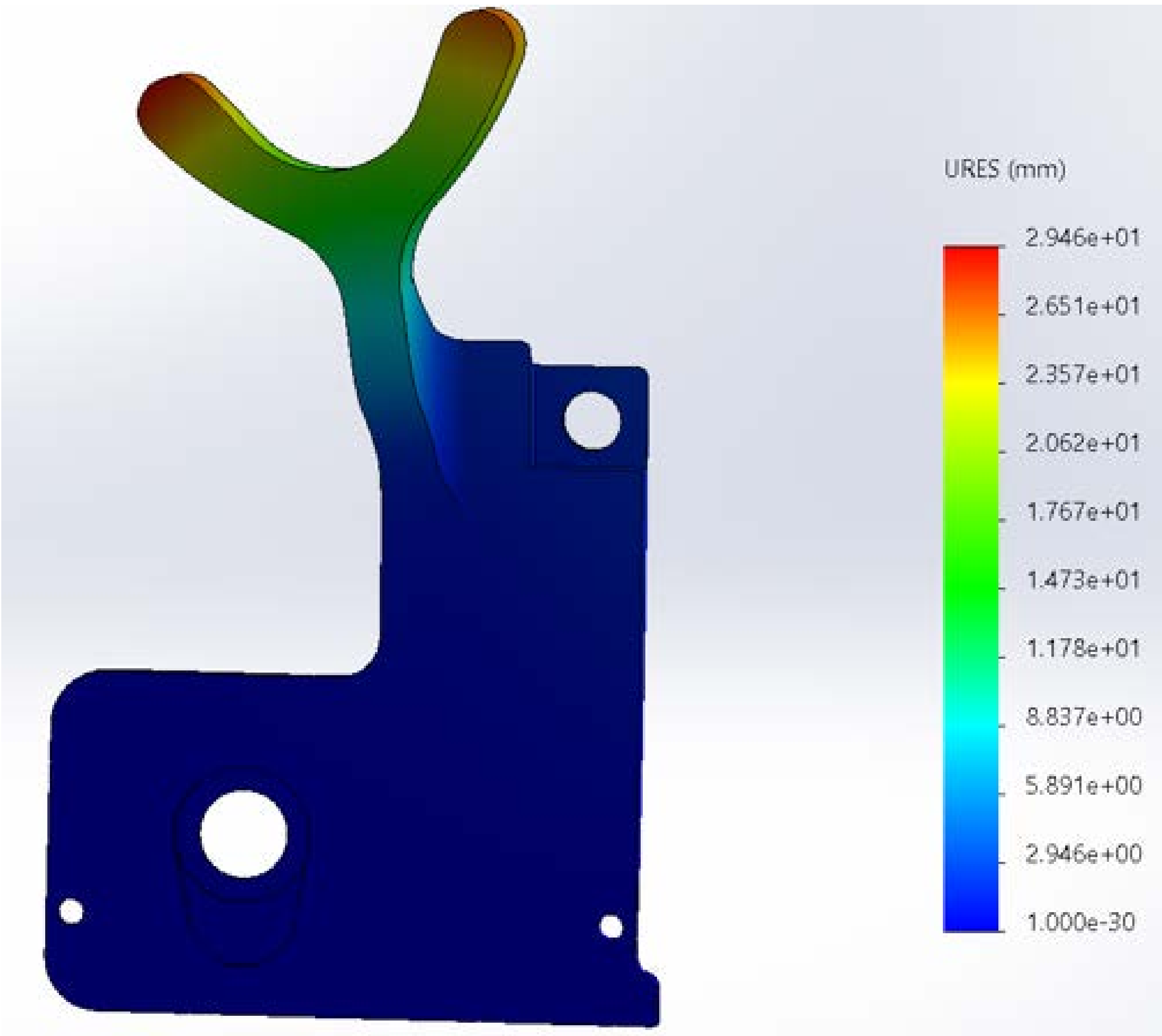


Figure #. Antler Standard Side Deformation. The antler deflects almost 30mm towards the standard side of the rower when subject to a very high and extreme load.

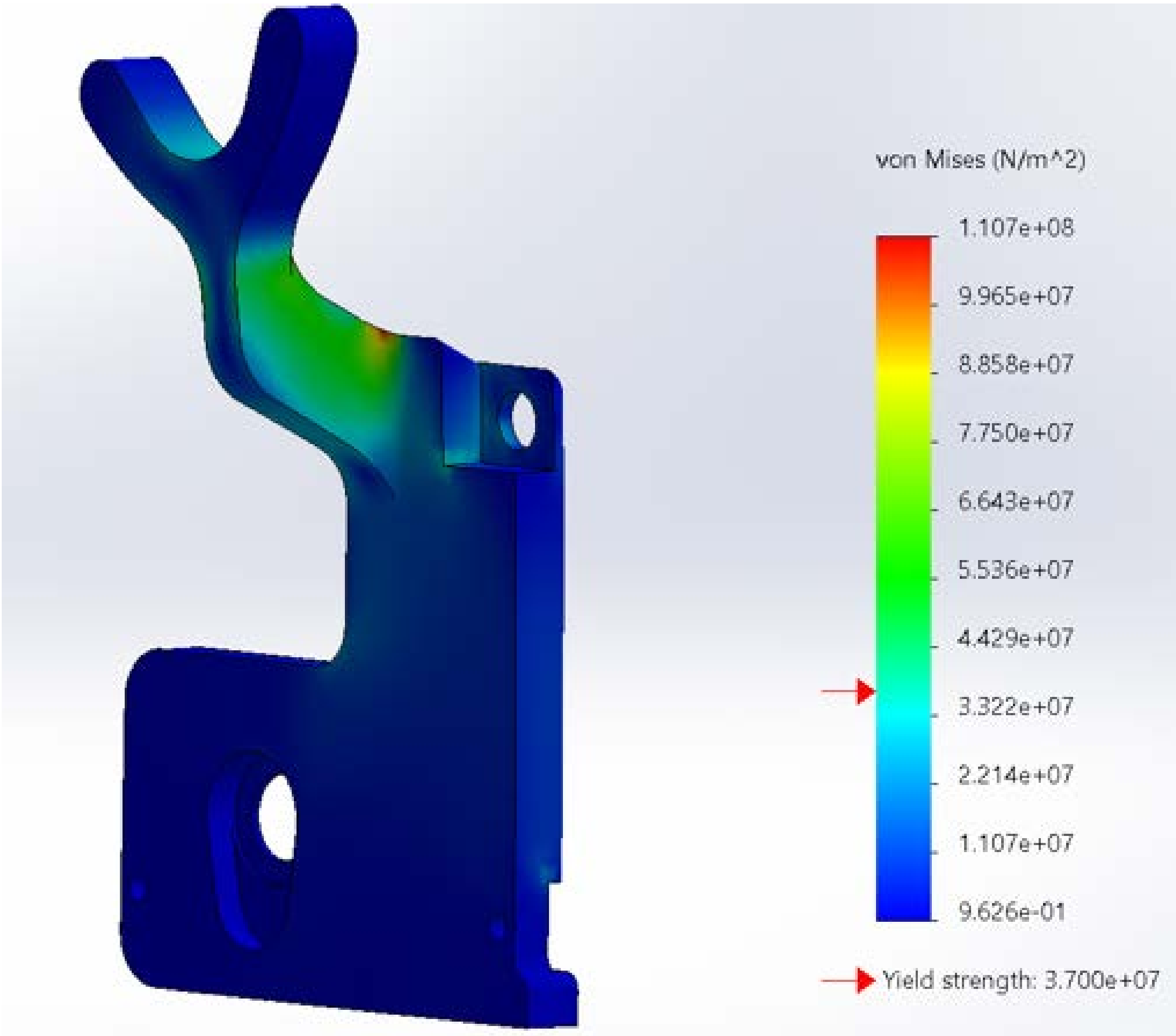


Figure #. Antler Standard Side Max Stress. The antler develops significant stress in the arm of the antler support under extremely high and excessive loading, causing the structure to fail under this given loading scenario.

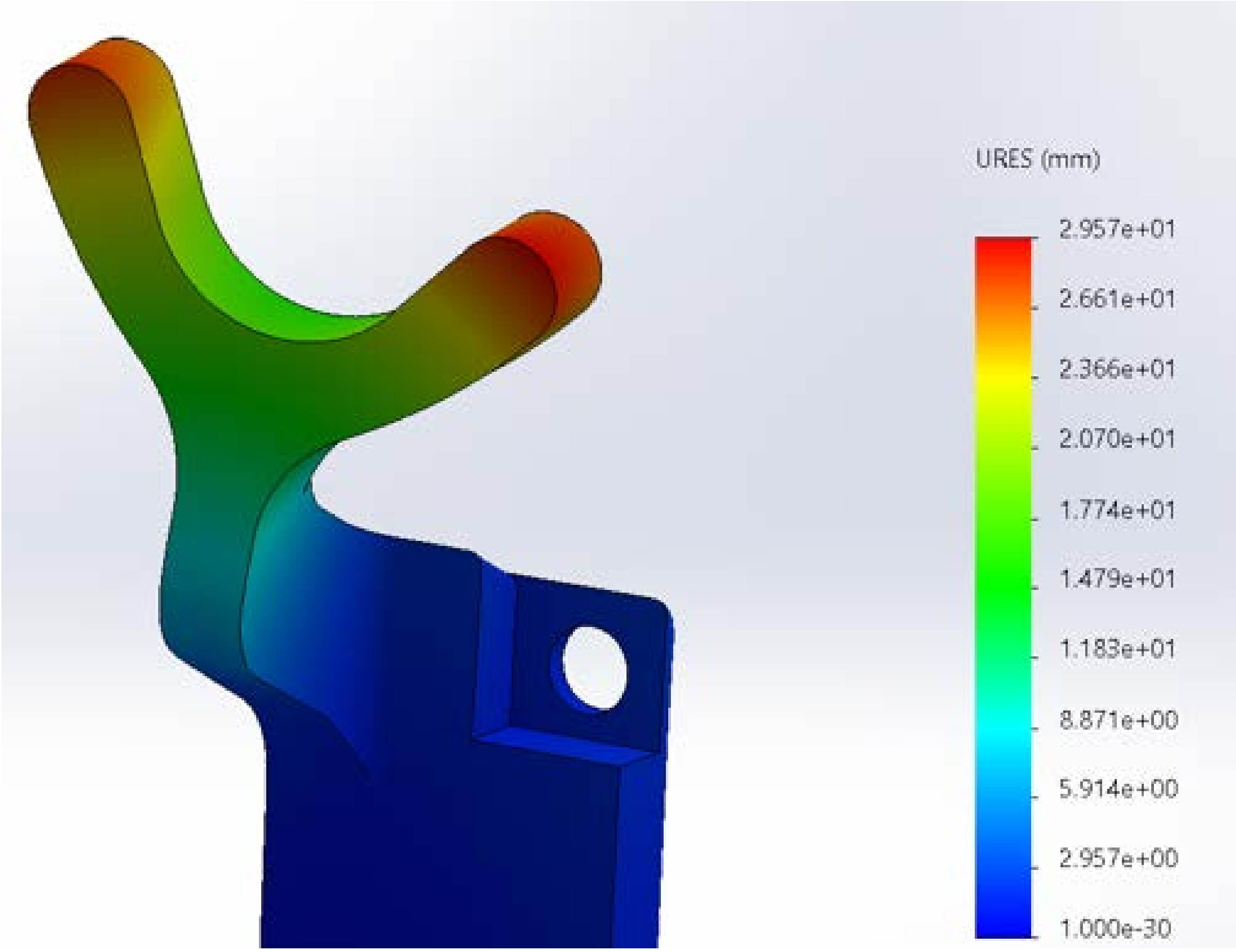


Figure #. Antler Adaptive Side Deformation. The antler deflects almost 30mm towards the adaptive side of the rower when subject to a very high and extreme load.

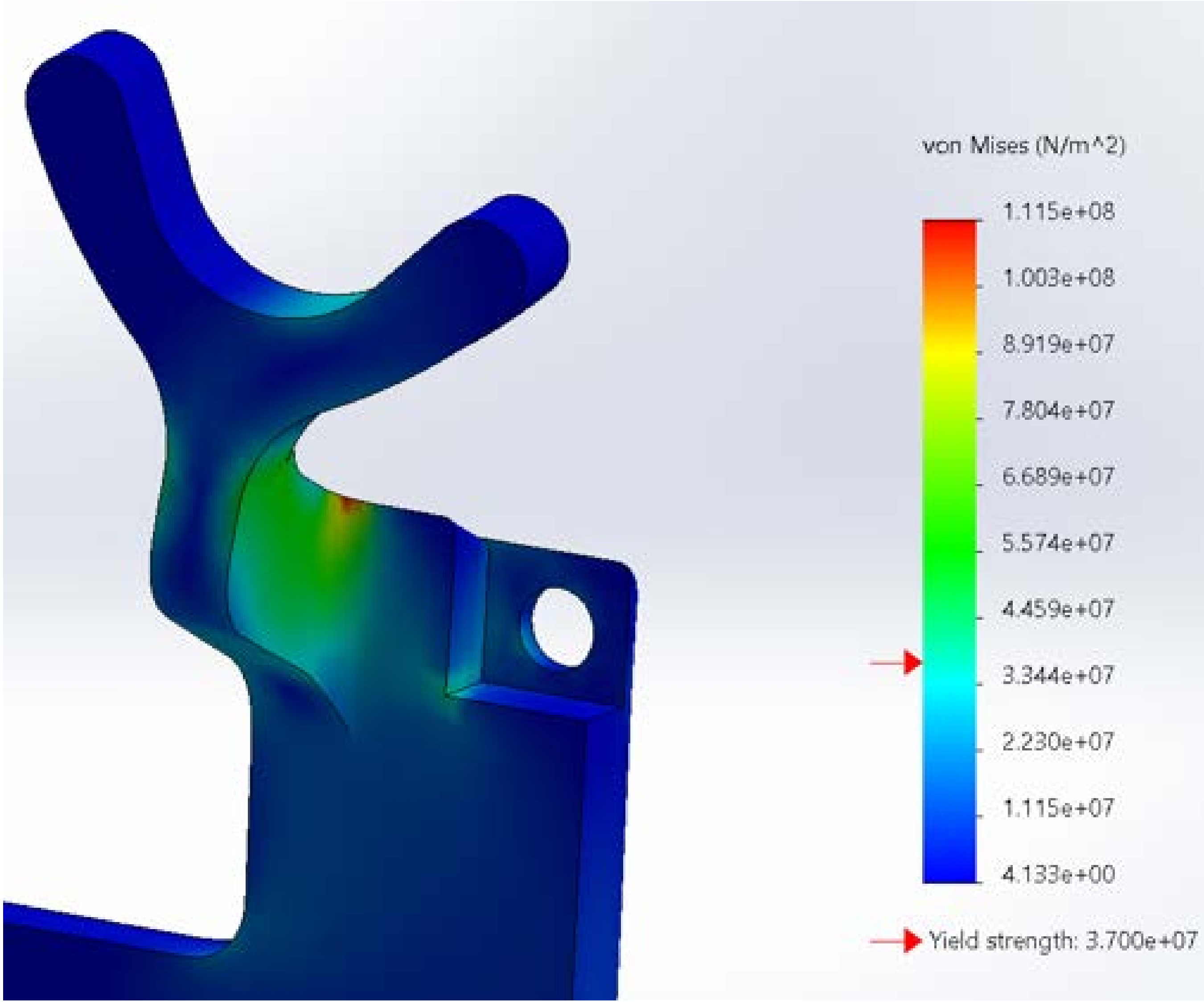


Figure #. Antler Adaptive Side Max Stress. The antler develops significant stress in the arm of the antler support under extremely high and excessive loading, causing the structure to fail under this given loading scenario.

After completing the SolidWorks simulation testing on the motor box, the resulting stresses and displacements were analyzed to determine the strength of the Tough PLA material and the designed geometries. After applying a 50 N load to the bottom surface of the box, a maximum displacement of 0.9422 mm occurred at the left side of the box (**Figure #**). This was expected because since the box is rigidly connected to the underside of the pulley plates, it is likely to bend more the further the material is away from this fixed location. Thus, the left side of the box deflected the most. Throughout the rest of the plate, displacements were also less than 0.9422 mm, proving that the geometry for the box will be strong enough to withstand typical external loads. Additionally, the maximum stress that developed under this maximum load was only 5.559 MPa (**Figure #**). This is much less than the yield strength of Tough PLA of 37 MPa [12]. This maximum stress developed along the edge where the structure first is able to bend from where it is rigidly connected to the underside of the pulley plates. This was expected because when the load is applied, the box will begin to kink at this location. Loading with a safety factor of 2.25 shows that the motor box will be able to withstand loads of the console, electronics, and extra downward directed forces, such as from the user pressing down slightly on the console when pressing a button, without fracturing or deforming excessively.

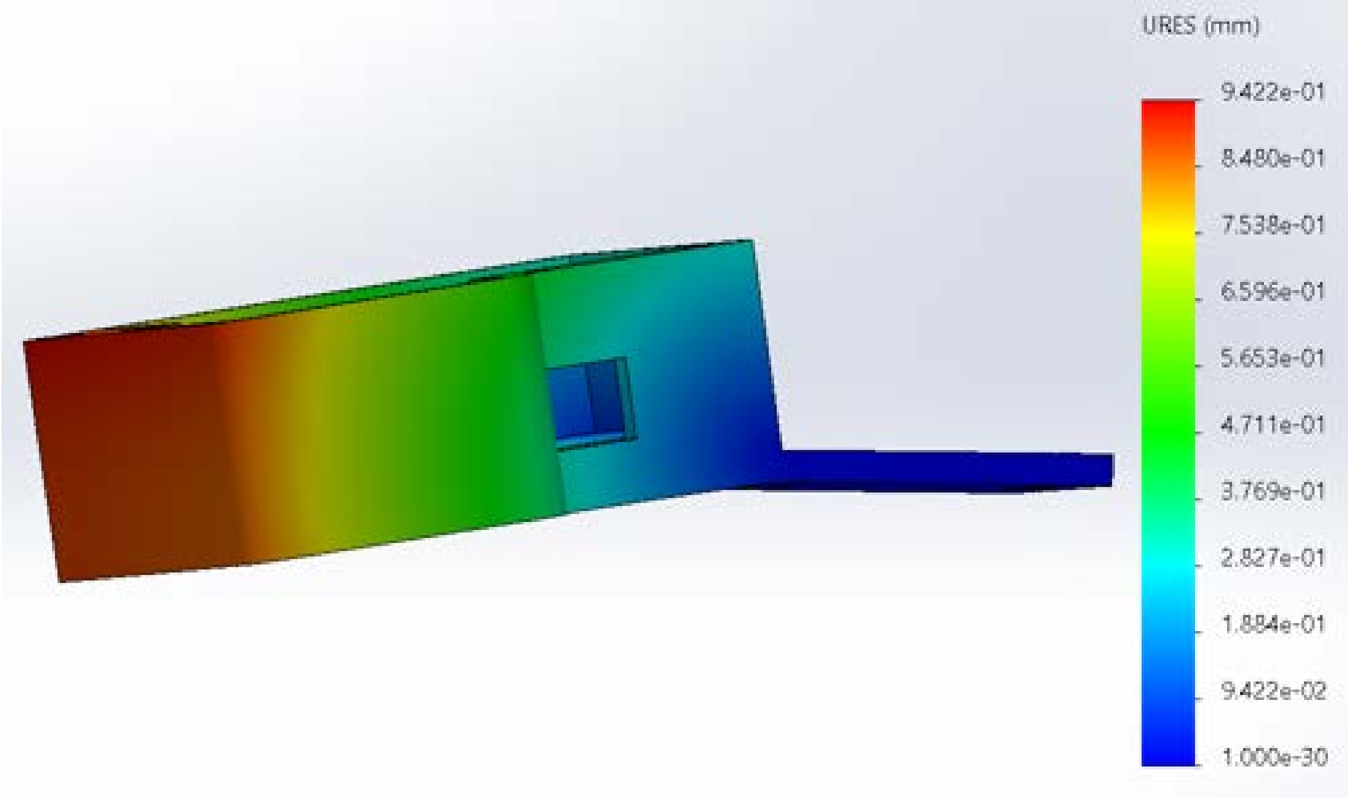


Figure #. Motor Box Deformation. The motor box deflects less than 1mm under a worst case loading, proving it is likely to succeed in holding the weight of our designed circuit.

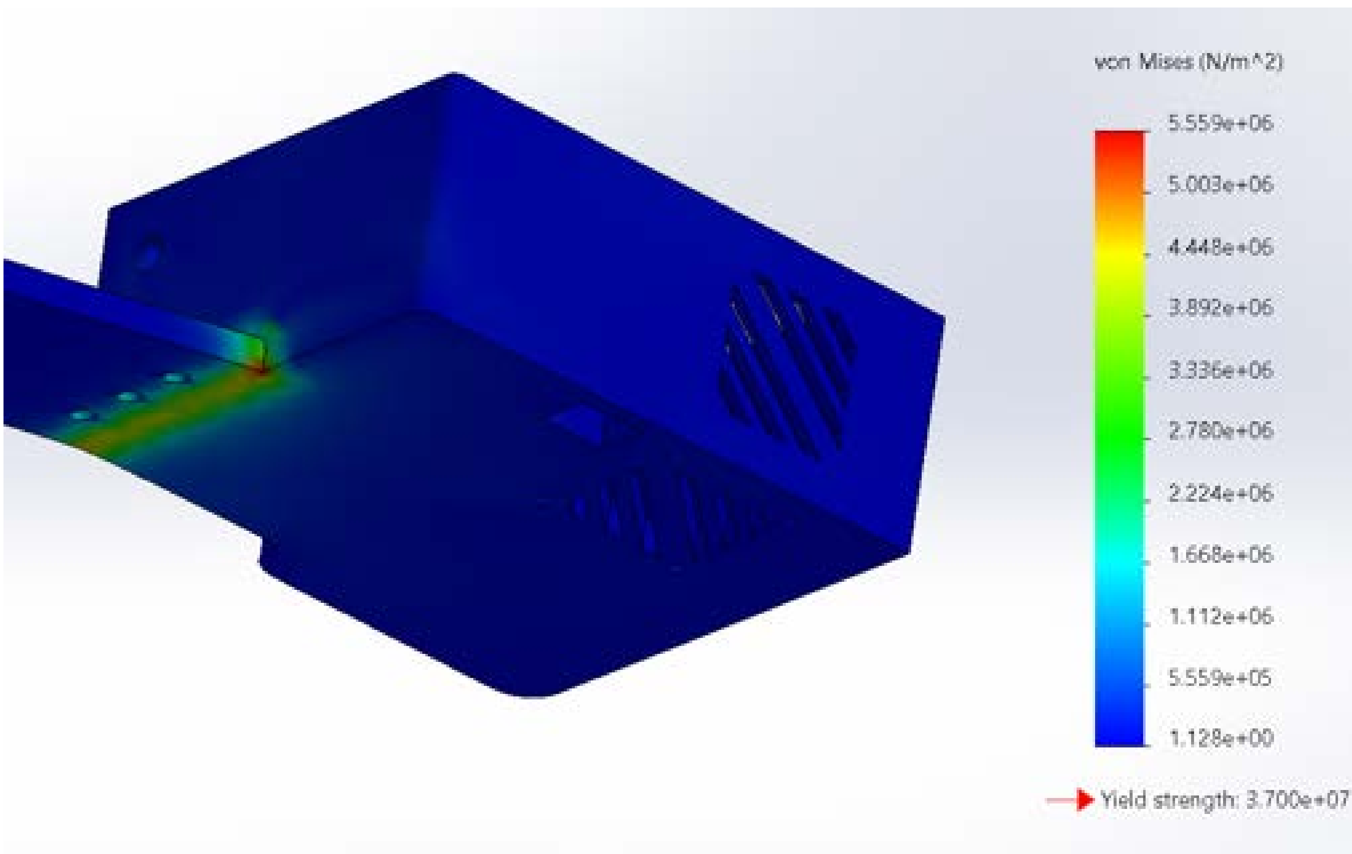


Figure #. Motor Box Max Stress. The motor box has a higher likelihood to fail right at the location where it begins to bend and is no longer rigidly connected to the underside of the pulleys. However, these developed stresses are much less than the yield stress of Tough PLA so the box is not predicted to actually fracture.

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

Conclusion:

The team is confident that all of the structures will perform better than predicted by simulation due to the inability to simulate a 100% infill, and the fact that the material properties of Tough PLA are hard to correctly simulate in solidworks.

Action Items:

-Pick up Print of motor box and lid, separation blocks, and console field goal posts monday

-Begin print of pulley plates and antlers

-Gather screws and connect everything with Annabel

Josh ANDREATTA - Dec 03, 2022, 11:59 AM CST


Technical data sheet Tough PLA

Ultimaker

Filament specifications

Color information

Download

TDS_Tough_PLA.pdf (72.3 kB)

12.8.22 - Wheelchair and Frame Displacement Testing

Josh ANDREATTA - Dec 13, 2022, 4:57 PM CST

Title: Wheelchair and Frame Displacement Testing

Date: 12/8/22

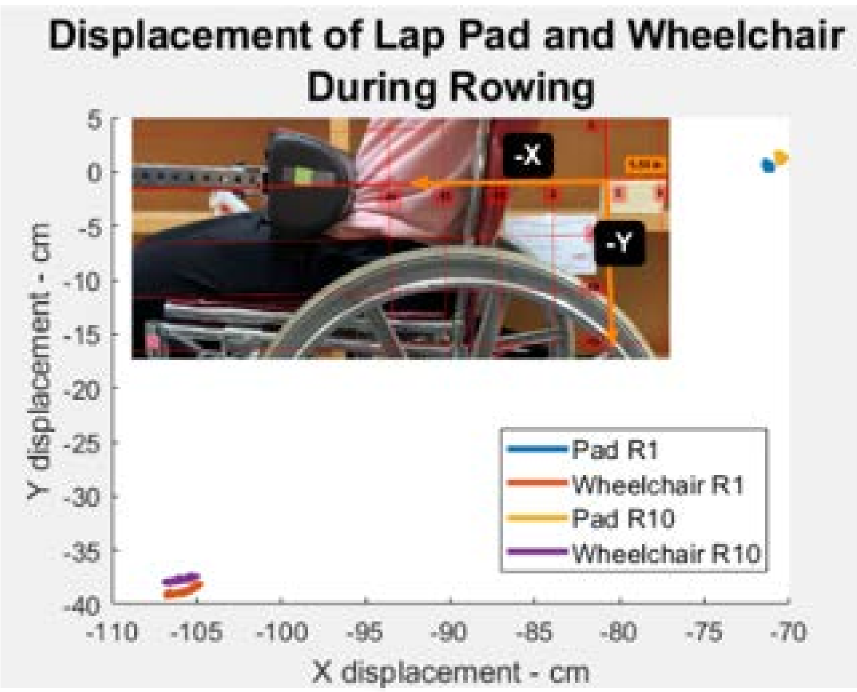
Content by: Tim

Present: Annabel, Roxi, Josh, Sam

Goals: Show displacement of the wheelchair and frame during rowing.

Content:

Motion capture of the stability frame and wheelchair was conducted to quantify the displacement during rowing. The setup of the displacement testing included two bright markers cut from paper, one taped onto the lap pad, and one taped onto the leg of the wheelchair. A camera was set up to track the motion of the two trackers during rowing. A test participant was recorded rowing for 30 seconds on both the maximum and minimum resistance settings. The videos were imported to Kinovea for motion analysis. In order to scale the displacement, a calibration measurement is needed. This was achieved by placing an object of known dimensions in the video frame. In Kinovea, digital trackers were placed on the paper trackers to record their position over time. To ensure accurate measurements, each individual frame is looked over to confirm the digital trackers were still over the paper markers. The max displacements were calculated by finding the range between the minimum and maximum coordinate values. The raw data from Kinovea was exported as an excel file and then loaded into MATLAB to create a visualization of the movement of the lap pad and wheelchair.



	Lap Pad		Wheelchair	
	R1	R10	R1	R10
x (cm)	0.48	0.58	2.06	1.93
y (cm)	0.79	0.99	1.19	0.69

The two figures above are the result of the motion capture testing. Movement was seen in the lap pad and the wheelchair; this is above the threshold of zero displacements that was set in the PDS. The wheelchair saw a max displacement value of 2.06 cm in the x direction when rowing with the lowest resistance level, and the lap pad had a max displacement value of 0.99 cm in the y direction when rowing with the max resistance value. The displacements seen during max resistance rowing and minimum resistance rowing are similar. The lap pad moved more during the max resistance trial in both the x and y directions, and the wheelchair had more motion during the minimum resistance trial.

The updated stability frame yielded improved displacement values compared to the frame created last semester. Wheelchair displacement was reduced from 4.09 cm in the x direction to 2.06 cm. The stability frame's displacement was reduced from 1.86 cm in the x direction to 0.58. The maximum displacement in the y direction for the wheelchair was 1.19 cm, while this value is greater than zero, it falls in the acceptable safety range, and shows that the stability frame is effectively securing the user.

Conclusions/action items: Please reference report for an official description of the testing discussion for Kinovea.

Project Proposal

ANNABEL FRAKE - Sep 10, 2022, 5:02 PM CDT

Title: 10SEP2022 BME 400 Project Proposal

Date: 10SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: include the project proposal in the notebook

Content:

see attached pdf

References: see attached pdf

Conclusions:

Attached to this entry is a copy of our BME 400 Project proposal for this semester. It is included in the design notebook for reference.

Action items: none

ANNABEL FRAKE - Sep 10, 2022, 4:59 PM CDT

Download

BME_400_Proposal.pdf (35.9 kB)

PDS

ANNABEL FRAKE - Sep 21, 2022, 10:52 PM CDT

Title: PDS

Date: 21SEP2022

Content:

-Please see the attached document for the pdf version of the PDS.

-This is a live document and will be updated throughout the semester.

References: Please see the references included in the document.

ANNABEL FRAKE - Sep 21, 2022, 10:53 PM CDT


Johnson Healthtech: Adaptive Indoor Rower for Wheelchair Users

[Download](#)

PDS__Johnson_Healthtech__Adaptive_Indoor_Rower_for_Wheelchair_Users_.pdf (135 kB)

ANNABEL FRAKE - Oct 10, 2022, 8:03 PM CDT


Johnson Health Tech: Adaptive Indoor Rower for Wheelchair Users

Download

PDS__Johnson_Healthtech__Adaptive_Indoor_Rower_for_Wheelchair_Users_.pdf (136 kB) Updated PDS based on feedback from Dr. Tracy Puccinelli.

Design Matrices

ANNABEL FRAKE - Sep 28, 2022, 10:23 AM CDT

Title: Design Matrices

Date: 28SEP2022

Content:

-Please see the attached documents for the pdf versions of the console rotational mechanism and stabilization frame design matrices.

References: none

ANNABEL FRAKE - Sep 28, 2022, 10:29 AM CDT

Design Matrix Criteria

Download

Console_Design_Matrix.pdf (1.07 MB)

ANNABEL FRAKE - Sep 29, 2022, 3:10 PM CDT

Download

Stablization_Design_Matrix.pdf (1.07 MB)

Preliminary Presentation Slides

ANNABEL FRAKE - Oct 06, 2022, 7:11 PM CDT

Title: Preliminary Presentation Slides

Date: 6OCT2022

Content:

-Please see the attached documents for the pdf version of the preliminary presentation slides.

References: none

ANNABEL FRAKE - Oct 06, 2022, 7:09 PM CDT

Download

Preliminary_Presentation.pdf (3.32 MB)

Preliminary Report

ANNABEL FRAKE - Oct 10, 2022, 8:05 PM CDT

Title: Preliminary Report

Date: 10OCT2022

Content:

-Please see the attached document for the pdf version of the preliminary report.

References: Please see the references included in the document.

ANNABEL FRAKE - Oct 11, 2022, 1:46 PM CDT


Adaptive Rowing Machine

Download

Adaptive_Rowing_Machine_BME_400_Preliminary_Report.pdf (12.3 MB)

Matrix Rower Service Manual

ANNABEL FRAKE - Nov 10, 2022, 8:06 PM CST

Title: Matrix Rower Service Manual

Date: 10NOV2022

Content:

-Please see the attached document for a pdf of the Matrix rower service manual.

References: Please see the references included in the document.

ANNABEL FRAKE - Nov 10, 2022, 8:05 PM CST

MATRIX

ROWER-02 (AR11)
SERVICE MANUAL

Download

Rower_Service_Manual.pdf (13.1 MB)

Final Poster

ANNABEL FRAKE - Dec 07, 2022, 6:04 PM CST

Title: Final Poster

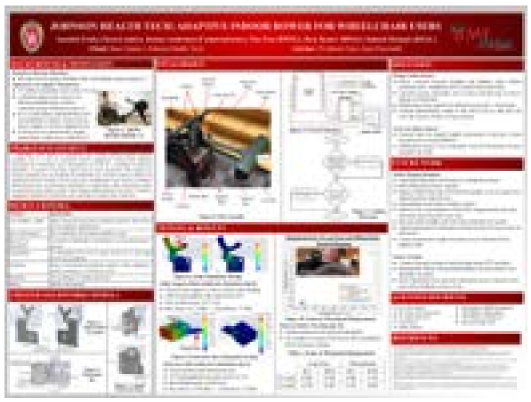
Date: 7DEC2022

Content:

-Please see the attached document for the pdf version of the final poster.

References: Please see the references included in the document.

ANNABEL FRAKE - Dec 07, 2022, 6:03 PM CST



Download

Final_Poster_-_Adaptive_Rower_Fall_2022.pdf (2.1 MB)

Final Report

ANNABEL FRAKE - Dec 13, 2022, 2:30 PM CST

Title: Final Report

Date: 13DEC2022

Content:

-Please see the attached document for the pdf version of the final report.

References: Please see the references included in the document.

Josh ANDREATTA - Dec 13, 2022, 4:56 PM CST

Adaptive Rowing Machine

Download

Adaptive_Rowing_Machine-Final_Report.pdf (27.4 MB)

Folder Explanation

ANNABEL FRAKE - Sep 09, 2022, 2:40 PM CDT

Title: Folder Explanation

Date: 9SEP2021

Content by: Annabel Frake

Present: Annabel Frake

Goals:

-explain the purpose of this meeting notes folder (separate from the team meeting notes)

Content:

-no content, please see conclusion for explanation

References: none

Conclusions:

I wanted to include an entry explaining the purpose of this extra meeting notes folder. I like to take notes during meetings as a way of engaging in the conversation and jotting down things I think are important or would like to come back to later on. Therefore, this folder contains any meeting notes I have taken that were not included in the team meeting notes folder (ie it was not my turn to specifically record meeting notes). This folder should be considered supplemental to the main source of information in the team activities folder.

Action items: none

14SEP2022 Team Meeting

ANNABEL FRAKE - Sep 14, 2022, 9:21 PM CDT

Title: 14SEP2022 Team Meeting

Date: 14SEP2022

Content by: Annabel Frake

Present: Annabel, Roxi, Sam, Josh, Tim

Goals:

- discuss the current design
- brainstorm implementation methods for improvements list

Content:

- FILL OUT PR
- will need to update PDS based on our meeting with the client - we are going to schedule a time to do that next week on Friday
- we need to email the client about bi-monthly meeting times
- we spent some time brainstorming around the rowing machine
- the list of improvements we would like to make in order of importance are:
    1. tension removal device
        - we talked about moving the handlebar resting point farther up on the rowing machine to make it easier for someone in a wheelchair to access from the other side
        - we need something that can grab the rope, pull it to generate slack, and then hold position while the rope is being transitioned
        - we decided the best way to do this is to mechanically and manually clamp down on the rope, then use some type of motor (mostly likely linear actuator) to pull the clamped section to generate slack
        - then the user will transition the rope, the user can unclamp the rope, and then the motor will need to return to it's resting position
        - it seemed like we needed more slack to transition from the adaptive side to the standard side than when going from standard to adaptive - we might be able to solve this by moving the handlebar holder on the front of the machine higher up such that the slack distance is the same going either way
        - we also discussed using an arm to push down on the rope and displace it, then have the user manually clamp the rope and have the motor move away
        - then the rope can be transitioned
        - right now, this method seems less efficient to me, but it is definitely something to consider in a design matrix
    2. adjustable wheel chair frame
        - make this out of steel
        - Sam expressed interest in learning how to weld
        - also need to improve attachment point to ensure that the wheelchair doesn't move (displacement occurred with previous design)
        - need to research range of wheelchair dimensions

- when I asked why the cross braces in the current design aren't cut to 45 deg angles, they said they were meant to be, but they made a mistake cutting

3. making the pulley plates sturdier and fit better
    - Josh will work on this in SolidWorks
4. console rotation mechanism
    - I shared my idea about using a horizontal pin instead of a vertical one
    - Tim said we would need to ensure it could only turn one way, otherwise the wire going to the LCD display would get tangled/caught
    - Roxi suggested that we still use the vertical pin as a guide and make a 180 deg channel so that the pin only allows rotation one direction
5. resistance dial
    - ideally, the user would be able to adjust the resistance dial from the adaptive side
    - Josh suggested a translational arm device that could translate motions on an adaptive side knob to ones on the standard side
    - it would need to move out of the way for standard users
    - we don't have any ideas about how to do this yet and it is a lower priority, but we will continue to think on it

- we plan to split into a group of 2 and a group of 3 to work on multiple things at once
- we will start with the 2 highest priority designs (tension removal and adjustable frame) and then we will move onto the other improvements
- we are going to meet next week to discuss the PDS and do more brainstorming as a large group before we split off into groups

References: previous design material

Conclusions:

During today's meeting, we discussed the relative importance of each of the design improvements we would like to make. We plan to start with the tension removal device and the adjustable base. We completed initial brainstorming, but we still need to think more about the ideas and research components, etc. We are meeting next week to brainstorm and update the PDS.

Action items:

1. fill out the Progress Report (PR)
2. Tim and Josh - upload PR to website and email to client/advisor by Thursday 5pm
3. During the Friday meeting, we will discuss times in the upcoming week to meet for the PDS and more brainstorming
4. Josh - email Staci meeting time options (we will discuss this on Friday most likely)
5. Notebook - work on for the advisor meeting

16SEP2022 Team Meeting + Advisor Meeting

ANNABEL FRAKE - Sep 16, 2022, 1:53 PM CDT

Title: 16SEP2022 Team Meeting + Advisor Meeting

Date: 16SEP2022

Content by: Annabel Frake

Present: Annabel, Josh, Sam, Roxi, Tim, Dr. Tracy P

Goals:

- schedule meetings for the upcoming week to update the PDS and continue brainstorming
- meet with advisor

Content:

Team Meeting:

- Josh added the previous PDS to the google drive, so we can update it there
- Wednesday 2:15-3:15pm to work on PDS
- update things individually and then do final check for Wednesday meeting
- sections that need updates: client requirements (Josh), performance requirements (Roxi), safety (electrical, Annabel), ergonomics (Tim), materials (Sam), aesthetics (Sam)
- look at rubric for PDS to make sure everything is covered
- briefly discussed my idea with them to warn that we may not want to word the PDS with tension removal device, but instead, easier way to transition rope
- we will meet to brainstorm ideas (and I can tell them about my idea in more depth) sometime Monday afternoon
- Sam gave his availability for something during that time, so we are waiting until his schedule is confirmed to pick the exact time
- we will meet in ECB

Advisor Meeting:

- Annabel and Roxi are new
- summary
  - JHT, Staci Quam
  - traditional rowing machine accessible to wheelchair users
  - not permanently change device so only used for wheelchair user - want it to be used by standard users and wheelchair users
  - moved user 180 deg around using pulleys
  - made 3D print to rotate console
  - wooden stabilization frame - held in place by weight of rower
- improvements
  - ready to ship out the door
  - wooden base - make adjustable for different wheelchair sizes, sturdier, out of metal
  - easier to transition rope from standard to adaptive side - tension removal device or move placement of handle
  - updating other components of design: pulley plates
  - maybe bring in bioinstrumentation
  - resistance dial
- they have their own fab lab, they can help us with that

- budget: baseline $200, but may get approval for more
- we have a funding request from BME department
- we have 1 wheelchair from hospital that Dr. P got us
- doing research on range of wheelchair sizes
- try to get more wheelchairs for testing
- Dr. P mentioned there was someone who would like this last semester, but we didn't hear more (Dr. Tracy P will ask him)
- Our client most likely will have electric wheelchair? But manual wheelchair users would need the upper body strength and would be more likely to want to exercise their upper body
- Notebooks:
    - rubric
    - continual grading vs only twice a semester
    - we showed her the project info (only have to do once) and then the individual notebooks (every time)
    - each person shared their own progress so far
- in traditional rower, user legs to propel backward
- in wheelchair, more of upper body and use core to stabilize yourself
- height difference, 2nd pulley determines this (Should we make this adjustable?)
- next week: we have outreach seminar in Tong lecture hall (10 min advisor meetings after that, we will be the third)
- Think about whether the advisor meetings should be on zoom or in person (maybe a combination of the 2)
- make sure to document individual design ideas before meeting as a group, so can show individual effort
- be careful of disconnect between new and old team members

References: none

Conclusions:

Before our advisor meeting, we discussed plans for the upcoming week. We looked through the PDS document and determined which sections needed to be updated based on the improvements we plan on making. Each member was assigned one of those sections. We will meet next Wednesday 2:15-3:15pm to review the changes before submission of the final document. I also briefly shared my idea from last night with the team and suggested that we meet sometime Monday afternoon in ECB to discuss it further since it would change our strategy for the semester.

During the advisor meeting, Josh updated Dr. Tracy P on the progress the team made last semester and the improvements we would like to make this semester. We shared our design notebook with her and received feedback on areas of concern for the design (ie maybe adjust the second pulley height depending on wheelchair height so the user only needs to pull straight back and not at an angle, think about how the movement is different because the user isn't sliding back like in the standard orientation).

Action items:

1. update my section of the PDS for the Wednesday meeting
2. continue to research background info
3. continue to brainstorm ideas for meeting on Monday
4. attend the outreach meeting next Friday and a short 10 min advisor meeting after that

19SEP2022 Team Meeting

ANNABEL FRAKE - Sep 19, 2022, 4:58 PM CDT

Title: 19SEP2022 Team Meeting

Date: 19SEP2022

Content by: Annabel Frake

Present: Annabel, Sam, Josh, Roxi, Tim

Goals: talk about my idea from last week in more depth and discuss steps moving forward

Content:

- talked about email from Staci - budget and weekly meetings
  - Budget is $500 for fall and spring semesters (may be able to get more approved)
  - we have access to the FabLab's materials at JHT through Staci
  - we will meet every other Friday 1:35-2:05 pm starting next Friday (Sep 30th)
- talked about PDS briefly
  - meeting on Wednesday 2:15-3:15 pm online to review it before submission
- next, I shared my idea with the group again
- I had briefly explained it over Zoom last Friday, but wanted to show them what I was thinking with the actual rower
- My idea (detailed in "15SEP2022 Tension Removal Brainstorming" under General Brainstorming in my Design Ideas Folder) was to move the resting place for the rower handle to directly above the pulley mechanism
- a user (on the standard side or adaptive side) would then be able to directly grab and handle and start rowing
- The purpose of the tension removal mechanism was to make the transition from standard to adaptive and back easier for the user
- it would provide slack in the rope to allow them to move the rope through the slit and to the other side
- however, if the slit is gone (the whole arm would be gone), then there is no need to generate the slack
- the user can simply grab the handle and start rowing
- Once I explained this, we brainstormed ways to improve this approach as a team
- I suggested that we might be able to strengthen Josh's pulley plate design by connecting the 2 plates where it wouldn't interfere with the rope
- we would extend the pulley plates upwards and then have handle holders
- someone suggested we improve my idea by having a handle holder on each plate so that the rope can go directly forward or backward
- my original sketches show the handle holders coming from one side only and would require moving the rope around the handles
- we have termed this design the antlers design
- there were concerns about moving the console to the side
- Josh felt that it would be awkward for a user to look off to the side while rowing
- we discussed ways to bring the console arm out and then back to the center to avoid the handle of the rope as it is transitioned
- Sam suggested that we put the handle holders high enough that the console can be attached directly to the pulley plates just below that
- we talked about using the console rotation mechanism idea from before with this
- we termed this the 3 in 1 design: includes pulley plates, handle holders, and console in one structure
- Roxi suggested we could also use something similar to a dentist light arm that swings in and out so that the user can adjust the exact position of the console
- Josh talked about the issues in fit that arose from the welds on the rowing machine
- I suggested that we use the 2nd hole (originally pivot point for arm) that was empty as a second attachment point for the pulley plate to the machine
- this would give 2 points of contact and eliminate the wiggling they saw last semester
- we also talked about the wooden base
- Roxi suggested we just use a lap bar like in the competing design AROW
- this prompted a discussion about whether the base was needed or not and how effective a lap bar would be by itself

- we discussed having a chest bar, but discarded that idea because allowing the user to move forward and backward adds to the workout (it also makes it easier to grab the handle)
- we could either have an adjustable base or just use a base with a lap bar
- the lap bar would stop the user from tipping backwards or coming out of their seat, but it wouldn't necessarily stop the wheelchair from moving
- I suggested that we attach straps to the lap bar that can be secured to the wheelchair, but I'm not sure how effective that would be
- we also talked about putting the wheelchair on a surface with more friction (mat of some kind)
- or we could use some kind of wheel track idea
- however, fitting multiple types of wheels would be difficult
- we think we would primarily target manual wheelchair users because they are the ones who have/need upper body strength
- people in electric wheelchairs may have been prescribed that because of a lack of upper body strength (they may want to work on that, but it could also be something out of their control)
- we would like to see if there is a person interested in this so we can gauge their opinion on wheelchair types most likely to use our device
- right now, it seems like we want to only use the lap bar and then add more if that is insufficient
- I would like some way to test this concept beforehand, but still working on a way to do that
- part of the issue is the wheelchair we were given doesn't have very good brakes
- we are still brainstorming, but our design matrices will most likely include the following
    1. antlers 3 in 1 design vs linear actuator with tension removal mechanism
    2. lap bar alone vs lap bar and outer frame vs outer frame alone
    3. Add-ons like mat vs wheel restraint?

References: none

Conclusions:

I asked the team to meet today to talk about my idea for a work-around that does not require a tension removal mechanism. After sharing my sketches and demonstrating the process with the rower, the team and I brainstormed ways to improve my idea. We also talked about the wooden frame improvement and whether or not a single lap bar would be sufficient to hold the user and wheelchair in place. We started brainstorming design matrices for the preliminary presentation, but will discuss this more during the Wednesday meeting. Overall, today's meeting was a successful brainstorming session; I'm really glad the team found merit in my idea and took it to the next level.

Action items:

1. continue to brainstorm these ideas
2. meet on Wednesday 2:15-3:15 pm on teams to work on PDS and brainstorm
3. outreach seminar and advisor meeting on Friday

ANNABEL FRAKE - Sep 19, 2022, 4:58 PM CDT

Download

Meeting_notes.HEIC (2.04 MB)

23SEP2022 Outreach Seminar

ANNABEL FRAKE - Sep 23, 2022, 2:57 PM CDT

Title: 23SEP2022 Outreach Seminar

Date: 23SEP2022

Content by: Annabel Frake

Present: BME 400

Goals: learn out the outreach project

Content:

- Why outreach?
  - inspire people who wouldn't otherwise consider engineering
  - give technical talk to non-technical people
  - scientific literacy - general public understanding (where you get funding, etc.)
- Why diversity?
  - diversity of background skills
  - designs need to be applicable to all groups
  - cultural awareness
- make sure content is age-appropriate
  - ask teacher in advance
- be organized and plan ahead - always takes longer than you think
- do a practice run
  - transitions take x3 with children
- allow enough setup time (have to ask if you can arrive early)
- some school districts require a background check
- seek out locations with underrepresented minorities and could receive funding for cost of materials (Tracy can pay for materials if 30% of underrepresented students)
- have closet full of stuff
- ways to get around purchase if use recycled items
- need to submit paragraph proposal for why you deserve funds
- table with materials and costs
- funds limited
- past events: Madison/manona/sun prairie/milwaukee
- boys and girls glubs
- events in WID (science festival in Oct and Saturday Science (has to fit with biomedical))
- Madison children's museum
- Deliverables:

- individual or teams up to 5
- presentation: 10 min intros (personal story), define BME, activity
- activity: 20-40 min fun hands-on activity, could get 1.5 hours; needs to have clear learning objectives, don't need to come up with own activity (have guides out there)
- report: details on who was there and how it went, pictures (need photo release form unless can't identify child based on photo ie back of head)
  - teachers are great help with photo release
- teacher/leader evaluation:

- Submit Deliverables Online
  - do not email it
  - naming convention
  - activity guide (or mentor plan): due Wed Dec 14th, 2022
    - If use someone else's activity guide, must cite them
    - look into mentor program
  - final outreach deliverables due: Friday, April 21st, 2023
    - including updated activity plan
    - 1 week before final poster session
- when you think you are ready, meet with Prof T. Puccinelli
- look at Teach Engineering
- list of resources on PP
- Helmet presentation/activity
- Presentation
  - introduce what biomedical is
  - talk about your life as biomedical engineering (focus on more if high school)
  - background material for project, give them a so what
  - activity steps
  - post-activity discussion
- Helmet Activity
  - we used egg cartons, popsicle sticks, rubber bands, newspapers and tape to make a helmet encasement for a water balloon
  - requirements: must look like a helmet (opening for face and neck)
  - sadly, ours broke

References: Professor T. Puccinelli

Conclusions:

Today, we met to discuss the outreach project. We received a general overview of the requirements, but were ultimately referred to the rubrics on the website. We also received some advice for how to approach the project. Finally, we completed the helmet activity.

Action items:

1. Start to work on the outreach project with our team

ANNABEL FRAKE - Sep 23, 2022, 12:07 PM CDT

[Download](#)

Outreach_Seminar_Slides.pdf (2.04 MB)

25SEP2022 Antler Sub-group Meeting

ANNABEL FRAKE - Sep 25, 2022, 3:29 PM CDT

Title: 25SEP2022 Antler Sub-group Meeting

Date: 25SEP2022

Content by: Annabel Frake

Present: Annabel, Roxi, Josh

Goals: create design criteria for the console rotation mechanism design matrix

Content:

- we started the meeting by deciding on the design criteria
- we based it off of criteria we had used in previous design projects and then specialized it to the console design
- we then weighted the criteria based on importance
- our criteria are:
    - Ease of use / ergonomics (20%)
    - versatility (20%)
    - position / orientation (15%)
    - ease of fabrication (15%)
    - durability (15%)
    - safety (10%)
    - cost (5%)
- after that, we wrote the design criteria descriptions and edited them all together
- I was a little concerned that the ergonomics one overlapped with the position/orientation one, but we have defined ergonomics to be about the user and the position to be about the minimum distance from the midline
- we updated the design criteria within the design matrix table and copied in the sketches of the designs
- Josh showed us his updated 3D SolidWorks design for the console rotation mechanism with the horizontal pin
- he came up with a cool key mechanism to hold everything in place
- other than that, it was as we discussed during brainstorming
- I am slightly concerned that the forward weight of the console will cause it to tip out of the mechanism, but Josh made everything thicker and added the locking mechanism, so it should be all right (we will just have to be careful of that)
- we then added figures with captions for each of the designs
- josh wrote the 1 pivot one, Roxi wrote the 2 pivot one, and I wrote the motor one
- we edited the captions together
- I suggested Josh add labels to figure 2

References: none

Conclusions:

The purpose of today's meeting was to create the design criteria and weighting for the design matrix. That way, when we meet on Tuesday to rank the designs with the other sub-group, we can quickly explain the criteria to them, rank the designs, and then write the final design paragraph. I believe that we came up with good criteria for the rotation mechanism. The two most important considerations are the ergonomics and the ability of the console to be used from either side of the machine.

Action items:

1. meet with the entire team to fill out the design matrices on Tuesday

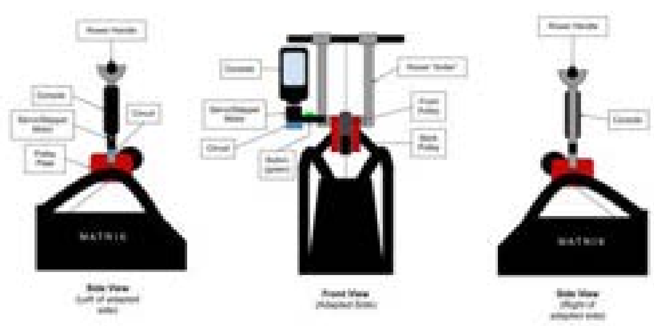
ANNABEL FRAKE - Sep 25, 2022, 3:27 PM CDT

Design Matrix Criteria

[Download](#)

Console_Design_Matrix.pdf (1.07 MB)

ANNABEL FRAKE - Sep 25, 2022, 3:30 PM CDT



[Download](#)

Console_with_Servo_Stepper_Motor_Rotation.jpg (75.4 kB) Roxi made the sketches and then allowed me to alter them for the servo/stepper motor design.

30SEP2022 Team Meeting + Advisor Meeting + Client Meeting

ANNABEL FRAKE - Sep 30, 2022, 4:58 PM CDT

Title: 30SEP2022 Team Meeting + Advisor Meeting + Client Meeting

Date: 30SEP2022

Content by: Annabel Frake

Present: Annabel, Josh, Sam, Roxi, Tim, Professor T. Puccinelli, Staci Quam

Goals: distribute workload for preliminary presentation and report, share progress with client and advisor

Content:

Team Meeting:

- Need to ask Tracy about the structure of the report, how does it work when we are continuing?
- Preliminary Presentation Work
    - Keep from last semester: physiology, competing designs
    - PDS
    - last semester (where current matrix slide is)
    - antler design
    - design matrices
    - future work
    - 1st person: intro, client, problem statement, motivation, physiology (slides 1-7) - Tim
    - 2nd: competing design, last semester, PDS (slides 8-10) - Josh
    - 3rd: antler design, console design matrix (slides 11-16) - Roxi
    - 4th: stabilization design matrix (slides 17-20) - Sam
    - 5th: testing, prelim design, future work (slides 21-24) - Annabel
    - Have slides done by Wednesday for editing meeting
        - meeting Oct 5th: 2:15pm - 3:15 pm on teams
    - Practice presentation on
        - meeting Oct 6th: 4:00-5:00 pm in ECB

Advisor Meeting:

- I talked about the console design matrix
    - she suggested that we go to a motors workshop that the Makerspace is putting on next week
    - the Makerspace can help us with the motor toque calculation
- Sam talked about the stabilization frame matrix
- she does not think that we need to include the design matrices in the prelim presentation
    - the stabilization one is just comparing the old design to the new and the console one is a very small part of the design
- she hasn't graded the PDS yet, but will get us feedback next week
- the updated PDS must be submitted with the prelim deliverables

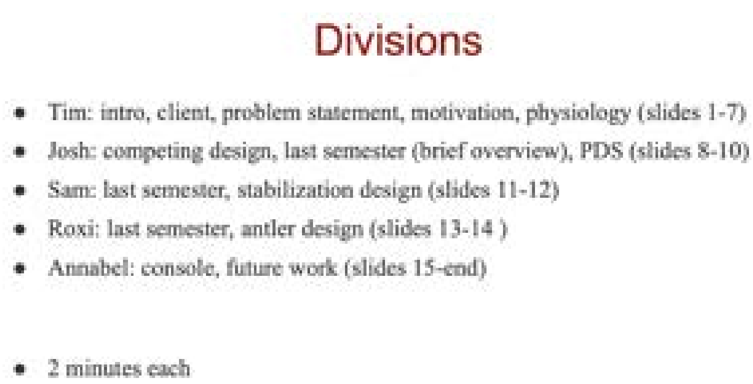
- She has office hours next Wednesday (Oct 5th) from 2-3pm if we want to ask her opinion on our slides and get feedback about what she expects

Client Meeting:

- Staci read over the design matrices before the meeting and then asked us some questions
- she wanted to know how the antler design would work, so Josh explained the concept to her
- she was concerned about the center alignment of the console and wanted to see if it could split out and then come back into the middle
- we explained that it would have to come out past the handle bars of the rope and was likely not feasible/the best option
- she then asked about the button and if there was a way to move it closer to the wheelchair user (potentially on the lap bar)
- I explained my brainstorming for 1 button vs 2 buttons and said that it was possible to move the buttons closer to the user
- she suggested that there might be a way to use a limit switch to make the console rotation automatic
- if the lap bar is brought down, it will trigger the console to move to the adaptive side
- if the lap bar is in brought back up or is in the resting position, it will move the console to the standard side
- I think this is an awesome idea and makes the transition even easier for the user
- Tim asked her if she had any racket mechanism's at JHT
- she tried to explain a mechanism that they could use, but didn't have any images readily available, so she will send us a presentation of it next Monday
- after the client meeting, we brainstormed the lap bar a little further and instead of having a pivot point near the ground and one at the 2nd pivot point, we are thinking that we only need to make the 2nd pivot point adjustable

Team Meeting:

- after Tracy told us that we may not need to cover the matrices in the prelim presentation, we reworked the slideshow
- we are not going over the matrices anymore and focusing more time on the designs themselves
- Josh suggested that we do a side by side comparison of the current design to the new designs
- he will give a 30 second overview of last semester
- then sam will say what they did for the stabilization frame specifically and then go into the lap bar design
- then Roxi will mention last semester's pulley plate design and then go into the current antler design
- I will talk about the console mechanism and then future work
- Here is a snapshot of the divisions that I put into the prelim slides



- we will divide up the prelim report sections at our Wednesday meeting next week
  - sections that will need to be added: summary of last semester, explanation of antler design, fabrication and testing plans, future work

- can reuse: background, physiology, competing designs, design matrices

References: none

Conclusions:

Today, we met as a group before our advisor meeting to discuss the preliminary presentation. Originally, we were going to present the design matrices we created. However, after talking with Professor T. Puccinelli, we decided to focus on the chosen designs so that we could spend more time explaining the concepts and what really matters moving forward. She also mentioned a MakerSpace workshop for servo and stepper motors on Oct 14th that I will try to attend. After that, we had a meeting with our client. She suggested that we use a limit switch to make the adjustment of the console using the motor automatic. We will have to be careful about this (we don't know how much the lap bar will move depending on the user's needs and limit switches can't be depressed too much), but I think it is feasible and would make the design that much more efficient. I've already got some ideas on how we would do this and plan to make notebook entries for those in the upcoming week. Staci is also going to send us some information on materials/tools we could use for the lap bar design. We set up meeting times for the upcoming week and will break up sections for the preliminary report next Wednesday.

Action items:

1. Motor seminar at Makerspace: Oct 14th 4:30 pm
2. update PDS once we have feedback from Professor T. Puccinelli and submit with the prelim deliverables
3. Josh will ask tracy if she can look at our prelim slides via email instead of her office hours
4. assign report sections next Wednesday during our slide editing meeting
5. complete individual slide assignments and prepare for prelim presentations
6. individual lab notebooks
7. Meetings:
    1. Meeting to edit slides: Wednesday, Oct 5th 2:15-3:15 pm on Teams
    2. Meeting to practice presenting: Thursday, Oct 6th 4-5 in ECB

5OCT2022 Team Meeting

ANNABEL FRAKE - Oct 05, 2022, 9:42 PM CDT

Title: 5OCT2022 Team Meeting

Date: 5OCT2022

Content by: Annabel Frake

Present: Annabel, Josh, Roxi, Sam

Goals: edit the prelim presentation slides, get feedback from advisor, assign sections for prelim report

Content:

- we went through the slides for the presentation chronologically and made edits
- to be consistent, we changed "arm" to "rower neck"
- I expressed concern about some of the dimensions being too small, we will check it tomorrow when we practice, but the rest of the group thought it would be all right
- Halfway through, Sam left to attend Dr. Tracy Puccinelli's office hours to get her feedback on the slides
    - can check the BME 402 grading rubric form to check individual slides (she will grade using this because we are a continuing project)
- when he came back, we made the edits that she suggested
- we ran out of time to assign report sections, so we will do that at tomorrow's meeting instead

References: none

Conclusions:

During today's meeting, we edited the preliminary presentation slides. We gave each other feedback on the assigned slides and also received feedback from Dr. Tracy Puccinelli. We ran out of time to assign report sections, so we will do that at our meeting tomorrow.

Action items:

1. practice presenting (meeting tomorrow to practice in ECB 4-5pm)
2. assign sections for and start work on prelim report
3. update PDS based on feedback from Dr. T Puccinelli
4. fill out PR

ANNABEL FRAKE - Oct 05, 2022, 9:40 PM CDT

BME Design: Preliminary Presentation Evaluation

Download

Faculty_Form-Preliminary_Presentations-BME402.docx (27 kB)

14OCT2022 Team Meeting + Advisor Meeting + Client Meeting

ANNABEL FRAKE - Oct 14, 2022, 2:03 PM CDT

Title: 14OCT2022 Team Meeting + Advisor Meeting + Client Meeting

Date: 14OCT2022

Content by: Annabel Frake

Present: Annabel, Josh, Sam, Roxi, Tim, Dr. Tracy Puccinelli, Staci Quam

Goals: touch base about the design status

Content:

Team Meeting:

- first question from Staci:
  - bring down bar to 1 level above where you would lock it, adjust horizontal bar length, finish adjusting height
  - when will console turn around?
  - have an override button to turn? add later if needed
- second question from Staci:
  - have the arm go straight up in the air
- third question from Staci:
  - have Arduino in sleep mode and then use interrupts so battery consumption is good
  - we need the second conditional statement because we can't keep rotating in the same direction (wire would get wound up)

Advisor Meeting:

- d

Client Meeting:

- d

HAVE JOSH RESPOND TO STACI'S QUESTION ABOUT PRESENTATION DATES

set up meeting times for upcoming week

References: none

Conclusions:

Action items:

19OCT2022 Coding Meeting

ANNABEL FRAKE - Oct 19, 2022, 2:12 PM CDT

Title: 19OCT2022 Coding Meeting

Date: 19OCT2022

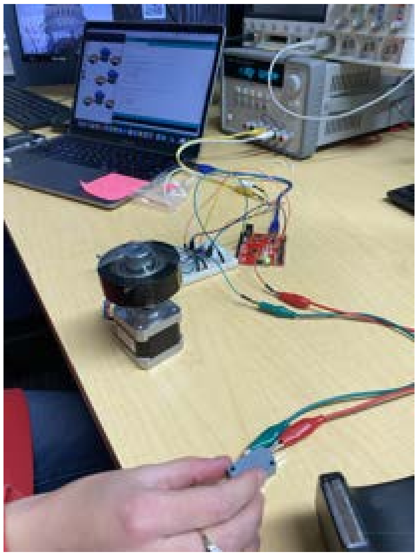
Content by: Annabel Frake

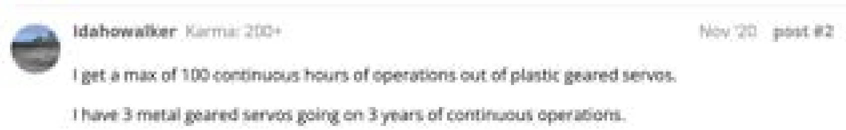
Present: Annabel and Roxi

Goals: discuss motor selection

Content:

- I showed Roxi and progress I had made so far
- I told her about my concerns with the sturdiness of the shaft
- we then grabbed an object from the green room storage space that was comparable in weight to the console
- we taped it to the servo motor, and I was very surprised that it rotated without any issue
    - 
    - the weight wasn't as far from the shaft as it would be with the console, so maybe this will be a factor?
    - talk to Josh on Friday to see if we can print a small interface to the console to test with the servo motor
- we tried it with the stepper motor, and as predicted, it had no issue rotating

- 

- see attached videos
- this means that the project is roughly plausible with either motor
- we came up with a list of pros and cons for each
- Servo:
    - PRO:
        - simpler circuit and code
        - smaller motor size
        - cheaper (would need Arduino, 9V battery to power Arduino and servo motor, servo motor, limit switch)
            - depending on the servo motor, the cost of the servo may be comparable to the cost of the stepper + motor controller
        - shaft is notched for a better connection point to the console
    - CON:
        - shaft is not as sturdy
        - doesn't last as long as a stepper motor
            - I found one forum that said plastic geared stepper motors won't last longer than 100 hours of continuous use (see references)
            - 

              Idahowalker Karma: 200+ Nov '20 post #2

              I get a max of 100 continuous hours of operations out of plastic geared servos.

              I have 3 metal geared servos going on 3 years of continuous operations.
        - less precise rotation
- Stepper:
    - PRO:
        - more durable (lasts years)
        - sturdier shaft
        - more precise rotation

- CON:
    - more expensive (would need 12V power supply, 9V battery to power Arduino, Arduino, limit switch, stepper motor, and motor controller)
        - so essentially the 12V power supply and motor controller are added expenses
        - depending on the servo motor, the cost of the servo may be comparable to the cost of the stepper + motor controller
    - takes up more space than the servo circuitry
    - more complex code and circuitry (although that is pretty much worked out)

References:

"How to make servo lives longer ? - Using Arduino / Motors, Mechanics, Power and CNC," *Arduino Forum*, Nov. 01, 2020. https://forum.arduino.cc/t/how-to-make-servo-lives-longer/680853 (accessed Oct. 19, 2022).

Conclusions:

At the beginning of the meeting, I showed Roxi the progress I made with the code (polling working for both motors, interrupt is a work in progress but functional for servo). We found an object in ECB that was approximately the same weight as the console and taped it to the motor shafts. Both the servo and stepper motor were able to rotate with the weight of the object. This means that both are plausible options, although I have concerns about the servo motor's stall weight when the weight is farther from the shaft. We made a list of pros and cons for each motor (see content), but weren't sure what the best way to go is. We are going to meet with the whole team 12-1 pm in ECB on Friday before our advisor meeting to get feedback from Tim, Josh, and Sam. We can also ask Tracy what she thinks.

I'm also not sure how Staci will integrate our circuitry into the Matrix rowing circuitry after we pass off our project to them. Depending on her answer, we may or may not need to worry overly much about the power supply for example. This is something we can talk about among the Team on Friday and ask Staci in an upcoming client meeting / through email.

Action items:

1. ask Josh, Sam, and Tim's opinion on our list of pros and cons on Friday
2. keep developing the code

ANNABEL FRAKE - Oct 19, 2022, 11:58 AM CDT

Download

Servo_with_object.MOV (5.69 MB)

ANNABEL FRAKE - Oct 19, 2022, 11:58 AM CDT

Download

Stepper_with_object.MOV (6.25 MB)

28OCT2022 Team Meeting + Advisor Meeting + Client Meeting

ANNABEL FRAKE - Oct 28, 2022, 5:35 PM CDT

Title: 28OCT2022 Team Meeting + Advisor Meeting + Client Meeting

Date: 28OCT2022

Content by: Annabel Frake

Present: Annabel, Roxi, Sam, Josh, Tim, Dr. Tracy Puccinelli, Staci

Goals: progress checks

Content:

Team Meeting:

-
- we discussed show and tell details
- we plan to show the circuit and the 3D prints Josh has / will make
- we will also bring the rower for easier visualization
- potential questions to solicit:
  - Is there a better way to attach the stabilization frame to the rower?
  - Is there a more secure way to secure the console box to the pulley plates?
  - Any ideas for changing the resistance level from the adaptive side (next semester plans)?
- we discussed the JHT visit and what we would like to accomplish
  - tour for Roxi and I
  - Tim and Sam have a fabrication plan for the stabilization frame
- Josh gave an update on the electronics box
  - I told him that the motor was getting pretty hot during testing, so we may need a fan
  - I will research this further and let him know
  - Josh will add grates for ventilation for now and we will add a fan in the final iteration if we need one
  - I also told the team that we don't need the 9V power supply because the 12V power supply will power both the Arduino and the motor
- Josh thinks that both antlers will be roughly $60

Advisor Meeting:

- Show and Tell will be in the Tong next week
- Have Josh email Dr. Tracy P when we confirm the JHT visit
- we showed her the 3D print of the antler and Josh explained the updates he made
- I showed her the circuit function
- we discussed testing plans - motion capture, physical tensile testing of 3D print
- if we want to test with us or other people, we need to ask IRB - institutional review board

  - can be tedious
  - Dr. Tracy P is our PI for this
  - may want to do this over winter break
  - should start the process now
  - we will probably be exempt because of the low risk level, but have to make sure if we are publishing our results in a paper at the end of BME 402

Client Meeting:

- JHT visit Nov 4th, 3-4:30 pm
  - will be able to tour
  - have Sam and Tim send her the fabrication plan with approximate lengths of metal so she can set them aside
- Josh showed her the SolidWorks models
  - she suggested making the jut out portion of the antler at a diagonal to help with stresses
  - she may be able to have the antlers milled out of plastic
  - she doesn't think we will need the fan, she suggested the heating was due to amperage of the power supply (I will look into this)
- I showed her the circuit
  - she has limit switches we can get during the site visit (may have smaller ones for the position switches)

References: none

Conclusions:

During our team meeting, we prepared for Show and Tell and decided on potential questions we can ask our peers for advice on. Josh updated everyone on his progress with the 3D modeling. I informed him about the motor heating issue, so he will add venting grates (and we may add a fan if the issue cannot be resolved). I informed the team that we no longer need a 9V power supply because the 12V power supply powers the Arduino and the motor.

During our advisor meeting, we updated Dr. Tracy P on our progress. She asked us about our testing plans and informed us that we may need IRB approval unless we can get an exemption. We should start to work on this sooner rather than later.

During our client meeting, we confirmed details for the site visit next week. We updated her on our progress and she gave feedback on the antler design and electronics box (ie fan necessity).

Action items:

1. everyone keep working in their sub-groups to further the design
2. if possible, come 5-10 minutes early to Show and Tell to hash out the elevator pitch
3. JHT visit Friday, Nov 4th (3-4:30pm)
   1. Tim and Sam to email her fabrication plan and approximate lengths of bars
   2. Josh to let Dr. Tracy P know when we are going to JHT
   3. Josh to send Staci SolidWorks files for antler design so she can show her employees for plastic milling options
4. look into getting IRB approval for human testing

4NOV2022 Show & Tell Reflection

ANNABEL FRAKE - Nov 04, 2022, 11:34 PM CDT

Title: 4NOV2022 Show & Tell Reflection

Date: 4NOV2022

Content by: Annabel Frake

Present: Annabel Frake + BME 400 groups

Goals: tell other teams about the challenges we have been facing and solicit potential solution ideas

Content:

-
- Tim couldn't make it because he was sick
- Roxi and I gave the elevator pitch for the first round of show and tell
- we asked one of 2 questions depending on the experience of the people we were talking with
    1. How can we adjust the resistance level knob on the rowing machine from the adaptive side? (suggestions below)
        - use a remote control
        - open up the rower to see how the insides work
    2. How can we keep the console in place once the relay turns off the power to the motor (solution to the heating issue)? (suggestions below)
        - use a second locking mechanism that holds it in place
        - use a D ring stepper motor
- Josh and Sam did the second round of the elevator pitch while Roxi and I made rotations
- it was definitely interesting to hear more about the other projects and what progress teams have made since prelims

References: BME 400 students

Conclusions:

During show and tell, we asked our peers about their background and chose our question based on their level of expertise. If they had experience with electronics and/or stepper motors, we asked them the question about the console (see content section). If they had experience with mechanics, we asked them the resistance knob question (see content section). For the console question, the two main ideas people contributed involved using a second locking mechanism that would hold the console in place while the power is cut off from the motor. This may involve a pin that "pops up" in the path of the console's flag or some type of braking arm that clamps down on the motor shaft. For the resistance knob question, most people suggested that we take a look inside of the rower to gain a better understanding of how we could "hijack" the rower's existing system. A couple of our peers suggested a remote mechanism.

Moving forward, I will consider using a stepper motor with a D shaft. Josh suggested that I use my personal motor to test with the D shaft and then we could purchase another stepper motor later on if it works out. I will also consider using the second locking mechanism that a lot of my peers suggested. I am going to look into other motor controllers to see if there is something I could use that wouldn't cause a heating problem since my peers who had worked with stepper motors previously didn't have heating issues (therefore, there must be a way to avoid this). If I can create a circuit that doesn't have heating issues and doesn't require the relay, then we may not have to worry about the console rotating when pressure is applied to the screen because the motor will still be on. We would need to test this to make sure. If I can't find a motor controller that prevents heating, then I will consider the second locking mechanism proposed by my peers.

*NOTE: please see the team activities folder for a full accounting of show and tell. This entry only contains ideas/suggestions that I heard while giving the elevator pitch.

Action items:

1. take this feedback into account when moving forward with the design

4NOV2022 JHT Visit

ANNABEL FRAKE - Nov 04, 2022, 11:47 PM CDT

Title: 4NOV2022 JHT Visit

Date: 4NOV2022

Content by: Annabel Frake

Present: Annabel, Josh, Sam, Roxi, Staci

Goals: JHT tour; help Sam build a mock-up of the stabilization frame

Content:

- Staci gave us a tour of JHT - very impressive!
- Staci gave me 3 limit switches with shorter switch arms, which will be very helpful indeed
- we then used the perforated bars she has on hand to build a mock-up of the stabilization frame
- Sam led the prototyping on this one, but Roxi, Josh, and I helped with whatever he needed
- we are concerned that the stabilization frame will interfere with the rowing motion (ie rope) or process for grabbing the handle
    - this is something Staci recommended playing around with in CAD to see if it would even be an issue
- we offset the vertical bar to try to mitigate this
- we need to be careful that it doesn't go too far off-center that it hits the wheelchair's side
- the design may need to go out and then jut back in
- we aren't going to do the horizontal adjustment yet because Staci doesn't think we will need it
    - she said that you often design for the 80% (called it the 80 20 rule)
- if we try the prototype and decide that it would be useful, then we can add it later
- we are thinking about using a small cushion that JHT uses on some of its other machines
    - we would need to modify it, but it would give us a staring point
- we finished making the mock-up, took pictures, and disassembled it
- Staci said we should model it is CAD to figure out dimensions, then she can have people cut bars for us, and then we will try our hand at welding
- Staci said to make sure that the height of the stabilization frame is such that the lap pad will be brought down to the user to make sure that there is a downward force

References: Staci

Conclusions:

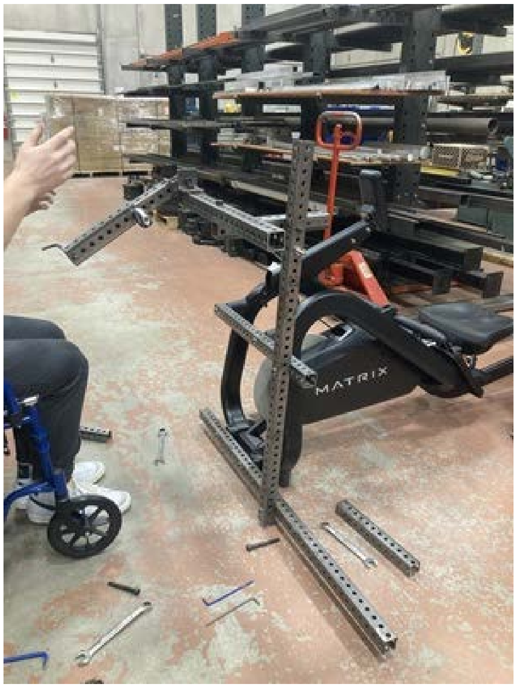
We visited JHT today to create a mock-up of the stabilization frame. Roxi, Josh, and I assisted Sam with building his idea using the perforated bars Staci had on hand. We created a prototype of the general structure, but it will need to be refined. There are potential concerns with the stabilization frame hindering the rowing motion / preventing someone from grabbing the handle. We are also cautious of the bar hitting the side of the wheelchair. We decided to offset the bar and bring it back toward the center closer to the user. We will need to model the design in SolidWorks to test the dimensions of the design and confirm whether these concerns will be a full-blown problem.

Action items:

1. Josh/Sam: create a 3D model of the stabilization frame

2. me: use the new limit switches (and keep working on the circuit in general)

ANNABEL FRAKE - Nov 04, 2022, 11:42 PM CDT



Download

IMG_6235.jpeg (3.19 MB) Mock-up of the stabilization frame.

ANNABEL FRAKE - Nov 04, 2022, 11:42 PM CDT

Download

IMG_6236.jpeg (3.61 MB) Mock-up of the stabilization frame.

ANNABEL FRAKE - Nov 04, 2022, 11:42 PM CDT

Download

IMG_2895.jpeg (4.66 MB) Mock-up of the stabilization frame.

18NOV2022 Team + Advisor + Client Meeting

ANNABEL FRAKE - Nov 18, 2022, 5:36 PM CST

Title: 18NOV2022 Team + Advisor + Client Meeting

Date: 18NOV2022

Content by: Annabel Frake

Present: Annabel, Josh, Roxi, Tim, Dr. Tracy Puccinelli, Staci Quam

Goals: catch-up, plan rest of semester

Content:

Team Meeting:

- Josh updates on box
- wire estimate for limit switch going to lap bar
  - vertical bar 68 cm long
  - roughly 30 cm to go back up to console
- outreach project
  - Tim waiting to reach out to school until we have a plan
  - potato project
  - presentation - how batteries work
  - Roxi will start to put together an outline
  - ask Tracy when we could meet with her
  - Roxi and Tim - ask anyone if you need help
- IRB
  - Roxi started ARROW application
  - once that is approved, we have a second application
  - mostly multiple choice, but will need a protocol
  - Roxi will work on it slowly
  - the whole team will work on it over winter break
  - Roxi - ask anyone if you need help
- added channel for box lid in CAD to slid on and off
- Fabrication procedures and testing protocols
  - Josh doesn't think he will need a fabrication plan for his stuff, but will email Tracy to check
  - he does an entry in LabArchives for testing instead of protocol
  - Sam and Tim have preliminary fabrication plan from JHT visit
  - I am working on mine
  - we will need a final integration plan
- use bar width that we used before

Client Meeting:

- Rollercoaster design
  - will show Staci today
  - changed position of 2nd pulley
    - can hopefully can do downward leverage
    - height also makes rowing motion more like the standard size (ie pull straight out instead of up and out)
    - makes antlers more stable
- Josh will print all 3D components on 100% infill this weekend
- Josh will do SolidWorks stimulation testing in the upcoming week

- gave an update on the electronics
  - motor vibration solved
  - sleep mode doesn't work - talk to John Lombardo at MakerSpace next semester to see if I can figure it out
- Outreach
  - meeting to approve it - can bring it to last advisor meeting on December 2nd
  - for next semester
  - potato project
  - for middle schoolers - Spring Harver middle school (down University)
  - final deliverables - activity guide
    - finding sources online, copy and paste, and cite accordingly
  - plan ahead on buying electronics
- IRB
  - Roxi will work on it this semester
  - whole team will work on it over winter break
  - investigator-initiated study? - Tracy will look into it
- testing will be done
  - focus on what we've changed - console and stabilization frame
- look at her comments on the final report

<u>Client Meeting:</u>

-
- final SolidWorks model for antlers and box/lid
- will print all CAD 100% infill over the weekend
- added 2nd pulley
- doublecheck with 100% infill with MakerSpace workers to make sure that they can do it
- print max of whatever % they say they can do
- gave update on circuit
- Sam's questions
  - rollercoaster design looks good, but thicknesses of bars might change (they look kind of thin right now)
  - screws and bolts
    - use size that's there or drill out and retap our frame to be larger size
    - they have all available sizes - probably M6 or M8, might be able to go up to M10 but shouldn't need to
  - the lap pad is all one piece, but could maybe cut it into 2 and slide on from both sides
  - do FEA testing next semester
  - pick a width and she will tell us whether it will work, but she won't just tell us what to do
  - have to design angle pin joints and horizontal ones and then she can fabricate it for us
    - we design it, they can make it
  - for this semester, build it same way as the prototype and then design and fabricate the joints next semester
  - materials list - how long will it take?
    - usually doesn't take too long
    - if above a certain price, she needs to get approval from her boss
- make drawings of bar lengths so she doesn't have to for shop
- pick up bars Nov 28th
- do FEA testing next semester?

References: none

Conclusions:

During our advisor and client meetings, we shared updates regarding the design progress. During our team meeting, we discussed the printing of the 3D components and planned our goals for the rest of the semester. We will integrate the sub-components of the design after Thanksgiving.

Action items:

1. Josh - email Tracy about fabrication procedure / testing protocol for CAD
2. Josh - print final versions of CAD
3. Josh and Annabel - put electronics and CAD together
4. Annabel - finish fabricating circuit, fabrication plan, testing protocol
5. Tim - make drawings of bars and send to Staci
6. Tim and Sam - put stabilization frame together, fabrication plan/testing protocol
7. Roxi - outreach plan, once we have this finalized, Tim to reach out to his contact
8. Roxi - work on IRB (ask if need help)
9. keep time open in schedule for meetings in December

5DEC2022 Final Poster Editing

ANNABEL FRAKE - Dec 05, 2022, 9:28 PM CST

Title: 5DEC2022 Final Poster Editing

Date: 5DEC2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: edit final poster, set up meeting to practice

Content:

- we went through the comments everyone left and edited the poster
- Josh will email Dr. Tracy Puccinelli about meeting on Wednesday to look over the poster
- we set up a meeting time to practice presenting on thursday
- we split up the report sections

Report Sections

- Add sources to introduction - Roxi
- Final design Fabrication (include materials and fabrication - doesn't need to be dedicated section)
    - Antlers - Josh
    - Console - Annabel
    - Stabilization - Sam
    - Full assembly - Josh
- Testing
    - Antlers - Josh
    - Console - Annabel
    - Stabilization - Tim
- Results
    - Antlers - Josh
    - Console - Annabel
    - Stabilization - Tim
- Discussion - Roxi
- Conclusion - together
- Future work - Sam

- we set up meetings to edit the report

References: none

Conclusions:

We edited the poster and planned our action items for the following week (i.e., meeting times and deadlines).

Action items:

- Josh - email Tracy about poster feedback
- Meetings:
    - Wednesday, Dec 7th (2pm) - poster feedback (TENTATIVE)
    - Thursday, Dec 8th (4pm) - practice presenting

- Sunday, Dec 11th (4-6pm) - edit report and write conclusion (read through report before this)
- Monday, Dec 12th (7:30-9:00pm) - edit report

30SEP2022 PDS and Design Matrix

ANNABEL FRAKE - Sep 30, 2022, 5:13 PM CDT

Title: 30SEP2022 PDS and Design Matrix

Date: 30SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: document my individual contribution to the PDS and design matrices

Content:

- during our notebook check today, I noticed that some of my teammates were including entries on their contribution to the team deliverables
- I decided this would be a good thing to do going forward
- this entry includes all of the work I did not the PDS and the design matrices
- in future entires, I will document the work I do when I complete it
- For PDS:
    - I reviewed the safety section and added the following:
        - Electrical components incorporated into the design will be covered to prevent harm to the circuit and/or user (i.e. water damage or electrocution).
    - I edited the entire document and left comments where discussion was needed
- For console design matrix:
    - I wrote the following for design criteria:
        - Position/Orientation (15%): The console should be positioned as close to the midline of the rowing machine as possible. In other words, the design should minimize the angle at which the user must turn their head to view the console. Designs with smaller displacements from the midline will receive a higher score.
        - Ease of fabrication (15%): Designs with a greater ease of fabrication will score higher than more complicated designs. All components of the design should be readily available for purchase.
    - For design justification, I wrote the following (with edits from teammates since I can't distinguish after the fact anymore)
        - The 2 Pivot Points design scored the highest in ergonomics with a 5/5, and the 1 Pivot Point and Motor designs received a slightly lower score of 4/5. The second pivot point allows the user to bring the console closer to the midline of the rowing machine, as well as closer to the user in general. It minimizes the angle at which the user must turn their head to view the display and decreases the distance the user must reach to use the console. Therefore, the 2 Pivot Points Design is the easiest to use and the least likely to alter a user's rowing form. Both the 1 Pivot Point and Motor designs do not incorporate the second pivot point and cannot move closer to the user or the midline of the rowing machine. Consequently, they received the same score. While these designs are limited by the single pivot point, the distance of the console from the midline of the machine will still be minimized. For this reason, the designs received a relatively high scoring of 4/5.
          Ease of rotation describes the amount of effort by the user to transition the console from the standard to the adaptive side and vice versa. The Motor design scored 5/5 in this category because the user can rotate the console with the press of a button. The 1 Pivot Point and 2 Pivot Points designs scored significantly lower because the user must manually rotate the console. Both designs secure the console with a pin mechanism after rotation. The 1 Pivot Point design has one point at which the user must adjust the device, whereas the 2 Pivot Points design has two pivots that require user adjustment. The ease of rotation declines with the addition of each new pivot point, and that is reflected in the scoring; the 1 Pivot Point design scored 3/5 and the 2 Pivot Points design scored 2/5.

- I wrote the caption for the motor design

3. Design 3: Motor

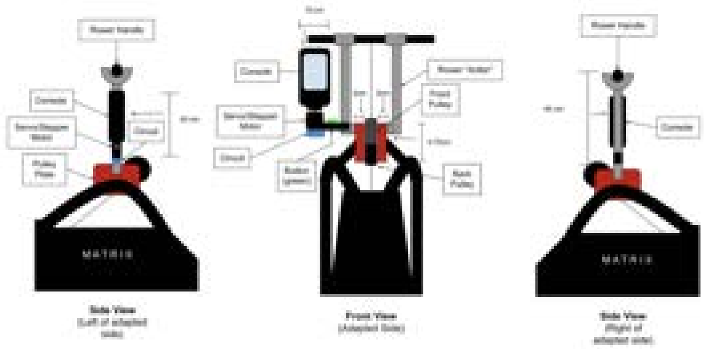


Figure 4. Design 3: Motor. This design utilizes a servo/stepper motor to electronically turn the console 180° with the push of a button (shown in green). The motor is secured to a platform attached to one of the antlers on the rowing machine. The distance the console is offset from the midline of the rowing machine will be minimized. A 3D printed bracket will secure the console to the motor with the help of glue or screws. The motor will be controlled using an Arduino that rotates the console between the standard and adaptive orientations when the user presses the button. All circuit components, except the button and motor, will be stowed in a compartment (shown in blue) below the platform for safety and aesthetic purposes.

References: see attached documents

Conclusions:

During a team notebook check, I noticed that some of my teammates were recording their individual contributions to the team deliverables in the notebook. I decided that this would be a good thing to do from now on and this entry specifies everything I have done for deliverables up to this point.

Action items:

1. continue to work on deliverables

2OCT2022 Prelim Presentation

ANNABEL FRAKE - Oct 02, 2022, 5:59 PM CDT

Title: 2OCT2022 Prelim Presentation

Date: 2OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: complete my assigned slides for the prelim presentation

Content:

- after brainstorming the updated motor design with automatic movement, I added the sketches to my preliminary slides
- I added text to the slides
- I made edits to the acknowledgments page
- I also added the design matrices we created to the end of the presentation in case someone asked us about our decision making process

Script:

Thank you, Roxi.

With the elimination of the original Matrix arm, we decided to reposition the console on one of the antlers that hold the rowing handle bar in place when the machine is not in use. The extension that supports the console will be integrated into the design such that the distance of the console from the midline of the machine is minimized. This is an important design criteria because it ensures the comfort of the user and minimizes changes in their rowing form that may result from looking at the console instead of straight ahead.

The console will be attached to a motor that allows 180 degree rotation between the adaptive and standard sides of the machine. The transition from one side to the other will be automated with the use of a limit switch placed above the lap bar near its pivot point. When the lap bar is all the way up in its unused position, the limit switch is depressed. As the lap bar is lowered to secure the user, the force applied to the limit switch is removed and the switch is no longer pressed. We will use an Arduino to program the motor to rotate the console to either side based on feedback from the limit switch. This coding flow chart shows the basic concept. We will start by checking the state of the limit switch. If it is depressed, indicating that the adaptive side is not in use, and the console is already on the standard side, nothing will happen. If the console is not already on the standard side, the motor will rotate 180 degrees. Similarly, if the limit switch was not originally depressed, the code will check the position of the console and ensure that it is facing the adaptive side. Therefore, the console will face the standard side of the machine by default and when a wheelchair user secures themselves with the lap bar, the console will automatically rotate to face them and they can begin rowing.

As for future work, we will create 3D CAD models of our design improvements for modeling and testing purposes. We will then obtain necessary supplies from Johnson Health Tech, the MakerSpace, and other commercial stores to begin fabrication. We will also develop testing plans for design verification and validation.

Thank you to our advisor and teacher Dr. Tracy Puccinelli and to our client Staci Quam for their guidance on our project.

Here are the references for this presentation. Are there any questions?

References: none

Conclusions:

I made slides for my assigned section of the preliminary presentation covering the console rotational mechanism, future work, acknowledgements, and references. I also added our design matrices as an appendix in case we were asked how we made the decisions we made during Q&A. I also started planning out what I would say during my 2 minutes of the presentation.

Action items:

1. practice presenting my slides

ANNABEL FRAKE - Oct 02, 2022, 5:24 PM CDT

Download

My_slides_for_the_prelim_presentation.pdf (1.42 MB)

Practicing Prelim Presentation

ANNABEL FRAKE - Oct 03, 2022, 5:30 PM CDT

Title: 3OCT2022 Prelim Presentation

Date: 3OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: practice presenting my portion of the prelim presentation

Content:

Script:

Thank you, Roxi.

With the elimination of the original Matrix arm, we decided to reposition the console on one of the antlers that hold the rowing handle in place when the machine is not in use. The extension that supports the console will be integrated into the design such that the distance of the console from the midline of the machine is minimized. This is an important design criteria because it ensures the comfort of the user and minimizes changes in their rowing form that may result looking to the side instead of straight ahead.

The console will be attached to a motor that allows 180 degree rotation between the adaptive and standard sides of the machine. The transition from one side to the other will be automated with the use of a limit switch placed above the lap bar near its pivot point. When the lap bar is all the way up in its unused position, the limit switch is depressed. As the lap bar is lowered to secure the user, the force applied to the limit switch is removed and the switch is no longer pressed. We will use an Arduino to program the motor to rotate the console to either side based on feedback from the limit switch. This coding flow chart shows the basic concept. We will start by checking the state of the limit switch. If it is depressed, indicating that the adaptive side is not in use, and the console is already on the standard side, nothing will happen. If the console is not already on the standard side, the motor will rotate 180 degrees. Similarly, if the limit switch was not originally depressed, the code will check the position of the console and ensure that it is facing the adaptive side. Therefore, the console will face the standard side of the machine by default and when a wheelchair user secures themselves with the lap bar, the console will automatically rotate to face them and they can begin rowing.

As for future work, we will create 3D CAD models of our design improvements for modeling and testing purposes. We will then obtain necessary supplies from Johnson Health Tech, the MakerSpace, and other commercial stores to begin fabrication. We will also develop testing plans for design verification and validation.

Thank you to our advisor and teacher Dr. Tracy Puccinelli and to our client Staci Quam for their guidance on our project.

Here are the references for this presentation. Are there any questions?

References: none

Conclusions:

Today, I started practicing the delivery of my script for the prelim presentation.

Action items:

1. continue to practice

ANNABEL FRAKE - Oct 04, 2022, 1:36 PM CDT

Title: 4OCT2022 Practicing Preliminary Presentation

Date: 4OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: practice delivery of my preliminary presentation slides

Content:

Script:

Thank you, Roxi.

With the elimination of the original Matrix arm, we decided to reposition the console on one of the antlers that hold the rowing handle in place when the machine is not in use. The extension that supports the console will be integrated into the design such that the distance of the console from the midline of the machine is minimized. This is an important design criteria because it ensures the comfort of the user and minimizes changes in their rowing form that may result from looking to the side instead of straight ahead.

The console will be attached to a motor that allows 180 degree rotation between the adaptive and standard sides of the machine. The transition from one side to the other will be automated with the use of a limit switch placed above the lap bar near its pivot point. When the lap bar is all the way up in its unused position, the limit switch is depressed. As the lap bar is lowered to secure the user, the force applied to the limit switch is removed. We will use an Arduino to program the motor rotation of the console based on feedback from the limit switch. This coding flow chart shows the basic concept. The loop starts by checking the state of the limit switch. If it is depressed, indicating that the adaptive side is not in use, and the console is already on the standard side, nothing will happen. If the console is not already on the standard side, the motor will rotate 180 degrees to make it so. Similarly, if the limit switch is not depressed, the code will check the position of the console and ensure that it faces the adaptive side. Therefore, the console will face the standard side of the machine by default and when a wheelchair user secures themselves with the lap bar, the console will automatically rotate to face them and they can begin rowing.

As for future work, we will create 3D CAD models of our design improvements for modeling and testing purposes. We will then obtain necessary supplies from Johnson Health Tech, the MakerSpace, and other commercial stores to begin fabrication. We will also develop testing plans for design verification and validation.

Thank you to our advisor and teacher Dr. Tracy Puccinelli and to our client Staci Quam for their guidance on our project.

Here are the references for this presentation. Are there any questions?

References: none

Conclusions:

I edited my script. I practiced the delivery of my script for the prelim presentation. Memorized up until the future work section.

Action items:

1. continue to practice

ANNABEL FRAKE - Oct 05, 2022, 10:25 PM CDT

Date: 5OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: practice delivery of my preliminary presentation slides

Content:

Script:

Thank you, Roxi.

With the elimination of the original Matrix rower neck, we decided to reposition the console onto one of the antlers. The extension that supports the console will be integrated into the design such that the distance of the console from the midline of the machine is minimized. This is an important design criteria because it ensures the comfort of the user and minimizes changes in their rowing form that may result from looking to the side instead of straight ahead.

The console will be attached to a motor that allows 180 degree rotation between the adaptive and standard sides of the machine. The transition from one side to the other will be automated with the use of a limit switch placed above the lap bar near its pivot point. When the lap bar is all the way up in its unused position, the limit switch is depressed. As the lap bar is lowered to secure the user, the force applied to the limit switch is removed. We will use an Arduino to program the motor rotation of the console based on feedback from the limit switch. If it is depressed, indicating that the adaptive side is not in use, and the console is not already on the standard side, the motor will rotate 180 degrees to make it so. Similarly, if the limit switch is not depressed, the code will check the position of the console and ensure that it faces the adaptive side. Therefore, the console will face the standard side of the machine by default and when a wheelchair user secures themselves with the lap bar, the console will automatically rotate to face them and they can begin rowing.

As for future work, we will create 3D CAD models of our design improvements. We will then obtain necessary supplies from Johnson Health Tech, the MakerSpace, and other commercial stores to begin fabrication. We will also develop testing plans for design verification and validation.

Thank you to our advisor and teacher Dr. Tracy Puccinelli and to our client Staci Quam for their guidance on our project.

Here are the references for this presentation. Are there any questions?

References: none

Conclusions:

I made edits to and practiced the delivery of my script for the prelim presentation. I had to trim out some content to meet the 2 minute maximum time allotment. I finished memorizing the entire script.

Action items:

1. continue to practice
2. practice with the team

ANNABEL FRAKE - Oct 06, 2022, 7:31 PM CDT

Date: 6OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: practice delivery of my preliminary presentation slides

Content:

Script:

Thank you, Roxi.

With the elimination of the original Matrix rower neck, we decided to reposition the console onto one of the antlers. The extension that supports the console will be integrated into the design such that the distance of the console from the midline of the machine is minimized. This is an important design criteria because it ensures the comfort of the user and minimizes changes in their rowing form that may result from looking to the side instead of straight ahead.

The console will be attached to a motor that allows 180 degree rotation between the adaptive and standard sides of the machine. The transition from one side to the other will be automated with the use of a limit switch placed above the lap bar near its pivot point. When the lap bar is all the way up in its unused position, the limit switch is depressed. As the lap bar is lowered to secure the user, the force applied to the limit switch is removed. We will use an Arduino to program the motor rotation of the console based on feedback from the limit switch. If it is depressed, indicating that the adaptive side is not in use, and the console is not already on the standard side, the motor will rotate 180 degrees to make it so. Similarly, if the limit switch is not depressed, the code will check the position of the console and ensure that it faces the adaptive side. Therefore, the console will face the standard side of the machine by default and when a wheelchair user secures themselves with the lap bar, the console will automatically rotate to face them and they can begin rowing.

As for future work, we will create 3D CAD models of our design improvements. We will then obtain necessary supplies from Johnson Health Tech, the MakerSpace, TeamLab, and other commercial stores to begin fabrication. We will also develop testing plans for design verification and validation.

Thank you to our advisor and teacher Dr. Tracy Puccinelli and to our client Staci Quam for their guidance on our project.

Here are the references for this presentation. Are there any questions?

References: none

Conclusions:

I practiced my script a few more times after our team meeting

Action items:

1. present tomorrow

6OCT2022 Preliminary Report

ANNABEL FRAKE - Oct 06, 2022, 10:06 PM CDT

Title: 6OCT2022 Preliminary Report

Date: 6OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: start working on the general formatting of the report and my written sections

Content:

-see attachment

References: see references in document

Conclusions:

I started formatting the preliminary report and making the sections with the proper headings, etc. I also took the information from last semester's final report and put it into an appendix. If the information (ie background) was the same, I did not include it in the appendix so that information is not needlessly repeated. I then took the information from the console design matrix and placed it into the proper sections (part of my assigned workload). I will need to make the design criteria into a paragraph format. I am also going to take the information from the design description figure captions and convert that into a paragraph. I will need to update the motor design based on improvements we have made with the limit switch addition.

Action items:

1. continue to work on my sections of the report

ANNABEL FRAKE - Oct 06, 2022, 10:05 PM CDT


WISCONSIN

Adaptive Rowing Machine

Download

BME_400_Prelim_Report.pdf (9.66 MB)

7OCT2022 Prelim Presentation Reflection

ANNABEL FRAKE - Oct 07, 2022, 2:47 PM CDT

Title: 7OCT2022 Prelim Presentation Reflection

Date: 7OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: comment on the prelim presentation

Content:

-no content, presented to class today

References: none

Conclusions:

My team presented in the Tong lecture hall today. We had three questions about battery life, securement to prevent the user from moving backwards, and the reachability of the rower handle. We answered questions succinctly. Overall, I think that our delivery was great! I am happy with how I presented my slides and how the team performed as a whole.

Action items:

1. work on preliminary report

8OCT2022 Preliminary Report

ANNABEL FRAKE - Oct 08, 2022, 4:55 PM CDT

Title: 8OCT2022 Preliminary Report

Date: 8OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: write my sections of the prelim report

Content:

-see attached document

References: see attached document

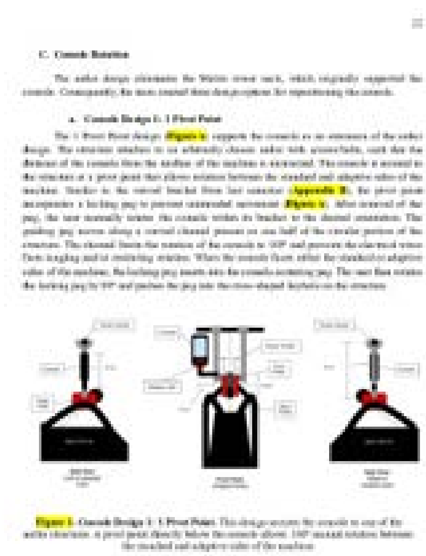
Conclusions:

I wrote my assigned sections of the preliminary report (console portion of the revised design and evaluation section, console portion of the fabrication section). I was able to reuse a large portion of the design matrix document, but I needed to update everything to include the limit switch.

Action items:

1. read and edit the report before our Monday meeting (after Sun night - deadline for sections to be done)

ANNABEL FRAKE - Oct 08, 2022, 4:44 PM CDT



[Download](#)

BME_400_Prelim_Report_My_Sections_.pdf (2.17 MB)

10OCT2022 Preliminary Report

ANNABEL FRAKE - Oct 10, 2022, 8:06 PM CDT

Title: 10OCT2022 Preliminary Report

Date: 10OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: read and edit the prelim report; final read through of the prelim

Content:

- before our group meeting today, I read through everyone else's sections of the report and made edits
- If the change was more substantial or required discussion, I left a comment
- I also updated my sections based on comments left by other members (ie add rotation arrows to the figures and use close-ups of the console in the design matrix)
- after the meeting, I did a final read through of the report

References: none

Conclusions:

Once everyone had completed their assigned sections, I read and edited the entire report before the group meeting. After the meeting, I did a final read through and let the group know.

Action items:

1. upload the prelim report to the notebook once everyone is finished reading through it

29OCT2022 Preliminary Report Feedback Reflection

ANNABEL FRAKE - Oct 29, 2022, 1:12 AM CDT

Title: 29OCT2022 Preliminary Report Feedback Reflection

Date: 29OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: reflect on Dr. Tracy P's feedback on our preliminary report

Content:

- See attached document for her feedback
- General trends for improvement:
  - all figures need dimensions
  - include more references
  - explain the technical side of things better
  - don't have 1-2 sentences alone, she wants full paragraphs
  - expand on testing

References: see attached document

Conclusions:

For the final report, we need to expand on our background section so that we have more sources. We need to make sure all figures have labels and captions and that there are no stand-alone sentences / pairs of sentences. We need to work on wording / explaining the technical aspects better. We should also expand on the testing section and make sure it is clear what each part of testing entails.

Action items:

1. use this feedback to improve the final report

ANNABEL FRAKE - Oct 29, 2022, 1:08 AM CDT


Adaptive Rowing Machine

Download

Annotated_Prelim_Report_with_Feedback.pdf (12.3 MB)

3DEC2022 Final Poster

ANNABEL FRAKE - Dec 03, 2022, 12:27 PM CST

Title: 3DEC2022 Final Poster

Date: 3DEC2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: complete my sections of the final poster (final design for electronics, future work for electronics)

Content:

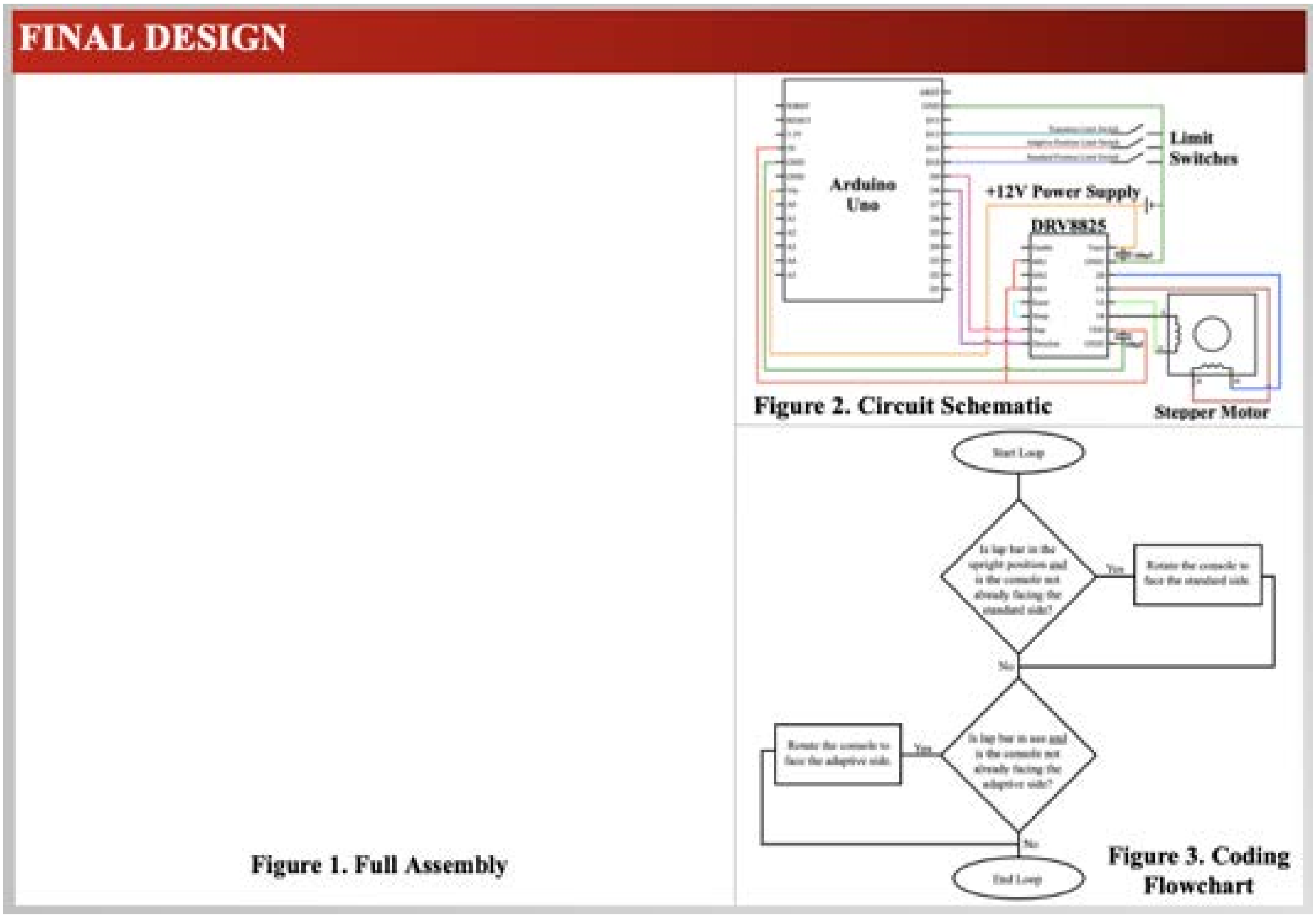
FUTURE WORK

Design Improvements:

- Add angle adjustment mechanism to the stabilization frame
- Weld stabilization frame together
- Reduce the width of lap bar to fit between the handles of an average sized wheelchair
- Add braces to the stabilization frame that prevent the rowing machine from rocking during use
- Permanently secure the limit switches in place
- Reduce the power consumption of the circuit by implementing interrupts and sleep mode functions into the code
- Increase the height of the antlers to provide more clearance for the console during rotation
- Adjust dimensions of the electronics box/lid to allow for easy access to the electronics
- Create a mechanism by which the user can adjust the resistance level of the flywheel from the adaptive side of the machine

Future Testing:

- Conduct strength testing of the antler design using an MTS machine
- Intentionally release the rowing handle during the rowing motion to test the durability of the antlers
- Invite wheelchair users and non-wheelchair users to operate the device and collect feedback of ease of use



References: none

Conclusions:

Today, I completed my sections of the final poster. I ended up doing the entirety of the future work section (instead of just electronics).

Action items:

1. edit the poster with the team
2. practice presenting my sections of the poster (design criteria and final design)

5NOV2022 Edit Final Poster

ANNABEL FRAKE - Dec 05, 2022, 1:50 PM CST

Title: 5NOV2022 Edit Final Poster

Date: 5NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: edit poster

Content:

- See attached file of the poster (my comments included)

References: none

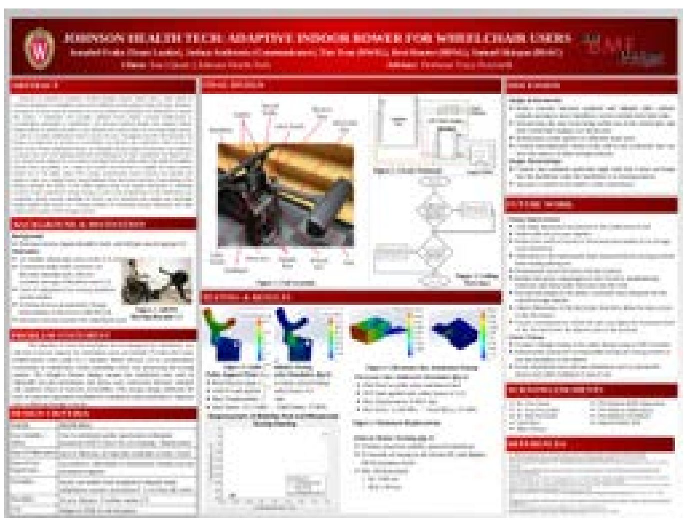
Conclusions:

In anticipation of our meeting later today to edit the poster, I made comments on the content and visual appeal of each section.

Action items:

1. meet with team later tonight to go over comments and finalize the poster

ANNABEL FRAKE - Dec 05, 2022, 1:49 PM CST



Download

Comments_on_Final_Poster_-_Adaptive_Rower_Fall_2022.pptx (6.4 MB)

7DEC2022 Final Presentation

ANNABEL FRAKE - Dec 07, 2022, 8:16 PM CST

Title: 7DEC2022 Final Presentation

Date: 7DEC2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: write my script for the final presentation and memorize it for our meeting tomorrow

Content:

Thank you, Tim.

In terms of design criteria, the rowing machine must be accessible to wheelchair users and require zero external assistance to operate. Additionally, the design must be compatible with average wheelchair dimensions and prevent wheelchair tipping and displacement during the rowing motion. The pulley mechanism must also withstand a maximum force of 1050 Newtons. Other design criteria include safety, ease of fabrication, ease of use, durability, and cost.

Last semester, the previous design team created a slit in the original Matrix rower neck through which the user could transition the rope from one side of the machine to the other. This semester, the team removed that same rower neck and replaced it with two antler-like structures that hold the rowing handle when the machine is not in use. Now, a user from either side of the machine can grab the handle and pull it towards themselves to start their workout, which drastically improves the design's ease of use.

In regards to user stability, the previous semester's design secured the wheelchair user with a wooden stabilization frame. This semester, we changed the frame to a lap bar design similar to those seen on rollercoasters. We fabricated the design using metal to increase durability and secured the device directly to the rowing machine for added stability. A pin angle adjustment mechanism allows for the accommodation of different sized wheelchairs.

With the elimination of the original Matrix rower neck, we decided to reposition the console to a point adjacent to one of the antlers. We then used a stepper motor to automate the rotation of the console between the adaptive and standard sides of the machine. The transition from one side to the other relies on feedback from a limit switch positioned behind the lap bar near its pivot point. Two more limit switches placed near the base of the console provide feedback about the orientation of the display. To demonstrate, when the lap bar is lowered to secure the user, the console automatically rotates to face the adaptive side of the machine. Once the user completes their workout and returns the lap bar to its upright position, the console automatically rotates to face the standard side of the machine.

I will now hand things over to Josh to talk about testing.

References: none

Conclusions:

Today, I wrote my script for the final poster presentation (my sections are design criteria and final design). I then practiced presenting my portion in anticipation of our group meeting tomorrow.

Action items:

1. practice presenting with the group tomorrow

8DEC2022 Final Presentation

ANNABEL FRAKE - Dec 08, 2022, 6:25 PM CST

Title: 8DEC2022 Final Presentation

Date: 8DEC2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: write my script for the final presentation and memorize it for our meeting tomorrow

Content:

Thank you, Tim.

In terms of design criteria, the rowing machine must be accessible to wheelchair users and require zero external assistance to operate. Additionally, the design must be compatible with average wheelchair dimensions and prevent wheelchair tipping and displacement during the rowing motion. The pulley mechanism must also withstand a maximum force of 1050 Newtons. Other design criteria include safety, ease of fabrication, ease of use, durability, and cost.

Last semester, the previous design team created a slit in the original Matrix rower neck through which the user could transition the rope from one side of the machine to the other. This semester, the team removed that same rower neck and replaced it with two antler-like structures that hold the rowing handle when the machine is not in use. Now, a user from either side of the machine can grab the handle and pull it towards themselves to start their workout, which drastically improves the design's ease of use.

In regards to user stability, the previous semester's design secured the wheelchair user with a wooden stabilization frame. This semester, we changed the frame to a lap bar design similar to those seen on rollercoasters. We fabricated the design using metal to increase durability and secured the device directly to the rowing machine for added stability.

With the elimination of the original Matrix rower neck, we decided to reposition the console to a point adjacent to one of the antlers. We then used a stepper motor to automate the rotation of the console between the adaptive and standard sides of the machine. The transition from one side to the other relies on feedback from a limit switch positioned behind the lap bar near its pivot point. Two more limit switches placed near the base of the console provide feedback about the orientation of the display. To demonstrate, when the lap bar is lowered to secure the user, the console automatically rotates to face the adaptive side of the machine. Once the user completes their workout and returns the lap bar to its upright position, the console automatically rotates to face the standard side of the machine.

I will now hand things over to Josh to talk about testing.

References: none

Conclusions:

I practiced my script.

Action items:

1. present tomorrow

9DEC2022 Final Report

ANNABEL FRAKE - Dec 09, 2022, 1:01 AM CST

Title: 9DEC2022 Final Report

Date: 9DEC2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: start working on my sections of the final report

Content:

a. Circuit and Code Functionality

To test the functionality of the circuit and code, eight edge cases representing likely operational scenarios were tested. **TABLE X.** describes the testing setup and expected outcome of the scenario. The testing protocol stipulated that each edge case be tested three times. During testing, the response (or lack thereof) of the console was recorded and compared to the expected response to determine whether the circuit and code passed or failed the functionality test.

TABLE X. Edge Case Protocol Description. This table contains instructions for implementing eight edge cases that test the functionality of the final circuit and code. The table also specifies the expected outcome of each test.

Edge Case	Testing Setup and Implementation Instructions	Expected Outcome
1	• Before power application: Position the console in no-man's land (not facing the standard or adaptive sides). Lower the lap bar such that the transition limit switch is not pressed. • Apply power.	The console rotates to the adaptive side.
2	• Before power application: Position the console in no-man's land (not facing the standard or adaptive sides). Raise the lap bar such that the transition limit switch is pressed. • Apply power.	The console rotates to the standard side.
3	• Before power application: Position the console on the adaptive side such that the adaptive limit switch is suppressed. Lower the lap bar such that the transition limit switch is not pressed. • Apply power.	The console remains stationary until the lap bar is raised such that the transition limit switch is suppressed. Then the console rotates to the standard side.
4	• Before power application: Position the console on the standard side such that the standard limit switch is suppressed. Raise the lap bar such that the transition limit switch is pressed. • Apply power.	The console remains stationary until the lap bar is lowered such that the transition limit switch is no longer suppressed. Then the console rotates to the adaptive side.

5	• Before power application: Position the console on the adaptive side such that the adaptive limit switch is suppressed. Raise the lap bar such that the transition limit switch is pressed. • Apply power.	The console rotates to the standard side.
6	• Before power application: Position the console on the standard side such that the standard limit switch is suppressed. Lower the lap bar such that the transition limit switch is not pressed. • Apply power.	The console rotates to the adaptive side.
7	• Apply power. • After power application: Disconnect the power supply while the console is rotating between the standard and adaptive sides (or vice versa). Supply the circuit with power.	The console rotates to the appropriate side of the rowing machine in accordance with the state of the transition limit switch when power is reconnected.
8	• Apply power. • After power application: Induce rotation of the console. Raise and lower the lap bar multiple times (such that the transition limit switch is pressed and released multiple times) during the rotation from one side of the machine to the other (either adaptive to standard or standard to adaptive, the choice is arbitrary). Before the console finishes rotating, either raise or lower the lap bar and keep it there.	After the console finishes rotating to the position to which it was originally traveling, the console either stays there or rotates to the opposite side in accordance with the state of the transition limit switch.

References: none

Conclusions:

I started to write the testing section for the circuit and code. I transformed the edge case protocol into a table, but I'm not sure if it would be better to write everything out in paragraph form, so I'm waiting to ask the team before continuing.

Action items:

1. continue to work on my sections of the report
2. ask the team about the effectiveness of the table and whether it should all be in paragraph format

9DEC2022 Final Poster Presentation Reflection

ANNABEL FRAKE - Dec 09, 2022, 7:40 PM CST

Title: 9DEC2022 Final Poster Presentation Reflection

Date: 9DEC2022

Content by: Annabel Frake

Present: BME department + visitors

Goals: present our final design

Content:

- no content, presented our final design at the BME poster session
- Constructive feedback from peers
  - include more quantitative data in design criteria section
  - poster is wordy
  - explain more about the testing
  - speak louder
  - bigger poster
  - bigger figures
  - explain circuitry more
  - displacement figure was confusing
  - better figure captions
  - more images on poster
  - add more cushioning / make more aesthetic
  - find way to secure wheelchair directly to rowing machine

References: none

Conclusions:

We presented at the final poster presentation today, and I think it went really well! I am happy with the progress we have made this semester, and I'm excited to improve the design further next semester. I don't agree with all of the feedback from my peers, but it is a good idea to take note of it for next semester's poster. For example, we can strive to make the figures larger and clearer while cutting down on the bullet points.

Action items:

1. work on final report

10-11DEC2022 Final Report

ANNABEL FRAKE - Dec 11, 2022, 2:21 AM CST

Title: 10-11DEC2022 Final Report

Date: 10-11DEC2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: work on my sections of the final report

Content:

Fabrication section:

B. Console Rotation

Last semester, the console was located at the top of the original Matrix rower neck. 3D printed goalposts with a manual pin adjustment allowed the console to rotate from one side of the machine to the other. With the removal of the rower neck this semester, the console was repositioned to a point adjacent to one of the antlers. Furthermore, the rotation of the console between the standard and adaptive sides of the machine was automated with the use of a NEMA17 stepper motor. The transition from one side to the other relies on feedback from a normally open (NO) limit switch placed directly behind the lap bar (on the side with the rower) near its pivot point. Two more NO limit switches placed near the base of the console provide feedback about the orientation of the display. If the lap bar is raised, indicating that the adaptive side is not in use and the console should face the standard side, then the console will rotate toward the standard side if it is not already in the correct orientation. Similarly, if the lap bar is lowered, indicating that the adaptive side is in use and the console should face the wheelchair user, then the console will automatically rotate toward the adaptive side if it is not already in the correct orientation. **Fig. X** illustrates the logic in a coding flowchart.

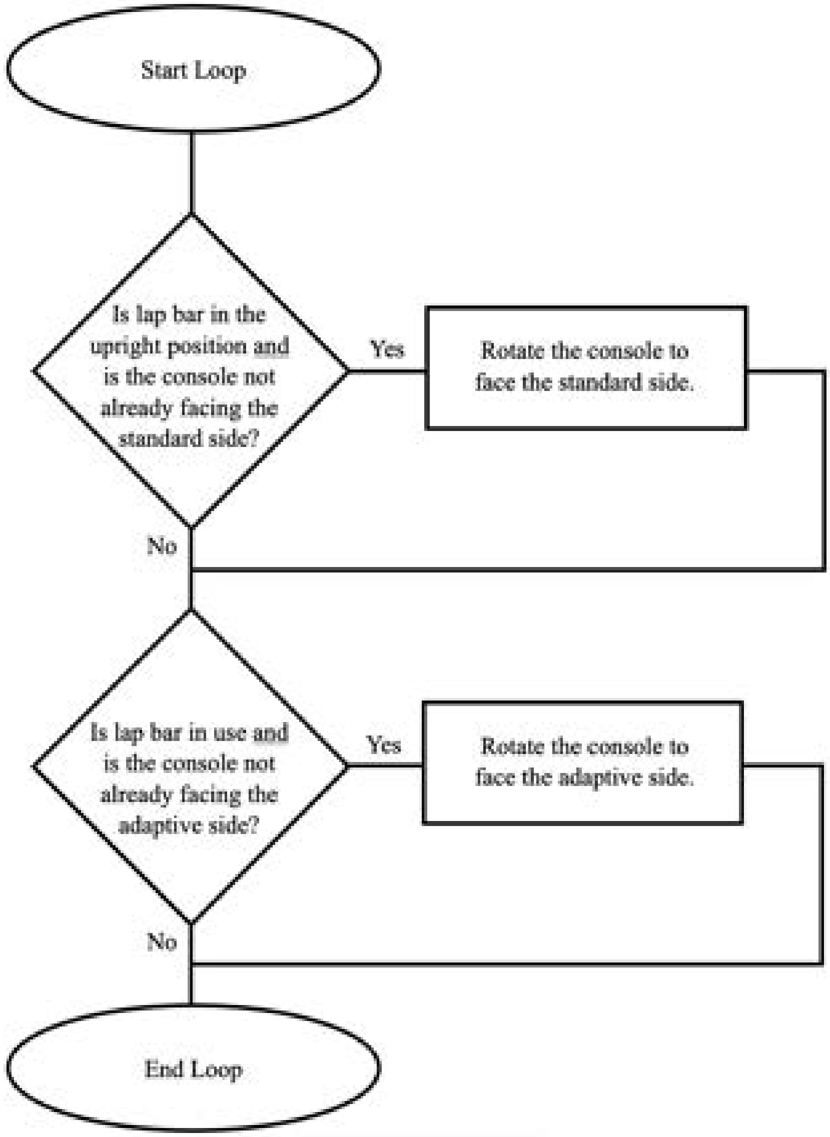


Figure X. Final Coding Flowchart. Each loop iteration, the code checks the position of the console and compares it to its expected location according to the state of the transition limit switch placed near the pivot point of the lap bar. If the lap bar is raised, indicating that the adaptive side is not in use and the console should face the standard side, then the console will rotate toward the standard side if it is not already in the correct orientation. Similarly, if the lap bar is lowered, indicating that the adaptive side is in use and the console should face the wheelchair user, then the console will rotate toward the adaptive side if it is not already in the correct orientation. The loop continuously repeats these checks to ensure the console faces the user.

The circuit required to complete the automatic rotation includes the following components: an Arduino Uno, DRV8825, NEMA17 stepper motor, +12V power supply, two 100 µFarad capacitors, and three NO limit switches. **Fig. X,** the final design schematic, illustrates the connections between each component. The Arduino Uno contains the code that receives feedback from the NO limit switches and rotates the NEMA17 stepper motor accordingly. The DRV8825 is a motor driver that interfaces between the NEMA17 stepper motor and Arduino. The state of the DIR pin on the DRV8825 determines which direction the motor will rotate while the STEP pin controls the stepping motion of the motor. By setting the MS1 and MS3 pins to high (+5V), the microstep resolution is set at 1/32 steps [], []. The SLEEP and RESET pins on the DRV8825 must be tied for the motor driver to operate []. The +12V power supply provides power to the stepper motor and Arduino Uno. The +5V power supply for the DRV8825 comes from the +5V power source on the Arduino Uno. The two 100 µFarad capacitors placed over the power supplies act as decoupling electrolytic capacitors that prevent sudden changes in voltage and protect the DRV8825 from damage [].

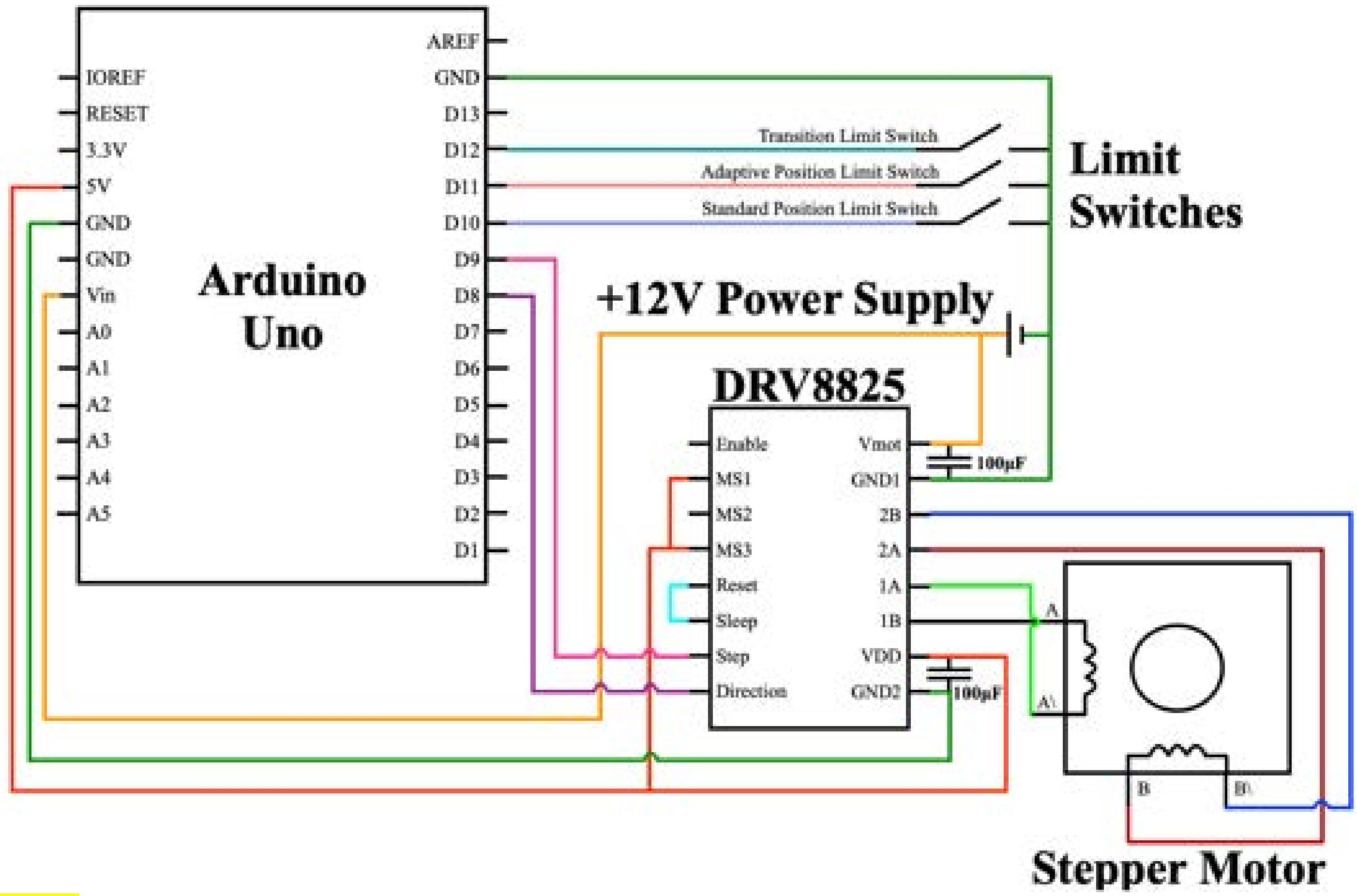


Figure X. Final Circuit Schematic. The final circuit consists of an Arduino Uno, DRV8825, NEMA17 stepper motor, +12V power supply, two 100 µF capacitors, and three NO limit switches. The colored lines represent the wire connections present between each physical component.

After troubleshooting and conducting preliminary testing on a temporary circuit built using a breadboard, the final circuit was constructed. A solder board sourced from the BME400 storage room was cut from 6.985 cm x 3.01625 cm down to roughly 4.7625 cm x 3.01625 cm using a bandsaw (**Fig. X**). The new dimensions allowed the solder board to fit within the electronics box.

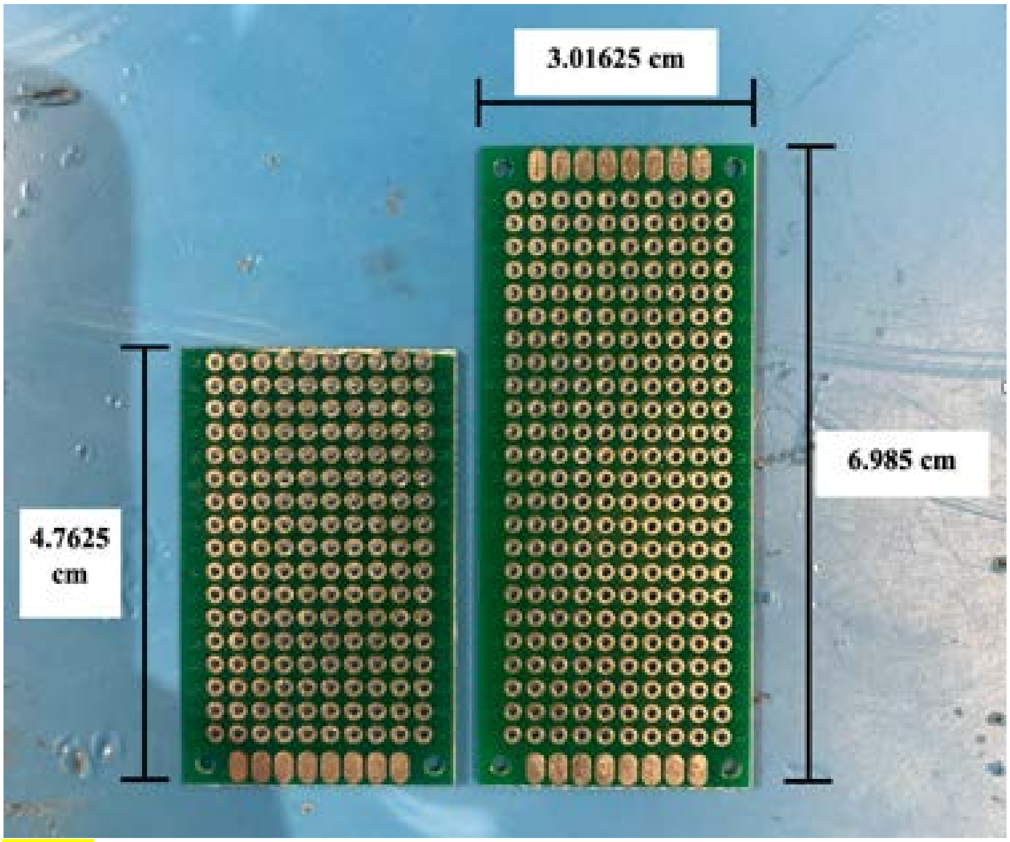


Figure X. **Solder Board.** The solder board was sourced from the BME 400 storage closet. To fit within the electronics box, its length was cut down to 4.7625 cm from 6.985 cm.

Next, two wires of approximately 20.32 cm in length were soldered to the standard position limit switch. The GND wire was connected to the terminal labeled "C" and the digital pin wire was connected to the terminal labeled "NO". The exposed metal was covered with heat shrink. The same process was executed for the adaptive position limit switch. Then, two wires of approximately 91.44 cm were soldered to the transition limit switch that goes to the lap bar on the stabilization frame. The GND wire was connected to the terminal labeled "C" and the digital pin wire was connected to the terminal labeled "NO". The exposed metal was covered with heat shrink.

The solder board was populated with the DRV8225 and two 100 µFarad capacitors. After cutting the stepper motor wires to approximately 0.394 cm in length, the stepper motor wires were soldered to the board using the pin designations from **Fig. X**. The ground wires from the standard and adaptive position limit switches were also soldered to the board in a common ground. The transition limit switch ground was not soldered this semester but will be soldered next semester after the final length of the wires running from the lap bar to the electronics box are determined. The remaining connections to the power sources were soldered to the board. On the back side of the board, the appropriate rows were soldered together to create the connections defined by the final circuit schematic. **Fig. x** shows the top and bottom face of the solder board.

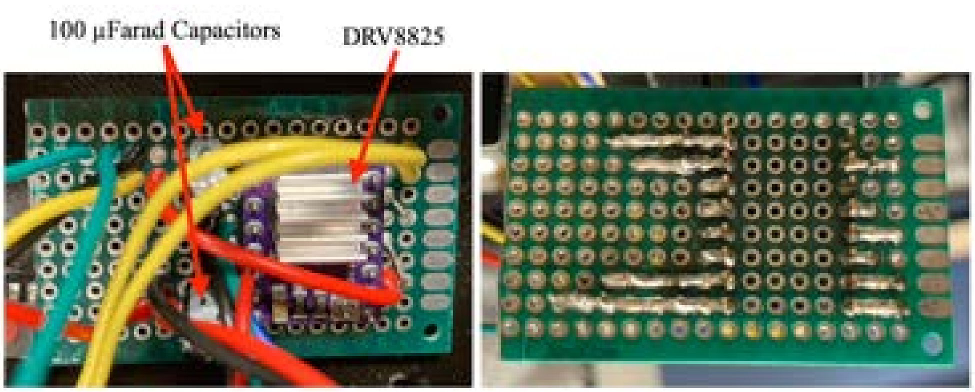


Figure X. **Solder board.** The image on the left shows the top face of the solder board populated with the DRV8825, two 100 µFarad capacitors, and wire connections. The image on the right shows the bottom face of the solder board with the ties for each row of connections.

The remaining wires to the Arduino Uno from the solder board (digital pin connections D8, D9; ground; Vin; +5V) and limit switches (digital pin connections D10, D11, D12) were connected without solder. The GND and Vin wires from the solder board were also screwed into the terminals on the +12V power supply connector. **Fig. X** illustrates these connections according to the final circuit schematic.

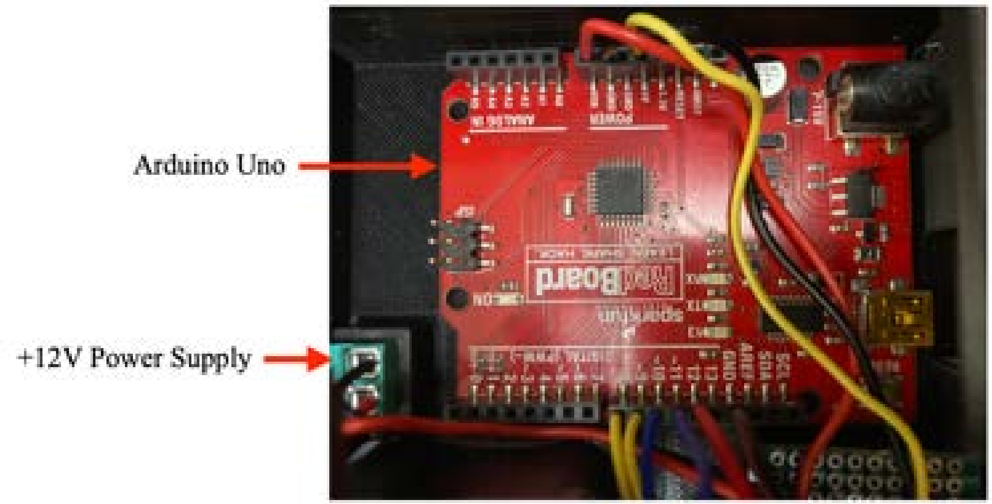


Figure X. Arduino Uno and +12V Power Supply Connections. This image shows the wires connecting to the Arduino Uno and +12V power supply.

At this point, the final code (**Appendix X**) was uploaded to the Arduino Uno. Within the void loop(), the code checks the state of the transition limit switch and the orientation of the console based on feedback from the three NO limit switches. If the console is not in the correct orientation, the void loop() will call either the rotateToStandard() or rotateToAdaptive() functions to rotate the console to the correct side such that the display faces the user. The speed of rotation is altered manually with the use of pulse width modulation (PWM). After uploading the code to the Arduino Uno and supplying the circuit with power using the +12V power supply, the current potentiometer on the DRV8825 was adjusted such that the current was enough to rotate the motor but as low as possible to limit noise and vibration.

Testing section:

a. Circuit and Code Functionality

To test the functionality of the circuit and code, eight edge cases representing likely operational scenarios were tested. For instance, edge case seven tests the ability of the console to rotate to the proper location after power is disconnected and reconnected during rotation. **TABLE X.** describes the testing setup and expected outcome of all eight scenarios. During testing, the response (or lack thereof) of the console was recorded and compared to the expected response to determine whether the circuit and code passed or failed the functionality test. Each edge case was tested three times.

TABLE X. Edge Case Protocol Description. This table contains instructions for implementing eight edge cases that test the functionality of the final circuit and code. The table also specifies the expected outcome of each test.

Edge Case	Testing Setup and Implementation Instructions	Expected Outcome
1	• Before power application: Position the console in no-man's land (not facing the standard or adaptive sides). Lower the lap bar such that the transition limit switch is not pressed. • Apply power.	The console rotates to the adaptive side.

2	• Before power application: Position the console in no-man's land (not facing the standard or adaptive sides). Raise the lap bar such that the transition limit switch is pressed. • Apply power.	The console rotates to the standard side.
3	• Before power application: Position the console on the adaptive side such that the adaptive limit switch is suppressed. Lower the lap bar such that the transition limit switch is not pressed. • Apply power.	The console remains stationary until the lap bar is raised such that the transition limit switch is suppressed. Then the console rotates to the standard side.
4	• Before power application: Position the console on the standard side such that the standard limit switch is suppressed. Raise the lap bar such that the transition limit switch is pressed. • Apply power.	The console remains stationary until the lap bar is lowered such that the transition limit switch is no longer suppressed. Then the console rotates to the adaptive side.
5	• Before power application: Position the console on the adaptive side such that the adaptive limit switch is suppressed. Raise the lap bar such that the transition limit switch is pressed. • Apply power.	The console rotates to the standard side.
6	• Before power application: Position the console on the standard side such that the standard limit switch is suppressed. Lower the lap bar such that the transition limit switch is not pressed. • Apply power.	The console rotates to the adaptive side.
7	• Apply power. • After power application: Disconnect the power supply while the console is rotating between the standard and adaptive sides (or vice versa). Supply the circuit with power.	The console rotates to the appropriate side of the rowing machine in accordance with the state of the transition limit switch when power is reconnected.
8	• Apply power. • After power application: Induce rotation of the console. Raise and lower the lap bar multiple times (such that the transition limit switch is pressed and released multiple times) during the rotation from one side of the machine to the other (either adaptive to standard or standard to adaptive, the choice is arbitrary). Before the console finishes rotating, either raise or lower the lap bar and keep it there.	After the console finishes rotating to the position to which it was originally traveling, the console either stays there or rotates to the opposite side in accordance with the state of the transition limit switch.

Results section:

a. Circuit and Code Functionality

The circuit and code passed all eight edge cases implemented three times each (**TABLE X**). A deviation from the testing protocol occurred for edge case eight. During testing, the lap bar did not rotate freely and often became stuck. As a consequence, the lap bar could not be moved fast enough to press and release the transition limit switch multiple times during the rotation of the console between the standard and adaptive sides of the machine. To simulate the lap bar movement, the tester directly pressed and released the transition limit switch with a finger. Because the circuit and code cannot differentiate between a finger and the lap bar, this deviation still accomplished the intent of the edge case to test the system's reaction to multiple, rapid changes in the transition limit switch state. All in all, the circuit and code functioned as intended and passed all eight edge cases.

TABLE X. Edge Case Protocol Results. This table contains instructions for implementing eight edge cases that test the functionality of the final circuit and code. Each edge case was tested three times. The experimental results were compared with the expected outcome to determine whether the circuit and code passed or failed each edge case.

Edge Case	Testing Setup and Implementation Instructions	Expected Outcome	Experimental Outcome	Number of Tests	Pass/Fail
1	• Before power application: Position the console in no-man's land (not facing the standard or adaptive sides). Lower the lap bar such that the transition limit switch is not pressed. • Apply power.	The console rotates to the adaptive side.	The console rotates to the adaptive side.	3	Pass
2	• Before power application: Position the console in no-man's land (not facing the standard or adaptive sides). Raise the lap bar such that the transition limit switch is pressed. • Apply power.	The console rotates to the standard side.	The console rotates to the standard side.	3	Pass
3	• Before power application: Position the console on the adaptive side such that the adaptive limit switch is suppressed. Lower the lap bar such that the transition limit switch is not pressed. • Apply power.	The console remains stationary until the lap bar is raised such that the transition limit switch is suppressed. Then the console rotates to the standard side.	The console remains stationary until the lap bar is raised such that the transition limit switch is suppressed. Then the console rotates to the standard side.	3	Pass
4	• Before power application: Position the console on the standard side such that the standard limit switch is suppressed. Raise the lap bar such that the transition limit switch is pressed. • Apply power.	The console remains stationary until the lap bar is lowered such that the transition limit switch is no longer suppressed. Then the console rotates to the adaptive side.	The console remains stationary until the lap bar is lowered such that the transition limit switch is no longer suppressed. Then the console rotates to the adaptive side.	3	Pass
5	• Before power application: Position the console on the adaptive side such that the adaptive limit switch is suppressed. Raise the lap bar such that the transition limit switch is pressed. • Apply power.	The console rotates to the standard side.	The console rotates to the standard side.	3	Pass

6	• Before power application: Position the console on the standard side such that the standard limit switch is suppressed. Lower the lap bar such that the transition limit switch is not pressed. • Apply power.	The console rotates to the adaptive side.	The console rotates to the adaptive side.	3	Pass*
7	• Apply power. • After power application: Disconnect the power supply while the console is rotating between the standard and adaptive sides (or vice versa). Supply the circuit with power.	The console rotates to the appropriate side of the rowing machine in accordance with the state of the transition limit switch when power is reconnected.	The console rotates to the appropriate side of the rowing machine in accordance with the state of the transition limit switch when power is reconnected.	3	Pass
8	• Apply power. • After power application: Induce rotation of the console. Raise and lower the lap bar multiple times (such that the transition limit switch is pressed and released multiple times) during the rotation from one side of the machine to the other (either adaptive to standard or standard to adaptive, the choice is arbitrary). Before the console finishes rotating, either raise or lower the lap bar and keep it there.	After the console finishes rotating to the position to which it was originally traveling, the console either stays there or rotates to the opposite side in accordance with the state of the transition limit switch.	After the console finishes rotating to the position to which it was originally traveling, the console either stays there or rotates to the opposite side in accordance with the state of the transition limit switch.	3	Pass

*Note: A deviation from the testing protocol occurred for edge case eight. The tester used their finger to directly press and release the limit switch.

References: none

Conclusions:

I wrote the first draft of my sections for the final report. I'm not sure if I have the order quite right for the fabrication section yet, so I will look over it again before the group meeting to edit.

Action items:

1. edit my sections of the report before the group editing session
2. edit final report with team

ANNABEL FRAKE - Dec 11, 2022, 10:54 AM CST

I added some content to the fabrication section:

A. Console Rotation

Last semester, the console was located at the top of the original Matrix rower neck. 3D printed goalposts with a manual pin adjustment allowed the user to rotate the console from one side of the machine to the other. With the removal of the rower neck this semester, the console was repositioned to a point adjacent to one of the antlers. Furthermore, the rotation of the console between the standard and adaptive sides of the machine was automated with the use of a stepper motor. The transition from one side to the other relies on feedback from a normally open (NO) limit switch placed directly behind the lap bar (on the side with the rower) near its pivot point. Two more NO limit switches placed near the base of the console provide feedback about the orientation of the display (**Fig. X**). If the lap bar is raised, then the adaptive side is not in use and the console should face the standard side. The console will rotate toward the standard side until the standard position limit switch is depressed if the console is not already in the correct orientation. Similarly, if the lap bar is lowered, then the adaptive side is in use and the console should face the wheelchair user. The console will automatically rotate toward the adaptive side until the adaptive position limit switch is depressed if the console is not already in the correct orientation. **Fig. X** illustrates this logic in a coding flowchart.

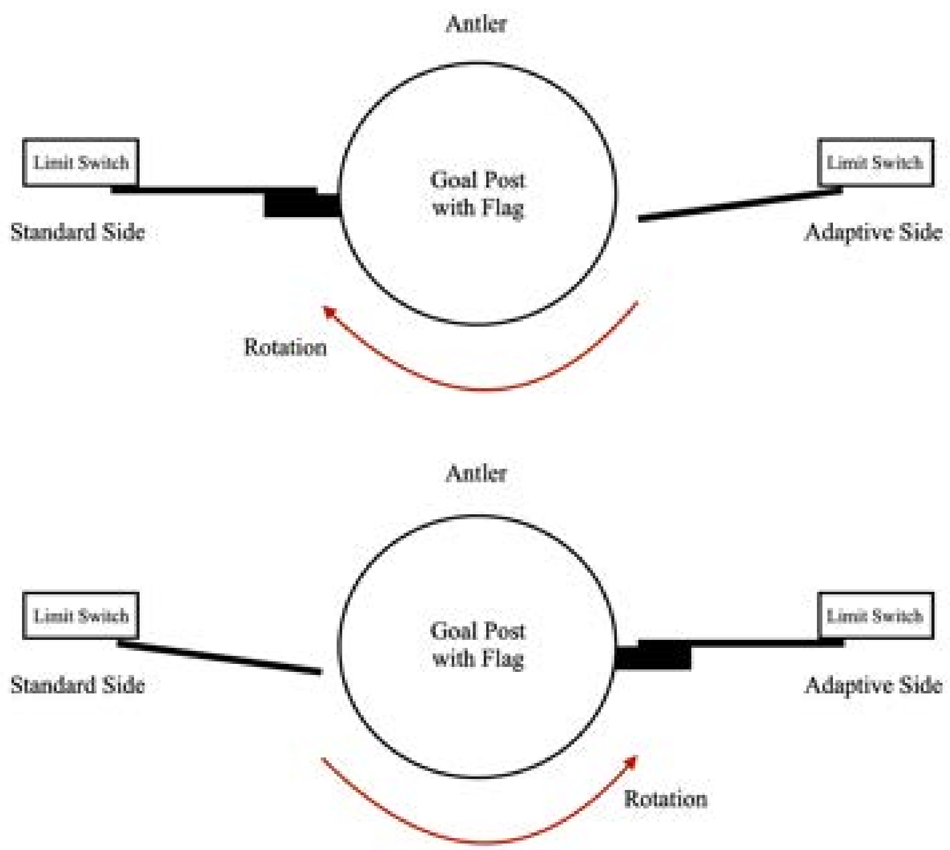


Figure X. Standard and Adaptive Position Limit Switch Placement. Two limit switches are placed at 180 degrees from each other such that they create stop blocks for rotation between the standard and adaptive sides of the machine. In the top image, the flag on the goal post depresses the standard position limit switch, indicating that the display faces the standard side of the machine. In the bottom image, the flag depresses the adaptive position limit switch, indicating that the display faces the wheelchair user. The console rotates 180 degrees between these two limit switches and does not complete a full 360 degree rotation to avoid tangling the electrical wires leading to the console.

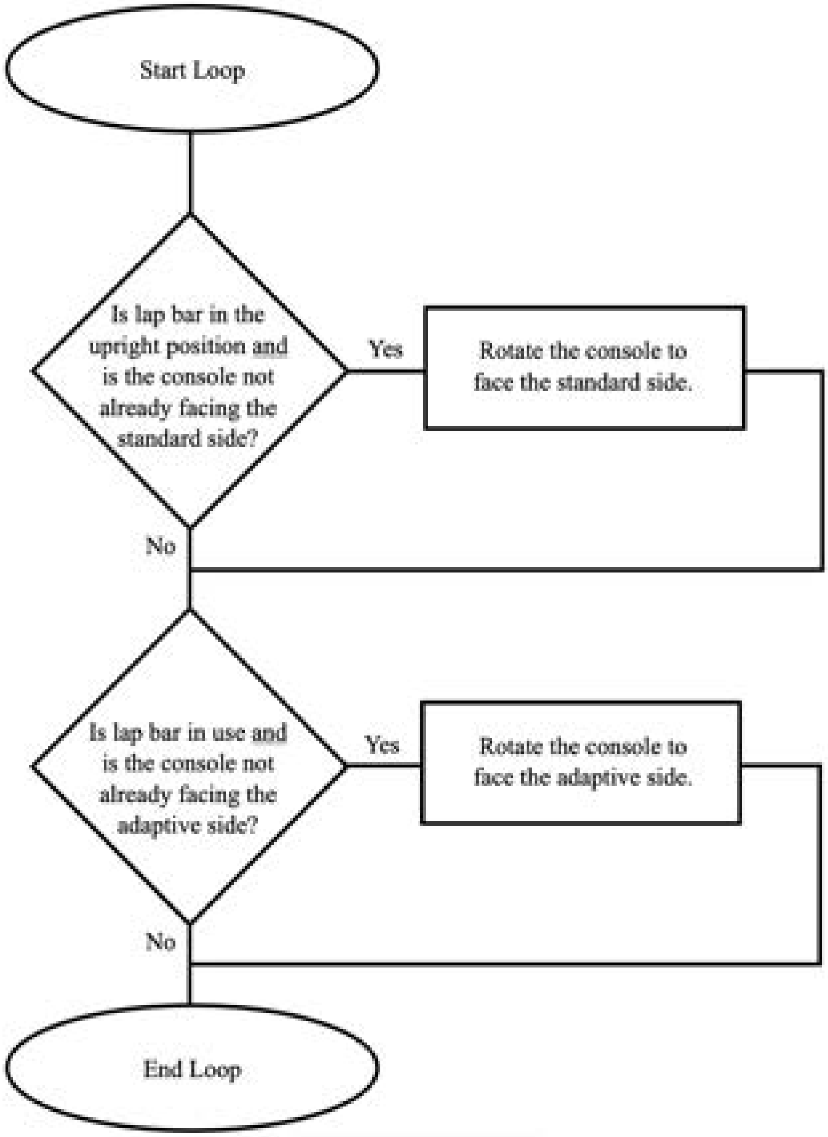


Figure X. Final Coding Flowchart. Each loop iteration, the code checks the position of the console and compares it to its expected location according to the state of the transition limit switch placed near the pivot point of the lap bar. If the lap bar is upright and the console is not already facing the standard side, then the console will rotate to face the standard side. Similarly, if the lap bar is in use and the console is not already facing the adaptive side, then the console will rotate to face the adaptive side. The loop continuously repeats these checks to ensure the console faces the current user.

The circuit required to complete the automatic rotation includes the following components: an Arduino Uno, DRV8825, NEMA17 stepper motor, +12V power supply, two 100 μFarad capacitors, and three NO limit switches. **Fig. X,** the final design schematic, illustrates the connections between each component. The Arduino Uno contains the code that receives feedback from the NO limit switches and rotates the NEMA17 stepper motor accordingly. The DRV8825 is a motor driver that interfaces between the NEMA17 stepper motor and Arduino. The state of the DIR pin on the DRV8825 determines which direction (i.e., clockwise or counterclockwise) the motor will rotate while the STEP pin controls the stepping motion of the motor. By setting the MS1 and MS3 pins to high (+5V), the microstep resolution is set at 1/32 steps [], []. The SLEEP and RESET pins on the DRV8825 must be tied for the motor driver to operate []. The +12V power supply provides power to the stepper motor and Arduino Uno, and the +5V power supply for the DRV8825 is supplied by the +5V pin on the Arduino Uno. The two 100 μFarad capacitors (sourced from the BME 400 storage closet) placed over the power supplies act as decoupling electrolytic capacitors that prevent sudden changes in voltage and protect the DRV8825 from damage [].

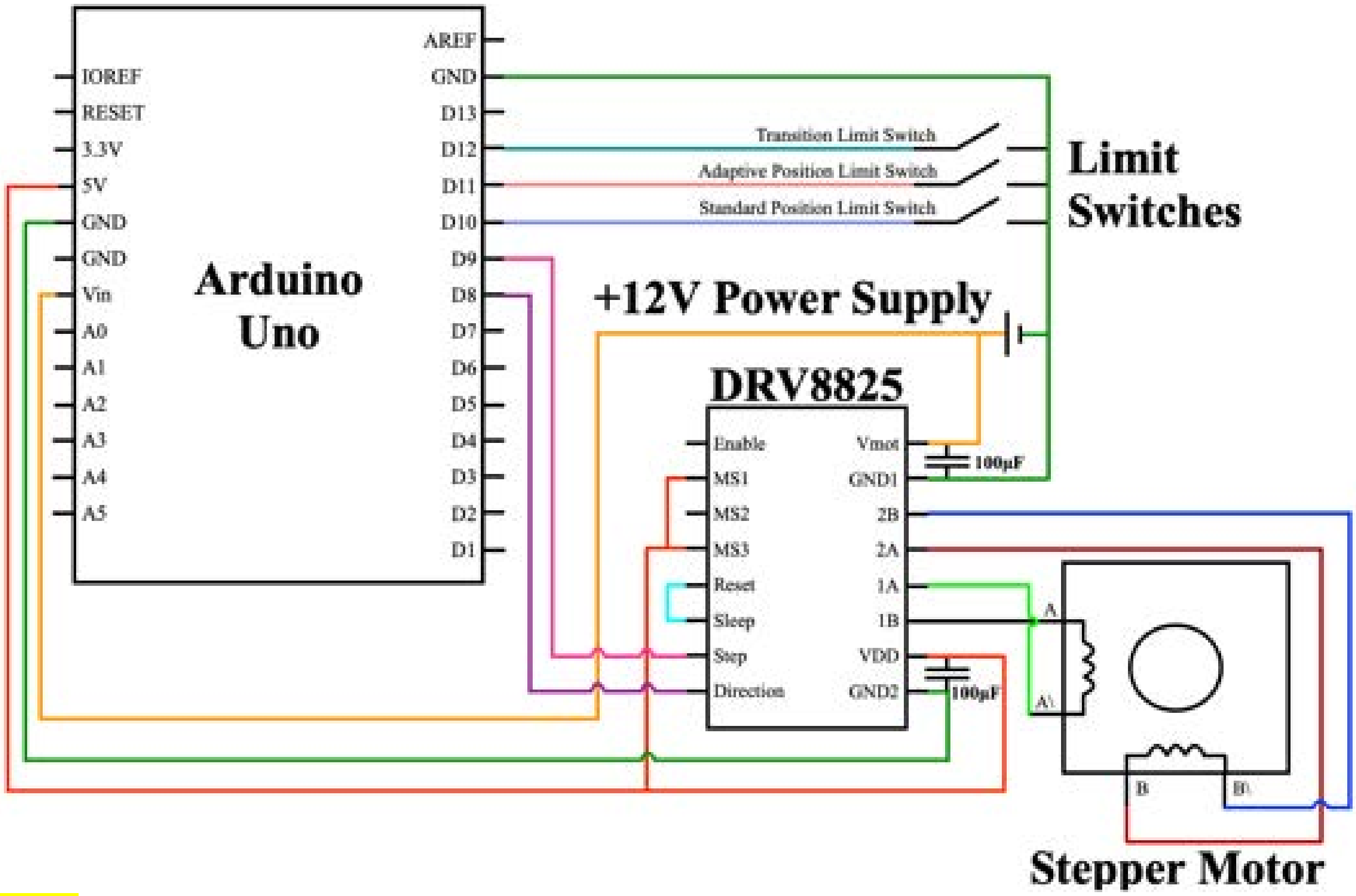


Figure X. Final Circuit Schematic. The final circuit consists of an Arduino Uno, DRV8825, NEMA17 stepper motor, +12V power supply, two 100 µF capacitors, and three NO limit switches. The colored lines represent the wire connections present between each physical component.

After troubleshooting and conducting preliminary testing on a temporary circuit built using a breadboard, the final circuit was constructed. A solder board sourced from the BME 400 storage room was cut from 6.985 cm x 3.01625 cm down to roughly 4.7625 cm x 3.01625 cm using a bandsaw (**Fig. X**). The new dimensions allowed the solder board to fit within the electronics box.

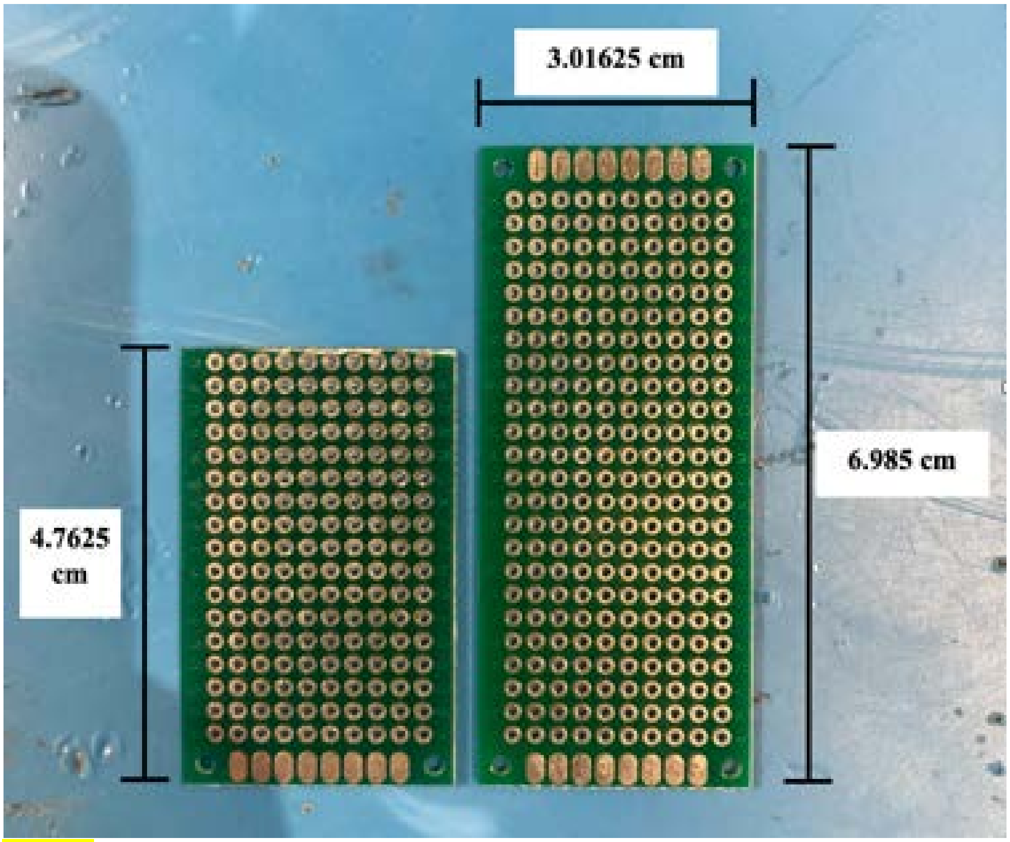


Figure X. **Solder Board.** The solder board was sourced from the BME 400 storage closet. To fit within the electronics box, its length was cut down to 4.7625 cm from 6.985 cm.

Next, two wires of approximately 20.32 cm in length were soldered to the standard position limit switch. The ground (GND) wire was connected to the terminal labeled "C" and the digital pin wire was connected to the terminal labeled "NO". The exposed metal was covered with heat shrink. **Fig. X** shows the connections to the standard position limits switch. The same process was executed for the adaptive position limit switch. Then, two wires of approximately 91.44 cm were soldered to the transition limit switch that goes to the lap bar on the stabilization frame. The GND wire was connected to the terminal labeled "C" and the digital pin wire was connected to the terminal labeled "NO". The exposed metal was covered with heat shrink.

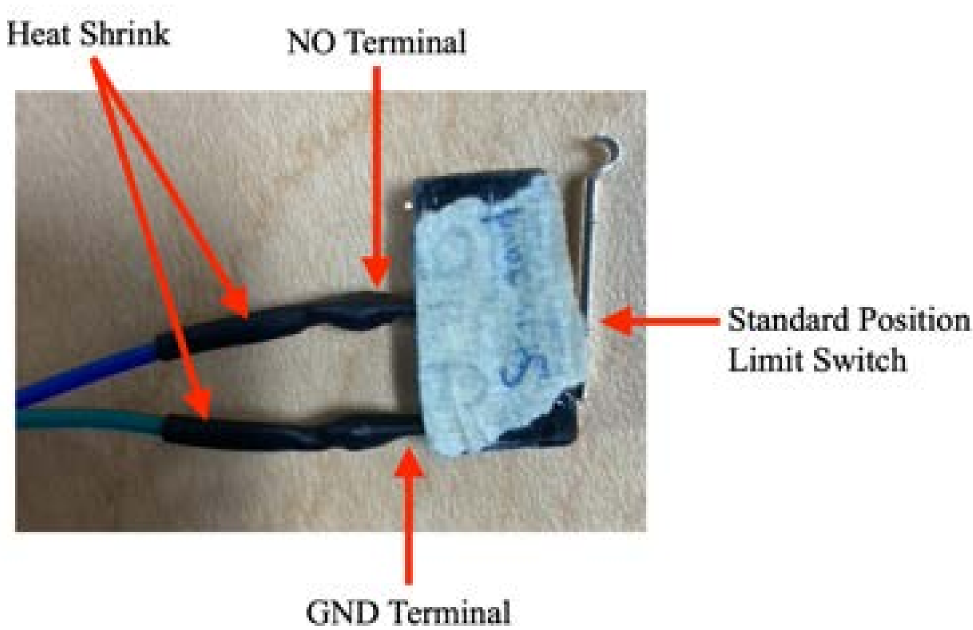


Figure X. **Standard Position Limit Switch Connections.** Two wires of approximately 20.32 cm in length are soldered to the standard position limit switch. The green wire (GND) is connected to the terminal labeled with “C” while the blue wire (D10) is connected to the terminal labeled with “NO”. These connections can be extrapolated to the adaptive position limit switch and transition limit switch.

The solder board was populated with the DRV8225 and two 100 µFarad capacitors. After cutting the stepper motor wires to approximately 0.394 cm in length, they were soldered to the board using the pin designations from the final circuit schematic (**Fig. X)**. The ground wires from the standard and adaptive position limit switches were also soldered to the board in a common ground. The transition limit switch GND was not soldered to the board this semester but will be soldered next semester after the final length of the wires running from the lap bar to the electronics box are determined. Instead, this GND connection was plugged directly into the Arduino GND. The remaining connections to the power sources were soldered to the board. On the back side of the board, the appropriate rows were soldered together to create the connections defined by the final circuit schematic (**Fig. X)**. **Fig. x** shows the top and bottom face of the solder board.

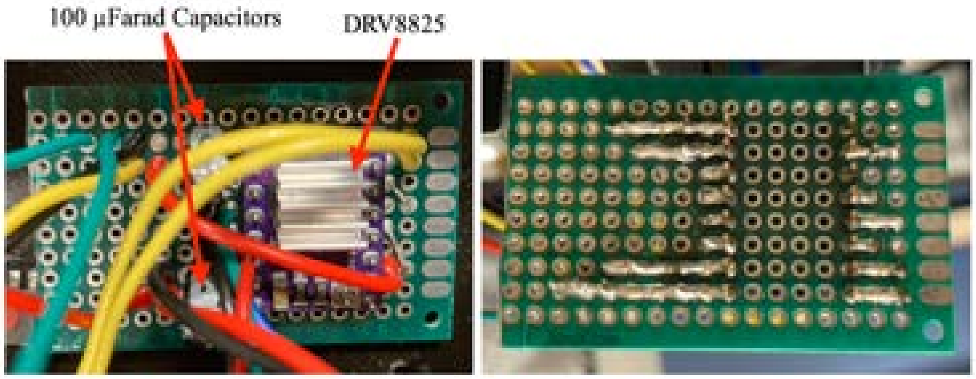


Figure X. Solder board. The image on the left shows the top face of the solder board populated with the DRV8825, two 100 µFarad capacitors, and wire connections. The image on the right shows the bottom face of the solder board with the ties for each row of connections.

The remaining connections from the solder board (digital pin connections D8, D9; ground; Vin; and +5V) and limit switches (digital pin connections D10, D11, D12) were plugged into the Arduino Uno. The GND and Vin wires from the solder board were also screwed into the terminals on the +12V power supply connector. **Fig. X** illustrates these connections according to the final circuit schematic (**Fig. X)**.

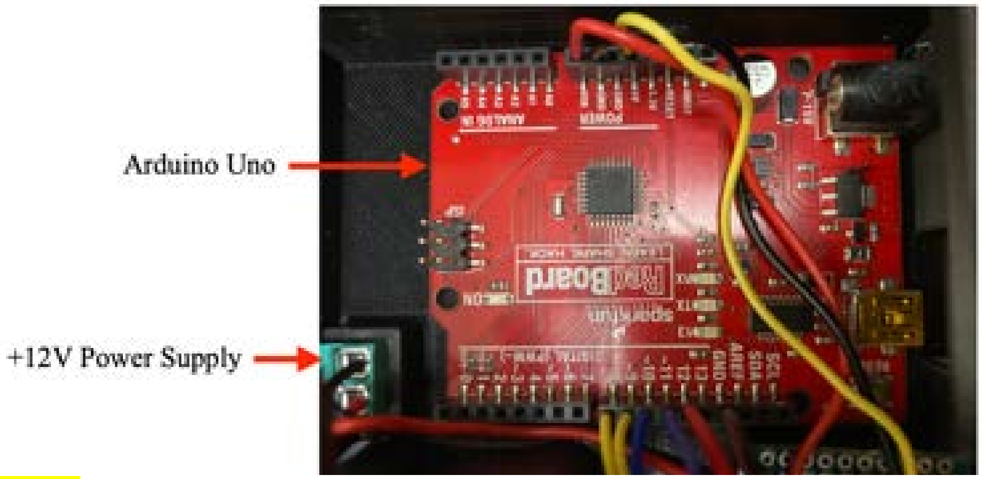


Figure X. Arduino Uno and +12V Power Supply Connections. This image shows the wires connecting to the Arduino Uno and +12V power supply.

At this point, the final code (**Appendix X**) was uploaded to the Arduino Uno. Within the void loop(), the code checks the state of the transition limit switch and the orientation of the console based on feedback from the three NO limit switches. If the console is not in the correct orientation, the void loop() will call either the rotateToStandard() or rotateToAdaptive() functions to rotate the console to the correct side so that the display faces the user. The speed of rotation is altered manually with the use of pulse width modulation (PWM). After uploading the code to the Arduino Uno and supplying the circuit with power using the +12V power supply, the current potentiometer on the DRV8825 was adjusted with a screwdriver such that the current was enough to rotate the motor but as low as possible to limit noise and vibration.

13DEC2022 Final Report

ANNABEL FRAKE - Dec 13, 2022, 2:29 PM CST

Title: 13DEC2022 Final Report

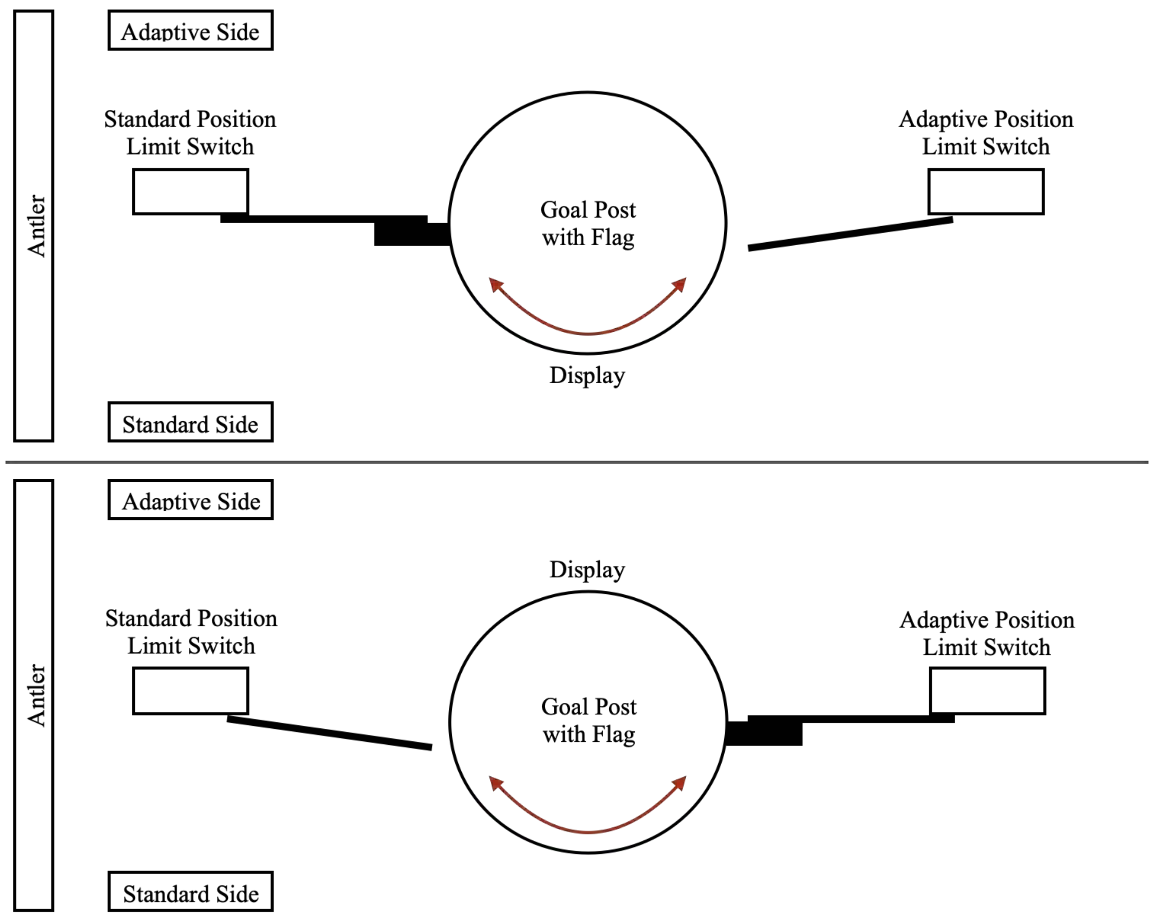
Date: 13DEC2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: edit formatting of report (final checks)

Content:

- I went through and fixed small formatting issues
- I realized that the one of my figures was inaccurate
  - It was from earlier on in the design process when we planned to put the limit switches on the standard and adaptive sides
  - but in reality, the limit switches were placed next to the antler and on the opposite side
  - I updated the figure
  - 

References: none

Conclusions:

Today, I looked over the final report one more time to ensure the formatting looked good. In the process of checking the formatting, I noticed that one of my figures needed to be updated.

Action items:

1. fill out peer evals

10SEP2022 Review of Spring 2022 Final Report

ANNABEL FRAKE - Sep 10, 2022, 4:32 PM CDT

Title: 10SEP2022 Review of Spring 2022 Final Report

Date: 10SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: read and comment on spring 2022 final report as part of onboarding process to the project

Content:

- most exercise machines in gyms not accessible to wheelchairs
- this project focuses on rowing machine
- adapted standard Matrix rowing machine
- in US, 5.5 million nee wheelchair for daily tasks
- current adaptions to workout machines adapted by consumer
- space also issue in gyms - maneuverability of wheelchair around space
- most adaptive products are 3rd party and void any warranty
- 2 common methods for rowers: 1. replace sliding seat with fixed one and 2. remove sliding rail
- both methods requires outside assistance
- Adaptive Rowing Machine (AROW) at British Columbia Institute for Technology
    - removes sliding rail
    - permanent transformations that don't allow for standard use
    - extensive fabrication and time
    - chest bar prohibits interaction with console
- market opening: convertible rowing machine that allows standard and wheelchair use
- client: Ms. Stacy Quam leads biomech lab at Johnson Health Tech
- wheelchair users require upper body strength
- common complaint among wheelchair athletes in shoulder pain
- 4 phases of rowing
    - catch phase: flex torso in forward motion
    - drive phase: pull handle towards abdomen
    - finish phase: final pull; abs / lower back stabilize and biceps help keep torso in place
    - recovery phase: return back to catch phase
- $200 budget
- most important design specifications are safety, stability, operation from wheelchair, simulate same muscle groups as 4 phases of rowing, seamless transition between standard and wheelchair use
- will last 10 yrs, withstand stresses up to 1050N

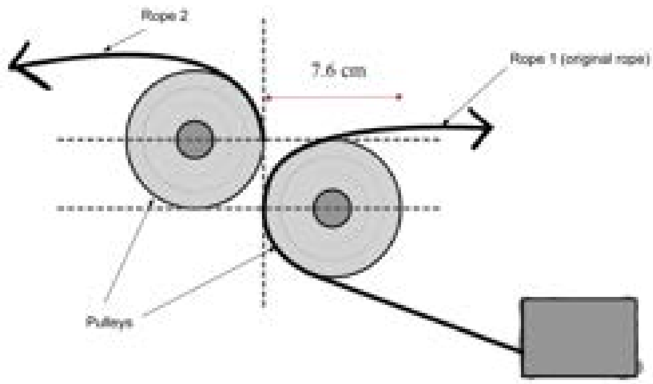
- viable for fitness centers with limited space
- users won't nee to reach more than 70 cm from wheelchair (average reach from shoulder to fingertip)
- max deformation: 1.5mm
- Prelim designs
    - Pulley design 1: 2 pulleys with slit
    - 

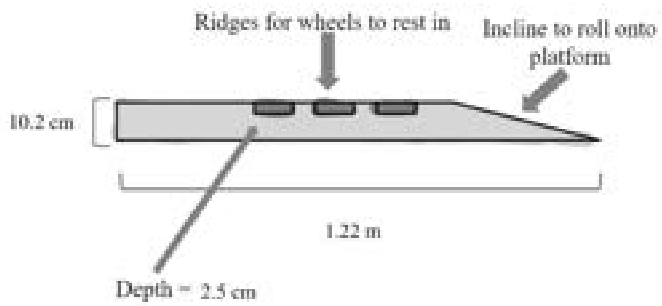
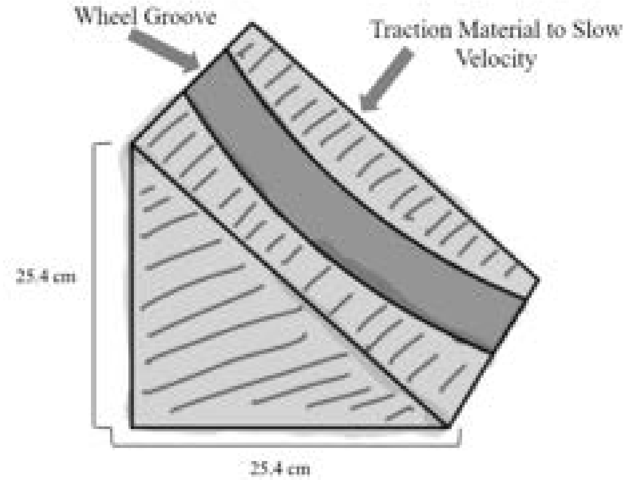
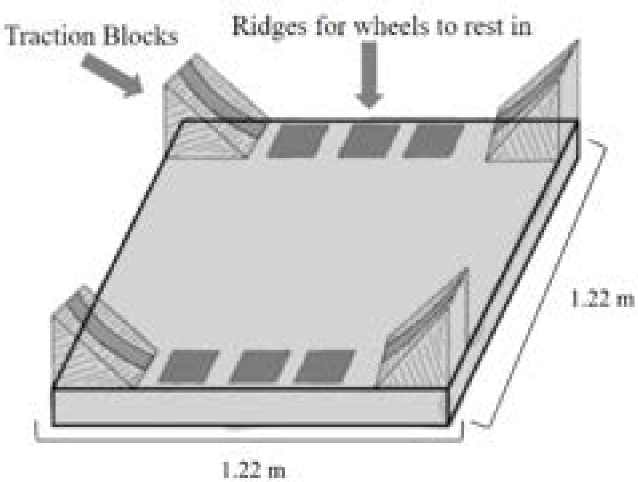
Figure 5. Visual Representation of 2 Pulleys with 2 Ropes. The 2 Pulleys with 2 Ropes design involves adding an additional pulley, handle, and rope to the existing rowing machine. The transitioning of the handle and rope from the standard side to the adaptive side would not be required since there would be a rope permanently positioned on both sides of the rowing machine.
    - Stability design 1: highway ridges
    - 

Figure 6. Visual Representation of the Highway Ridges Design. The platform has an incline down to the floor so that the user can roll up and into place on top of the platform. The base will have ridges cut into it for the wheels to rest in during the action of rowing to stabilize the wheelchair.
    - Stability design 2: traction blocks



- **Figure 7. Visual Representation of the Traction Blocks Design.** The block has a semicircle groove down the middle which allows for the user to experience slight recoil during the action of rowing. The user will roll up and into the block, which is covered in a traction-like material to reduce velocity, to prevent forward / backward tipping.
- Stability design 3: combined design



- **Figure 8. Visual Representation of the Combined Design.** The inclined platform with ridges is combined with 4 traction blocks to prevent translation / rotation of the wheelchair during the action of rowing.
- Common design: armrest hooks

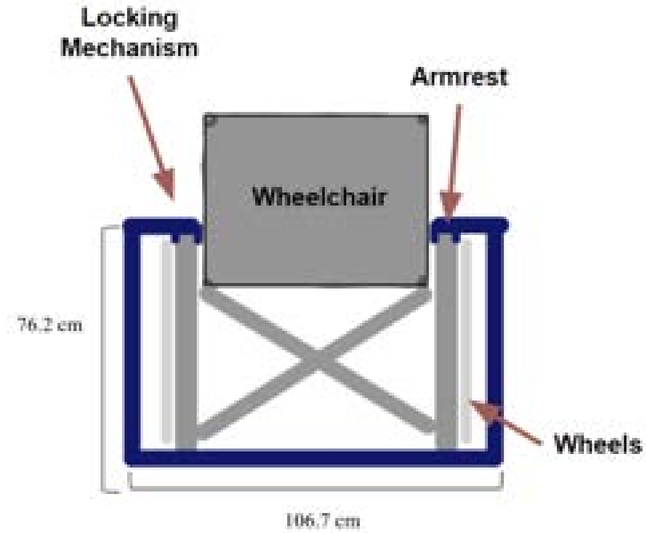


Figure 9. Visual Representation of the Armrest Hooks Design. The base platform will have two sideboards connected via a hinge that can swing up to be parallel with the wheels. Extendable hooks will reach out and grasp the armrests of the wheelchair to prevent side-to-side rotation during the action of rowing.

- I agree with the team's decision to pursue the 2 pulleys with slit concept, it seemed to be the simplest approach
- the team didn't end up using a stability design, this may be something we can explore this semester if this area of the design has room for improvement
- I am impressed by the 3D SolidWorks modeling, the design is functional and appears as if it were manufactured with the machine (except for the white color)
- The console design is interesting, but may be more complicated than necessary
    - I am not sure why there are 4 peg holes since the screen only needs to face 2 directions (adaptive vs not)
- I think that the wooden base could have been constructed to be more solid (ex: use 45 deg angle for cross braces)

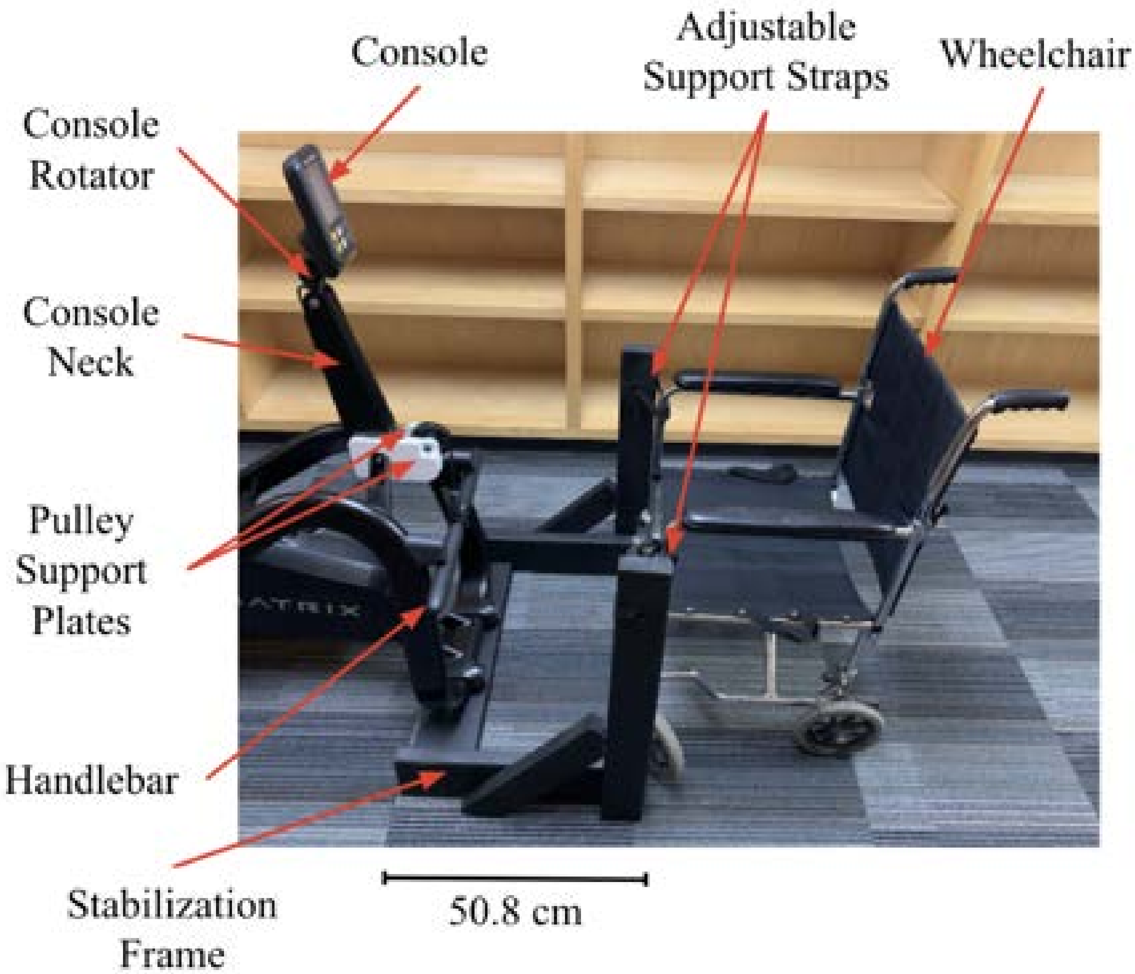


Figure 24. Full Assembly. The full assembly includes the pulley support plates, the console rotator, and the wooden support base. The wheelchair is locked into the support base using adjustable straps.

-
- Testing
  - SolidWorks simulation to analyze stresses and displacements from max (worst case) load
  - tension protocol to see if difficulty of resistance was same between two configurations
    - adapted side had a lower performance, could be something to address in the improvements (rope pulled less distance between can't lean back in wheel chair like you can on the standard side and can't use legs)
    - spring gauge altered natural rowing motion
  - Kinovea Protocol to measure displacement of wooden frame
    - the wooden frame did not hold the wheelchair entirely secure, there was displacement of the wheelchair (PDS calls for 0 displacement)
    - can potentially improve stability of design
  - Survey for usability
    - Who were the people in the survey? Were they from the rowing team?
    - some said that rowing on adaptive side was more taxing, might be because they had to refrain from using their legs
    - could have easier transition and comfort
- Improvements:

- adjustability for different wheelchairs
- sand slit to remove sharp edges that could harm (and abrasions to rope)
- construct pulley, support plates, console rotation mechanism, and support base from steel
- additional support for stability
- chest support to prevent slipping from wheelchair
- mechanism to remove tension in rope while transitioning
- handle bar on adaptive side
- mechanism to allow for adjustment of resistance level from adaptive side
- use EMG in testing to ensure legs not used
- attach spring gauge directly to rowing handlebar to more accurately replicate rowing motion

- Potential Sources of Error:
  - spring gauge altered natural rowing motion, user deviating from baseline stroke, and participant unintentionally using legs in tension testing
  - breaks on wheelchair used in testing worn out

References: see attached pdf

J. Andreatta et al., "Adaptive Rowing Machine Final Report," Technical Report, College of Eng., University of Wisconsin, Madison, May 2022. [Online]. Available: https://bmedesign.engr.wisc.edu/projects/s22/adaptive_rower

Conclusions:

Josh, Sam, and Tim worked on the Adaptive Rowing Machine project last semester, but Roxi and I are new. Therefore, I am reviewing the important documents from last semester as a form of onboarding myself to the project. I had read the report before project selection when my team considered writing a proposal for this project, but I skimmed the document again today and jotted down some important notes. I now understand the motive for the project and the gap in the market for convertible rowing machines (between standard and adaptive configurations). I am also aware of the four phases of rowing that this project is trying to replicate for wheelchair users to the best of their ability. I agree with the previous team's decision to pursue the 2 pulley with slit preliminary design idea. The team did not implement any of their preliminary designs for stability, and based on the deformation results from final design testing, we may want to revisit that topic this semester. The console rotation mechanism is nifty, but could potentially be simplified or made more secure. I think that the team did a wonderful job writing the report and completing the testing. There are definitely improvements that can be made to the design, and they have highlighted those in their future work section. I am excited by the work ahead of us and how I will be able to contribute to these improvements.

Action items:

- continue to review spring 2022 materials
- read research articles related to the topic
- brainstorm how to implement improvements

ANNABEL FRAKE - Sep 10, 2022, 1:22 PM CDT


Adaptive Rowing Machine

Final Report

Download

Adaptive_Rowing_Machine-Final_Report.pdf (15.6 MB)

10SEP2022 Review of Spring 2022 Final Poster

ANNABEL FRAKE - Sep 10, 2022, 4:31 PM CDT

Title: 10SEP2022 Review of Spring 2022 Final Poster

Date: 10SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: read and comment on spring 2022 final poster as part of onboarding process to the project

Content:

See attached pdf and conclusion

References: see attached pdf

J. Andreatta, et al., 'Johnson Health Tech: Adaptive Indoor Rower for Wheelchair Users', University of Wisconsin Madison, 2022.

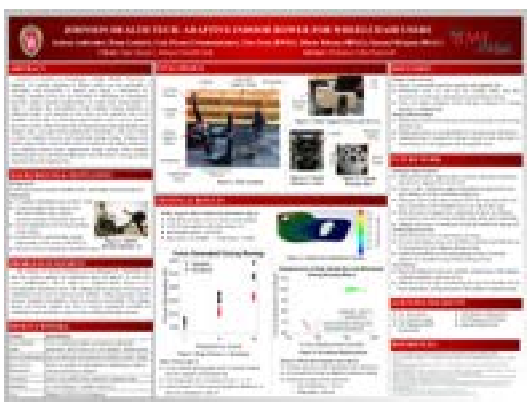
Conclusions:

The information on the poster is the same as that provided in the report (naturally), so there was not a lot of new information to learn. I think that the layout of the poster made sense; however, it many have been helpful to provide an image showcasing the difference between the standard and adaptive configurations of the rower. This would allow an audience to more easily understand the changes that were implemented and the associated challenges. There may not be enough space on the poster for this suggestion, and it may be easier to show in person during a presentation, but it may still be something to consider for the upcoming semester.

Action items:

- continue to review spring 2022 materials
- read research articles related to the topic
- brainstorm how to implement improvements

ANNABEL FRAKE - Sep 10, 2022, 2:43 PM CDT



Download

Adaptive_Rowing_Machine-Final_Presentation.pdf (2.03 MB)

10SEP2022 Review of Spring 2022 Executive Summary

ANNABEL FRAKE - Sep 10, 2022, 4:03 PM CDT

Title: 10SEP2022 Review of Spring 2022 Executive Summary

Date: 10SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: read and comment on spring 2022 executive summary as part of onboarding process to the project

Content:

- rowers combine cardio and strength training
- Fitness centers have limited space, so not feasible to have standard and adapted machines, better to combine functionality

References: see attached pdf

Conclusions:

I studied abroad during BME 301, so I have not completed a project that requires an executive summery. It was interesting to see how the previous team created one and what information they deemed the most important. I did learn a few new things from the summery. Specifically, that rowers combine cardio and strength training and that fitness centers are reluctant to implement standard and adaptive machines due to space limitations. It makes more sense now why combined machines are such attractive options.

Action items:

- continue to review spring 2022 materials
- read research articles related to the topic
- brainstorm how to implement improvements

ANNABEL FRAKE - Sep 10, 2022, 4:00 PM CDT

Download

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

10SEP2022 Review of Spring 2022 Final PDS

ANNABEL FRAKE - Sep 10, 2022, 4:29 PM CDT

Title: 10SEP2022 Review of Spring 2022 Final PDS

Date: 10SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: read and comment on spring 2022 final PDS as part of onboarding process to the project

Content:

- wheelchairs needed for physical disabilities or injuries to brain, spinal cord, or lower extremities
- client requirements:
  1. magnetic rowing machine built to better understand functionality
  2. wheelchair users must be able to fit into machine and use it properly
  3. wheelchair users would ideally be able to use device without assistance
  4. user friendly and not overly complex
  5. will be used several times a day, will not degrade over short period of time
  6. mechanism to reduce excessive recoil force to prevent users from tipping backwards
  7. user will remain in wheelchair for entire exercise
- Important design requirements of note
  1. stability to prevent backwards tipping
  2. resist and endure stresses caused by pulling force of up to 1050N
  3. should accurately simulate feeling of normal rowing machine
  4. life in service: 10 yrs or at least 8 million meters
  5. safe locking system to ensure wheelchair doesn't move during use
  6. support user's body
  7. max external loads applied will be limited to 158.76kg
  8. storage temp range: -20degC to 45degC
  9. shelf life: 30 yrs
  10. operating temp range: 5degC to 35degC
  11. no large water sources around device to prevent damage to LCD display, etc.
  12. additions will not extend farther than 1.6067m from the dimensions of the current device
  13. users will not need to reach farther than 70cm front front of wheelchair to grab handlebar
  14. max of 7kg will be added to existing rower
- Production Characteristics:
  1. 1 rower modified
  2. budget: $200

References: see attached pdf

Conclusions:

I read through the previous semester's PDS document, and we will need to update it for the upcoming semester. The concept of a convertible rowing machine that allows for standard and adaptive use is listed as an ideal criteria, but not a requirement. Now that the current design actually operates in this fashion, it would be prudent to update the PDS to match that. We would also want to include information regarding the improvements we plan on making, such as the mechanism that removes tension in the rope for easier transitioning between configurations of the device. There are also requirements referencing a locking system for the wheelchair and straps to secure the user. Last semester, the team used the locking mechanism of the wheelchair itself to prevent movement, but displacement of the wheelchair still occurred during testing. Therefore, it may be worthwhile to reconsider the stability of the device, as well as stability of the user. We plan to meet with the client in the upcoming weeks, so we can update the PDS after we speak with her about design improvements.

Action items:

- continue to review spring 2022 materials
- read research articles related to the topic
- brainstorm how to implement improvements

ANNABEL FRAKE - Sep 10, 2022, 4:06 PM CDT

Johnson Healthtech: Adaptive Indoor Rower for Wheelchair Users

[Download](#)

PDS__Johnson_Healthtech__Adaptive_Indoor_Rower_for_Wheelchair_Users_.pdf (7.06 MB)

10SEP2022 Review of Spring 2022 Preliminary Report

ANNABEL FRAKE - Sep 10, 2022, 4:47 PM CDT

Title: 10SEP2022 Review of Spring 2022 Preliminary Report

Date: 10SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: read and comment on spring 2022 prelim report as part of onboarding process to the project

Content:

see attached pdf and conclusion

References: see attached pdf

J. Andreatta et al., "Adaptive Rowing Machine Preliminary Report," Technical Report, College of Eng., University of Wisconsin, Madison, 2022. [Online]. Available: https://bmedesign.engr.wisc.edu/projects/s22/adaptive_rower

Conclusions:

I skimmed the preliminary report because the majority of the sections were identical to those in the final report. I did not gain any knowledge from this report that I did not already know based on reading the final project materials, but I figured it was worth reviewing in case the preliminary design ideas were discussed in more depth here. The team discarded their stability design for the final prototype because they deemed the wooden support mechanism to be sufficient. After testing, they saw that displacement of the wheelchair did occur (ideally none would), so it may be worth revisiting these preliminary designs for stability in the upcoming semester.

Action items:

- continue to review spring 2022 materials
- read research articles related to the topic
- brainstorm how to implement improvements

ANNABEL FRAKE - Sep 10, 2022, 4:06 PM CDT


Adaptive Rowing Machine

Download

Prelim_Report.pdf (7.02 MB)

10SEP2022 Review of Spring 2022 Preliminary Presentation

ANNABEL FRAKE - Sep 10, 2022, 4:55 PM CDT

Title: 10SEP2022 Review of Spring 2022 Preliminary Presentation

Date: 10SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: read and comment on spring 2022 prelim presentation as part of onboarding process to the project

Content:

References: see attached pdf

J. Andreatta, et al., 'Adaptive Rowing Machine Preliminary Presentation', University of Wisconsin Madison, 2022.

Conclusions:

I did not learn any new information by reviewing the preliminary presentation because I have already looked at all of the major documents from last semester. However, it was helpful because the presentation included images of the rower before adaptation. This helped me fully appreciate the design changes that occurred last semester and how the adaptive rower differs from the original machine. I was extremely pleased to come across those images.

Action items:

- read research articles related to the topic
- brainstorm how to implement improvements

ANNABEL FRAKE - Sep 10, 2022, 4:06 PM CDT

Download

Preliminary_Presentation.pdf (3.4 MB)

11SEP2022 "Muscles Used on a Rowing Machine"

ANNABEL FRAKE - Sep 11, 2022, 2:25 PM CDT

Title: 11SEP2022 "Muscles Used on a Rowing Machine"

Date: 11SEP2022

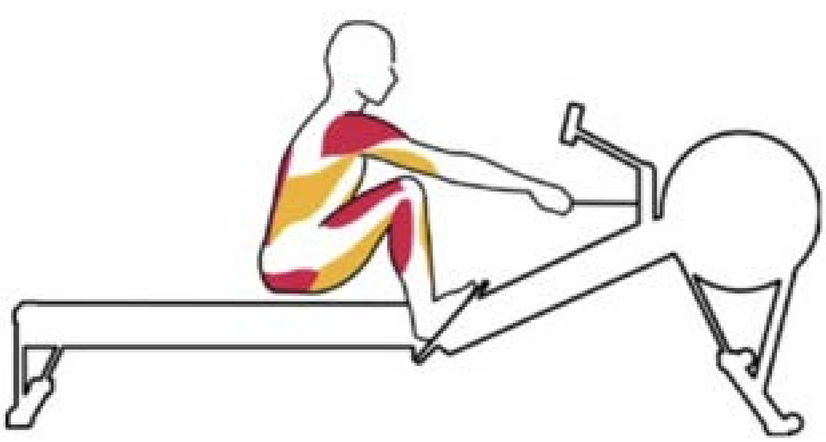
Content by: Annabel Frake

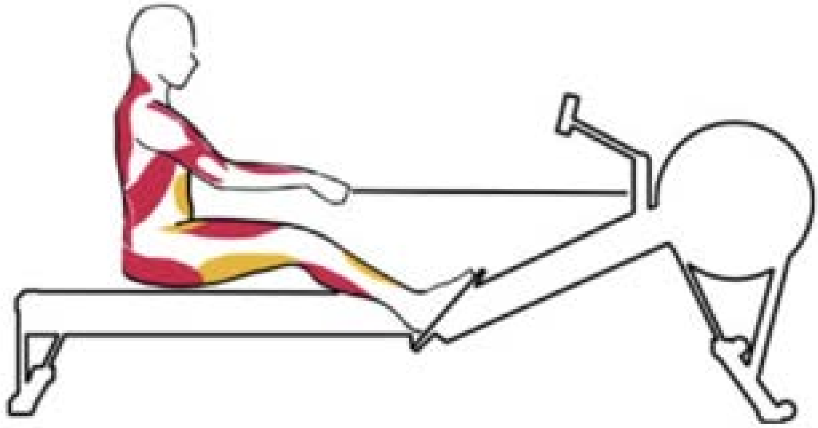
Present: Annabel Frake

Goals: learn about the four phases of rowing

Content:

- rowing involves every large muscle group in body
- 4 phases of rowing

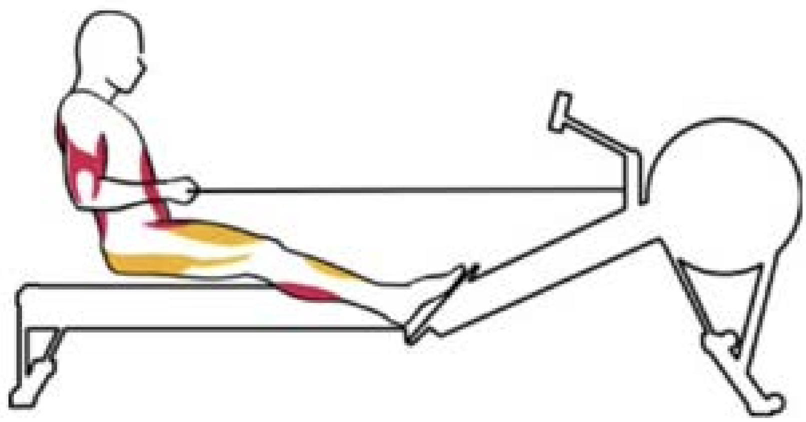
  1. The Catch
     - legs compressed
     - shins vertical
     - triceps extend arms
     - flexor muscles of fingers and thumbs grab handle
     - back muscles relaxed
     - abdominals flex torso forward
     - 
  2. The Drive
     - initiated by leg muscles
     - shoulder muscles contract
     - biceps pull handle toward abdomen
     - back muscles work as swing torso open
     - glutes and hamstrings contract to extend hip
     - finish with arm pull-through, engaging nearly all muscles in upper body



-

3. The Finish

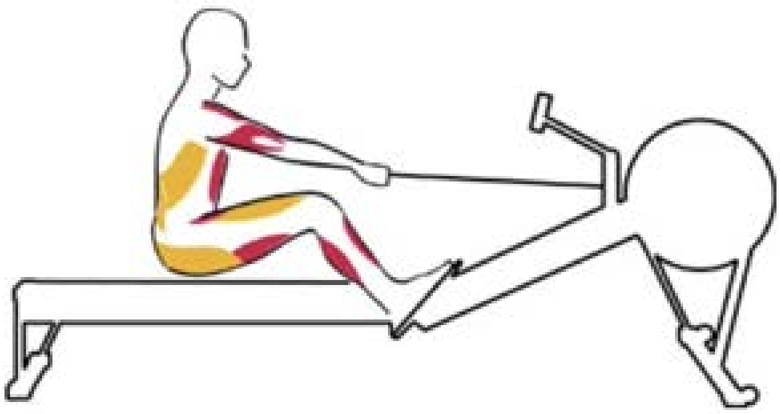
    - abdominals stabilize body
    - glutes and quads contract
    - biceps and many of back muscles contract to keep torso in finish position and to internally rotate upper arms



-

4. The Recovery

    - triceps push arms forward and away from body
    - abdominals flex torso forward
    - hamstrings and calves contract as slide into catch phase



References:

David, “Muscles used,” *Concept2*, 26-Jul-2021. [Online]. Available: https://www.concept2.com/indoor-rowers/training/muscles-used. [Accessed: 11-Sep-2022].

Conclusions:

I found this reference in the final report from the previous design semester and decided to read it in order to gain a better understanding of the physical requirements of rowing. There are four key phases: the catch, the drive, the finish, and the recovery. The muscles used in each phase are highlighted above. This is a useful reference because we need to understand how a rower moves during a workout so that we can replicate that on the adaptive side of the rowing machine provided to us. A user in a wheelchair will not be able to use their leg muscles or lean back in their wheelchair during the finish phase, so we cannot replicate the movements exactly, but they should be as close as possible to ensure a similar workout is achieved. We could potentially discuss ways to improve the caliber of the workout from the adaptive side for the upcoming year, but that will depend on the enhancements the client would like us to make.

Action items:

1. continue to research rowing, gym equipment for wheelchair users, standards, and competing designs

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ANNABEL FRAKE - Sep 11, 2022, 1:49 PM CDT

Download

_Muscles_used_on_a_rowing_machine_.pdf (581 kB)

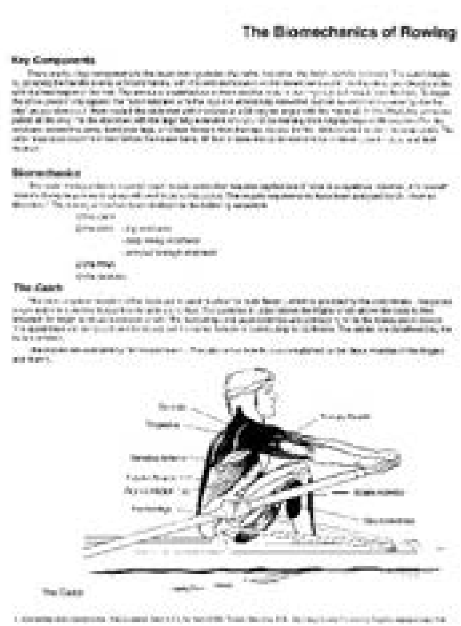
ANNABEL FRAKE - Sep 12, 2022, 9:40 AM CDT

I started using Zotero for InterEGR397 and decided to use it for this class as well to keep things consistent.

Updated reference using Zotero:

“Muscles used on a rowing machine,” *Concept 2*. https://www.concept2.com/indoor-rowers/training/muscles-used (accessed Sep. 12, 2022).

ANNABEL FRAKE - Sep 11, 2022, 2:10 PM CDT


The Biomechanics of Rowing

Key Components

Biomechanics

The Catch

Download

Training_MusclesUsed_Biomechanics_of_Rowing.pdf (446 kB)

12SEP2022 "Wheelchair and Power Mobility for Adults"

ANNABEL FRAKE - Sep 12, 2022, 10:38 AM CDT

Title: 12SEP2022 "Wheelchair and Power Mobility for Adults"

Date: 12SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: learn more about mobility for adults in wheelchairs

Content:

- "An estimated 5.5 million people, or 2.3% of the United States adult population, uses a wheelchair for mobility" (para. 1).
- aged over 65 are 4 times more likely to use wheelchair
- independent mobility important for work, education, daily activities
- if no independent mobility, more likely to develop secondary health complications from delayed healthcare and be financially dependent on someone else
- multidisciplinary wheelchair assessment team to prescribe right wheelchair for patient
    - patient, rehabilitation engineer, occupational therapist, physical therapist, rehabilitation technology supplier, rehabilitation physician
- Types of wheelchairs
    1. Manual Wheelchair
        - propelled by user or attendant
        - if propelled by user, must have good upper body function and stamina
        - lighter in weight
        - easier to transport without additional equipment
        - less maintenance than other kinds
        - classes: standard to extra-heavy duty (Bariatric)
    2. Power Wheelchair
        - for those who cannot manually propel
        - need to have cognitive ability and coordination to manipulate machine
        - may be: patients with upper limb weakness, cardiopulmonary disease, poor trunk stability, upper limb pain, limited endurance, obesity
        - power-assist manual wheelchairs: motors mounted to wheel hub or add-on's to wheel/axle
            - requires less upper limb strength
            - need battery system, which increases weight and makes transportation more difficult
            - Ex: Xtender, E-motion, SmartDrive, Twion
        - power scooters: 3-4 wheels, captain style seat with tiller for steering
            - need ability to independently transfer device, good trunk control, good upper limb function
            - lighter in weight, less costly, easier to transport than power wheelchair

            - larger turning radius makes indoor maneuverability difficult
            - ex: Spitfire Scout, Pride Travel, Pride Maxima
        - power wheelchair: for tetraplegia, poor upper limb coordination, or severe range of motion restrictions
            - joystick, touch-pad, head control, sip and puff
            - proportional control = pressure matches speed
            - non-proportional control = speed can't be controlled
            - ex: Electra, Air Hawk, Hoveround
            - Group 1
                - basic configuration / seating
                - no special seating or controls
                - no power seating
            - Group 2
                - folding and transport
            - Group 3
                - Combination indoor-outdoor power wheelchairs
            - Group 4
                - all-terrain
            - Group 5
                - designed for pediatric use
                - usually single power option
- temporarily disabled may benefit from rental chair
- chronic probably want a tailored one for their body type and functional needs
- Personalized fit
    - frame type/composition: rigid vs fold
    - adjustable rear axle: horizontal vs vertical
        - axles more posterior are more stable, but less maneuverable
        - axles more anterior are tippy, but have better positioning for wheel propulsion and tighter turns
    - rear wheel camber: angles rear wheel is tilted toward chair
        - allow stability, but are wider and may not fit through standard doorway
    - caster tires: smaller wheels in front (smaller = more likely to get stuck in crack)
    - seat: width, depth, and dumps adjustment (angle seat goes back)
    - seat cushion: foam vs gel vs saddle vs wedge vs sling
    - armrests: length, height, fixed vs removable, flat vs tubular
    - footrests: fixed vs elevated vs swing-away
    - front-rigging for stability of feet
    - adductor and abductor pads for positioning
    - wheels: mag vs spoke vs composite material
    - tires: pneumatic vs polyurethane, tread differences
    - hand rim: chrome vs aluminum vs composite vs foam covered; shape, diameter, and spacing differences
    - back support: sling vs solid vs cushion; height ranges
    - anti-tippers
    - wheel locks

  - headrests
  - optional postural supports
  - pelvic belts
  - power wheelchair - front-wheel (stable for uneven terrain), mid-wheel (turns in place, increases indoor maneuverability), rear-wheel (predictable handling and high speed)
  - power input device: joystick vs breath control vs head array vs switches
  - seat functions: recline, tilt-in-space, seat elevators, standing, elevating leg rests

- What is wanted for seating and mobility: postural support, max function and mobility, safety, skin integrity and skeletal alignment with correct pressure relief, match lifestyle of consumer, aesthetics
- incorrectly prescribed wheelchairs can lead to postural deformities or pressure ulcers
- the following may interfere with use of a wheelchair / require alterations: cognitive deficits, spasticity or movement disorders, vision or hearing deficits, spatial neglect, obesity, malnutrition
- prior to getting wheelchair, undergo pelvis and hip posture exam
- Contraindication for manual wheelchairs
  - can't use arms for propulsion because of decreased ROM (range of motion), strength, coordination
  - need for features used independently by user (power tilt, recline, seat elevation)
  - cardiopulmonary impariments
- Contraindications for power mobility:
  - visual deficits
  - poor motor coordination
  - uncontrolled seizures within last 6 months
  - imaged cognition / judgement
- Things to consider when considering a wheelchair prescription:
  - ability to move
  - history of falls
  - activities wheelchair is proposed to help
  - living environment
- Things to consider when prescribing wheelchair:
  - diagnosis / prognosis
  - static / progressive condition
  - age
  - cognitive function
  - physical ability
  - transfer ability
  - mental preparedness
  - body weight
  - leisure interest
  - environment it will be used in
  - time spent in wheelchair daily
  - level of independence for daily living
  - transportation outside home
  - insurance coverage
  - medical issues (incontinence, skin breakdown, spasticity, etc.)
  - catheter requirements
  - paralysis and paresis
  - sensory issues
- Dimension suggestions:
  - generally 90 deg angles at knees, hips, elbows, but not guaranteed
  - seat width: widest point of hips, buttocks, or thighs and then add 1-2 inches
  - seat depth: length from posterior buttocks to popliteal fossa and then subtract 2 inches
  - seat footrest height: popliteal fossa to bottom of foot and then add 2-4 inches for height off the ground

- footrest length: 1-2 inches above floor
- height of back: bottom of buttocks to shoulders or bottom of scapula (depends on propulsion method intentions)
- armrest height: elbow-to buttocks
- armrest length: consider height to desk or table

- Effects/injuries if improper fit:
  - pressure ulcers if inadequate cushioning
  - improper seat back leads to trunk instability and poor posture
  - unstable tipping leads to injury
  - improper position of push rims leads to upper extremity injuries
  - inadequate trunk support can cause pain, pressure ulcers, deformity
- overuse injuries of upper body common - should pain and injury
- wheelchair skills training programs help with overuse
- wheelchairs need repairs frequently
- insurance companies often require detailed letter of necessity
  - often limit replacement to 5 yrs, so patients with progressive disease will have to consider which option is best

References:

J. Roberts, J. Tram, and H. Azizi, "Wheelchair and Power Mobility for Adults," *PM&R KnowledgeNow*, Oct. 13, 2021. https://now.aapmr.org/wheelchair-and-power-mobility/ (accessed Sep. 12, 2022).

Conclusions:

This article is listed in the references of the final report from last semester, so I thought it prudent to review the material it contains. This article is extremely helpful and offered more varied information about wheelchairs than I anticipated. It covered different types of wheelchairs, as well as the reasons someone may or may not be suited for a particular sort of wheelchair. It also listed the options and add-ons for personalization of a wheelchair. Health professionals must consider a plethora of information when considering prescribing a wheelchair and recommending a certain prescription, such as cognitive function, mobility, environment, etc. The recommended sizing of wheelchairs was also listed, which will be particularly important for us to know when altering the current design to be adjustable for different wheelchair sizes. It appears that every wheelchair can be different, so we will want to make the adjustability of our device continuous instead of discrete. Lastly, the article touched on insurance issues related to wheelchairs and potential health issues caused by overuse.

Action items:

1. continue to review research articles used in the final report from last semester

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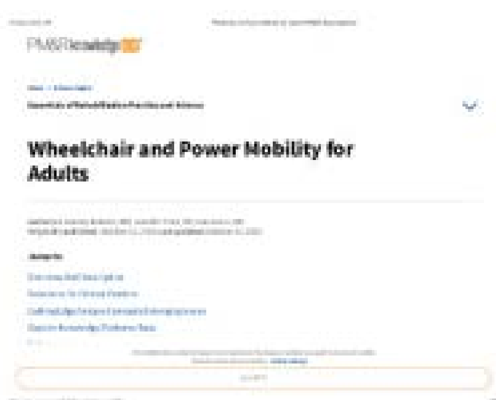
ANNABEL FRAKE - Sep 12, 2022, 10:32 AM CDT



Wheelchair and Power Mobility for Adults

Download

Wheelchair_and_Power_Mobility_for_Adults.pdf (462 kB)

18SEP2022 "Physical Activity Participation Among Persons with Disabilities"

ANNABEL FRAKE - Sep 18, 2022, 7:00 PM CDT

Title: 18SEP2022 "Physical Activity Participation Among Persons with Disabilities"

Date: 18SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: learn more about the limitations of persons with diasbilities in regard to physical exercise

Content:

- this source may be outdated, but it is cited on the final report, so I decided to read it
- "The following themes were identified: (1) barriers and facilitators related to the built and natural environment; (2) economic issues; (3) emotional and psychological barriers; (4) equipment barriers; (5) barriers related to the use and interpretation of guidelines, codes, regulations, and laws; (6) information-related barriers; (7) professional knowledge, education, and training issues; (8) perceptions and attitudes of persons who are not disabled, including professionals; (9) policies and procedures both at the facility and community level; and (10) availability of resources" (p. 419).
- benefits to physical activity for health and functioning of people with disabilities
- less people exercise who have disabilities compared to percentage that don't exercise and don't have disability
- physical activity improves well-being and helps prevent/delay chronic disease
- unknown why people with disabilities exercise less
- published literature on the topic is limited
- accessibility in public spaces has limited engagement of people with disabilities historically
- "One study on access to environmental settings among adult wheelchair us- ers, including recreational and leisure facilities, re- ported that many people who use wheelchairs were unable to gain access to these facilities because of such barriers as bad weather or climate, no curb cuts or blocked curb cuts, limited strength or fitness, inacces- sible doors and bathrooms, no parking, poor travel surfaces, obstructed travel, personal illness, no ramps or ramps too steep, and wheelchair problems.[15]" (p. 419).
- Title III of Americans with Disabilities Act (ADA) addresses these issues
- law passed in 1990
- accessibility of recreation and fitness facilities still barrier for those with disabilities
- limited research done on topic, need to complete it to update policies, etc.
- 10 major barriers identified in study:
    1. built and natural environment
        - "This included lack of curb cuts, inaccessible access routes, doorways being too narrow for wheelchair access, facility front desk being too high for persons in wheelchairs to communicate with the person at the desk, and lack of elevators" (p. 421).
        - "These included provid- ing nonslip mats in locker rooms; providing an ade- quate number of accessible parking spaces; installing push-button operated doors; constructing multilevel front desks that can accommodate both wheelchair users and nonwheelchair users; lowering or removing door thresholds to facilitate wheelchair access; provid- ing ramp access to whirlpools and hot tubs; and in new construction, building zero-depth entry pools that can be entered by a person using a wheelchair without the need for a ramp or pool lift. One of the most frequently mentioned facilitators was to provide family changing rooms, which would make it easier for parents to help their children with disabilities with changing, or in situations where a person with a disability needs assis- tance dressing and undressing usually by another family member or a personal assistant" (p. 421).

2. cost/economic
   - budget limited for small places and rural areas
   - more concerned with "bottom line"
   - profit > accessibility mentality
   - more costly to adapt existing facility to be inclusive than to do it at the onset
   - expected to pay same fee as those without disabilities even though can't access whole facility
3. equipment
   - "Members of the consumer and fitness/recre- ation professional groups identified three main equip- ment-related barriers: not enough space between equipment for wheelchair access, poor equipment maintenance, and lack of adaptive and/or accessible equipment" (p. 422).
4. guidelines, codes, regulations, and laws
   - some thought designing accessibility limited architect ceativity
   - some thought ADA provided the min requirements and few are likely to improve upon those requirements to make things better
   - ADA often not enforced
5. information
   - lack of info available
   - professional facility staff not knowledgable about disabilities
   - don't know how to go about adapting equipment, etc.
6. emotional/psychological
   - negative attitude towards those with disabilities
   - self-consciousness
   - "Fitness and recreation professionals noted that feel- ing self-conscious in a fitness facility, lack of support from friends and family, perception of facility as un- friendly, fear of the unknown, and fear of failure were major emotional/psychological barriers experienced by persons with disabilities" (p. 423).
   - family members may be overprotective
7. knowledge, education, and training
   - view accessibility as inconvenience / necessary evil
   - concerns about liability and injury
8. perceptions and attitudes
   - lacking in policies relevant to persons with disabilities
   - don't have designated staff that is responsible for accessibility issues
   - not allowing service animals or making assistants pay for entry
   - don't have maintenance plan for accessibility
9. policies and procedures
   - lack of transportation and accessible facilities
   - especially in rural areas
   - could pool money between several communities and then make a central facility?

10. resources availability

References:

J. H. Rimmer, B. Riley, E. Wang, A. Rauworth, and J. Jurkowski, “Physical activity participation among persons with disabilities: barriers and facilitators,” *Am J Prev Med*, vol. 26, no. 5, pp. 419–425, Jun. 2004, doi: 10.1016/j.amepre.2004.02.002.

Conclusions:

This article is cited in the final report from last semester, so I decided to read it as well. Because it was published in 2004, it may be outdated. The article addresses the need to research accessibility issues for persons with disabilities that would like to partake in physical exercise. They conducted an initial study of the barriers to accessibility and identified the following: built and natural environment; cost/economic; equipment; guidelines, codes, regulations, and laws; information; emotional/psychological; knowledge, education, and training; perceptions and attitudes; policies and procedures; and resources availability. The article outlines the issues from the perspective of the disabled, professionals in the field of fitness, architects, and city planners/park managers. The authors also suggest solutions to each of these barriers, but ultimately claim that more research needs to be conducted on the influence of these barriers on participation. Although there might be more recent data on this topic, this article is still useful in identifying concerns related to accessibility in fitness facilities. Our design project would target the equipment barrier, and may influence some of the other categories related to perceptions, emotions, etc.

Action items:

1. Continue to research background information related to the project and its design

ANNABEL FRAKE - Sep 18, 2022, 6:52 PM CDT

Physical Activity Participation Among Persons with Disabilities
Barriers and Facilitators

Download

Physical_Activity_Participation_Among_Persons_with_Disabilities.pdf (89.6 kB)

18SEP2022 AROW

ANNABEL FRAKE - Sep 18, 2022, 5:52 PM CDT

Title: 18SEP2022 AROW

Date: 18SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: learn about one of the competing design listed in the final report from last semester

Content:

- consult physician before starting exercise program
- if pain or difficulty, stop and consult doctor
- AROW with or without chest pad
- Option 1: Split rowing ergometer and use AROW
  - why use? most versatile
  - don't need to lengthen rowing chain or have space to position wheelchair behind ergometer
  - adapter stabilizes you as you row
  - chest pad or abdominal binder if need more stability than that or have neck strain
  - don't use chest pad if want to max torso movement
  - can row from regular chair too
  - stick/cane can adjust tension on ergometer
  - 

- 

- Option 3: rowing on fixed seat
  - why use? good option if willing to transfer to and from wheelchair
  - set up similar to how you row in a boat, so can fine tune positioning and/or practice stroke on dry land
  - 
- I watched the videos on the website that demonstrate people using the rowing machine in a wheelchair vs regular chair, with the chest pad vs without, and with the abdominal binder vs not. There is also a video of someone adjusting the tension using a cane.

References:

"Rowing Solutions – Adapted Rowing Machine (AROW)." https://adaptederg.commons.bcit.ca/rowing-solutions/ (accessed Sep. 18, 2022).

Conclusions:

The Adapted Rowing Machine (AROW) is designed specifically for wheelchair users. It has three different orientations. The first makes use of an adapter and chest pad to stabilize the user during throughout the rowing motion. The second configuration is an option for people without the ergonomic adapter; instead, they use an abdominal binder. Lastly, users can row from a standard chair instead of their wheelchair. This design is catered specifically to wheelchair users, and besides the need to adjust tension using a cane, the ergonomics of the device seem to work well. The major drawback of this product is the fact that it cannot also be used for standard rowing (with sliding seat, etc.). Therefore, there is still a gap in the market for a rower that can operate for a standard user, as well as wheelchair users.

Action items:

1. continue to research background information for this project
2. conduct a general search to see if any competing designs have emerged since last semester

ANNABEL FRAKE - Sep 18, 2022, 6:52 PM CDT

Download

Rowing_Solutions_Adapted_Rowing_Machine_AROW_.pdf (2.17 MB)

26SEP2022 Adapt2Row

ANNABEL FRAKE - Sep 26, 2022, 10:10 AM CDT

Title: 26SEP2022 Adapt2Row

Date: 26SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: search for adapted rowing machines not listed in the final report last semester (see if there is anything new)

Content:

- only ship to EU, have to contact www.Concept2.nl if outside the EU
- row directly from wheelchair
- rowing is full-body workout
- wheelchair users often can't sit on rower seat or is very difficult
- adapted Concept2 rowing machine
- no tools required to connect to Adapt2Row
- restoring original Concept2 can be done in 1 minute (by person not in wheelchair)
- they don't sell Concept2 rowing machines, you have to buy one and then pay for the adaption
- Concept2 not responsible or associated with 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

- 
- 
all functions remain the same
just drive your
wheelchair towards
the Adapt2Row
- 
-

- 

References:

"Adapt2Row: rowing on a Concept2 rowing machine from your wheelchair," *Gerofitness*. https://gerofitness.nl/export/406-adapt2row.html (accessed Sep. 26, 2022).

Conclusions:

I did a general web search for adaptable rowing machines and found the Adapt2Row, which is an add-on to the Concept2 rower exclusively. This company sells their product separate from Concept2 and only ships within the EU. Therefore, a user needs to buy a Concept2 Rower and then purchase the Adapt2Row device (shipped within the EU). The Adapt2Row allows a wheelchair user to row directly from their wheelchair. However, they cannot transition the rower to the adaptive state without assistance. This competing design allows both standard and adaptive use, but it requires outside assistance to set up and is only shipped within the EU. This makes it an unlikely option for wheelchair users in the US and an unattractive option for gyms because they would need to provide assistance when transitioning the rower.

Action items:

1. Continue to research background info for the project

ANNABEL FRAKE - Sep 26, 2022, 10:00 AM CDT

Download

rowing_on_a_Concept2_rowing_machine_from_your_wheelchair.pdf (3.3 MB)

14SEP2022 Matrix Rowing Machine

ANNABEL FRAKE - Sep 14, 2022, 10:15 AM CDT

Title: 14SEP2022 Matrix Rowing Machine

Date: 14SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: learn more about the rowing machine before it was adapted

Content:

https://www.matrixfitness.com/us/eng/group-training/cardio/rower

- there is a video on the site of people operating the rowing machine, which is helpful to see
- the rowing machine can be stored vertically
- cardio workout that exercises whole body
- "It includes: aluminum flywheel; 10 magnetic resistance settings; adjustable, backlit console; program quick keys; ergonomic seat with lock; comfortable, reinforced handle; reinforced aluminum rail; low-maintenance cord; and compact footprint that stands vertically and rolls for storage convenience" (para. 1).
- magnetic resistance system
- assembled dimensions: 87.6" x 21.5" x 38" or 223 x 55 x 97 cm
- whisper-quiet operation

https://www.matrixfitness.com/us/eng/group-training/cardio/rower/specifications

- Backlist LCD Display 3.5" x 2.5" screen
- display reads time, distance, SPM (strokes per minute), stroke, watts, heart rate, calories, 500 mtr/split
- programs: manual, interval, challenge
- has telemetric receiver
- drive system is coil spring poly-V belt
- max user weight: 158.76 kg or 350 lbs
- product weights: 59 kg or 130 lbs
- shipping weight: 69 kg or 152 lbs
- L x W x H: 223 x 55 x 58 cm / 87.6” x 21.5” x 22.8”
- power requirement: generated powered LCD display with Back-up memory battery
- warranty on the frame

References:

“Rower | Matrix Fitness - United States.” https://www.matrixfitness.com/us/eng/group-training/cardio/rower (accessed Sep. 14, 2022).

“Matrix Fitness - United States.” https://www.matrixfitness.com/us/eng/group-training/cardio/rower/specifications (accessed Sep. 14, 2022).

Conclusions:

Today, I looked at Johnson Health Tech's Matrix rowing machine webpage. The highlighted features are the LCD display, magnetic resistance system, aluminum flywheel, ergonomics, and ability to turn upright for easier storage. It was helpful to see images and videos of the rower in use before any adaptation since I was not on the previous design team for this project. It will allow me to bring a fresh perspective to the project instead of relying solely on the previous semester's design. An adjacent site to the first also included more specifications such as dimensions and weight. Attached to this entry are the Matrix sell sheet, Matrix Warranty and Service document, and pdfs of the two webpages discussed above. This is a useful source because it helps with defining product specifications, and I now understand where the previous team found certain information for the PDS, such as a max external load of 158.76 kg (Shelf Life i.).

Action items:

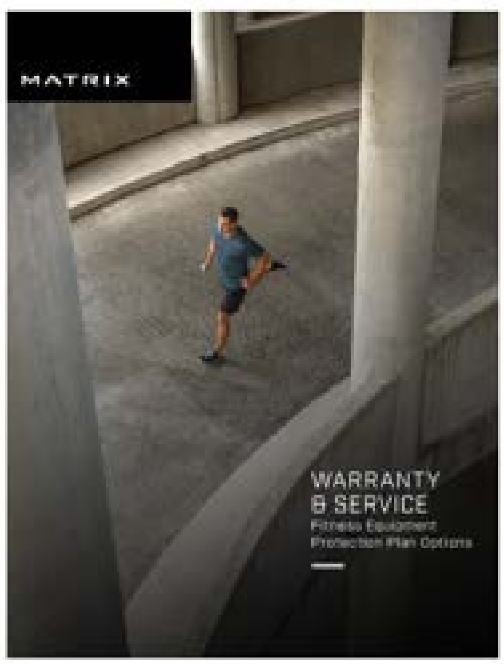
1. continue to review research articles used in the final report from last semester

ANNABEL FRAKE - Sep 14, 2022, 10:04 AM CDT

Download

Matrix_Sell_Sheet.pdf (212 kB)

ANNABEL FRAKE - Sep 14, 2022, 10:05 AM CDT



Download

Matrix_Warranty_and_Service.pdf (521 kB)

ANNABEL FRAKE - Sep 14, 2022, 10:00 AM CDT

Download

Rower___Matrix_Fitness_-_United_States.pdf (3.06 MB) The first reference above containing general information.

ANNABEL FRAKE - Sep 14, 2022, 10:00 AM CDT

Download

Matrix_Fitness_-_United_States.pdf (184 kB) The second reference above containing Matrix specifications.

15SEP2022 Linear Actuators

ANNABEL FRAKE - Sep 15, 2022, 6:35 PM CDT

Title: 15SEP2022 Linear Actuators

Date: 15SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: leverage previous research on linear actuators that may be useful for the tension removal mechanism for my current project

Content:

- please see entry titled "What’s the Difference Between Pneumatic, Hydraulic, and Electrical Actuators?" below

References:

C. Gonzalez, “What’s the Difference Between Pneumatic, Hydraulic, and Electrical Actuators?,” *Machine Design*, Apr. 16, 2015. https://www.machinedesign.com/mechanical-motion-systems/linear-motion/article/21832047/whats-the-difference-between-pneumatic-hydraulic-and-electrical-actuators (accessed Sep. 15, 2022).

Conclusions:

In one of my previous design projects, I researched linear actuators. I am leveraging that research for my current project and reapplying it to the tension removal mechanism. The electric linear actuator (not pneumatic or hydraulic) would be the best choice for our project. We need something that can generate slack in the rope by clamping onto it and then pulling x amount of distance. So far, the team has decided that the clamping should be mechanical for simplicity's sake (still up for debate, keep an open mind). A linear actuator would work well for moving the clamped section of the rope a certain distance and then returning to its home position. We would need to make sure that we purchase a linear actuator with a large enough stroke length and a high enough force rating.

Action items:

1. continue to brainstorm design ideas for the tension removal mechanism
2. look into specific linear actuators we could use with the proper stroke length and force rating

ANNABEL FRAKE - Sep 25, 2020, 12:11 PM CDT

Title: "What's the Difference Between Pneumatic, Hydraulic, and Electrical Actuators?"

Date: 9/12/2020

Content by: Annabel Frake

Present: Annabel Frake

Goals:

-learn about which linear actuator to use

Content:

1. Pneumatic Linear Actuators

    -piston in hollow cylinder

    -pressure from external compressor / manual pump

    -moves piston

    -as pressure inc, cylinder moves along axis

    -linear force

    -spring-back force or fluid to return to position

    -simple

    -Aluminum most max pressure rating 150 psi

        -1/2 to 8 in

        -30 to 7500 lb of force

    -Steel most max pressure rating 250 psi

        -1/2 to 14 in

        -50 to 38465 lb of force

    -precise linear motion

    -within 0.1 in, repeatably within 0/001 in

    -used in areas of extreme temp

    - neg 40 to 250 deg F

    -no magnetic interference

    -$50-150

    -lightweight

    -minimal maintenance

    -pressure losses and air's compressibility - less efficient

    -at lower pressures will have lower forces and slower

    -compressor must run continually

    -must be sized for specific job

    -air can be contaminated by oil, etc.

2. Hydraulic Linear Actuator

-similar to pneumatic

-incompressible liquid rather than air

-high force applications

-forces 25 times greater than pneumatic of equal cylinder size

-pressures up to 4000 psi

-high horsepower-to-weight ratio by 1 to 2 hp/lb greater than pneumatic

-can hold force

-can have pumps/motors distance away with minimal loss of power

-leak fluid

-loss of fluid = less efficient

    -less clean, potential damage

-require companion parts, fluid reservoir, motors, pumps release valves, heat exchangers, noise-reduction equipment

3. Electric Linear Actuator

-converts electrical energy into torque

-electric motor

-electric motor turns lead screw

-threaded lead or ball nut w/ corresponding threads of screw can't rotate with screw

-when screw rotates, nut drives along threads

-dir of nut depends on rotation of screw

-motor part of actuator and not separate

-highest precision

- +/- 0.000315 in

-repeatability 0.0000394 in

-large spacing requirements

-quiet, smooth

-repeatable

-scalable,

-can be programmed quickly

-encoders to control velocity, position, torque, applied force

-more expensive than other 2

-$150 to 2000

-not good for hazardous and flammable areas

-continuously running motor will overheat

-wear and tear of gears

-motor can be large

-set force, thrust, and speed limit - must be manually changed

References:

C. Gonzalez. (2015, April). *What's the Difference Between Pneumatic, Hydraulic, and Electrical Actuators?* [Online]. MachineDesign. Available: https://www.machinedesign.com/mechanical-motion-systems/linear-motion/article/21832047/whats-the-difference-between-pneumatic-hydraulic-and-electrical-actuators

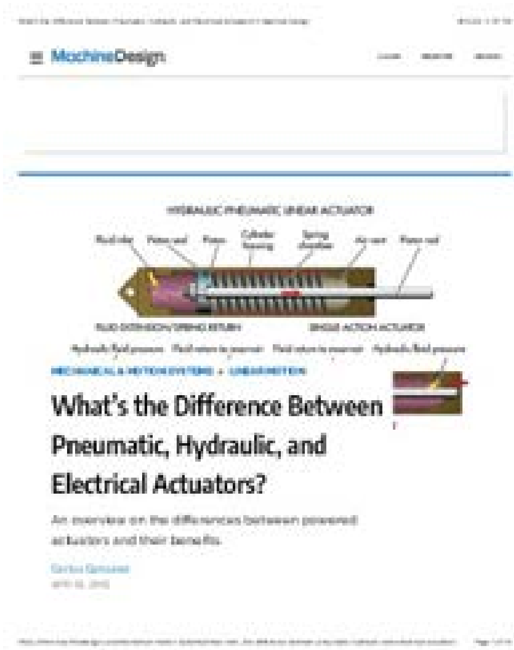
Conclusions:

This article covers the three types of linear actuators: pneumatic, hydraulic, and electric. I have used a linear actuator in the past to raise and lower an arm, so I thought they might be helpful for this project. Depending on the range of motion of our arm, we can use this to move the arm or to apply pressure to the patient. I believe that the electric version would be most helpful to us. In the past, I have used ones that extend 3-6 inches. This website seems to be for much larger applications, so I'm not sure if the prices and specifications apply to our size range. Linear actuators can be expensive, so it is worth looking into other options for motion. The main reason I considered them was their accuracy and their linear motion.

Action items:

-research more on different movement methods

ANNABEL FRAKE - Sep 12, 2020, 11:28 PM CDT


MachineDesign

What's the Difference Between Pneumatic, Hydraulic, and Electrical Actuators?

An overview on the differences between powered actuators and their benefits.

Download

What_s_the_Difference_Between_Pneumatic_Hydraulic_and_Electrical_Actuators_Machine_Design.pdf (6 MB)

20SEP2022 ISO 20957-7:2020

ANNABEL FRAKE - Sep 20, 2022, 1:55 PM CDT

Title: 20SEP2022 ISO 20957-7:2020

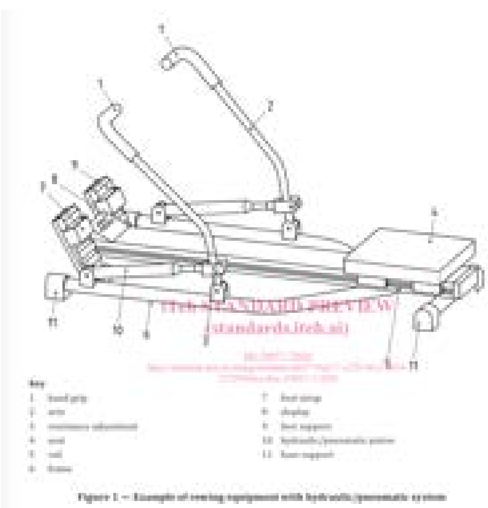
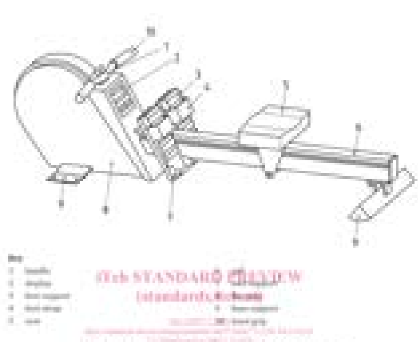
Date: 20SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: learn more about standards for rowing machines

Content:

- the previous team cited ISO 20957-7:2005
- when I used the link in the references section, I was redirect to a page that told me it had been withdrawn
- the standard is now ISO 20957-7:2020
- I could not find a free version online (or through UW library subscriptions), only a preview, so that is the material I was able to review
- scope: safety for rowing equipment
- intended to be used with ISO 20957-1
- rowing type stationary equipment = rowing equipment for this document
- within classes H, S and I and classes A, B and C or accuracy
- rowing equipment = "stationary training equipment with a moving seat simulating a rowing-like motion" (p. 1)
- 
- 
- "The squeeze, shear and reciprocating points within the accessible area shall be in accordance with ISO 20957-1" (p. 3).

- "Transmission elements, fans and flywheels shall be in accordance with ISO 20957-1" (p. 3).
- accessible surfaces of equipment should be <= 65 degC
- seat can't derail when >= 100 N applied in all directions
- must withstand load 2.5 x larger than max user's body mass with tolerance of +/-5% or 2500N, whichever larger
- "In rowing equipment where the handle is connected to the rowing equipment by a flexible member (rope, belt or chain) the mass of the handle without a flexible member shall be ≤600 g" (p. 4).
- "The range of movement of the handle shall be more than 1 600 mm measured from the centre line of the foot rest to the centre of the handle" (p. 4).
- "Rowing equipment using ropes, belts, chains and attachment components (e. g. snap links, shackles, carabineers, clamps or similar) shall withstand a static load of six times (350 ± 5) N" (p. 4).
- must be able to fasten foot (classes S and I must be adjustable)
- each foot strap withstand >=500 N perpendicular to foot support
- foot support withstand >= 1000N perpendicular
- endurance: 12000 cycles for class H and 100000 for S and I while load is 100 kg or max body weight specified by manufacturer (whichever larger with max resistance)
- stability: can't tip over
- "For values ≥50 W, the accuracy of the power display shall be within the tolerance of ±10 % and for values of <50 W, the accuracy of the power display shall be within the tolerance of ±5 W" (p. 5).

References:

"ISO 20957-7:2020 - Stationary training equipment - Part 7: Rowing machines, additional specific safety requirements and test methods." https://subscriptions-techstreet-com.ezproxy.library.wisc.edu/products/878217# (accessed Sep. 20, 2022).

Conclusions:

I've been reading through the sources from last semester, and today I looked at ISO 20957-7:2005. However, this one has been withdrawn and was replaced by ISO 20957-7:2020. I tried to find this updated standard within UW Madison's library system, but it was not included in the subscription. I also tried searching for a free version on the internet, but did not find anything. I did find a preview and read that, but I do not have access to the entire standard. Perhaps our client would have it, but it is meant for regular rowing machines and not adapted ones. Therefore, some things are not applicable. For example, our design doesn't have a foot fastener or support on the adaptive side. While the standard side does have those items, the Matrix is commercially sold and would most likely meet the specifications of the standard or have a justification for why it doesn't (I would hope). It may be helpful to view the standard so that we make sure none of our alterations jeopardize the specifications, but ultimately, it would be better if there was a standard for adaptive rowers.

Action items:

1. inform team about the standard update and ask them if they had access to the 2005 one somehow

ANNABEL FRAKE - Sep 20, 2022, 1:47 PM CDT


INTERNATIONAL STANDARD

ISO 20957-7

Stationary training equipment —

Part 7:

Rowing equipment, additional specific safety requirements and test methods

Download

ISO-20957-7-2020.pdf (370 kB)

24SEP2022 Servo Motors

ANNABEL FRAKE - Sep 24, 2022, 7:14 PM CDT

Title: 24SEP2022 Servo Motors

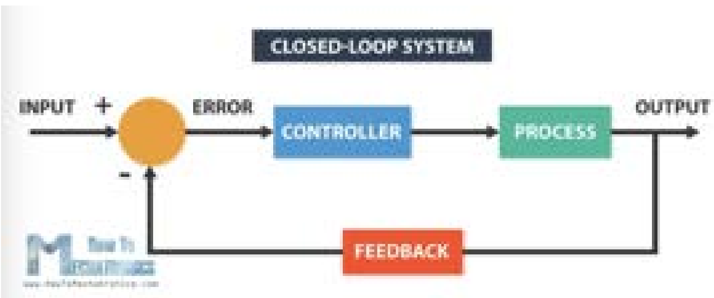
Date: 24SEP2022

Content by: Annabel Frake

Present: Annabel Frake

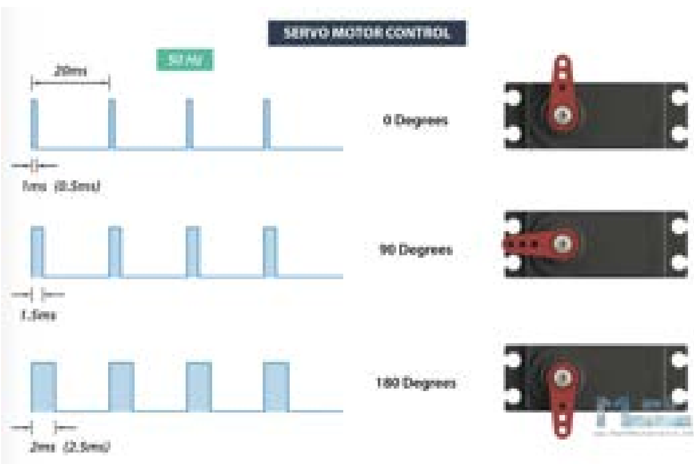
Goals: learn more about servo motors and how they could be integrated into the console rotation mechanism

Content:

- servos good for: robotics, automation, RC models
- servo motor is closed-loop system that uses position feedback to control motion and final position
- main feature: precisely control position of shaft
- 

- industrial: position feedback usually high precision encoder
- smaller RC or hobby: position sensor is simple potentiometer
- actual position goes to error doctor and compared to target position
- controller corrects actual position of motor to match target
- this article focuses on hobby servo motors
- 4 main components of hobby servo
    1. DC motor: high speed, low torque
    2. gearbox: reduces speed to 60 rpm, increases torque
    3. potentiometer: attached to final gear on output shaft, produces voltage related to absolute angle of output shaft
    4. control circuit: compares potentiometer voltage to voltages from signal line
        - if needed, controller activates integrated H-Bridge to rotate motor until difference between actual and target angles is 0

- 

- servo motor controlled by series of pulses through signal line
- frequency of control signal is 50Hz (period of 20 ms)
- width of pulse determines angular position of servo
- usually hobby ones can rotate 180 degrees
- 

- can vary with brand
- what to consider when buying: torque, operating volt, current draw, size
- 2 most popular
  1. SG90 Micro Servo
     - **SG90 Micro Servo** technical specifications:

Stall Torque	1.2kg-cm @4.8V, 1.6kg-cm @6V,
Operating Voltage	3.5 – 6V
No Load Current	100mA
Stall Current	650mA
Max Speed	60 degrees in 0.12s
Weight	9g

  2. MG996R

- **MG996R Servo** technical specifications:

Stall Torque	11kg.cm @4.8v, 13kg.cm @6V
Operating Voltage	4.8 – 7.2V
No Load Current	220mA @4.8V, 250mA @6V
Stall Current	650mA
Max Speed	60 degrees in 0.20s
Weight	55g

- Example Arduino code:

```
/*
   Servo Motor Control - 50Hz Pulse Train Generator
        by Dejan, https://howtomechatronics.com
*/

#define servoPin 9

void setup() {
  pinMode(servoPin, OUTPUT);
}

void loop() {
   // A pulse each 20ms
    digitalWrite(servoPin, HIGH);
    delayMicroseconds(1450); // Duration of the pusle in microseconds
    digitalWrite(servoPin, LOW);
    delayMicroseconds(18550); // 20ms - duration of the pusle
    // Pulses duration: 600 - 0deg; 1450 - 90deg; 2300 - 180deg
}
```

- Example Arduino Code using the Servo Library:

```
/*
   Servo Motor Control using the Arduino Servo Library
        by Dejan, https://howtomechatronics.com
*/

#include <Servo.h>

Servo myservo;  // create servo object to control a servo

void setup() {
  myservo.attach(9,600,2300);  // (pin, min, max)
}

void loop() {
  myservo.write(0);  // tell servo to go to a particular angle
  delay(1000);

  myservo.write(90);
  delay(500);

  myservo.write(135);
  delay(500);

  myservo.write(180);
  delay(1500);
}
```

- the servo library supports the control of up to 12 servos per arduino board or 48 for a mega board
- Another way is to use the PCA9685 PWM/Servo Driver

  - 16-channel
  - 12-bit PWM
  - communicates with Arduino via I2C bus
  - built-in clock
- Common error: servo motor jitters and resets Arduino board
  - hobby ones can draw significant current when at load
  - can cause board to reset, especially if powering directly from board
  - solution: use cap across ground and 5V pin (acts as decouple cap that provides additional current at start up)
- Common error: servo won't move entire 180 degrees
  - pulse width varies amongst brands
  - solution: adjust pulse width
  - solution: use attach() function in servo library
    - myservo.attach(pin, min, max);

References:

“How to Control Servo Motors with Arduino - Complete Guide.” https://howtomechatronics.com/how-it-works/how-servo-motors-work-how-to-control-servos-using-arduino/ (accessed Sep. 24, 2022).

Conclusions:

For the console rotation mechanism, we are including an electric design in the design matrix. Therefore, I wanted to research servo motors and how to control them with an Arduino so that I could better plan the solution for this design. We would most likely be using a hobby servo motor, but we would have to consider the torque, operating voltage, current draw, and size. Because the console is fairly large and hefty, we would most likely need a larger servo motor capable of a higher torque rating. This article also provided two ways to code the servo motors: one by changing the pulse width and one that uses the servo library. For this project, we would use the servo library to alter the angle of the console.

Action items:

1. brainstorm ways to incorporate a servo motor into the console rotation mechanism for the design matrix

ANNABEL FRAKE - Sep 24, 2022, 6:47 PM CDT

Download

How_to_Control_Servo_Motors_with_Arduino_-_Complete_Guide.pdf (11 MB)

24SEP2022 Control Stepper Motor with L298N Motor Driver & Arduino

ANNABEL FRAKE - Sep 24, 2022, 7:36 PM CDT

Title: 24SEP2022 Control Stepper Motor with L298N Motor Driver & Arduino

Date: 24SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: leverage previous research on stepper motors that may be useful for the console rotation mechanism for my current project

Content:

- please see entry titled "26OCT2021 Control Stepper Motor with L298N Motor Driver & Arduino" below

References:

"Control Stepper Motor with L298N Motor Driver & Arduino," *Last Minute Engineers*, Dec. 15, 2018. https://lastminuteengineers.com/stepper-motor-l298n-arduino-tutorial/ (accessed Sep. 24, 2022).

Conclusions:

In one of my previous design projects, I used stepper motors. I am leveraging that research for my current project and reapplying it to the console rotation mechanism. This combination of stepper motor and linear actuator was extremely successful in my previous project, so I would probably use the same components. I am not sure whether a servo motor would be sufficient given the console's size and weight. We would need to check the torque requirements, but if we determined that a servo motor was insufficient, we could use this stepper motor. This motor was around $16 and the controller was $7.

Action items:

1. continue to brainstorm design ideas for the console rotation mechanism

ANNABEL FRAKE - Oct 26, 2021, 9:52 AM CDT

Title: 26OCT2021 Control Stepper Motor with L298N Motor Driver & Arduino

Date: 26OCT2021

Content by: Annabel Frake

Present: Annabel Frake

Goals:

-look at the article I found on using stepper motors with the L298N in more detail

Content:

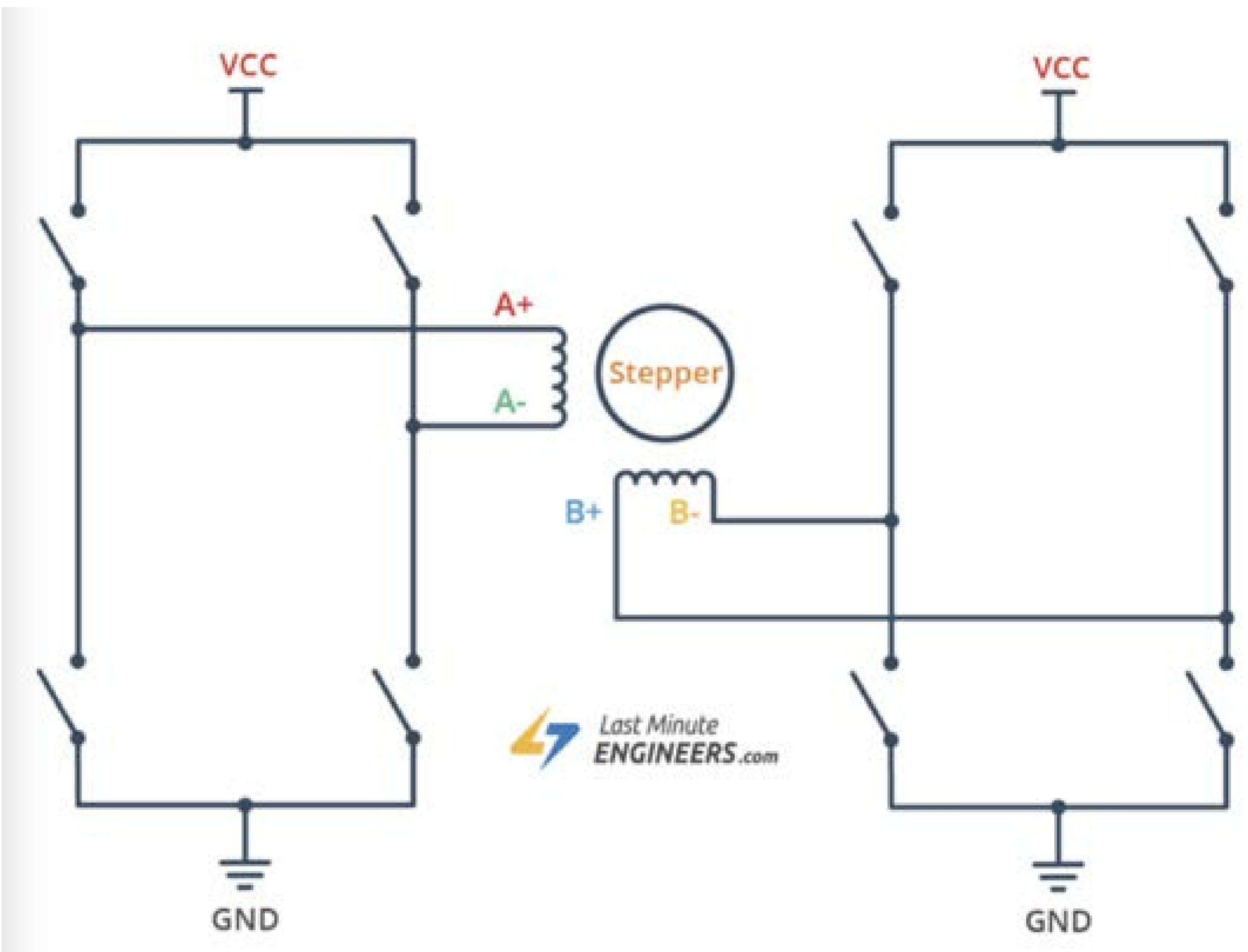
-L298N motor driver is easy and inexpensive to operate stepper motor

-controls speed and direction of bipolar motor

-has 2 H brides, each driving one electromagnetic coil of stepper motor

-speed of motor depends on how often coils are energized

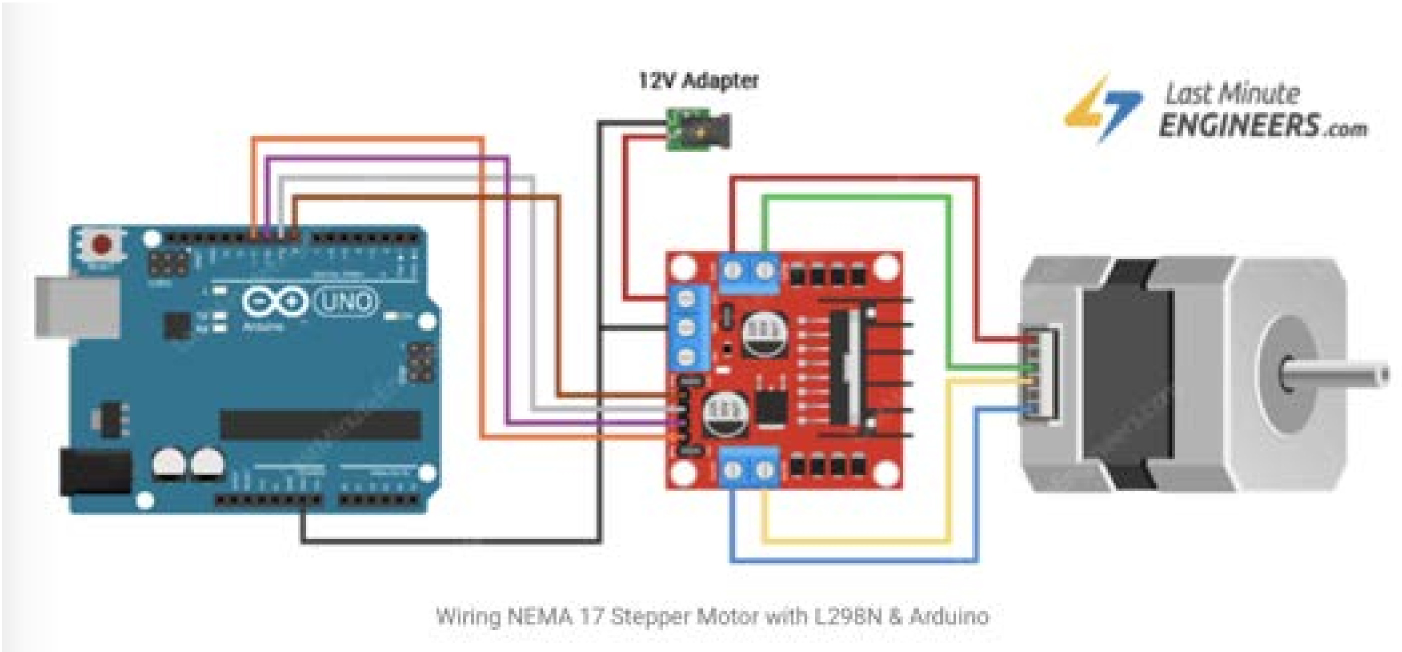
-Below is an image of the 2 H bridges in a circuit diagram



-they use NEMA 17 (12 V, 200 steps per rotation, 60 RPM)

-check data sheet of motor to find out the A, A-, B-, and B terminal placements

-Below is a circuit diagram showing the connections between the motor, L298N, Arduino, and battery



-Next is the Arduino code

-Below is the code from the website

```
// Include the Arduino Stepper Library
#include <Stepper.h>

// Number of steps per output rotation
const int stepsPerRevolution = 200;

// Create Instance of Stepper library
Stepper myStepper(stepsPerRevolution, 8, 9, 10, 11);


void setup()
{
    // set the speed at 60 rpm:
    myStepper.setSpeed(60);
    // initialize the serial port:
    Serial.begin(9600);
}

void loop()
{
    // step one revolution in one direction:
    Serial.println("clockwise");
    myStepper.step(stepsPerRevolution);
    delay(500);

    // step one revolution in the other direction:
    Serial.println("counterclockwise");
    myStepper.step(-stepsPerRevolution);
    delay(500);
}
```

-need to include the Stepper.h library

-define the number of steps per revolution (this should be in the data sheet of the motor)

-to create an instance of the library, you need to include the steps per rev and the Arduino pins from the L298N

-the setSpeed() function sets the rpm of the motor

-they use serial monitor to debug

-step() function steps motor specified number of steps at speed from setSpeed()

-using negative numbers reverses the direction

References:

Last Minute Engineers, "Control Stepper motor with L298n Motor Driver & Arduino," *Last Minute Engineers*, 18-Dec-2020. [Online]. Available: https://lastminuteengineers.com/stepper-motor-l298n-arduino-tutorial/. [Accessed: 26-Oct-2021].

Conclusions:

This source was extremely helpful in picking out the motor controllers and type of stepper motor. We decided as a team to get a NEMA stepper motor and the L298N to control it. Once we receive the parts, I can use this source as a starting point for the connections and the code. The figures are a little small to read exactly which pins certain wires are connected to, so I will need to be cautious that everything is hooked up the same.

In terms of our program, we can set an arbitrary speed (I assume something slow) and then tell the motors to step +/-x amount of times. This works perfectly with my coding logic idea where the motors are reset to a home position before any movement occurs (please see the Code Logic Brainstorming entry under the Code folder in Design Ideas). This code will require quite a few functions.

Action items:

-start writing the coding logic

-eventually create a circuit diagram in Fritzing

27SEP2022 Calculating Motor Torque

ANNABEL FRAKE - Sep 27, 2022, 10:39 AM CDT

Title: 27SEP2022 Calculating Motor Torque

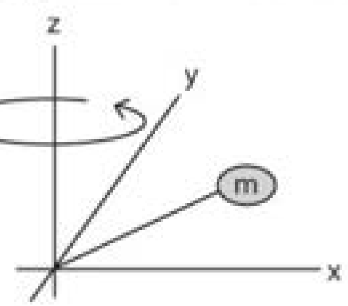
Date: 27SEP2022

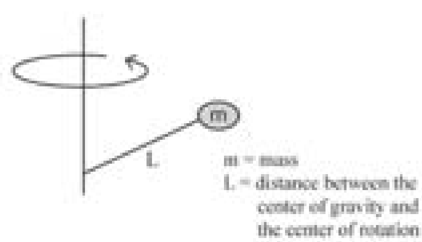
Content by: Annabel Frake

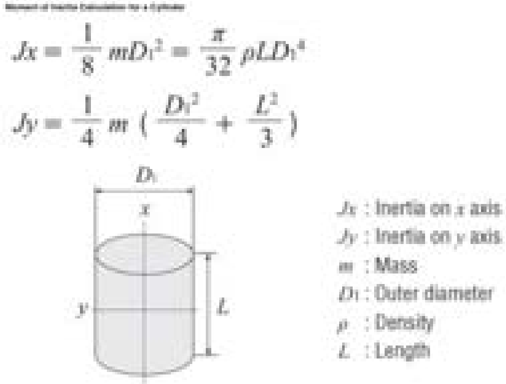
Present: Annabel Frake

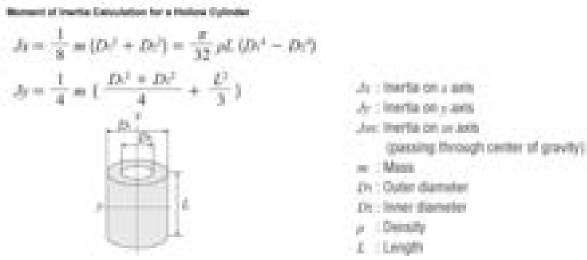
Goals: confirm how to calculate the required motor torque

Content:

- I am not sure if a servo motor would have enough torque to work for the console rotational mechanism
- we may need to use a stepper motor to get more torque
- therefore, to make this decision, we need to calculate the minimum torque required to move the console
- from statics, I know how to calculate torque, but I wanted to confirm the methodology for motors specifically
- I found this article detailing the steps for finding the necessary torque for a motor
- to pick a motor, you need to calculate Moment of Inertia, Torque, and speed
- "Moment of inertia is the measure of an object's resistance to changes in its rotation rate."
    - if no motion, moment of inertia = 0
    - $$J = \iiint \rho(x,y,z)(x^2 + y^2)dxdydz$$
      

    - $$J = mL^2$$
      

- 

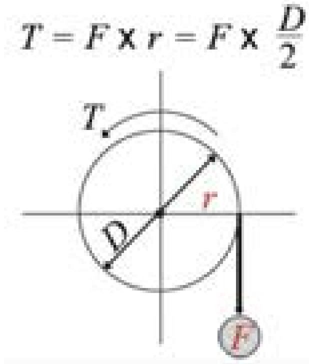
- 

- units: oz-in² (includes gravity) and oz-in-sec² (only includes mass)
- "Theoretically, inertia is factor of mass so it should not include gravity, however, practically we can not easily measure mass on the earth."

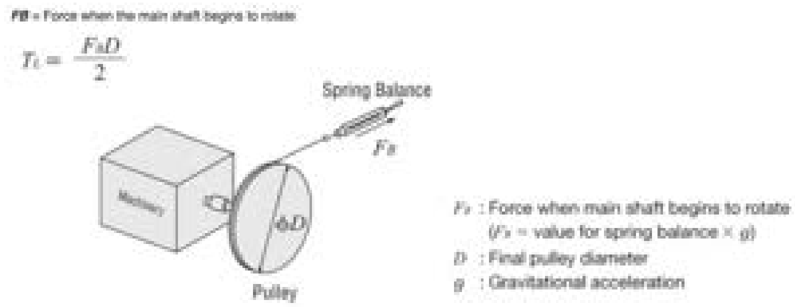
  Gravity = 386 in/sec²
  - oz-in² = Inertia based on weight
  - oz-in-sec² = Inertia based on mass

  Calculation for oz-in² to oz-in-sec²
- $$\frac{\text{oz-in}^2}{386\ \text{in/sec}^2} = \text{oz-in-sec}^2$$

* "Torque is the tendency of a force to rotate an object about an axis."
  - 2 components: a load and an acceleration
  - load usually due to friction or gravity; always acts on motor
    - figure out by calculator or using torque wrench
  - acceleration
    - only acts on motor when accelerating / decelerating
    - if at constant speed, goes away
    - measuring this is difficult and dangerous
    - torque wrench likely to fly off
    - therefore, as function of moment of inertia of system and acceleration rate
  - load torque = product of force and distance between applied force and center of rotation
  - T = F x r = F x (D/2)

- 

- Measure torque directly if possible because takes care of efficiency and friction coefficient

- 

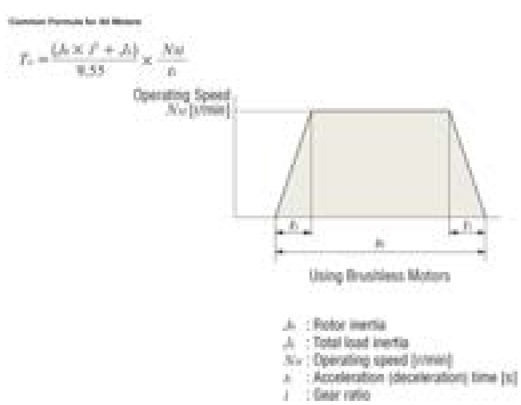
- can calculate acceleration torque if you know moment of inertia of system and acceleration rate

$$Ta = J \times A$$

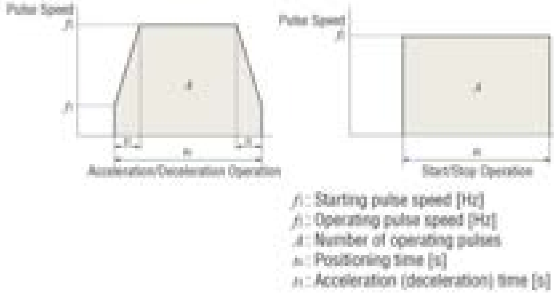
- Ta : Acceleration Torque
  J : Moment of Inertia
  A : Acceleration Rate

- "If the motor speed is varied, the acceleration torque or deceleration torque must always be set.

  The basic formula is the same for all motors. However, use the formulas below when calculating the acceleration torque for stepper or servo motors on the basis of pulse speed."

- 

- "There are two basic motion profiles. Acceleration/deceleration operation is the most common. When operating speed is low and load inertia is small, start/stop operation can be used."

- 

- ① For acceleration/deceleration operation

$$T_a = (J_0 \cdot i^2 + J_L) \times \frac{\pi \cdot \theta_s}{180} \times \frac{f_2 - f_1}{t_1}$$

② For start/stop operation

$$T_a = (J_0 \cdot i^2 + J_L) \times \frac{\pi \cdot \theta_s}{180 \cdot n} \times f_2^2 \qquad n: 3.6°/(\theta_s \times i)$$

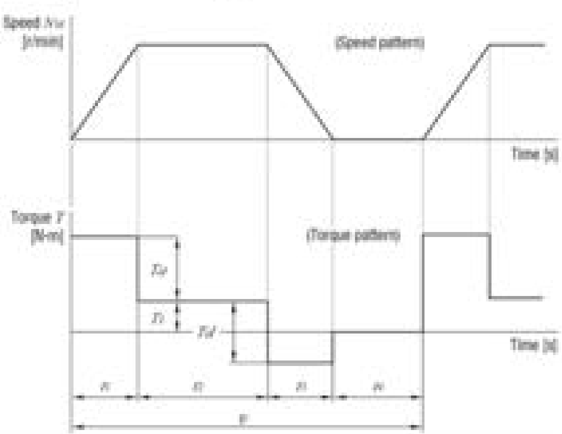
- Required torque is calculated using load torque and acceleration torque with a certain safety factor

$$T_M = (T_L + T_a) \times S_f$$

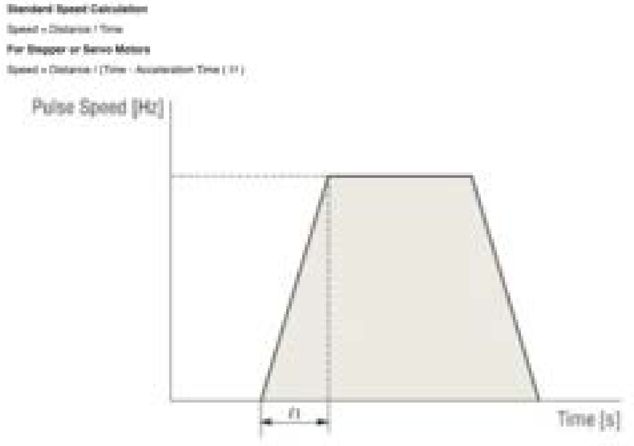
T_M : Required torque
T_L : Load torque
T_a : Acceleration torque
S_f : Safety factor

- "When the required torque for the motor varies over time, determine if the motor can be used by calculating the effective load torque. The effective load torque becomes particularly important for operating patterns such as fast-cycle operations where acceleration/deceleration is frequent. Calculate the effective load torque when selecting servo motors or the BX Series brushless motors."

$$T_{rms} = \sqrt{\frac{(T_a + T_L)^2 \cdot t_1 + T_L^2 \cdot t_2 + (T_d - T_L)^2 \cdot t_3}{t_f}}$$



* when calculating speed for servo motors, acceleration time needs to be accounted for

- 

References:

"Motor Sizing Calculations," *Oriental Motor U.S.A. Corp.* https://www.orientalmotor.com/technology/motor-sizing-calculations.html (accessed Sep. 27, 2022).

Conclusions:

I know how to calculate torque from statics, but I wanted to research how it is done for motor selection specifically. Turns out, it is more complex than force x r. The required torque is made up of the load torque and acceleration torque with an applied safety factor. The website recommends measuring the load torque directly to account for efficiency and friction coefficients. It also covers the calculations for moment of inertia and speed. Some of the equations change slightly for stepper and/or servo motors. Ultimately, you should use moment of inertia, torque, and speed calculations to determine what motor will work for your project.

Action items:

1. If we pursue the motor design for the console rotational mechanism, weigh the console and measure the distance from the midline of the console to its outer edge
2. use this information to find the torque required to rotate the motor
3. find a servo or stepper motor that will work

ANNABEL FRAKE - Sep 27, 2022, 10:29 AM CDT

Download

Motor_Sizing_Calculations.pdf (913 kB)

2OCT2022 Limit Switch

ANNABEL FRAKE - Oct 02, 2022, 2:44 PM CDT

Title: 2OCT2022 Limit Switch

Date: 2OCT2022

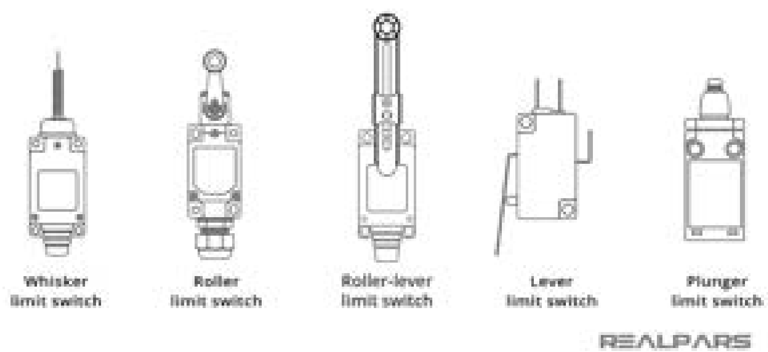
Content by: Annabel Frake

Present: Annabel Frake

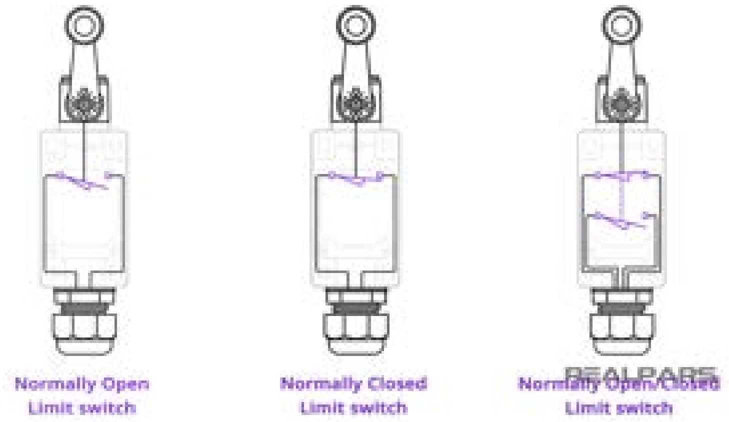
Goals: record research on limit switches

Content:

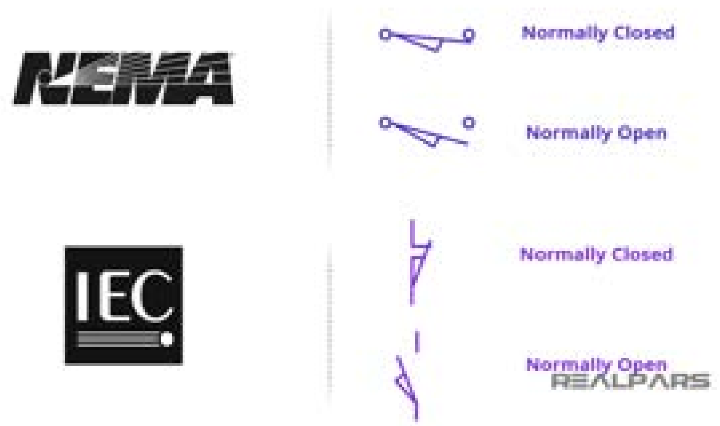
- I have used limit switches in past projects, but I wanted to touch up on them and see if there was anything I had forgotten or any new developments
- Video:
- 4 types:
    1. whisker
    2. roller
    3. level
    4. plunger



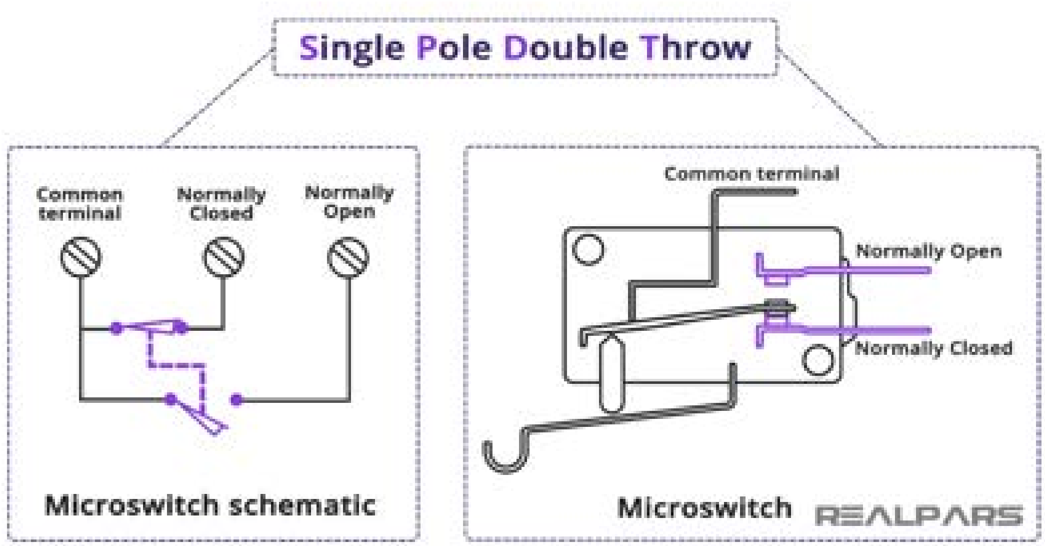
- may be combination of 4 general types depending on application (ex: roller-level)
- limit switch = electromechanical device operated by applied physical force
- used to detect presence/absence of object
- originally used to define limit of travel of object
- ex: limit switch detects whether fridge door open or closed and then light turns on or off
- ex: limit switch stops garage door once it is up
- how it works
    - "...actuator mechanically linked to an electrical switch..."
    - when object contacts actuator, electrical connection is made or broken
- configurations:
    1. normally open
    2. normally closed
    3. one of each



- limit switch symbol (slightly different for NEMA vs IEC)



- microswitch is a type of limit switch
  - 2 limit switches working together
  - share common terminal
  - one normally open, other normally closed
  - Single Pole Double Throw (SPDT)



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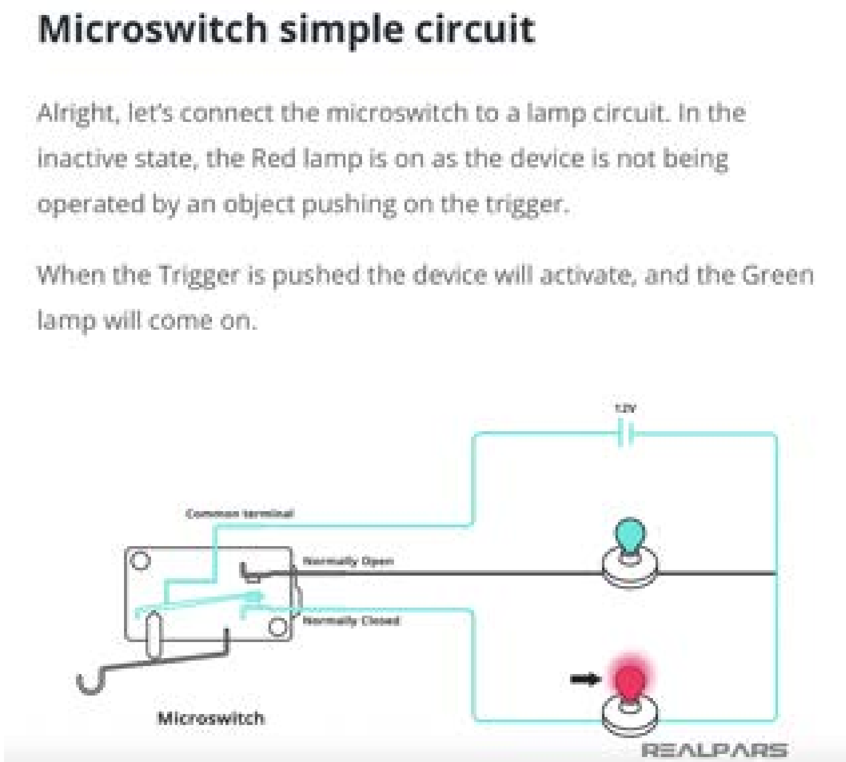


Microswitch simple circuit

Alright, let's connect the microswitch to a lamp circuit. In the inactive state, the Red lamp is on as the device is not being operated by an object pushing on the trigger.

When the Trigger is pushed the device will activate, and the Green lamp will come on.

- limit switch vs proximity sensor
    - proximity has no mechanical moving parts
    - limit switch more reliable for operation in difficult environments
    - limit switches can handle higher current

References:

T. Mortenson, “Limit Switches Explained - Working Principles & Types,” *PLC Programming Courses for Beginners | RealPars*, Oct. 19, 2020. https://realpars.com/limit-switch/ (accessed Oct. 02, 2022).

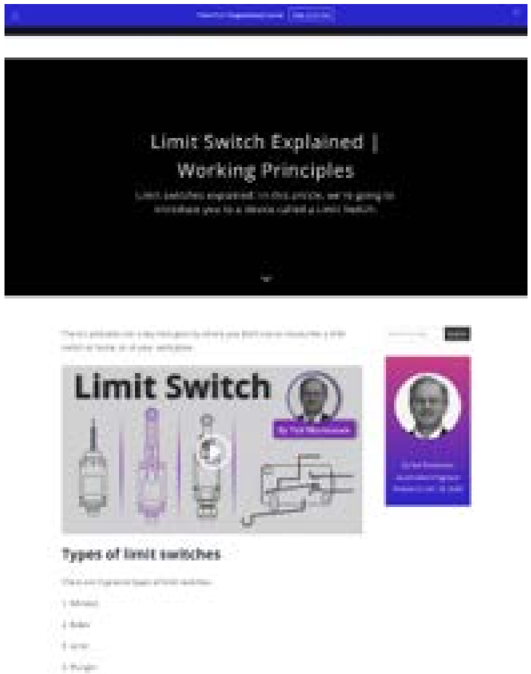
Conclusions:

There are four general limit switches: a whisker, roller, level, or plunger. Depending on the application, these may be combined. The three orientations for a limit switch are normally open, normally closed, or both. A limit switch operates as a mechanical actuator either makes or breaks an electrical circuit within the switch. A micro switch consists of two limit switches, one normally open and the other normally closed. The micro switch seems like the perfect chose for our project. When the actuator is pressed, the console will rotate to the standard view and when it is not pressed, the console will rotate to the adaptive side. The article also mentions that a lot of limit switches are being replaced by proximity sensors in industry, but limit switches are still superior in durability and allowed current flow.

Action items:

1. research micro switches
2. apply this research to the motor console rotation design

ANNABEL FRAKE - Oct 02, 2022, 2:14 PM CDT



Download

Limit_Switches_Explained_-_Working_Principles_Types_RealPars.pdf (4.41 MB)

2OCT2022 Micro or Snap-Action Switch

ANNABEL FRAKE - Oct 02, 2022, 3:59 PM CDT

Title: 2OCT2022 Micro or Snap-Action Switch

Date: 2OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: learn more about micro-switches

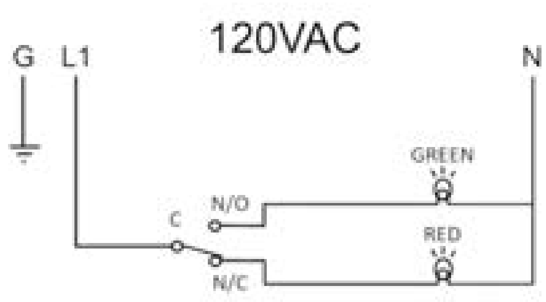
Content:

[1] https://www.circuitspecialists.com/blog/what-are-micro-switches-and-what-makes-them-so-great/

- require little force to operate rapidly
- reliable, fast, efficient
- also known as snap-action switch
- How to select?
    - lever terminal options: pin plunger, short straight lever, standard straight lever, long straight lever, extended straight lever, small stimulated roller lever, standard simulated roller level, roller level, L-shaped level
- How to use?
    - share common terminal
    - NC = normally closed
    - NO = normally open
    - depression of switch changes circuit from NO or NC or vice versa
- Why so great?
    - used in a lot of smart appliances

[2] https://www.youtube.com/watch?v=q6nP1FjxAMU

- changes direction of power when arm moved
- snap-action switch more common name
    - uses spring to open and close connections inside of it
- if move lever, should hear spring snap back and forth
- 3 pins
    - C for common
    - N/O for normally open
    - N/C for normally closed
- spring lever opens/closes internal contacts
- power usually goes to common terminal (energizes spring)
- when not depressed, spring on contact for N/C pin, so power goes through there
    - called resting state
- when arm moved, spring moves to contact for N/O pin and power goes through there

- 

References:

[1] Khang, “What are Micro-switches and what makes them so great?,” *Simply Smarter Circuitry Blog*, Feb. 23, 2022. https://www.circuitspecialists.com/blog/what-are-micro-switches-and-what-makes-them-so-great/ (accessed Oct. 02, 2022).

[2] *Understanding a Microswitch*, (Jan. 31, 2014). Accessed: Oct. 02, 2022. [Online Video]. Available: https://www.youtube.com/watch?v=q6nP1FjxAMU

Conclusions:

I found two resources (one article and one video) on the micro switch, more commonly called the snap-action switch. It has three pins: common (C), normally closed (NC), and normally open (NO). The power is connected to C and depending on the state of the lever, the internal contacts will direct the current through the NC or NO terminals. This results in 2 different actions/results. Now that I am thinking about this further, we won't have two separate motors, so there will not be anything attached to the second pin. We also need to supply power to the motor the entire time to have it move between states, so we probably need a regular limit switch and not a SPDT micro switch. Unless we can attach the NC and NO to pins on the Arduino and then read the state of those pins to tell the motor to move or remain stationary?

Action items:

1. keep thinking about how limit switches can be included in the motor design

---

ANNABEL FRAKE - Oct 02, 2022, 2:44 PM CDT

Download

What_are_Micro-switches_and_what_makes_them_so_great_.pdf (1.76 MB)

8OCT2022 Electronic Materials Search

Title: 8OCT2022 Electronic Materials Search

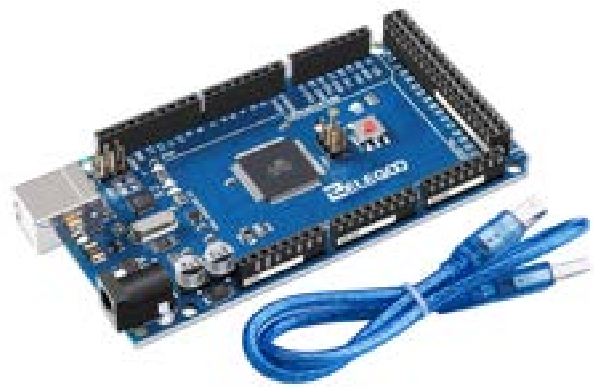
Date: 8OCT2022

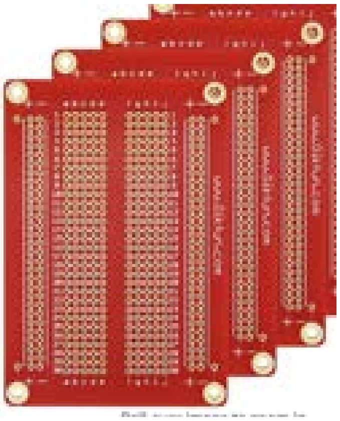
Content by: Annabel Frake

Present: Annabel Frake

Goals: find material options for the motor design in the preliminary report

Content:

- Arduino Mega: https://www.amazon.com/ELEGOO-ATmega2560-ATMEGA16U2-Projects-Compliant/dp/B01H4ZLZLQ/ref=sr_1_2_sspa?keywords=Arduino%2Bmega&qid=163675116 spons&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEyVjQ0NjdYUkpHVkxEJmVuY3J5cHRlZElkPUExMDA0Nzg4MVNQSk41UkxGTEJNTyZlbmNyeXB0ZWRBZElkPUEwNDA1Mj
- 
- Arduino Uno: https://www.amazon.com/ELEGOO-Board-ATmega328P-ATMEGA16U2-Compliant/dp/B01EWOE0UU/ref=sr_1_6?crid=6UK8ECLX9D8R&keywords=Arduino+uno&qid
- 
- Limit switch: https://www.amazon.com/ELEGOO-ATmega2560-ATMEGA16U2-Projects-Compliant/dp/B01H4ZLZLQ/ref=sr_1_2_sspa?keywords=Arduino%2Bmega&qid=16367511638 spons&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEyVjQ0NjdYUkpHVkxEJmVuY3J5cHRlZElkPUExMDA0Nzg4MVNQSk41UkxGTEJNTyZlbmNyeXB0ZWRBZElkPUEwNDA1Mj
- 
- battery: will depend on motor and what is required to power everything
- solder board: https://www.amazon.com/Gikfun-Solder-able-Breadboard-Plated-Arduino/dp/B071R3BFNL/ref=sr_1_5?keywords=solder+board&qid=1636752226&sr=8-5

- 

References:

"ELEGOO MEGA R3 Board ATmega 2560 + USB Cable Compatible with Arduino IDE Projects RoHS Compliant," Amazon. https://www.amazon.com/ELEGOO-ATmega2560-ATME spons&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEyVjQ0NjdYUkpHVkxEJmVuY3J5cHRlZElkPUExMDA0Nzg4MVNQSk41UkxGTEJNTyZlbmNyeXB0ZWRBZElkPUEwNDA1 Oct. 08, 2022).

"ELEGOO UNO R3 Board ATmega328P with USB Cable(Arduino-Compatible) for Arduino," *Amazon*. https://www.amazon.com/ELEGOO-Board-ATmega328P-ATMEGA16U2-Compliant/dp/I crid=6UK8ECLX9D8R&keywords=Arduino+uno&qid=1665264318&qu=eyJxc2MiOiIzLjk5IiwicXNhIjoiMi44OSIsInFzcCI6IjIuNzQifQ%3D%3D&sprefix=arduino+uno%2Caps%2C101&sr=8

"Cylewet 6Pcs V-153-1C25 Micro Limit Switch Long Straight Hinge Lever Arm SPDT Snap Action LOT for Arduino (Pack of 6) CYT1068," Amazon. https://www.amazon.com/Cylewe b45d-69fe835e098d%3Aamzn1.sym.6b029eb3-7d41-4744-b45d-69fe835e098d&crid=1146GKXQGC61U&cv_ct_cx=lever+arm+limit+switch&keywords=lever+arm+limit+swi b45d-69fe835e098d&pf_rd_r=41MD6CX7MWGXW6KT0G8V&qid=1665213277&qu=eyJxc2MiOiIxLjg5IiwicXNhIjoiMS41OSIsInFzcCI6IjAuMDAifQ%3D%3D&sprefix=lever+a

"Gikfun Solder-able Breadboard Gold Plated Finish Proto Board PCB DIY Kit for Arduino (Pack of 5PCS) GK1007 : Electronics," *Amazon*. https://www.amazon.com/Gikfun-Solder-able-Breadbo

Conclusions:

One of my assigned sections for the preliminary report is the fabrication plan for the motor design. I looked up options for an Arduino Mega (same one I used in BME 300) and Uno, limit switches likely only require an Arduino Uno for this project, but I need to finalize the motor selection to ensure that we will have enough pins before purchasing an Arduino for the project.

Action items:

1. continue to explore materials options

13OCT2022 Poling vs Interrupt?

ANNABEL FRAKE - Oct 13, 2022, 6:40 PM CDT

Title: 13OCT2022 Poling vs Interrupt?

Date: 13OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: learn about poling and interrupting

Content:

https://www.allaboutcircuits.com/technical-articles/using-interrupts-on-arduino/:

- Interrupt mechanism built into Arduino
- makes sure processor responds fast to important stuff
- when certain signal detected, Interrupt stops what code is doing, executes code defined for interrupt, returns processor to what it was doing at the start
- Example of using polling for button press:

```
const int buttonPin = 2;    // the number of the pushbutton pin
const int ledPin = 13;     // the number of the LED pin

// variables will change:
int buttonState = 0;       // variable for reading the pushbutton status

void setup() {
 // initialize the LED pin as an output:
 pinMode(ledPin, OUTPUT);
 // initialize the pushbutton pin as an input:
 pinMode(buttonPin, INPUT);
}

void loop() {
 // read the state of the pushbutton value:
 buttonState = digitalRead(buttonPin);

 // check if the pushbutton is pressed.
 // if it is, the buttonState is HIGH:
 if (buttonState == HIGH) {
  // turn LED on:
  digitalWrite(ledPin, HIGH);
 }
 else {
  // turn LED off:
  digitalWrite(ledPin, LOW);
 }
}
```

- Example of using interrupts for button press:

```
const int buttonPin = 2;    // the number of the pushbutton pin
const int ledPin = 13;    // the number of the LED pin

// variables will change:
volatile int buttonState = 0;      // variable for reading the pushbutton status

void setup() {
  // initialize the LED pin as an output:
  pinMode(ledPin, OUTPUT);
  // initialize the pushbutton pin as an input:
  pinMode(buttonPin, INPUT);
  // Attach an interrupt to the ISR vector
  attachInterrupt(0, pin_ISR, CHANGE);
}

void loop() {
  // Nothing here!
}

void pin_ISR() {
  buttonState = digitalRead(buttonPin);
  digitalWrite(ledPin, buttonState);
}
```

- ISR() is interrupt service routine - stop, do interrupt commands, get back to it
- ISRs should be short (don't want to derail main loop for too long)
- no input variables or returned values, all changes need to be made on global variables
- attachInterrupt() sets up interrupt
  - 3 arguments
  - interrupt vector determines what pin can generate interrupt
    - not number of pin itself, but reference to where in memory Arduino processor has to look to see if interrupt occurs
    - given space in vector corresponds to specific external pin
    - not all pins can do interrupts
    - Arduino Uno: pins 2 and 3 can do interrupts (interrupt vectors 0 and 1)
    - go to arduino documentation for attachInterrupt() for more info
  - function name of interrupt service routine - what code run when it happens
  - interrupt mode determines what pin action triggers an interrupt
    - 4 interrupt modes
    - rising - activates interrupt on rising edge of interrupt pin
    - falling - activates on falling edge
    - change 0 responds to any change in interrupt pin's value
    - low - triggers when pin is digital low
- voltatile int
  - volatile means variable not entirely in program's control, buttonState can change in a way that program can't predict
  - prevents any accidental compiler optimization
  - compilers have few purposes in addition to turning source code into machine code
  - compilers trim unused source code variables out of machine code
  - buttonState not used or called directly in loop() or setup(), so risk it will be removed
  - volatile tells compiler not to get rid of it

https://avrgeeks.com/polling-vs-interrupt/:

- Polling Method:

    - continuously checks status of register and do task according to state of register
    - Arduino not doing anything but checking register
- Interrupt Method:
    - faster than polling
    - Arduino not continuously checking, wait for trigger signal that interrupt is happening
    - resumes where it left off when interrupt code executed
- Advantages of Interrupt over polling
    - performance of microcontroller better
    - chances of data loss greater for polling than interrupt
- Disadvantages of interrupt
    - increases risk of being non-synchronous with rest of program
    - hard to debug
    - more complex than polling

References:

N. Reilly, “Using Interrupts on Arduino,” *All About Circuits*, Aug. 12, 2015. https://www.allaboutcircuits.com/technical-articles/using-interrupts-on-arduino/ (accessed Oct. 13, 2022).

P. Bhatt, “Polling vs Interrupt-Which approach is right for you?,” *AVR Geeks*, Nov. 11, 2017. https://avrgeeks.com/polling-vs-interrupt/ (accessed Oct. 13, 2022).

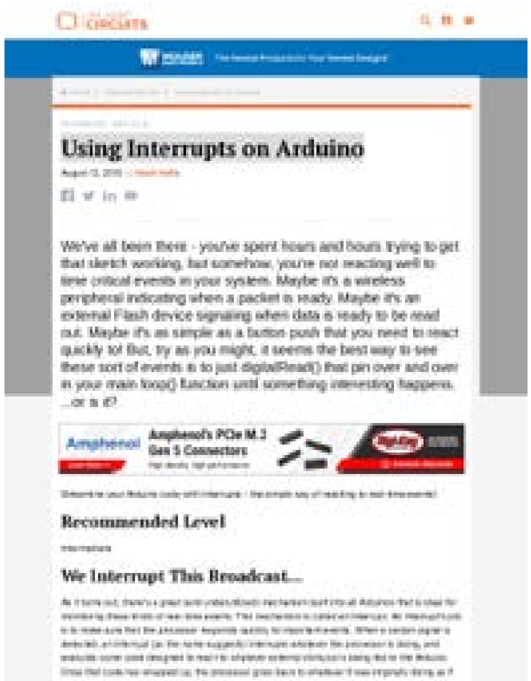
Conclusions:

The polling method continuously checks the state of interest and the Arduino can do nothing else while it is checking. The interrupt method allows the code to work on other things and only interrupts the main loop if triggered by an interrupt. I have only ever used polling in past projects, but interrupts seem like handy tools. I'm not sure that an interrupt is necessary for this project because the code is only checking the state of the limit switch and moving the motor accordingly; nothing else needs to happen. It might consume less battery power to use interrupts, but I would need to explore that further. I am going to talk with my team and the client about which method to use before moving forward.

Action items:

1. apply this knowledge to answer client's questions regarding which method we will use

ANNABEL FRAKE - Oct 13, 2022, 6:06 PM CDT



Using Interrupts on Arduino

We've all been there - you've spent hours and hours trying to get that sketch working, but somehow, you're not reacting well to time critical events in your system. Maybe it's a wireless peripheral indicating when a packet is ready. Maybe it's an external Flash device signaling when data is ready to be read out. Maybe it's as simple as a button push that you need to react quickly to! But, try as you might, it seems the best way to see these sort of events is to just digitalRead() that pin over and over in your main loop() function until something interesting happens. ...or is it?

Recommended Level

We Interrupt This Broadcast...

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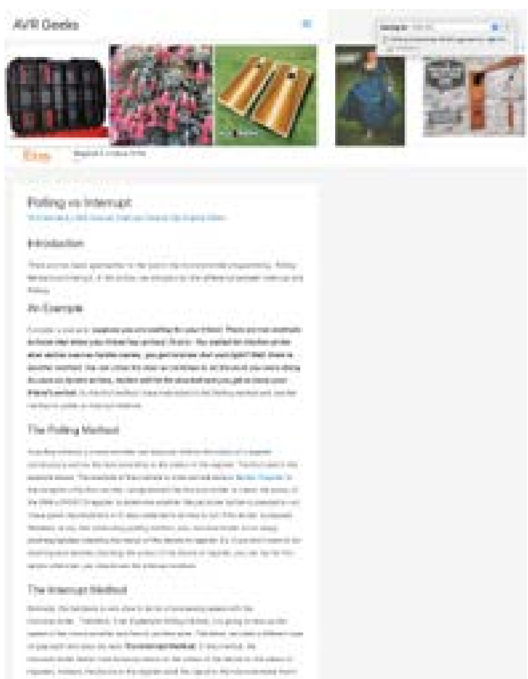
Using_Interrupts_on_Arduino.pdf (2.58 MB)

ANNABEL FRAKE - Oct 13, 2022, 6:26 PM CDT



Polling vs Interrupt

Introduction

An Example

The Polling Method

The Interrupt Method

[Download](#)

Polling_vs_Interrupt.pdf (2.86 MB)

14OCT2022 Electronics II MakerSpace Workshop

ANNABEL FRAKE - Oct 15, 2022, 2:45 PM CDT

This entry was uploaded the day after the meeting because I was having issues with LabArchives. It would not load the notebook in my browser. The issue is resolved now.

ANNABEL FRAKE - Oct 15, 2022, 2:41 PM CDT

Download

LabArchives_Error.jpg (182 kB)

ANNABEL FRAKE - Oct 15, 2022, 2:40 PM CDT

Title: 14OCT2022 Electronics II MakerSpace Workshop

Date: 14OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: learn more about servo and stepper motors, ask advice on motor selection

Content:

- motors contain several electromagnets
- apply electric field to coil wrapped around iron core
- keep motor spinning in direction of electron flow
- Servo (go to rotation)
- DC motors (spin fast, but not a lot of torque)
- Stepper (specific rotation)
- Geared DC motors (get more torque)
- PWM - controls speed
- Arduino does PWM for you
- H-bridge: controls direction of current and voltage flow to control direction of motor (through motor controller)
- Types of servo
  - continusous rotation servo
  - standard servo
- we setup a servo motor in a group, but we couldn't get the sweep to work
- the MakerSpace staff troublshooted with us for 30 min, but couldn't get it to work and said it was a bad servo motor
- they we're going to close soon, so I asked about our project
- i showed them the console and described what we wanted to do
- one said to use a stepper motor because a servo wouldn't be able to do it
- another said that a high torque might be able to do it if the console was only 1-2 lbs
- the 1-2 lbs was only any approximation on my part because I haven't been able to weigh it
- i am skeptical of the servo motors, especially since we could not get our demo to work
- right now, I am leaning towards a stepper motor

References: MakerSpace

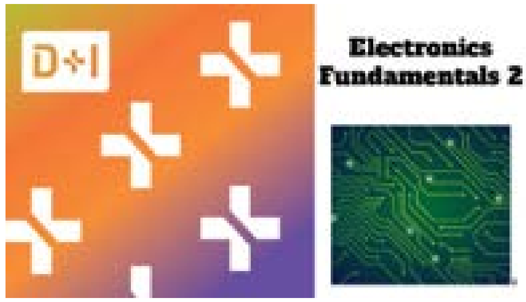
Conclusions:

A lot of people were at the workshop for class requirements (ie interEGR170), so it was harder to get out of it what I needed to. The demo was not all that helpful considering we couldn't get it to work and I only got to try the servo motor before running out of time. One MakerSpace employee recommended using a stepper motor for our project and the another one said we might be able to get away with using a servo motor if the console doesn't weight much.

Action items:

1. Finalize motor selection
2. start programming

ANNABEL FRAKE - Oct 14, 2022, 6:22 PM CDT



Download

Electronics_Fundamentals_2.pdf (3.36 MB)

ANNABEL FRAKE - Oct 14, 2022, 6:22 PM CDT

Download

Servo_Motor_MakerSpace_Workshop.ino (617 B)

18OCT2022 Putting Arduino Uno to Sleep

ANNABEL FRAKE - Oct 18, 2022, 11:03 PM CDT

Title: 18OCT2022 Putting Arduino Uno to Sleep

Date: 18OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: learn about how to put an Arduino Uno to sleep

Content:

- which board to use?
    - can use Uno, but recommend using Pro mini
    - Uno uses 30-40 mA awake and 19 mA asleep
    - Pro Mini uses 25 mA awake and 0.57 mA asleep
- when using Pro Mini, need to solder headers onto board and need FTDI cable to upload sketch
- documentation for ATmega328p processor (used in Uno and Pro mini)
- many sleep modes available
- only one mode that is useful
- power down mode (SLEEP_MODE_PWR_DOWN)
- turns off all unnecessary components, reduces power consumption of MCU (Microcontroller Unit)
- only way to wake up is through external influence (ie give nudge)
- Uno and Pro Mini have 2 pins (d2 and d3) that do interrupts
- interrupts are the nudge that wakes Arduino back up
- LED on arduino will turn off when in sleep mode
- I tried his example code and got it to work
- 

References:

arduinomakerman, “A Guide to Putting Your Arduino to Sleep,” *Instructables*. https://www.instructables.com/A-Guide-to-Putting-Your-Arduino-to-Sleep/ (accessed Oct. 18, 2022).

Conclusions:

I wanted to understand if and how I could put an Arduino Uno to sleep to make sure that the interrupts would actually be useful. This article recommends using the Pro Mini to save on power consumption, so that is something to consider, but will depend on the motor we use and the number of pins we need. To put the Arduino to sleep, you use SLEEP_MODE_PWR_DOWN. Then, to wake up the Arduino, you use an interrupt.

Action items:

1. apply this info to the project

ANNABEL FRAKE - Oct 18, 2022, 10:56 PM CDT

Download

arduino_sleep_tutorial_sketch1v1_0_0.ino (1.65 kB)

10NOV2022 Encoders

ANNABEL FRAKE - Nov 10, 2022, 8:25 PM CST

Title: 10NOV2022 Encoders

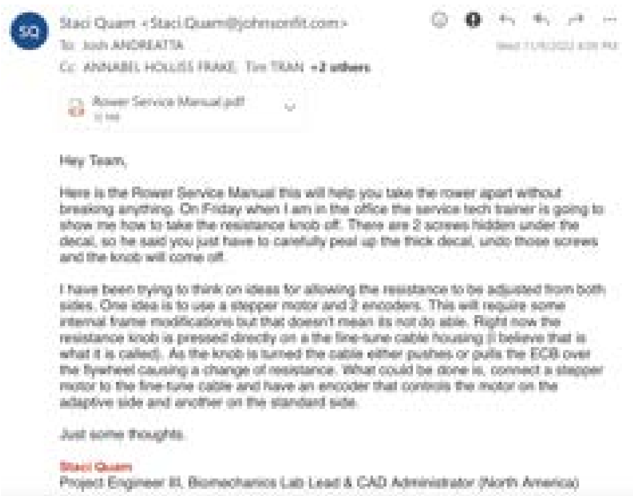
Date: 10NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: research encoders

Content:

- Staci provided us with the service manual for the rowing machine and the following ideas:
- 

  Staci Quam <Staci.Quam@johnsonfit.com>
  To: Josh ANDREATTA
  Cc: ANNABEL HOLLISS FRAKE; Tim TRAN +2 others

  Rower Service Manual.pdf

  Hey Team,

  Here is the Rower Service Manual this will help you take the rower apart without breaking anything. On Friday when I am in the office the service tech trainer is going to show me how to take the resistance knob off. There are 2 screws hidden under the decal, so he said you just have to carefully peal up the thick decal, undo those screws and the knob will come off.

  I have been trying to think on ideas for allowing the resistance to be adjusted from both sides. One idea is to use a stepper motor and 2 encoders. This will require some internal frame modifications but that doesn't mean its not do able. Right now the resistance knob is pressed directly on a the fine-tune cable housing (I believe that is what it is called). As the knob is turned the cable either pushes or pulls the ECB over the flywheel causing a change of resistance. What could be done is, connect a stepper motor to the fine-tune cable and have an encoder that controls the motor on the adaptive side and another on the standard side.

  Just some thoughts.

  Staci Quam
  Project Engineer III, Biomechanics Lab Lead & CAD Administrator (North America)
- My team decided that we would tackle this problem next semester, but I wanted to do some initial research on encoders in case Staci wants to discuss her ideas at our next client meeting
- encoders are used for motion feedback/control
- sensing device
- provides feedback
- convert motion to electrical signal read by control device such as counter or PLC
  feedback signal can be used for position, count, speed, or direction
- encoders may use mechanical, magnetic, resistive, or optical tech
- optical is the most common
  - feedback based on interruption of light
- can make incremental or absolute signals
  - incremental = don't tell you position, only that position has changed
  - absolute = tells you position has changed and and where that position is
    - has different 'word' for each position
    - single turn = any increment within 1 shaft rotation
    - multiple shaft = position over many shaft rotations

- often preferred if device moves at slow rate or is at rest for long period of time

- optical encoder
  - beam of light from LED goes through transparent disk with opaque lines
  - as light passes through disk, goes to photosensor that produces sinusoidal wave based on light
  - converted to square wave
  - square wave processed and gives commands back to machine
- used for distance, position, or speed applications

References:

E. P. Company, “Encoder: The Ultimate Guide | What is an Encoder, Uses & More | EPC.” https://www.encoder.com/article-what-is-an-encoder (accessed Nov. 10, 2022).

Conclusions:

Staci provided us with the rower manual so that we can begin to think about how we will tackle the resistance knob problem next semester. The resistance should be adjustable from both the standard and adaptive sides of the machine. According to Staci's email, we will be able to remove the knob without damaging the rower. She suggested using a stepper motor and two encoders, so I did some preliminary research on encoders. I have never used one before, but I have heard about them in my classes. There are two types of encoders: incremental and absolute. It seems like we would need an absolute encoder, but I would like to take a look at how the ECB moves over the flywheel before making any conclusions.

Action items:

1. keep this in the back of my mind for next semester

ANNABEL FRAKE - Nov 10, 2022, 8:04 PM CST


MATRIX

ROWER-02 (AR11)
SERVICE MANUAL

Download

Rower_Service_Manual.pdf (13.1 MB)

3OCT2022 Console dimensions

ANNABEL FRAKE - Oct 03, 2022, 1:13 PM CDT

Title: 3OCT2022 Console dimensions

Date: 3OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: record the dimensions of the console for later torque calculations

Content:

- I used a handheld ruler to approximately measure the dimensions of the console
- height: 7 5/8 inches
- width: 4 1/16 inches
- thickness: 2 1/4 inches at thickest point and 1 3/16 inches for the top slimmer region
- the exact dimensions were hard to obtain because of the fillets and curved shape of the console
- these measurements are an approximate only
- 

- 
- 

References: none

Conclusions:

Through discussion of the design dimensions and my research on motor torque calculations, I realized that we would need the approximate dimensions of the console. Therefore, I went to ECB today to measure them. They are approximations only because the fillets and curved design of the console makes it difficult to measure. Now that we know the dimensions, we can make better informed decisions moving forward.

Action items:

1. use these dimensions to plan our design dimensions
2. use these dimensions for motor torque calculations

12SEP2022 Brainstorming

ANNABEL FRAKE - Sep 12, 2022, 9:50 PM CDT

Title: 12SEP2022 Brainstorming

Date: 12SEP2022

Content by: Annabel Frake

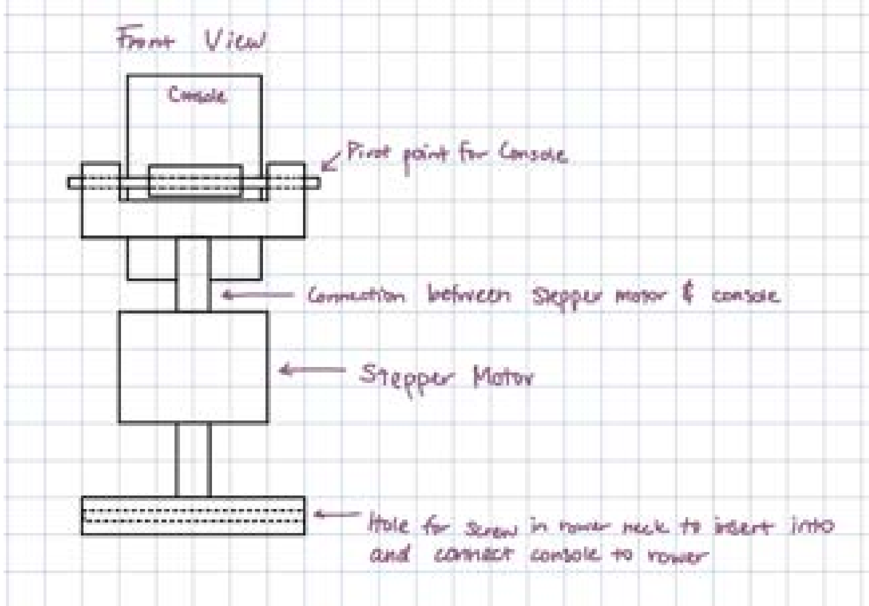
Present: Annabel Frake

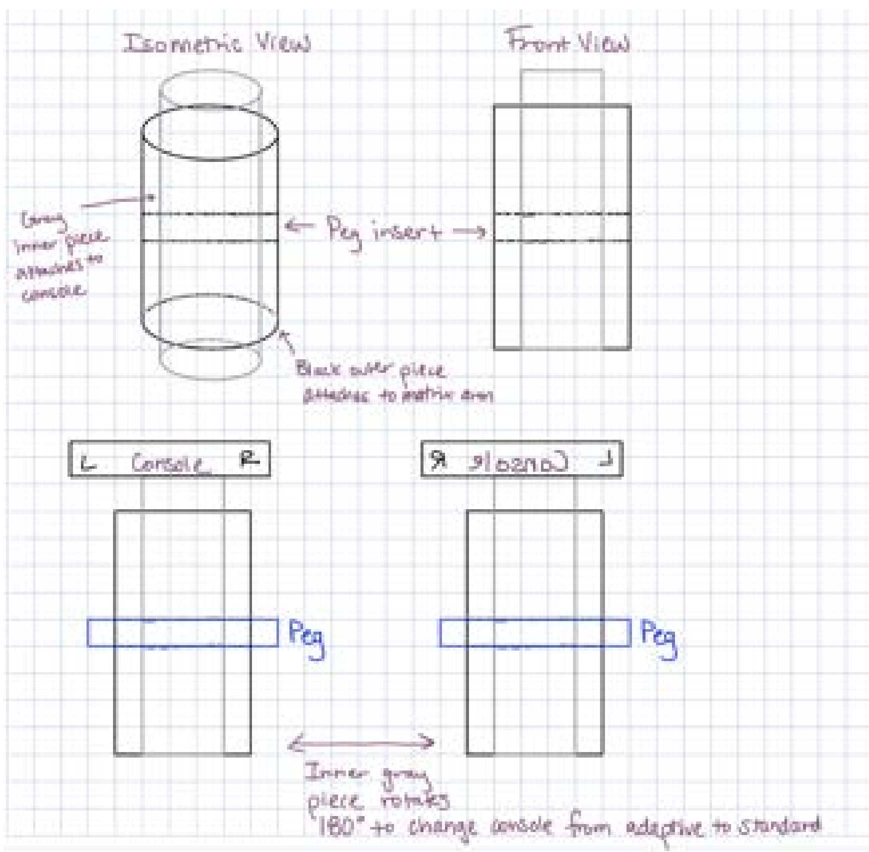
Goals:

- compile a list of questions to ask Josh, Sam, and Tim about last semester's design
- start brainstorming ideas for how to implement the design improvements

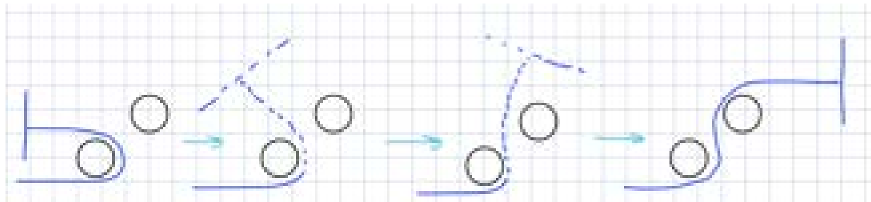
Content:

- List of questions for Josh, Sam, and Tim about last semester's design
    1. Can you explain each type of testing you conducted and why you chose to do it that way?
    2. Who were the participants for the rowing data collected?
    3. Who answered the survey questions you talked about in the final report?
    4. Why didn't you use a 45 deg angle for the cross brace of the wooden support base?
    5. Why did you make 4 peg holes on the console display rotating 3D print?
    6. Why did your future work state that the cut on the arm of the rowing machine needed to be sanded down?
- Ideas for the design improvements
    1. rotating console
        1. use a stepper motor to turn the 3D print and therefore the console
            - Use the same 3D print for the console, but instead of using the peg portion of it, connect that to a stepper motor
            - 

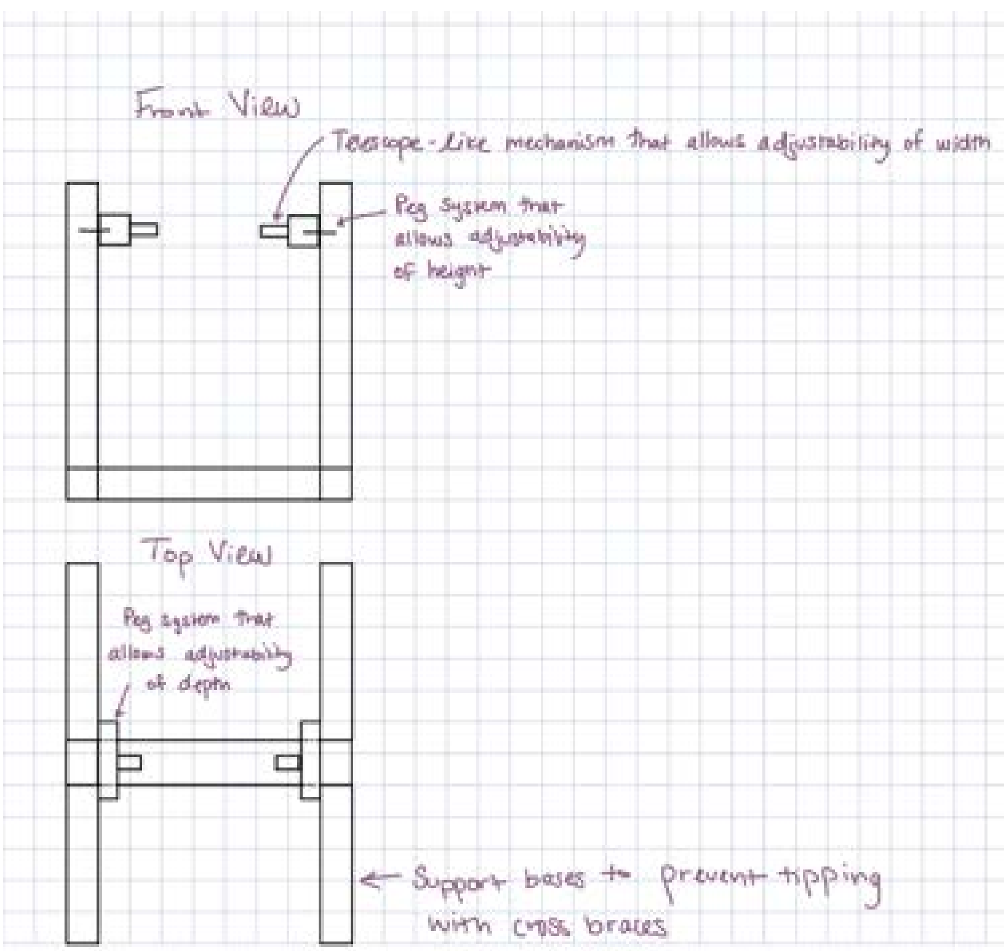
- 

2. instead of using a vertical peg, use a horizontal peg
    - You can use the same design for the console 3D print as they had before, expect use a horizontal peg
    - that way, you can rotate the console without taking it out of the fixture, you just spin it around 180 deg and replace the pin
    - you can even have a lock / ridge fit design that ensures the two pieces of the console 3D print can't come apart, simply rotate
    - 

2. way to remove tension in rope when transitioning between standard and adaptive sides
    1. remove upper arm and put the center console somewhere else

- this design would still use 2 pulleys with the 3D print from the current design, but with the upper arm gone, the rope would not have to be threaded through the slit and therefore may not need the tension removed to transition the rope
- this would require that the console is attached somewhere else, but the client had suggested moving it down, so the upper arm may not be needed anyway
- 

2. make a mechanism that can pull the rope out slightly to give freedom of motion, then hold/clamp the rope in place while the handlebar is being transitioned to the adaptive side from the standard or vice versa and then release the rope
    - maybe we can use electronics here?
    - Another question to ask is how far someone in a wheelchair needs to reach to move the handlebar from one side to another -- will have to try this when we meet in person...

3. adjustable wheelchair base
    - use peg lock-in mechanisms with steel
    - basically, the point of the base that needs to be adjustable is the top section that secures the rope to the wheelchair
    - although we may want to explore more secure ways to holding the wheelchair in place
    - however, with all of the sliding / pegs, the stability of that one point may weaken, so we would have to be cautious of that
    - 

4. chest brace

    1. incorporate a chest strap into the adjustable wooden base

References: previous design material

Conclusions:

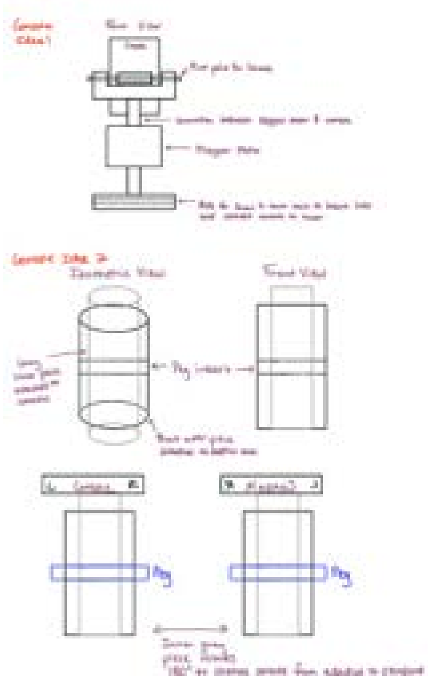
The team is meeting on Wednesday to discuss the current design from last semester and to continue to onboard Roxi and I to the project. Thus, I wanted to compile a list of questions to ask about the final report, as well as start brainstorming solutions to the implementation tasks we have for the upcoming year. For the console design, I think the best course of action would be to implement the horizontal peg system. However, if this is the place where we incorporate bioinstrumentation (instead of the tension removal mechanism), then it might be better to use a stepper motor. The vertical peg is definitely simpler, but it would still require more effort on the part of the user than pressing a button to rotate the console. As for the tension removal mechanism, I would like to explore the option of removing the upper portion of the arm and relocating the console. If the rope does not need to be guided through the slit, then perhaps the tension removal device is not needed. I would need to try moving the rope for myself in person to see if this idea is feasible (can try on Wednesday). Otherwise, we would need some clamping system to hold the rope in place while it is being repositioned. A potential issue here would be the amount of slack required to move the handlebar to the resting position on the adaptive side. The mechanism may need to introduce slack and then clamp the rope so that the handlebar can be transitioned properly. Lastly, the adjustable base could use a peg and hole system to change the position of the straps in height, depth, and width. This may have stability issues depending on the security of the sliding / peg mechanism, so we should be cautious of that. We could also add a chest strap to the adjustable base depending on how the structure of the base changes (if at all). This is simply initial brainstorming and will evolve as I discuss ideas with the team.

Action items:

1. meet with the team on Wednesday to discuss the previous design

2. continue to brainstorm

ANNABEL FRAKE - Sep 12, 2022, 9:41 PM CDT



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12SEP2022_Brainstorming_.pdf (518 kB)

ANNABEL FRAKE - Sep 15, 2022, 6:43 PM CDT

Title: 15SEP2022 Answers

Date: 15SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: record the answers I received from Sam, Josh, and Tim

Content:

- I had several questions for Josh, Sam, and Tim about the previous design
- I asked some of them, but haven't gotten to all of them yet

List of questions:

1. Can you explain each type of testing you conducted and why you chose to do it that way?
    - did not get to
2. Who were the participants for the rowing data collected?
    - the team members, some of their roommates, and some people Dr. Puccinelli asked to try the rower
3. Who answered the survey questions you talked about in the final report?
    - the team members, some of their roommates, and some people Dr. Puccinelli asked to try the rower
4. Why didn't you use a 45 deg angle for the cross brace of the wooden support base?
    - they intended to, but cut the angles wrong
5. Why did you make 4 peg holes on the console display rotating 3D print?
    - Sam didn't know why they chose that
6. Why did your future work state that the cut on the arm of the rowing machine needed to be sanded down?
    - did not get to

References: Sam, Josh, Tim

Conclusions:

The received answers to some of the questions I compiled in the entry above this one. The cross brace angle was supposed to be 45deg, but was cut incorrectly. The testing and survey participants were closely linked to the design / its members. I would suggest trying to randomize the survey / testing for this semester to create a more robust data set. Or, at least, get the opinion of more people and/or wheelchair users.

Action items:

1. ask remaining questions if applicable

15SEP2022 Tension Removal Brainstorming

ANNABEL FRAKE - Sep 15, 2022, 8:10 PM CDT

Title: 15SEP2022 Tension Removal Brainstorming

Date: 15SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: record an idea I had about the tension removal device and whether or not it is needed

Content:

see attached pdf of sketches

References: none

Conclusions:

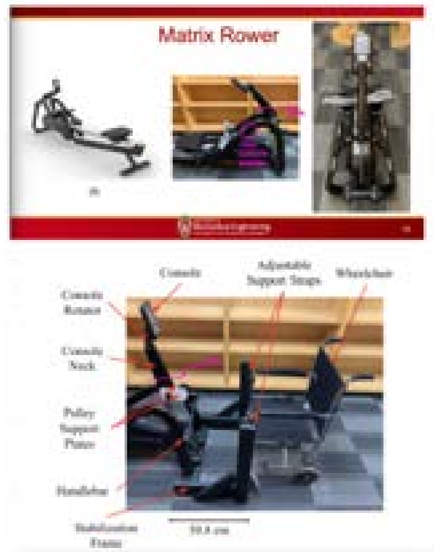
During our initial meeting with the client, she made a comment about moving the console. It made me realize that the only reason the arm extends above the pulley is to hold the console. Therefore, if we move the console to one of the side braces, we could remove the upper portion of the arm. This would eliminate the need for a slit to transition the rope from the standard side to the adaptive side and vice versa. Originally, I didn't think that this had too much merit because it would not solve the tension issue. However, if we move the handlebar (defined as the piece that holds the handle in place in my sketches) directly above the 2 pulley mechanism, then the tension removal mechanism may be unnecessary.

We wanted to remove the tension to make it easier to transition the handle. Anytime a user removes the handle from its holder, they have to deal with the tension. In other words, the tension removal device was proposed to make the transitioning easier, and not to make grabbing the handle easier. So, if we simply make the handle easier to grab from either side (more accessible), then the difficulty of transitioning is eliminated and the tension removal mechanism is obsolete (or an added bonus that is no longer as important because it is something that users already deal with). This design also has other benefits. For instance, the user no longer has to thread the rope through the slit in the arm (the rope won't fray or be damaged as easily). They only have to pick the handle up, move it around the handlebar (depending on how they placed the handle its holder, they may need to move the rope to the other side of the handlebar - shown in my sketches), and start rowing. It also reduces material costs and increases the simplicity of the design. I'm really excited to share my idea with the team!

Action items:

1. continue to brainstorm and share with the team

ANNABEL FRAKE - Sep 15, 2022, 7:56 PM CDT



Download

15SEP2022_Brainstorming.pdf (3.16 MB)

19SEP2022 Brainstorming for Design Matrices

ANNABEL FRAKE - Sep 19, 2022, 6:44 PM CDT

Title: 19SEP2022 Brainstorming for Design Matrices

Date: 19SEP2022

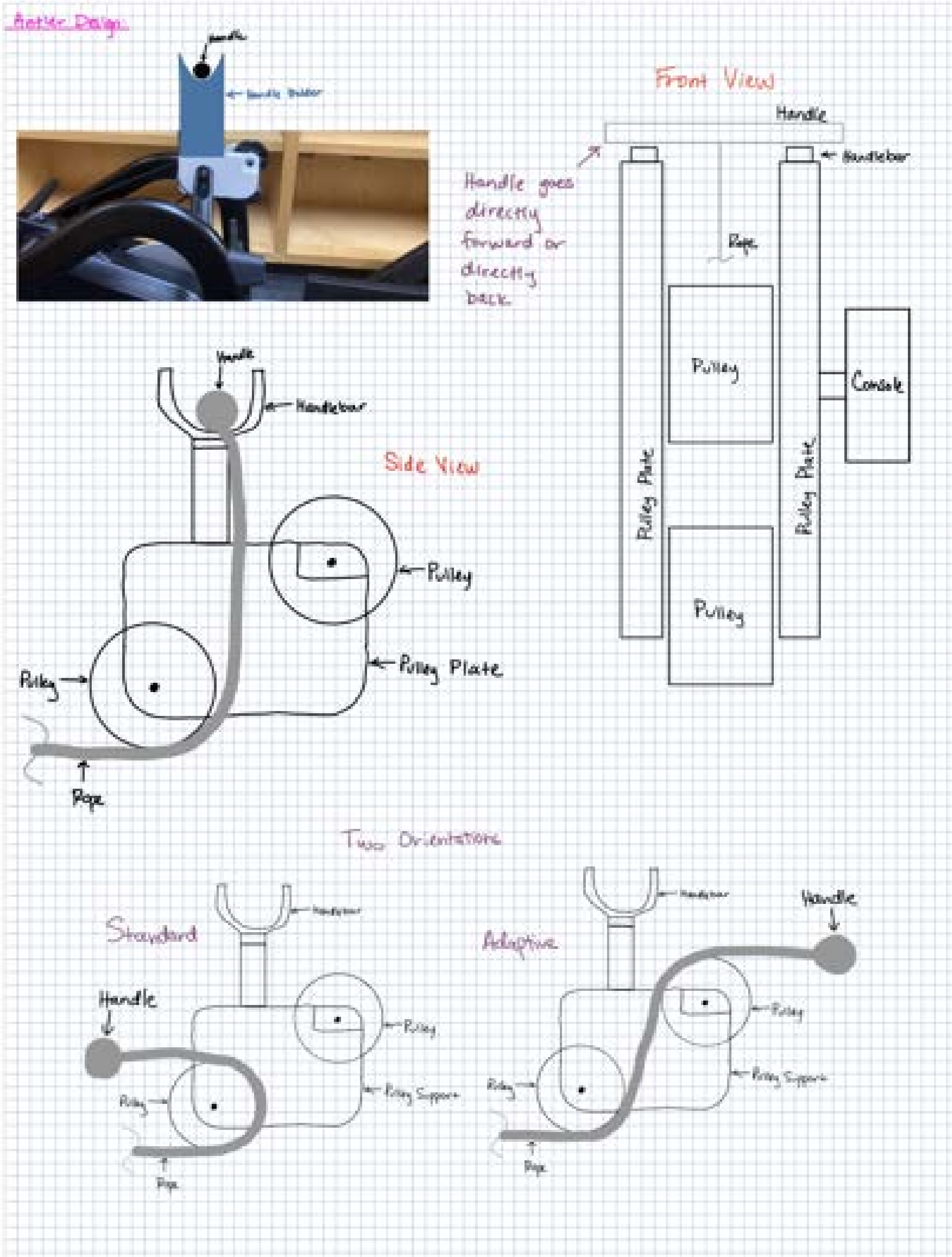
Content by: Annabel Frake

Present: Annabel Frake

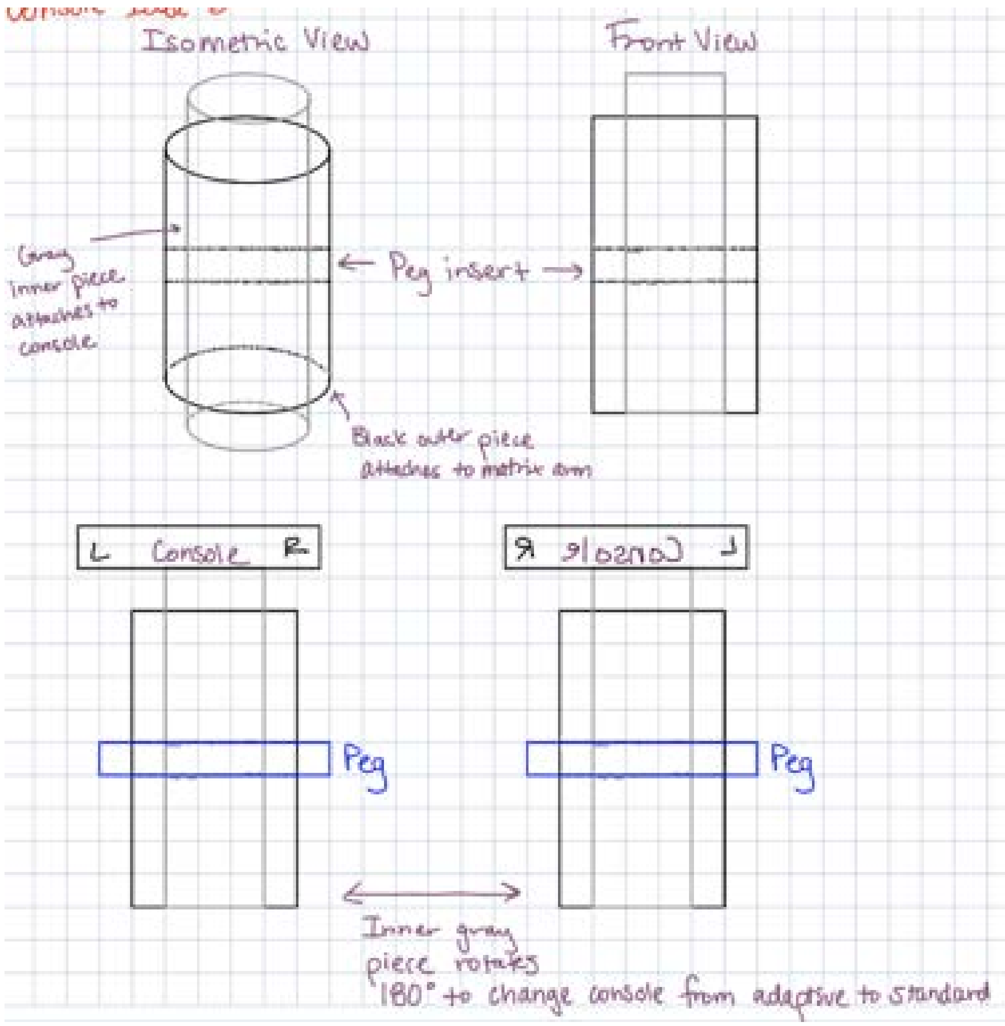
Goals: sketch some of the ideas we talked about during today's team meeting and think more about them

Content:

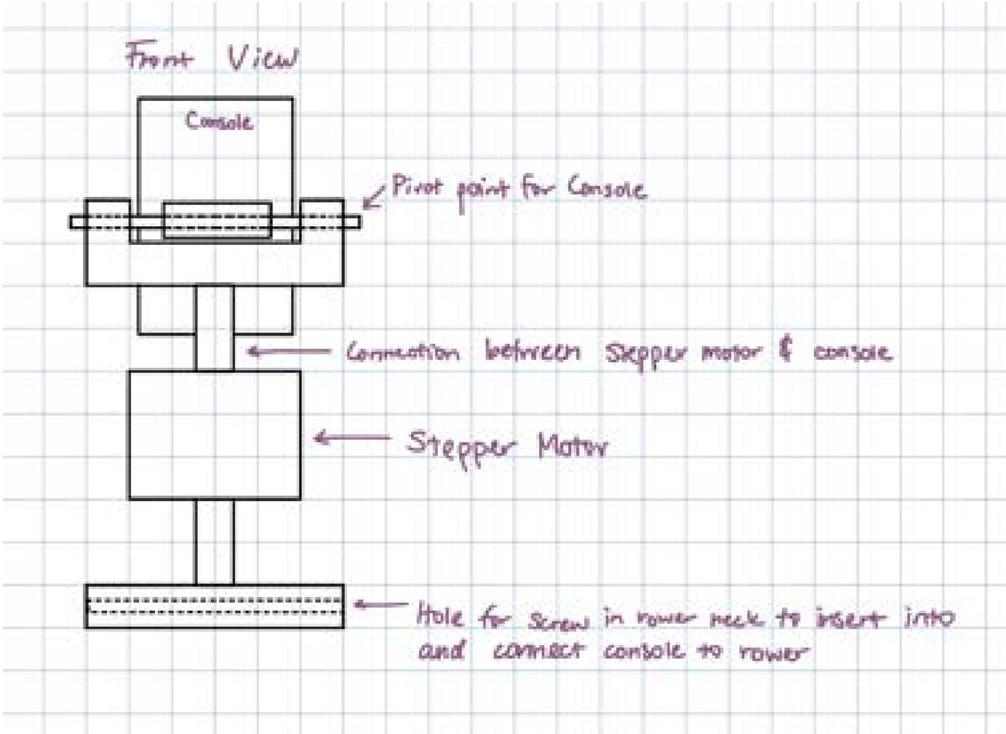
- Antler Design (3 in 1 Design)
    - Removal of the rower arm
    - combine pulley panel structure with handle holders and console holder (and then discuss console rotation designs)
    - connect the 2 pulley plates for added stability where it would not interfere with the rope
    - use 2 bolts to connect the pulley panels to the rower (holes already exist in rower, just need to add second hole in panels)

- 

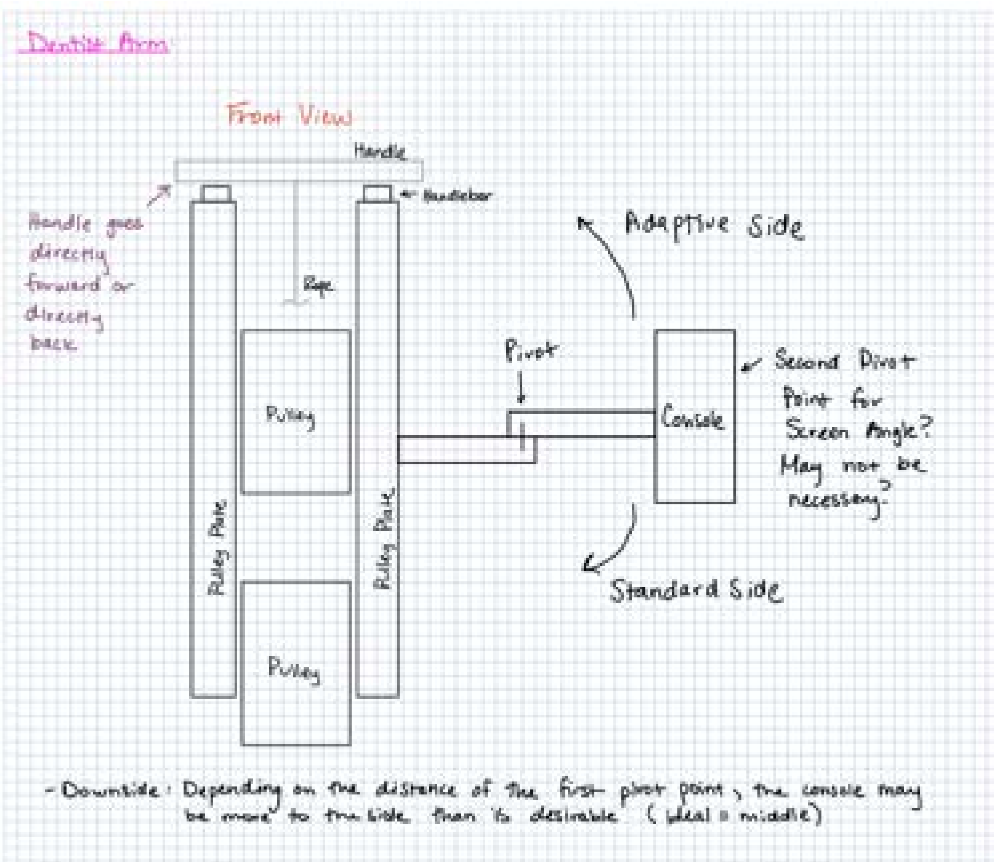
- Console Rotation Design
  - the more I think about it, the more I wonder if we should think about incorporating a stepper motor for this task
  - depending on the cost, it would make the design more user friendly, but would be more complex
  - Option 1: Manual Rotation with Pin
    - have console rotate around using rod inside of another rod
    - use a horizontal pin to secure in place
    - have channel that only allows rotation in one direction to avoid twisting the console's electrical wire

- 

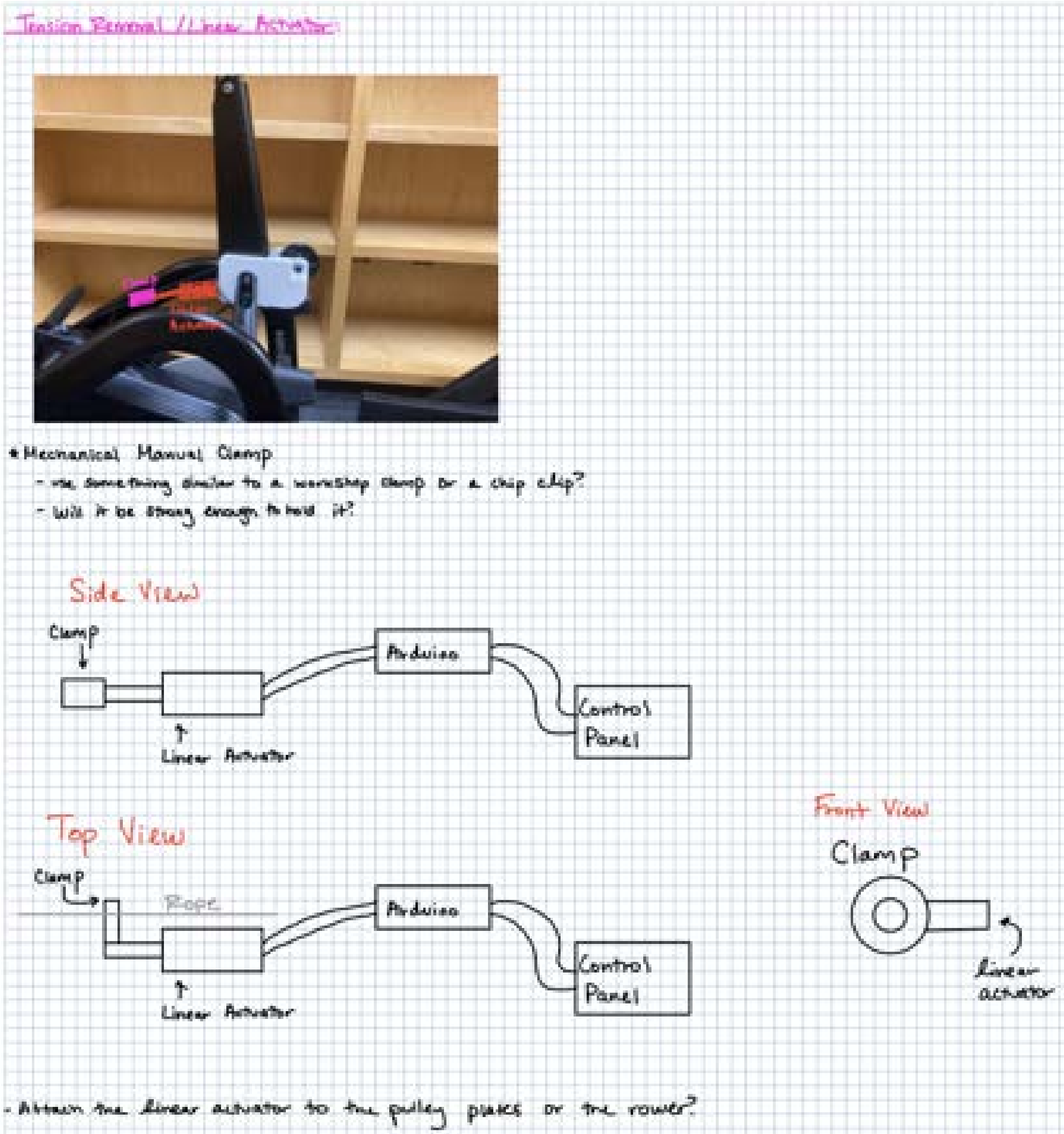
- Option 2: Electronic Rotation
    - use a stepper motor to rotate the console
    - build a 3D structure around the stepper motor to hold it in place
    - build a 3D structure to hold the console and place that on the stepper motor



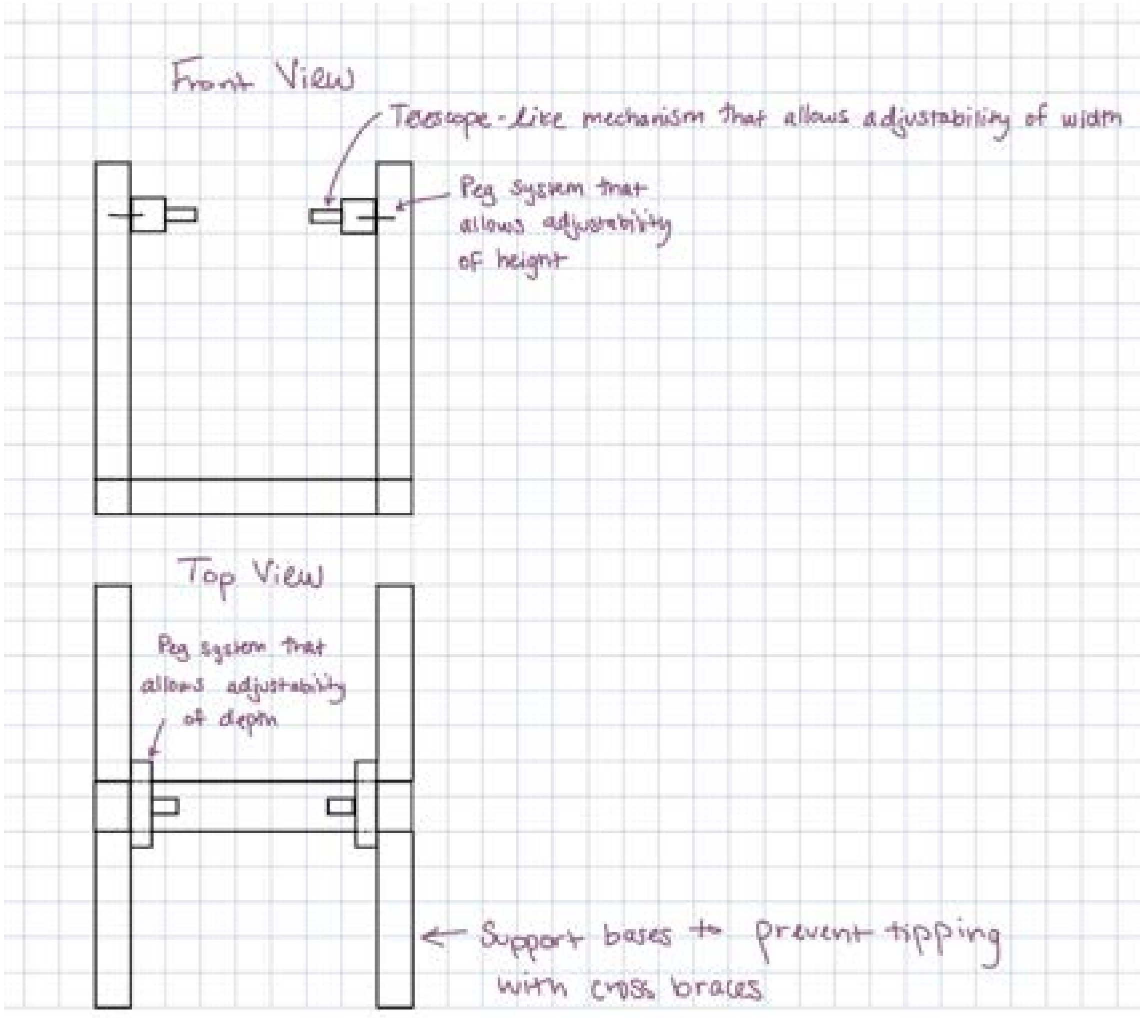
- Option 3: Dentist Arm Rotation
  - use a pivot point similar to dentist lights that allows console to swivel back and forth
  - use 2nd pivot point for rotating console around or utilize the manual rotation with pin idea here



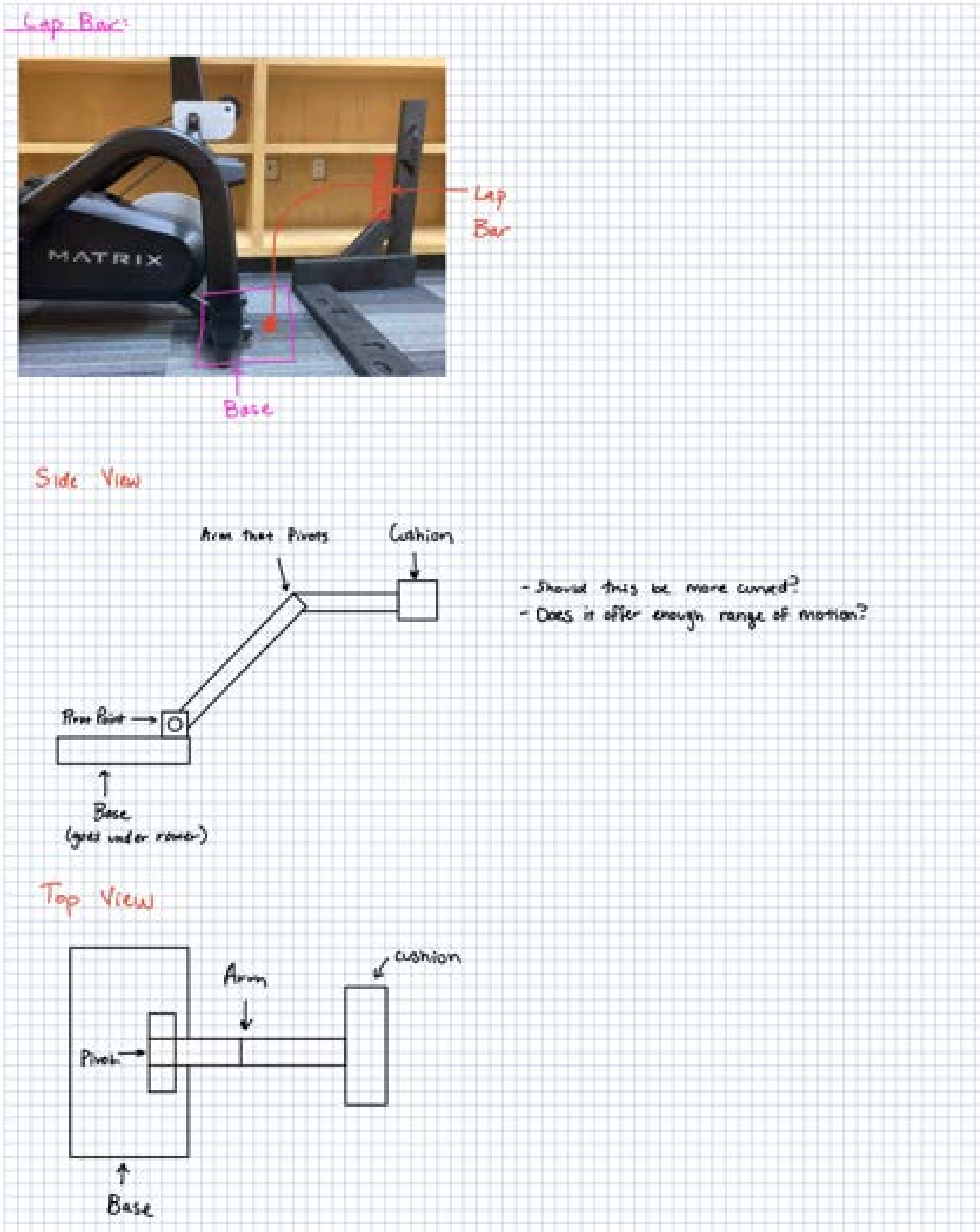
- Tension Removal Design (Linear Actuator)
  - create a manual mechanical clamp that holds the rope
  - then pull the rope back using a linear actuator that is connected to the mechanical clamp

  - allow the user to transition the rope
  - unclamp the mechanical clamp
  - allow the linear actuator to return to a "home" position
  - placed somewhere below pulley plates
  - 

- Adjustable Frame Design
  - adjust the positioning of the straps that attach to the wheelchair using a peg and hole design
  - need to adjust in the x, y, and z directions

- 

- Lap Bar Design
  - build a base that is held in place by the weight of the rower (similar to current wooden frame)
  - extend a lap bar from that point using a hinge or pivot point
  - allow lap bar to lock in place once it reaches user's legs
  - similar to roller coaster lap bars



References: none

Conclusions:

After our team brainstorming session, I wanted to compile sketches for each of the designs I believe we should consider moving forward. Some of the sketches are from previous entries of mine while some of them are new. Personally, I think we should create a design matrix for "Ease of Transition Between Standard and Adaptive" to compare the Antler (3 in 1) Design and the Tension Removal Mechanism/Linear Actuator design. Right now, I believe that the Antler design is the best option, but we need to create the design criteria and matrix to check that. As for the "Wheelchair and User Stability" design matrix, we should evaluate the Lap Bar design against the Adjustable Base design. We could also combine these two designs for added stability. It would help if we could test an early prototype of the lap bar design to determine whether that is sufficient or not. It would certainly be the simplest and cheapest (or at least it looks that way right now), but if it is not effective, then that doesn't do us much good. Roxi also suggested the idea based on the AROW competing design, so we may need to check on patent restrictions. We could also have a design matrix for the "Console Attachment/Rotation Mechanism" in which we compare an electronic version, the horizontal peg version, and a dentist arm-like design. This could be a place to incorporate bioinstrumentation. We would need to analyze whether the added usability of a push button was worth the additional cost and complexity. During the team meeting today, we briefly discussed a way to change the tension dial from the adaptive side, but didn't come up with any design ideas. We are going to save this of next semester because we want to ensure that we complete the other designs and they function really well (rather than spreading ourselves too thin). Then, we can focus on the tension dial (which can be adjusted by a wheelchair user before moving into the rowing position). This is also a way to potentially incorporate bioinstrumentation.

Action items:

1. discuss ideas with the team during our Wednesday meeting

ANNABEL FRAKE - Sep 19, 2022, 6:26 PM CDT

Download

19SEP2022_Brainstorming.pdf (0 B)

ANNABEL FRAKE - Sep 23, 2022, 2:39 PM CDT

Update: the file I previously uploaded is corrupted, so I re-uploaded the document.

ANNABEL FRAKE - Sep 23, 2022, 2:39 PM CDT

Download

19SEP2022_Brainstorming.pdf (17 MB)

24SEP2022 Electric Console Rotation Brainstorming

ANNABEL FRAKE - Sep 24, 2022, 8:13 PM CDT

Title: 24SEP2022 Electric Console Rotation Brainstorming

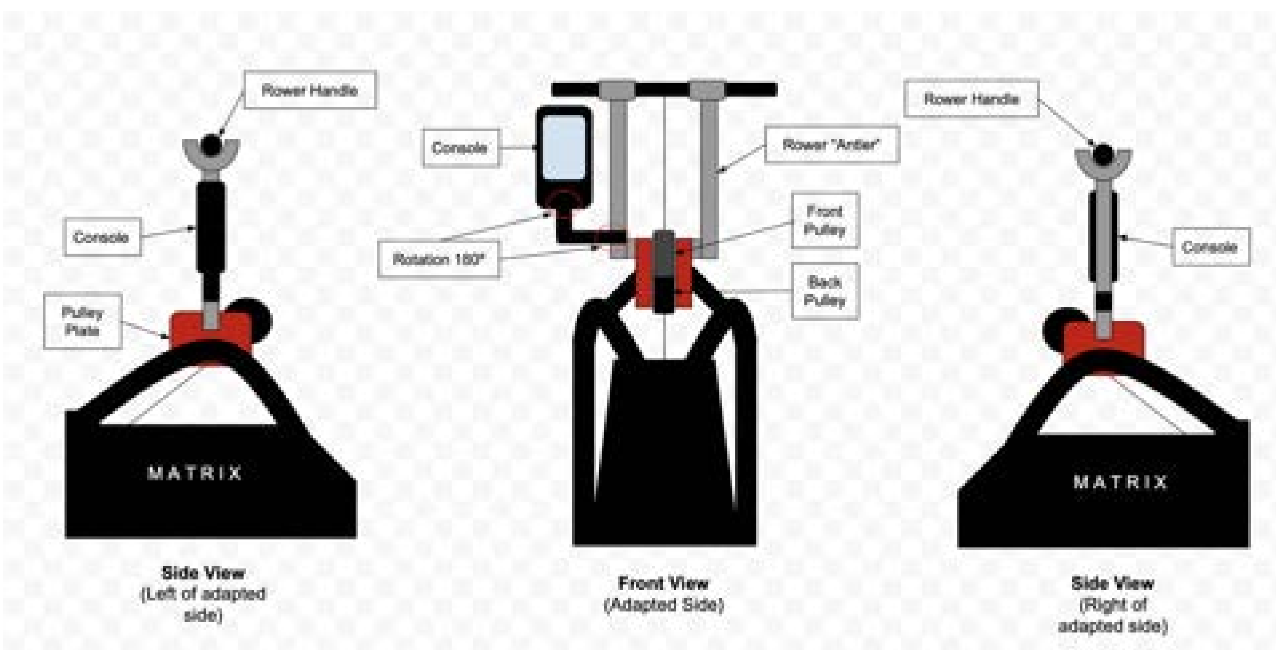
Date: 24SEP2022

Content by: Annabel Frake

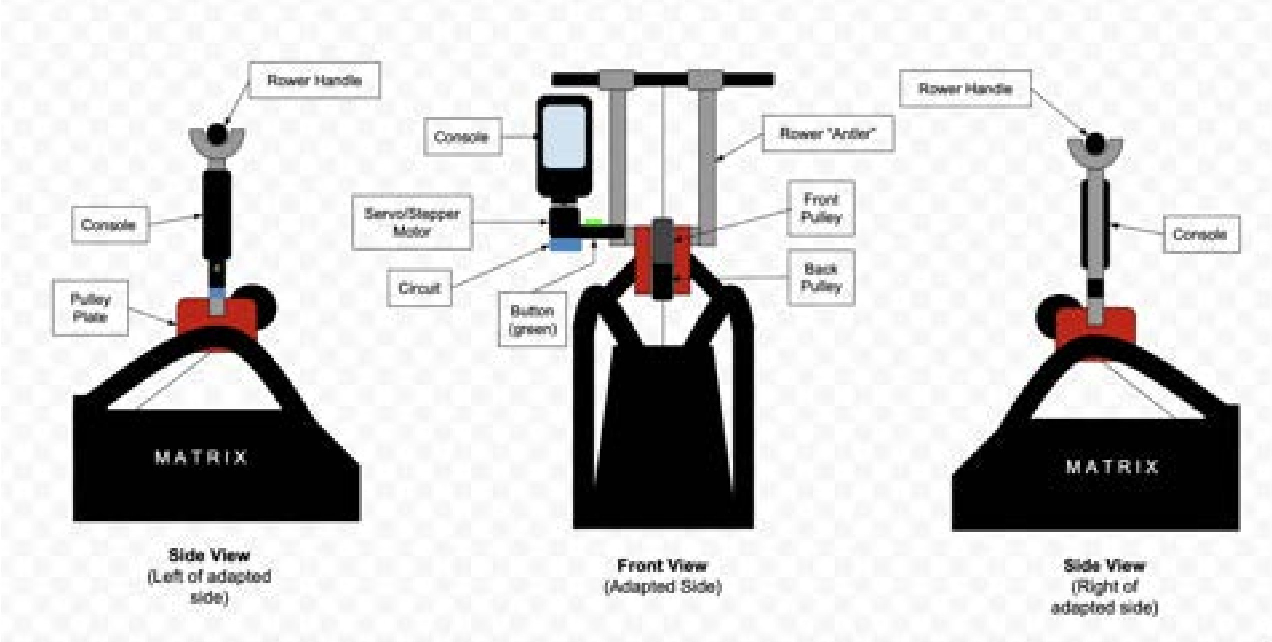
Present: Annabel Frake

Goals: think about ways to incorporate a servo motor into the console rotation design

Content:

- we could incorporate a servo motor into our console rotation mechanism
- by attaching the servo motor to one side of the pulley plate, we can then rest the console on top of the servo motor shaft
- we would need to consider weight of the console and the required torque to turn
- also, most servo hobby servo motors only turn 180 deg
    - that is all that we would need, but if the servo doesn't meet the specifications, we risk rotation slightly less than 180 deg
- we may also want to consider using a stepper motor (not sure if that would be overkill, but it would definitely work)
- I have used stepper motors in past projects, so it would be relatively easy to translate that knowledge to this project
- the stepper motor circuit and code is more complicated than a servo motor and is may be more expensive (depending on the components chosen)
- Roxi made some beautiful representations of the antler design and console
- 

- She allowed me to change her images to include the servo/stepper motor

- 

References: none

Conclusions:

I did some research on servo motors and leveraged previous research on stepper motors while brainstorming this design. It is difficult to decide which is the better motor type without knowing the weight of the console or the required torque to turn it. If it is relatively light, we may be able to get away with using a servo motor, which would be a simpler circuit and code. However, if the weight and torque are too great, we would need to use a stepper motor. I already have code and components that I know work for operating that type of circuit.

Basically, with this design, we would create an extension off of the pulley plate on one side. The motor would rest on that platform (could create a cutout to fit it exactly and then secure using screws). We would then 3D print a piece to connect the console to the motor (similar to their current design, but change the dimensions to fit the shaft of the motor. We would need to secure it to the shaft with glue or screws potentially. An Arduino and battery supply (and potentially a motor controller if we use a stepper motor) would be placed in an enclosed box on the platform or secured underneath it. There would then we a button accessible to both the standard user and wheelchair users.

Action items:

1. meet with Roxi and Josh to create the design matrix criteria for the console mechanism tomorrow

3OCT2022 Staci's Suggestions

ANNABEL FRAKE - Oct 03, 2022, 5:04 PM CDT

Title: 3OCT2022 Staci's Suggestions

Date: 3OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: think about Staci's suggestion

Content:

- the first slide is a suggestion for the locking mechanism: pin in plate, use linkages
- second slide: suggestion for changing the rotation point of the lap bar design
- During our last team meeting, we already decided to change the pivot point to the location that Staci suggested
- I also said that we could make that first bar vertical for greater stability of the frame, but Josh suggested keeping the angle would afford more room for the legs
- the main difference is the suggestion to swing the lap bar down when not in use
- this would decrease the amount of space it took up and would potentially make the limit switch placement easier
- it could be harder for a user to pull the lap bar up and then adjust it back down to secure themselves than to just bring it down from a higher resting position (current design)
- I will have to talk with Tim and Sam to see if they would like to do this because it will change my limit switch sketches for the prelim presentation

References: Staci Quam

Conclusions:

During our last client meeting, Staci told us that she would look into the clamping methods used at JHT. She sent us a presentation containing images of what is used in her office. She also made a suggestion about the pivot point of the lap bar design. We had already decided to move the pivot point to her suggested location, but I also like her suggestion about moving the lap bar completely down when not in use. It could simplify the placement of the limit switch slightly. However, it may be harder for a wheelchair user to lift up the bar and then bring it back down secure themselves than it would be to simply bring the bar down from a higher resting point. I will need to talk to Sam and Tim about this because if they change the design, it will alter the placement of the limit switch and my sketches for the prelim presentations.

Action items:

1. talk to Tim and Sam about how they think this will fit into their stabilization design
2. ask Tim and Sam if they want to have the lap bar rest down in the home state - ie if the limit switch placement needs to change

ANNABEL FRAKE - Oct 03, 2022, 4:53 PM CDT

Download

Adaptive_Rower_Stabilization_Design_Suggestion_by_Staci_Quam_.pptx (4.2 MB)

29SEP2022 Code Logic Brainstorming

ANNABEL FRAKE - Sep 29, 2022, 4:13 PM CDT

Title: 29SEP2022 Code Logic Brainstorming

Date: 29SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: start to map out the coding logic for the motor design for console rotation

Content:

- Basic Requirements:
    - must activate 180 deg turn of a motor with the press of a button
- Should we have 1 button that you press and it moves to the opposite orientation?
    - if you press the button, it moves to the opposite position
    - Rough draft of code below:

```
// Define button pin
byte const buttonPin = 1;
```

```
// Declare states for the button
int buttonState = HIGH;
```

```
// Define motor position for standard and adaptive orientations
int standardPosition = 0; // arbitrarily chosen, need to update once motor selection completed
int adaptivePosition = 180; // arbitrarily chosen, need to update once motor selection completed
```

```
void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);
```

```
  // Set up pinmodes for button using INPUT_PULLUP.
  pinMode(buttonPin, INPUT_PULLUP);

  // Motor Setup - add once motor selection completed
}
```

```
void loop()
{
```

```
  // Read state of the button.
  int lastButtonState = buttonState;
  buttonState = digitalRead(buttonPin);
  Serial.print("buttonState = ");
  Serial.println(buttonState);

  // Read current console position
  int consolePosition = ;  // Fill in later once motor selected

  if (lastButtonState != buttonState)
  {
   // If button pressed, rotate console to opposite orientation from current position
```

```
   // If console is on the standard side
   if(consolePosition == standardPosition)
   {
     // move motor such that consolePosition = adaptivePosition - fill in later after motor
selection
   }

   // If console is on the adaptive side
   if(consolePosition == adaptivePosition)
   {
     // move motor such that consolePosition = standardPosition - fill in later after motor
selection
   }
```

```
  }
    // Add delay to prevent multiple button state changes with single click.
    delay(200);
}
-----------------------------------------------------------------------------------------------------------------------------------------------------------------
```

- Or 2 buttons, one that moves to the standard side and one that moves to the adaptive side?
    - if you have 2 buttons, you could label them and maybe make it more intuitive for the user
    - you could also place the buttons on the side of the electronic compartment box instead of needing to place a button on the top face of the arm that supports the motor and console
    - Rough draft of code below:

```
// Define button pin
byte const standardButtonPin = 1;
byte const adaptiveButtonPin = 2;
```

```
// Declare states for the button
int standardButtonState = HIGH;
int adaptiveButtonState = HIGH;
```

```
// Define motor position for standard and adaptive orientations
int standardPosition = 0; // arbitrarily chosen, need to update once motor selection completed
int adaptivePosition = 180; // arbitrarily chosen, need to update once motor selection completed
```

```
void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);
```

```
  // Set up pinmodes for button using INPUT_PULLUP.
  pinMode(standardButtonPin, INPUT_PULLUP);
  pinMode(adaptiveButtonPin, INPUT_PULLUP);

  // Motor Setup - add once motor selection completed
}
```

```
void loop()
{
```

```
  // Read state of the standard button
  int lastStandardButtonState = standardButtonState;
  standardButtonState = digitalRead(standardButtonPin);
  Serial.print("standardButtonState = ");
  Serial.println(standardButtonState);

  // Read state of the adaptive button
  int lastAdaptiveButtonState = adaptiveButtonState;
  adaptiveButtonState = digitalRead(adaptiveButtonPin);
  Serial.print("adaptiveButtonState = ");
  Serial.println(adaptiveButtonState);

  // Read current console position
  int consolePosition = ;  // Fill in later once motor selected

  if (lastStanardButtonState != standardButtonState)
  {
```

```
    // If console is currently on the standard side, do nothing
    if(consolePosition == standardPosition)
    {
      // console already on standard side, do nothing
    }

    // If standard button is pressed and console is on adaptive side, rotate console to standard
position
    {
      // move motor such that consolePosition = standardPosition - fill in later after motor
selection
    }
  }
  else if (lastAdaptiveButtonState != adaptiveButtonState)
  {
    // If console is currently on the adaptive side, do nothing
    if(consolePosition == adaptivePosition)
    {
      // console already on adaptive side, do nothing
    }
```

```
    // If adaptive button is pressed and console is on standard side, rotate console to adaptive
position
    {
      // move motor such that consolePosition = adaptivePosition - fill in later after motor
selection
    }
  }
    // Add delay to prevent multiple button state changes with single click.
    delay(200);
}
```

** These are only a rough draft of the code required. Will need to change after motor selection. Can also streamline using functions for some of it (especially code with 2 buttons).

References: none

Conclusions:

I wanted to start thinking about ways to code the button logic for the motor design of the console rotational mechanism. We could either have one button that moves the console between the two states and automatically goes to the opposite side after the button is pressed. Or, we could have two buttons, one dedicated to the standard side and one dedicated to the adaptive side. I wrote up rough drafts of each code, but they will need to be changed once we select a motor. The library/commands for servo motors and stepper motors differ, so I cannot fill that in until later. Additionally, I can make some of the code more streamlined using functions. Especially for the two button code.

Action items:

1. Keep brainstorming the coding logic and the motor circuitry

2OCT2022 Limit Switch Idea

ANNABEL FRAKE - Oct 02, 2022, 5:22 PM CDT

Title: 2OCT2022 Limit Switch Idea

Date: 2OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: brainstorm how the limit switch idea our client suggested would work

Content:

- during our client meeting this week, Staci suggested that we move the button to the lap bar for easier accessibility
- then she wondered if we could make the console rotation automatic based on the positioning of the lab bar using a limit switch
- I have used limit switches for motion related trigger actions before and am fairly confident we could do it will minimal extra effort
- We would place the limit switch above the lap bar arm such that the lever is depressed when the arm is in its home position
- as the lap bar is lowered to secure the wheelchair user, the switch is unpressed and that will trigger the console to rotate to the adaptive side
- in the code, we would read the state of the limit switch and then use if statements to move the motor depending on that information
- I made a coding logic diagram for what needs to happen depending on the state of the limit switch (pdf attached to this entry)
- I also updated the sketches for the motor design by removing the button and cleaning up some of the dimension lines
- Then, I used Sam and Tim's sketch of the lap bar design and added a limit switch to show the placement of the electronics
- we could not put the limit switch underneath the bar because the amount that the bar is lowered will vary by wheelchair and user
- we also want to be careful not to push the bar too far into the limit switch that we break it
- therefore, we need a stop block mechanism to prevent that
- this design is also dependent on the user putting the lap bar back in its home base position after the workout
- we may also want to create a delay of some kind so that someone adjusting the lap bar a lot will not trigger the response an unnecessary number of times

References: none

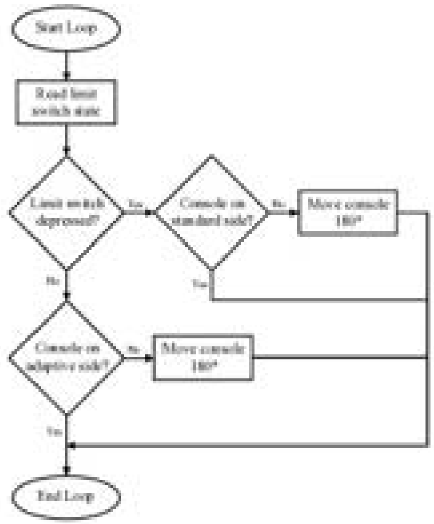
Conclusions:

After speaking with the client about using a limit switch, I did some more brainstorming on the placement of that switch and how the coding logic would work. Based on my research of limit switches, we would have two states. When the lap bar is in its home position, the code will read the state of the limit switch (pressed) and then check if the console is in the standard or adaptive orientation. If the console is in the standard position, nothing will happen and if the console is on the wheelchair side, the motor will activate and rotate to the standard side. Once the bar is lowered to secure the wheelchair user, the limit switch will no longer be pressed and the code will check the position of the console. If the console is in the adaptive orientation, nothing will happen but if the console is in the standard orientation, the console will move to be on the adaptive side. We will need to secure the limit switch above the bar such that it is depressed when the bar is fully up and no longer depressed once the bar moves down to the first adjustable locking position. The wires for the limit switch will need to run along the lap bar structure to the electronics housing box on the antler portion of the Matrix machine.

Action items:

1. continue to brainstorm fabrication of this idea
2. add this info to the prelim presentation
3. start coding

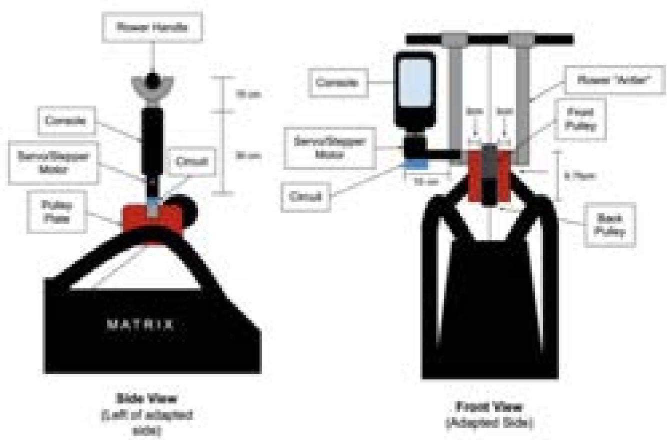
ANNABEL FRAKE - Oct 02, 2022, 4:00 PM CDT



[Download](#)

Motor_Coding_Logic_Using_Limit_Switch.pdf (32.9 kB)

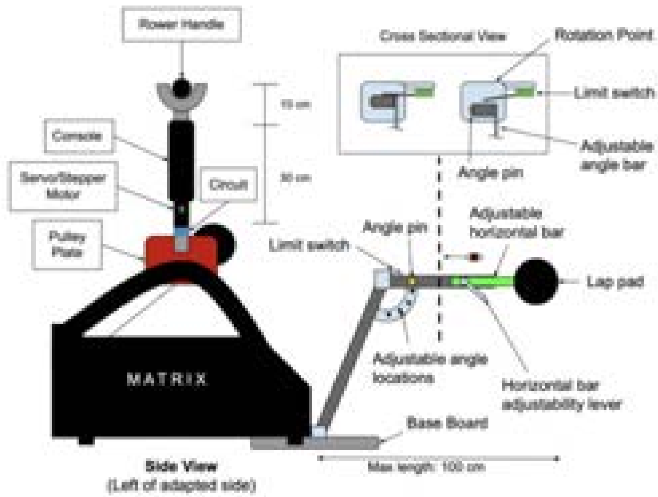
ANNABEL FRAKE - Oct 02, 2022, 4:17 PM CDT



[Download](#)

Screen_Shot_2022-10-02_at_4.13.30_PM.png (224 kB) Sketches of the servo/stepper motor design for the console rotational mechanism.

ANNABEL FRAKE - Oct 02, 2022, 5:06 PM CDT



Download

Screen_Shot_2022-10-02_at_5.04.48_PM.png (249 kB) This image shows the placement of the limit switch on the lap pad bar.

13OCT2022 Reflection on Client's Feedback

ANNABEL FRAKE - Oct 13, 2022, 7:49 PM CDT

Title: 13OCT2022 Reflection on Client's Feedback

Date: 13OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: think about the client's feedback and come up with responses for the questions related to the console rotational mechanism

Content:

- Josh emailed Staci our preliminary report, and she sent the following response:

RE: Adaptive Rowing Machine Preliminary Report

Staci Quam <Staci.Quam@johnsonfit.com>

Wed 10/12/2022 10:27 AM

To: Josh ANDREATTA <jandreatta@wisc.edu>;Tracy Jane Puccinelli <tracy.puccinelli@wisc.edu>

Cc: SAMUEL GLOVER SKIRPAN <skirpan@wisc.edu>;ANNABEL HOLLISS FRAKE <frake@wisc.edu>;ROXI MORGYN REUTER <rmreuter@wisc.edu>;Tim TRAN <ttran28@wisc.edu>

Hi Team!

Good work, I am really excited by how this project is coming together. The antler design is an approach I had never considered before so I am loving how it is developing.

I have three things I would like you to think about before Friday.

1. Order of operation for the user; If you were in a wheelchair and rolled up to this rower, what order would you do the adjustments? This is important for evaluating the usability of the adjustments as they stand or if linkages must be designed to make them more reachable.
2. What is the "not in use" position and why?: When there is no user, is the intent to have the stabilization frame straight up, folded down or sticking out? This will affect the logic for your limit switch because the limit switch needs to know that the stabilization bar is at different angles for different user heights. I do have an opinion, but I can be swayed by your decision points if you have a different opinion than me.
3. I know that the coding flowchart is not the final, but I did want to let you know that you have extra conditional blocks. The conditional block of "Limit switch depressed?" should be the only conditional block you need because from there you will know if the console needs to more 180deg or not. The other logic question I have is, are you planning on using poling or interrupt for reading the limit switch state?

Reading through the materials described for the design, I recommend using steel for the stabilization frame design because it is more readily available in our shop. The Team will also be able to be part of the initial prototype fabrication, we will just need to coordinate a time. We have a perf tube library that can be used and does not require any welding.

Is the calendar for the presentations set in advance? If so, if you send it my way I can add those dates to my work calendar so that I can make sure to not have any interfering meetings.

Thanks, and talk to you soon.

Staci Quam
Project Engineer III, Biomechanics Lab Lead & CAD Administrator (North America)

From: Josh ANDREATTA <jandreatta@wisc.edu>
Sent: Wednesday, October 12, 2022 7:32 AM
To: Staci Quam <Staci.Quam@johnsonfit.com>; Tracy Jane Puccinelli <tracy.puccinelli@wisc.edu>
Cc: SAMUEL GLOVER SKIRPAN <skirpan@wisc.edu>; ANNABEL HOLLISS FRAKE <frake@wisc.edu>; ROXI MORGYN REUTER <rmreuter@wisc.edu>; Tim TRAN <ttran28@wisc.edu>
Subject: Adaptive Rowing Machine Preliminary Report

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Dear Staci,

Attached below is a link to our preliminary report, and a pdf incase the link does not work. Please let us know if you have any questions or any feedback! We look forward to meeting with you this Friday from 1:35-2:05 on teams for our bi-weekly check in! Thank you!

https://bmedesign.engr.wisc.edu/projects/f22/adaptive_rower/file/view/bd4f0c76-ae4e-41ae-97cd-952fe2fe820d/Adaptive%20Rowing%20Machine%20BME%20400%20Preliminary%20Report.pdf

Best,
Josh Andreatta & Team

- I wanted to reflect on her questions so that I am prepared to talk about them at our client meeting tomorrow

1. Order of operation:
    1. roll wheel chair up to lap bar
    2. adjust the horizontal bar length for the correct reach distance
    3. adjust the rotation of the lap bar for the correct height
    4. row

- Depending on what is adjusted first, the console may or may not have been triggered to rotate towards the wheelchair user yet

- I am curious to see what Tim and Sam think on this one since it is their design

2. Resting position of the lap bar

- originally, we had planned to have the lap bar be at a slight positive angle from the horizontal plane

- I had suggested having the lap bar straight up, but we didn't go with that idea

- after seeing Staci's question, I think we should reconsider having it be straight upwards at rest

- I don't think it should be down because that would be more difficult for a user to raise up and then secure over their lap from a wheelchair (have to be far enough out or to the side to have it swing up)

- It could be sticking out like in our prelim design photos, but this would take up more space than putting the lap bar in an upright position

3. Coding flowchart and poling vs interrupt

- if we use a servo motor, then you can use the servo library to rotate the console to x angle and if it already at that angle and the code tells it to move there, nothing will happen (it essentially does the check for us)

- if we use a stepper motor, we would use the stepper library to say more in this direction for x amount of time, and that would be determined such that it rotates 180 degrees

- if there is no check for the position of the console, then the motor would just keep rotating each time it checks the limit switch state (for the way I have the code laid out right now)

- for example, if the limit switch is depressed and the motor moves to the wheelchair side (ie rotate counterclockwise 180 deg), and then it checks the limit switch again and it is still depressed, the code would rotate counterclockwise 180 degrees again

- there could also be implications if a user moves the lap bar in such a way that it presses and depresses the limit switch multiple times in the span of a few sections (not sure what this would do because it depends on how fast the stepper motor rotates the console to the new position)

- unless we write the code in such a way that if it moved to one side, a boolean value becomes true/false and you cannot enter the if loop to move to that position again (but this is essentially checking the position like I have previously described and is still a conditional block)

- we could have a boolean value standardState and then when it is true, we are in standard state, when false, we are in the adaptive state

- then you could have a conditional statement for whether the motor should move based on this boolean value (ex: if standardState = 1 and limit switch is pressed, do nothing vs if standardState = 0 and limit switch is pressed, move console to standard side)

- I completed some preliminary research on polling vs interrupts (see entry "13OCT2022 Poling vs Interrupt?" under Technical Information in the Research Notes folder)

- I have only ever used polling in past projects, but it looks like interrupt is a useful tool

- I'm not sure whether we need it for this project though because the only thing we are planning on doing is monitoring the state of the limit switch and moving the motors accordingly

- interrupt might consume less battery power, but I'm not sure

- I will discuss this with the team and client at tomorrow's meeting

References: Staci Quam

Conclusions:

After reading our preliminary report, Staci provided us with some feedback. I used this entry to think about her questions and form my own opinions on what should be done. Tomorrow, I will talk to the team about it before our client meeting and then we can have a discussion with Staci about what we have decided / what she thinks we should do.

Action items:

1. meet with the team and client to discuss

16OCT2022 Code Development

ANNABEL FRAKE - Oct 16, 2022, 9:14 PM CDT

Title: 16OCT2022 Code Development

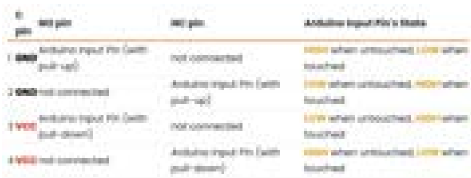
Date: 16OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: start to develop the code for the project

Content:

- https://arduinogetstarted.com/tutorials/arduino-limit-switch:
    - use ezButton library to debounce limit switch
    - 

# pin	NO pin	NC pin	Arduino Input Pin's State
1 GND	Arduino input Pin (with pull-up)	not connected	HIGH when untouched, LOW when touched
2 GND	not connected	Arduino input Pin (with pull-up)	LOW when untouched, HIGH when touched
3 VCC	Arduino input Pin (with pull-down)	not connected	LOW when untouched, HIGH when touched
4 VCC	not connected	Arduino input Pin (with pull-down)	HIGH when untouched, LOW when touched

    - can swap GND pin and Arduino input, so have 8 total options

```
/*
 * Created by ArduinoGetStarted.com
 *
 * This example code is in the public domain
 *
 * Tutorial page: https://arduinogetstarted.com/tutorials/arduino-limit-switch
 */

#include <ezButton.h>

ezButton limitSwitch(7);  // create ezButton object that attach to pin 7;

void setup() {
  Serial.begin(9600);
  limitSwitch.setDebounceTime(50); // set debounce time to 50 milliseconds
}
```

```
void loop() {
 limitSwitch.loop(); // MUST call the loop() function first

 if(limitSwitch.isPressed())
  Serial.println("The limit switch: UNTOUCHED -> TOUCHED");

 if(limitSwitch.isReleased())
  Serial.println("The limit switch: TOUCHED -> UNTOUCHED");

 int state = limitSwitch.getState();
 if(state == HIGH)
   Serial.println("The limit switch: UNTOUCHED");
 else
   Serial.println("The limit switch: TOUCHED");
}
```

- https://arduinogetstarted.com/faq/why-needs-debounce-for-button:
  - if you don't debounce...
    - 1 button press will be detected as several
    - single button count will be counted multiple times
  - happens because of physical and mechanical issues
  - called chattering or debounce phenomenon
  - when you need debounce: detecting if button pressed or released, counting button presses
  - when you don't need debounce: if state is high, turn on LED; if low, turn off LED
- https://www.arduino.cc/reference/en/language/functions/external-interrupts/attachinterrupt/:
  -
    - **LOW** to trigger the interrupt whenever the pin is low,
    - **CHANGE** to trigger the interrupt whenever the pin changes value
    - **RISING** to trigger when the pin goes from low to high,
    - **FALLING** for when the pin goes from high to low.

BOARD	DIGITAL PINS USABLE FOR INTERRUPTS
Uno, Nano, Mini, other 328-based	2, 3
Uno WiFi Rev.2, Nano Every	all digital pins
Mega, Mega2560, MegaADK	2, 3, 18, 19, 20, 21 (**pins 20 & 21** are not available to use for interrupts while they are used for I2C communication)
Micro, Leonardo, other 32u4-based	0, 1, 2, 3, 7
Zero	all digital pins, except 4
MKR Family boards	0, 1, 4, 5, 6, 7, 8, 9, A1, A2
Nano 33 IoT	2, 3, 9, 10, 11, 13, A1, A5, A7
Nano 33 BLE, Nano 33 BLE Sense	all pins
Due	all digital pins
101	all digital pins (Only pins 2, 5, 7, 8, 10, 11, 12, 13 work with **CHANGE**)

- Arduino Function Reference List: https://www.arduino.cc/reference/en/

* See attached code

References:

"Arduino - Limit Switch | Arduino Tutorial," *Arduino Getting Started*. https://arduinogetstarted.com/tutorials/arduino-limit-switch (accessed Oct. 16, 2022).

"Why needs debounce for button | Arduino FAQs," *Arduino Getting Started*. https://arduinogetstarted.com/faq/why-needs-debounce-for-button (accessed Oct. 16, 2022).

"attachInterrupt() - Arduino Reference." https://www.arduino.cc/reference/en/language/functions/external-interrupts/attachinterrupt/ (accessed Oct. 16, 2022).

"Arduino Reference - Arduino Reference." https://www.arduino.cc/reference/en/ (accessed Oct. 16, 2022).

Conclusions:

After thinking more about the motor selection and asking advice from people, I came to the conclusion that the required torque is less important than the stall weight of the motor and the sturdiness of the motor shaft. The torque would be more applicable if we were trying to force something to rotate, but we aren't. We are just rotating the motor with the console on top of it. Therefore, the motor mostly just needs to withstand the weight of the console. It is also important that the console be attached well to the shaft. It would be better if this connection had notches as well. For these reasons, it seems like a stepper motor would be the better choice. However, I was looking through my own electronic components and realized that I have a baby servo motor and a stepper motor. Before I make any motor selection for purchase, I plan to try the motors I have to see which ones work. I don't have the right USB connector to go to my Arduino Uno, so I am going to look for one at the MakerSpace tomorrow. Then, I will be able to test the preliminary code I wrote tonight to see if I used the interrupts and debouncing correctly.

Action items:

1. continue to develop code
2. purchase USB connector so that I can test code using my own components

ANNABEL FRAKE - Oct 16, 2022, 8:46 PM CDT

```
// Code for Servo Motor
```

```
// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Code for rotating the console of the Matrix rowing machine between the
standard and adpative sides.
```

```
//Include servo library and debounce library
#include <Servo.h>;
#include <ezButton.h>;

// Define pins
const byte limitSwitchPin = 2;
const byte servoPin = 9;

// Create servo object to control a servo motor
Servo servo;

// Create ezButton object that matches the limit switch
ezButton limitSwitch(limitSwitchPin);

// Define servo position for standard and adaptive orientations
int standardPosition = 0; // arbitrarily chosen
int adaptivePosition = 180; // arbitrarily chosen

void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);

  // Assign the servo motor to servoPin
  servo.attach(servoPin);

  // Assign the limit switch with a debounce time of 50 milliseconds
  limitSwitch.setDebounceTime(50);

  // Define interrupt for limitSwitchPin whenever there is a change of state. Complete rotate
function.
  attachInterrupt(digitalPinToInterrupt(limitSwitchPin), rotate, CHANGE);
}

void loop()
{
  // Call the loop() function for the limit switch
  limitSwitch.loop();
}

void rotate()
{
  // If limit switch is pressed, standard side in use. Rotate console to standardPosition.
  if(limitSwitch.isPressed())
  {
    servo.write(standardPosition);
    Serial.println("Console position: standard");
  }

  // If limit switch is not pressed, adaptive side in use. Rotate console to adaptivePosition.
  if(limitSwitch.isReleased())
  {
    servo.write(adaptivePosition);
    Serial.println("Console position: adaptive");
```

```
  }
}
```

ANNABEL FRAKE - Oct 16, 2022, 9:04 PM CDT

```
// Code for Stepper Motor

// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Code for rotating the console of the Matrix rowing machine between the standard
and adaptive sides.

//Include stepper library and debounce library
#include <Stepper.h>
#include <ezButton.h>;

// Define pins
const byte limitSwitchPin = 2;
const byte stepperPin = 9;

// Create ezButton object that matches the limit switch
ezButton limitSwitch(limitSwitchPin);

// Number of steps per output rotation
const int stepsPerRevolution = 200;

// Create stepper object to control a stepper motor
Stepper stepper(stepsPerRevolution, 3, 4, 5, 6);

// Number of steps per half rotation
const int stepsPerHalfRevolution = stepsPerRevolution / 2;

// Define servo position for standard and adaptive orientations
int stepsToStandard = stepsPerHalfRevolution;
int stepsToAdaptive = -stepsPerHalfRevolution;

// Define boolean for whether the stepper motor is on the standard side or not
boolean standard = true;

void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);

  // Set the motor speeds at 40 rpm.
  stepper.setSpeed(40);

  // Assign the limit switch with a debounce time of 50 milliseconds
  limitSwitch.setDebounceTime(50);

  // Define interrupt for limitSwitchPin whenever there is a change of state. Complete rotate
function.
  attachInterrupt(digitalPinToInterrupt(limitSwitchPin), rotate, CHANGE);

  // Read state of limit switch when program initiates to define standard boolean value
  standard = digitalRead(limitSwitchPin);
  Serial.println("Initial boolean standard state = " + standard);
}
```

```
void loop()
{
  // Call the loop() function for the limit switch
  limitSwitch.loop();
}

void rotate()
{
  // If limit switch is pressed, standard side in use. Rotate console to standardPosition.
  if(limitSwitch.isPressed() && !standard)
  {
    stepper.step(stepsToStandard);
    standard = true;
    Serial.println("Console position: standard");
  }

  // If limit switch is not pressed, adaptive side in use. Rotate console to adaptivePosition.
  if(limitSwitch.isReleased() && standard)
  {
    stepper.step(stepsToAdaptive);
    standard = false;
    Serial.println("Console position: adaptive");
  }
}
```

ANNABEL FRAKE - Oct 16, 2022, 9:05 PM CDT

Download

Servo_Motor_Example_Code.ino (421 B)

ANNABEL FRAKE - Oct 16, 2022, 9:05 PM CDT

Download

Stepper_Code_With_Limit_Switch_Interrupt.ino.ino (2.22 kB)

17OCT2022 Code Development

ANNABEL FRAKE - Oct 17, 2022, 7:36 PM CDT

Title: 17OCT2022 Code Development

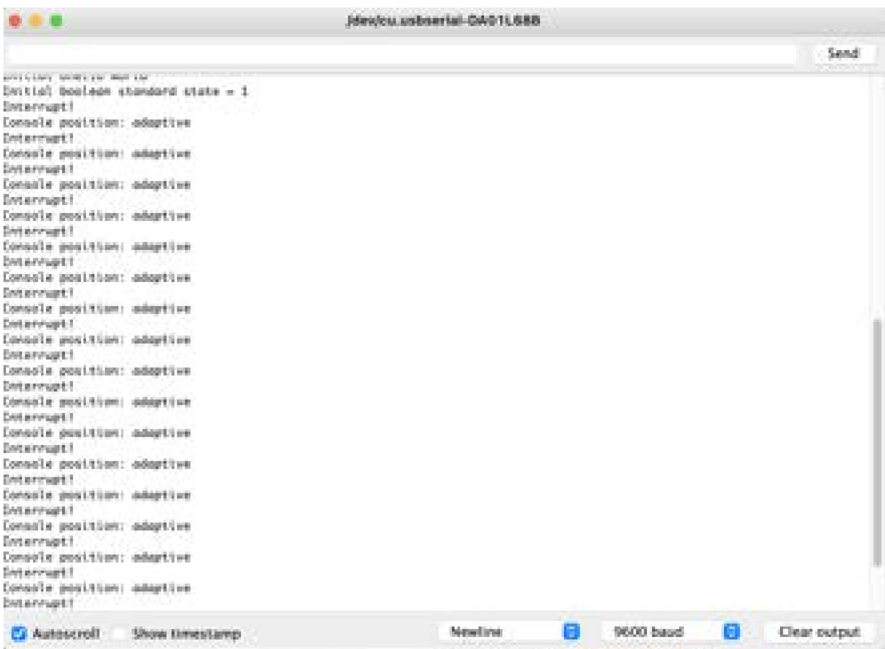
Date: 17OCT2022

Content by: Annabel Frake

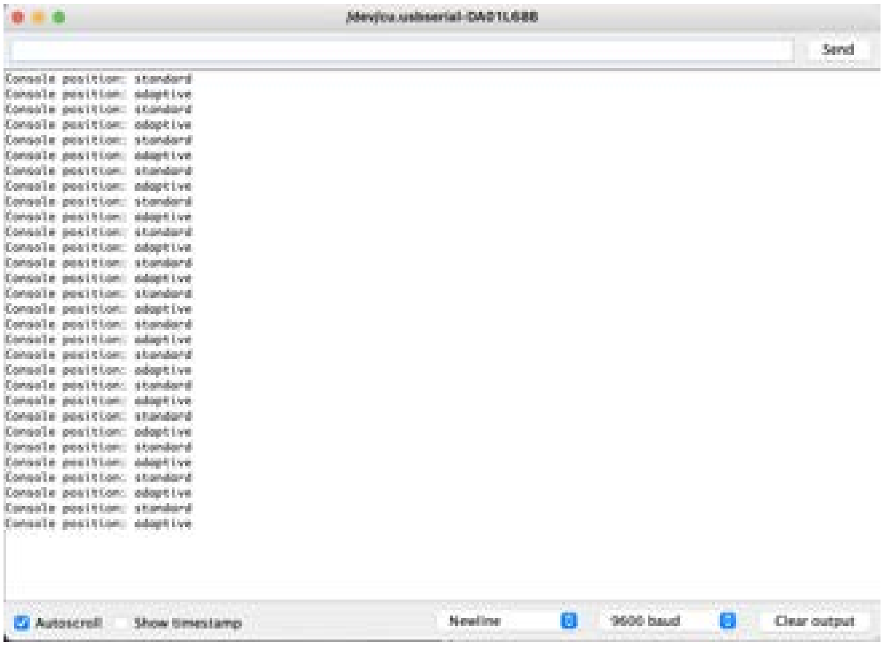
Present: Annabel Frake

Goals: try the code I wrote yesterday now that I have the correct USB plug

Content:

- I went to the MakerSpace today and got the USB plug I need to connect to the Arduino Uno
- I tried the servo with interrupt code with just the limit switch attached to see if the code worked with the print statements
- It seemed that the interrupt was reading the change in the limit switch state, but by the time the code got to the interrupt loop, the isPressed and isReleased no longer worked because the code essentially missed it
- 

- therefore, I don't think that the interrupting will work with the limit switch if the change in state of the limit switch is meant to trigger both the interrupt and an if loop
- To see if the rest of the coding logic worked, I switched to polling
- initially, the servo motor was stalling
- I tried reading the voltage and changing the power source, but that didn't work
- based on what I was taught at the MakerSpace workshop, the middle wire was meant to go to the digital signaling pin
- however, this always seemed odd to me because the wire colors didn't match conventions for ground (black) and power (red) then
- I tried wiring it according to the color connections and it worked!
- The servo code with polling works (see attached images, code, and videos)

- 

- the servo motor rotates a bit fast, so we may have to find a way to slow it down
- I also have a LEMO stepper motor and a DRV8825 motor controller, so I looked at a website (https://how2electronics.com/control-stepper-motor-with-drv8825-driver-arduino/) and some of my old code to start wiring the circuit and changing the current code I had (using a different motor controller)
- I don't have a 12V battery, so I will need to wait to try it until I have a power supply

References:

"Arduino Reference - Arduino Reference." https://www.arduino.cc/reference/en/ (accessed Oct. 16, 2022).

Admin, "How to Control Stepper Motor with DRV8825 Driver & Arduino," *How To Electronics*, Dec. 22, 2020. https://how2electronics.com/control-stepper-motor-with-drv8825-driver-arduino/ (accessed Oct. 17, 2022).

Conclusions:

Today, I started to troubleshoot the preliminary code I wrote yesterday. I got a USB plug from the MakerSpace that works with the Arduino Uno, so I was able to upload the program to the board and power it. I initially tried the interrupting code I wrote for the servo motor with only the limit switch hooked up. I wanted to make sure that the logic of the code worked by using print statements before I added the motor. I saw issues with the interrupting code. Every time I pressed or unpressed the limit switch, the state of the switch would change several times and the code would print that it entered the interrupt loop several times in a row. My theory is that the switch is imperfect - this is the sort of thing that the debounce library fixes. However, when I used the limit switch state change as the trigger for the interrupt, the state had already changed by the time the code entered the interrupt loop and the .isPressed and .isReleased statements no longer worked. Therefore, my theory is that we can only use the change in the limit switch state for one thing or the other.

To continue to make progress, I changed the code to use polling, and that code worked. I added the servo motor, but it was stalling and would not rotate. After checking the voltage and looking up potential solutions on the internet, I decided to change the wiring. In the MakerSpace workshop I attended, they said that the middle pin on the servo motor should be connected to the digital signal pin. This didn't make sense to me at the time because it goes against the color conventions for ground and power connections. We couldn't get the servo motor to work at the workshop, so I decided to try changing the wiring to match the convention. As soon as I did that, the motor moved. I took pictures and a video of the servo motor switching between the standard and adaptive sides (180 deg rotation) based on feedback from the limit switch.

I also have a stepper motor and a DRV8825 motor controller, so I decided to start the wiring and coding for the stepper motor using polling as well. I referenced past code I had written with stepper motors and that driver, as well as a website listed in the references section of this entry. I cannot try the setup in my apartment because I don't have a 12V battery, so I will need to wait until I can go into ECB and use one of the power supplies. Hopefully, the setup work I have done will make things going smoothly.

At this point, I have shown proof of concept for a servo motor with polling. Once I get the stepper motor working with poling, I can test out the stall weights for each motor and see which motor type would be a better selection for our project. After that, I can revisit the interrupt code and sleep mode for the Arduino as enhancement projects.

Action items:

1. continue developing the polling code for the servo and stepper motor

2. once that is working, select the best motor to use and revisit the interrupt code

ANNABEL FRAKE - Oct 17, 2022, 6:30 PM CDT

Download

Servo_Motor_and_Limit_Switch.HEIC (4.14 MB)

ANNABEL FRAKE - Oct 17, 2022, 6:30 PM CDT

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Servo_Motor_Whole_Circuit_View.HEIC (3.66 MB)

ANNABEL FRAKE - Oct 17, 2022, 6:30 PM CDT

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Servo_Setup_Arduino_Closeup.HEIC (3.66 MB)

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Servo_Label_Closeup.HEIC (2.61 MB)

ANNABEL FRAKE - Oct 17, 2022, 6:30 PM CDT

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Servo_Motor_with_Polling.MOV (12.2 MB)

ANNABEL FRAKE - Oct 17, 2022, 6:31 PM CDT

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Servo_Motor_Example_Code.ino (421 B)

ANNABEL FRAKE - Oct 17, 2022, 6:32 PM CDT

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Servo_Code_With_Limit_Switch_Polling.ino.ino (1.44 kB)

ANNABEL FRAKE - Oct 17, 2022, 6:32 PM CDT

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Servo_Code_With_Limit_Switch_Interrupt_2.0.ino.ino (2.06 kB)

ANNABEL FRAKE - Oct 17, 2022, 7:22 PM CDT

Download

Stepper_Code_With_Limit_Switch_Polling.ino.ino (2.19 kB)

ANNABEL FRAKE - Oct 17, 2022, 7:23 PM CDT

Download

Stepper_Motor_Controller_Connections.HEIC (3.44 MB)

ANNABEL FRAKE - Oct 17, 2022, 7:23 PM CDT

Download

Stepper_Setup_Arduino_Closeup.HEIC (3.44 MB)

ANNABEL FRAKE - Oct 17, 2022, 7:23 PM CDT

Download

Stepper_Setup.HEIC (3.5 MB)

18OCT2022 Interrupt Exploration

ANNABEL FRAKE - Oct 19, 2022, 12:19 AM CDT

Title: 18OCT2022 Interrupt Exploration

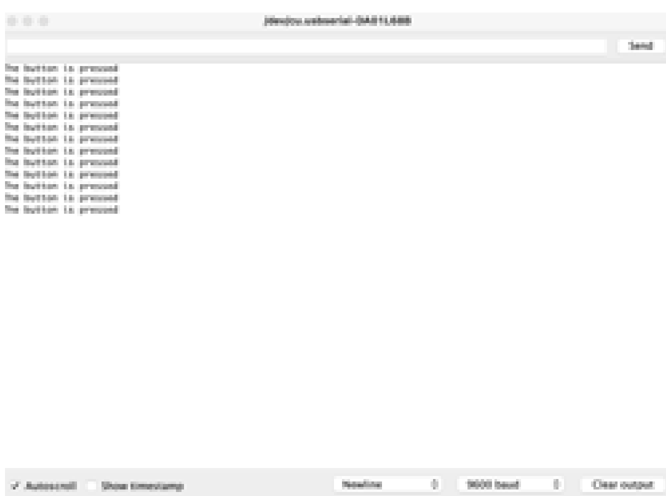
Date: 18OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: mess with the interrupt again

Content:

- My theory from yesterday was that the .isPressed() and .isReleased() functions only detect button state changes and I already used the state change to trigger the interrupt
- I downloaded and altered an example code for the ezButton library to try this
- I used .isPressed() with my limit switch and monitored when .isPressed() was true
- whenever I pressed the button, I would get a few print statements all at once and sometimes when I released the button
- I added a debounce time and only got 1 print statement for every button press
- nothing printed when the limit switch was pressed for a long time, only at the onset of the change in state
- 

- this confirms my theory that the function works with state changes (perhaps there is an internal interrupt in the program for this)
- To accommodate for this, I changed the .isPressed() and .isReleased() to .getState()
- .getState() reads the state of the button after the debounce time
- however, when I did this, I still got multiple interrupts per limit switch change state
- I tried adding a delay to the end of the interrupt (even went as high as 1000 ms), but I still got multiple interrupts in a row (ie adaptive printed twice indicates that the one interrupt code was run twice for 1 change of state)

- 
- https://forum.arduino.cc/t/getting-multiple-runs-of-interrupt/503431/14
- I looked at a forum (link above) and it said to try using noInterrupts() when the interrupt code starts and interrupts() before leaving the loop
- I tried that, but it didn't work
- even when I didn't use interrupt() at the end to enable interrupts again, I still saw multiple interrupts and could continue to get interrupts with more state changes
- the post also said not to use interrupts for long code and to avoid using print statements
- I decided to reevaluate and make sure I could use sleep mode with the Uno before worrying about using interrupts to wake it up
- Please see "18OCT2022 Putting Arduino Uno to Sleep" in the Technical Information folder of Research Notes
- I integrated the example code into my existing code
- instead of defining the interrupt in void setup(), it is defined in the go to sleep protocol
- the interrupt code only wakes up the Arduino and then the code returns to void loop(), goes into the function for rotating the console, and then returns to the sleep protocol function
- I was able to get everything working, but I had to use the manual method for debouncing (defining my own button state and using delays)
- for some reason, the debounce library was not working with this code
- I can try troubleshooting this again later, but wanted to write something that I knew was going to work for my meeting with Roxi tomorrow
- example of print statements:
- 
- sometimes, the "Arduino awake!" statement is printed twice, and I'm not sure why, so that would be something to look into
- I also needed to add a delay to allow the motor time to rotate before the Arduino goes to sleep again
- this delay might be problematic if there are multiple button presses in a row

- this is something to include in a testing protocol and something I will try as I continue to develop the code
- Please see the attachments below for example code, videos, and the code I wrote

References:

"Arduino Reference - Arduino Reference." https://www.arduino.cc/reference/en/ (accessed Oct. 16, 2022).

"Getting multiple runs of interrupt - Using Arduino / Programming Questions," *Arduino Forum*, Jan. 21, 2018. https://forum.arduino.cc/t/getting-multiple-runs-of-interrupt/503431 (accessed Oct. 18, 2022).

arduinomakerman, "A Guide to Putting Your Arduino to Sleep," *Instructables*. https://www.instructables.com/A-Guide-to-Putting-Your-Arduino-to-Sleep/ (accessed Oct. 18, 2022).

Conclusions:

I tried using interrupts again today. I was having issues with the debounce library and the interrupts occurring multiple times. After reading that the interrupt code shouldn't be long and should not include print statements, I reevaluated. I found an example code for putting the Arduino Uno to sleep and waking it up with a button press using interrupts. I updated my code to match the example. I removed the ezButton library logic and accounted for the debounce manually using button states and delays. I was able to get the code to work with the servo motor, but there are some things I would want to troubleshoot. First of all, the print statement "Arduino is awake!" (occurs right after Arduino wakes up) sometimes printed twice before the motor moved. I am not sure if this is an issue or why it occurs, but I will want to look into that later. Second, I needed to add a delay that gives the motor enough time to rotate before the Arduino goes into sleep mode. Because of this delay, we may miss button presses that are really close together. This would be something to troubleshoot / include in a testing protocol. The code I have now is just a rough draft and needs to be cleaned up, but it works!

Action items:

1. continue to troubleshoot the code
2. meet with Roxi tomorrow in ECB at 10 am to discuss motor selection

ANNABEL FRAKE - Oct 18, 2022, 10:20 PM CDT

Download

ezButton_example.ino (377 B)

ANNABEL FRAKE - Oct 19, 2022, 12:03 AM CDT

Download

Servo_Motor_with_Interrupts.MOV (24.6 MB)

ANNABEL FRAKE - Oct 19, 2022, 12:03 AM CDT

Download

Servo_Code_With_Limit_Switch_Interrupt_2.0.ino (2.99 kB)

ANNABEL FRAKE - Oct 19, 2022, 12:04 AM CDT

```
Servo_Code_With_Limit_Switch_Interrupt_2.0

// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Code for rotating the console of the Matrix rowing machine between the standard
and adpative sides.


//Include necessary libraries
#include <Servo.h>;
#include <avr/sleep.h>;


// Create servo object to control a servo motor
Servo servo;


// Define pins
const byte limitSwitchPin = 2;
const byte servoPin = 9;


// Define servo position for standard and adaptive orientations
int standardPosition = 0; // arbitrarily chosen
int adaptivePosition = 180; // arbitrarily chosen


// Define the state of the limit switch.
int limitSwitchState = true;


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);


  // Set LED on pin 13 to output. Will be used as an indicator of the Arduino's awake (LED on) /
asleep (LED off) state.
  pinMode(LED_BUILTIN, OUTPUT);
  digitalWrite(LED_BUILTIN, HIGH);

  // Assign the servo motor to servoPin
  servo.attach(servoPin);


  // Set limit switch pin to INPUT_PULLUP
  pinMode(limitSwitchPin, INPUT_PULLUP);
}


void loop()
{
  // Put the Arduino to Sleep.
  goToSleep();
```

```
  // Once Arduino is awake (triggered by limit switch change), rotate the console accordingly.
  rotate();
}


void goToSleep()
{
  // Enable sleep mode
  sleep_enable();


  // Attach interrupt to cause console rotation
  attachInterrupt(digitalPinToInterrupt(limitSwitchPin), wakeup, CHANGE);


  // Set full sleep mode
  set_sleep_mode(SLEEP_MODE_PWR_DOWN);


  // Turn off LED on pin 13 as a visual indicator that the Arduino entered sleep mode
  digitalWrite(LED_BUILTIN, LOW);


  // Add delay to allow motor time to move before Arduino sleeps
  delay(200);


  // Activate sleep mode
  sleep_cpu();


  // After the rotate interrupt, the code will resume here
  Serial.println("Arduino awake!");


  // Turn on LED on pin 13 as a visual indicator that the Arduino is awake
  digitalWrite(LED_BUILTIN, HIGH);
}


void wakeup()
{
  // Disable interrupts.
  noInterrupts();

  // Disable sleep mode
  sleep_disable();


  // Detach interrupt from limit switch
  detachInterrupt(limitSwitchPin);
```

```
  // Enable interrupts.
  interrupts();
}


void rotate()
{
  // Read state of limit switch
  int lastlimitSwitchState = limitSwitchState;
  limitSwitchState = digitalRead(limitSwitchPin);


  if (lastlimitSwitchState != limitSwitchState)
  {
    // If limit switch is pressed, standard side in use. Rotate console to standardPosition. Note: logic reversed because of INPUT_PULLUP (reads LOW when pressed and HIGH when not pressed).
    if(!limitSwitchState)
    {
      servo.write(standardPosition);
      Serial.println("Console position: standard");
    }

    // If limit switch is not pressed, adaptive side in use. Rotate console to adaptivePosition.
    else
    {
      servo.write(adaptivePosition);
      Serial.println("Console position: adaptive");
    }

    // Add delay to prevent multiple button state changes with single click
    delay(200);
  }
}
```

19OCT2022 Stepper Motor Polling

ANNABEL FRAKE - Oct 19, 2022, 9:57 AM CDT

Title: 19OCT2022 Stepper Motor Polling

Date: 19OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: try the stepper motor with the power supply in ECB

Content:

- Since I am meeting Roxi at 10 am in ECB, I came early to use the power supply
- I need 12V to power the stepper motor, so I couldn't try it in my apartment
- I tried hooking everything up with a DRV8825 board I already had from previous projects (see attached images), but it wasn't working
- I tried using the example code from the tutorial I read, but that didn't work either
- I tried using the wiring that they provided in the tutorial and was able to get the tutorial code to work
- I must have done some kind of trick on my old board that I can't remember
- I then tried my limit switch polling code with the servo motor, but that wasn't working
- I troubleshooted by putting the tutorial code directly into my code
- the error still occurred, so I knew it was something I had added
- I slowly removed sections of my code (in a duplicate sketch) until I realized that I had switched the pin definitions for STEP and DIR
- in my code, it was STEP = D8 and DIR = D9, but in the tutorial, it was STEP = D9 and DIR = D8
- once I fixed that, my code worked!
- see the attached images and video

References:

"Arduino Reference - Arduino Reference." https://www.arduino.cc/reference/en/ (accessed Oct. 16, 2022).

Admin, "How to Control Stepper Motor with DRV8825 Driver & Arduino," *How To Electronics*, Dec. 22, 2020. https://how2electronics.com/control-stepper-motor-with-drv8825-driver-arduino/ (accessed Oct. 17, 2022).

Conclusions:

Today, I tried my stepper motor with polling code using a power supply in ECB. Initially, it wasn't working because I had wired the stepper motor incorrectly. After some troubleshooting, I was able to get the stepper motor to rotate 180 deg between standard and adaptive sides based on feedback from the limit switch. We could use the DRV8825 in our final design, but it does require more code and isn't as streamlined. In my project from last year, I used an L298N that allows you to use a stepper motor library in Arduino. I would probably recommend that we use this because it will make the code easier to interpret once we pass everything off to JHT.

Next steps would include getting the code to work with the interrupt logic. However, if Roxi and I make a motor selection at our meeting today, it may be a null point. I think there is a good chance we will use a stepper motor because the shaft is sturdier and the rotation is more precise.

Action items:

- try getting the interrupt to work with the stepper motor once I flush the interrupt logic out with the servo motor (and assuming we haven't decided to use a servo motor in the project by then)

ANNABEL FRAKE - Oct 19, 2022, 9:47 AM CDT

Download

DRV8825_bottom_from_old_project.HEIC (2.42 MB)

ANNABEL FRAKE - Oct 19, 2022, 9:48 AM CDT

Download

DRV8825_right_from_old_project.HEIC (1.75 MB)

ANNABEL FRAKE - Oct 19, 2022, 9:48 AM CDT

Download

DRV8825_top_from_old_project.HEIC (2.2 MB)

ANNABEL FRAKE - Oct 19, 2022, 9:48 AM CDT

Download

DRV8825_left_from_old_project.HEIC (1.79 MB)

ANNABEL FRAKE - Oct 19, 2022, 9:48 AM CDT

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Stepper_Motor_Example.ino (808 B)

ANNABEL FRAKE - Oct 19, 2022, 9:49 AM CDT

Download

stepper_motor_and_limit_switch_closeup.HEIC (2.45 MB)

ANNABEL FRAKE - Oct 19, 2022, 9:49 AM CDT

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breadboard_closeup.HEIC (2.48 MB)

ANNABEL FRAKE - Oct 19, 2022, 9:49 AM CDT

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Stepper_motor_with_polling_circuitry.HEIC (2.95 MB)

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Arduino_closeup.HEIC (3.06 MB)

ANNABEL FRAKE - Oct 19, 2022, 9:49 AM CDT

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Power_Supply.HEIC (1.44 MB)

ANNABEL FRAKE - Oct 19, 2022, 9:49 AM CDT

Download

Stepper_Motor_with_Polling.MOV (10.7 MB)

ANNABEL FRAKE - Oct 19, 2022, 9:50 AM CDT

Download

Stepper_Code_With_Limit_Switch_Polling.ino (2.19 kB)

ANNABEL FRAKE - Oct 19, 2022, 9:50 AM CDT

Stepper_Code_With_Limit_Switch_Polling.ino

```
// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Code for rotating the console of the Matrix rowing machine between the standard
and adaptive sides.


//Include stepper library and debounce library
#include <Stepper.h>
#include <ezButton.h>;


// Define pins
const byte limitSwitchPin = 2;
const byte dirPin = 8;
const byte stepPin = 9;


// Create ezButton object that matches the limit switch
ezButton limitSwitch(limitSwitchPin);


// Number of steps per output rotation
const int stepsPerRevolution = 200;


// Number of steps per half rotation
const int stepsPerHalfRevolution = stepsPerRevolution / 2;


// Define boolean for whether the stepper motor is on the standard side or not
boolean standard = true;


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);

  // Set the stepper pin modes.
  pinMode(stepPin, OUTPUT);
  pinMode(dirPin, OUTPUT);


  // Assign the limit switch with a debounce time of 50 milliseconds
  limitSwitch.setDebounceTime(50);


  // Read state of limit switch when program initiates to define standard boolean value
  standard = digitalRead(limitSwitchPin);
  Serial.println("Initial boolean standard state = " + standard);
}
```

```
void loop()
{
  // Call the loop() function for the limit switch
  limitSwitch.loop();


  // If limit switch is pressed, standard side in use. Rotate console to standardPosition.
  if(limitSwitch.isPressed() && !standard)
  {
    digitalWrite(dirPin, HIGH);
    for(int i = 0; i < stepsPerHalfRevolution; i++)
    {
      digitalWrite(stepPin, HIGH);
      delayMicroseconds(2000);
      digitalWrite(stepPin, LOW);
      delayMicroseconds(2000);
    }
    standard = true;
    Serial.println("Console position: standard");
  }

  // If limit switch is not pressed, adaptive side in use. Rotate console to adaptivePosition.
  if(limitSwitch.isReleased() && standard)
  {
    digitalWrite(dirPin, LOW);
    for(int i = 0; i < stepsPerHalfRevolution; i++)
    {
      digitalWrite(stepPin, HIGH);
      delayMicroseconds(2000);
      digitalWrite(stepPin, LOW);
      delayMicroseconds(2000);
    }
    standard = false;
    Serial.println("Console position: adaptive");
  }
}
```

21OCT2022 Material Purchasing and Planning

ANNABEL FRAKE - Oct 21, 2022, 4:30 PM CDT

Title: 21OCT2022 Material Purchasing and Planning

Date: 21OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: buy the stepper motor, send Roxi the plan for the electronics portion of the design so she can add it to the Gantt chart

Content:

- after making the motor selection with the team, I purchased the stepper motor (same one I used in my design project for BME 300): https://www.digikey.com/en/products/detail/sparkfun-electronics/ROB-09238/5318747
    - cost $27.20 with shipping
    - All prices are in USD

#	Product Details	Quantity	Availability	Unit Price	Extended Price
1	1568-1105-ND ROB-09238 STEPPER MOTOR HYBRID BIPOLAR 12V	1	Immediate	18.79000	$18.79

Summary

Subtotal:	$18.79
Shipping:	$6.99
Sales Tax:	$1.42
Total:	$27.20

- I sent the receipt to Roxi for BPAG responsibilities
- I sent the link to Josh so that he can find a CAD model of the motor and use it to design the electronics housing box
- I also came up with plans for the electronics portion of the design for the Gantt chart
    - Create rough draft of code using stepper motor with sleep mode and 3 limit switches by Oct 28th
    - Purchase motor, power supplies (9V and 12V), Arduino Uno, and motor controller by Nov 4th
    - Create preliminary code and circuit by Nov 23rd
    - Integrate circuit and code with antler design and stabilization frame by Dec 2nd (this date may change depending on when everyone else will be done)
    - Test circuit and code by Dec 6th (?)
    - Present on Dec 9th
    - Report by Dec 14th
- Roxi said that I could send her this info and she would integrate it with Josh's list so that everything for the antler design sub-group matches within the Gantt chart

References:

https://www.digikey.com/en/products/detail/sparkfun-electronics/ROB-09238/5318747

Conclusions:

After deciding to use a stepper motor at the meeting today, I went ahead and purchased the same one Josh, Sam, and I used in our BME 300 project. It should arrive in 1-3 business days. Roxi is going to send me the link for the 12V power supply she used in a previous design course, and then I will purchase the 12V power supply and L298N motor controller (same as in BME 300 project) off of Amazon. I will look into purchasing the 9V battery supply and connector as well as the Arduino Uno from either the MakerSpace or some other site depending on what is cheapest. I believe that an Arduino Uno is $21 from the MakerSpace and upwards of $20 dollars on Amazon. I also generated a rough list of deadlines for the motor portion of the design. Roxi offered to put them into the Gantt chart, so I have sent her the list.

Action items:

1. Once Roxi sends me the link for the power supply she has used in past projects, I will purchase that and the motor controller off of amazon
2. explore options for purchasing the 9V batter and connector clip to Arduino
3. continue to develop the code

ANNABEL FRAKE - Oct 21, 2022, 10:48 PM CDT

Title: 21OCT2022 Material Purchasing and Planning

Date: 21OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: purchase the Arduino Uno, 12V power supply, and L298N motor controller

Content:

- I purchased the Arduino Uno, 12V power supply, and L298N motor controller from amazon
- Arduino Uno: https://www.amazon.com/gp/product/B01EWOE0UU/ref=ppx_od_dt_b_asin_title_s01?ie=UTF8&psc=1
  - $17.99
- 12V power supply: 12V 5A Power Supply for LED Strip Lights, 60W Power Adapter, 120V AC to 12V DC Transformer(1 set)
  - $9.59
- L298N: Qunqi L298N Motor Drive Controller Board Module Dual H Bridge DC Stepper For Arduino
  - $6.99
-

Order Summary	
Item(s) Subtotal:	$34.57
Shipping & Handling:	$5.99
Total before tax:	$40.56
Estimated tax to be collected:	$2.23
Grand Total:	**$42.79**

- I sent the links and receipt to Roxi for BPAG duties
- I sent the links (including the one for the stepper motor) to Josh so he can factor the dimensions into his design of the electronics housing box

References: see links in content

Conclusions:

After Roxi sent me the link for the 12V power supply, I purchased it along with an Arduino Uno and the L298N motor controller from Amazon. I had briefly considered using an Arduino Nano since the tutorial on using sleep mode with Arduino recommended it because it consumes less power. However, you have to power the Nano with a USB plug instead of a batter pack, so I decided to stick with the Arduino Uno. I forwarded the purchasing info to Roxi for BPAG duties and I shared the links with Josh so he can use the dimensions for developing the electronics housing box / arm that supports the console.

Action items:

1. explore options for 9V batteries and connector clips
2. once the components arrive, build the circuit and start adapting the code to the new components (the L298N works with the stepper motor library)

22OCT2022 Code Development

ANNABEL FRAKE - Oct 22, 2022, 5:08 PM CDT

Title: 22OCT2022 Code Development

Date: 22OCT2022

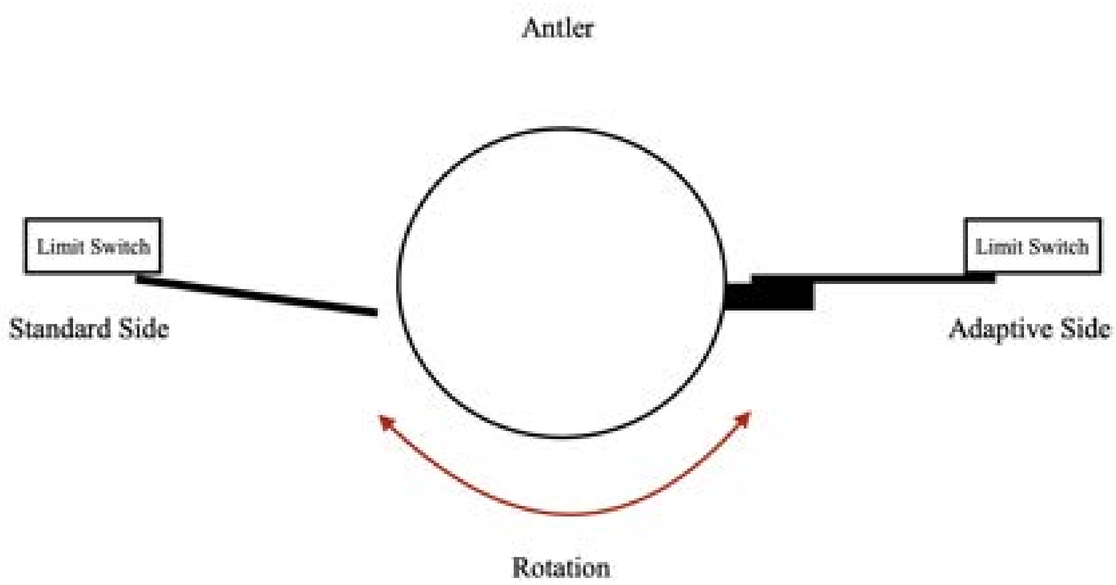
Content by: Annabel Frake

Present: Annabel Frake

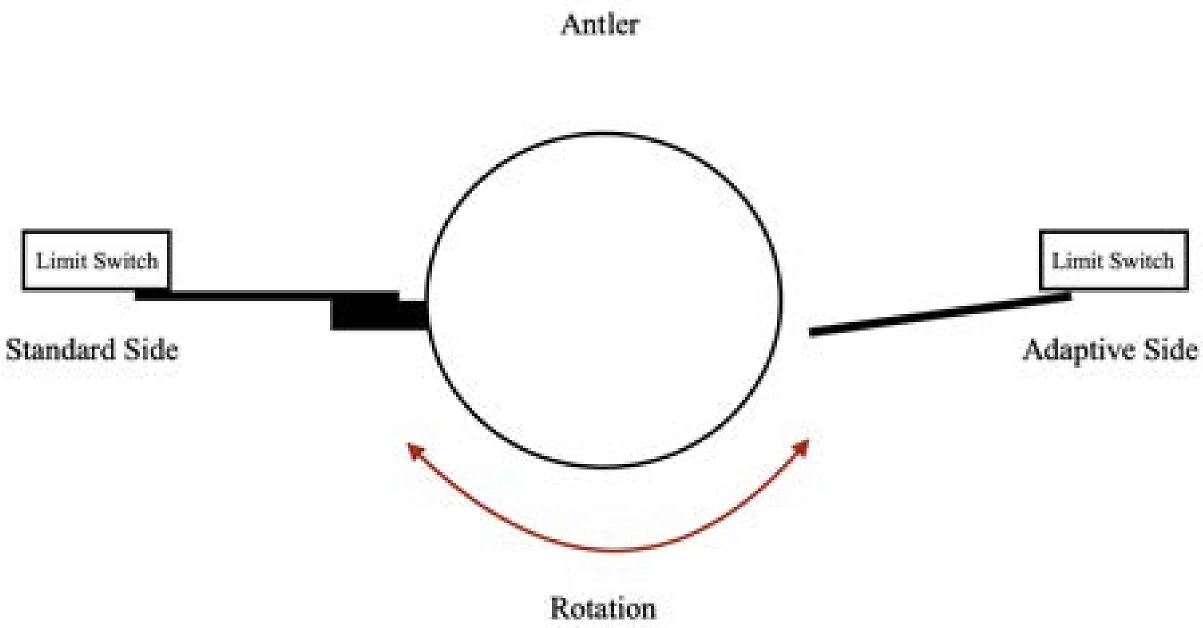
Goals: alter existing sketches for stepper motor with sleep mode and multiple limit switches

Content:

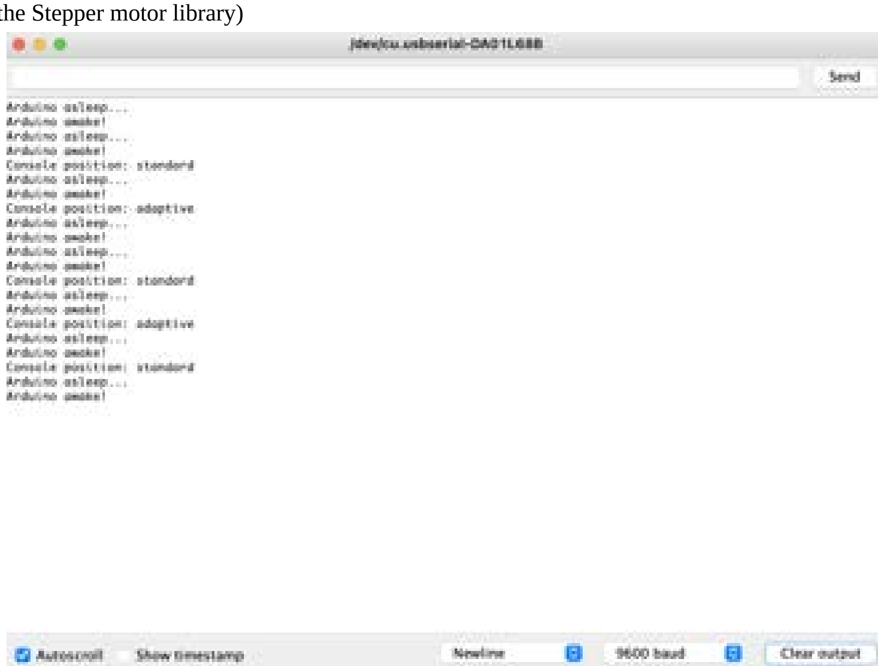
- Code specifications:
    - uses a stepper motor
    - uses sleep mode to save on power consumption and an interrupt to wake up the Arduino Uno
    - uses 3 limit switches
        1. one placed near the lap bar to trigger the interrupt that wakes up the Arduino and signals a rotation change
        2. one placed near the console on the standard side to indicate when the console faces the standard user and rotation should stop
        3. one placed near the console on the adaptive side to indicate when the console faces the adaptive user and rotation should stop
- there will be a flag on the console setup that activates the limit switches and provides feedback on the orientation of the console



-



- I created a sketch following the above specifications (see below attachments)
- I hooked 3 limit switches up to the Arduino and started to debug the code using print statements (I don't have the L298N yet to use with the Stepper motor library)



- The logic seems to work based on the print statements, but I sometimes got multiple print statements with an interrupt (as I was seeing before)
- I am still not sure why this is happening or if it will cause an issue once I try it with the motor rotation
- it usually happened right after the board was reset, so I added a delay to the setup and that seemed to get rid of the issue, but it did not solve it for subsequent interrupts
- it may need a delay after (or within) the interrupt code, so I will continue to debug that once the L298N arrives

References: none

Conclusions:

Today, I altered my previous sketches to generate a new one that works with the stepper motor (using the Stepper library since I purchased the L298N motor controller), uses sleep mode and interrupts, and incorporates 3 limit switches into the logic. The first limit switch wakes up the Arduino from sleep mode and indicates which direction the console needs to rotate (if pressed, rotate to standard and if not pressed, rotate to adaptive). The other two limit switches provide feedback on the position of the console (standard vs adaptive). They are a physical check that the console is where the code believes it to be. I troubleshooted the logic with 3 limit switches and print statements, but the code needs further refinement. It will be easier to test once the motor and L298N are incorporated into the circuit.

Action items:

1. test the code once the parts arrive next week

ANNABEL FRAKE - Oct 22, 2022, 4:56 PM CDT

Download

Stepper_Sleep_Mode_3_Switches_1.0.ino (5.12 kB)

ANNABEL FRAKE - Oct 22, 2022, 4:56 PM CDT

```
// Stepper_Sleep_Mode_3_Switches_1.0.ino


// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Code for rotating the console of the Matrix rowing machine between the standard and adaptive sides.


//Include necessary libraries
#include <Stepper.h>
#include <avr/sleep.h>;


// Define limit switch pins
byte const transitionSwitchPin = 2; // This limit switch is placed near the stabilization frame. When its state changes, the rower is transitioned between adaptive and standard use or vice versa. When this limit switch is pressed, the console should be on the standard side and when it is not pressed, the console should be on the adaptive side.
byte const standardSwitchPin = 3; // This limit switch is placed near the console on the standard side. When it is pressed, the consle is facing the standard user.
byte const adaptiveSwitchPin = 4; // This limit switch is placed near the console on the adaptive side. When it is pressed, the consle is facing the wheelchair user.


// Declare states for the buttons.
int transitionSwitchState = HIGH;
int standardSwitchState = HIGH;
int adaptiveSwitchState = HIGH;


// Number of steps per output rotation
int const stepsPerRevolution = 200;


// Create servo object to control a servo motor
Stepper stepper(stepsPerRevolution, 8, 9, 10, 11);


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);


  // Set LED_BUILTIN on pin 13 to output. This LED indicates whether the Arduino is awake (LED on) or asleep (LED off).
  pinMode(LED_BUILTIN, OUTPUT);


  // Turn LED_BUILTIN on
  digitalWrite(LED_BUILTIN, HIGH);

  // Set the motor speed to 40 rpm.
  stepper.setSpeed(40);
```

```
  // Set limit switch pins to INPUT_PULLUP
  pinMode(transitionSwitchPin, INPUT_PULLUP);
  pinMode(standardSwitchPin, INPUT_PULLUP);
  pinMode(adaptiveSwitchPin, INPUT_PULLUP);


  // Delay to allow time to setup.
  delay(200);
}


void loop()
{
  // Put the Arduino to Sleep.
  goToSleep();


  // Once Arduino is awake (triggered by transitionSwitchPin change), rotate the console
accordingly.
  rotate();
}


void goToSleep()
{
  // Print that the Arduino is going to sleep.
  Serial.println("Arduino asleep...");

  // Enable sleep mode.
  sleep_enable();


  // Enable interrupts.
  interrupts();


  // Attach interrupt to wakeup Arduino when the transitionSwitchPin changes state.
  attachInterrupt(digitalPinToInterrupt(transitionSwitchPin), wakeup, CHANGE);


  // Set full sleep mode.
  set_sleep_mode(SLEEP_MODE_PWR_DOWN);


  // Add delay to allow the motor time to move before Arduino sleeps.
  delay(200);


  // Turn off LED_BUILTIN as a visual indicator that the Arduino entered sleep mode.
  digitalWrite(LED_BUILTIN, LOW);


  // Activate sleep mode.
```

```
  sleep_cpu();


  // After the wakeup interrupt, the code will resume here.
  Serial.println("Arduino awake!");


  // Turn on LED_BUILTIN as a visual indicator that the Arduino is awake.
  digitalWrite(LED_BUILTIN, HIGH);
}


void wakeup()
{
  // Prevent multiple interrupts by disabling them.
  noInterrupts();

  // Disable sleep mode.
  sleep_disable();


  // Detach interrupt from transition limit switch.
  detachInterrupt(transitionSwitchPin);
}


void rotate()
{
  // Read state of the standard side limit switch.
  standardSwitchState = digitalRead(standardSwitchPin);


  // Read state of the adaptive side limit switch.
  adaptiveSwitchState = digitalRead(adaptiveSwitchPin);


  // Read state of the transition limit switch.
  int lastTransitionSwitchState = transitionSwitchState;
  transitionSwitchState = digitalRead(transitionSwitchPin);


  // If the transition limit switch state is different from the previous state, enter the loop.
  if (lastTransitionSwitchState != transitionSwitchState)
  {
    // If transition limit switch is pressed, then rotate the console to the standard side. Note:
logic reversed because of INPUT_PULLUP (reads LOW when pressed and HIGH when not pressed).
    if(!transitionSwitchState)
    {
      // Rotate the stepper motor towards the standard side until the standard side limit switch is
pressed.
      while(digitalRead(standardSwitchPin))
      {
        stepper.step(1);
        standardSwitchState = digitalRead(standardSwitchPin);
      }
```

```
      Serial.println("Console position: standard");
    }

    // If transition limit switch is pressed, then rotate the console to the adaptive side. Note: logic reversed because of INPUT_PULLUP (reads LOW when pressed and HIGH when not pressed).
    else if(transitionSwitchState)
    {
      // Rotate the stepper motor towards the adaptive side until the adaptive side limit switch is pressed.
      while(adaptiveSwitchState)
      {
        stepper.step(-1);
        adaptiveSwitchState = digitalRead(adaptiveSwitchPin);
      }
      Serial.println("Console position: adaptive");
    }


    // If neither of the first two if statements are entered, an error has occurred and the console position is out of whack.
    else
    {
      Serial.println("Error: check orientation of console");
    }

    // Add delay to prevent multiple button state changes with single click
    delay(200);
  }
}
```

ANNABEL FRAKE - Oct 22, 2022, 4:56 PM CDT

Download

3_Limit_Switches.HEIC (3.26 MB)

24OCT2022 Power Supply Testing

ANNABEL FRAKE - Oct 24, 2022, 7:55 PM CDT

Title: 24OCT2022 Power Supply Testing

Date: 24OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: test the 12V power supply I purchased to make sure it works with our circuit

Content:

- I received the 12V power supply, Arduino Uno, and NEMA stepper motor in the mail today
- I wanted to try using the 12V power supply with the motor to make sure it works as we intend
- I used the purchased Arduino Uno, NEMA stepper motor, and 12V power supply in the same circuit I used previously to show a proof of concept
- It took a while to get it working because I had forgot to wire two of the pins on the motor controller together
- After that, I everything was working
- However, when I was taking pictures, I unplugged the 12V power supply (red wire) from the breadboard, untangled it from some other wires to make the picture clearer, and then plugged it back in
- After that, the circuit wouldn't work
- I tried using the stepper motor example code
- I tried using my NEMA stepper motor
- nothing worked
- I tried using another motor driver I had (same model), but that didn't work either
- I'm not sure if I fried the board or something else
- Using a voltmeter, I was getting 12V at the 12V power supply connections on the driver and 5V at the 5V power supply connections
- I tried my Arduino to make sure I didn't somehow damage the one we purchased, but it also wasn't working
- The print statements in my polling code work when the limit switch is pressed/unpressed
- After a lot of troubleshooting, I still couldn't get it to work
- I will come back to it tomorrow

References:

"Arduino Reference - Arduino Reference." https://www.arduino.cc/reference/en/ (accessed Oct. 16, 2022).

Admin, "How to Control Stepper Motor with DRV8825 Driver & Arduino," *How To Electronics*, Dec. 22, 2020. https://how2electronics.com/control-stepper-motor-with-drv8825-driver-arduino/ (accessed Oct. 17, 2022).

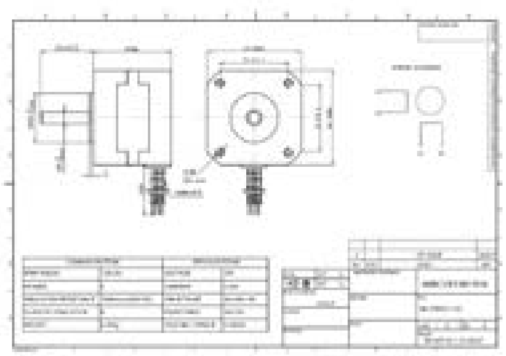
Conclusions:

I wanted to try the circuit with the components I purchased specifically for this project. Specifically, I wanted to make sure the 12V power supply worked since I had never used the model before (recommended by Roxi). I did get the circuit to work and the motor to spin, however, right before I took a video of it operating, the circuit stopped working. Despite extensive troubleshooting, I haven't found the issue yet. I will continue troubleshooting tomorrow and potentially try it with the L298N motor controller instead when it arrives (perhaps the driver I have is fried?).

Action items:

1. troubleshoot the circuit to get it operational again
2. try this with the L298N motor controller once it arrives in the mail

ANNABEL FRAKE - Oct 24, 2022, 7:46 PM CDT



Download

Stepper_motor_data_sheet.pdf (179 kB)

ANNABEL FRAKE - Oct 24, 2022, 7:47 PM CDT

Download

Breadboard_closeup.HEIC (2.81 MB)

ANNABEL FRAKE - Oct 24, 2022, 7:47 PM CDT

Download

Overall_setup.HEIC (3.46 MB)

ANNABEL FRAKE - Oct 24, 2022, 7:47 PM CDT

Download

Arduino_Closeup.HEIC (3.34 MB)

ANNABEL FRAKE - Oct 24, 2022, 7:47 PM CDT

Download

Power_Supply_and_Limit_Switch_Connections.HEIC (3.08 MB)

ANNABEL FRAKE - Oct 24, 2022, 7:48 PM CDT

Download

Stepper_Motor_Example.ino (808 B)

ANNABEL FRAKE - Oct 24, 2022, 7:48 PM CDT

Download

Stepper_Code_With_Limit_Switch_Polling.ino (2.25 kB)

24OCT2022 Control Stepper Motor with L298N Motor Driver & Arduino

ANNABEL FRAKE - Oct 24, 2022, 6:26 PM CDT

Title: 24OCT2022 Control Stepper Motor with L298N Motor Driver & Arduino

Date: 24OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: leverage previous design work with the L298N and NEMA stepper motor

Content: see text entry below

References: see text entry below

Conclusions:

I have used the NEMA stepper motor with the L298N in a previous design project. I used an entry from a previous lab notebook to review information relevant to the components' function.

Action items:

1. Apply this information to my current design project

ANNABEL FRAKE - Oct 26, 2021, 9:52 AM CDT

Title: 26OCT2021 Control Stepper Motor with L298N Motor Driver & Arduino

Date: 26OCT2021

Content by: Annabel Frake

Present: Annabel Frake

Goals:

-look at the article I found on using stepper motors with the L298N in more detail

Content:

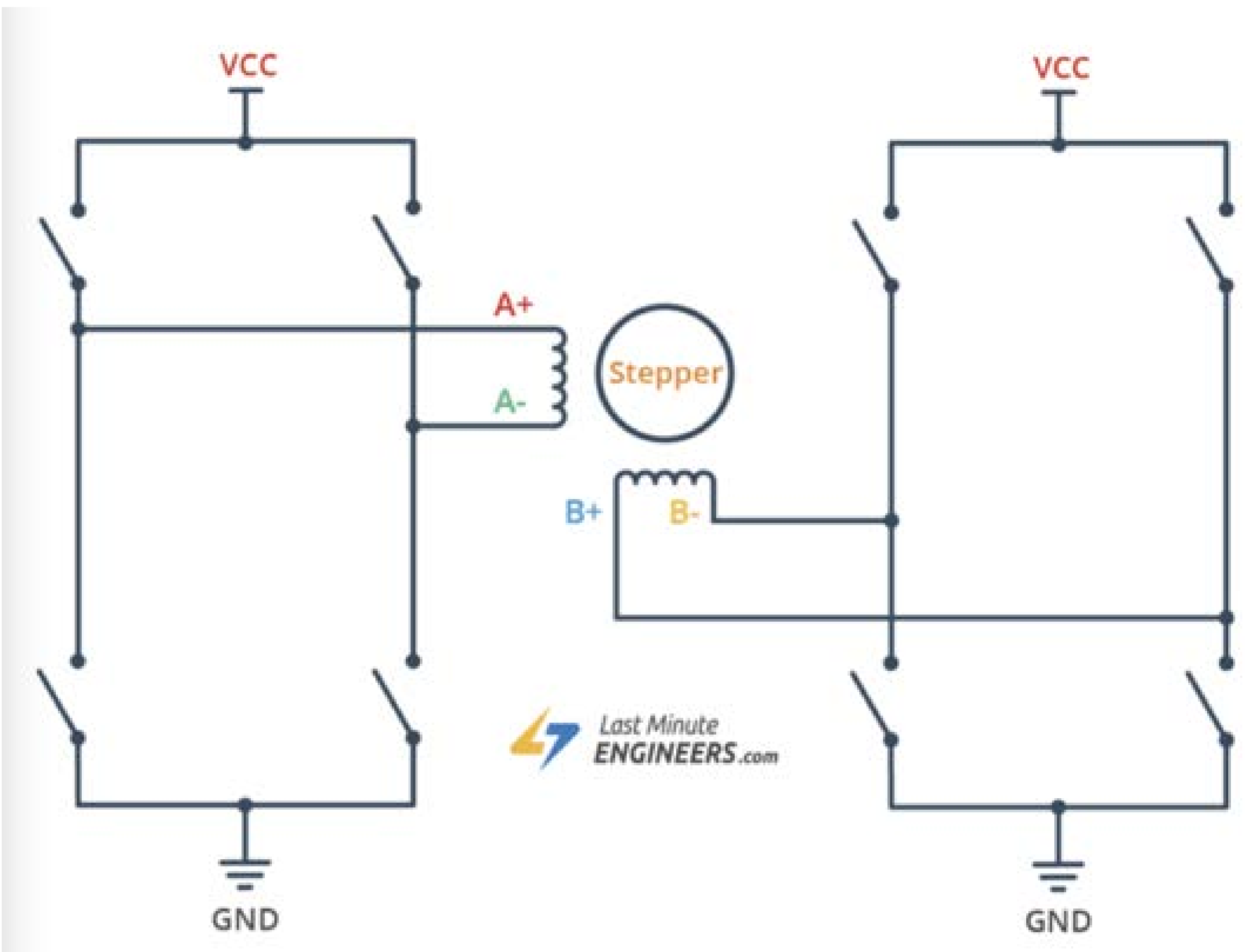
-L298N motor driver is easy and inexpensive to operate stepper motor

-controls speed and direction of bipolar motor

-has 2 H brides, each driving one electromagnetic coil of stepper motor

-speed of motor depends on how often coils are energized

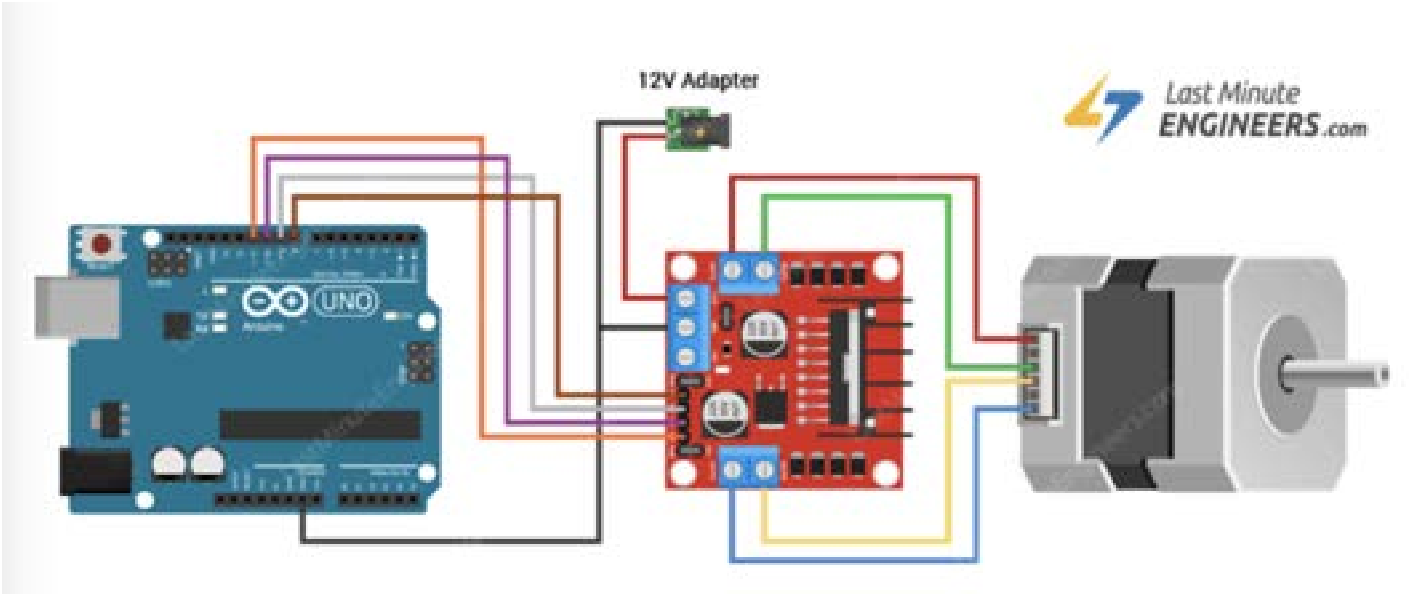
-Below is an image of the 2 H bridges in a circuit diagram



-they use NEMA 17 (12 V, 200 steps per rotation, 60 RPM)

-check data sheet of motor to find out the A, A-, B-, and B terminal placements

-Below is a circuit diagram showing the connections between the motor, L298N, Arduino, and battery



Wiring NEMA 17 Stepper Motor with L298N & Arduino

-Next is the Arduino code

-Below is the code from the website

```
// Include the Arduino Stepper Library
#include <Stepper.h>

// Number of steps per output rotation
const int stepsPerRevolution = 200;

// Create Instance of Stepper library
Stepper myStepper(stepsPerRevolution, 8, 9, 10, 11);


void setup()
{
    // set the speed at 60 rpm:
    myStepper.setSpeed(60);
    // initialize the serial port:
    Serial.begin(9600);
}

void loop()
{
    // step one revolution in one direction:
    Serial.println("clockwise");
    myStepper.step(stepsPerRevolution);
    delay(500);

    // step one revolution in the other direction:
    Serial.println("counterclockwise");
    myStepper.step(-stepsPerRevolution);
    delay(500);
}
```

-need to include the Stepper.h library

-define the number of steps per revolution (this should be in the data sheet of the motor)

-to create an instance of the library, you need to include the steps per rev and the Arduino pins from the L298N

-the setSpeed() function sets the rpm of the motor

-they use serial monitor to debug

-step() function steps motor specified number of steps at speed from setSpeed()

-using negative numbers reverses the direction

References:

Last Minute Engineers, "Control Stepper motor with L298n Motor Driver & Arduino," *Last Minute Engineers*, 18-Dec-2020. [Online]. Available: https://lastminuteengineers.com/stepper-motor-l298n-arduino-tutorial/. [Accessed: 26-Oct-2021].

Conclusions:

This source was extremely helpful in picking out the motor controllers and type of stepper motor. We decided as a team to get a NEMA stepper motor and the L298N to control it. Once we receive the parts, I can use this source as a starting point for the connections and the code. The figures are a little small to read exactly which pins certain wires are connected to, so I will need to be cautious that everything is hooked up the same.

In terms of our program, we can set an arbitrary speed (I assume something slow) and then tell the motors to step +/-x amount of times. This works perfectly with my coding logic idea where the motors are reset to a home position before any movement occurs (please see the Code Logic Brainstorming entry under the Code folder in Design Ideas). This code will require quite a few functions.

Action items:

-start writing the coding logic

-eventually create a circuit diagram in Fritzing

25OCT2022 Circuit Construction / Testing

ANNABEL FRAKE - Oct 26, 2022, 1:27 AM CDT

Title: 25OCT2022 Circuit Construction / Testing

Date: 25OCT2022

Content by: Annabel Frake

Present: Annabel

Goals: use the motor controller we bought (arrived in the mail today) in the circuit and troubleshoot

Content:

- Okay, so I started by trying the L298N with the example code provided in the tutorial
- I was able to get the motor to spin, so I probably fried my person drivers from yesterday (I think I needed a cap over the power supplies)
- Then, I tried it with the 1 limit switch polling code and got that working
- Next, I tried my newest code I wrote for 3 limit switches with sleep mode
- I made 3 iterations (1.0, 2.0, and 3.0) trying different things
- The motor would rotate, but not necessarily when I wanted / expect it to
- I tried writing a code where there are 2 interrupts, 1 on rising and 1 on falling of the transition limit switch so I would know which direction the console needed to rotate off the bat without needing to read the state of that switch later on
- However, the motor got really hot and the print statements from the serial monitor started to get wonky (see attached image at the end), so I stopped for the night
- I think I am going to try using polling without sleep mode and see if I can figure out the 3 limit switch logic
- then, once it's working, I can try the wake up and interrupts again

References:

Last Minute Engineers, "Control Stepper motor with L298n Motor Driver & Arduino," *Last Minute Engineers*, 18-Dec-2020. [Online]. Available: https://lastminuteengineers.com/stepper-motor-l298n-arduino-tutorial/. [Accessed: 26-Oct-2021].

Conclusions:

I made some decent progress tonight. I confirmed that the stepper motor, L298N, Arduino Uno, and 12V power supply all work together. I was able to get polling with a single limit switch to work. However, my code for 3 limit switches wasn't working as expected. I tried changing certain things in different iterations, but nothing worked. Eventually, the motor got too hot, so I will try again later on. I think I'm going to reassess my strategy and write a polling code with the 3 limit switches before I integrate the sleep mode / interrupt logic since that seems to be where issues arise.

Action items:

1. try 3 limit switch logic using polling

ANNABEL FRAKE - Oct 25, 2022, 11:59 PM CDT

Download

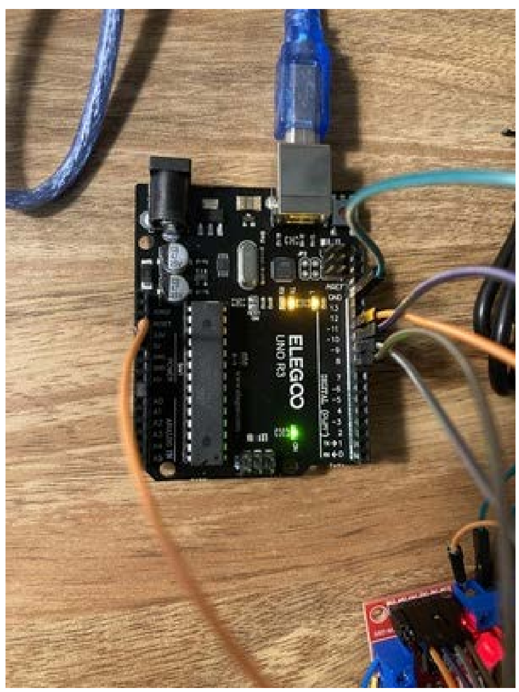
Stepper_Example_with_L298N.ino (643 B)

ANNABEL FRAKE - Oct 26, 2022, 12:01 AM CDT

Download

IMG_6127.jpeg (4.28 MB) Overall circuit for example stepper code using L298N.

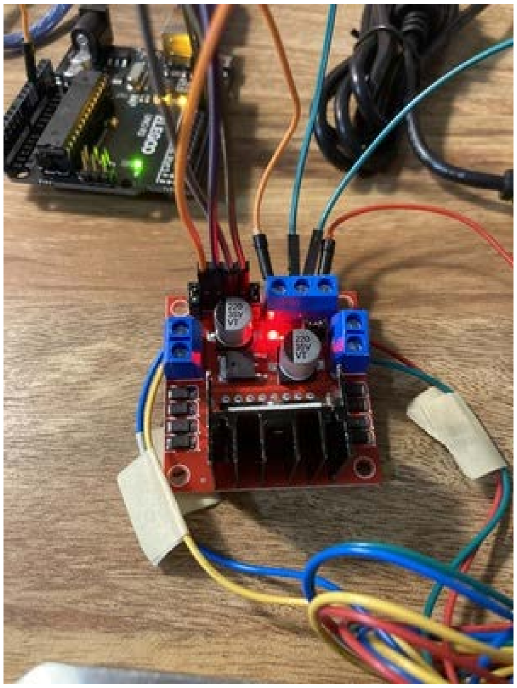
ANNABEL FRAKE - Oct 26, 2022, 12:01 AM CDT



Download

IMG_6129.jpeg (4.81 MB) Closeup of Arduino for example stepper code using L298N.

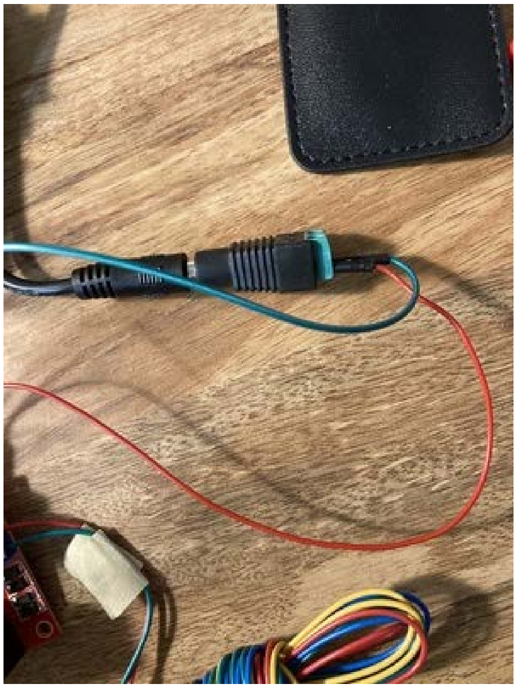
ANNABEL FRAKE - Oct 26, 2022, 12:01 AM CDT



Download

IMG_6128.jpeg (3.15 MB) Closeup of L298N for example stepper code using L298N.

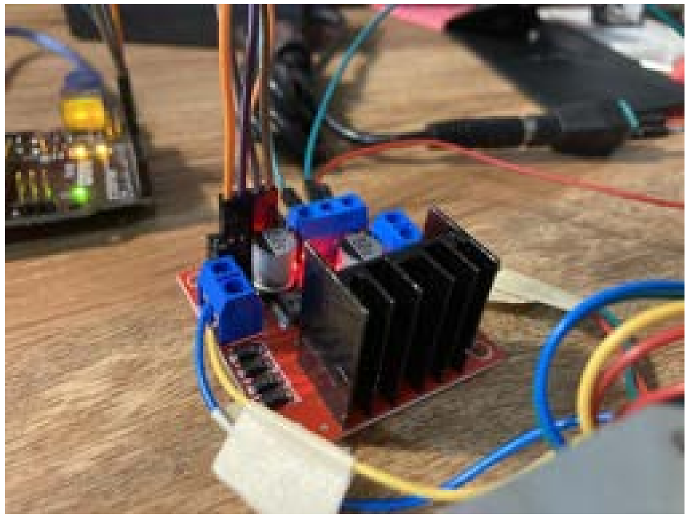
ANNABEL FRAKE - Oct 26, 2022, 12:02 AM CDT



Download

IMG_6130.jpeg (4.83 MB) Closeup of 12V power supply connection for example stepper code using L298N.

ANNABEL FRAKE - Oct 26, 2022, 12:02 AM CDT



Download

IMG_6131.jpeg (3 MB) Side view of L298N for example stepper code using L298N.

ANNABEL FRAKE - Oct 26, 2022, 12:02 AM CDT

Download

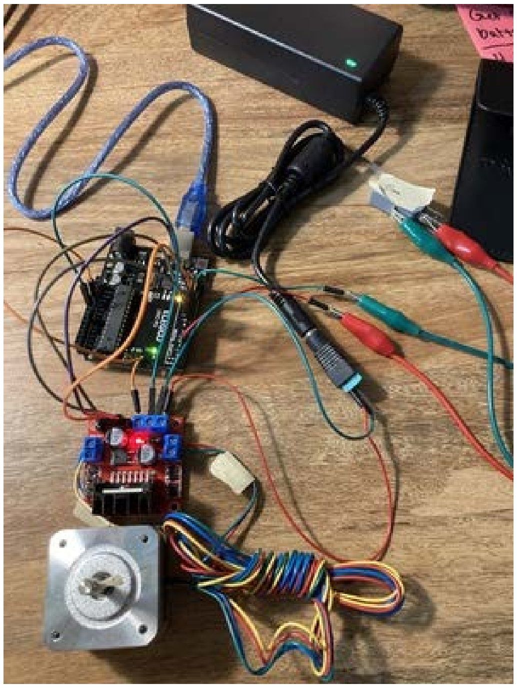
IMG_6132.MOV (6.2 MB) Video of motor sweep from L298N example code (sourced from referenced tutorial).

ANNABEL FRAKE - Oct 26, 2022, 12:10 AM CDT

```
// Stepper_Code_With_Limit_Switch_Polling_L298N

// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Code for rotating the console of the Matrix rowing machine between the standard
and adaptive sides.


//Include stepper library and debounce library
#include <Stepper.h>
#include <ezButton.h>;


// Define pins
const byte limitSwitchPin = 2;


// Create ezButton object that matches the limit switch
ezButton limitSwitch(limitSwitchPin);


// Number of steps per output rotation.
int const stepsPerRevolution = 200;


// Number of steps per half rotation
const int stepsPerHalfRevolution = stepsPerRevolution / 2;


// Create servo object to control a servo motor.
Stepper stepper(stepsPerRevolution, 8, 9, 10, 11);


// Define boolean for whether the stepper motor is on the standard side or not
boolean standard = true;


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);

  // Set the motor speed to 40 rpm.
  stepper.setSpeed(40);


  // Assign the limit switch with a debounce time of 50 milliseconds
  limitSwitch.setDebounceTime(50);


  // Read state of limit switch when program initiates to define standard boolean value
  standard = digitalRead(limitSwitchPin);
  Serial.print("Initial boolean standard state = ");
  Serial.println(standard);
}
```

```
void loop()
{
  // Call the loop() function for the limit switch
  limitSwitch.loop();


  // If limit switch is pressed, standard side in use. Rotate console to standardPosition.
  if(limitSwitch.isPressed() && !standard)
  {
    stepper.step(stepsPerHalfRevolution);
    standard = true;
    Serial.println("Console position: standard");
  }

  // If limit switch is not pressed, adaptive side in use. Rotate console to adaptivePosition.
  if(limitSwitch.isReleased() && standard)
  {
    stepper.step(-stepsPerHalfRevolution);
    standard = false;
    Serial.println("Console position: adaptive");
  }
}
```

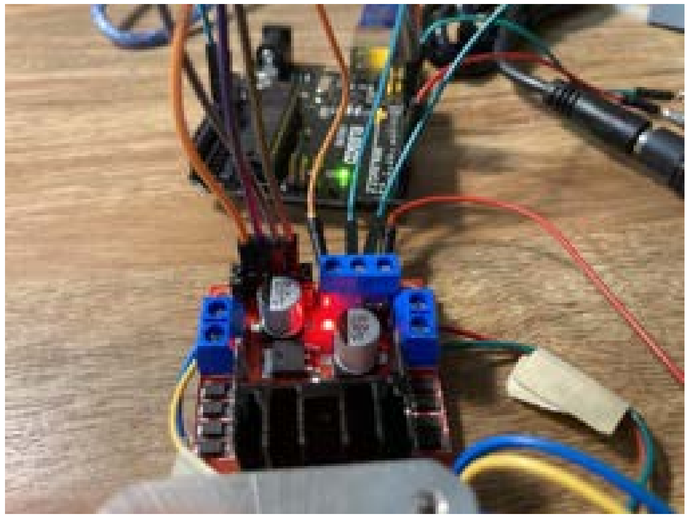
ANNABEL FRAKE - Oct 26, 2022, 12:12 AM CDT



Download

IMG_6133.jpeg (4.22 MB) Overall circuitry with 1 limit switch using polling.

ANNABEL FRAKE - Oct 26, 2022, 12:13 AM CDT



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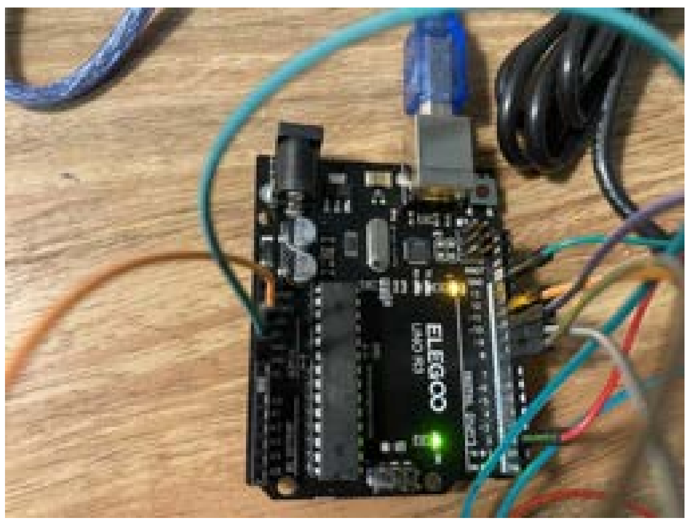
IMG_6134.jpeg (2.89 MB) Closeup of L298N for 1 limit switch with polling.

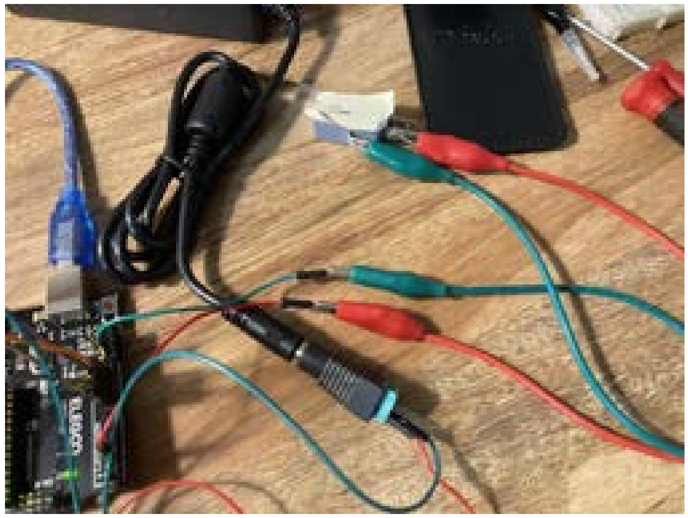
ANNABEL FRAKE - Oct 26, 2022, 12:13 AM CDT



Download

IMG_6135.jpeg (4.19 MB) Closeup of Arduino for 1 limit switch with polling.

ANNABEL FRAKE - Oct 26, 2022, 12:13 AM CDT



Download

IMG_6136.jpeg (4.35 MB) Closeup of 12V power supply and limit switch connections for 1 limit switch with polling.

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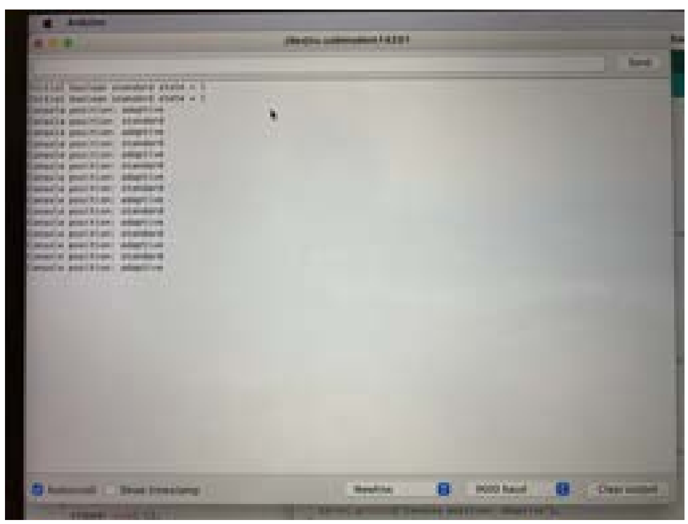
Download

IMG_6137.MOV (12.7 MB)

ANNABEL FRAKE - Oct 26, 2022, 12:13 AM CDT



Download

IMG_6138.jpeg (4.43 MB) Serial monitor for 1 limit switch with polling.

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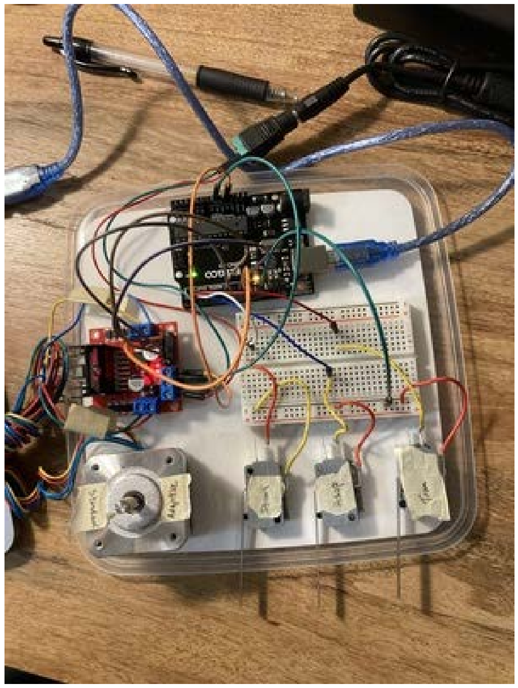
Download

Stepper_Code_With_Limit_Switch_Polling_L298N.ino (1.86 kB)

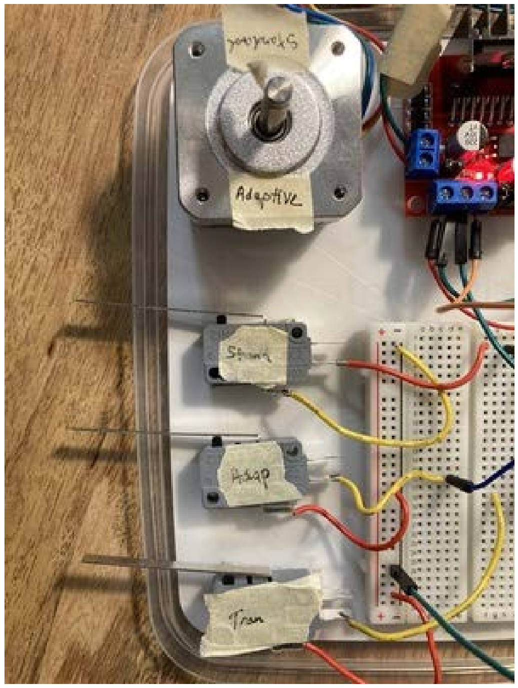
ANNABEL FRAKE - Oct 26, 2022, 1:17 AM CDT



Download

IMG_6139.jpeg (4.35 MB) Overall circuitry for 3 limit switches with interrupt.

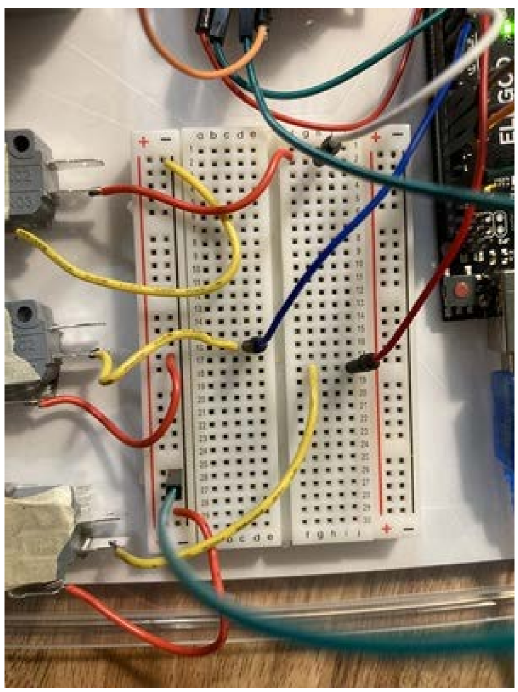
ANNABEL FRAKE - Oct 26, 2022, 1:17 AM CDT



Download

IMG_6140.jpeg (3.72 MB) Closeup of motor and limit switches for 3 limit switches with interrupt.

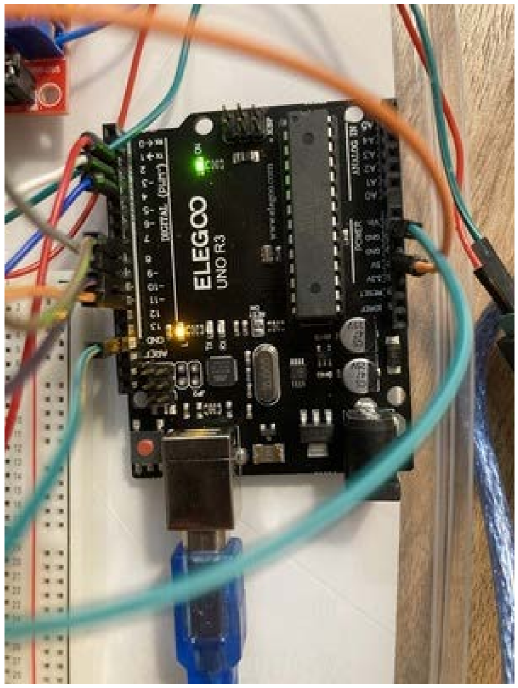
ANNABEL FRAKE - Oct 26, 2022, 1:17 AM CDT



Download

IMG_6141.jpeg (3.32 MB) Closeup of breadboard for 3 limit switches with interrupt.

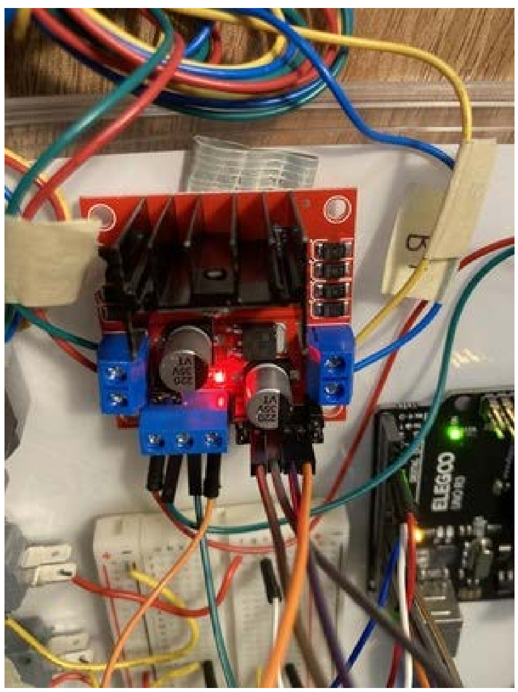
ANNABEL FRAKE - Oct 26, 2022, 1:17 AM CDT



Download

IMG_6142.jpeg (3.13 MB) Closeup of Arduino for 3 limit switches with interrupt.

ANNABEL FRAKE - Oct 26, 2022, 1:18 AM CDT



Download

IMG_6143.jpeg (2.58 MB) Closeup of L298N for 3 limit switches with interrupt.

ANNABEL FRAKE - Oct 26, 2022, 1:18 AM CDT

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IMG_6144.jpeg (2.91 MB) Serial Monitor example for 3 limit switches with interrupt.

ANNABEL FRAKE - Oct 26, 2022, 1:18 AM CDT

Download

Stepper_Sleep_Mode_3_Switches_1.0.ino (5.29 kB)

ANNABEL FRAKE - Oct 26, 2022, 1:19 AM CDT

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Stepper_Sleep_Mode_3_Switches_2.0.ino (4.29 kB)

ANNABEL FRAKE - Oct 26, 2022, 1:19 AM CDT

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Stepper_Sleep_Mode_3_Switches_3.0.ino (5.45 kB)

28OCT2022 Code Development

ANNABEL FRAKE - Oct 28, 2022, 12:30 PM CDT

Title: 28OCT2022 Code Development

Date: 28OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: continue to develop the code

Content:

- I tried the single limit switch polling again
  -
  - I changed the if logic slightly to match the INPUT_PULLUP (1s and 0s were swapped for the response I wanted)
  - I also realized that we should probably have a function checking the position of the console when the Arduino is turned on (may need to move console to match transition limit switch)
  - see "Stepper_Code_With_Limit_Switch_Polling_L298N_2.0.ino"
- Ok, then I returned to the 3 limit switch code and wrote a function to check the position of the console when the program starts
- The logic for that code works assuming that the console starts on either the standard or adaptive sides
  -
  - I have to make it more robust for edge cases where it doesn't start with one of the position limit switches pressed
  - basically, I need to add corrective positioning code
- ok, so I made the function corrective
  - the code checks the position of the console in the setup and corrects the position based on the state of the transition limit switch
  - within that code, I made functions for correcting to the standard side and correcting to the adaptive side
  - see "Stepper_Code_With_3_Limit_Switches_Polling_L298N_2.0.ino"
- I then generalized the correctToStandard and corrrectToAdaptive to rotateToStandard and rotateToAdaptive
  - I updated the void loop of the code to use these generalized functions instead of stepping half a rotation
  - the code at this point uses 3 limit switches
    - the transition limit switch uses the ezButton library so that when the limit switch is pressed, it triggers a rotation to the standard side and when the switch is unpressed, it triggers a rotation to the adaptive side
    - the standard and adaptive position switches then tell the console when it has reached the desired location and stops the rotation
  - See "Stepper_Code_With_3_Limit_Switches_Polling_L298N_4.0.ino" below
- I then tried to add the sleep mode code to what I have
  -
  - had to use .getStateRaw() instead of .isPressed() and .isReleased()
  - It worked for the first few transition state limit switch presses, but then subsequent presses wouldn't do anything and the serial monitor wouldn't print anything
  - the Arduino LED turns on, so I know the Arduino wakes up, but it doesn't do anything else after "Arduino asleep..."

- 

- I then tried it again, and it worked for 10+ presses in a row
- I think maybe I had forgotten to press one of the standard or adaptive position limit switches - in which case, the if statements wouldn't be true and nothing would happen
- this does reveal an issue I need to fix - what happens if the console is not in either of the expected positions when the transition limit switch state changes
- I added an else statement that calls the checkConsolePosition code if neither of the first two cases are true
- when I tried to upload the program to the board, my computer wouldn't recognize the port anymore (this happened earlier in the week too)
- I tried restarting my computer, but it still won't recognize it
- oh, wait, after a few minutes, it did recognize it
- perhaps I need to update my Arduino software
- that seems to work, but there were glitches when nothing would happen with a button press
- I'm wondering if the connections to the switches are causing it since I just wrapped the wires around the terminals and they don't have the best contact
- I found some wire connectors in ECB that I'm going to use and see if that changes things
- I have to go to the MakerSpace to find a crimper though
- I also tried running the code without plugging the Arduino into my computer
    - The 12V power supply powered the Arduino, so we do NOT need a 9V power supply

References:

"Arduino Reference - Arduino Reference." https://www.arduino.cc/reference/en/ (accessed Oct. 16, 2022).

Conclusions:

I went back to the basic 1 limit switch code with polling and worked my way up to the 3 limit switch code with sleep mode, adding one new thing at a time. I made great progress on the code today. There are some glitches that I want to work out and I will need to clean up the code to make it more streamlined with more descriptive comments (some of them are confusing with the INPUT_PULLUP to someone who doesn't know), but the current code is a good first draft. I can't wait to show the team!

Additionally, I realized that we don't need a 9V power supply because the 12V power supply will power the Arduino Uno and the motor.

Action items:

1. continue to develop the code

ANNABEL FRAKE - Oct 28, 2022, 11:40 AM CDT

```
// Stepper_Code_With_Limit_Switch_Polling_L298N_2.0.ino

// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Code for rotating the console of the Matrix rowing machine between the standard
and adaptive sides.


//Include stepper library and debounce library
#include <Stepper.h>
#include <ezButton.h>;


// Define pins
const byte limitSwitchPin = 2;


// Create ezButton object that matches the limit switch
ezButton limitSwitch(limitSwitchPin);


// Number of steps per output rotation.
int const stepsPerRevolution = 200;


// Number of steps per half rotation
const int stepsPerHalfRevolution = stepsPerRevolution / 2;


// Create servo object to control a servo motor.
Stepper stepper(stepsPerRevolution, 8, 9, 10, 11);


// Define boolean for whether the stepper motor is on the standard side or not
boolean standard = true;


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);

  // Set the motor speed to 40 rpm.
  stepper.setSpeed(40);


  // Assign the limit switch with a debounce time of 50 milliseconds
  limitSwitch.setDebounceTime(50);


  // Read state of limit switch when program initiates to define standard boolean value
  standard = digitalRead(limitSwitchPin);
  Serial.print("Initial boolean standard state = ");
  Serial.println(standard);
}
```

```
void loop()
{
  // Call the loop() function for the limit switch
  limitSwitch.loop();


  // If limit switch is pressed, standard side in use. Rotate console to standardPosition.
  if(limitSwitch.isPressed() && standard)
  {
    stepper.step(stepsPerHalfRevolution);
    standard = false;
    Serial.println("Console position: standard");
  }

  // If limit switch is not pressed, adaptive side in use. Rotate console to adaptivePosition.
  if(limitSwitch.isReleased() && !standard)
  {
    stepper.step(-stepsPerHalfRevolution);
    standard = true;
    Serial.println("Console position: adaptive");
  }
}
```

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Download

Stepper_Code_With_Limit_Switch_Polling_L298N_2.0.ino (1.86 kB)

ANNABEL FRAKE - Oct 28, 2022, 11:41 AM CDT

```
// Stepper_Code_With_3_Limit_Switches_Polling_L298N_2.0.ino
```

```
// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Code for rotating the console of the Matrix rowing machine between the standard and adaptive sides.


//Include stepper library and debounce library
#include <Stepper.h>
#include <ezButton.h>;


// Define pins
byte const transitionSwitchPin = 2; // This limit switch is placed near the stabilization frame. When its state changes, the rower is transitioned between adaptive and standard use or vice versa. When this limit switch is pressed, the console should be on the standard side and when it is not pressed, the console should be on the adaptive side.
byte const standardSwitchPin = 3; // This limit switch is placed near the console on the standard side. When it is pressed, the consle is facing the standard user.
byte const adaptiveSwitchPin = 4; // This limit switch is placed near the console on the adaptive side. When it is pressed, the consle is facing the wheelchair user.


// Declare states for the buttons.
int standardSwitchState = HIGH;
int adaptiveSwitchState = HIGH;


// Create ezButton object that matches the limit switch
ezButton transitionSwitch(transitionSwitchPin);


// Number of steps per output rotation.
int const stepsPerRevolution = 200;


// Number of steps per half rotation
const int stepsPerHalfRevolution = stepsPerRevolution / 2;


// Create servo object to control a servo motor.
Stepper stepper(stepsPerRevolution, 8, 9, 10, 11);


// Define boolean for whether the stepper motor is on the standard side or not
boolean standard = false; // Note: flilpped logic because of INPUT_PULLUP


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);


  // Set the motor speed to 40 rpm.
  stepper.setSpeed(40);
```

```
  // Set limit switch pins to INPUT_PULLUP
  pinMode(standardSwitchPin, INPUT_PULLUP);
  pinMode(adaptiveSwitchPin, INPUT_PULLUP);


  // Assign the limit switch with a debounce time of 50 milliseconds
  transitionSwitch.setDebounceTime(50);


  checkConsolePosition();
}


void loop()
{
  // Call the loop() function for the limit switch
  transitionSwitch.loop();


  // If limit switch is pressed, standard side in use. Rotate console to standardPosition.
  if (transitionSwitch.isPressed() && !digitalRead(adaptiveSwitchPin))
  {
    stepper.step(stepsPerHalfRevolution);
    standard = false;
    Serial.println("Console position: standard");
  }


  // If limit switch is not pressed, adaptive side in use. Rotate console to adaptivePosition.
  else if (transitionSwitch.isReleased() && !digitalRead(standardSwitchPin))
  {
    stepper.step(-stepsPerHalfRevolution);
    standard = true;
    Serial.println("Console position: adaptive");
  }
}


void checkConsolePosition()
{
  // Read state of the standard side limit switch.
  standardSwitchState = digitalRead(standardSwitchPin);
  Serial.print("standardSwitchState = ");
  Serial.println(standardSwitchState);


  // Read state of the adaptive side limit switch.
  adaptiveSwitchState = digitalRead(adaptiveSwitchPin);
  Serial.print("adaptiveSwitchState = ");
  Serial.println(adaptiveSwitchState);


  if (!standardSwitchState)
```

```
  {
    Serial.println("Console actually on standard side");
  }


  else if (!adaptiveSwitchState)
  {
    Serial.println("Console actually on adaptive side");
  }


  else
  {
    Serial.println("error, console not where it should be. Correcting...");


    Serial.print("transitionSwitchState = ");
    Serial.println(transitionSwitch.getState());


    // If transition limit switch is pressed, standard side in use. Rotate console to
standardPosition.
    if (!transitionSwitch.getState())
    {
      correctToStandard(standardSwitchPin);
      standard = false;
      Serial.println("Console position: standard");
    }
    // If transition limit switch is not pressed, adaptive side in use. Rotate console to
adaptivePosition.
    else if (transitionSwitch.getState())
    {
      correctToAdaptive(adaptiveSwitchPin);
      standard = true;
      Serial.println("Console position: adaptive");
    }
  }
}


void correctToStandard(int standardSwitchPin)
{
  while (digitalRead(standardSwitchPin))
  {
    stepper.step(1);
  }
}


void correctToAdaptive(int adaptiveSwitchPin)
{
  while (digitalRead(adaptiveSwitchPin))
  {
    stepper.step(-1);
```

```
  }
}
```

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Download

Stepper_Code_With_3_Limit_Switches_Polling_L298N_2.0.ino (4.26 kB)

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Download

1_Step_Troubleshooting.ino (2.15 kB) I used this to make try the while loop separate from the rest of the code.

ANNABEL FRAKE - Oct 28, 2022, 11:41 AM CDT

```
// Stepper_Code_With_3_Limit_Switches_Polling_L298N_4.0.ino
```

```
// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Code for rotating the console of the Matrix rowing machine between the standard
and adaptive sides.


//Include stepper library and debounce library
#include <Stepper.h>
#include <ezButton.h>;


// Define pins
byte const transitionSwitchPin = 2; // This limit switch is placed near the stabilization frame.
When its state changes, the rower is transitioned between adaptive and standard use or vice versa.
When this limit switch is pressed, the console should be on the standard side and when it is not
pressed, the console should be on the adaptive side.
byte const standardSwitchPin = 3; // This limit switch is placed near the console on the standard
side. When it is pressed, the consle is facing the standard user.
byte const adaptiveSwitchPin = 4; // This limit switch is placed near the console on the adaptive
side. When it is pressed, the consle is facing the wheelchair user.


// Declare states for the buttons.
int standardSwitchState = HIGH;
int adaptiveSwitchState = HIGH;


// Create ezButton object that matches the limit switch
ezButton transitionSwitch(transitionSwitchPin);


// Number of steps per output rotation.
int const stepsPerRevolution = 200;


// Create servo object to control a servo motor.
Stepper stepper(stepsPerRevolution, 8, 9, 10, 11);


// Define boolean for whether the stepper motor is on the standard side or not
boolean standard = false; // Note: flilpped logic because of INPUT_PULLUP


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);


  // Set the motor speed to 40 rpm.
  stepper.setSpeed(40);


  // Set limit switch pins to INPUT_PULLUP
  pinMode(standardSwitchPin, INPUT_PULLUP);
```

```
  pinMode(adaptiveSwitchPin, INPUT_PULLUP);


  // Assign the limit switch with a debounce time of 50 milliseconds
  transitionSwitch.setDebounceTime(50);


  checkConsolePosition();
}


void loop()
{
  // Call the loop() function for the limit switch
  transitionSwitch.loop();


  // If limit switch is pressed, standard side in use. Rotate console to standardPosition.
  if (transitionSwitch.isPressed() && !digitalRead(adaptiveSwitchPin))
  {
    rotateToStandard(standardSwitchPin);
  }


  // If limit switch is not pressed, adaptive side in use. Rotate console to adaptivePosition.
  else if (transitionSwitch.isReleased() && !digitalRead(standardSwitchPin))
  {
    rotateToAdaptive(adaptiveSwitchPin);
  }
}


void checkConsolePosition()
{
  // Read state of the standard side limit switch.
  standardSwitchState = digitalRead(standardSwitchPin);
  Serial.print("standardSwitchState = ");
  Serial.println(standardSwitchState);


  // Read state of the adaptive side limit switch.
  adaptiveSwitchState = digitalRead(adaptiveSwitchPin);
  Serial.print("adaptiveSwitchState = ");
  Serial.println(adaptiveSwitchState);


  if (!standardSwitchState)
  {
    Serial.println("Console actually on standard side");
  }


  else if (!adaptiveSwitchState)
  {
    Serial.println("Console actually on adaptive side");
```

```
  }


  else
  {
    Serial.println("error, console not where it should be. Correcting...");


    Serial.print("transitionSwitchState = ");
    Serial.println(transitionSwitch.getState());


    // If transition limit switch is pressed, standard side in use. Rotate console to
standardPosition.
    if (!transitionSwitch.getState())
    {
      rotateToStandard(standardSwitchPin);
    }
    // If transition limit switch is not pressed, adaptive side in use. Rotate console to
adaptivePosition.
    else if (transitionSwitch.getState())
    {
      rotateToAdaptive(adaptiveSwitchPin);
    }
  }
}


void rotateToStandard(int standardSwitchPin)
{
  while (digitalRead(standardSwitchPin))
  {
    stepper.step(1);
  }
  standard = false;
  Serial.println("Console position: standard");
}


void rotateToAdaptive(int adaptiveSwitchPin)
{
  while (digitalRead(adaptiveSwitchPin))
  {
    stepper.step(-1);
  }
  standard = true;
  Serial.println("Console position: adaptive");
}
```

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Download

Stepper_Code_With_3_Limit_Switches_Polling_L298N_4.0.ino (4 kB)

ANNABEL FRAKE - Oct 28, 2022, 12:21 PM CDT

```
// Stepper_Code_With_3_Limit_Switches_Polling_L298N_5.0.ino
```

```
// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Code for rotating the console of the Matrix rowing machine between the standard
and adaptive sides.


//Include necessary libraries
#include <Stepper.h>
#include <ezButton.h>;
#include <avr/sleep.h>;


// Define pins
byte const transitionSwitchPin = 2; // This limit switch is placed near the stabilization frame.
When its state changes, the rower is transitioned between adaptive and standard use or vice versa.
When this limit switch is pressed, the console should be on the standard side and when it is not
pressed, the console should be on the adaptive side.
byte const standardSwitchPin = 3; // This limit switch is placed near the console on the standard
side. When it is pressed, the consle is facing the standard user.
byte const adaptiveSwitchPin = 4; // This limit switch is placed near the console on the adaptive
side. When it is pressed, the consle is facing the wheelchair user.


// Declare states for the buttons.
int standardSwitchState = HIGH;
int adaptiveSwitchState = HIGH;


// Create ezButton object that matches the limit switch
ezButton transitionSwitch(transitionSwitchPin);


// Number of steps per output rotation.
int const stepsPerRevolution = 200;


// Create servo object to control a servo motor.
Stepper stepper(stepsPerRevolution, 8, 9, 10, 11);


// Define boolean for whether the stepper motor is on the standard side or not
boolean standard = false; // Note: flilpped logic because of INPUT_PULLUP


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);


  // Set LED_BUILTIN on pin 13 to output. This LED indicates whether the Arduino is awake (LED on)
or asleep (LED off).
  pinMode(LED_BUILTIN, OUTPUT);
```

```
  // Turn LED_BUILTIN on
  digitalWrite(LED_BUILTIN, HIGH);


  // Set the motor speed to 40 rpm.
  stepper.setSpeed(40);


  // Set limit switch pins to INPUT_PULLUP
  pinMode(standardSwitchPin, INPUT_PULLUP);
  pinMode(adaptiveSwitchPin, INPUT_PULLUP);


  // Assign the limit switch with a debounce time of 50 milliseconds
  transitionSwitch.setDebounceTime(50);


  checkConsolePosition();
}


void loop()
{
  // Call the loop() function for the limit switch
  transitionSwitch.loop();


  // Put the Arduino to Sleep.
  goToSleep();


  // If limit switch is pressed, standard side in use. Rotate console to standardPosition.
  if (!transitionSwitch.getStateRaw() && !digitalRead(adaptiveSwitchPin))
  {
    rotateToStandard(standardSwitchPin);
  }


  // If limit switch is not pressed, adaptive side in use. Rotate console to adaptivePosition.
  else if (transitionSwitch.getStateRaw() && !digitalRead(standardSwitchPin))
  {
    rotateToAdaptive(adaptiveSwitchPin);
  }


  // If the console is not in one of the excpected positions, correct orientation.
  else
  {
    checkConsolePosition();
  }
}


void checkConsolePosition()
{
```

```
  // Read state of the standard side limit switch.
  standardSwitchState = digitalRead(standardSwitchPin);
  Serial.print("standardSwitchState = ");
  Serial.println(standardSwitchState);


  // Read state of the adaptive side limit switch.
  adaptiveSwitchState = digitalRead(adaptiveSwitchPin);
  Serial.print("adaptiveSwitchState = ");
  Serial.println(adaptiveSwitchState);


  if (!standardSwitchState)
  {
    Serial.println("Console actually on standard side");
  }


  else if (!adaptiveSwitchState)
  {
    Serial.println("Console actually on adaptive side");
  }


  else
  {
    Serial.println("error, console not where it should be. Correcting...");


    Serial.print("transitionSwitchState = ");
    Serial.println(transitionSwitch.getState());


    // If transition limit switch is pressed, standard side in use. Rotate console to
standardPosition.
    if (!transitionSwitch.getState())
    {
      rotateToStandard(standardSwitchPin);
    }
    // If transition limit switch is not pressed, adaptive side in use. Rotate console to
adaptivePosition.
    else if (transitionSwitch.getState())
    {
      rotateToAdaptive(adaptiveSwitchPin);
    }
  }
}


void rotateToStandard(int standardSwitchPin)
{
  while (digitalRead(standardSwitchPin))
  {
    stepper.step(1);
  }
```

```
  standard = false;
  Serial.println("Console position: standard");
}


void rotateToAdaptive(int adaptiveSwitchPin)
{
  while (digitalRead(adaptiveSwitchPin))
  {
    stepper.step(-1);
  }
  standard = true;
  Serial.println("Console position: adaptive");
}


void goToSleep()
{
  // Print that the Arduino is going to sleep.
  Serial.println("Arduino asleep...");

  // Enable sleep mode.
  sleep_enable();


  // Enable interrupts.
  interrupts();


  // Attach interrupt to wakeup Arduino when the transitionSwitchPin changes state.
  attachInterrupt(digitalPinToInterrupt(transitionSwitchPin), wakeup, CHANGE);


  // Set full sleep mode.
  set_sleep_mode(SLEEP_MODE_PWR_DOWN);


  // Add delay to allow the motor time to move before Arduino sleeps.
  delay(200);


  // Turn off LED_BUILTIN as a visual indicator that the Arduino entered sleep mode.
  digitalWrite(LED_BUILTIN, LOW);


  // Activate sleep mode.
  sleep_cpu();


  // After the wakeup interrupt, the code will resume here.
  Serial.println("Arduino awake!");


  // Turn on LED_BUILTIN as a visual indicator that the Arduino is awake.
  digitalWrite(LED_BUILTIN, HIGH);
```

```
}


void wakeup()
{
  // Prevent multiple interrupts by disabling them.
  noInterrupts();

  // Disable sleep mode.
  sleep_disable();


  // Detach interrupt from transition limit switch.
  detachInterrupt(transitionSwitchPin);
}
```

ANNABEL FRAKE - Oct 28, 2022, 12:21 PM CDT

Download

Stepper_Code_With_3_Limit_Switches_Polling_L298N_5.0.ino (5.53 kB)

28OCT2022 Motor Heating Issue

ANNABEL FRAKE - Oct 28, 2022, 5:50 PM CDT

Title: 28OCT2022 Motor Heating Issue

Date: 28OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: look into the amperage of the power supply as Staci suggested

Content:

-
- Staci suggested that the motor heating may result from the amperage of the power supply
- The power supply is 12V - 5A
- the motor takes 12VDC and is rated at 330 mA
- I did some general web searches to see if the current from the power supply could be larger than the current rating of the motor, and they said that it was acceptable
    - https://www.jameco.com/Jameco/content/high-wattage-power-supply-selection.html
        - "There is no truth to the myth that a large wattage power supply will force too much power into your devices causing overheating and burnout. The power supply will only provide the needed wattage. For example, a device that needs 50 watts will only get 50 watts from a 250 watt supply, not the entire 250 watts."
    - https://electronics.stackexchange.com/questions/175222/is-it-really-ok-to-supply-more-current-than-what-the-component-is-rated-for
        - image below taken from a post on a forum linked above
        - To answer the title of your question, the answer is no. It is not ok to supply more current to a component than its rated value.

          However, it is ok to have a voltage power supply rated for more current than the components rated value because the component will draw as much as it needs. If you are pushing more current into (forcefully) the component, then the component will exceed its rated value, heat up and be destroyed. Such as if you use a constant current source or you use a large voltage (which will cause more current to flow). But if you use the rated voltage, then the load will only take what is required, regardless of how much current is available to be drawn from the source.
        - other posts suggest a rate-limiting resistor solution
- It seems like the power supply should be fine, so I went to the MakerSpace to ask their opinion
- I told an employee there about our circuit and the parameters that we have
- he asked about the voltage seen at the motor controller
    - I told him it was around 12.4V, but he said that isn't too much higher than the rating and shouldn't be causing the heating
    - he suggested that I measure the current going to the motor controller and see if it exceeds the 330 mA rating
        - if so, he said we could add a resistor to lower the current, but that would affect the voltage as well

References:

MakerSpace

https://www.jameco.com/Jameco/content/high-wattage-power-supply-selection.html

https://electronics.stackexchange.com/questions/175222/is-it-really-ok-to-supply-more-current-than-what-the-component-is-rated-for

Conclusions:

After talking to the team and client about the heating problem with the stepper motor, I looked into the specifications of the power supply. According to a general internet search, as long as the voltage of the power supply matches the voltage rating of the motor, there shouldn't be an issue (although I may need a rate-limiting resistor). I went to the MakerSpace to ask their advice and they suggested that I measure the current seen by the motor. If it is too high for the motor's rating, then we could add a resistor to lower it. I will try this over the weekend most likely.

Action items:

1. measure the current going to the motor and compare to the rating of 330 mA

30OCT2022 Edge Case + Motor Heating Testing

ANNABEL FRAKE - Oct 30, 2022, 6:00 PM CDT

Title: 30OCT2022 Edge Case + Motor Heating Testing

Date: 30OCT2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: investigate the motor heating issue, test edge cases

Content:

- after talking to someone at the MakerSpace, I measured the current going to the motor
  - I put the multimeter in series with the 12V power supply to the L298N motor controller that powers the motor
  - the values ranged from 0.22 and 0.28 A, which is within the 330 mA current rating of the motor
  - I did some edge case testing and came back to it when the motor was actually hot
    - the current read 0.56 A, which exceeds the current rating of the motor
    - although I am not sure why the current increases over time
    - I am going to go back to the MakerSpace and ask at some point in the upcoming week
- I then used the wire connectors I found in ECB to make the connections to the limit switches more secure
- I did some jerry-rigging with duct tape to attach the standard and adaptive limit switches to the motor so that we can actually see what happens when rotation occurs
- I troubleshooted some edge cases and adjusted the code accordingly
- edge cases (videos attached to this entry):
  - console in no-man's land (not on adaptive or standard sides) and transition limit switch is not pressed => when power supplied, console rotates to adaptive side
  - console in no-man's land (not on adaptive or standard sides) and transition limit switch is pressed => when power supplied, console rotates to standard side
  - console is on adaptive side and transition limit switch is not pressed => when power supplied, console remains stationary until transition limit switch is released
  - console is on standard side (had to tape limit switch because motor wouldn't press it without power) and transition limit switch is pressed => when power supplied, console remains stationary until transition limit switch is released
  - console is on adaptive side and transition limit switch is pressed (console on wrong side to start) => when power supplied, console rotates to standard side
  - console is on standard side (had to tape limit switch because motor wouldn't press it without power) and transition limit switch is not pressed (console on wrong side to start) => when power supplied, console rotates to adaptive side
  - I restarted the Arduino during rotation => rotation halted and then resumed and the console ended up where it should be based on the feedback from the transition limit switch
- there is an additional edge case: when both limit switches are pressed
  - right now, the motor won't move if both of the limit switches are pressed at any given time
  - I couldn't get a video of it because I don't have enough hands for that
  - once both of the limit switches are no longer pressed at one time, the motor will rotate to the appropriate side according to what switch is still pressed

    - ex: if both position switches are pressed to start (and the transition switch is not pressed - indicating adaptive side in use) and then the standard switch is released, the motor will rotate to the adaptive side

  - I'm thinking that this is the best solution for this edge case because both limit switches should not be pressed unless someone has their hand where it should not be or there is damage to the device, in which case, we don't want movement anyways

References: none

Conclusions:

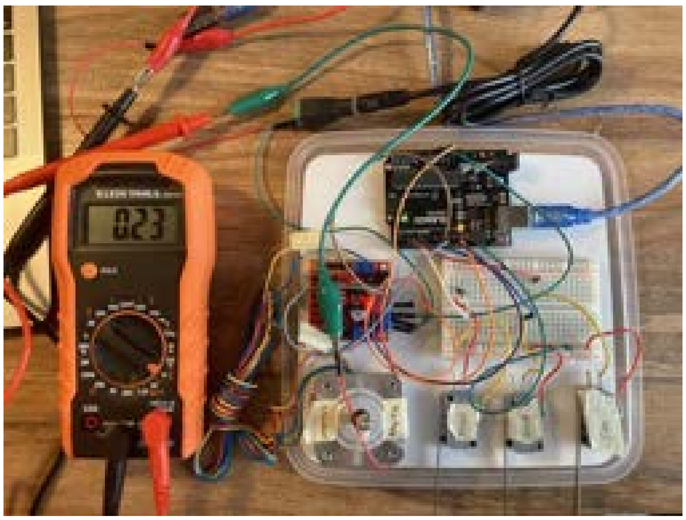
I tested the motor heating problem today by measuring the current delivered to the motor through the L298N controller. When the motor was first plugged in, the current levels looked normal. I waited until the end of today's testing session (motor now hot) and measured again. At this point, the current was higher than the rating. I'm not sure why the current draw would increase over time and if a current limiting resistor would solve the problem, so I am going to ask someone at the MakerSpace this week.

I also troubleshooted my most recent code (without sleep mode though) using edge cases and adjusted things as necessary. By the end of the session, the code passed all of the edge cases (see videos below). The only edge case I'm not entirely sure about is when both limit switches are pressed. Right now, rotation stops if both switches are pressed and resumes when only one limit switch is pressed. I think this is an ideal response because if both limit switches are pressed, something is wrong and you probably wouldn't want the console to rotate anyways, but I will continue to think on this. Overall, this was a very satisfying testing session because I could actually see how the motor rotation integrated with the circuit logic.

Action items:

1. continue developing the code
2. go to the MakerSpace to ask about the heat problem

ANNABEL FRAKE - Oct 30, 2022, 5:48 PM CDT



Download

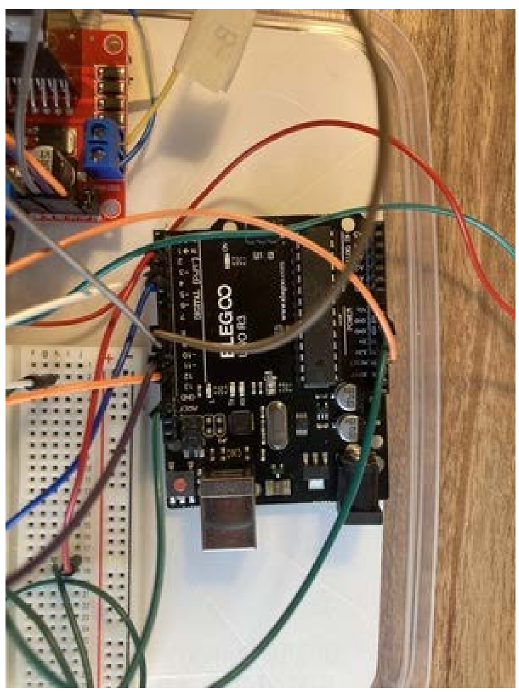
IMG_6177.jpeg (3.96 MB) Image of the circuit while testing amperage to the motor. I inserted the multimeter in series between the 12V power supply and the L298N.

ANNABEL FRAKE - Oct 30, 2022, 5:20 PM CDT

Download

IMG_6178.jpeg (4.28 MB) Image of the entire testing setup today. Most of the components are taped to a plastic lid for transportation ease.

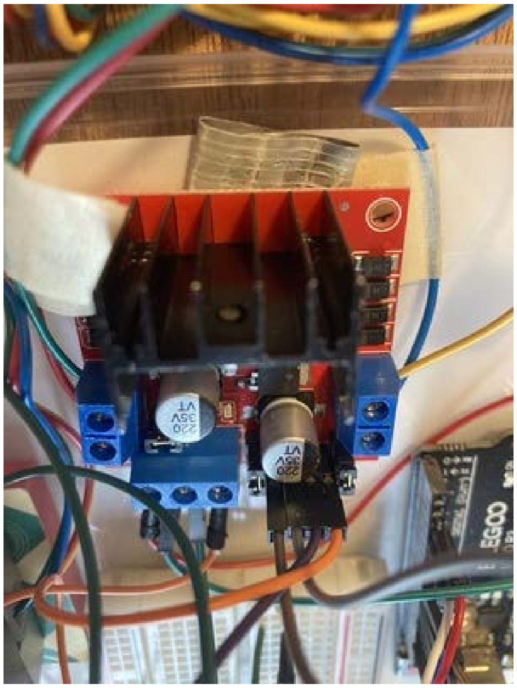
ANNABEL FRAKE - Oct 30, 2022, 5:21 PM CDT



Download

IMG_6179.jpeg (3.34 MB) Closeup of Arduino connections.

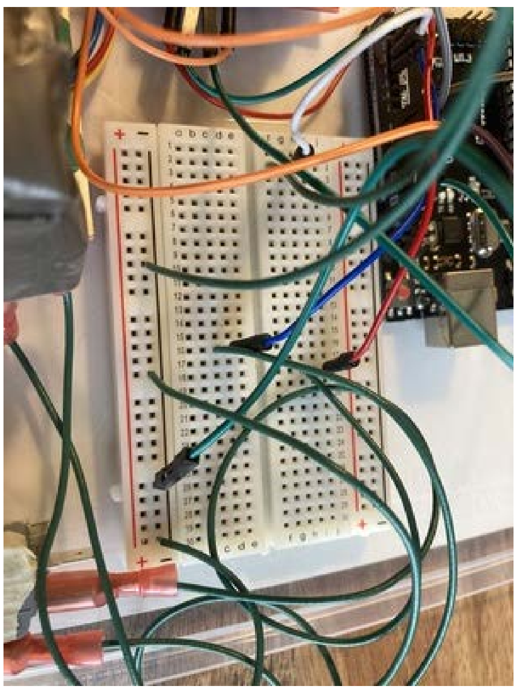
ANNABEL FRAKE - Oct 30, 2022, 5:21 PM CDT



Download

IMG_6180.jpeg (2.91 MB) Closeup of L298N connections.

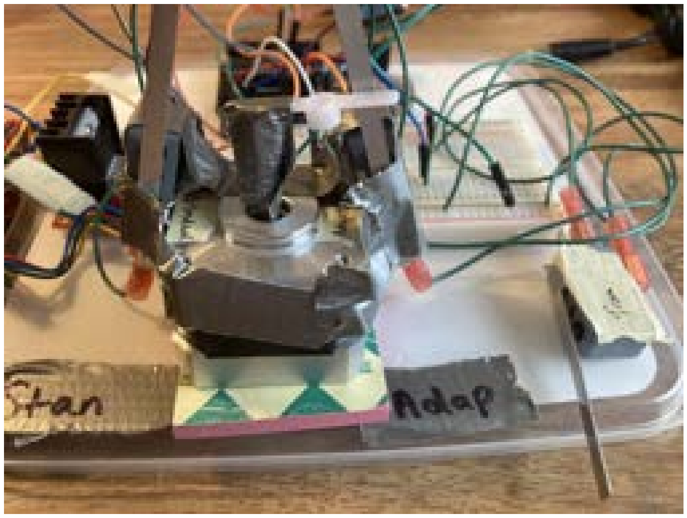
ANNABEL FRAKE - Oct 30, 2022, 5:22 PM CDT



Download

IMG_6181.jpeg (3.29 MB) Closeup of Arduino board connections.

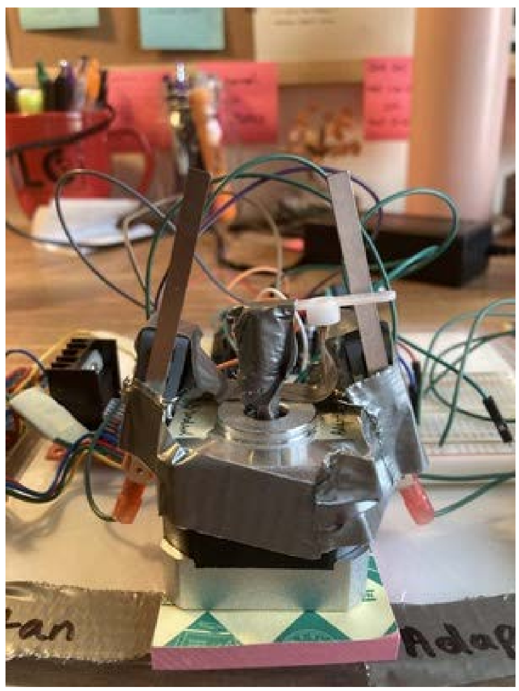
ANNABEL FRAKE - Oct 30, 2022, 5:23 PM CDT



Download

IMG_6182.jpeg (3.31 MB) Stepper motor and limit switches. Tape marks which side is "standard" vs "adaptive" at 180 deg from each other. The standard limit switch is on the standard side and the adaptive limit switch is on the adaptive side of the motor. The transition limit switch (will be placed near lap bar) is off to the right in the image.

ANNABEL FRAKE - Oct 30, 2022, 5:23 PM CDT



Download

IMG_6183.jpeg (2.18 MB) Closeup of stepper motor and tape designations.

ANNABEL FRAKE - Oct 30, 2022, 5:43 PM CDT

Download

IMG_6191.MOV (16.1 MB) Console starts in no-man's land (not on adaptive or standard sides) and transition limit switch is not pressed => when power supplied, console rotates to adaptive side.

ANNABEL FRAKE - Oct 30, 2022, 5:44 PM CDT

Download

IMG_6192.MOV (16.7 MB) Console starts in no-man's land (not on adaptive or standard sides) and transition limit switch is pressed => when power supplied, console rotates to standard side. I used a weight to depress the transition limit switch to start because I didn't have enough hands.

ANNABEL FRAKE - Oct 30, 2022, 5:45 PM CDT

Download

IMG_6193.MOV (18.4 MB) Console starts on adaptive side and transition limit switch is not pressed => when power supplied, console remains stationary until transition limit switch is released.

ANNABEL FRAKE - Oct 30, 2022, 5:47 PM CDT

Download

IMG_6201.MOV (21.8 MB) Console starts on standard side (had to tape limit switch because motor wouldn't press it without power) and transition limit switch is pressed => when power supplied, console remains stationary until transition limit switch is released.

ANNABEL FRAKE - Oct 30, 2022, 5:48 PM CDT

Download

IMG_6203.MOV (19.4 MB) Console starts on adaptive side and transition limit switch is pressed (console on wrong side to start) => when power supplied, console rotates to standard side.

ANNABEL FRAKE - Oct 30, 2022, 5:51 PM CDT

Download

IMG_6204.MOV (18.6 MB) Console starts on standard side (had to tape limit switch because motor wouldn't press it without power) and transition limit switch is not pressed (console on wrong side to start) => when power supplied, console rotates to adaptive side.

ANNABEL FRAKE - Oct 30, 2022, 5:51 PM CDT

Download

IMG_6205.MOV (15.8 MB) I restarted the Arduino during rotation => rotation halted and then resumed and the console ended up where it should be based on the feedback from the transition limit switch.

ANNABEL FRAKE - Oct 30, 2022, 5:53 PM CDT

```
// Stepper_Code_With_3_Limit_Switches_Polling_L298N_6.0.ino

// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Code for rotating the console of the Matrix rowing machine between the standard
and adaptive sides.


//Include stepper library and debounce library
#include <Stepper.h>
#include <ezButton.h>;


// Define pins
byte const transitionSwitchPin = 2; // This limit switch is placed near the stabilization frame.
When its state changes, the rower is transitioned between adaptive and standard use or vice versa.
When this limit switch is pressed, the console should be on the standard side and when it is not
pressed, the console should be on the adaptive side.
byte const standardSwitchPin = 3; // This limit switch is placed near the console on the standard
side. When it is pressed, the consle is facing the standard user.
byte const adaptiveSwitchPin = 4; // This limit switch is placed near the console on the adaptive
side. When it is pressed, the consle is facing the wheelchair user.


// Declare states for the buttons.
int standardSwitchState = HIGH;
int adaptiveSwitchState = HIGH;


// Create ezButton object that matches the limit switch
ezButton transitionSwitch(transitionSwitchPin);


// Number of steps per output rotation.
int const stepsPerRevolution = 200;


// Create servo object to control a servo motor.
Stepper stepper(stepsPerRevolution, 8, 9, 10, 11);


// Define boolean for whether the stepper motor is on the standard side or not
boolean standard = false; // Note: flilpped logic because of INPUT_PULLUP


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);


  // Set the motor speed to 40 rpm.
  stepper.setSpeed(40);
```

```
  // Set limit switch pins to INPUT_PULLUP
  pinMode(standardSwitchPin, INPUT_PULLUP);
  pinMode(adaptiveSwitchPin, INPUT_PULLUP);


  // Assign the limit switch with a debounce time of 50 milliseconds
  transitionSwitch.setDebounceTime(50);


  checkConsolePosition();
}


void loop()
{
  // Call the loop() function for the limit switch
  transitionSwitch.loop();


  // If limit switch is pressed, standard side in use. Rotate console to standardPosition.
  if (transitionSwitch.isPressed() && !digitalRead(adaptiveSwitchPin))
  {
    rotateToStandard(standardSwitchPin);
  }


  // If limit switch is not pressed, adaptive side in use. Rotate console to adaptivePosition.
  else if (transitionSwitch.isReleased() && !digitalRead(standardSwitchPin))
  {
    rotateToAdaptive(adaptiveSwitchPin);
  }


  // If the console is not in one of the excpected positions, correct orientation.
  else
  {
    checkConsolePosition();
  }
}


void checkConsolePosition()
{
  // If transition limit switch is pressed, standard side in use. Rotate console to
standardPosition.
  if (!transitionSwitch.getState())
  {
    rotateToStandard(standardSwitchPin);
  }
  // If transition limit switch is not pressed, adaptive side in use. Rotate console to
adaptivePosition.
  else if (transitionSwitch.getState())
  {
    rotateToAdaptive(adaptiveSwitchPin);
  }
```

```
}


void rotateToStandard(int standardSwitchPin)
{
  while (digitalRead(standardSwitchPin))
  {
    stepper.step(1);
  }
  standard = false;
  Serial.println("Console position: standard");
}


void rotateToAdaptive(int adaptiveSwitchPin)
{
  while (digitalRead(adaptiveSwitchPin))
  {
    stepper.step(-1);
  }
  standard = true;
  Serial.println("Console position: adaptive");
}
```

ANNABEL FRAKE - Oct 30, 2022, 5:53 PM CDT

Download

Stepper_Code_With_3_Limit_Switches_Polling_L298N_6.0.ino (3.35 kB)

31OCT2022 Motor Heating Problem

ANNABEL FRAKE - Oct 31, 2022, 5:55 PM CDT

Title: 31OCT2022 Motor Heating Problem

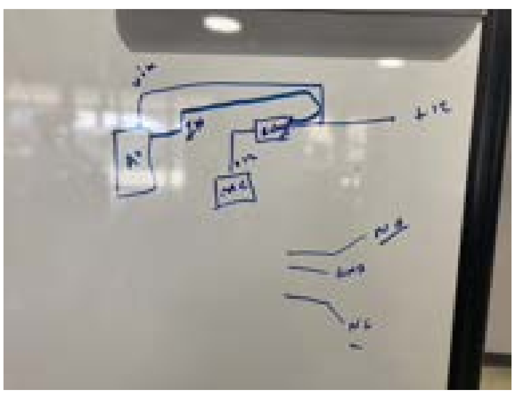
Date: 31OCT2022

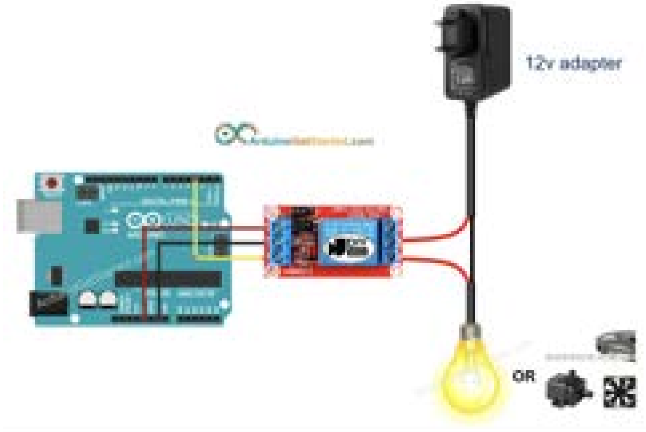
Content by: Annabel Frake

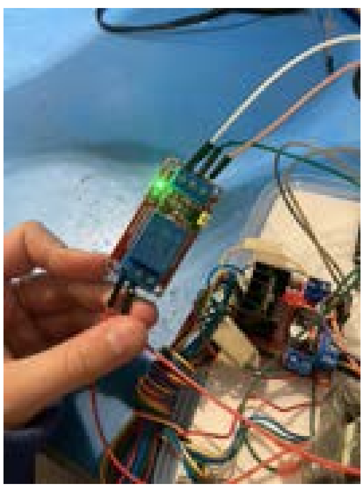
Present: Annabel Frake, Yash Wani (MakerSpace employee)

Goals: solve the motor heating problem

Content:

- I went to the MakerSpace to ask Yash's opinion on the current readings I recorded yesterday
- he suggested using a relay to physically cut power to the motor and motor controller, then there would be no power and no way to heat up the motor
- he said that because the motor is constantly holding its position even when not rotating (ie you can't rotate the shaft of the motor when the motor is powered), then it can heat up
- he said that the L298N can't module its own current, so it needs to be given exactly what it wants
- He drew the picture below of what the circuit relay would look like in my circuit
- 
- I went ahead and purchased the relay from the MakerSpace for $2.11
- I reworked the code to turn on the relay at the beginning of the rotate functions and turn it off at the end of the rotate functions
- I tried hooking it up according to the whiteboard drawing, but it did not seem to work as expected
- I looked up how to use a relay with Arduino (https://arduinogetstarted.com/tutorials/arduino-relay) and rewired things according to the image below

- 

- this worked, but the motor controller started to heat up
- I asked Yash, and he said that was not the way he had intended since this means that the 12V power supply cannot power the Arduino
- we rewired it so that the input to the relay is the 5V power supply on Arduino (orange) and ground (green) with a wire (white) going to digital pin 5 (and later 7) on the Arduino
- this digital pin controls the state of the relay based on 1 or 0
- the output of the relay goes to the motor controller (red) and the 12V power supply strip on the breadboard (also red)
- 
- this worked initially, but the motor controller and motor heated up after a while (I kept it turned on to double check the issue had been solved)
- I asked Yash again, and we did some more troubleshooting
- eventually, we realized that while the limit switches stopped the rotation of the motor (and should have also switched the relay because of the code structure), the relay was never turned on / off
- also, the motor could not be spun when the relay was "supposed to be" off
- we figured out that this is because of the checkConsolePosition() function that was being called (since the first 2 conditions of a transition limit switch state change were not met)
- because it was constantly calling the checkConsolePosition() code which called the rotation functions, the relay never turned off
- I commented this code and everything worked
- we heard the relay change and the power to the motor controller and motor were cut (ie light on motor controller turned off and motor shaft could be rotated freely by hand)

- I changed the logic of the first 2 if statements to not require the standard or adaptive switches to be pressed at the time of the transition limit state change
    - I believe this will replace the checkConsolePosition() logic, but I will need to test this further in the next few days

References:

Yash Wani

“Arduino Reference - Arduino Reference.” https://www.arduino.cc/reference/en/ (accessed Oct. 16, 2022).

how to use relay with Arduino: https://arduinogetstarted.com/tutorials/arduino-relay

relay (I'm 90% sure this is the relay I have, but the one I purchased from the MakerSpace doesn't have a part number, so I had to go off of appearance.): https://www.amazon.com/dp/B095SZRPD9/ref=sspa_dk_detail_3?psc=1&pd_rd_i=B095SZRPD9&pd_rd_w=WUftE&content-id=amzn1.sym.88097cb9-5064-44ef-891b-abfacbc1c44b&pf_rd_p=88097cb9-5064-44ef-891b-abfacbc1c44b&pf_rd_r=A3R1VXCRAZBC345VASAV&pd_rd_wg=U6sEN&pd_rd_r=ef9e1b3d-1384-4474-bd6f-8eac49dc6458&s=electronics&sp_csd=d2lkZ2V0TmFtZT1zcF9kZXRhaWw

Conclusions:

I went to the MakerSpace today to try and solve the heating issue once and for all. Yash suggested that I use a relay to physically cut power to the stepper motor when it is not in use. Even though the motor may not be rotating, it is constantly holding its position (cannot be manually rotated) and this is what most likely allows the heating up over time. There are also apparently issues with the L298N because it cannot modulate current. Therefore, he suggested the relay as a way to cut the power and prevent heating. Yash and I did a lot of troubleshooting today, but we eventually got the relay to work with the circuit. I will have to redo some testing with the edge cases to make sure that the code still operates the way I would like it to. I also want to rebuild the circuit and clean things up so that I can take clearer pictures (I will also be making a Fritzing diagram soon now that the circuit should be finalized). My duct tape job also came undone today during testing, so I will need to reattach the arm/flag to the motor to continue testing (and possibly for show and tell).

Action items:

1. Rebuilt circuit to make things cleaner
2. continue to develop, test, and debug

ANNABEL FRAKE - Oct 31, 2022, 5:42 PM CDT

```
// relay_example.ino
byte const relayPin = 7;


void setup()
{
  // put your setup code here, to run once:
pinMode(relayPin, OUTPUT);
Serial.begin(9600);
}

void loop()
{
// put your main code here, to run repeatedly:
digitalWrite(relayPin, LOW);
Serial.println("Relay off");
delay(5000);

digitalWrite(relayPin, HIGH);
Serial.println("Relay on");
delay(5000);
}
```

ANNABEL FRAKE - Oct 31, 2022, 5:41 PM CDT

Download

relay_example.ino (349 B) We used this code to troubleshoot the relay and make sure it worked separate from my code.

ANNABEL FRAKE - Oct 31, 2022, 5:43 PM CDT

```
// Stepper_Code_With_3_Limit_Switches_Polling_L298N_7.0
// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Code for rotating the console of the Matrix rowing machine between the standard
and adaptive sides.


//Include stepper library and debounce library
#include <Stepper.h>
#include <ezButton.h>;


// Define pins
byte const transitionSwitchPin = 2; // This limit switch is placed near the stabilization frame.
When its state changes, the rower is transitioned between adaptive and standard use or vice versa.
When this limit switch is pressed, the console should be on the standard side and when it is not
pressed, the console should be on the adaptive side.
byte const standardSwitchPin = 3; // This limit switch is placed near the console on the standard
side. When it is pressed, the consle is facing the standard user.
byte const adaptiveSwitchPin = 4; // This limit switch is placed near the console on the adaptive
side. When it is pressed, the consle is facing the wheelchair user.
byte const relayPin = 7;


// Declare states for the buttons.
int standardSwitchState = HIGH;
int adaptiveSwitchState = HIGH;


// Create ezButton object that matches the limit switch
ezButton transitionSwitch(transitionSwitchPin);


// Number of steps per output rotation.
int const stepsPerRevolution = 200;


// Create servo object to control a servo motor.
Stepper stepper(stepsPerRevolution, 8, 9, 10, 11);


// Define boolean for whether the stepper motor is on the standard side or not
boolean standard = false; // Note: flilpped logic because of INPUT_PULLUP


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);


  // Set the motor speed to 40 rpm.
  stepper.setSpeed(40);
```

```
  // Set limit switch pins to INPUT_PULLUP
  pinMode(standardSwitchPin, INPUT_PULLUP);
  pinMode(adaptiveSwitchPin, INPUT_PULLUP);


  pinMode(relayPin, OUTPUT);


  // Assign the limit switch with a debounce time of 50 milliseconds
  transitionSwitch.setDebounceTime(50);


  checkConsolePosition();
}


void loop()
{
  // Call the loop() function for the limit switch
  transitionSwitch.loop();


  // If limit switch is pressed, standard side in use. Rotate console to standardPosition.
  if (transitionSwitch.isPressed())
  {
    rotateToStandard(standardSwitchPin);
  }


  // If limit switch is not pressed, adaptive side in use. Rotate console to adaptivePosition.
  else if (transitionSwitch.isReleased())
  {
    rotateToAdaptive(adaptiveSwitchPin);
  }
}


void checkConsolePosition()
{
  // If transition limit switch is pressed, standard side in use. Rotate console to
standardPosition.
  if (!transitionSwitch.getState())
  {
    rotateToStandard(standardSwitchPin);
  }
  // If transition limit switch is not pressed, adaptive side in use. Rotate console to
adaptivePosition.
  else if (transitionSwitch.getState())
  {
    rotateToAdaptive(adaptiveSwitchPin);
  }
}
```

```
void rotateToStandard(int standardSwitchPin)
{
  digitalWrite(relayPin, HIGH);
  while (digitalRead(standardSwitchPin))
  {
    stepper.step(1);
  }
  standard = false;
  Serial.println("Console position: standard");
  digitalWrite(relayPin, LOW);
}


void rotateToAdaptive(int adaptiveSwitchPin)
{
  digitalWrite(relayPin, HIGH);
  while (digitalRead(adaptiveSwitchPin))
  {
    stepper.step(-1);
  }
  standard = true;
  Serial.println("Console position: adaptive");
  digitalWrite(relayPin, LOW);
}
```

ANNABEL FRAKE - Oct 31, 2022, 5:43 PM CDT

Download

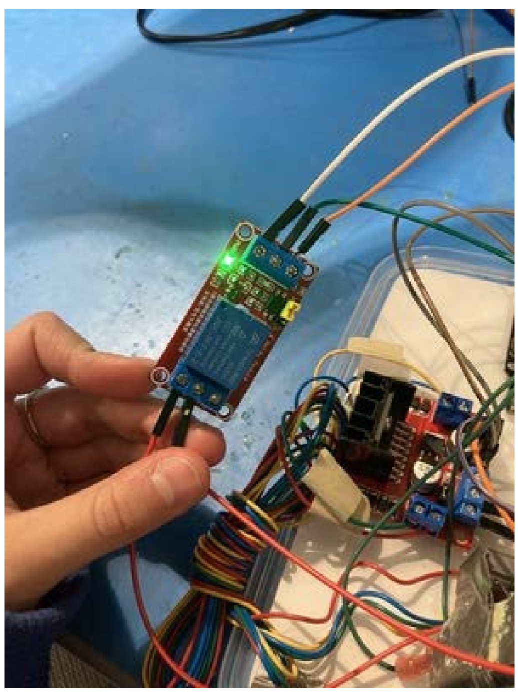
Stepper_Code_With_3_Limit_Switches_Polling_L298N_7.0.ino (3.34 kB)

ANNABEL FRAKE - Oct 31, 2022, 5:44 PM CDT

Download

IMG_6211.jpeg (2.81 MB) Side view of breadboard, Arduino Uno, and L298N.

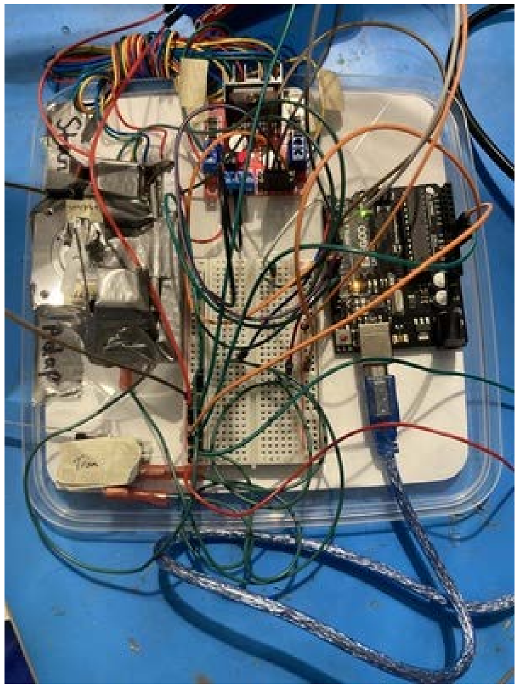
ANNABEL FRAKE - Oct 31, 2022, 5:44 PM CDT



Download

68894375025__07251C45-C9CE-43A9-A945-E8D0385FBBEB.jpeg (2.61 MB) Closeup of relay.

ANNABEL FRAKE - Oct 31, 2022, 5:45 PM CDT



Download

IMG_6210.jpeg (2.93 MB) Overall circuit minus the relay (cut out on left).

2NOV2022 Circuit Construction

ANNABEL FRAKE - Nov 03, 2022, 12:59 AM CDT

Title: 2NOV2022 Circuit Construction

Date: 2NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: build the circuit within the 3D print I got from Josh today

Content:

- I got the 3D print of the electronics box and the console holder from Josh today
- I remade the circuit within the electronics box
- the Arduino had to be inserted at an angle and pushed down to fit
- the holes are too small and the location of the holes is slightly off (for all components)
- the console holder shaft hole is too small for the shaft of the motor and it split in 2 when I tried to slide it onto the motor shaft
- the relay doesn't seem like it will fit
- I'm thinking that instead of putting everything in the console box at that location, that we only have the motor
- then, all other components would be in another box under the pulley plates or someplace else convenient
- I don't think we can make the box much bigger within interfering with the matrix machine's structure
- I attempted to place the limit switches around the console using tape, etc.
- it didn't work well
- The code is running as it should, but the flag is too small
- the flag either misses the limit switch or starts to hit it and then stalls
- I'm not sure why there is stalling since I have used stepper motors like these to move a person (wheels attached to the motor shaft) in other projects
- I tried making the flag bigger with cardboard, but it isn't rigid, so it didn't help
- I did put the limit switches horizontal instead of vertical (like previous duct tape job), so maybe it has to do with pressing the switch at its tip?
- I will need to investigate this further later on

References: none

Conclusions:

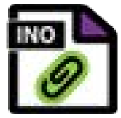
I grabbed the electronics box and console holder 3D prints from Josh today. I remade the circuit within the electronics box (and outside for the relay and breadboard). I added labels for the jumper wires using masking tape. The fit of the box is off, and we are extremely tight on space. I think we should keep the motor in the box and relocate everything else in the circuit to another box below the pulley plates (or another convenient location). I could not get the flag to reliably hit the limit switches and there seems to be an issue with motor stalling (ie motor would hit the limit switch but not press it enough to cause the state change in that limit switch). I will investigate this further later in the week.

Action items:

1. investigate motor stalling issue

ANNABEL FRAKE - Nov 03, 2022, 12:44 AM CDT

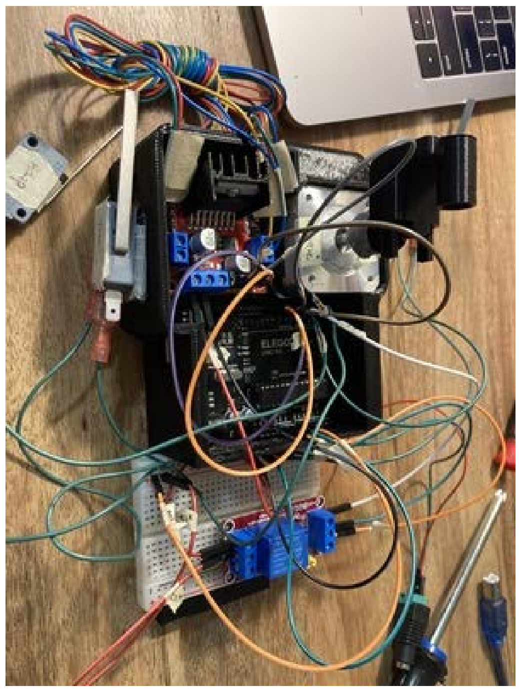
ANNABEL FRAKE - Nov 03, 2022, 12:45 AM CDT



Download

Stepper_Code_With_3_Limit_Switches_Polling_L298N_7.0.ino (3.44 kB)

ANNABEL FRAKE - Nov 03, 2022, 12:56 AM CDT



Download

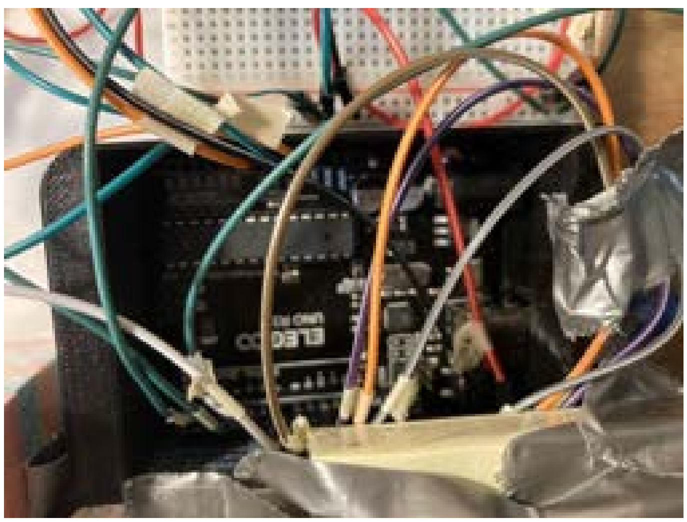
68914393368__B3E2950C-071A-4EF8-8EA3-D8B1ECE5D293.jpeg (3.67 MB) Overall photo of the circuit in the prototype of the electronics box.

ANNABEL FRAKE - Nov 03, 2022, 12:56 AM CDT

Download

IMG_6228.jpeg (3.48 MB) Image showing the standard and adaptive position limit switches relative to the console flag.

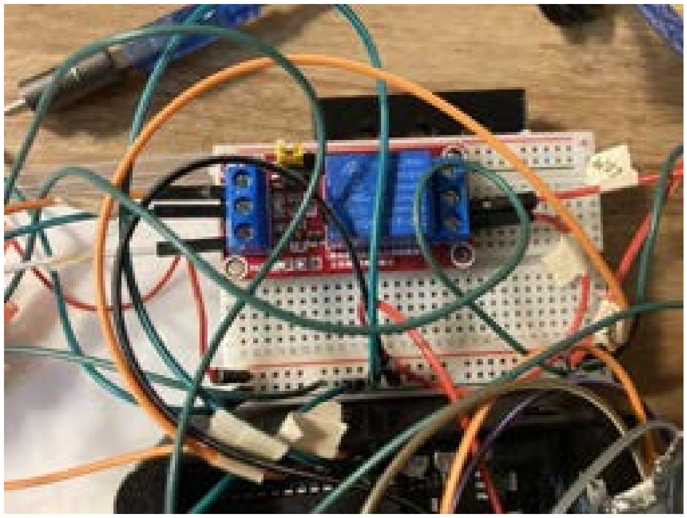
ANNABEL FRAKE - Nov 03, 2022, 12:57 AM CDT



Download

IMG_6230.jpeg (3.04 MB) Closeup of the Arduino connections.

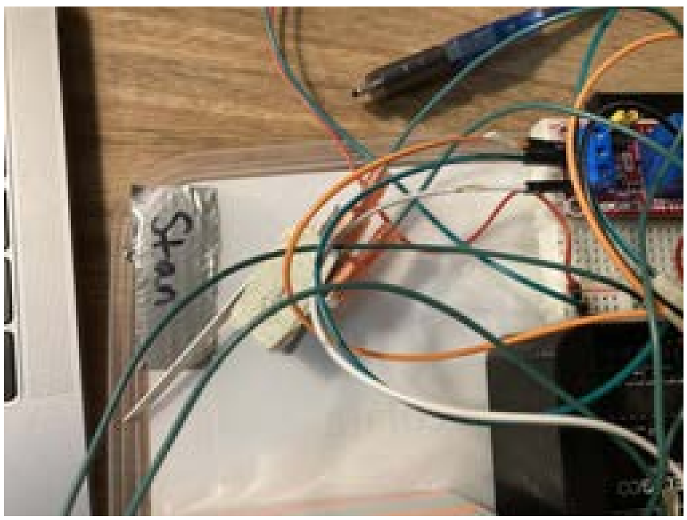
ANNABEL FRAKE - Nov 03, 2022, 12:57 AM CDT



Download

IMG_6231.jpeg (3.24 MB) Closeup of the relay and breadboard connections. The breadboard is used only for a +12V strip and a GND strip.

ANNABEL FRAKE - Nov 03, 2022, 12:57 AM CDT



Download

IMG_6232.jpeg (2.98 MB) Closeup of the transition limit switch connections.

3NOV2022 Motor Troubleshooting

ANNABEL FRAKE - Nov 03, 2022, 9:15 PM CDT

Title: 3NOV2022 Motor Troubleshooting

Date: 3NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: keep working with the jerry-rigged testing setup to get it ready for show and tell tomorrow

Content:

- I tried taking the press-fit off and realized that the crack had spread apart, so it wasn't snug on the motor shaft
- I redid the duct tape job that is holding it together and put it back on
- the flag was able to depress the switches now
- this means that the fit isn't snug enough and that's why it wasn't working yesterday
- however, as I kept playing with it, it loosened again
- I added even more duct tape and that seemed to help, but now the motor is purring
- I looked at some forums and videos
  - https://www.youtube.com/watch?v=rJGi3QxAHkY
  - https://docs.openbuilds.com/doku.php?id=docs:blackbox:faq-identify-motor-coils
  - https://3dprinterly.com/how-to-fix-an-extruder-motor-thats-vibrating-but-not-turning/
- I redid the connections, I changed the motor speed, I removed the motor from the electronics box - that didn't work
- the other suggestion was that the current is too low, but I don't see how that could be possible if it worked yesterday and nothing has changed
- I measured the current going to the L298N and it was 0.46 A
  - this is higher than the current rating of the motor, but when I had measured the current of 0.56 A while troubleshooting the heating issue, the motor wasn't vibrating then
- I put the circuit back together with the limit switches in place so that I can show it tomorrow for show and tell
- I will have to troubleshoot the vibrations later

References:

- https://www.youtube.com/watch?v=rJGi3QxAHkY
- https://docs.openbuilds.com/doku.php?id=docs:blackbox:faq-identify-motor-coils
- https://3dprinterly.com/how-to-fix-an-extruder-motor-thats-vibrating-but-not-turning/

Conclusions:

I figured that the motor was stalling because the 3D press-fit was too loose on the motor shaft. After reinforcing the crack with duct tape, I got the flag to depress the limit switches. However, as I was testing this, I noticed that the motor vibrated and made noise. I troubleshooted this for a couple of hours, but still haven't resolved the issue. According to forums/videos, it is likely because of a loose connection, incorrect wiring, or insufficient current. I redid all of the connections and tried it with my personal stepper motor, but the vibrations persisted. I double checked the coil couples, and those should be right. I measured the current and it was a little higher than the last time I measured it without heating, but lower than when heating was present (and it wasn't vibrating then). I'm not sure what the issue is, but I put everything back together for show and tell. I will most likely need to ask someone at the MakerSpace if they have any suggestions.

Action items:

1. present at show and tell and reflect on feedback from my peers

4NOV2022 Motor Troubleshooting

ANNABEL FRAKE - Nov 04, 2022, 11:19 PM CDT

Title: 4NOV2022 Motor Troubleshooting

Date: 4NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: figure out why the motor is purring

Content:

- I went to the MakerSpace this morning to troubleshoot the motor issue that arose last night
- I tried the voltage supply there
  - it did not fix the purring
- I soldered the tips of the wires from the motor to improve the connections to the L298N (some sources yesterday suggested bad connections could cause the purring)
  - it did not fix the purring
- I bought a L298N for my personal stash and tried swapping it out in the circuit to see if the component was bad
  - it did not fix the purring
- I swapped out the Arduino for my personal one to see if the Arduino was bad
  - it did not fix the purring
- I purchased a relay (same one used in the project) for my personal stack and tried it in the circuit to see if the component went bad
  - it did not fix the purring
- I used some of the solid wire available at the MakerSpace and swapped out some of the jumper wires for that to test if the connections / wires were bad
  - it did not fix the purring
- I put the circuit back together for show and tell

References: none

Conclusions:

Before show and tell, I went to the MakerSpace to troubleshoot the motor purring. I tried the power supply at the MakerSpace to see if the current was the issue, but it did not fix the issue. I soldered the ends of the stepper motor wires going to the L298N to improve the connections, but that did not solve the issue. I tried swapping out every component (except for the motor since I tried that yesterday) one at a time to test if any of the components were fried / bad. However, the motor purring persisted. I put the circuit back together for show and tell and will need to keep looking into this later. At this point, I will most likely need to ask someone at the MakerSpace since I've tried everything I can think of.

Action items:

1. continue to investigate this issue

6NOV2022 Circuit Construction

ANNABEL FRAKE - Nov 06, 2022, 10:15 PM CST

Title: 6NOV2022 Circuit Construction

Date: 6NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: build the circuit using the DRV8825 motor controller setup so I can test it as soon as they arrive

Content:

- After all of my troubleshooting and researching, I think that the L298N is causing the heating issues
- to that end, I ordered DRV8825 motor controllers (another option with current adjustability) to see if that will work instead of the L298N
- hopefully, this would eliminate the heating problem, which would eliminate the need for the relay, which would potentially prevent the console from moving if someone touched the display (would still need to test this)
- if the DRV8825 doesn't work for whatever reason, I will simply keep it in my personal supply since they are good to have on hand (ie it won't cost JHT anything)
- the DRV8825 (sold in packet of 5) should arrive tomorrow, so I remade the circuit using the circuit configuration I tried early on in the design process so that I can test my theory as soon as it arrives
    - I used one of my own DRV8825 that I most likely damaged (because I forgot to put capacitors over the power supplies) as a placeholder for the new one I ordered
- the tutorial I found said that `Current Limit = VRef x 2`
    - so for a current limit of 330 mA, we would need 0.165V
    - I will need to adjust this on the DRV8825 once it arrives
- I also need to use a 100µF capacitor over the power supplies to make sure no sudden changes in voltage
- the tutorial also suggests using the AccelStepper.h library
    - see example code below

```
#include <AccelStepper.h>

// Define stepper motor connections and motor interface type. Motor interface type must be set to 1 when using a driver:
#define dirPin 2
#define stepPin 3
#define motorInterfaceType 1

// Create a new instance of the AccelStepper class:
AccelStepper stepper = AccelStepper(motorInterfaceType, stepPin, dirPin);

void setup() {
  // Set the maximum speed in steps per second:
  stepper.setMaxSpeed(1000);
}

void loop()
{
  // Set the current position to 0:
  stepper.setCurrentPosition(0);

  // Run the motor forward at 200 steps/second until the motor reaches 400 steps (2 revolutions):
  while(stepper.currentPosition() != 400)
  {
    stepper.setSpeed(200);
    stepper.runSpeed();
  }

  delay(1000);
```

```
  // Reset the position to 0:
  stepper.setCurrentPosition(0);

  // Run the motor backwards at 600 steps/second until the motor reaches -200 steps (1 revolution):
  while(stepper.currentPosition() != -200)
  {
    stepper.setSpeed(-600);
    stepper.runSpeed();
  }

  delay(1000);

  // Reset the position to 0:
  stepper.setCurrentPosition(0);

  // Run the motor forward at 400 steps/second until the motor reaches 600 steps (3 revolutions):
  while(stepper.currentPosition() != 600)
  {
    stepper.setSpeed(400);
    stepper.runSpeed();
  }

  delay(3000);
}
```

- I don't think we will need this library since we don't need to accelerate or decelerate (although we could if needed)
- I think it will be easier to just use digitalWrite to the direction and step pins
- I adjusted my code to reflect this
- I also used my personal NEMA 17 in the setup because it has the D shaft
  - my team suggested that I do this and that we may want to order a motor with a D shaft and see about returning the other motor
- for the flag, I used a plastic clip from a bagel bag
  - hopefully, this will work better than the cardboard
  - using the D shaft helped with securement because I had a flat edge to tape it to
- the wire connectors going to the switches are too large, but I clamped down on them using a needle nose to make it work for now
  - I will eventually solder these or find smaller connectors
  - since the limit switches Staci gave me are much smaller, I had an easier time attaching them to the motor for testing

References:

Admin, "How to Control Stepper Motor with DRV8825 Driver & Arduino," *How To Electronics*, Dec. 22, 2020. https://how2electronics.com/control-stepper-motor-with-drv8825-driver-arduino/ (accessed Oct. 17, 2022).

Conclusions:

I ordered some DRV8825 motor controllers because I think the L298N must be causing the heating issue (and perhaps the vibration issue) because of discrepancies in the current supply. The DRV8825 has a potentiometer on the board to adjust the current. The new ones I ordered should be here tomorrow. I used my own DRV8825 as a placeholder for the new one, but I'm fairly certain that I damaged this one, so I won't use it for testing. Once the new one arrives, I will swap it in and then begin to test. I set up everything else in the circuit with the motor (using mine because it has the D shaft) and limit switches. I then adjusted the most recent code I had (version 7.0 of the L298N) for compatibility with the DRV8825. Instead of using the Stepper.h library, this motor controller just has pins for DIR and STEP that can be turned HIGH or LOW using digitalWrite(). I removed the relay from the circuit and code. If the DRV8825 solves the heating issue, we will not need the relay.

Action items:

1. Once the DRV8825 arrives, insert it into the circuit and test

ANNABEL FRAKE - Nov 06, 2022, 9:54 PM CST

```
// Stepper_3_Switches_DRV8825_1.0.ino

// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Code for rotating the console of the Matrix rowing machine between the standard
and adaptive sides.


//Include stepper library and debounce library
#include <ezButton.h>;


// Define pins
byte const transitionSwitchPin = 12; // This limit switch is placed near the stabilization frame.
When its state changes, the rower is transitioned between adaptive and standard use or vice versa.
When this limit switch is pressed, the console should be on the standard side and when it is not
pressed, the console should be on the adaptive side.
byte const standardSwitchPin = 10; // This limit switch is placed near the console on the standard
side. When it is pressed, the consle is facing the standard user.
byte const adaptiveSwitchPin = 11; // This limit switch is placed near the console on the adaptive
side. When it is pressed, the consle is facing the wheelchair user.
const byte dirPin = 8;
const byte stepPin = 9;


// Declare states for the buttons.
int standardSwitchState = HIGH;
int adaptiveSwitchState = HIGH;


// Create ezButton object that matches the limit switch
ezButton transitionSwitch(transitionSwitchPin);


// Number of steps per output rotation.
int const stepsPerRevolution = 200;


// Define boolean for whether the stepper motor is on the standard side or not
boolean standard = false; // Note: flilpped logic because of INPUT_PULLUP


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);


  // Set the stepper pin modes.
  pinMode(stepPin, OUTPUT);
  pinMode(dirPin, OUTPUT);


  // Set limit switch pins to INPUT_PULLUP
  pinMode(standardSwitchPin, INPUT_PULLUP);
  pinMode(adaptiveSwitchPin, INPUT_PULLUP);


  // Assign the limit switch with a debounce time of 50 milliseconds
  transitionSwitch.setDebounceTime(50);


  checkConsolePosition();
}
```

```
void loop()
{
  // Call the loop() function for the limit switch
  transitionSwitch.loop();


  // If limit switch is pressed, standard side in use. Rotate console to standardPosition.
  if (transitionSwitch.isPressed())
  {
    rotateToStandard(standardSwitchPin);
  }


  // If limit switch is not pressed, adaptive side in use. Rotate console to adaptivePosition.
  else if (transitionSwitch.isReleased())
  {
    rotateToAdaptive(adaptiveSwitchPin);
  }


  else
  {
    checkConsolePosition();
  }
}


void checkConsolePosition()
{
  // If transition limit switch is pressed, standard side in use. Rotate console to
standardPosition.
  if (!transitionSwitch.getState() && digitalRead(standardSwitchPin))
  {
    rotateToStandard(standardSwitchPin);
  }
  // If transition limit switch is not pressed, adaptive side in use. Rotate console to
adaptivePosition.
  else if (transitionSwitch.getState() && digitalRead(adaptiveSwitchPin))
  {
    rotateToAdaptive(adaptiveSwitchPin);
  }
}


void rotateToStandard(int standardSwitchPin)
{
  while (digitalRead(standardSwitchPin))
  {
    digitalWrite(dirPin, HIGH);
    digitalWrite(stepPin, HIGH);
  }
  digitalWrite(stepPin, LOW);
  standard = false;
  Serial.println("Console position: standard");
}


void rotateToAdaptive(int adaptiveSwitchPin)
{
  while (digitalRead(adaptiveSwitchPin))
  {
    digitalWrite(dirPin, LOW);
    digitalWrite(stepPin, HIGH);
  }
```

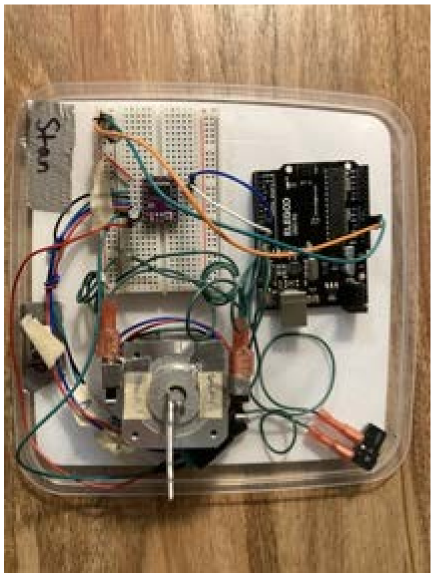
```
  digitalWrite(stepPin, LOW);
  standard = true;
  Serial.println("Console position: adaptive");
}
```

ANNABEL FRAKE - Nov 06, 2022, 9:55 PM CST

Download

Stepper_3_Switches_DRV8825_1.0.ino (3.37 kB)

ANNABEL FRAKE - Nov 06, 2022, 10:01 PM CST



Download

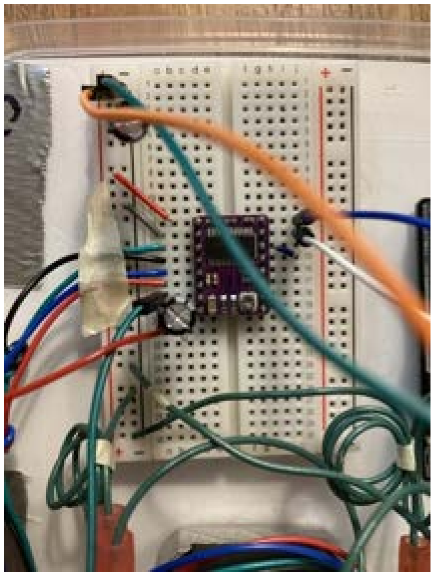
IMG_6253.jpeg (3.87 MB) The overall circuit. Note: the DRV8825 shown is most likely broken, so no testing was done with it.

ANNABEL FRAKE - Nov 06, 2022, 10:01 PM CST

Download

IMG_6254.jpeg (2.73 MB) A closeup of the Arduino connections. See the code for pin designations.

ANNABEL FRAKE - Nov 06, 2022, 10:02 PM CST



Download

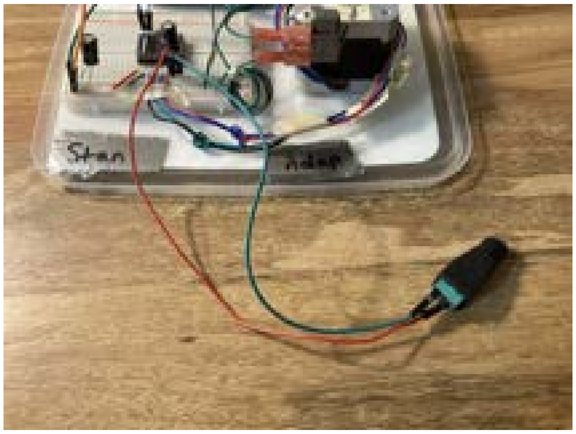
IMG_6256.jpeg (3.24 MB) A closeup of the breadboard connections. Note: the DRV8825 shown is most likely broken, so no testing was done with it. The blue wire going to the Arduino is the DIR pin (D8) and the white is the STEP pin (D9). The orange wire going to the Arduino is +5V and the green is GND.

ANNABEL FRAKE - Nov 06, 2022, 10:04 PM CST

Download

IMG_6257.jpeg (2.96 MB) A view of the limit switches. The COM pin goes to ground on the breadboard for each. See the code for pin designations for the NO pin designations of each switch.

ANNABEL FRAKE - Nov 06, 2022, 10:04 PM CST



Download

IMG_6258.jpeg (4.26 MB) A view of the +12V power supply connection. Note: the DRV8825 shown is most likely broken, so no testing was done with it.

ANNABEL FRAKE - Nov 06, 2022, 10:05 PM CST

Download

IMG_6259.jpeg (3.3 MB) A top view of the stepper motor to show the flag, labels, and limit switches. The flag is a plastic clip from a bagel bag.

8NOV2022 Circuit Testing

ANNABEL FRAKE - Nov 08, 2022, 11:48 PM CST

Title: 8NOV2022 Circuit Testing

Date: 8NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: test the DRV8825 motor controller

Content:

-
- the DRV8825 motor controllers I ordered arrived today
- I adjusted the current on the board based on the recommendation of the tutorial
  - Current Limit = VRef x 2
  - so for a current limit of 330 mA, we would need 0.165V
- at first, nothing was happening, but after some troubleshooting, I realized that I had accidentally swapped the +5V and ground pins on the board
- once I corrected the wiring, the motor moved without the buzzing sound seen with the L298N
- I also ran the motor continuously for about 10 minutes, and the motor didn't heat up
  - we wouldn't be running the motor continuously like this, but this would be the worst case scenario that should cause the motor to heat the most, so if it passes this, then it should be fine
  - I will most likely include some sort of temperature testing when we do formal testing at the end of the semester
- CONCLUSION: the DRV8825 solves both the heating issue and the sound issue I have been having with the L298N motor controller
- I uploaded my code for the limit switches, and it worked, but the flag whipped around really fast
- I realized that I had only 1 delay in my while loop, so I added a delay so that there is a delay after the motor turns on and after it turns off
- I increased the delay to lower the speed, but I noticed that the more I decreased the speed, the more the motor vibrated
- so while this isn't the same thing as the sound issue I had with the L298N, it is not desirable because the excessive vibration creates noise
- I found another article on the DRV8825 that talked about the vibration
  - it said that it there was excessive vibration, to try lowering the current on the board
  - I did as it suggested, and it did decrease the noise level
  - it still purrs/vibrates a little bit when it rotates, but I think that is a small price to pay for the heating issue solution
- I adjusted the delay to be what I think is a good speed, but I will need to test this once the console is on there
- I added a wire going from the +12V pin on the DRV8825 to the Vin pin on the Arduino so that the whole circuit is powered by the 12V supply

References:

Admin, “How to Control Stepper Motor with DRV8825 Driver & Arduino,” *How To Electronics*, Dec. 22, 2020. https://how2electronics.com/control-stepper-motor-with-drv8825-driver-arduino/ (accessed Oct. 17, 2022).

“Stepper Motor with DRV8825 and Arduino Tutorial (4 Examples).” https://www.makerguides.com/drv8825-stepper-motor-driver-arduino-tutorial/ (accessed Nov. 08, 2022).

Conclusions:

The DRV8825 I ordered arrived, so I put it into the circuit and, after some troubleshooting, was able to get the motor to rotate using my limit switch code. I ran the motor continuously for about 10 minutes and had it plugged into power without continuous rotation for probably about an hour besides that, and the motor didn't heat up at all. I also didn't hear the stalling noise I had heard last week with the L298N. Therefore, I have concluded that the L298N caused the heating and sound problems and that we should use the DRV8825 to avoid those problems. The motor did vibrate quite a bit though. I can minimize the vibrations by adjusting the current potentiometer on the DRV8825, but only to an extent. I think the vibration and associated noise level is reasonable for our design. I will research this further to see if I can make it any better, but I believe that it will work (especially considering that the motor will not be spinning that often).

Action items:

1. continue to look into the vibration of the motor

ANNABEL FRAKE - Nov 08, 2022, 11:30 PM CST

Download

Basic_Stepper_Motor_Control_Example_with_DRV8825.ino (862 B) Example code for motor control with the DRV8825. Sourced from the tutorial (first reference in text entry).

ANNABEL FRAKE - Nov 08, 2022, 11:30 PM CST

Download

Stepper_3_Switches_DRV8825_1.0.ino (3.66 kB)

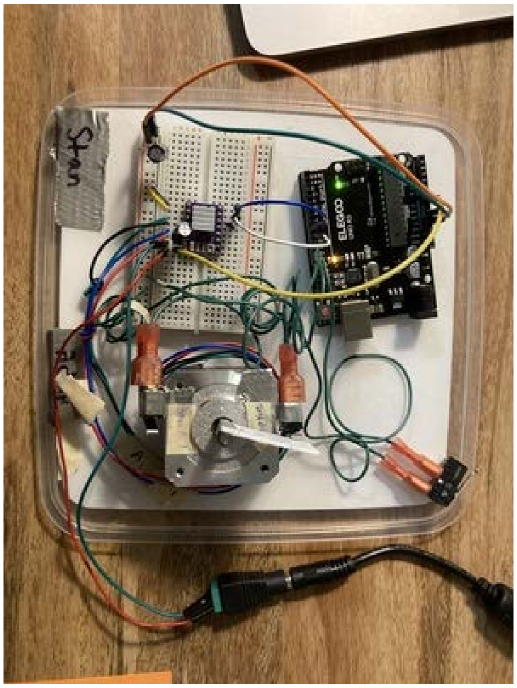
ANNABEL FRAKE - Nov 08, 2022, 11:31 PM CST

```
// Stepper_3_Switches_DRV8825_1.0.ino

// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Code for rotating the console of the Matrix rowing machine between the standard
and adaptive sides.


//Include stepper library and debounce library
#include <ezButton.h>;


// Define pins
byte const transitionSwitchPin = 12; // This limit switch is placed near the stabilization frame.
When its state changes, the rower is transitioned between adaptive and standard use or vice versa.
When this limit switch is pressed, the console should be on the standard side and when it is not
pressed, the console should be on the adaptive side.
byte const standardSwitchPin = 10; // This limit switch is placed near the console on the standard
side. When it is pressed, the consle is facing the standard user.
byte const adaptiveSwitchPin = 11; // This limit switch is placed near the console on the adaptive
side. When it is pressed, the consle is facing the wheelchair user.
const byte dirPin = 8;
const byte stepPin = 9;


// Declare states for the buttons.
int standardSwitchState = HIGH;
int adaptiveSwitchState = HIGH;


int speedDelay = 12000; // microseconds


// Create ezButton object that matches the limit switch
ezButton transitionSwitch(transitionSwitchPin);


// Number of steps per output rotation.
int const stepsPerRevolution = 200;


// Define boolean for whether the stepper motor is on the standard side or not
boolean standard = false; // Note: flilpped logic because of INPUT_PULLUP


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);


  // Set the stepper pin modes.
  pinMode(stepPin, OUTPUT);
  pinMode(dirPin, OUTPUT);
```

```
  // Set limit switch pins to INPUT_PULLUP
  pinMode(standardSwitchPin, INPUT_PULLUP);
  pinMode(adaptiveSwitchPin, INPUT_PULLUP);


  // Assign the limit switch with a debounce time of 50 milliseconds
  transitionSwitch.setDebounceTime(50);


  checkConsolePosition();
}


void loop()
{
  // Call the loop() function for the limit switch
  transitionSwitch.loop();


  // If limit switch is pressed, standard side in use. Rotate console to standardPosition.
  if (transitionSwitch.isPressed())
  {
    rotateToStandard(standardSwitchPin);
  }


  // If limit switch is not pressed, adaptive side in use. Rotate console to adaptivePosition.
  else if (transitionSwitch.isReleased())
  {
    rotateToAdaptive(adaptiveSwitchPin);
  }


  else
  {
    checkConsolePosition();
  }
}


void checkConsolePosition()
{
  // If transition limit switch is pressed, standard side in use. Rotate console to
standardPosition.
  if (!transitionSwitch.getState() && digitalRead(standardSwitchPin))
  {
    rotateToStandard(standardSwitchPin);
  }
  // If transition limit switch is not pressed, adaptive side in use. Rotate console to
adaptivePosition.
  else if (transitionSwitch.getState() && digitalRead(adaptiveSwitchPin))
  {
    rotateToAdaptive(adaptiveSwitchPin);
  }
```

```
}


void rotateToStandard(int standardSwitchPin)
{
  digitalWrite(dirPin, LOW);
  while (digitalRead(standardSwitchPin))
  {
    digitalWrite(stepPin, HIGH);
    delayMicroseconds(speedDelay); // use this to change speed
    digitalWrite(stepPin, LOW);
    delayMicroseconds(speedDelay); // use this to change speed
  }
  standard = false;
  Serial.println("Console position: standard");
}


void rotateToAdaptive(int adaptiveSwitchPin)
{
  digitalWrite(dirPin, HIGH);
  while (digitalRead(adaptiveSwitchPin))
  {
    digitalWrite(stepPin, HIGH);
    delayMicroseconds(speedDelay); // use this to change speed
    digitalWrite(stepPin, LOW);
    delayMicroseconds(speedDelay); // use this to change speed
  }
  standard = true;
  Serial.println("Console position: adaptive");
}
```

ANNABEL FRAKE - Nov 08, 2022, 11:46 PM CST



Download

IMG_6261.jpeg (3.42 MB) An image of the overall setup.

ANNABEL FRAKE - Nov 08, 2022, 11:45 PM CST

Download

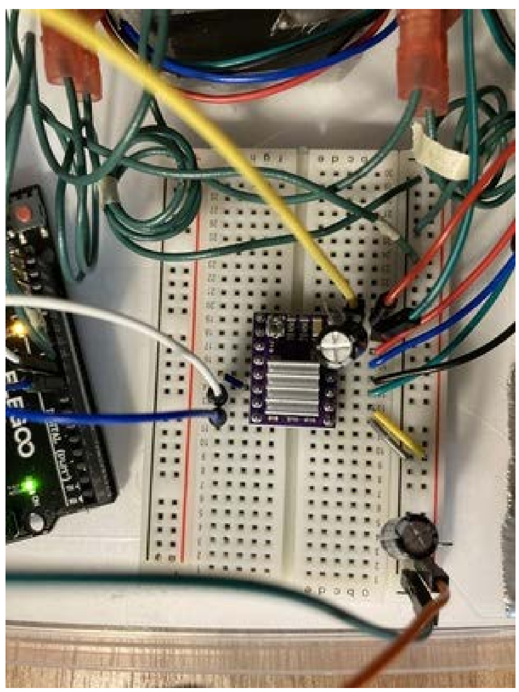
IMG_6262.jpeg (2.7 MB) Side view of the Arduino UNO. On the bottom, the blue wire is DIR, white is STEP, and the 3 green wires following that are for the limit switches. Please see the code for pin designations.

ANNABEL FRAKE - Nov 08, 2022, 11:46 PM CST

Download

IMG_6263.jpeg (3.31 MB) A top view of the Arduino UNO.

ANNABEL FRAKE - Nov 08, 2022, 11:46 PM CST



Download

IMG_6264.jpeg (3.23 MB) A closeup of the breadboard connections.

ANNABEL FRAKE - Nov 08, 2022, 11:47 PM CST

Download

IMG_6265.jpeg (3.49 MB) An image showing the stepper motor and limit switches. Also off to the side is the 12V power supply connector.

ANNABEL FRAKE - Nov 08, 2022, 11:48 PM CST

Download

IMG_6266.MOV (21.6 MB) Side perspective. Video of the motor rotating between the adaptive and standard sides.

ANNABEL FRAKE - Nov 08, 2022, 11:49 PM CST

Download

IMG_6267.MOV (22.6 MB) Top perspective. Video of the motor rotating between the adaptive and standard sides.

10NOV2022 Code Refinement

ANNABEL FRAKE - Nov 10, 2022, 9:47 PM CST

Title: 10NOV2022 Code Refinement

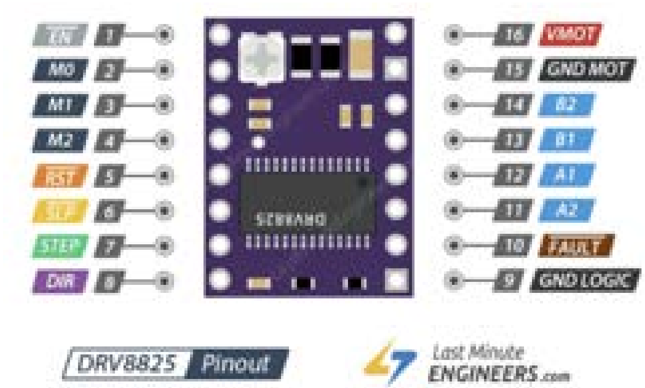
Date: 10NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: edit the code to make it as efficient as possible; update comments

Content:

-
- I cleaned up the code and got rid of some obsolete statements
- I expounded on the comments to make things clearer
- I found a source on the DRV8825 (https://lastminuteengineers.com/drv8825-stepper-motor-driver-arduino-tutorial/)
- 

- it said that you can put the motor controller in sleep mode to conserve on power when the motor isn't moving
    - active LOW pin
    - pulling it LOW puts motor controller into sleep mode
    - need 1 ms delay after wakeup before can execute step commands
- I added a wire from the SLP pin to D7
- I updated the code to pull the SLP pin low when the motor is not in use to save on power consumption
- I did some general searching on the vibration with the stepper motor
- one source stated the following: "Another benefit of microstepping control is very smooth motor rotation. This is because microstepping allows a gradual build-up and decay of current in each motor winding, which delivers more consistent torque and, therefore, smoother motion than full-step operation. This is especially evident at slower speeds, where full-step operation causes pronounced detent torque." (https://www.linearmotiontips.com/when-should-you-use-microstepping-control-for-stepper-motors/)
- I set M0 and M2 to high to achieve 1/32 step rotation

M0	M1	M2	Microstep Resolution
Low	Low	Low	Full step
High	Low	Low	Half step
Low	High	Low	1/4 step
High	High	Low	1/8 step
Low	Low	High	1/16 step
High	Low	High	1/32 step
Low	High	High	1/32 step
High	High	High	1/32 step

- I adjusted the PWM delay accordingly
- the vibrations were reduced, although not gone altogether
- I will keep this configuration for now and then test it with the weight of the console tomorrow
- I think that the weight of the console will help reduce the vibrations (which are not all together that noticeable at this point)
- I then realized that the SLP and FAULT pins are tied together, so by pulling SLP low to sleep mode, it disabled the whole chip and the motor was not held in position anymore
- I tried removing this tie, but the the circuit does not function without this connection
- therefore, I will not use sleep mode on the DRV8825
- As a side note, as I was testing, I noticed that if I pressed the transition limit switch and immediately released it, the console would rotate to the standard side and immediately back to the adaptive side
    - ultimately, the console gets where it needs to be, but it may be annoying depending on how fast the rotation is (will have to test this with the console)

References:

"Arduino Reference - Arduino Reference." https://www.arduino.cc/reference/en/ (accessed Oct. 16, 2022).

"In-Depth: Interface DRV8825 Stepper Motor Driver Module with Arduino," *Last Minute Engineers*, Dec. 23, 2018. https://lastminuteengineers.com/drv8825-stepper-motor-driver-arduino-tutorial/ (accessed Nov. 10, 2022).

D. Collins, "When should you use microstepping control for stepper motors?," *Linear Motion Tips*, May 31, 2019. https://www.linearmotiontips.com/when-should-you-use-microstepping-control-for-stepper-motors/ (accessed Nov. 10, 2022).

Conclusions:

I cleaned up the code and elucidated it with more/better comments. I found an article stating that a the micro-stepping offered smoother movement than full-step, so I altered the circuit to do 1/32 step rotation. I briefly tried using the sleep mode for the DRV8825, but ultimately discarded the idea because initiating sleep mode disabled the controller and allowed free rotation of the motor controller shaft. Overall, I think the circuit is in great shape to show Dr. Tracy P and the team tomorrow! I'm excited to test the circuit with the console.

Action items:

1. Show the team (and Dr. Tracey Puccinelli) the progress I have made tomorrow
2. test the circuit with the console once Josh gives me the new press-fit

ANNABEL FRAKE - Nov 10, 2022, 9:37 PM CST

```
// Stepper_3_Switches_DRV8825_3.0.ino
// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Rotate the console of a Matrix rowing machine between the standard and adaptive sides.


// Include necessary libraries.
#include <ezButton.h>;


// Define digital pins for the three limit swtiches.
byte const transitionSwitchPin = 12; // This limit switch is placed near the stabilization frame. When its state changes, the rower is transitioned between adaptive and standard use or vice versa. When this limit switch is pressed, the console should be on the standard side and when it is not pressed, the console should be on the adaptive side.
byte const standardSwitchPin = 10; // This limit switch is placed near the console on the standard side. When it is pressed, the consle is facing the standard user.
byte const adaptiveSwitchPin = 11; // This limit switch is placed near the console on the adaptive side. When it is pressed, the consle is facing the wheelchair user.


// Declare states for the position limit switches (standard and adaptive).
int standardSwitchState = HIGH;
int adaptiveSwitchState = HIGH;


// Create an ezButton object for the transition limit switch.
ezButton transitionSwitch(transitionSwitchPin);


// Define digital pins for the DIR and STEP features of the stepper motor.
byte const dirPin = 8;
byte const stepPin = 9;


// Define the time delay for the manual PWM of the stepper motor.
int speedDelay = 1000; // microseconds


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);


  // Set the stepper pinmodes to OUTPUT.
  pinMode(stepPin, OUTPUT);
  pinMode(dirPin, OUTPUT);


  // Set limit switch pins to INPUT_PULLUP. An internal pullup resistor reverses the logic. When the switch is open, the output is HIGH (1). When the switch is closed, the output is LOW (0).
  pinMode(standardSwitchPin, INPUT_PULLUP);
  pinMode(adaptiveSwitchPin, INPUT_PULLUP);
```

```
  // Assign the transition limit switch with a debounce time of 50 milliseconds
  transitionSwitch.setDebounceTime(50);


  // When the program first starts, check the position of the console and rotate accordingly.
  checkConsolePosition();
}


void loop()
{
  // Call the loop() function for the transition limit switch.
  transitionSwitch.loop();


  // If the transition limit switch is pressed, that means the standard side of the machine is now
in use. Rotate the console to face the standard side.
  if (transitionSwitch.isPressed())
  {
    // Call the function that rotates the console to face the standard side.
    rotateToStandard(standardSwitchPin);
  }


  // If the transition limit switch is released, that means the adaptive side of the machine is now
in use. Rotate the console to face the adaptive side.
  else if (transitionSwitch.isReleased())
  {
    // Call the function that rotates the console to face the adpative side.
    rotateToAdaptive(adaptiveSwitchPin);
  }


  // If the transition limit switch state does not change, check the position of the console to
ensure it is in the correct orientation.
  else
  {
    checkConsolePosition();
  }
}


// A function that checks the current position of the console when the system starts up (or in the
case of an unintended or intended reset).
void checkConsolePosition()
{
  // If the transition limit switch is pressed, that means the standard side of the machine is in
use. If the standard position limit switch is not pressed, rotate the console to face the standard
side.
  if (!transitionSwitch.getState() && digitalRead(standardSwitchPin)) // Note: logic is flipped
because of INPUT_PULLUP.
  {
    // Call the function that rotates the console to face the standard side.
```

```
    rotateToStandard(standardSwitchPin);
  }

  // If the transition limit switch not pressed, that means the adaptive side of the machine is in
use. If the adaptive position limit switch is not pressed, rotate the console to face the adaptive
side.
  else if (transitionSwitch.getState() && digitalRead(adaptiveSwitchPin)) // Note: logic is flipped
because of INPUT_PULLUP.
  {
    // Call the function that rotates the console to face the adpative side.
    rotateToAdaptive(adaptiveSwitchPin);
  }
}


// A function to rotate the console to face the standard side of the machine.
void rotateToStandard(int standardSwitchPin)
{
  // Specify the direction the motor will rotate: clockwise.
  digitalWrite(dirPin, LOW);


  // Rotate the motor in the specified direction until the standard position limit switch is
depressed.
  while (digitalRead(standardSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Manually perform PWM.
    digitalWrite(stepPin, HIGH);
    delayMicroseconds(speedDelay); // use this to change speed
    digitalWrite(stepPin, LOW);
    delayMicroseconds(speedDelay); // use this to change speed
  }

  Serial.println("Console position: standard");
}


// A function to rotate the console to face the adaptive side of the machine.
void rotateToAdaptive(int adaptiveSwitchPin)
{
  // Specify the direction the motor will rotate: counterclockwise.
  digitalWrite(dirPin, HIGH);


  // Rotate the motor in the specified direction until the adaptive position limit switch is
depressed.
  while (digitalRead(adaptiveSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Manually perform PWM.
    digitalWrite(stepPin, HIGH);
    delayMicroseconds(speedDelay); // use this to change speed
    digitalWrite(stepPin, LOW);
    delayMicroseconds(speedDelay); // use this to change speed
  }
```

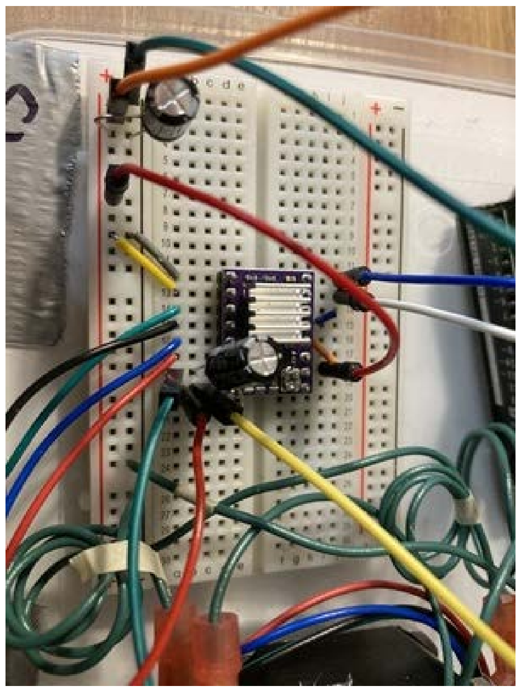
```
  Serial.println("Console position: adaptive");
}
```

ANNABEL FRAKE - Nov 10, 2022, 9:38 PM CST

Download

Stepper_3_Switches_DRV8825_3.0.ino (5.56 kB)

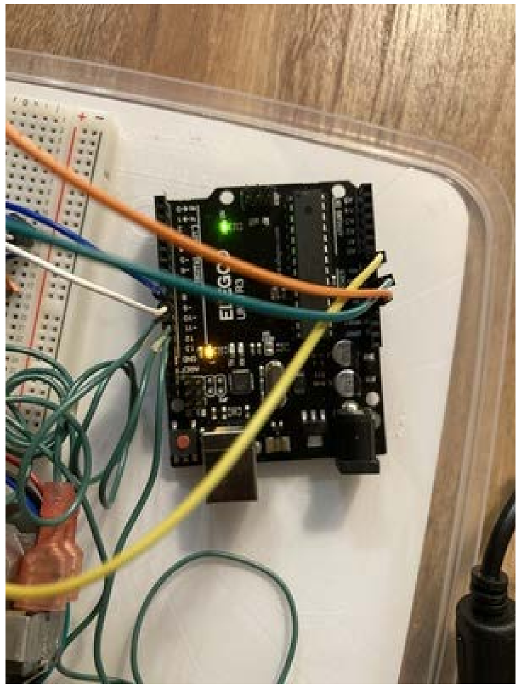
ANNABEL FRAKE - Nov 10, 2022, 9:45 PM CST



Download

IMG_6272.jpeg (3.23 MB) A closeup of the breadboard. The circuit is the same as the previous entry with the addition of pins M0 and M2 being tied to +5V (HIGH).

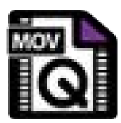
ANNABEL FRAKE - Nov 10, 2022, 9:45 PM CST



Download

IMG_6273.jpeg (2.71 MB) A closeup of the Arduino. The circuit connections are the same as the previous entry.

ANNABEL FRAKE - Nov 10, 2022, 9:46 PM CST



Download

IMG_6274.MOV (17.4 MB) A video of the code working with 1/32 step rotation.

11NOV2022 Motor Vibrations

ANNABEL FRAKE - Nov 11, 2022, 6:23 PM CST

Title: 11NOV2022 Motor Vibrations

Date: 11NOV2022

Content by: Annabel Frake

Present: Annabel Frake, MakerSpace

Goals: look for solder boards and ask Yash about the vibration of the motor

Content:

- I went to the Makerspace to for a solder board small enough to fit in the existing box design (2" by 2" space)
- they didn't have anything small enough, but Yash said that I could cut the board to make it smaller and it would still work
- I emailed Staci to see if she has any boards small enough on hand, and if not, I will cut up one of the boards I found at ECB
- I then asked about the motor vibrations and explained why I thought the manual PWM caused them
- he originally stated that stepper motors would vibrate like that and the only thing I could do was use a damper (Yash also suggested this)
- he then asked me to demonstrate the rotation again
- Tom didn't think that the console should have been vibrating as much as I observed
- he suggested that the fit between the console and motor shaft was too loose / off
- he also said that the vibrations might lessen if the motor is screwed down
- he told me to try the motor again with the new field goal posts once Josh prints them and then re-evaluate

References: Yash and Tom (I think that was his name, but I'm not sure I heard that correctly - couldn't find him on the website)

Conclusions:

I went to the MakerSpace today to ask Yash about the motor vibrations. He suggested that the motor may be low resolution and/or the coils may be worn out since my personal motor is older. He asked another employee about it, and he thought that there should be no reason why I observed the vibrations because the motor rotation I showed him without the console was smoother than he had seen when he worked with stepper motors in the past. He suggested that the fit between the console and motor shaft may have been loose, so he suggested trying it with the new print. Both Yash and Tom also suggested using a damper if all else fails.

Action items:

1. Test the circuit with the circular shaft motor to see if the vibrations persist
2. test the circuit with the new goalposts that fit better to see if the vibrations persist

12NOV2022 Motor Vibration

ANNABEL FRAKE - Nov 12, 2022, 1:38 AM CST

Title: 12NOV2022 Motor Vibration

Date: 12NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: try the circuit with the circular shaft motor to see if vibration persists

Content:

- Since Yash suggested that the age of the motor may be causing the vibrations, I was going to try the circuit with the circular shaft motor
- however, when I hooked up the circuit with the D shaft motor to make sure everything operated before swapping the motors, I noticed that the shaft turned smoothly
- perhaps I had lowered the current too much to reduce the noise and when I increased it so that the motor would rotate with the console, I had increased the current enough that there was no vibration when the console was removed once more
- I still tried hooking up the circular shaft stepper motor to the circuit
- I observed no vibration with the circular shaft motor
- this would lead me to believe that maybe the coils are worn out on my personal D shaft stepper motor like Yash suggested
- I will purchase the D shaft stepper motor for this project and see if the new motor vibrates, but based on this testing, I think that the new motor will work without vibration
- I did some searching, but I couldn't find the exact same motor that I have with the D shaft that would ship in a reasonable amount of time (the one I did find would come from China)
- I found another option that actually has better holding torque: https://www.amazon.com/Stepper-Motor-Bipolar-64oz-Printer/dp/B00PNEQI7W/ref=sr_1_6?crid=3A0RNJMODUTE8&keywords=NEMA+17+bipolar+stepper+motor&qid=1668236856&sprefix=nema+17+bipolar+stepper+motor%2Caps%2C86&sr=8-6
- The amperage is higher (2A), so I would definitely need the heatsink on the DRV8825 (current limit 2.5A) - I already put the heatsink on there, so it should be fine
    - I checked the tutorial I've been using for the DRV8825, and they used a stepper motor with 2A and the DRV8825, and it worked for them, so I am fairly confident that it would work fine

References:

NEMA 17 motor: https://www.amazon.com/Stepper-Motor-Bipolar-64oz-Printer/dp/B00PNEQI7W/ref=sr_1_6?crid=3A0RNJMODUTE8&keywords=NEMA+17+bipolar+stepper+motor&qid=1668236856&sprefix=nema+17+bipolar+stepper+motor%2Caps%2C86&sr=8-6

Admin, "How to Control Stepper Motor with DRV8825 Driver & Arduino," *How To Electronics*, Dec. 22, 2020. https://how2electronics.com/control-stepper-motor-with-drv8825-driver-arduino/ (accessed Oct. 17, 2022).

Conclusions:

I hooked up the circular shaft motor to the circuit and observed no vibration. This leads me to believe that the coils on my personal motor are worn out like Yash suggested. I found a motor with a D shaft to purchase that has a higher holding torque. It also has a higher current rating, but still within the operation capacity of the DRV8825.

Action items:

1. purchase new D shaft motor

12NOV2022 Sleep Mode?

ANNABEL FRAKE - Nov 12, 2022, 2:23 AM CST

Title: 12NOV2022 Sleep Mode?

Date: 12NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: try sleep mode one last time

Content:

- I wanted to try using sleep mode one last time
- I adapted version 3.0 of the DRV8825 code to use the goToSleep() function, but it would not work
- I troubleshooted with print statements and realized that the Arduino went into sleep mode and never came out of it
- I tried using the code I wrote with the servo motor to see if that would work since I have proof of it working in the past
- It did not work with that code either
- I added one of my limit switches (one I used originally) to another pin and reediting the transition state pin
- a change in state of that limit switch triggered the interrupt
- CONCLUSION: interrupts do not work with the limit switches Staci gave us (not sure why?)
- based on this, I have decided not to use the sleep mode feature
- I don't think we need it
- it was originally to save on power consumption if we used a 9V power supply for the Arduino, but now that it is plugged into an outlet, we won't have to worry about that
- it still would have been nice if could have saved on power (just for efficiency's sake), but it is not necessary and it is more important at this stage that the code operates correctly

References:

"Arduino Reference - Arduino Reference." https://www.arduino.cc/reference/en/ (accessed Oct. 16, 2022).

Conclusions:

I revisited my sleep mode functions and tried to make them work with the current circuit. After some troubleshooting, I determined that a state change in the limit switches Staci provided us with would not trigger an interrupt. I'm not sure why this is the case, but regardless, I do not think sleep mode is necessary and it does not really help us. Therefore, I have decided to abandon the sleep mode concept and simply use polling in the final code.

Action items:

1. continue to develop the code without sleep mode

ANNABEL FRAKE - Nov 12, 2022, 2:16 AM CST

Download

Stepper_Code_With_Limit_Switch_Polling_L298N_2.0.ino (1.86 kB)

ANNABEL FRAKE - Nov 12, 2022, 2:16 AM CST

Download

Stepper_3_Switches_DRV8825_Sleepmode_4.0.ino (5.56 kB)

ANNABEL FRAKE - Nov 12, 2022, 2:17 AM CST

```
// Stepper_3_Switches_DRV8825_Sleepmode_4.0.ino

// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Rotate the console of a Matrix rowing machine between the standard and adaptive
sides.


// Include necessary libraries.
#include <ezButton.h>;
#include <avr/sleep.h>;


// Define digital pins for the three limit swtiches.
byte const transitionSwitchPin = 12; // This limit switch is placed near the stabilization frame.
When its state changes, the rower is transitioned between adaptive and standard use or vice versa.
When this limit switch is pressed, the console should be on the standard side and when it is not
pressed, the console should be on the adaptive side.
byte const standardSwitchPin = 10; // This limit switch is placed near the console on the standard
side. When it is pressed, the consle is facing the standard user.
byte const adaptiveSwitchPin = 11; // This limit switch is placed near the console on the adaptive
side. When it is pressed, the consle is facing the wheelchair user.


// Define digital pins for the DIR and STEP features of the stepper motor.
byte const dirPin = 8;
byte const stepPin = 9;


// Define the time delay for the manual PWM of the stepper motor.
int speedDelay = 1000; // microseconds


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);


  // Set the stepper pinmodes to OUTPUT.
  pinMode(stepPin, OUTPUT);
  pinMode(dirPin, OUTPUT);


  // Set limit switch pins to INPUT_PULLUP. An internal pullup resistor reverses the logic. When the
switch is open, the output is HIGH (1). When the switch is closed, the output is LOW (0).
  pinMode(standardSwitchPin, INPUT_PULLUP);
  pinMode(adaptiveSwitchPin, INPUT_PULLUP);
  pinMode(transitionSwitchPin, INPUT_PULLUP);


  // Set LED on pin 13 to output. Will be used as an indicator of the Arduino's awake (LED on) /
asleep (LED off) state.
  pinMode(LED_BUILTIN, OUTPUT);
  digitalWrite(LED_BUILTIN, HIGH);
```

```
}


void loop()
{
  Serial.println("hello");
  // Put the Arduino to Sleep.
  goToSleep();
  Serial.println("hello");


  // Check the console position and rotate if necessary.
  checkConsolePosition();
}


void goToSleep()
{
  // Enable sleep mode
  sleep_enable();


  // Attach interrupt to cause console rotation
  attachInterrupt(digitalPinToInterrupt(transitionSwitchPin), wakeup, CHANGE);


  // Set full sleep mode
  set_sleep_mode(SLEEP_MODE_PWR_DOWN);


  // Turn off LED on pin 13 as a visual indicator that the Arduino entered sleep mode
  digitalWrite(LED_BUILTIN, LOW);


  Serial.println("Going to sleep...");
  Serial.println(digitalRead(transitionSwitchPin));


  // Add delay to allow motor time to move before Arduino sleeps
  delay(200);


  // Activate sleep mode
  sleep_cpu();


  // After the rotate interrupt, the code will resume here
  Serial.println("Arduino awake!");


  // Turn on LED on pin 13 as a visual indicator that the Arduino is awake
  digitalWrite(LED_BUILTIN, HIGH);
}
```

```
void wakeup()
{
  // Disable sleep mode
  sleep_disable();


  // Detach interrupt from limit switch
  detachInterrupt(transitionSwitchPin);
}


// A function that checks the current position of the console when the system starts up (or in the case of an unintended or intended reset).
void checkConsolePosition()
{
  // If the transition limit switch is pressed, that means the standard side of the machine is in use. If the standard position limit switch is not pressed, rotate the console to face the standard side.
  if (!digitalRead(transitionSwitchPin) && digitalRead(standardSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Call the function that rotates the console to face the standard side.
    rotateToStandard(standardSwitchPin);
  }

  // If the transition limit switch not pressed, that means the adaptive side of the machine is in use. If the adaptive position limit switch is not pressed, rotate the console to face the adaptive side.
  else if (digitalRead(transitionSwitchPin) && digitalRead(adaptiveSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Call the function that rotates the console to face the adpative side.
    rotateToAdaptive(adaptiveSwitchPin);
  }
}


// A function to rotate the console to face the standard side of the machine.
void rotateToStandard(int standardSwitchPin)
{
  // Specify the direction the motor will rotate: clockwise.
  digitalWrite(dirPin, LOW);


  // Rotate the motor in the specified direction until the standard position limit switch is depressed.
  while (digitalRead(standardSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Manually perform PWM.
    digitalWrite(stepPin, HIGH);
    delayMicroseconds(speedDelay); // use this to change speed
    digitalWrite(stepPin, LOW);
    delayMicroseconds(speedDelay); // use this to change speed
  }
```

```
  Serial.println("Console position: standard");
}


// A function to rotate the console to face the adaptive side of the machine.
void rotateToAdaptive(int adaptiveSwitchPin)
{
  // Specify the direction the motor will rotate: counterclockwise.
  digitalWrite(dirPin, HIGH);


  // Rotate the motor in the specified direction until the adaptive position limit switch is
depressed.
  while (digitalRead(adaptiveSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Manually perform PWM.
    digitalWrite(stepPin, HIGH);
    delayMicroseconds(speedDelay); // use this to change speed
    digitalWrite(stepPin, LOW);
    delayMicroseconds(speedDelay); // use this to change speed
  }


  Serial.println("Console position: adaptive");
}
```

14NOV2022 Fritzing Diagram

ANNABEL FRAKE - Nov 14, 2022, 8:06 PM CST

Title: 14NOV2022 Fritzing Diagram

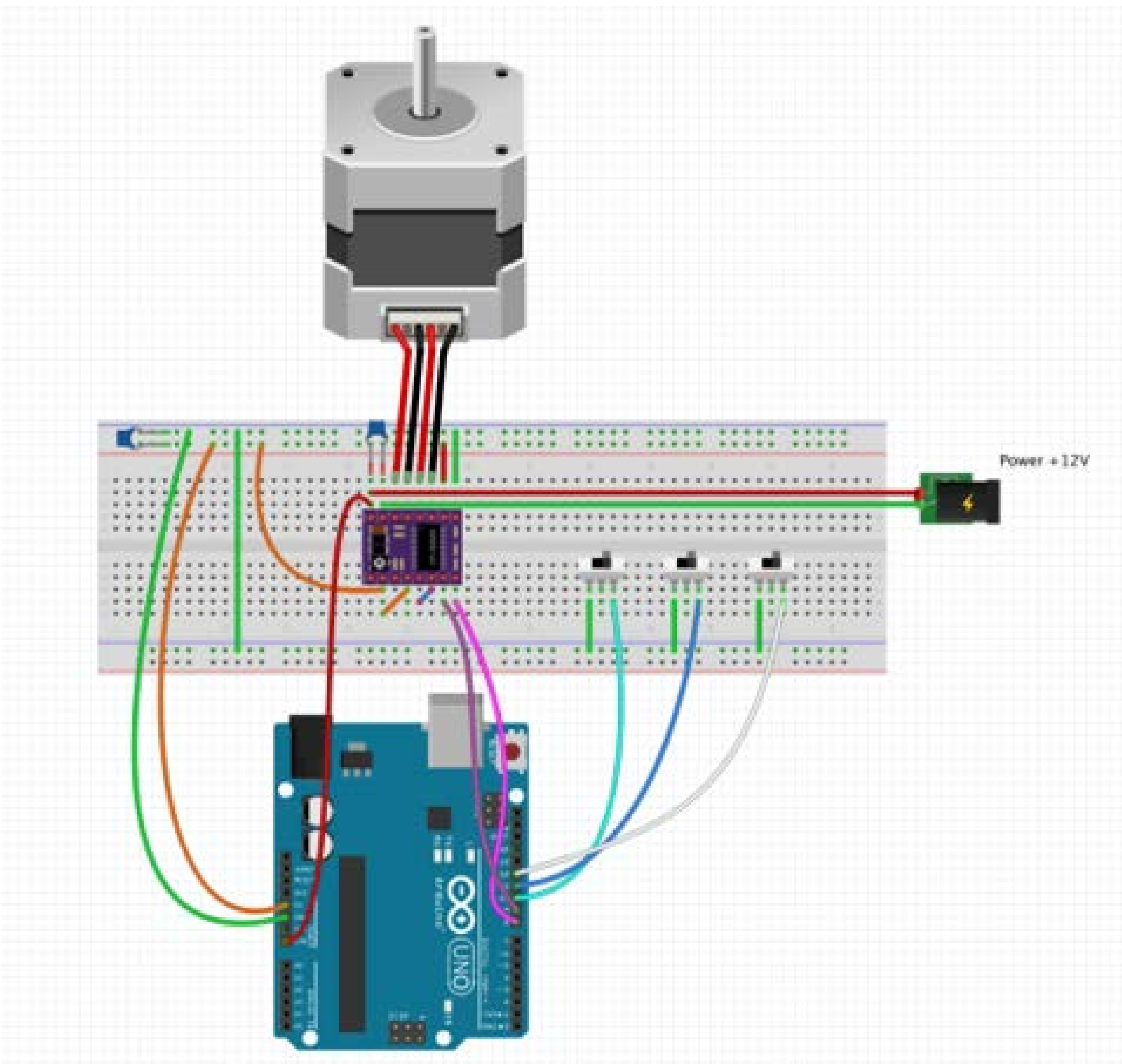
Date: 14NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: generate a circuit diagram of the final design using Fritzing

Content:

- 

- I used Fritzing to make a block diagram of the final circuit
- there wasn't an icon for a 100 microFarad capacitor, just a general one
- there wasn't an icon for a limit switch, so I substituted it with a SPDT switch
- I may want to make another block diagram with the actual components for clarity's sake

- the image above will require a descriptive caption to orient the viewer

References: Fritzing software

Conclusions:

Since I finalized the circuit earlier this week, I wanted to make a Fritzing block diagram of the circuit. Fritzing is no longer free, so I used the old version I had downloaded before the fee initiation. Because I have an older version, the image quality is not as good. Also, Fritzing didn't have icons for the limit switches or 100 microFarad capacitors, so I needed to use substitutes in the circuit. The diagram is good to have for the fabrication protocol, but I may want to see if I can make another block diagram with the actual components and clearer resolution.

Action items:

1. potentially create another block diagram with better labels / the actual components (and ideally less blurry)

2. create a coding flowchart

ANNABEL FRAKE - Nov 14, 2022, 7:59 PM CST

Download

Final_Circuit_Block_Diagram.fzz (218 kB)

15NOV2022 Vibration Testing

ANNABEL FRAKE - Nov 15, 2022, 9:33 PM CST

Title: 15NOV2022 Vibration Testing

Date: 15NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: test the new motor for vibration issues

Content:

- Motor connections (found on an informational card that came with the motor)
    - A BLK
    - A\ GRN
    - B RED
    - B\ BLU
- I inserted the new motor into the circuit and unplugged my personal motor
- when I supplied power to the circuit, the new motor rotated as expected without vibration
- there was a high-pitched whirring sound, but that is unavoidable with stepper motors (and my old one does that as well)
- therefore, the windings on my personal motor must be worn out as Yash suggested
- I will try the motor with the new goal posts Josh printed this week once I get them from him

References: none

Conclusions:

The new motor with D shaft arrived today. I replaced my personal motor with the new one in my circuit and observed no vibrations. Therefore, I have concluded that the windings on my personal motor are worn out as suggested by Yash. This is amazing news!

Action items:

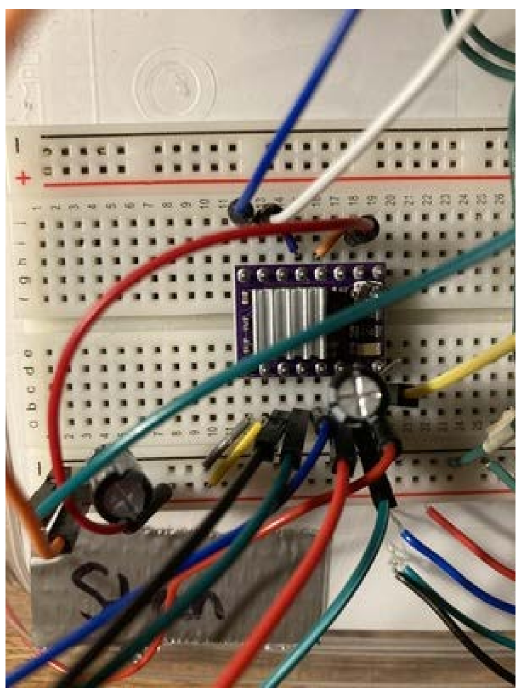
1. try the new motor with the console attached (after I get the new goal posts)

ANNABEL FRAKE - Nov 15, 2022, 9:38 PM CST

Download

IMG_6297.jpeg (4.14 MB) An image of the overall testing setup with the new D shaft motor (shown off to the side - not on the plastic).

ANNABEL FRAKE - Nov 15, 2022, 9:38 PM CST



Download

IMG_6299.jpeg (2.64 MB) A closeup of the new D shaft motor connections going to the DRV8825.

ANNABEL FRAKE - Nov 15, 2022, 11:09 PM CST

Download

IMG_6300.MOV (18.5 MB) A video of the new D shaft motor rotating without vibration.

16NOV2022 Console Testing

ANNABEL FRAKE - Nov 16, 2022, 8:19 PM CST

Title: 16NOV2022 Console Testing

Date: 16NOV2022

Content by: Annabel Frake

Present: Annabel Frake

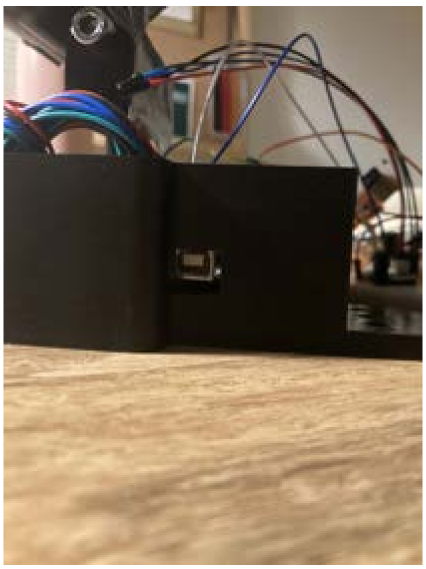
Goals: try rotating the console with the stepper motor

Content:

- I put the console onto the goalposts and then onto the motor shaft
- it rotated the console
- I messed around with the speed and found that it could rotate more smoothly at higher speeds
- also, faster rotation means that there is a quicker response for the user (especially in cases where the transition switch is pressed multiple times)
- I settled on a delay of 300 microseconds
- I also tried putting the electronics into the box Josh gave me
- the solder board holes lined up, but the Arduino holes did not
    - 

  - 

- also, the USB connector hole didn't quite line up, so the Arduino wouldn't sit in place (I looked at the holes from the bottom side)

  - 

References: none

Conclusions:

I got the new goal posts from Josh today, so I put everything together and powered it up. The console did rotate and while the motor didn't vibrate, the console did to a small degree. I tried varying the speed and found that, by increasing the speed, I could minimize the vibrations further. I chose a final speedDelay of 300 microseconds. I also placed the components in the box and gave Josh feedback of the hole placements. The holes worked for the circuit board, but not the Arduino. At this point, we might just drill out the holes. Josh said they shouldn't be that far off (see photos).

Action items:

1. solder the final circuit
2. final fabrication plans

ANNABEL FRAKE - Nov 16, 2022, 8:08 PM CST

Download

final_code_fall_2022_bme_400.ino (5.42 kB)

ANNABEL FRAKE - Nov 16, 2022, 8:15 PM CST

Download

IMG_6306.MOV (20.2 MB) The console rotating on the stepper motor.

ANNABEL FRAKE - Nov 16, 2022, 8:15 PM CST

Download

IMG_6312.MOV (6.74 MB) The console rotating on the stepper motor with a speedDelay of 300 microseconds. Final speed.

18NOV2022 Fabrication of Final Circuit

ANNABEL FRAKE - Nov 18, 2022, 5:46 PM CST

Title: 18NOV2022 Fabrication of Final Circuit

Date: 18NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: fabricate the final design

Content:

- see attached images

References: none

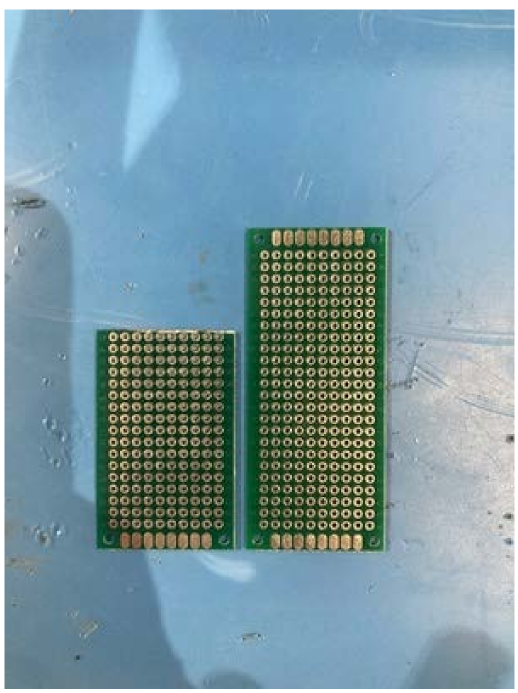
Conclusions:

I went to the MakerSpace several times today to work on the final circuit fabrication. I cut the solder board down so that it fits within the electronics box. I then soldered all components where possible (ie couldn't solder a connection to the Arduino for example). Please see the attached images.

Action items:

1. write up the fabrication procedure
2. test

ANNABEL FRAKE - Nov 18, 2022, 5:54 PM CST



Download

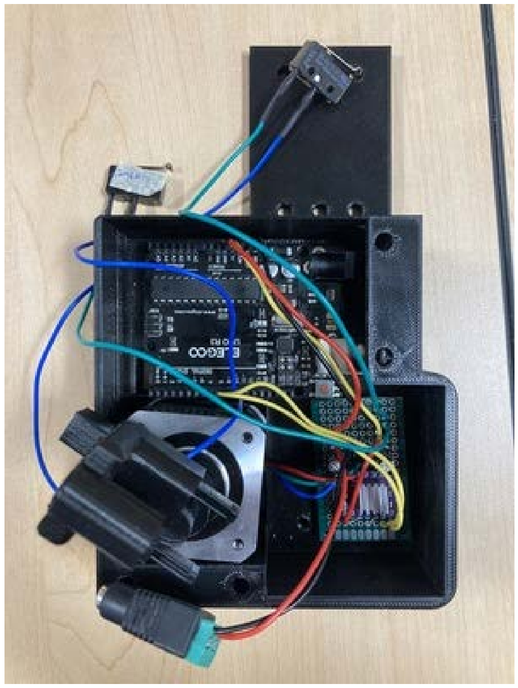
IMG_6320.jpeg (3.04 MB) An image of the cut-down breadboard compared to the original size.

ANNABEL FRAKE - Nov 18, 2022, 5:55 PM CST

Download

IMG_6321.MOV (4.58 MB) A video of the the circuit working after the DRV8825 was transferred from a breadboard to a solder board.

ANNABEL FRAKE - Nov 18, 2022, 5:55 PM CST



Download

IMG_6323.jpeg (3.72 MB) An image of the overall setup. The transition limit switch is not shown.

ANNABEL FRAKE - Nov 18, 2022, 5:56 PM CST

Download

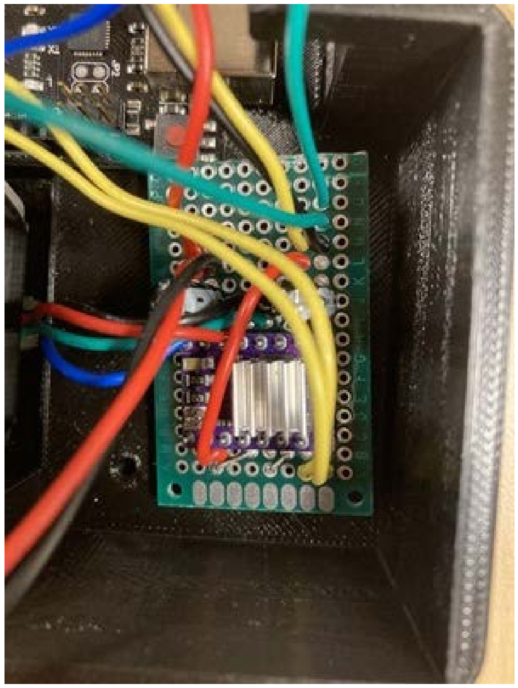
IMG_6324.jpeg (2.64 MB) A closeup of the standard position limit switch connections. I used heat shrink to cover the metal.

ANNABEL FRAKE - Nov 18, 2022, 5:57 PM CST

Download

IMG_6325.jpeg (3.76 MB) A closeup of the Arduino connections. D8 is the DIR pin. D9 is the STEP pin. D10 is the standard limit switch pin. D11 is the adaptive limit switch pin. D12 is the transition limit switch pin (not shown in image).

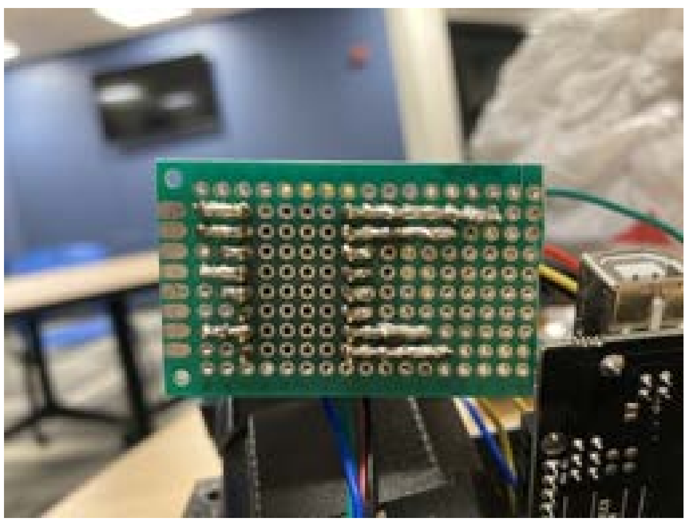
ANNABEL FRAKE - Nov 18, 2022, 5:57 PM CST



Download

IMG_6326.jpeg (3.81 MB) A closeup of the connections on the solder board. Components include the DRV8825 and two 100 microFarad capacitors.

ANNABEL FRAKE - Nov 18, 2022, 5:58 PM CST



Download

IMG_6327.jpeg (2.66 MB) An image of the bottom of the solder board.

ANNABEL FRAKE - Nov 18, 2022, 5:59 PM CST

Download

IMG_6328.jpeg (3.93 MB) An image of the transition limit switch and wire. I bought roughly 10 ft because it was cheap and I wanted to be on the safe side since the stabilization frame hasn't been constructed yet.

19NOV2022 Circuit Testing

ANNABEL FRAKE - Nov 19, 2022, 10:35 PM CST

Title: 19NOV2022 Circuit Testing

Date: 19NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: Test the circuit after fabrication to make sure everything still operates

Content:

- I changed the direction that the motor rotates for standard vs adaptive side in accordance with the motor's orientation relative to the rowing machine (ie so it doesn't hit the antlers)
- I repeated the edge case testing I performed previously, and everything operated as expected
- after integration with the 3D prints and stabilization frame, I will redo the edge case testing as a final test of the circuit's operability
    - note: I still need to cut the transition limit switch wires to length once the stabilization frame is fabricated

References: none

Conclusions:

I tested the circuit tonight to make sure everything still operated after transitioning the circuit to the solder board.

Action items:

1. perform final testing after design integration with the stabilization frame

ANNABEL FRAKE - Nov 19, 2022, 10:46 PM CST

Download

IMG_0679.MOV (40.3 MB) A video of the circuit operating as intended. Note: once the limit switches are secured in place, the flag on the console and the lap bar will suppress the limit switches instead of my hands.

27NOV2022 Code Finalization

ANNABEL FRAKE - Nov 27, 2022, 11:16 PM CST

Title: 27NOV2022 Code Finalization

Date: 27NOV2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: finalize the Arduino code

Content:

- I couldn't get my computer to recognize the serial port on the Arduino board
  - I researched the problem and it seems like the most likely cause is a bad USB connection
  - I tried 2 other USB cords and changed ports on my computer, but nothing worked
  - I tried uploading the code to my personal Arduino and that worked
  - therefore, it seems that the Arduino we bought is damaged in some way
  - it still operates with the last upload of the final code, but I can't upload any new programs to it
  - I will ask Josh what he thinks we should do tomorrow (we could just keep it assuming we don't have to change the speed of the console rotation or anything after integration, but it makes me nervous that we couldn't fix anything)
  - I am not sure how it got damaged
  - we may need to buy another one next semester
- I had an idea to potentially streamline the code further
- I adapted the code to only check the console position and used digitalRead() instead of the ezButton library
  - it was simply the previous check console position code called in the void loop with nothing else (and changed to digitalRead())
- while this does streamline the code, I hadn't initially done it because the state of the limit switch can change multiple times with one button press
- therefore, I used the ezButton library because it would automatically use a debounce and prevent false positives or multiple state changes readings that might mess up the code
- I used the code that is attached below, but it didn't not pass the edge cases from the testing protocol
- it failed edge case 2 consistently
- it did work every once in a while, but not reliably
- my guess is that the button state might flicker and get the code stuck in the wrong rotation function until the corresponding limit switch is depressed
- while this could be corrected eventually once the corresponding limit switch is depressed and the code exits the while loop, this code is not as reliable as the previous code I wrote
- I tried using the ezButton getState() to see if the debounce would work, but it didn't fix anything
- I uploaded the ezButton finalized code to the board and had the same issue

- I made sure that the connections were solid, but that didn't seem to fix anything
- I unplugged the USB going to my computer and it worked (no idea why)
- I uploaded the streamlined code and the code passed edge case 2
- I was a tad bit suspicious of this, so I tried plugging the circuit into the +12V power supply multiple times in a row and found that about 1/10 of the time, the console spun the wrong direction to start with
- I tried the same thing with the non-streamlined code and found the same result
- I tried it with the Arduino Uno we bought that has the non-streamlined code stuck on it, and found the same result
- I removed the checkConsolePosition() from the void setup() loop on the non-streamlined code, uploaded it to my personal Arduino, and tried again
    - I plugged and unplugged the +12V power supply 20 times and and the console rotated towards the adaptive side each time (transition limit switch not pressed)
    - I kept the power plugged in and restarted the board 20 times, and the console rotated towards the adaptive side each time
- based on this, I concluded that the code wasn't given enough time to start up before checking the transition limit switch state and therefore could get stuck in the wrong while rotation loop in the streamlined code
    - I added a short delay in the void setup() loop to allow the program time to set up
    - I plugged and unplugged the +12V power supply 20 times and and the console rotated towards the adaptive side each time (transition limit switch not pressed)
    - I kept the power plugged in and restarted the board 20 times, and the console rotated towards the adaptive side each time
- A lot of things were acting strange today, but once all was said and done, the streamlined code passed the edge cases

References: none

Conclusions:

I wrote a more streamlined code that just uses the checkConsolePosition() code without the if statements for the limit switch being depressed or released. After some problems with the edge cases failing, I sorted everything out and the streamlined code appears to be working. Since I had to alter the non-streamlined code to fix the glitch in the system that caused failure of edge case 2, we can't use the Arduino we purchased for the project that somehow got damaged. Therefore, I will use my personal Arduino for this semester and then we can see about purchasing a replacement next semester. To this end, I have decided to keep the streamlined code as the final code for the semester.

Action items:

1. finalize the coding flowchar

ANNABEL FRAKE - Nov 27, 2022, 11:05 PM CST

```
// streamlined_final_code_fall_2022_bme_400.ino
```

```
// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Rotate the console of a Matrix rowing machine between the standard and adaptive
sides.


// Define digital pins for the three limit swtiches.
byte const standardSwitchPin = 10; // This limit switch is placed near the console on the standard
side. When it is pressed, the consle is facing the standard user.
byte const adaptiveSwitchPin = 11; // This limit switch is placed near the console on the adaptive
side. When it is pressed, the consle is facing the wheelchair user.
byte const transitionSwitchPin = 12; // This limit switch is placed near the stabilization frame.
When its state changes, the rower is transitioned between adaptive and standard use or vice versa.
When this limit switch is pressed, the console should be on the standard side and when it is not
pressed, the console should be on the adaptive side.


// Define digital pins for the DIR and STEP features of the stepper motor.
byte const dirPin = 8;
byte const stepPin = 9;


// Define the time delay for the manual PWM of the stepper motor.
int speedDelay = 300; // microseconds


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);


  // Set the stepper pinmodes to OUTPUT.
  pinMode(stepPin, OUTPUT);
  pinMode(dirPin, OUTPUT);


  // Set limit switch pins to INPUT_PULLUP. An internal pullup resistor reverses the logic. When the
switch is open, the output is HIGH (1). When the switch is closed, the output is LOW (0).
  pinMode(standardSwitchPin, INPUT_PULLUP);
  pinMode(adaptiveSwitchPin, INPUT_PULLUP);
  pinMode(transitionSwitchPin, INPUT_PULLUP);


  // Delay to allow program time to start up. Avoids misreading of the transition limit switch
state.
  delay(500);
}


void loop()
{
  // Check the position of the console and react accordingly.
  checkConsolePosition();
}
```

```
// A function that checks the current position of the console and rotates accordingly when and if necessary.
void checkConsolePosition()
{
  // If the transition limit switch is pressed, that means the standard side of the machine is in use. If the standard position limit switch is not pressed, rotate the console to face the standard side.
  if (!digitalRead(transitionSwitchPin) && digitalRead(standardSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Call the function that rotates the console to face the standard side.
    rotateToStandard();
  }


  // If the transition limit switch not pressed, that means the adaptive side of the machine is in use. If the adaptive position limit switch is not pressed, rotate the console to face the adaptive side.
  if (digitalRead(transitionSwitchPin) && digitalRead(adaptiveSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Call the function that rotates the console to face the adpative side.
    rotateToAdaptive();
  }
}


// A function to rotate the console to face the standard side of the machine.
void rotateToStandard()
{
  // Specify the direction the motor will rotate: clockwise.
  digitalWrite(dirPin, HIGH);


  // Rotate the motor in the specified direction until the standard position limit switch is depressed.
  while (digitalRead(standardSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Manually perform PWM.
    digitalWrite(stepPin, HIGH);
    delayMicroseconds(speedDelay); // use this to change speed
    digitalWrite(stepPin, LOW);
    delayMicroseconds(speedDelay); // use this to change speed
  }


  Serial.println("Console position: standard");
}


// A function to rotate the console to face the adaptive side of the machine.
void rotateToAdaptive()
{
```

```
  // Specify the direction the motor will rotate: counterclockwise.
  digitalWrite(dirPin, LOW);


  // Rotate the motor in the specified direction until the adaptive position limit switch is
depressed.
  while (digitalRead(adaptiveSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Manually perform PWM.
    digitalWrite(stepPin, HIGH);
    delayMicroseconds(speedDelay); // use this to change speed
    digitalWrite(stepPin, LOW);
    delayMicroseconds(speedDelay); // use this to change speed
  }


  Serial.println("Console position: adaptive");
}
```

ANNABEL FRAKE - Nov 27, 2022, 11:05 PM CST

Download

streamlined_final_code_fall_2022_bme_400.ino (4.21 kB)

ANNABEL FRAKE - Nov 27, 2022, 11:06 PM CST

```
// final_code_fall_2022_bme_400.ino
```

```
// Written by:    Annabel Frake
// Class:         BME 400
// Purpose:       Rotate the console of a Matrix rowing machine between the standard and adaptive
sides.


// Include necessary libraries.
#include <ezButton.h>;


// Define digital pins for the three limit swtiches.
byte const transitionSwitchPin = 12; // This limit switch is placed near the stabilization frame.
When its state changes, the rower is transitioned between adaptive and standard use or vice versa.
When this limit switch is pressed, the console should be on the standard side and when it is not
pressed, the console should be on the adaptive side.
byte const standardSwitchPin = 10; // This limit switch is placed near the console on the standard
side. When it is pressed, the consle is facing the standard user.
byte const adaptiveSwitchPin = 11; // This limit switch is placed near the console on the adaptive
side. When it is pressed, the consle is facing the wheelchair user.


// Create an ezButton object for the transition limit switch.
ezButton transitionSwitch(transitionSwitchPin);


// Define digital pins for the DIR and STEP features of the stepper motor.
byte const dirPin = 8;
byte const stepPin = 9;


// Define the time delay for the manual PWM of the stepper motor.
int speedDelay = 300; // microseconds


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);


  // Set the stepper pinmodes to OUTPUT.
  pinMode(stepPin, OUTPUT);
  pinMode(dirPin, OUTPUT);


  // Set limit switch pins to INPUT_PULLUP. An internal pullup resistor reverses the logic. When the
switch is open, the output is HIGH (1). When the switch is closed, the output is LOW (0).
  pinMode(standardSwitchPin, INPUT_PULLUP);
  pinMode(adaptiveSwitchPin, INPUT_PULLUP);


  // Assign the transition limit switch with a debounce time of 50 milliseconds
  transitionSwitch.setDebounceTime(50);
}
```

```
void loop()
{
  // Call the loop() function for the transition limit switch.
  transitionSwitch.loop();


  // If the transition limit switch is pressed, that means the standard side of the machine is now in use. Rotate the console to face the standard side.
  if (transitionSwitch.isPressed())
  {
    // Call the function that rotates the console to face the standard side.
    rotateToStandard(standardSwitchPin);
  }


  // If the transition limit switch is released, that means the adaptive side of the machine is now in use. Rotate the console to face the adaptive side.
  else if (transitionSwitch.isReleased())
  {
    // Call the function that rotates the console to face the adpative side.
    rotateToAdaptive(adaptiveSwitchPin);
  }


  // If the transition limit switch state does not change, check the position of the console to ensure it is in the correct orientation.
  else
  {
    checkConsolePosition();
  }
}


// A function that checks the current position of the console when the system starts up (or in the case of an unintended or intended reset).
void checkConsolePosition()
{
  // If the transition limit switch is pressed, that means the standard side of the machine is in use. If the standard position limit switch is not pressed, rotate the console to face the standard side.
  if (!transitionSwitch.getState() && digitalRead(standardSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Call the function that rotates the console to face the standard side.
    rotateToStandard(standardSwitchPin);
  }

  // If the transition limit switch not pressed, that means the adaptive side of the machine is in use. If the adaptive position limit switch is not pressed, rotate the console to face the adaptive side.
  else if (transitionSwitch.getState() && digitalRead(adaptiveSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Call the function that rotates the console to face the adpative side.
```

```
    rotateToAdaptive(adaptiveSwitchPin);
  }
}


// A function to rotate the console to face the standard side of the machine.
void rotateToStandard(int standardSwitchPin)
{
  // Specify the direction the motor will rotate: clockwise.
  digitalWrite(dirPin, HIGH);


  // Rotate the motor in the specified direction until the standard position limit switch is
depressed.
  while (digitalRead(standardSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Manually perform PWM.
    digitalWrite(stepPin, HIGH);
    delayMicroseconds(speedDelay); // use this to change speed
    digitalWrite(stepPin, LOW);
    delayMicroseconds(speedDelay); // use this to change speed
  }

  Serial.println("Console position: standard");
}


// A function to rotate the console to face the adaptive side of the machine.
void rotateToAdaptive(int adaptiveSwitchPin)
{
  // Specify the direction the motor will rotate: counterclockwise.
  digitalWrite(dirPin, LOW);


  // Rotate the motor in the specified direction until the adaptive position limit switch is
depressed.
  while (digitalRead(adaptiveSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Manually perform PWM.
    digitalWrite(stepPin, HIGH);
    delayMicroseconds(speedDelay); // use this to change speed
    digitalWrite(stepPin, LOW);
    delayMicroseconds(speedDelay); // use this to change speed
  }


  Serial.println("Console position: adaptive");
}
```

ANNABEL FRAKE - Nov 27, 2022, 11:06 PM CST

Download

final_code_fall_2022_bme_400.ino (5.3 kB)

1DEC2022 Arduino Testing

ANNABEL FRAKE - Dec 01, 2022, 1:12 PM CST

Title: 1DEC2022 Arduino Testing

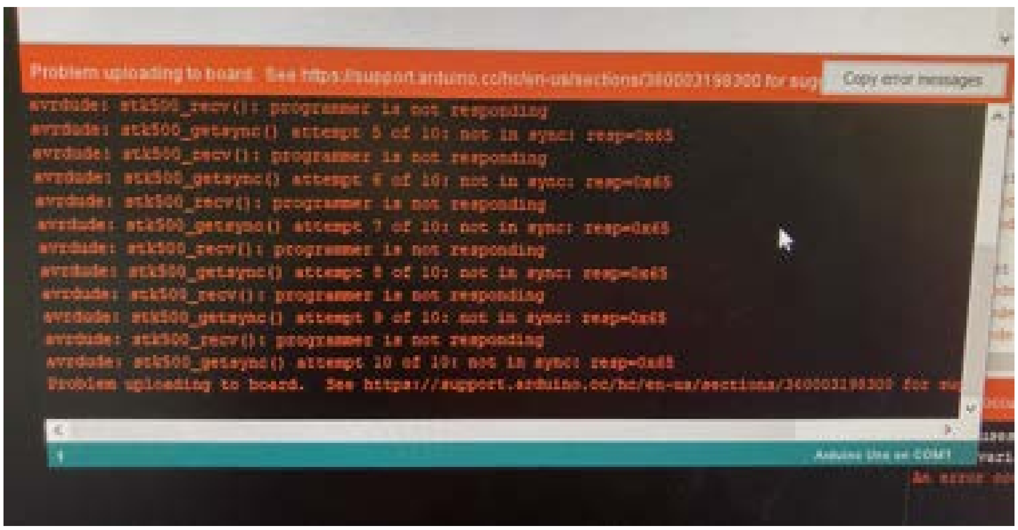
Date: 1DEC2022

Content by: Annabel Frake

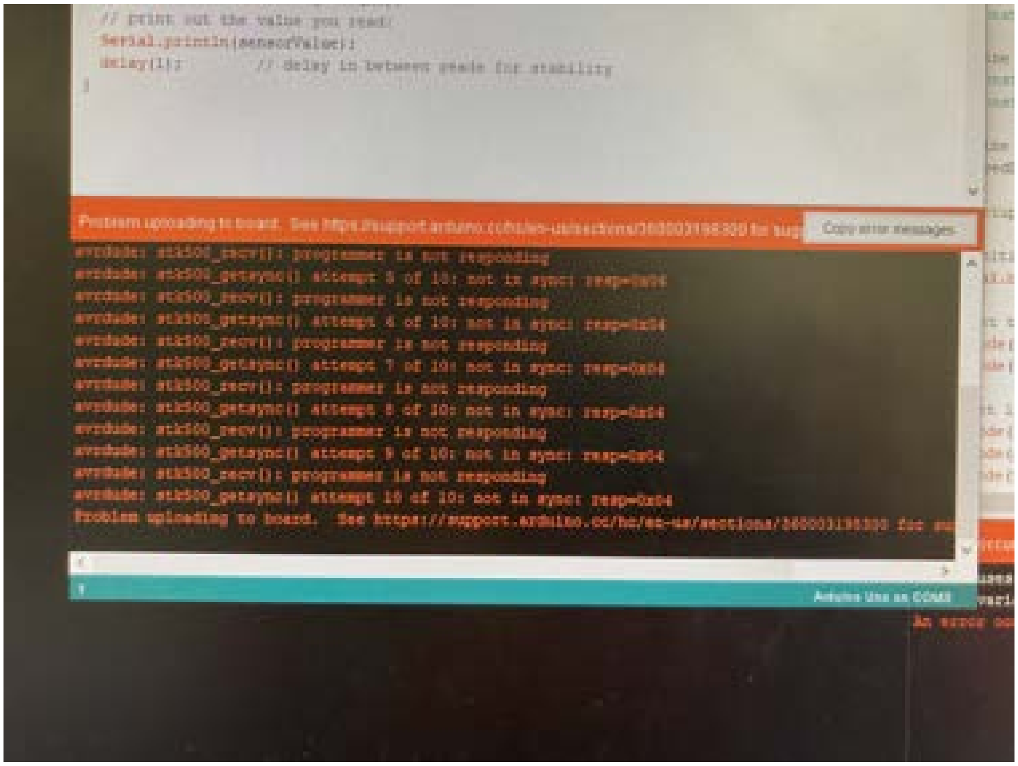
Present: Annabel Frake

Goals: test uploading a program to the damaged Arduino using a PC computer

Content:

- I thought that perhaps the USB connection issue between the computer and Arduino was faulty due to my use of a Mac computer
- I have to use an adapter to go from USB to my computer, so I thought I'd try a PC just to be sure the Arduino really is damaged
- There were 2 port options
    - When I tried COM1, I got the following error
        - 

    - When I tried COM 3, I got the following error

- 

References: none

Conclusions:

I tried uploading the final code to the damaged Arduino board using a PC computer, but the uploading error persisted. Therefore, I concluded that the Arduino really is damaged and the USB connection is not causing the problem.

Action items:

1. purchase a replacement next semester

Red Pass Documentation

ANNABEL FRAKE - Sep 12, 2022, 8:37 PM CDT

Title: Red Pass Documentation

Date: 12SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: provide documentation of red pass training

Content:

-see attached image

References: UW Madison TEAMLab Materials

ANNABEL FRAKE - Sep 11, 2021, 9:21 AM CDT

Download

IMG_1332.jpeg (4.22 MB) Red Pass

Green Pass Documentation

ANNABEL FRAKE - Sep 12, 2022, 8:37 PM CDT

Title: Green Pass Documentation

Date: 12SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: provide documentation of green pass training

Content:

-see attached image

References: UW Madison TEAMLab Materials

ANNABEL FRAKE - Sep 11, 2021, 9:22 AM CDT

Download

IMG_1333.jpeg (4.17 MB) Green Pass

Biosafety Training Documentation

ANNABEL FRAKE - Sep 12, 2022, 8:38 PM CDT

Title: Biosafety Training Documentation

Date: 12SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: provide documentation of biosafety training

Content:

-see attached pdf

References: UW Madison Biosafety Training Canvas Module

ANNABEL FRAKE - Mar 09, 2021, 10:32 PM CST

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Certificate_of_Completion_for_Biosafety_Training.pdf (13.8 kB)

Chemical Safety Training Documentation

ANNABEL FRAKE - Sep 12, 2022, 8:38 PM CDT

Title: Chemical Safety Training Documentation

Date: 12SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: provide documentation of chemical safety training

Content:

-see attached pdf

References: UW Madison Chemical Training Canvas Module

ANNABEL FRAKE - Mar 20, 2021, 9:53 PM CDT

Download

Certificate_of_Completion_for_ANNABEL_FRAKE.pdf (14.3 kB)

Animal Training Documentation

ANNABEL FRAKE - Sep 15, 2022, 6:48 PM CDT

Title: Animal Training Documentation

Date: 15SEP2022

Content by: Annabel Frake

Present: Annabel Frake

Goals: provide documentation of animal training

Content:

-see attached pdf

References: UW Madison Animal Training materials

ANNABEL FRAKE - Sep 15, 2022, 6:46 PM CDT

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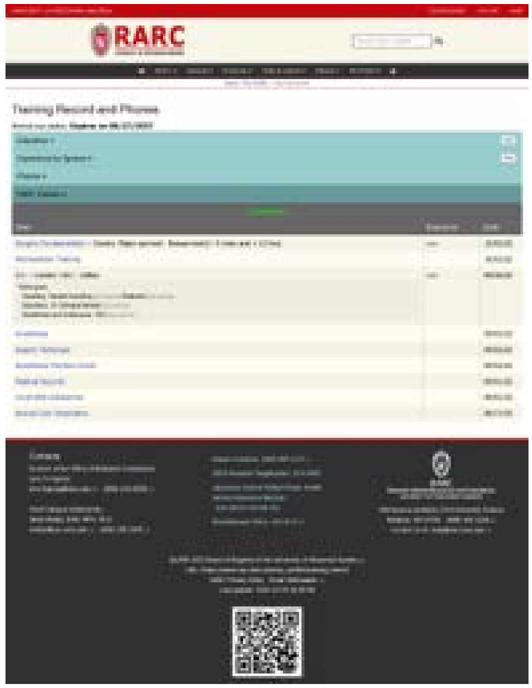
15SEP2022_Animal_Training_Record.pdf (36.7 kB)

ANNABEL FRAKE - Dec 13, 2022, 2:40 PM CST



Download

Training_Record_Research_Animal_Resources_and_Compliance_University_of_Wisconsin_Madison.pdf (161 kB) I completed the Surgery Fundamentals training on 2DEC2022.

Preferred Template

ANNABEL FRAKE - Sep 09, 2022, 2:00 PM CDT

Title:

Date:

Content by:

Present:

Goals:

Content:

References:

Conclusions:

Action items:

9-14-2022 - Review of linear actuators for removing rope tension

Josh ANDREATTA - Sep 14, 2022, 7:50 PM CDT

Title: 9-14-2022 - Review of linear actuators for removing rope tension

Date: 9-14-2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Learn how linear actuators work and certain designs of linear actuators

Content:

- Actuator = device that requires an energy source input and an external signal input to generate some motion or force
  - The motion can be either rotary or linear
- Users spur tooth gears to control a motor shaft that is attached to a screw which drives the actuator
- Converts rotational motion of AC/DC motor into linear motion to provide both push and pull movements
- Actuators vary in motor size, the specific gearing, and the leadscrew size (determines stroke length)
- Electronic actuators are used instead of hydraulic actuators when lower forces are needed, as immense pressure/force is required to power a hydraulic actuator
- Electronic actuators have long lifetimes with little to no required maintenance, so they would be a good option to include in the rower in order to remove the need of excessive outside maintenance
- Need to consider the amount of static load and dynamic load when choosing an actuator
- DC motors are typically the most common and are 12V for typical small scale applications
- Linear actuators can extend/retract at different speeds, so when researching, it is best to take into account the rate at which we want extension

The above image shows the interior cross section of a typical linear actuator.

References:

R. Dickson, “Linear Actuators 101 - everything you need to know about linear actuators,” *Firgelli Automations*, 16-Nov-2018. [Online]. Available: https://www.firgelliauto.com/blogs/actuators/linear-actuators-101. [Accessed: 14-Sep-2022].

Conclusions:

Linear actuators are used to apply tension or compression onto systems or objects. Linear actuators come in varying lengths, speeds, motor types and voltages. For our application, we are interested in using a linear actuator to move the rope of the handlebar to put slack into the rope so that it is easy to transition from one side of the rower to the other. We are planning on developing a mechanical structure that holds the actuator and grasps the rope. The actuator will then be programmed using Arduino code to extend a set distance, determined from our measurements, to produce enough slack in the rope. When the user wants to then put the handlebar back to the side from which it was originally taken, the linear actuator will be programmed to retract and move in the opposite direction. This will put slack in the rope and again allow for the user to easily switch the rope to the other side. To begin, we will come up with a few mechanical designs for the structure (on the ground or attached to the rower) and using the tension in the rope that we recorded last semester, we will then pick a linear actuator that meets the force and dimensional requirements.

Action items:

-Meet with team on Friday to discuss other's research results and assign PDS sections

-Send out progress report tomorrow afternoon

9-16-2022 - Review of Wheelchair Dimensions

Josh ANDREATTA - Sep 16, 2022, 10:31 AM CDT

Title: 9-16-2022 - Review of Wheelchair Dimensions

Date: 9-16-2022

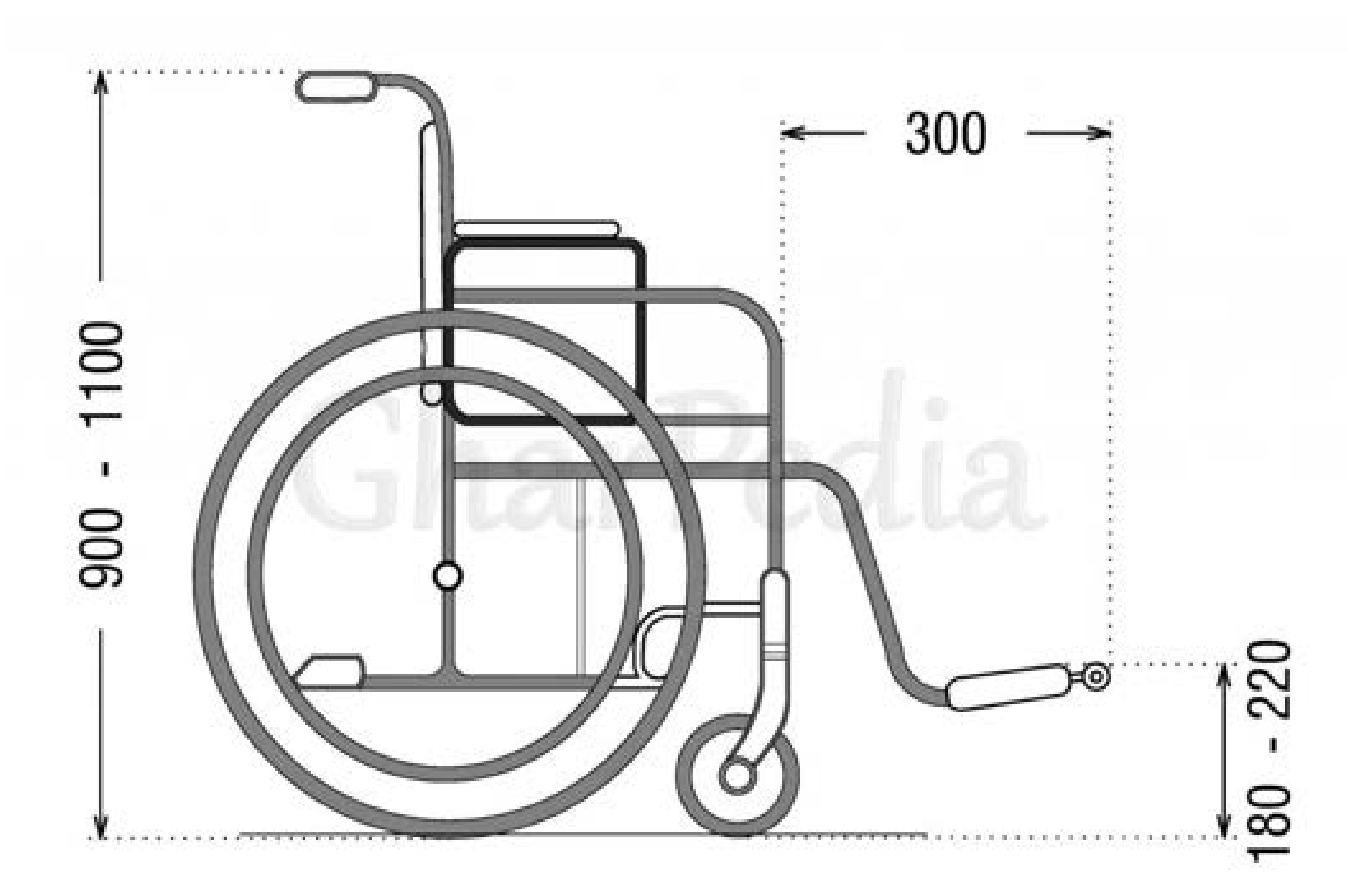
Content by: Josh Andreatta

Present: Josh Andreatta

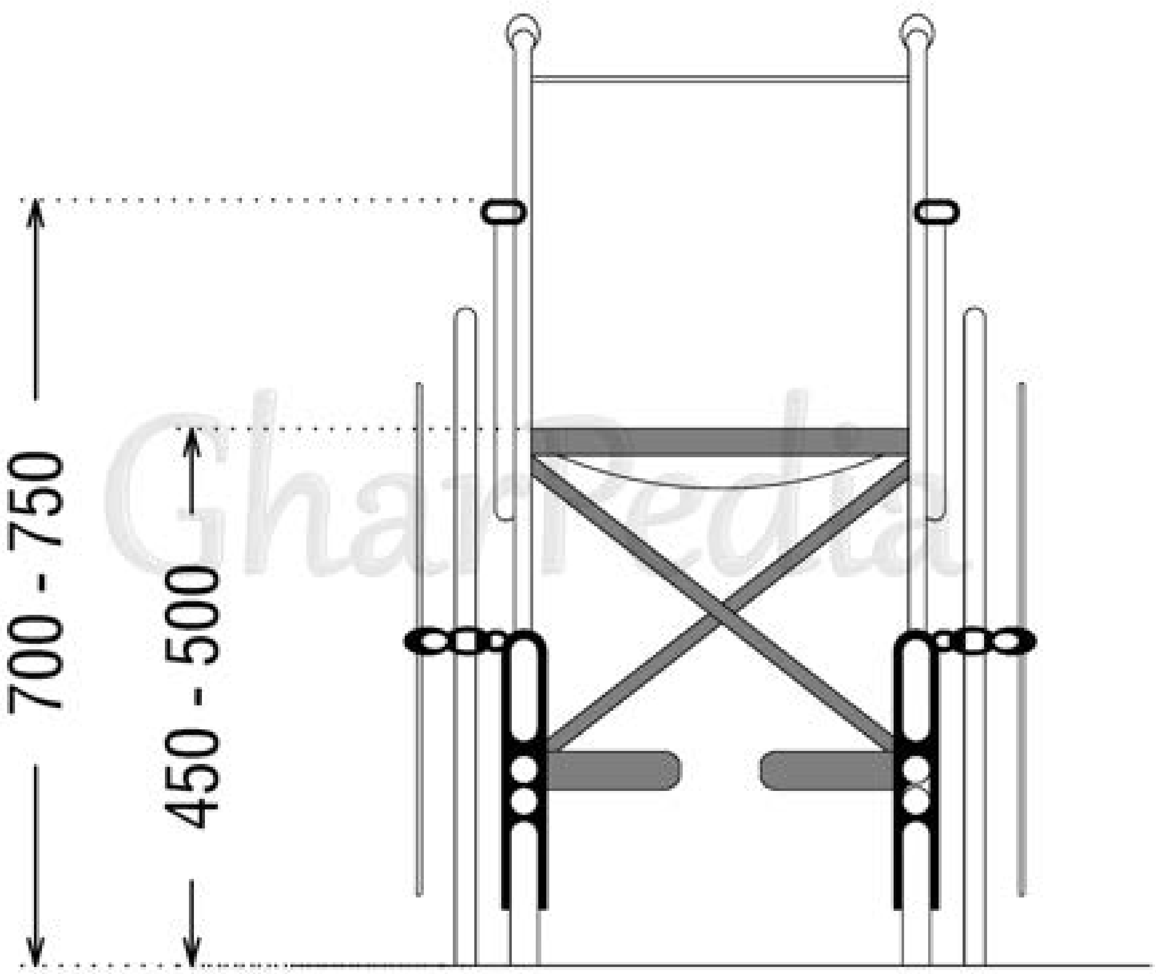
Goals: Learn the typical ranges for height, width, and length of wheelchairs

Content:

- The ideal sitting position in a wheelchair is 90-90-90
  - 90 deg bend at the hip, 90 deg bend at the knee, and 90 deg bend in the ankle
- The typical length: 3 foot 7 inches to 4 foot 1 inch
- The typical length: 3 foot to 3 foot 7 inches
- The typical seat height off the ground: 1 foot 6 inches to 1 foot 8 inches
- The typical width: 600-700mm



The above image shows the typical height of the wheelchair along with typical heights of specific components of the wheelchair.



The above image shows the typical height of the wheelchair seat and arm rests, which will be important to consider when making our support frame adjustable.

References:

P. Patel, “Wheelchair Dimensions – A Complete Wheelchair Size Guide,” *GharPedia*, 23-Apr-2016. [Online]. Available: https://gharpedia.com/blog/need-dimensions-wheelchairs/. [Accessed: 16-Sep-2022].

Conclusions:

The ranges of the height and width of typical ranges is not excessively large, so we should be able to accommodate these specific ranges in our support frame. We will work as a group to define the proper or necessary number of adjustable intermediate positions we should have and what the gap size should be between each increment.

Action items:

-Discuss these dimensions with the group to see if we found agreeing dimensions

-Work on PDS and initial design ideas

9/25/2022 - Typical Materials/Methods used for Metal Working

Josh ANDREATTA - Sep 25, 2022, 3:36 PM CDT

Title: 9/25/2022 - Typical Materials/Methods used for Metal Working

Date: 9/25/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Research different metals and their metal working process characteristics to understand what we should use for our fabrication

Content:

- Important to know the environment our metal will be working in and the stresses it must withstand
- Temperature: many metals will warp or freeze at high or low temps
- Corrosion resistance: take into account if metal will be in contact with salts or acids or alkalis or moisture
- Fabrication process: take into account difficulty for cutting and welding
- Stainless Steel
    - 304: Chromium, nickel, steel,
        - Clean shiny appearance, high corrosion resistance, and decent durability, easy to form and weld
    - 316: Also contains molybdenum, and small amounts of silicon, phosphorus, and sulfur, which make it more resistant to corrosion
- Aluminum Alloys
    - main advantage is light weight composition and inexpensive
    - More sensitive to stress and heat than stainless steel
- Nickel Alloys
    - very resistant to thermal expansion and electromagnetic interference
        - Good for sensitive measurement and electromagnetic shielding
    - High corrosion resistance

References:

apec_access, "Choosing the right alloy for your custom fabrication design," *APEC USA*, 12-Apr-2021. [Online]. Available: https://www.apecusa.com/blog/choosing-the-right-alloy-for-your-custom-fabrication-design/. [Accessed: 25-Sep-2022].

Conclusions:

For our application of wanting to make the pulley plates out of a metal that is strong, durable, and easy to machine, I think the best choice is a form of stainless steel. The high corrosion resistance is beneficial incase sweat or water gets on the metal during working out. The increased strength of this metal too is a beneficial factor as the pulley plates and antlers need to be able to withstand large forces and moments that may be applied in worst case scenarios. We do not need to worry about temperature affects since this will be on equipment that is inside of a gym.

Action items: Meet with the team to discuss my findings, and score design matrices. Then begin work on prelim presentation.

9/19/2022 - Antler Design Sketches

Josh ANDREATTA - Sep 19, 2022, 9:34 PM CDT

Title: 9/19/2022 - Antler Design Sketches

Date: 9/19/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Create sketches of antler design for holding the handle bar

Content:

Attached below are sketches I made of the Antler design that we all brainstormed together through productive group thinking and feedback. The goal of this design is to remove the need for any special mechanism that would take the tension off the rope. With the current design, the rope must be transitioned from one side to the other through a slit in the rower neck. To do so, the tension in the rope must be removed first, and this requires a mechanism that would remove the tension in the rope. This design aims to move the handle bar so that you don't need to transition the rope through the neck. In fact, this design completely removes the rower neck as a whole. Rather, the handlebar is placed on the line of action that separates the two pulleys, thus placing it in the middle of the two pulleys. This way, users from either side can just lean up to the handle bar and grab it, removing the need to transition it through the narrow cut and remove its tension. The handlebar will be held in place by adding a vertical portion to each pulley plate that has a semicircular cut at the top to hold the handlebar. Additionally, since the rower neck will be removed, the pulley plates will include blocks of SLA material between them that will push them apart to counter any inward bending they may face. The plates will most likely be made as two pieces still, with each piece screwing into the other at the front or back. As shown in the images below, each plate will have one antler to hold the handlebar.

Since this design removes the rower neck, we needed to find a way to hold the console in place. A simple solution is just creating a small extension off of one of the antler supports and placing the console there. The current swivel bracket can still be used, but it will be modified so that now intermediate locating pegs are necessary. Rather, there will still be 1 locating peg, but it will follow in a 180 degree extruded track to guide the rotation of the console within its centering peg, as shown in the images below. Then, once set down all the way into its centering peg, a horizontal peg will be inserted into the base of the bracket to lock it in place. This will prevent the console from turning or rotating during rowing. Since it will be at the side, it will not interfere with the users ability to row. Although it won't be perfectly centered (as this would then block the user from grabbing the rope and handlebar), we will aim to put the display console as close to center as possible, so that it is not uncomfortable for the user to look at while rowing. The images below contain sketches of the antler design and update swivel bracket. I will work over the next 2-3 weeks to create these changes in solidworks for proof of concept before we print them for the first time out of SLA material.

References: n/a

Conclusions:

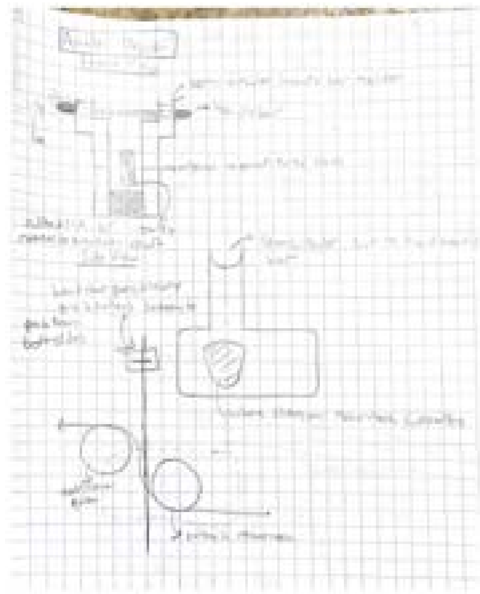
After a large discussion with the team, we all believe that this antler design is going to greatly reduce the complexity of the current design. By removing the need for the rower neck to hold the console, and by placing the handlebar directly along the line of action that is between the two pulleys, there won't be any need to remove the tension in the rope when grabbing it. The rope will not even need to be transitioned from one side to the other as it will now be placed right in between, so users can just pull it towards them based off of which side of the rower they are sitting on. We can still incorporate the manual display console swivel bracket, just along the side of one of the antlers. Overall, we are confident this design will work better than the current design and reduce complexity.

Action items:

-Meet as a team on wednesday to edit PDS and discuss our brainstormed sketches

-Assign design matrices to complete in subgroups on wednesday to begin working on them for next week

Josh ANDREATTA - Sep 19, 2022, 9:20 PM CDT



Download

Antler_Brainstorm_Design_Sketches.pdf (774 kB)

9/22/2022 - Thoughts on Fabricating new Antler Design

Josh ANDREATTA - Sep 22, 2022, 8:38 AM CDT

Title: 9/22/2022 - Thoughts on Fabricating new Antler Design

Date: 9/22/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Jot down initial thoughts about changing the pulley plate design and how this would affect fabrication

Content:

Using the antler design, we remove the rower neck completely from the design. Since the handle bar will now be supported by the antler horns in the plane that divides the two pulleys, users from either side may grab it and thus there is no need to transition the rope through the neck, and thus the neck is no longer necessary. Because the neck is no longer necessary, I am thinking that we can make changes to the pulley plates. Currently, the pulley plates have a very unique geometry where they are thinner between where the neck sits, and thicker out where it holds the pulley. This was necessary to accommodate the rower neck physically taking up space within the neck arm supports. However, I would like to change this geometry if the neck is to be removed, to make the plates stronger and easier to fabricate out of metal. Below are my proposed changes:

- Make the plates one continuous width thickness to make them stronger around where they slide onto the neck support arms
- Make the same height with no dip after the part that holds the pulley
  - These above two changes will make the outer profile more of a rectangular shape with rounded corners
- When adding the antlers, to start, we can make them as separate pieces and screw them into the sides of the pulley plate to make sure the concept will work. Eventually, we can have them just be continuous with the pulley plates. If it is easier to fabricate once made out of metal as separate pieces, we will need to ensure that the bending moment about the screwed in portion of the antlers is low.
- We will add portions of material between the two pulley plates at the front and back to act as spacers that will push the plates apart in order to keep them from slipping off of the neck arm supports.

To fabricate out of metal, I think all we would need to do is make the cavity hole to slide onto the rower neck arm supports, make the cavity hole for holding the pulley, and weld together pieces of petal to make the antlers. I think by altering the geometry of the pulley plates, it will make it much easier to fabricate.

References: n/a

Conclusions:

I think in order to reduce the fabrication complexity required for the pulley plates, changing their geometry is essential. By doing so, we will not only create a plate that is easier to make, but it will also be stronger because it will be thicker in width throughout.

Action items: Develop FBD of Pulley Plate and Antler design to assess reaction forces under 1050N load (safety factor of 2). Create design matrix for antler design with linear actuator design. Create updated SolidWorks model of this new design.

9/22/2022 - Initial FBD of Antler Design

Josh ANDREATTA - Sep 22, 2022, 12:15 PM CDT

Title: Initial FBD of Antler Design

Date: 9/22/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Create initial FBD of antler design to assess internal and reaction forces and moments

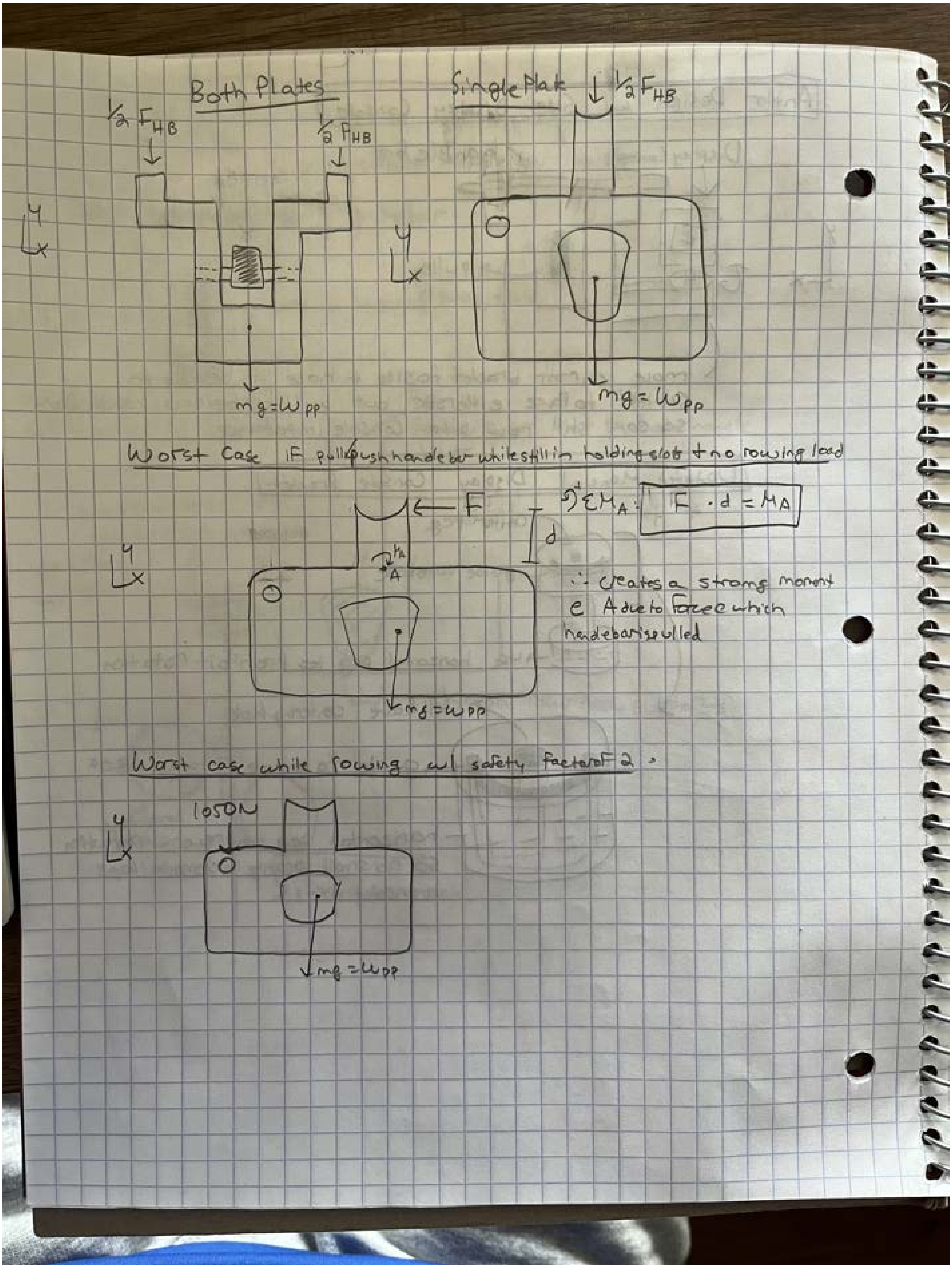
Content:

Fhb = weight of handle bar

Wpp = weight of pulley plate

d = unknown distance

The FBD below shows what the antler design would like under resting conditions, and 2 worst case conditions. The top two FBDs show the design under resting conditions, when the handle bar is sitting in the two horns of the antlers. At this state, the handlebar weight is distributed evenly between the two antler horns and this is why it is labeled as 0.5 of the Force of the Handlebar. The only other weight on this design would be the weight of the pulley and pulley plate, which is computed together in the total Wpp. In the first worst case scenario, the user would pull on the handlebar parallel to the floor, resulting in a large moment generate where the horn begins to extend upward from the plate. The moment generated could be in either direction, depending on which side of the rower the user is sitting on and thus which way they yank on the handlebar. We need to make sure to design the structure to withstand this load - ideally, the 1050N (safety factor of 2) can be used as a good proxy for ensuring the strength of our geometry and material of the new pulley plate with horns. In the second worst case scenario, which occurs while rowing, the 1050N load is applied directly down on the pulley plate where the pulley holds the pulley bearing. This is a replica of the FBD created from last years design, as that worst case scenario still holds true in the antler design. The only other design we need to design around is the bending moment from improper grabbing of the handlebar. SolidWorks simulation can be done to simulate this loading - I would make the cavity that goes around the rower neck arms rigid and then apply a force to the horn of the antler to analyze the stresses and deformations that arise.



The above image shows resting conditions and worst case loading FBDs of the antler design.

References: n/a

Conclusions:

I will discuss these FBDs with the team, and then after creating the design in solidworks, will run a solidworks simulation on the part to analyze the two worst case loading scenarios we want to analyze. In the FBDs, the reaction at the rower neck arm cavity is not drawn, but it would be a reaction at every point of contact, which is the entire surface of the cavity cut. In SolidWorks, that portion is held rigid to simulate this.

Action items: Create design matrix for antler design and linear actuator design. Create Antler design in SolidWorks and adapt pulley plates as necessary.

9/25/2022 Update to Console Swivel Bracket - Locking Peg

Josh ANDREATTA - Sep 25, 2022, 11:33 AM CDT

Title: 9/25/2022 - Update to Console Swivel Bracket - Locking Peg

Date: 9/25/2022

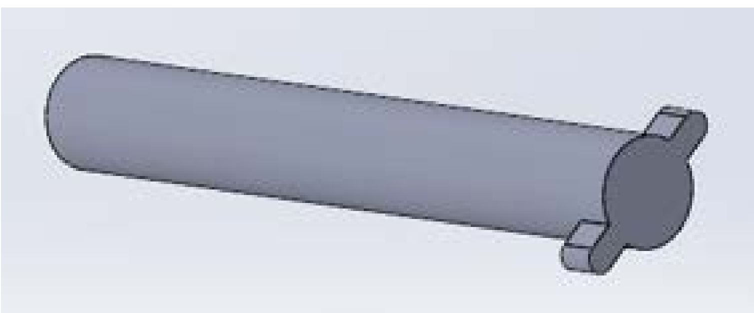
Content by: Josh Andreatta

Present: Josh Andreatta

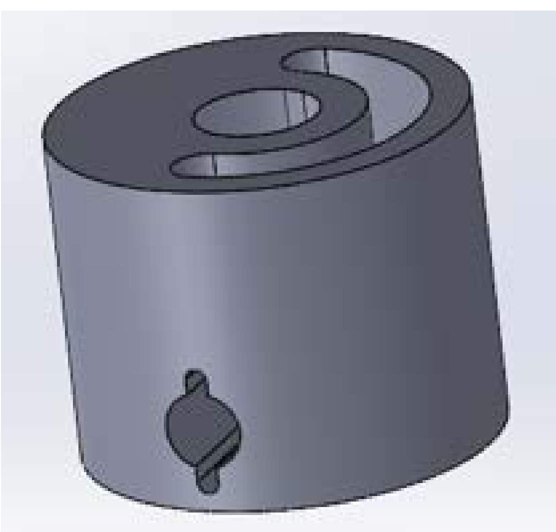
Goals: Update CAD for swivel bracket for easy descriptions and initial SLA 3D print

Content:

I updated the SolidWorks model of our swivel bracket so that it is easier to use. First, I made the base one consistent diameter so that it is easier to print. Then, I widened the centering peg to make it large and thus more stiff/durable so that it is less likely to break. The team wanted to include a horizontal locking mechanism that would prevent the console from turning once it is positioned to face the user. We wanted to make this change so that we could get rid of the intermediate centering pegs, which can be hard to fit into. Thus, I converted the several intermediate positioning pegs into 1 180 degree extruded cut that just guides the console throughout its 180degree rotation. I then made a locking peg. This locking peg has two spokes at one end which will hold the assembly in place. The swivel bracket has an indent for the pegs so that it may be turned and put into the locking position. I then made a cavity in the centering peg of the console field goal post for this locking peg to fit through. It was important that I put this through the console centering peg, because it now prevents rotation of the console. Please see images below for visual descriptions of these changes. I will go over this design with the team to ensure its what we wanted, and then look to begin an initial 3D print.

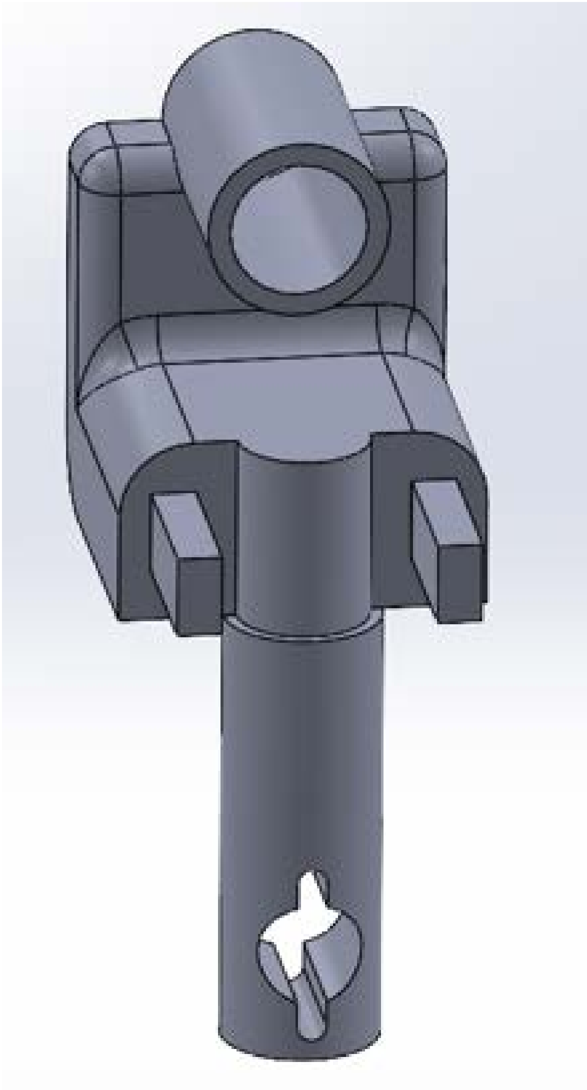


The above image is the locking peg with 2 spokes at one end.

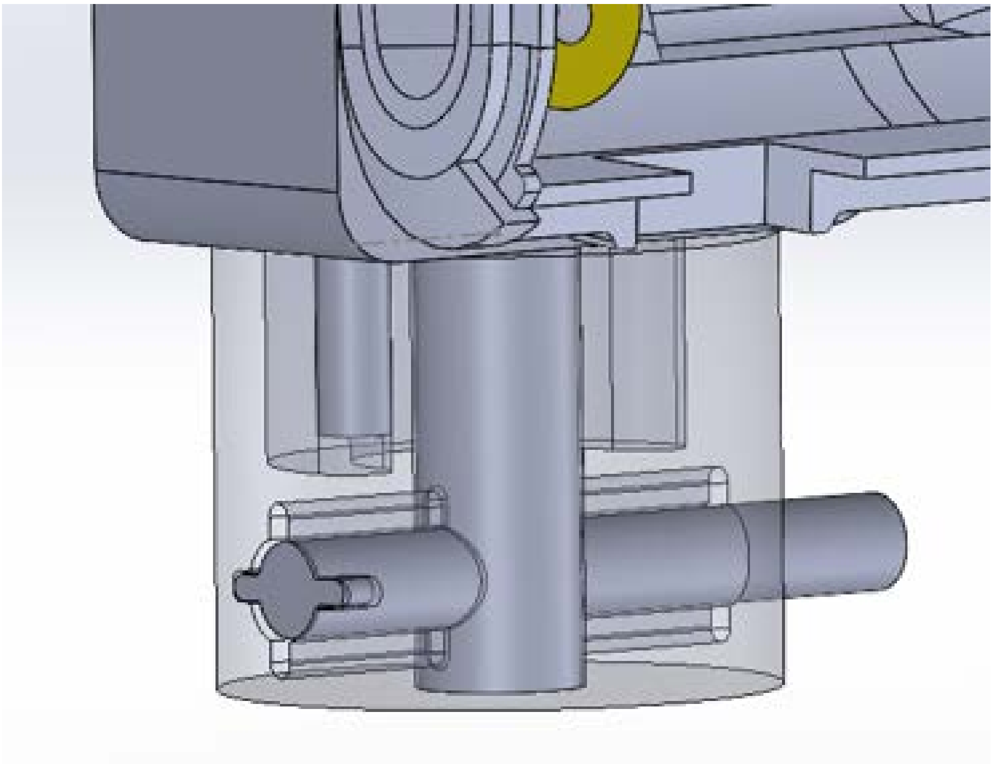


The above image is the swivel bracket base, which has a 180 degree guide and a cavity for the locking peg to fit into on one end.

The above image shows the opposite side of the swivel bracket base, with horizontal indents for the spokes of the locking peg to fit into to lock into place. The locking peg just needs to be rotate 90 degrees outside of this cavity and then retracted into place. The peg was made 0.5inches longer than the diameter of the base to account for this need.



The above image shows the cavity in the centering peg of the console field goal post, which allows the locking peg to enter through it to prohibit rotation.



The above image shows what the assembly will look like when the console is inserted and the locking peg is in the locked position.

References: n/a

Conclusions:

This design is more user friendly than the previous design. This design incorporates one locking peg that just needs to be turned and put into place to hold the console in 1 of 2 positions. The peg slides through the centering peg of the console which allows it to restrict movement of the console once locked into place. The bracket now also has a continuous 180degree guide for the swivel bracket to turn in, ensuring it only has 180 degrees of rotation available.

Action items: Meet with team to show design and get feedback. Meet to make design matrix for the antler design.

Josh ANDREATTA - Sep 25, 2022, 11:23 AM CDT

Download

Bearing_Socket_for_Console_Display.SLDPRT (172 kB)

Josh ANDREATTA - Sep 25, 2022, 11:23 AM CDT

Download

Field_Goal_for_Console_Display_LEFTLEFT_Part.SLDPRT (200 kB)

Josh ANDREATTA - Sep 25, 2022, 11:24 AM CDT

Download

Full_Swivel_Assembly.SLDASM (1.46 MB)

Josh ANDREATTA - Sep 25, 2022, 11:24 AM CDT

Download

Locking_Peg.SLDPRT (70.6 kB)

9/25/2022 - Individual Work on PDS

Josh ANDREATTA - Sep 25, 2022, 11:36 AM CDT

Title: 9/25/2022 - Individual Work on PDS

Date: 9/25/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Document portions I was in charge of for the PDS

Content:

My responsibility was to update the client requirements to reflect the changes we are wanting to make to our rower to make it more user friendly and more of a finished product. Please see below for my update section:

Client Requirements:

- A magnetic rowing machine will be built to better understand how the overall assembly fits together. This will aid in the design of optimized adaptations to the current assembly process.
- The adapted rowing machine should allow individuals in wheelchairs to easily fit into the machine and use it properly. The machine should be accessible to both wheelchair and non-wheelchair users.
- Users with varying sized wheelchairs should be able to adjust the equipment to still be able to use the rower comfortably.
- Individuals in wheelchairs will be able to lock themselves into a stabilization frame without assistance. Individuals will also be able to change the resistance, view the display console, and grab the handlebar without external assistance.
- The rowing machine will be user-friendly and alterations to the rower will not hinder the rowing motion.
- The rowing machine will be used several times in a day, and components will not degrade over a short period of time.
- The rowing machine will have a mechanism to reduce excessive recoil force to prevent users from tipping backwards in the wheelchair.
- The user will remain in their wheelchair for the duration of the exercise.
- The added components to the current rower will be made out of metal to ensure a professional finish.

References: n/a

Conclusions:

I will use these client requirements as I work on creating the CAD for this project. I also helped the team edit the entire PDS before turning it in.

Action items: Meet with team to score design matrices.

9/25/2022 - Creation of Design Matrix Criteria for Antlers

Josh ANDREATTA - Sep 25, 2022, 2:56 PM CDT

Title: 9/25/2022 - Creation of Design Matrix Criteria for Antlers

Date: 9/25/2022

Content by: Josh Andreatta

Present: Josh, Annabel, Roxi

Goals: Document my contributions to developing the criteria for assessing the different antler designs

Content:

I met with Annabel and Roxi today to create the design criteria for the display console rotation mechanism and create the descriptive paragraphs for each of the three designs. Specifically, I wrote the Ease of Use/Ergonomics and Versatility Criteria. I also wrote the descriptions for the Singular Pivot Design and the Updated Console Swivel Bracket Design. My work is shown below:

Ease of Use/Ergonomics (20%): The console display should be easily accessible for individuals in a wheelchair, and not require outside assistance for proper use. While using the rowing machine from either the standard or adaptive side, the user should be comfortable accessing and viewing the console. The user should not have to place themselves in an uncomfortable position to access and move the display. The user should not have to alter their rowing form in order to easily view the display.

Versatility (20%): Versatility is the ability of the display console mechanism to change between an adaptive and standard state. The rotation mechanism should minimize the complexity of transitioning between states. The console should be equally viewable from either side of the rower.

1. **Design 1: 1 Pivot Point**

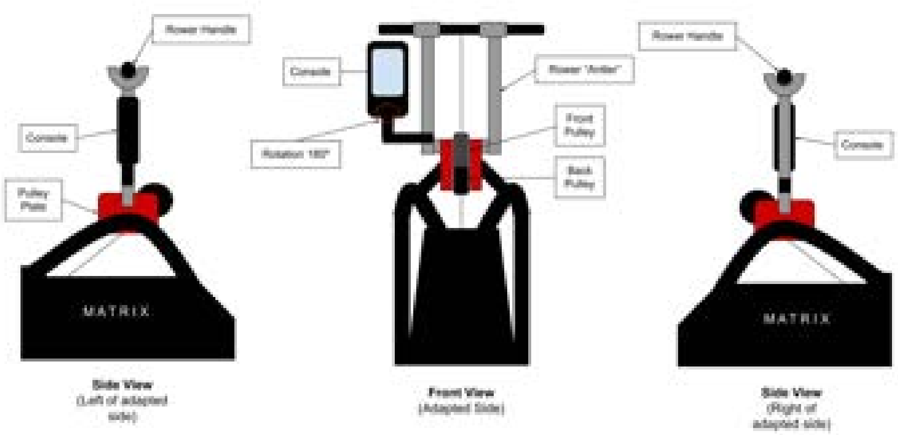


Figure 1. Design 1: 1 Pivot Point. This design attaches the structure holding the display console directly to the antlers that are attached to the pulley plates. The structure will only be attached to one of the antlers. This design only includes 1 pivot point, which is at the location of the console. This singular pivot design (shown below) incorporates a locking peg to hold the console in place. When the locking peg is removed, the console can be manually rotated within its bracket housing 180 degrees. This allows the console to be turned to be viewed from either the standard or adapted side of the rower. Since the design does not have a second pivot point where it attaches to the antler, the console will be positioned slightly off midline so that it does not hit the antler upon rotation.

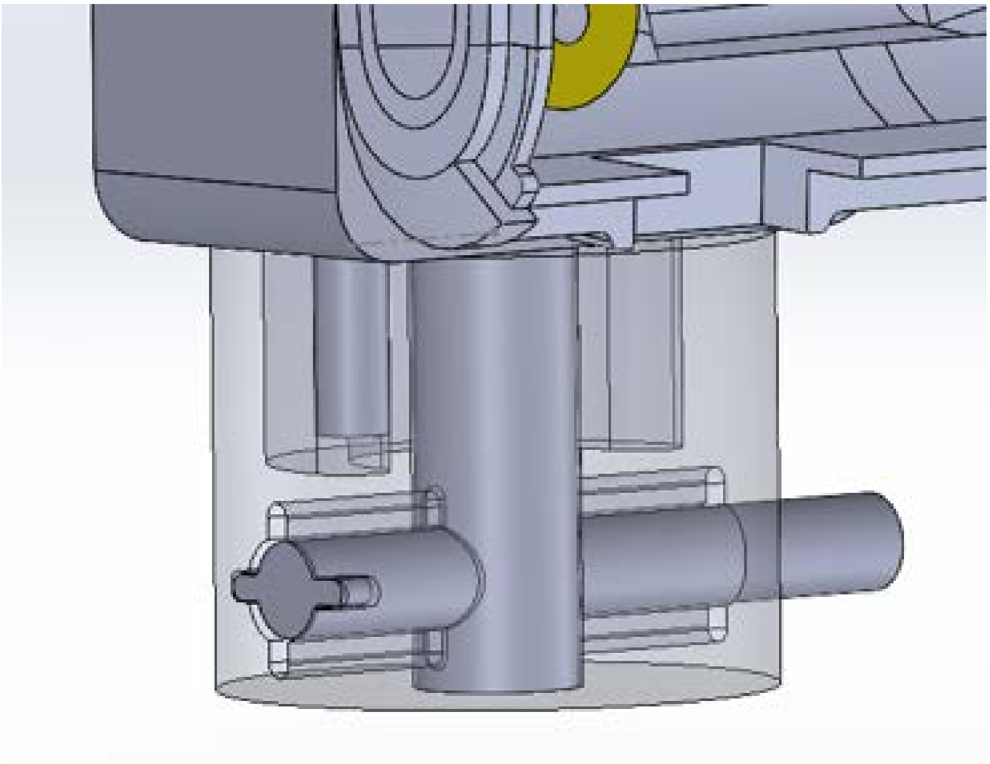


Figure 2. Updated Console Swivel Bracket with Locking Peg. The updated console swivel bracket has a locking peg that prevents rotation of the display console after it is positioned to its intended orientation. When unlocked, the display can be rotated 180 degrees to face either the standard or adapted side, but it can only be locked in these two positions.

References: n/a

Conclusions:

We all agree on our chosen design criteria, descriptions, and weights. The next step is to meet with our full team Tuesday to score the designs. This ensures that the entire team agrees upon the next steps moving forward. However, doing the work beforehand in our sub-teams makes our meetings more efficient, as we will be able to tackle more problems and design challenges at once, as compared to if we were all working on each component fully together,

Action items: Meet with team on Tuesday 4-5:15pm to score design matrices.

9/27/2022 - Scoring Design Matrices

Josh ANDREATTA - Sep 27, 2022, 6:50 PM CDT

Title: 9/27/2022 - Scoring Design Matrices

Date: 9/27/2022

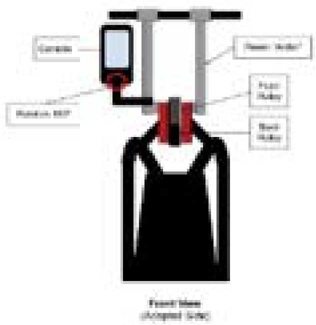
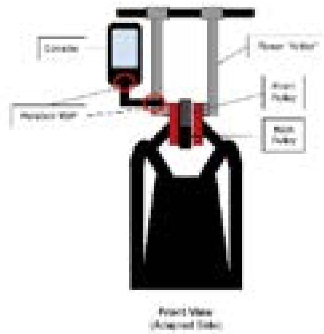
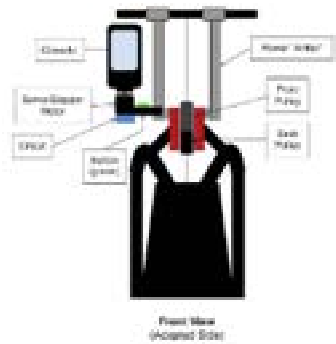
Content by: Josh Andreatta

Present: Josh, Sam, Roxi, Tim, Annabel

Goals: Write down my thoughts about the scores given to the different designs

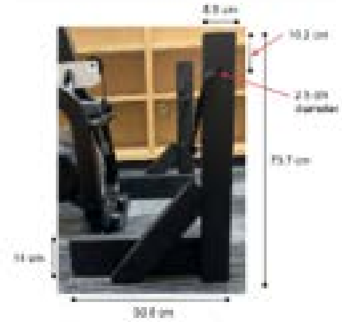
Content:

Today our sub groups met as a full design team to discuss our designs for the console rotation mechanism and the stabilization frame for the wheelchair. We then scored each design. I helped to score each design and ensure that the criteria for each was beneficial for assessing each design between the two design matrices. Below, I will explain my thoughts on each design.

Design	**Design 1: 1 Pivot Point** 		**Design 2: 2 Pivot Points** 		**Design 3: Motor** 	
Ergonomics (30%)	4/5	24	5/5	30	4/5	24
Ease of Rotation (20%)	3/5	12	2/5	8	5/5	20
Ease of Fabrication (20%)	5/5	20	4/5	16	4/5	16
Durability (15%)	4/5	12	3/5	9	5/5	15
Safety (10%)	5/5	10	4/5	8	3/5	6
Cost (5%)	5/5	5	5/5	5	4/5	4
Total for each design:	**83**		**76**		**85**	

The above table shows the design matrix for the 3 console designs.

For the console design matrix, I think the best option is the winning option which uses a stepper motor to control the rotation of the console. I think this one has the simplest fabrication and the easiest interface for the user. Although I already made a design for the new swivel bracket, I can easily modify this design to transform instead into the housing for the motor and the wires and arduino that will connect to it. I think that this design, although it requires coding, will be the best interface for the user, as all they will have to do is push a button depending on which way they are sitting. The other two designs would require for the user to lean forward out of their seat and manually pick up the console to move it. Although the swivel bracket, since updated, would be easier to use than the current prototype, it would still be more difficult than the motor design. Additionally, although the 2 point rotation design would better place the console in the midline, we as a team do not feel that by being slightly off-centered the rowing experience will be hindered. We will minimize the distance the console must be placed from the midline to accommodate rotation. Overall, I feel that given the best user interface and easiest fabrication (in my opinion) that we made the right choice. I think it would have been slightly difficult to make the second point of rotation at the attachment to the antler, and would only complicate the user experience. As long as being off centered doesn't harmfully affect the users rowing experience, the motor is the best option.

Design	Bar-in-Bar Pad Support 		Base Stabilization Frame 	
Safety / Security (30%)	5/5	30	3/5	18
Adjustability (25%)	5/5	25	1/5	5
Ease of Fabrication (15%)	2/5	6	4/5	12
Ease of Use (15 %)	4/5	12	5/5	15
Cost (10%)	3/5	6	4/5	8
Integration to Environment (5%)	5/5	5	3/5	3
Total for each design:	**84**		**61**	

The above image shows the design matrix for the two wheelchair/user stability designs.

After meeting with the team to score the stability designs, I also feel that we picked the clear best choice. The bar-in-bar pad support design is definitely my favorite choice for this design criteria. One negative about this design is the complexity of fabricating it, since the parts will need to be adjustable to accommodate varying heights and lengths away from the rower. However, I think we will be able to figure this dilemma out. This design is more compact than the regular frame design. Although the frame of the losing design would also be made out of metal, there is not lap or chest support to prevent the user from sliding out of the wheelchair. With the addition of this lap bar pad, the user will be better held in place in their chair. Overall, despite the complexity in designing and fabricating, I think this design will better enhance user safety and stability as compared to if we just made our current frame out of metal.

References: n/a

Conclusions:

Overall, I think we as a team had an excellent discussion about our designs and picked the correct choices to proceed forward with. I am excited to begin developing these initial prototypes.

Action items: Meet with Annabel and Roxi tomorrow at 8:20 to write the final design paragraph. Meet on friday with advisor and client to discuss both design matrices and next steps. On friday, assign presentation slides and begin to work on these over the weekend.

9/28/2022 - Writing Final Design Paragraph for Console

Josh ANDREATTA - Sep 28, 2022, 9:05 AM CDT

Title: 9/28/2022 - Writing Final Design Paragraph for Console

Date: 9/28/2022

Content by: Josh Andreatta

Present: Josh, Roxi, Annabel

Goals: Write down my thoughts about the final design paragraph

Content:

I met with Annabel and Roxi to write the final design paragraph for the rotation mechanisms for the console display. I wrote the introduction paragraph, as well as the paragraphs describing the criteria of Ease of Fabrication and Durability. Please see below for my work:

"The team compared three designs for the console rotational mechanism: 1 Pivot Point, 2 Pivot Points, and Motor using a design matrix (Table 1). Although the 1 Pivot Point and Motor designs scored similarly, the team chose to proceed with the Motor design. This design incorporates a stepper/servo motor on which the console will rest. It is activated with the press of a button that causes the motor to rotate the console 180°, allowing access from both the standard and adaptive sides of the rower.

For Ease of Fabrication, the 1 Pivot Point design scored the highest at 5/5. Since it only requires one point of rotation, as compared to two points of rotation, its fabrication process will inherently be easier. This design needs to be attached to the antler and incorporate the updated console swivel bracket (Figure 2) to rotate the console. The 2 Pivot Points and Motor design each received a score of 4/5 because their fabrication processes would be slightly more complex than the 1 Pivot Point design. The 2 Pivot Points design requires the addition of a second rotational mechanism at the location where the structure attaches to the antler, and this would require a more robust fabrication process to ensure that location is strong and able to rotate freely. The Motor design requires the fabrication of an electronic circuit, as well as development of a safe housing compartment for all the electrical components. However, both of these fabrication processes are still feasible, which is why each received a 4/5.

In terms of durability, the Motor design received the highest score of 5/5. This design includes an electronic circuit, a motor, and a housing chamber for each of these electrical components. These components do not have any freedom to move, and thus can be developed within the rigid arm that attaches to the antler. Due to the lack of movement, and strength of the motor, this design has the most durable components. The 1 Pivot Point design scored a 4/5 and the 2 Pivot Points design scored a 3/5 because of the mechanical points of rotation, which are more susceptible to wear and tear under extreme loads. The rigid arm attaching to the antler is similar to that of the arm in the Motor design, but the mechanical rotation mechanism for each is a weak area in the design that may wear quickly or break under improper loading. The 2 Pivot Points design scored lowest because it has two of these weak points, while the 1 Pivot Point design only has one. "

References: n/a

Conclusions:

As a sub-team, we developed a very descriptive final design paragraph which thoroughly explains our scores and is ready to be put into the preliminary report.

Action items: Meet on friday with advisor and client to discuss both design matrices and next steps. On friday, assign presentation slides and begin to work on these over the weekend.

10/3/2022 - Prelim Presentation Slides & Script

Josh ANDREATTA - Oct 03, 2022, 6:33 PM CDT

Title: 10/3/22 - Prelim Presentation Slides & Script

Date: 10/3/2022

Content by: Josh Andreatta

Present: Josh Andreatta

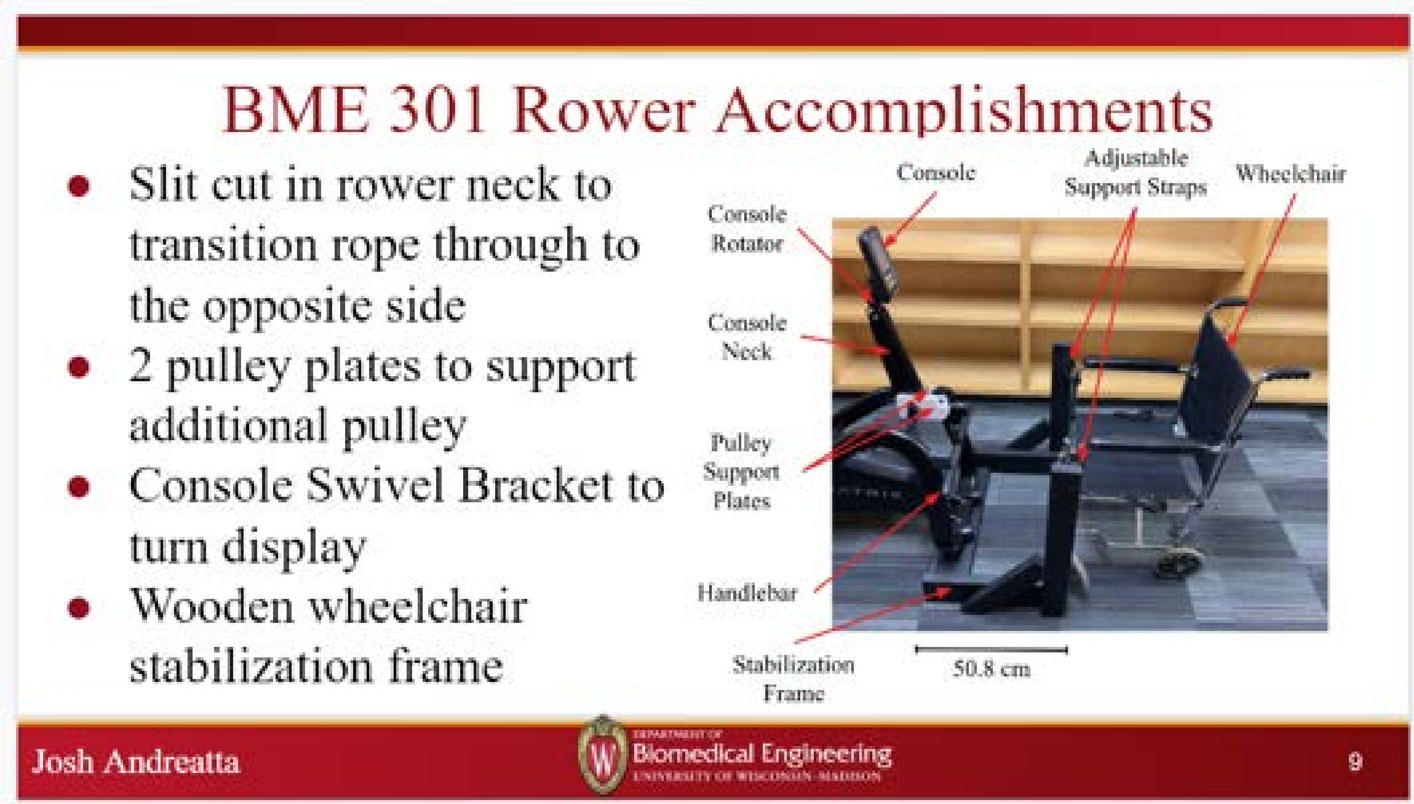
Goals: Show the slides I made for the prelim presentation and my prepared 2 minute script.

Content:

Script: Thanks Tim! Our main competing design is the Adaptive Rowing Machine, or AROW, develop by Concept 2. This design permanently changes the functionality of the rowing machine to only be used by those in wheelchairs. As you can see here, the slider seat and bar is removed and a permanent chest and lap pad are fixed to the machine. To attach themselves to the machine, the user adjusts the pads and uses this strap to wrap around their wheelchair leg supports. However, our design from last year and moving forward aims to make a rowing machine that can convert between traditional and adaptive use, which creates a more competitive and accommodating design as compared to this one. Shown here is our rowing machine that we developed from last semester. The design has 4 main components. The first is a slit cut in the neck of the rower, which allows the user to transition the rope out of the rower and align it to be pulled in the opposite direction. Second, we added these 2 pulley support plates to hold a second pulley, which allows the user to row from the adaptive side. In order to have the user be able to still view the console, we developed this rotation bracket for the display that allows it to be rotated 360 degrees. Finally, to stabilize the user while rowing, we made this wooden frame that the rower sits on top of to hold in place, and the user attaches themselves via 2 straps. However, this design can still vastly be improved, as some of our aspects from last year are not complete enough to be able to hand off to our client. Our goal this semester is to improve upon each of these 4 aspects to develop a more complete and finished product. For our PDS, one of our main focuses is to achieve zero external assistance required for the wheelchair user. Additionally, we want to ensure that our product is professional, so we intend to make all components out of metal, likely stainless steel. We have a $500 budget for the year to help with expenses, and we must ensure that no matter the changes we make, they do not inhibit the ability to row with proper technique. Next, roxi will discuss improvements upon our stabilization frame.

Slides:

The above image is my competing design slide.



The above image is my BME 301 Accomplishments slide.

The above image is my PDS slide.

References: n/a

Conclusions:

I was in charge of discussing the competing designs, our current design from last year, and the most important criteria from our PDS.

Action items: Meet with the team Wednesday to edit slides and Thursday to rehearse.

10/8/2022 - Writing Portions of Preliminary Report

Josh ANDREATTA - Oct 08, 2022, 11:49 AM CDT

Title: 10/8/2022 - Writing Portions of Preliminary Report

Date: 10/8/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Discuss the sections of the preliminary report that I wrote

Content:

For the preliminary report, I was assigned to write a section summarizing our work from last semester. In this section, I talked about the most important characteristics of the adaptive rower design. These were the slit cut in the rower neck, the pulley plates and additional pulley, the console rotation bracket, and the wooden stabilization frame. In this section, I described each of these components and their areas for improvement. I also included a photo of each component and of the final assembly from last semester. For the pulley plates, I discussed the solidworks simulation stress testing I completed last semester to show that the plates were strong enough to meet our requirements, but the geometry can still be adjusted. For the wooden stabilization frame, I talked about the Kinovea Motion Capture that we used last year to measure frame and user movement while rowing to show why we need to improve the design. Overall, I talked about each component, the testing previously done on each component, and areas for improvement of each component, to help set up the motivation for our project.

I also wrote the testing section of the report. I talked about re-doing the solidworks simulation tests on all fabricated components. First I think we should do the stress testing with the parts modeled as Tough PLA. This is because we are going to print each component (except possibly the stabilization frame) first, so I want to ensure that the 3D printed components for proof of concept testing can still be strong enough to support excessive loads. Then, once each design (pulley plates, antlers, console arm) are completed, I will model them as whatever metal we choose to fabricate with and then re run the simulation tests to ensure they are still strong enough. If they are strong enough as Tough PLA, they will undoubtedly be strong enough as metal because metal is more durable than the 3D printed resin, but it will still be good to show this quantitatively. I also discussed testing of the electronics via a DMM and print statements to test the code. I also talked about recruiting several actual wheelchair users to come use our device and fill out a survey based on their experience to help us make any other modifications that are necessary. I also talked about re-doing the tension testing from last semester which will help us ensure that users are still able to fine tune their workout from either side of the machine. Lastly, I talked about re-doing the Kinovea Motion Capture testing from last semester to ensure that the new design has improved upon and hopefully eliminated most of the movement of the user and frame while rowing. This testing will give us a comprehensive understanding of the strength of all fabricated mechanical components, the efficacy of all electrical components, and a holistic review of the device via tension tests, motion capture, and user feedback via a survey.

Lastly, I updated the PDS section to reflect the updates we made to the PDS. I mainly added a paragraph talking about the exact dimension ranges we want to be able to accommodate through the adjustable design.

References: n/a

Conclusions:

I will read through the document on monday morning to edit it myself before editing it together as a team monday afternoon.

Action items: Read through to edit personally. Edit as team. Submit report and peer evals. Once all submitted, begin work on CAD models of antler and pulley plates.

10/10/2022 - Editing Preliminary Report & Personal Thoughts through Prelims

Josh ANDREATTA - Oct 10, 2022, 5:52 PM CDT

Title: Editing Preliminary Report & Personal Thoughts through Prelims

Date: 10/10/2022

Content by: Josh Andreatta

Present: Josh, Sam, Tim, Annabel, Roxi

Goals: Write my personal thoughts on the semester so far

Content:

Today I met with the team to edit our final report. We each read the report before hand and made notes or comments on things we wanted to address to help streamline our editing process. This worked very well as we were able to finish editing the document and completing all of our goals within our 2 hour meeting. We then spent an hour making sure everything was formatted correctly and double checked all of the figures, appendices, and references.

Overall, I think our team is at a really good place for the second week of october. Me, Sam, and Tim all did a good job helping explain the project to roxi and annabel and getting them caught up to speed, and they did a great job responding to our help and letting us know what all they needed. I think that we have done a really good job working together as a team and following our team roles. Everyone makes sure that each other is heard and respected in our team meetings, and we dont move on until everyone agrees on something. I think that this is the best design team I have been a part of, and it has made working together very fun and successful. We have a great team dynamic! I think our work this semester so far has put us in a really good place to succeed during the rest of the semester. We have helped annabel and roxi complete necessary background research to get acquainted with the project. Individually, we broke up into sub teams and tackled brainstorming designs, creating design matrices, and doing our work for the prelim deliverables based on our sub-team design component. My component is the antler and pulley plate design. So far this semester, I have focused my work on helping the team develop a good concept of what these designs should look like. I gave feedback to what would be achievable for me to model in solidworks for us to help tailor our design away form unnecessarily complicated geometries. I drew up some sketches and FBDs of what the antler and pulley plate design will look like. I also modeled a new and improved console rotation mechanism for us to use in the case that the motor does not work. Thus, I have helped with brainstorming, FBD generation, CAD modeling, and independent work on team deliverables. Next, my tasks will be to model the antlers and pulley plates in solidworks and make iterative 3D prints to figure out the correct geometry we will proceed forward with before we fabricate out of metal. I hope by show and tell we will have narrowed down these design constraints and will be ready to start fabricating out of metal before thanksgiving, giving us time right before thanksgiving and after break to test.

References: n/a

Conclusions:

I think we have set ourselves up for a good place for the rest of the semester. I think that we will have ample time to work on fabricating and testing our design and getting started next week!

Action items: Read through prelim report one last time, turn in peer evals, meet with team to discuss next steps (likely CAD modeling of pulley plates and antlers for me)

12/3/2022 - Work on Final Poster

Josh ANDREATTA - Dec 03, 2022, 11:57 AM CST

Title: 12/3/2022 - Work on Final Poster

Date: 12/3/2022

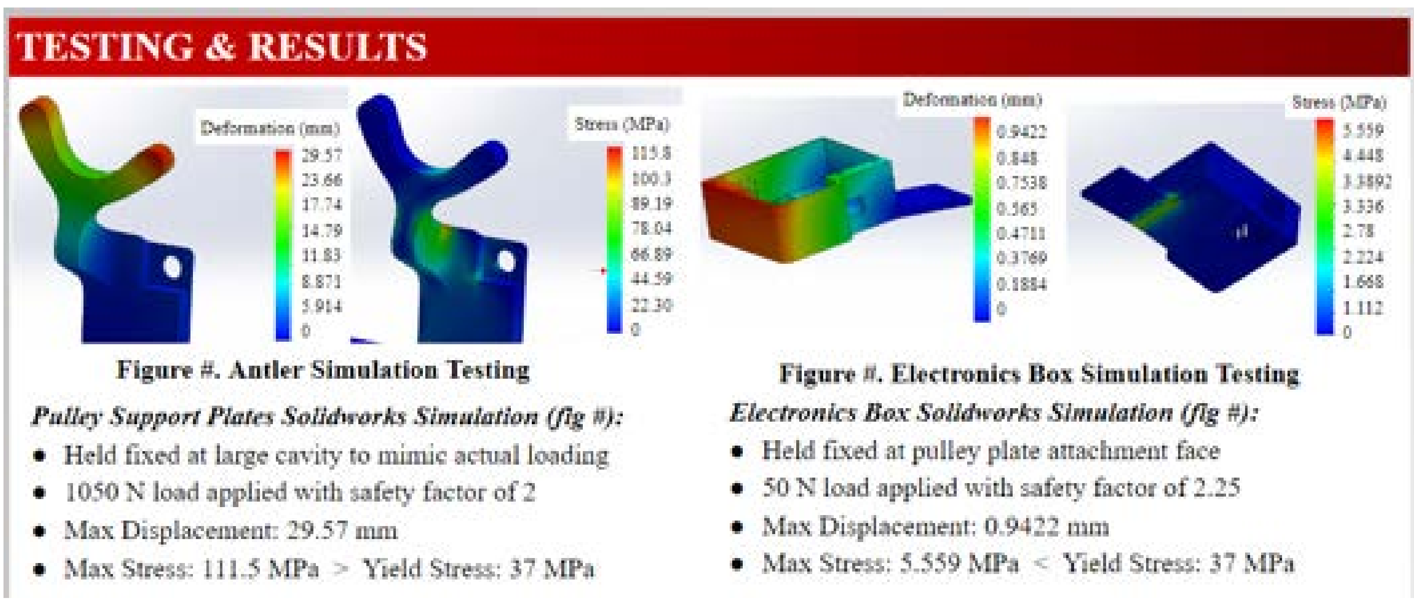
Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Complete assigned sections of final poster

Content:

I was assigned to make the portion of the poster that discusses the solidworks simulations tests of the pulley plate antlers and the motor box. I showed images from the simulation and highlighted the key points about max deformations and stresses developed in the parts. I also helped annabel write and edit the future work section to make sure we addressed any future changes we wanted to make in testing and in the design itself.



The above image is my work on the testing section.

References: n/a

Conclusions:

I used feedback and guidance from how we set up our poster last semester to make my section, that way we already know it is easy to visually understand and look at.

Action items:

-Edit Poster with Team Monday and with Tracy Wednesday

-Print Poster Wednesday

-Write and Practice Script

-Meet to practice thursday in person

-Work on final report after assigning sections Monday

12/5/2022 - Script for Final Poster

Josh ANDREATTA - Dec 06, 2022, 4:58 PM CST

Title: 12/6/2022 - Script for Final Poster

Date: 12/6/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Write script for final poster presentation

Content:

I am talking about the testing and results sections for the final poster presentation. My script is below:

"Thanks Annabel. The first thing that we wanted to assess was the strength and durability of our 3D printed components, specifically the new antler feature on the pulley plates and the motor box that holds all of the electronics. To simulate a worst-case loading condition for the antlers, the material properties were set to mimic Tough PLA and 2 simulations were run with a 1050N load applied at the distal tip of the antler facing either the standard or the adaptive side. The plates were held rigid around the cavity where they sit on the rower neck support arms. This test showed that the maximum displacement was 29.57mm at the distal tip with a stress developing along this slanted region of 111.5 MPa. Clearly, the antler is predicted to fail under this load, however, this may be due to inaccurate material properties of the simulated Tough PLA, but geometric changes to the antler can be made to further improve its integrity.

Next, a similar test was run for the motor box. The box was held fixed on this surface where it is screwed into the 2 pulley plates. A 50N load was applied to the center of the box to simulate around 2.25 times the weight the motor box is expected to endure. As shown, the max displacement was only 0.9422mm with a stress of around 5.5MPa. Thus, the motor box is likely to perform very well under the expected conditions.

Lastly, we wanted to analyze the ability of the stabilization frame to limit the movement of the wheelchair while rowing. To do this, we used Kinovea Motion capture to track the movement of both the wheel chair and the frame itself while rowing at the lowest and highest resistance levels. As shown in the upper corner of the graph, the frame & pad itself essentially did not move during the rowing motion at either resistance level. Shown in the lower left corner, you can see that the wheelchair moves slightly back and forth and just barely raises up off the ground, proving the success of the pad to keep the user and wheelchair grounded. Overall, the stabilization frame is a huge improvement over the previously built wooden structure and greatly limits the movement of the frame and the user while rowing. Next I will hand it off to roxi to talk about our discussion."

References: n/a

Conclusions:

I will memorize this script and practice with the team thursday.

Action items:

-Edit Poster Monday & Wednesday

-Print Poster Wednesday

-Practice with team thursday

-Individually practice script

-Begin writing final report sections

12/7/2022 - Final Poster Sections

Josh ANDREATTA - Dec 07, 2022, 4:48 PM CST

Title: 12/7/2022 - Final Poster Sections

Date: 12/7/2022

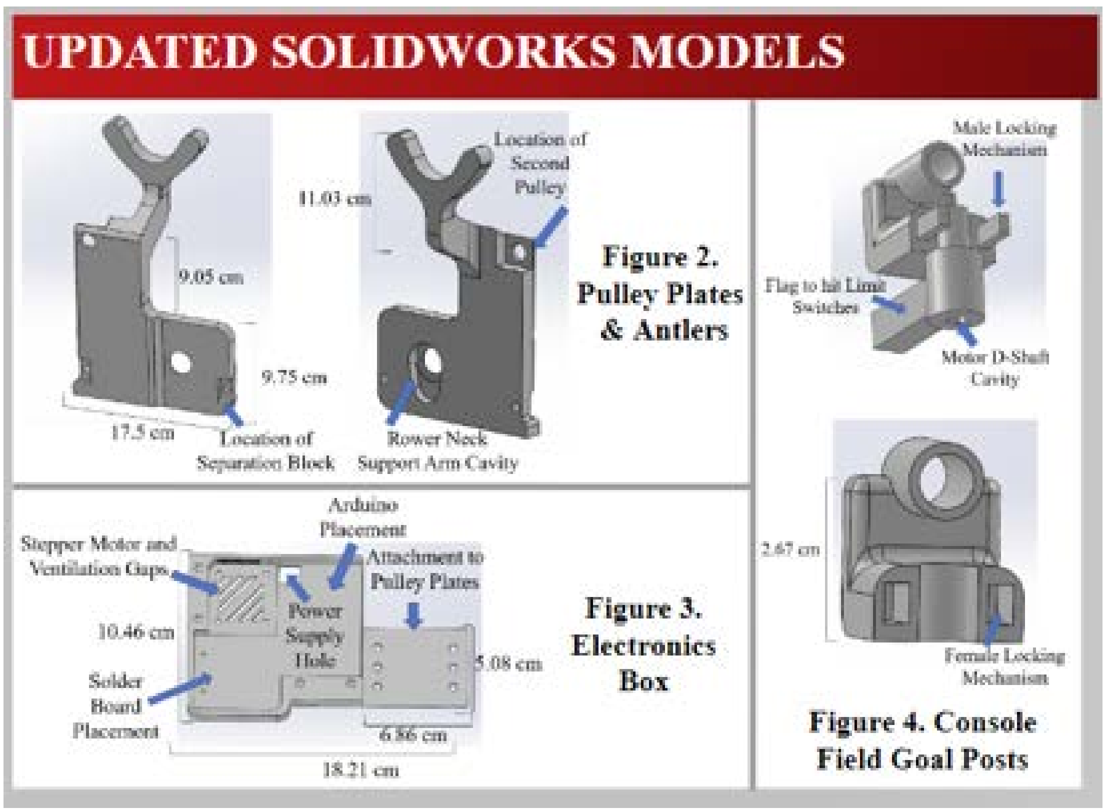
Content by: Josh Andreatta

Present: Josh, Sam, Annabel, Roxi, Tim

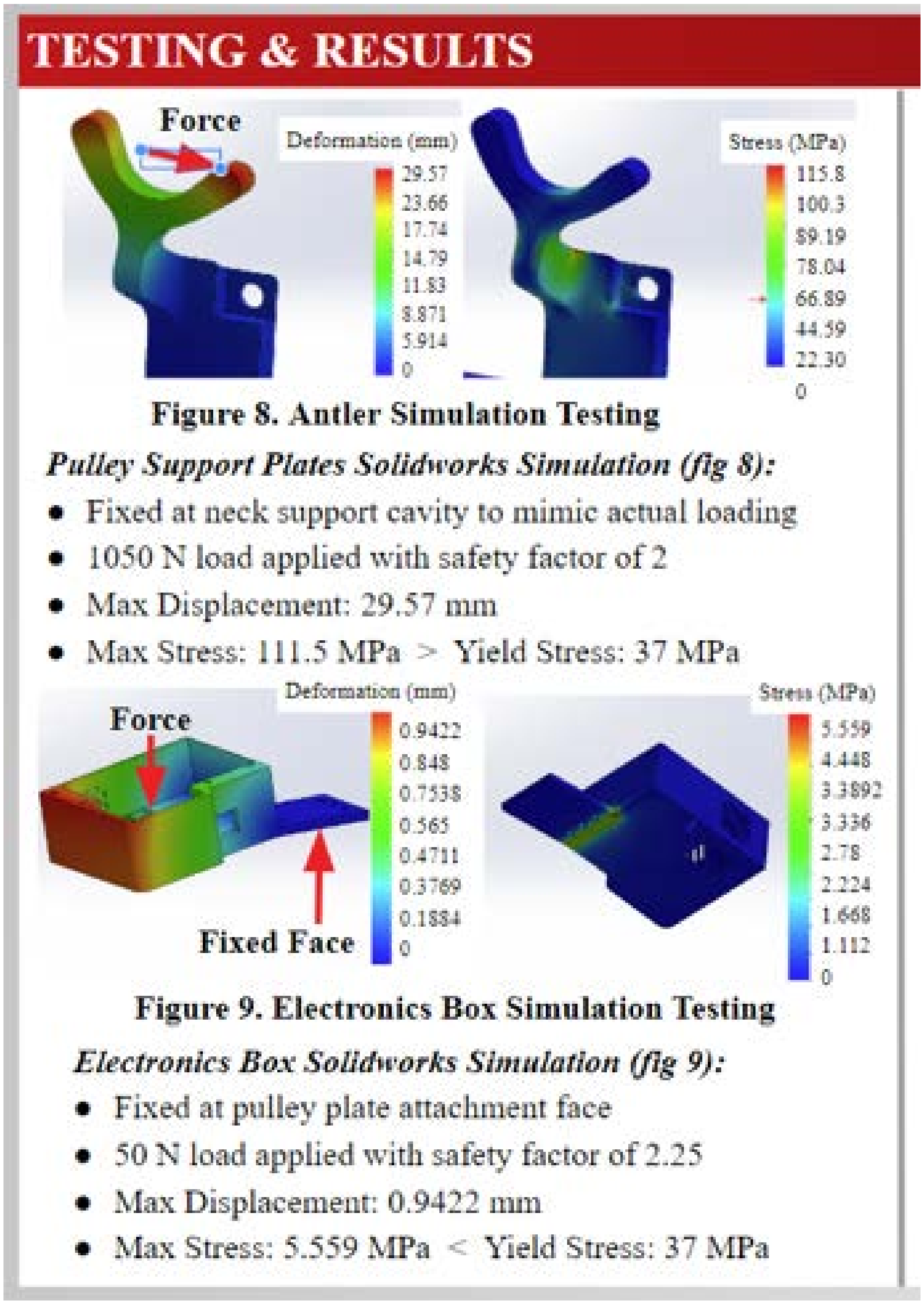
Goals: Edit poster based off of advisor feedback

Content:

Today we met with Dr. Puccinelli and she gave us good feedback on how to improve our poster. I worked on fixing the testing section for the solidworks section and created a CAD section that shows our 3D models of all of our printed components with labeled images and dimensions. These photos can be found in the next entry which details my work on the report (it also has these same images plus more).



The above image is the CAD section of the poster.



The above image is the solidworks simulation section of the poster.

References: n/a

Conclusions:

The poster has been edited and finalized and sent to print.

Action items:

-Pick up poster once printed

-Practice script

-Meet with team thursday at 4pm to practice presentation

-Edit report sunday/monday

12/7/2022 - Work on Final Report

Josh ANDREATTA - Dec 07, 2022, 4:55 PM CST

Title: 12/7/2022 - Work on Final Report

Date: 12/7/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Write my sections of the final report

Content:

I was assigned to write the sections for the final report as listed: Fabrication/Materials for the solidworks models, Testing for the solidworks models, results and analysis for the solidworks, the final design paragraph, and update images from the prelim report that needed dimensions. Below is my work with the edited text and final labeled and dimensioned images.

Labeled Images from Prelim Report:

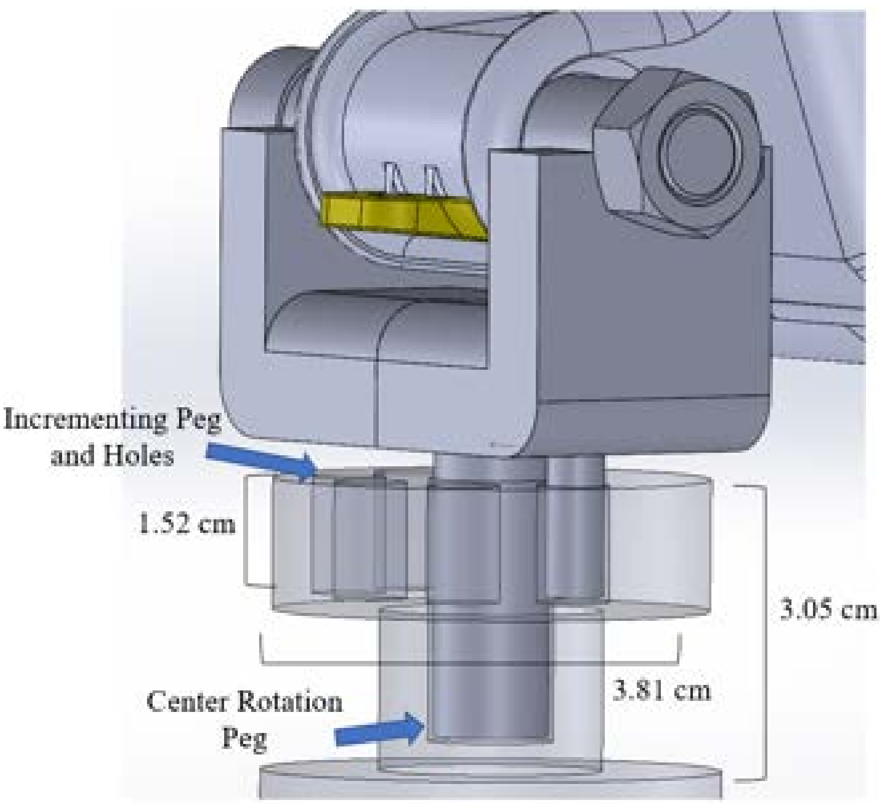


Figure 6. Rotation of Display Console. The large peg fits into the center rotating cavity of the receiving bracket, while the guiding peg fits into one of five smaller cavities to adjust the degree of rotation of the console.

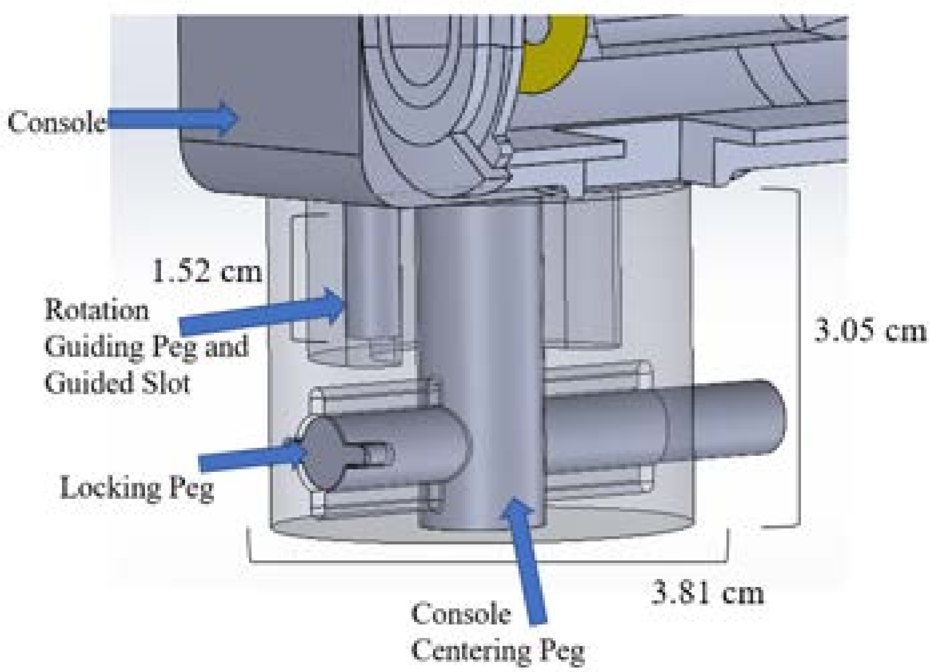


Figure 13. Updated Console Swivel Bracket with Locking Peg. The updated console swivel bracket contains a locking peg to prevent unwanted rotation of the display. When unlocked, the display can rotate 180º to face either the standard or adaptive sides of the machine. Locking only occurs in these two positions, and not at any other point along the guided slot.

Fabrication:

The pulley support plates and antlers (**Figure #**) are used to stabilize the additional pulley that is added to the rower to allow for rowing from the adaptive side. The sole purpose of these plates is to hold the additional pulley in place under normal loads experienced during typical rowing motions. Each plate has a layered cavity that allows it to slip onto the outside surface of the two metal support arms that used to connect to the rower neck (the neck is now removed from the current design). Since these support arms are metal and welded to the bottom frame of the rowing machine, the cavities in the plates were designed to remain fixed around these support arms in order to keep the additional pulley stationary. Each pulley plate also has a circular cavity that fits around the rotational bearing of the additional pulley. This allows the plates to replace the two washers that were previously on the pulley and fit tightly onto the bearing to prevent any unwanted motion of the pulley. Compared to the previous semester’s pulley plates, the pulley itself is now raised 9 cm higher than before to accommodate the inclusion of the updated stabilization frame. Each plate is held rigidly in place by the tight fit around the two metal support arms on the rower. Furthermore, a stabilization block is inserted on the standard side of the rower between the two pulley plates and screwed in tightly to the two plates, which offers an outward reaction force to help prohibit the plates from slipping off inward (**Figure #**).

The new pulley plate design also includes an antler on each plate (**Figure #**). The sole purpose of each antler is to hold the rower handlebar directly between the two pulleys in such a way that the rope is perpendicular to the ground and thus does not apply any force on either pulley until rowing begins. Additionally, by placing the antlers in this location, the handlebar can be easily reached from either the standard or adaptive side of the rower, which eliminates the need for external assistance to grab the handlebar from the adaptive side, while retaining the ability to still comfortably grab the handlebar from the standard side. The antlers extend 17.2 cm above the top surface of each plate and thus place the handlebar high enough above the other components of the design to remove any negative interaction, such as the console hitting the antlers. The right and left plates with antlers are exact mirror images. Each plate was designed in SolidWorks and 3D printed out of Tough PLA due to its high Elastic Modulus and Yield Strength (see **Section #**). Additionally, a layer height of 0.2 mm and a 100% infill were used during printing to increase the strength of the plates.

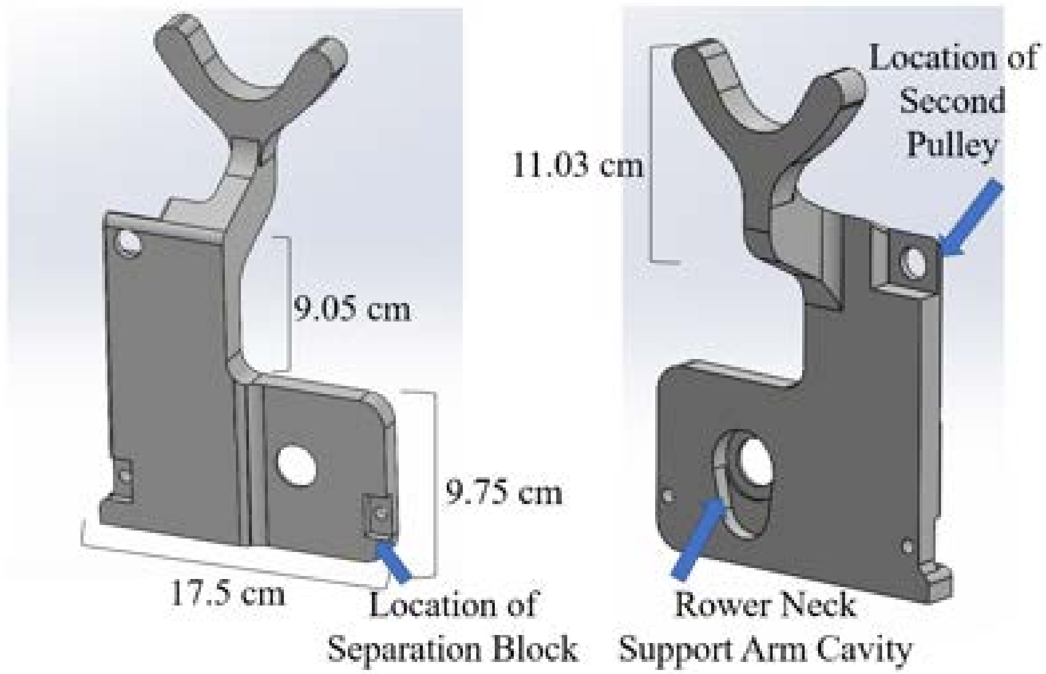


Figure #. Pulley Support Plates with Antlers. The left and right pulley support plates are mirror images and fit tightly around the pulley bearing and have a cavity that fits around the metal support arms for the rower neck. The antler extending upward on each plate holds the handlebar in a central position that allows it to be easily reachable from both the standard and adaptive sides of the rower.

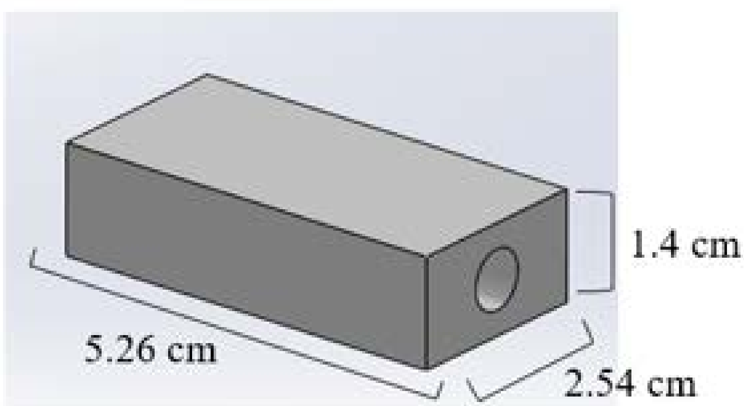


Figure #. Pulley Support Plates Back Separation Block. The back separation block is inserted between the two pulley plates on the standard side of the rower to offer an outward reaction force that prevents the plates from slipping off the rower neck support arms inward.

The console field goal posts are used to allow the console to rotate 180° so that it is visible from both the standard and adapted sides. Each of the field goal post components have a cylindrical tube that replaces the metal cylindrical tubes in the back of the console (**Figure #**). This allows the console to still rotate about its previous axis forwards and backwards to adjust the angle at which the user looks at the display screen. The male field goal post has two extruded rectangle inserts that fit into cavities on the female field goal post. These act as a locking mechanism that secures the pieces tightly together to prevent the console from becoming loose and slipping off. Additionally, the male field goal post has a large peg that extends downward. This large peg has a cavity cut out in the shape of the motor D-shaft, which allows for this piece to be press fit onto the stepper motor (**Figure #**). This will stabilize the console on the motor as it rotates. The female field goal post has a semi-circular cavity that accepts half of that peg so that the two field goal posts sit flush together. The male and female components can be seen in **Figure #**. The male field goal post also includes a rectangular prism flag that extends directly off to the side. This flag is used to contact the limit switches to tell the motor to stop rotating in a given direction. Each of these three components were printed out of Tough PLA due to its high Elastic Modulus and Yield Strength (see **Section #**). Additionally, a layer height of 0.2 mm and a 100% infill were used during printing to increase the strength of the assembly.

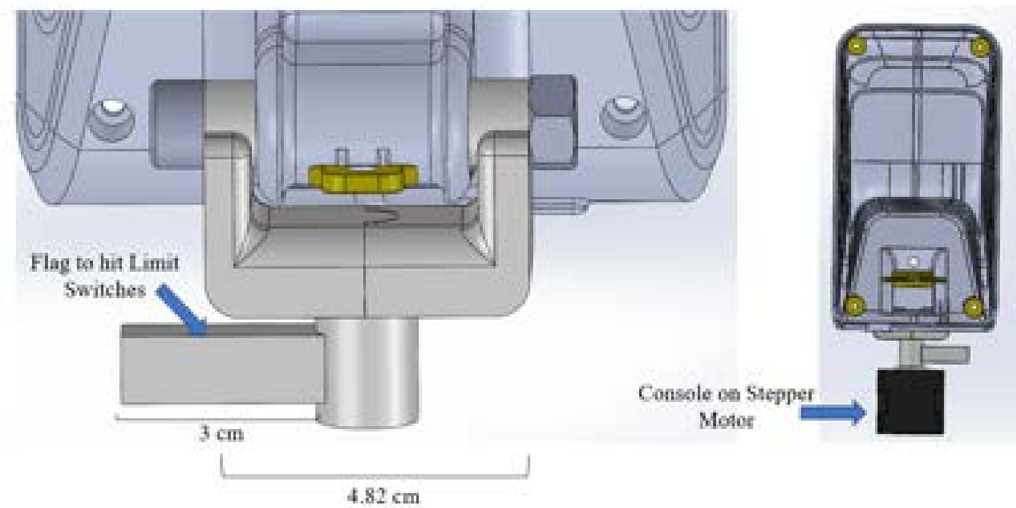


Figure #. Field Goal Posts Allow Original Console Rotation. The field goal posts have cylindrical components that insert into the back of the display console to allow it to rotate about its original axis (left). This allows the user to adjust the angle at which the console is bent. The full console-field goal post assembly is shown attached to the stepper motor (right).

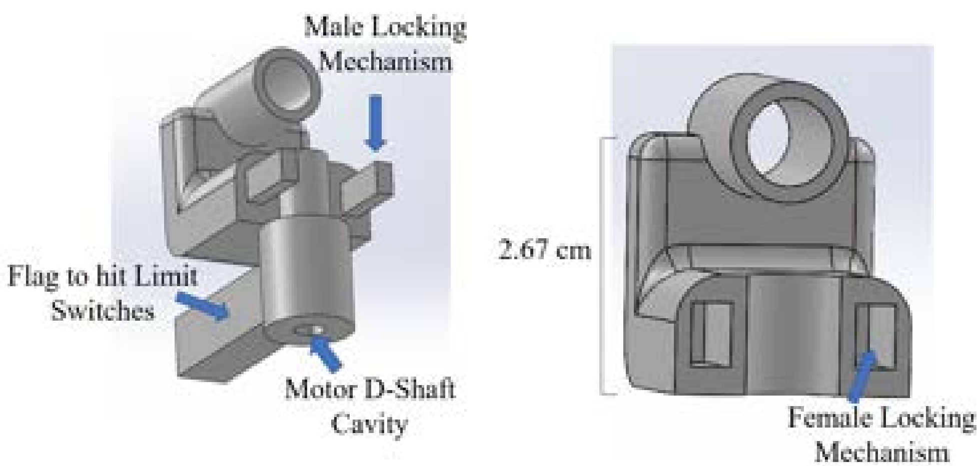


Figure #. Female and Male Field Goal Posts. The male (left) and female (right) field goal posts fit together via extending inserts on the male piece and a circular peg on the male piece that fit into corresponding cavities on the female piece. The male piece has a large central peg which is press-fit onto the stepper motor D-shaft, and a flag to contact the limit switches.

The motor box is used to store and secure all of the electrical components of the device that allow the console to rotate (**Figure #**). The box itself has compartments for each electrical component. First, the stepper motor sits in the back left corner of the box. The bottom and back faces of this corner have ventilation gaps to allow air to flow to help prevent the motor from overheating during use. The solder board with the motor driver is screwed into the front left corner of the box. Lastly, the arduino will be set on the right half side of the box. There is a small hole in the bottom face of the box that the power supply goes through. This allows an easy access point for users to plugin and unplug the power source for the system. The motor box lid (**Figure #**) is screwed into the top of the motor box with 4 ¼-20 x 0.5 inch screws. The lid has a gap that goes around the motor shaft. This allows users to remove the lid by sliding it forward without having to remove the console from the motor shaft. Additionally, the lid has a small hole that will help feed the wires from the limit switches (which are secured to the top of the lid) inside the box. Lastly, the box itself attaches to the underside of the two pulley plates via 6 ¼-20 x 0.75 inch screws. This helps to keep the motor box flush with the pulley plates and parallel to the ground so that the console and interior electronic components do not tilt during use. Each of these components were printed out of Tough PLA due to its high Elastic Modulus and Yield Strength (see **Section #**). Additionally, a layer height of 0.2 mm and a 100% infill were used during printing to increase the strength of the assembly.

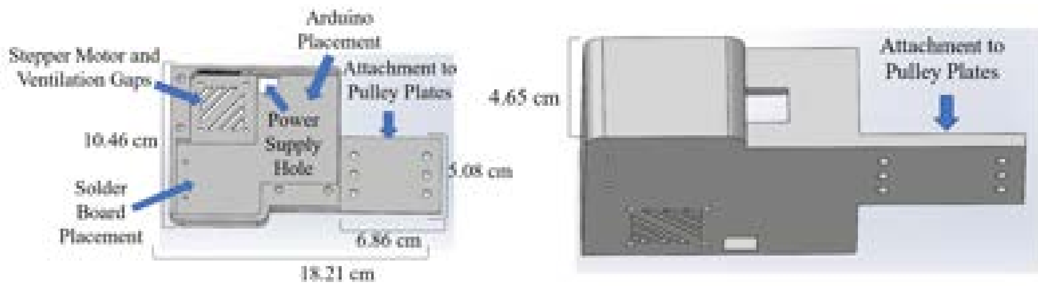


Figure #. Female and Male Field Goal Posts. The male (left) and female (right) field goal posts fit together via extending inserts on the male piece and a circular peg on the male piece that fit into corresponding cavities on the female piece. The male piece has a large central peg which is press-fit onto the stepper motor D-shaft, and a flag to contact the limit switches.

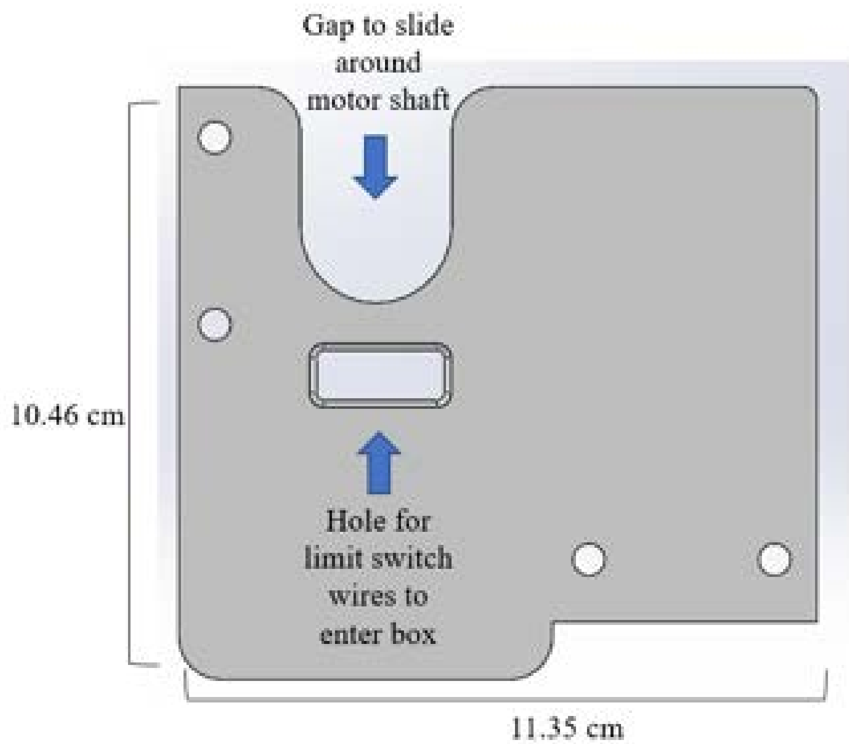


Figure #. Female and Male Field Goal Posts. The male (left) and female (right) field goal posts fit together via extending inserts on the male piece and a circular peg on the male piece that fit into corresponding cavities on the female piece. The male piece has a large central peg which is press-fit onto the stepper motor D-shaft, and a flag to contact the limit switches.

Once all of these modeled components were printed, they were assembled together. First, all components that required screws had their holes drilled out and tapped. Then, the pulley plates with antlers were slid on to the rower neck support arms and the pulley was attached. Then, the back separation block was inserted and screwed into place with 1 ¼-20 x 3 inch screw. Next, all electrical components were secured within the motor box. To connect the motor to the motor box, 4 #6-32 x 1.5 inch screws were required. To connect the solder board to the motor box, 2 #2 x 0.5 inch screws were required. The arduino was taped in place in the motor box. To secure the motor box lid to the motor box, 4 ¼-20 x 0.75 inch screws were required. The motor box was then connected to the pulley plates. The connection between the motor box and the bottom surface of the pulley plates required 6 ¼-20 x 0.75 inch screws. The full SolidWorks assembly can be seen in back, side, and front views in **Figure #,** and in top and bottom views in **Figure #**. This shows the front aspect of the rower with the second pulley, both pulley plates and antlers, the electronics motor box with lid, and the console with the updated field goal posts. The model does not include the updated stabilization frame as that was developed in a separate SolidWorks model. The full physically built assembly can be seen in **Figure #**.

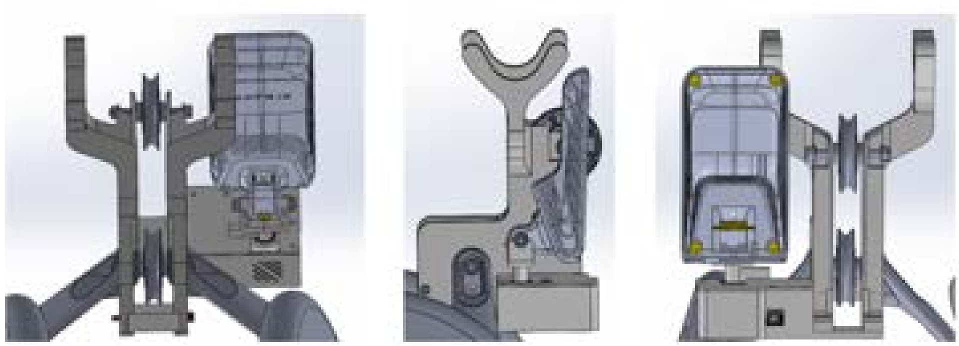


Figure #. Full SolidWorks Assembly Back, Side, & Front View. The back (left), side (middle), and front (right) views of the full rower assembly are shown. The adaptations made to the original rower include adding an additional pulley stabilized by mirroring support plates, antlers to hold the handlebar in a central location, and an electronics box to hold all the electrical equipment that rotates the console from the standard to the adaptive side.

Figure #. Full SolidWorks Assembly Top & Bottom View. The top (left) and bottom (right) views of the full rower assembly are shown. The adaptations made to the original rower include adding an additional pulley stabilized by mirroring support plates, antlers to hold the handlebar in a central location, and an electronics box to hold all the electrical equipment that rotates the console from the standard to the adaptive side.

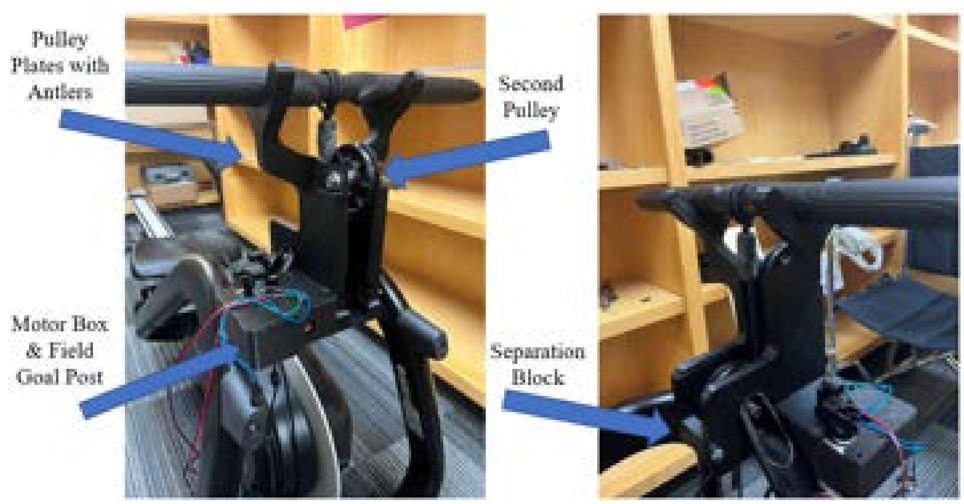


Figure #. Full Physical Assembly. The pulley plates with antlers, console rotation field goal posts, and motor box of the full rower assembly are shown in a front (left) and back (right) view.

Final Design:

After 3D printing the console field goal posts, pulley support plates with antlers, and motor box, and fabricating the updated stabilization frame out of metal bars, all components of the design were attached to the rowing machine to complete the full assembly (**Figure #**). The electronics were secured within the motor box and the console was placed on the motor shaft with the console field goal posts. The pulley support plates and second pulley were attached to the support arms of the rower neck with one on each side of the rower. Once the support plates were on, the motor box was screwed into the underside of the pulley plates and a 3D printed separation block was inserted on the standard side of the rower between the pulley plates to help push them apart. The handlebar was then lifted up into position within the antlers. Finally, the metal stabilization frame was screwed into the base of the rower and all limit switches were hot glued in place, completing the fully updated adaptive rower assembly.

Figure #. Full Assembly. The full assembly includes the pulley support plates with antlers, the console rotator and electronics box, and the metal adjustable stabilization frame. The wheelchair is held fixed using the downward pressure from the lap pad.

Testing:

A solidworks simulation was conducted to analyze the stresses and displacements acquired due to a maximum, worst case load. In order to properly test the strength and geometry of the pulley support plates, the plates were modeled as Tough PLA in SolidWorks. This was done by creating a new material and altering the mechanical properties as shown in **Figure #**. This ensured that the stress and displacement data that was acquired was representative of the material that the plates were printed in. To test the strength of the pulley support plates, a maximum load of 1050 N was applied to the inner circular cavity on each plate where the pulley is connected to the plates. According to the PDS in **Appendix #**, this would be the maximum load applied to the additional pulley under maximum rowing effort. Ideally, this load would be transmitted equally to each pulley plate. Thus, this load has a safety factor of two, and represents the maximum loading of the plates [source from zotero]. To model a worst case scenario, the load was applied directly downward onto this cavity. This is where the plate sits on the additional pulley bearing. Thus, if any force were directed onto the pulley plates, it would be transmitted to this inner cavity surface. During a typical rowing motion, tension in the rope follows along a path parallel to the floor. Thus, the worst case scenario was modeled as the maximum load placed on the plates perpendicular to the floor. The cavity that sits on the rower neck support arms and the two faces in which the front and back separator blocks are rigidly screwed into the pulley plates were held fixed during the simulation to model the plates when sitting on these support arms and being pushed apart by the separator blocks, as they should not move. Testing of the stresses and displacements that develop revealed the strength and rigidity of the chosen material and geometry of the support plates, which in turn revealed how well the plates stabilized the additional pulley under typical rowing conditions.

Next, another solidworks simulation was conducted to analyze the stresses and displacements acquired due to a maximum, worst case load on the new antlers added to the pulley plates. The antlers were modeled as Tough PLA. To simulate this worst case loading, the same 1050 N load (with a safety factor of two) was applied to two locations. First, this load was applied to the slanted edge of the inner surface of the handlebar cavity on the standard side of the rower directed towards the standard side of the rower. Next, the load was applied to the slanted edge of the inner surface of the handlebar cavity on the adaptive side of the rower directed towards the adaptive side of the rower. The plates were again held rigidly fixed at the two faces in which the plates contact the separator blocks and the cavity where the plate sits on the rower neck support arm. This loading simulates the worst case scenario of a user pulling directly on the handlebar while it is still sitting within the antler handlebar cavity. By placing the loads on either side of this cavity and directing the load to either the standard or adaptive side, this simulation will predict how the antlers will react to an excessive load being applied from either the standard or adaptive side of the rower.

Lastly, a final solidworks simulation was conducted to analyze the stresses and displacements due to a maximum, worst case load on the motor box. The motor box was modeled as Tough PLA. To simulate this worst case loading, a 50 N force was directed downward on the bottom surface of the motor box. This simulates any weight from the electronics, console, or the user slightly pressing down on the box. The box was held rigidly fixed where it is screwed into the two pulley plates. A 50 N force was arbitrarily chosen because the motor box is not expected to experience more than 5 lbs of weight being placed on it at any time. Thus, by applying a 50 N force (11.24 lbs), the box was tested with a safety factor of 2.25 to ensure its strength and rigidity under both normal and extreme loads.

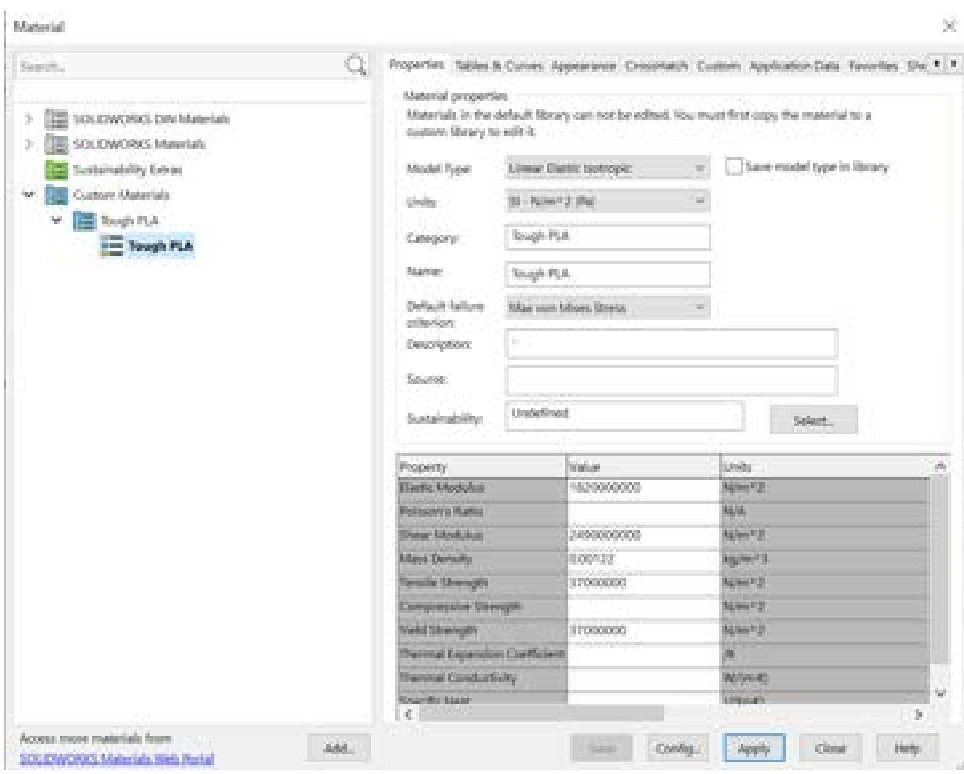


Figure #. Tough PLA Material Specifications. All 3D printed components were modeled as Tough PLA, to accurately predict the stresses and displacements that will develop in the plates under a maximum load.

Results:

Simulation testing for the pulley plates was only conducted on the Left Pulley Plate because the left and right plates are exact mirror images of each other and will thus perform identically. After completing the SolidWorks simulation testing on the pulley plates, the resulting stresses and displacements were analyzed to determine the strength of the Tough PLA material and the designed geometries. After applying a 1050 N load to the inner bearing surface of the pulley plates, a maximum displacement of 1.757 mm occurred at the top of the antler handlebar cavity (**Figure #**). This was expected because the region in which the load was applied is thin. However, since this cavity is supported by a thick base of Tough PLA material below it, the cavity itself did not deflect excessively. Rather, the less supported antler deflected more because it has the least amount of structural integrity, and this is why the tips of the handlebar cavity deflected the most. This displacement is incredibly small, and will likely be even less during actual load bearing, due to the metal pulley bearing being inserted into this cavity and accepting some of the applied load. Throughout the rest of the plate, displacements were also less than 1.757 mm, proving that the geometry for both plates will be strong enough to withstand typical rowing loads. Additionally, the maximum stress that developed under this maximum load was only 18.36 MPa (**Figure #**). This is much less than the yield strength of Tough PLA of 37 MPa [12]. This maximum stress developed along the inner surface of the bearing cavity where the load was directly applied. This was expected because when the load is applied, the cavity would want to fold in on itself. Loading with a safety factor of two shows that both pulley support plates will be able to withstand loads well under this maximum, like the loads experienced during typical rowing, and thus should hold the additional pulley stable.

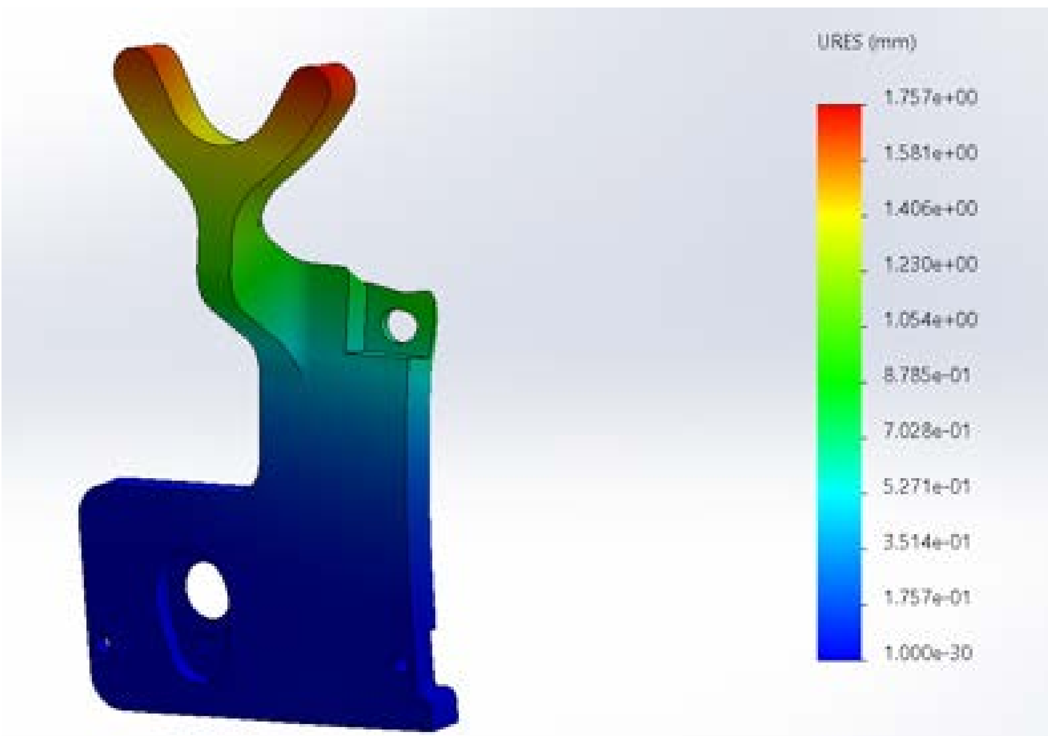


Figure #. Pulley Plate Deformation. The pulley plate deforms the most at the tips of the antler handlebar cavity due to having the least amount of structural integrity.

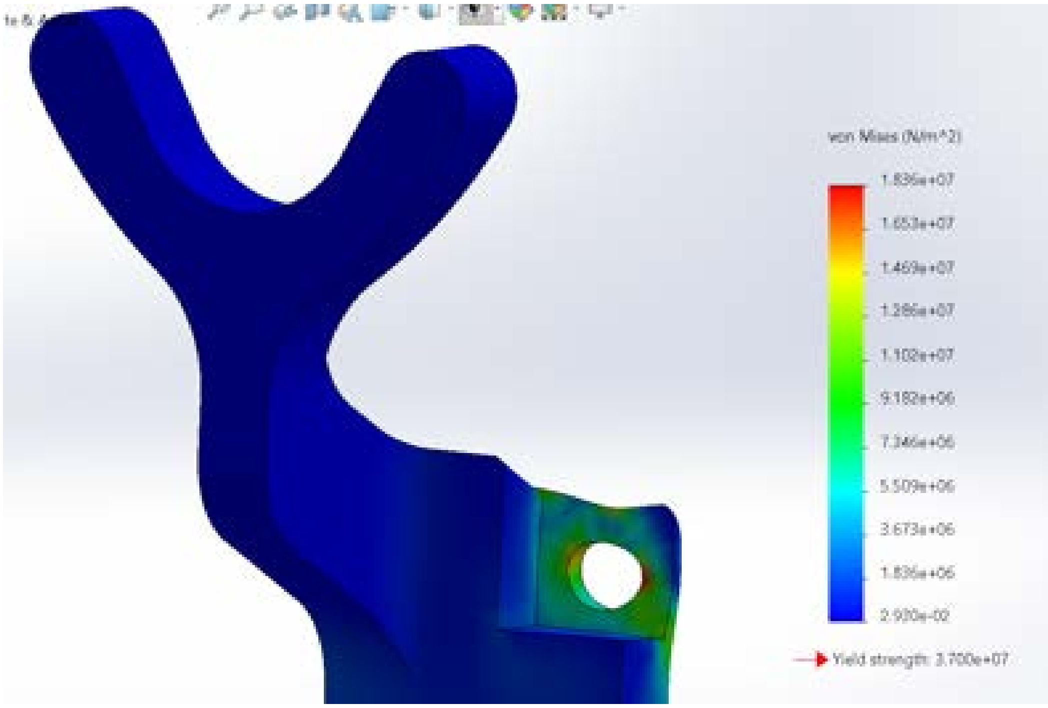


Figure #. Pulley Plate Stress. The pulley plate develops the largest stress concentration at the outer edge of the center of the cavity in which the load was applied due to the cavity wanting to fold in on itself.

After completing the SolidWorks simulation testing on the antlers, the resulting stresses and displacements were analyzed to determine the strength of the Tough PLA material and the designed geometries. After applying a 1050 N load to the slanted edge of the inner surface of the handlebar cavity on the standard side of the rower directed towards the standard side of the rower, a maximum displacement of 29.46 mm occurred at the top of the antler handlebar cavity (**Figure #**). This was expected because the region in which the load was applied has a relatively weak structural integrity when compared with the rest of the pulley plate. Thus, when an excessive load such as 1050 N is applied, this region will be likely to fail. Throughout the rest of the antler, displacements were greater than 6mm. However, since the antler will be printed out of a completely solid Tough PLA structure, the actual deformation of the handlebar cavity is likely to be much less than predicted. Additionally, the maximum stress that developed under this maximum load was 110.7 MPa (**Figure #**). This is much greater than the yield strength of Tough PLA of 37 MPa [zotero]. This maximum stress developed along the slanted surface of the antler which supports the handlebar cavity. This was expected because when the load is applied, the antler arm would want to bend away from the plate and fracture.

After applying a 1050 N load to the slanted edge of the inner surface of the handlebar cavity on the adaptive side of the rower directed towards the adaptive side of the rower, a maximum displacement of 29.57 mm occurred at the top of the antler handlebar cavity (**Figure #**). This was expected because the region in which the load was applied has a relatively weak structural integrity when compared with the rest of the pulley plate. Thus, when an excessive load such as 1050 N is applied, this region will be likely to fail. Throughout the rest of the antler, displacements were greater than 6mm. However, since the antler will be printed out of a completely solid Tough PLA structure, the actual deformation of the handlebar cavity is likely to be much less than predicted. Additionally, the maximum stress that developed under this maximum load was 111.5 MPa (**Figure #**). This is much greater than the yield strength of Tough PLA of 37 MPa [zotero]. This maximum stress developed along the slanted surface of the antler which supports the handlebar cavity. This was expected because when the load is applied, the antler arm would want to bend away from the plate and fracture.

Thus, the predicted stresses and loadings for both loading conditions of the antlers are very similar to one another. Despite the excessive deformations and stresses that the simulation predicts, the antlers are likely to actually experience a much smaller magnitude of force, which would greatly reduce their deformations and stresses. This is because users are not likely to begin rowing with the handlebar still placed in the cavity. Rather, users are more likely to pull strongly on the handlebar by accident, which would be a force much less than 1050 N. Finally, the antlers will be made out of a 100% infill structure of Tough PLA. This extra infill will greatly increase the structure's rigidity and therefore reduce the experienced deformations and stress concentrations. The antlers are predicted and likely to perform as intended under typical loading conditions, but are likely to fail under very extreme loading scenarios. Due to the limitations of simulating worst case loadings and accurately representing material properties, future testing will include physical failure tests to record the actual failure force required to fracture the antlers.

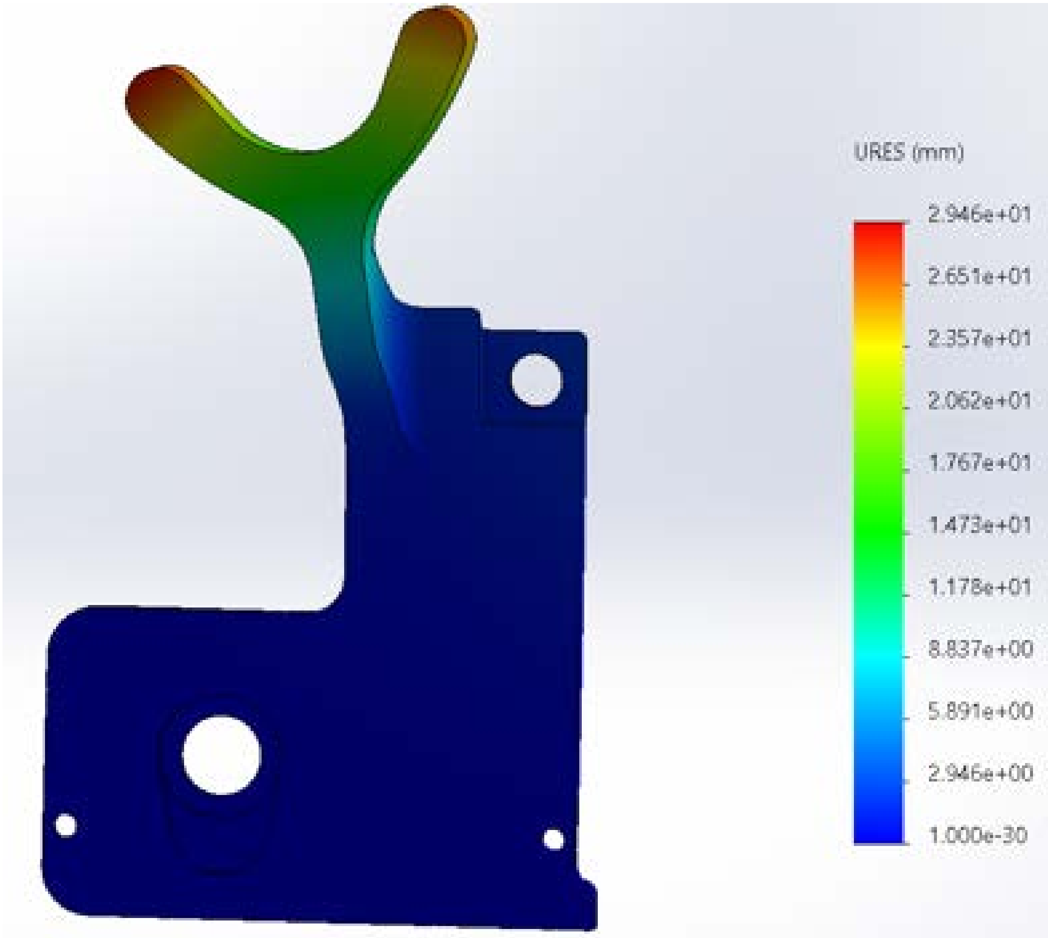


Figure #. Antler Standard Side Deformation. The antler deflects almost 30 mm towards the standard side of the rower when subject to a very high and extreme load.

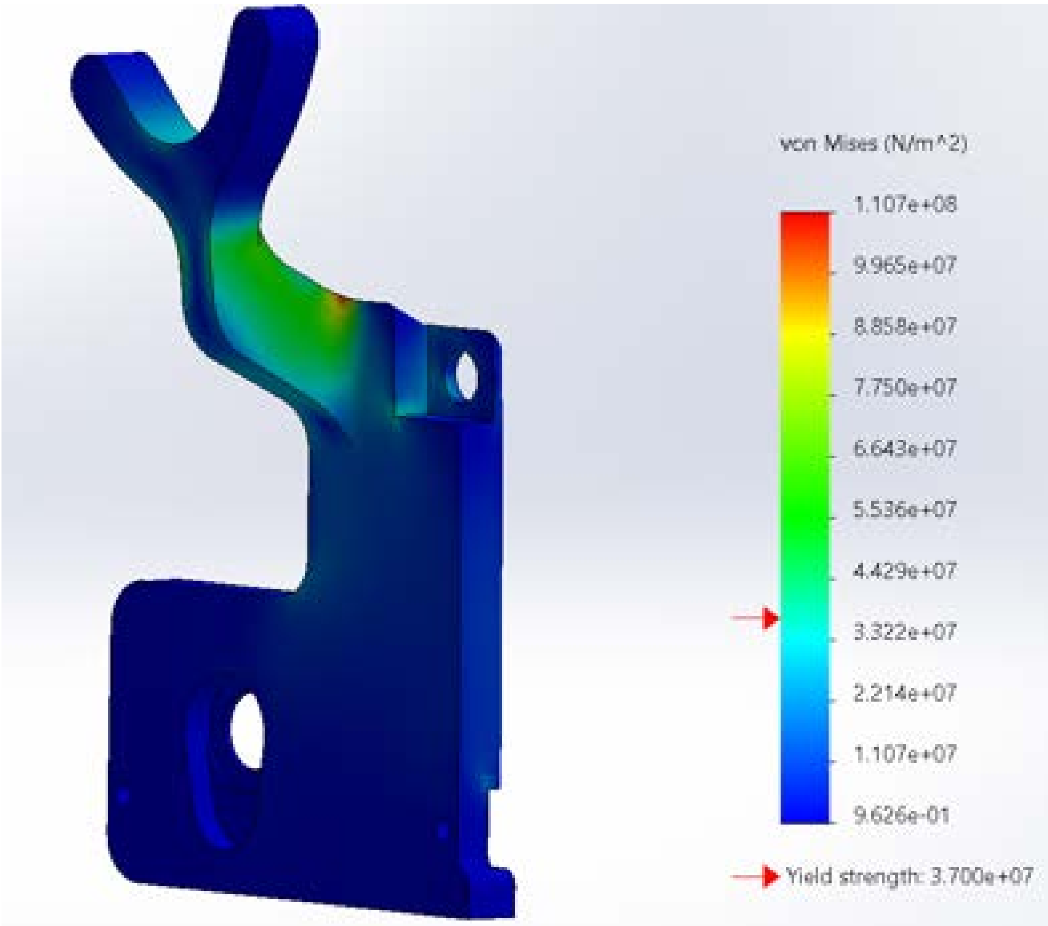


Figure #. Antler Standard Side Max Stress. The antler develops significant stress in the arm of the antler support under extremely high and excessive loading, causing the structure to fail under this given loading scenario.

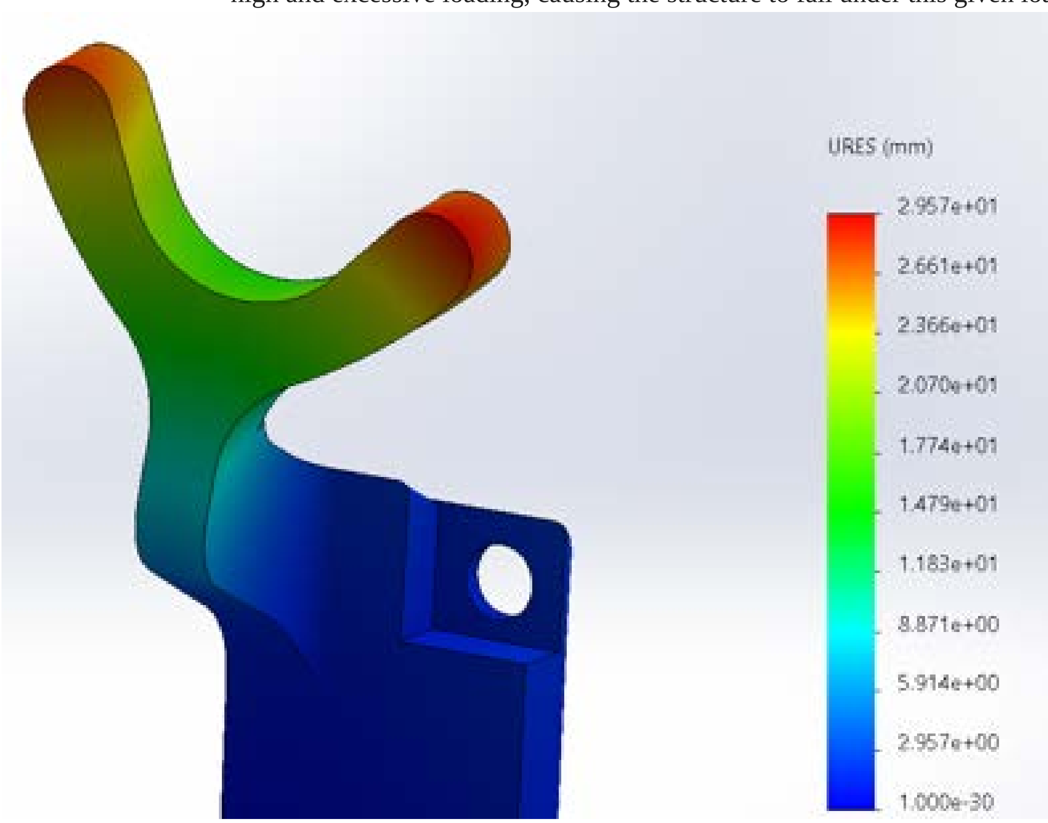


Figure #. Antler Adaptive Side Deformation. The antler deflects almost 30 mm towards the adaptive side of the rower when subject to a very high and extreme load.

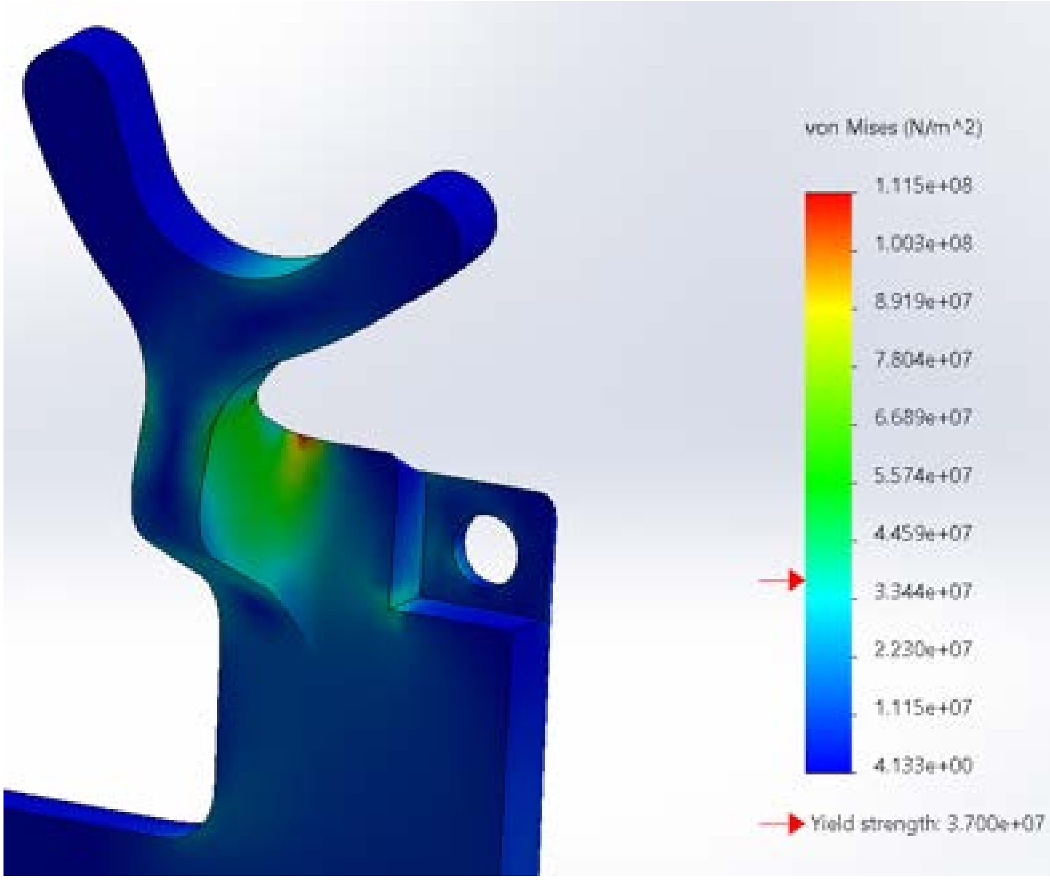


Figure #. Antler Adaptive Side Max Stress. The antler develops significant stress in the arm of the antler support under extremely high and excessive loading, causing the structure to fail under this given loading scenario.

After completing the SolidWorks simulation testing on the motor box, the resulting stresses and displacements were analyzed to determine the strength of the Tough PLA material and the designed geometries. After applying a 50 N load to the bottom surface of the box, a maximum displacement of 0.9422 mm occurred at the left side of the box (**Figure #**). This was expected because since the box is rigidly connected to the underside of the pulley plates, it is likely to bend more the further the material is away from this fixed location. Thus, the left side of the box deflected the most. Throughout the rest of the plate, displacements were also less than 0.9422 mm, proving that the geometry for the box will be strong enough to withstand typical external loads. Additionally, the maximum stress that developed under this maximum load was only 5.559 MPa (**Figure #**). This is much less than the yield strength of Tough PLA of 37 MPa [12]. This maximum stress developed along the edge where the structure first is able to bend from where it is rigidly connected to the underside of the pulley plates. This was expected because when the load is applied, the box will begin to kink at this location. Loading with a safety factor of 2.25 shows that the motor box will be able to withstand loads of the console, electronics, and extra downward directed forces, such as from the user pressing down slightly on the console when pressing a button, without fracturing or deforming excessively.

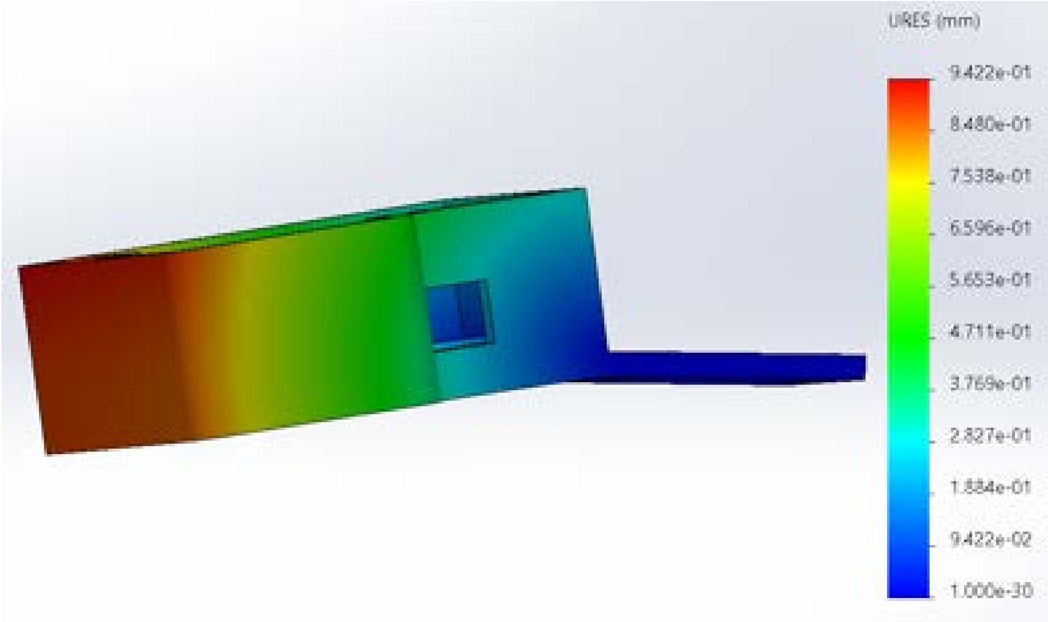


Figure #. Motor Box Deformation. The motor box deflects less than 1 mm under a worst case loading, proving it is likely to succeed in holding the weight of the designed circuit.

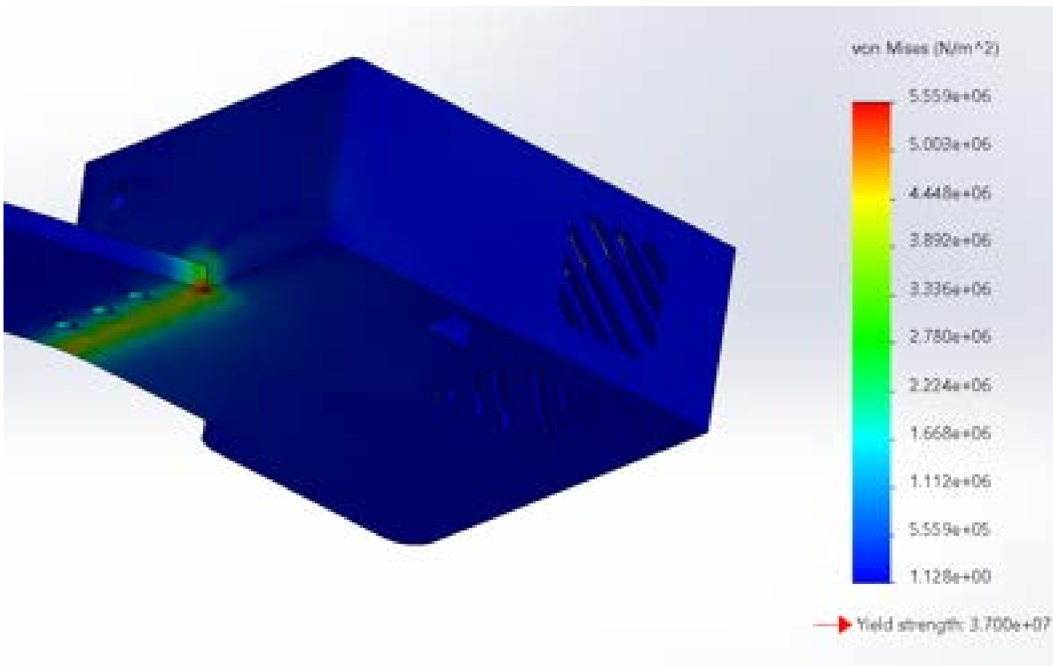


Figure #. Motor Box Max Stress. The motor box has a higher likelihood to fail right at the location where it begins to bend and is no longer rigidly connected to the underside of the pulleys. However, these developed stresses are much less than the yield stress of Tough PLA so the box is not predicted to actually fracture.

References: n/a

Conclusions:

I wrote all my sections for the report and edited them. I made clean images with labels and dimensions. I will read through the report with the rest of the team and edit it on sunday/monday. The missing references will be filled in once we update zotero.

Action items:

-Edit report with team sunday/monday

-Fill out peer evals

12/11/2022 - Fall 2022 Semester Final Thoughts

Josh ANDREATTA - Dec 11, 2022, 1:45 PM CST

Title: 12/11/2022 - Fall 2022 Semester Final Thoughts

Date: 12/11/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Write about my thoughts of how the semester went and what we want to accomplish next spring.

Content:

This semester our team set out with very ambitious goals which included creating a brand new stabilization frame that better held the user/wheelchair in place while rowing and was made out metal, automating the rotation of the console, and revamping all of our 3D printed components to make them the proper geometry and strength. Through a lot of hard work, our team was able to accomplish all of our goals. I think that we work very well as a team and that splitting into sub groups (console and 3D prints, and stabilization frame) really helped improve our team efficiency. We also made very thorough and detailed deliverables (reports and posters/presentations) that clearly explained our work and design process. I think that our team always puts forth the best work when working on team activities and that this further helped our team efficiency when it came to writing up everything about our design. Overall, the team dynamic was great and we executed our tasks and made significant process that we should all be proud of. I think that the stabilization is a huge improvement over the previously built wooden structure. It is much more compact, rigid, and greatly reduces the movement of the frame and the wheelchair while rowing. It fits in very well with the rower and the rest of the design and I think that this really helped our design. I also think that our 3D printed components turned out really well and they all are able to properly perform their functions without breaking or failing in any way. The work that Annabel did on the electronics was critical to our design's success as it relied heavily on the console rotation and use of limit switches. Overall, I am very proud of our team's ability to work together, produce high quality deliverables, and high quality prototypes.

As with anything, there is definitely room for improvement in our work. For the stabilization frame, we can continue to improve its accessibility by shortening the post the pad is connected to so it is easier to reach the handlebar. Additionally, the bars will be welded together next semester and the wires for the limit switches will be properly guided through the interior of these bars. For the electronics, the motor box will be adjusted to have screw holes for the arduino and better screw holes for the lid. It will also include a place to screw in the limit switches. Additionally, the console field goal posts need to be slightly improved to have a better tighter fit on the motor D shaft since we weren't able to achieve a perfect fit this semester. For the pulley plates, the antlers need to be made taller so the console doesn't have to be bent forward in order to spin properly. Then, we need to also figure out a way to adjust the resistance dial from the adaptive side of the rower.

Below is a list of things I will be tasked with adjusting at the start of next semester:

-Improve fit of console field goal posts on motor shaft (quick)

-Adjust motor box to have screw holes for limit switches and arduino. Make improved hole locations for attaching motor box lid (~2 weeks due to waiting on prints)

-Increase height and width of antlers to be stronger. Then, split pulley plate and antlers into two separate pieces and attach together with screws (~ 2 weeks)

-Conduct physical tests on new pulley plates and antlers with MTS machine to find failure strength and complete test in which we release handlebar towards antlers (~1 week)

-Once geometry of improved pulley plate and antlers is finalized as two separate pieces, work with staci and JHT to fabricate out of metal. Then maybe complete testing again? MTS machine may not be necessary if we run simulations for the metal since we dont want to waste the metal. We could still run the letting the handlebar go test (~ TBD)

Ideally, prior to spring break, the motor box will be finalized with proper screw holes for all components, the console will fit great on the motor, and the pulley plates and antlers will be updated as two parts. I would like to have these pieces all made out of metal (at least the plates and antlers, potentially the motor box too if staci's lab can do this). Then, we can complete simulation testing for the components made out of metal. We will also discuss which components we are actually going to make out of metal and what the required physical tests (MTS) should be for them. Ideally, by spring break, these parts will be finished, fabricated or almost done being fabricated out of Tough PLA/metal, and the testing will either be complete or at least fully planned and will be done after break. Then we will work on figuring out how to adjust the resistance dial from the adaptive side. This will be worked on in parallel over the entire semester since the other things are just quick geometric updates. Hopefully by the end of next semester, we will have a completely finished product with metal components, all fully tested, and fully functioning.

References: n/a

Conclusions:

This was a great semester of design. Our team was able to accomplish a lot in such a short amount of time and we were able to make a lot of progress with our design changes and iterations. Design iteration is such a crucial part to design so I think it was great for our team to get to experience that and see our work come to life and be successful. We are looking forward to continuing to improve the design next spring and create a completely finished product that can be handed off to an end user or to Johnson Health Tech.

Action items:

-Finish editing report and add to notebook once complete

-Turn in all final deliverables (notebook and report) to canvas, website, and email to client

-Fill out team and client evals

-Set end of semester meeting with advisor

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.

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)

9/23/2022 - Outreach Seminar

Josh ANDREATTA - Sep 23, 2022, 1:13 PM CDT

Title: 9/23/2022 - Outreach Seminar

Date: 9/23/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Learn about outreach requirements

Content:

- Doesn't have to be schools - could go to assisted living places
- Need diversity in engineering to solve complex problems more efficiently
    - Need to address diverse population in the design itself
- Content needs to be age appropriate
- Practice run of the activity at least once
- Have plan for cleaning and making transitions quick
- Arrive early at a set location
- Some schools require a background check so check in advance
- Seek out places with under-represented minority students
    - 30% URM - Tracy will pay for all supplies
- Submit a paragraph proposal with table of materials and costs to receive funds
- Requirements
    - Give presentation - personal introductions, define BME, and info needed for activity
    - 20-40 min FUN activity
    - 4-5 clear learning objectives
    - Dont have to make a brand new
    - Report with date, % URM, how the experience went
    - Teacher/Leader Evaluation
    - Need photo release form of pictures of any kids, unless non-identifiable
    - Activity guide due 12/14/22
    - Final deliverables due 4/21/23
    - Set up meeting with Tracy once we know when we are going, where we are going, and what activity we will be doing
    -

References: Tracy Puccinelli

Conclusions:

Activities can be pre-established activities, but we need to practice them before hand and be ready for a post discussion. We must talk it through with Tracy first to ensure it is age appropriate and geared towards BME design.

Action items: Create Design Matrices

10/16/2022 - Initial Update to Pulley Plates and Antler Design

Josh ANDREATTA - Oct 16, 2022, 12:16 PM CDT

Title: 10/16/2022 - Initial Update to Pulley Plates and Antler Design

Date: 10/16/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Make a CAD model of the updated pulley plates and antler design

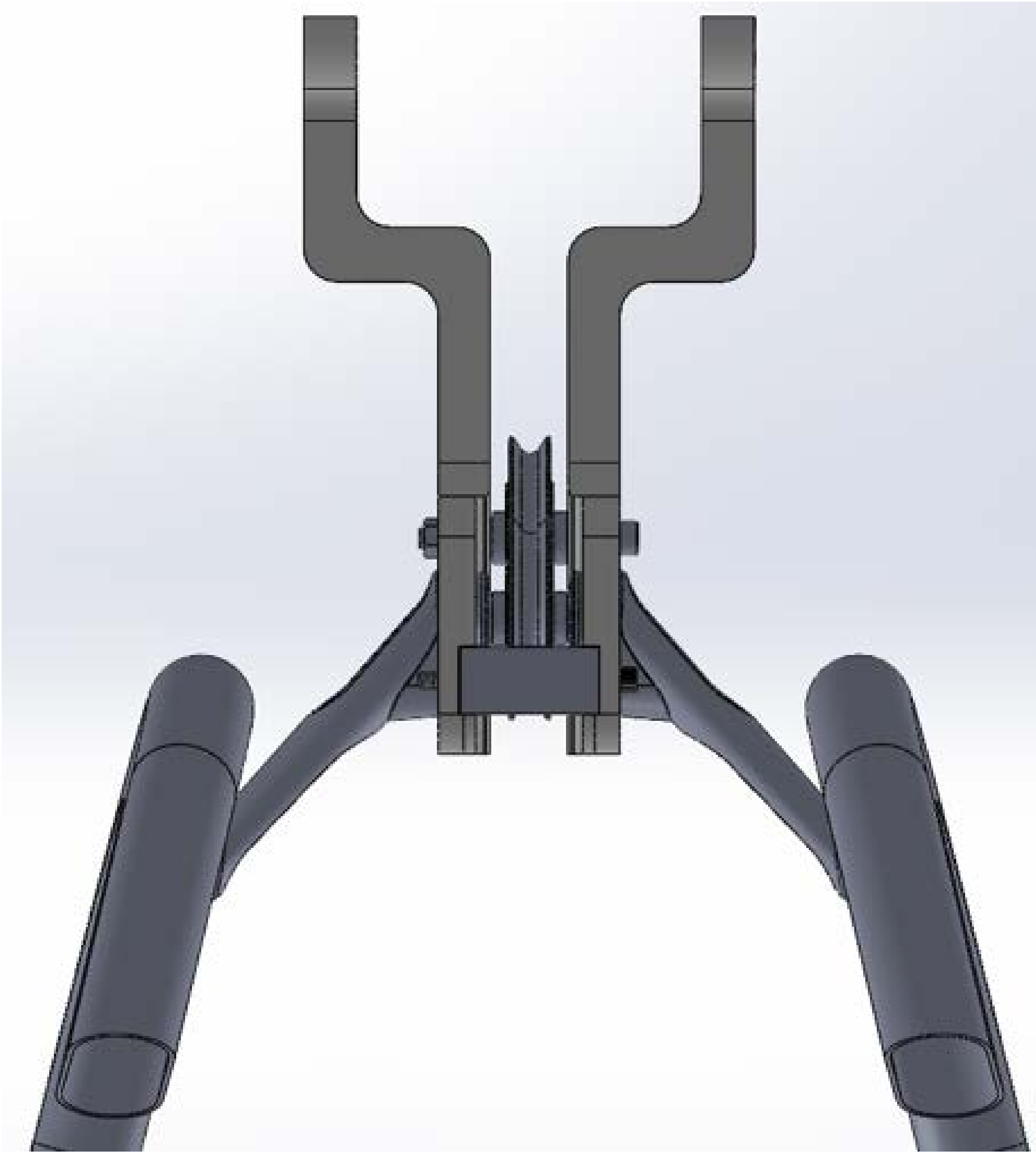
Content:

Today I worked on updating the SolidWorks files for the pulley plates and attempting to make an initial version of the antler design. First, I worked on modifying the pulley plates. Since we are removing the rower neck, we wanted to try to make the pulley plates a uniform thickness across its length. However, after removing the neck from the assembly file, I noticed that we could not do this because there are 2 washers that press fit the original pulley into place. In the past, they were pressed up against the inside face of the rower neck. However, since the neck is now gone, these washers will now press up against the inside face of the pulley plates. Although, due to this, we cannot make the plates a uniform thickness, we can make them thicker. Thus, the plates will still have more rigidity and structural integrity than the prior plates. Another change I made the plates was creating more of a molded fit for the plates to sit on the rocker neck support arms. As you can see in the image below, the outside face of the pulley plates where the rower neck sits into the plate has layers. The first layer is for the plate to bud up against the face of the rocker neck arm supports. Next, I added a layer of uniform thickness across the entire cross section for a smaller washer to fit inside. Next, I added another layer of uniform thickness for the outside washer to press up against from the original pulley. There is still a hole running through the pulley plate because the screw that centers the pulley still needs to be threaded through. Hopefully these layers will help create more surface contact between the washers and the plates, and allow for a better molded fit to the rower neck support arms. Lastly, I made 2 extruded cuts on the rower plates at the front and back of each plate. This allows for the insertion of a separation block which will act to push the plates apart from one another. One of the faults with the current plates was that they would slip a little inward off of the rower neck support arms. However, since the rower neck was in between them, they would run into the outside face of the neck, preventing them from completely slipping off the supports. With the neck now removed, we needed a way to ensure that plates would not slip off inward. So, I made two separation blocks shown below that slide in between each pulley plate at the front and back ends. They are rigidly attached to the plates via a 3in 1/4-20 screw that is threaded through the center. When tightened, it will offer a outward reaction force keeping the plates pushed apart in static equilibrium. With these changes to the pulley plate made, I believe that it will have a better fit on the rower, be able to prevent inward slippage, and be stronger than the original pulley plates.

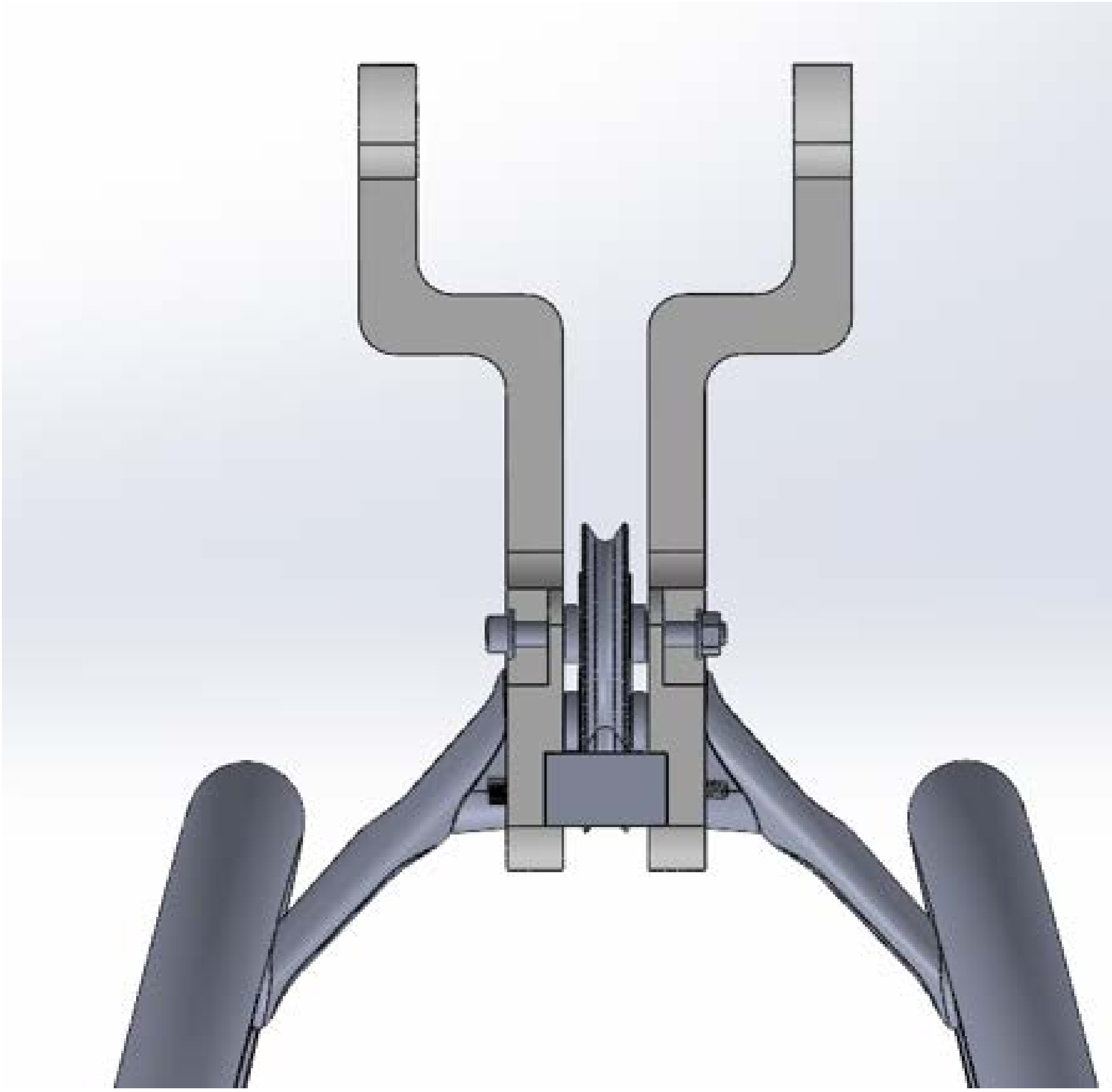
Next, I added the antlers to hold the rower handlebar. To do this, I found the approximate location where the vertical post of the antler should be placed so that it was centered between the two pulleys. This ensures that the rope does not rest on the pulleys while the rower is not in use, which could damage the pulleys. Then I made a 4 in vertical post, a 2 inch post out to the side, and another vertical 2 inch post. Then, I made an extruded cut from a rectangle to make the cylindrical holders for the rower handlebar. I added 0.5in radius fillets to every sharp corner and edge to smooth out the geometry so the user does not hurt themselves if they run into these edges. As you can see in the assembly images below, the handlebar will rest in equilibrium between the line of action of the two pulleys and will be about 6.25 inches above the top of the pulley, which allows for an easy reach to grab the handlebar.

The next step will be to make an initial 3D print of these structures to see how they fit onto the rower and how the handlebar fits inside of its holders. One thing I am not sure about is the geometry of the holders themselves. I don't know if just a cylindrical cavity will be stable enough to hold the bars, but I tried to make the cavity wide enough so that the handlebar would have some wiggle room for the user to rest it in. I also dont know if the holders themselves need to be thicker, as they are only 2 inches wide right now. After an initial print, we can assess and determine as a team what the actual fit should look like, but I think that this will be a good starting off point. For the initial print, I will do lower infill than the final print because we do not need to test the strength right away, but just figure out dimensions for a proper fit. This will make the first print cheaper.

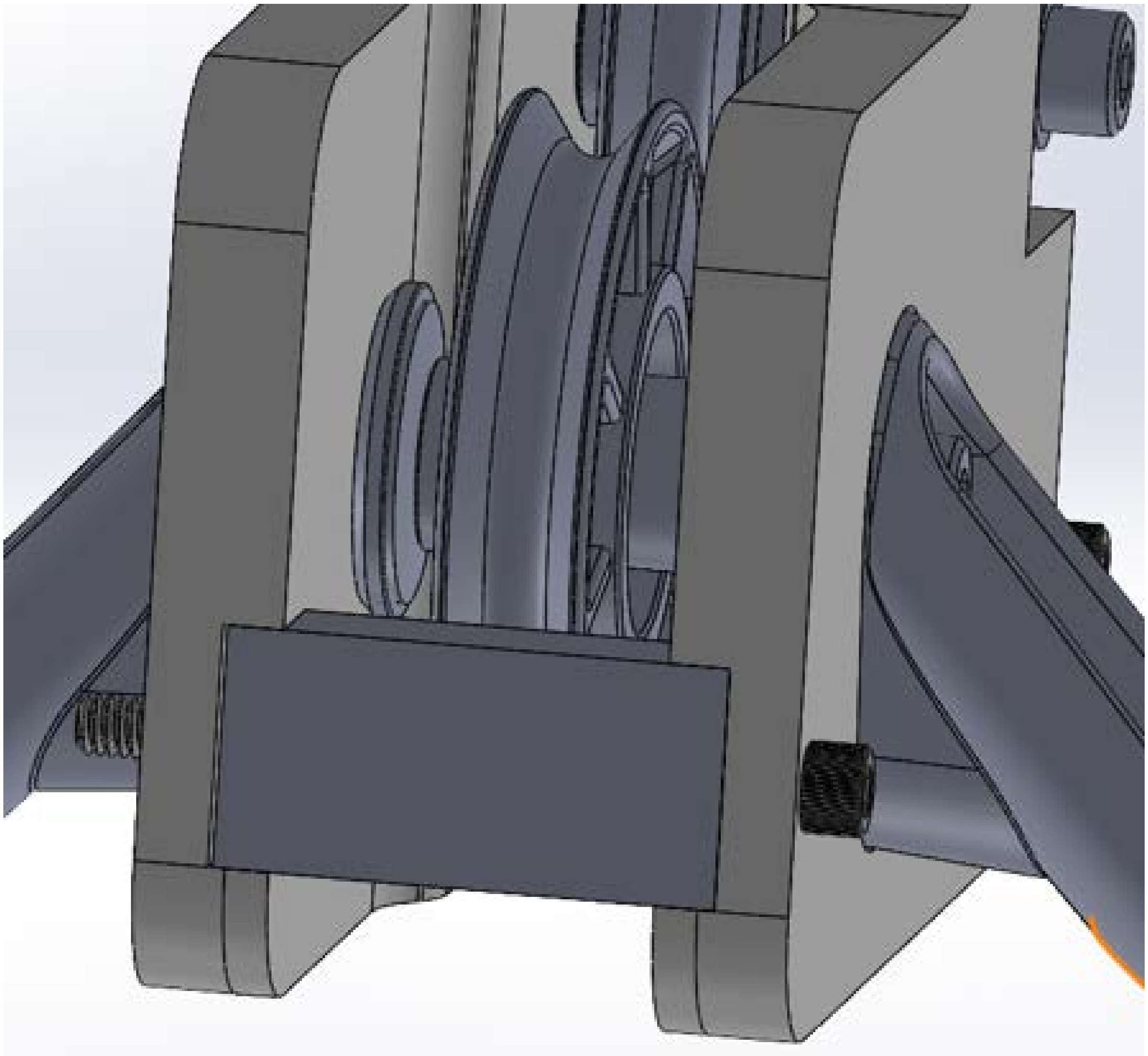
NOTE: Now that the rower neck is gone, the plates can now be symmetrical. Previously, one plate had to have a cut made in the top to allow for the rope to be transitioned from one side to the other. Now, the plates and rower will be completely symmetrical (minus the addition of the console arm, but that will be an attached piece via screws). Thus, I made changes to one pulley plate, and mirrored it about its inside face, KEEPING the link. Thus, any changes moving forward will only have to be done to the left plate and antler, and they will automatically be updated in the right plate and antler. Please see below for images and the CAD files themselves.



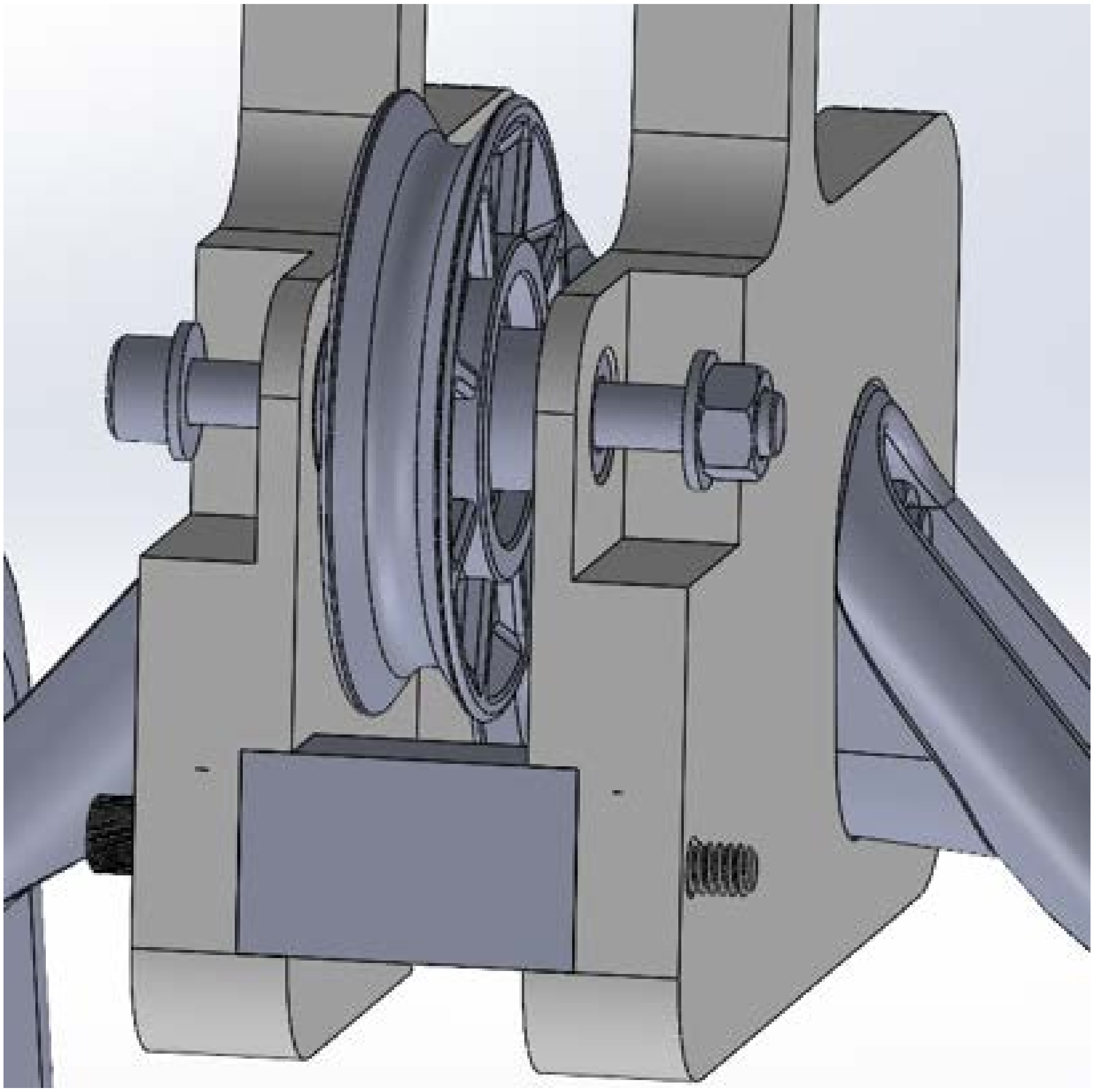
The above image is a back view of the plates and antlers on the rower. This shows the back separation block.



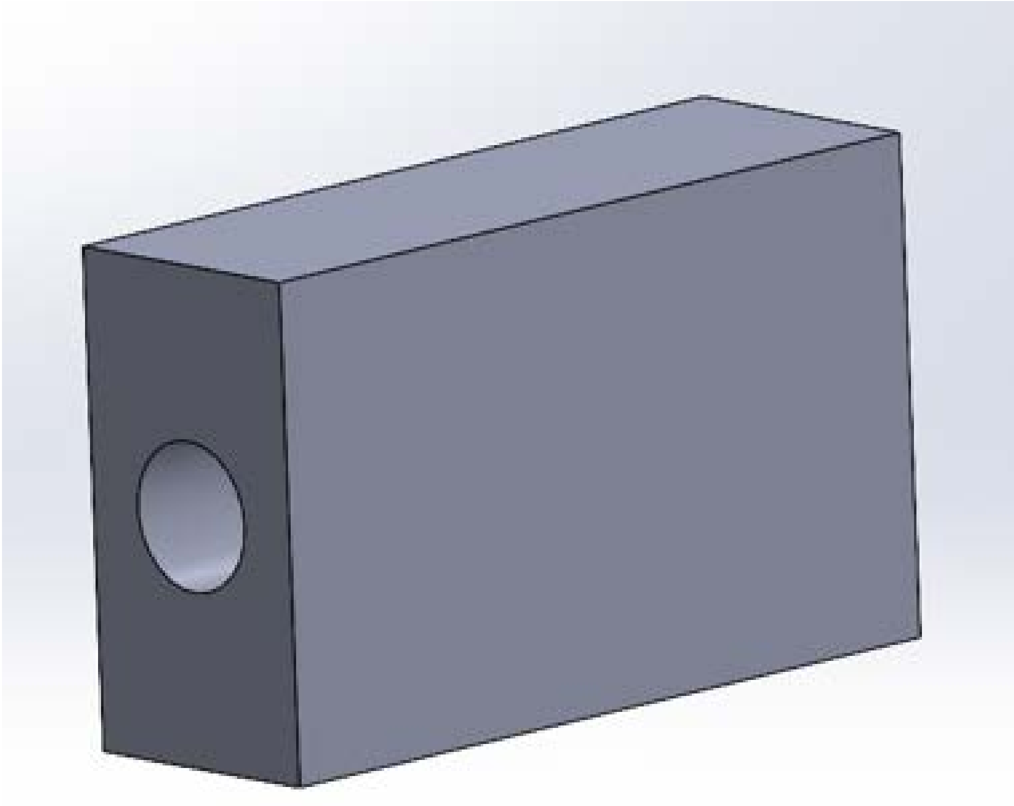
The above image shows a front view of the plates and antlers on the rower, showing the front separation block.



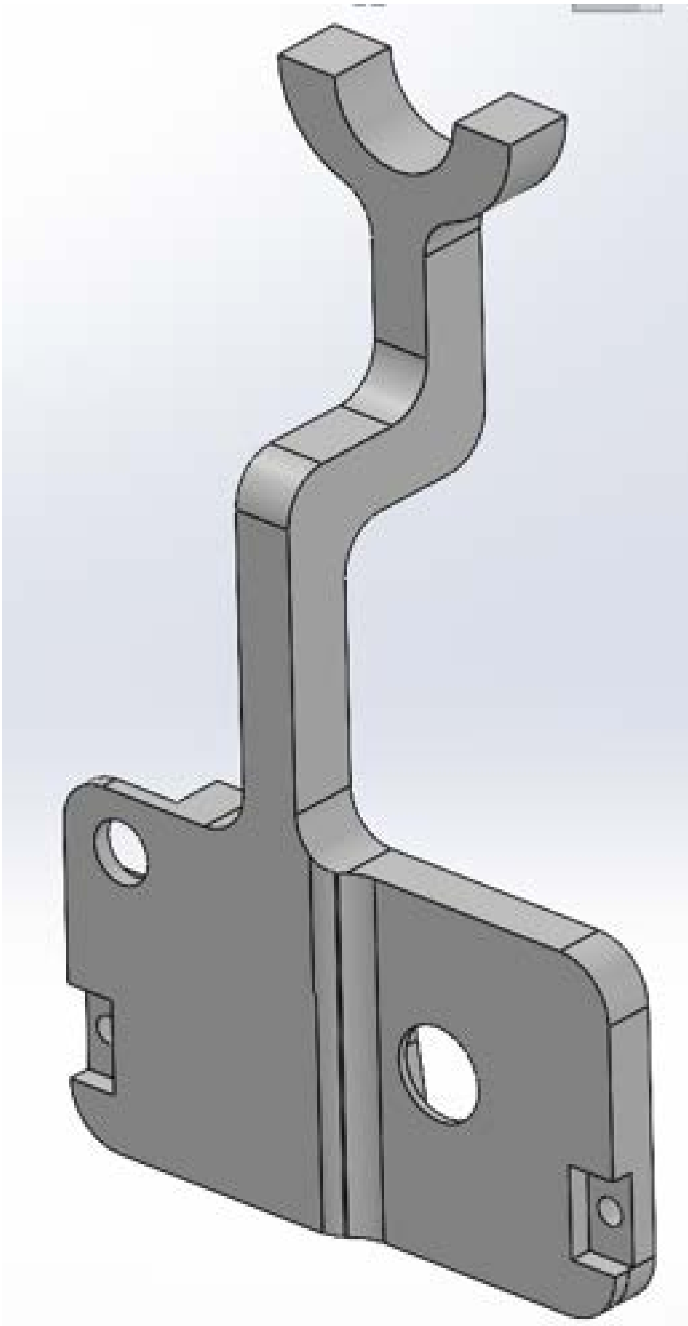
The above image shows a zoomed in view of the back separation block. You can also see where the washers will bud up against the inner face of each pulley plate.



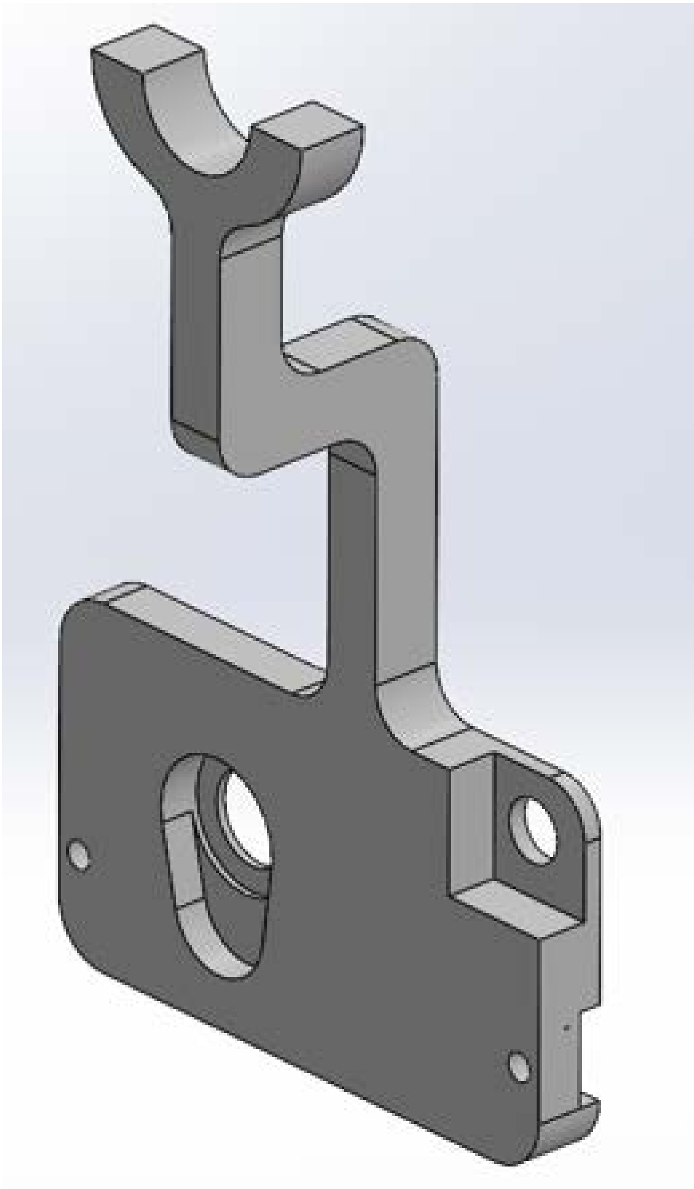
The above image shows a zoomed in view of the front separation block. You can see where the second pulley attaches to the plates and how it sits flush with the outside surface to allow for the placement of washers to hold tightly in place.



The above image shows the separation block. The front block has a length of 1.66in and the back block has a length of 2.07 inches due to the non uniform thickness of the pulley plates from front to back.



The above image shows the outside view of the pulley plate. You can see the front and back insert locations for the 2 separation blocks, as well as the antler sticking straight up.



The above image shows the inside face of the pulley plates. You can see the layered faces that the rower neck support arms will sit in, creating a more flush and guided fit.

References: n/a

Conclusions:

I think this design captures what our team wanted out of the antler design and the changes we wanted to make to the existing pulleys. The next step is to print an initial version to see how it fits on the rower, then modify the dimensions until the fit is exactly right.

Action items: Show to team to gather feedback, print initial version, modify CAD to have better fit, then print again.

Josh ANDREATTA - Oct 16, 2022, 12:16 PM CDT

Download

92196A823_18-8_Stainless_Steel_Socket_Head_Screw.SLDPRT (1.63 MB)

Josh ANDREATTA - Oct 16, 2022, 12:16 PM CDT

Download

Back_Separation_Block.SLDPRT (61.2 kB)

Josh ANDREATTA - Oct 16, 2022, 12:16 PM CDT

Download

Front_Separation_Block.SLDPRT (59.9 kB)

Josh ANDREATTA - Oct 16, 2022, 12:16 PM CDT

Download

Left_Pulley_Support_Plate_Antler.SLDPRT (345 kB)

Josh ANDREATTA - Oct 16, 2022, 12:16 PM CDT

Download

Matrix_Rower_with_Separated_Assemblies.SLDASM (3.05 MB)

Josh ANDREATTA - Oct 16, 2022, 12:16 PM CDT

Download

Right_Pulley_Support_Plate_Antler.SLDPRT (180 kB)

10/19/2022 - Initial Pulley Plate Print

Josh ANDREATTA - Oct 19, 2022, 1:29 PM CDT

Title: 10/19/2022 - Initial Pulley Plate Print

Date: 10/19/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Assess initial pulley plate and antler fit on rower and identify areas to adjust

Content:

Today I picked up the initial pulley plate and antler print from the MakerSpace - it costs $24 and the receipt has been sent to our BPAG for record keeping. Overall, the pulley plate printed very well! I took apart the rower neck and put on the pulley plate to see how well it fit onto the rower. I think that by adding in the layered cavities into the slot where the rower neck arm supports slide into the plate improved the fit on the rower. Once I tightened the pulley screw, the plate barely wobbled. I believe that once the second plate is added and the screw is completely tightened, that there will be little to no wiggle of the pulley plates. Thus, I believe we DO NOT need to adjust the rower neck arm support cavity any further. Since the console is a little over 7 inches in height, I will need to modify the antler to extend further above the top of the pulley plate itself to allow ample space for the console to fit while the user is rowing. Additionally, the inner parts of the handlebar are thicker in diameter than the outer edges, so I will need to make the cavity in the antler holder wider. Also, to improve the user friendliness, I will add a chamfer to this holder so the user can just slide the handle in and out and not have to lift it directly up, as this could be uncomfortable. Also, I will add some space for clearance for the two separation blocks because it was too tight to actually fit in. Once printed, the holes will need to be tapped, which is easy to do by hand. Overall, the plate printed really well and fit much better on the rower neck. Only small modifications needs to be made to leave space for the console, and improve the ability to hold the handle bar. Images are below.

As a side note, the geometry of the plates is very complex. Thus, I want to talk with Staci about if it will be necessary for us to fabricate out of metal. The several cavity layers and curves may make this part difficult to fabricate out of metal without a complex mold being made. Thus, I want to see if she thinks it would be okay for us to 3D print out of Tough PLA (the strongest material) at the highest infill level. This would be an incredibly strong part, and would be tested via simulation, and possibly using a MTS machine to prove it strength and rigidity under worst case scenario loads. I will ask her this in our meeting in two weeks.

The above image shows the antler holding the handle bar, and the bar being too thick to fit well in the cavity.

The above image shows the inside face of the pulley plate, which sits flush with the washers of the pulley.

The above image shows the outside face of the pulley plate fitting snug on the rower neck arm supports.

The above image shows the separation block.

References: n/a

Conclusions:

It may not be necessary to complete a second print right away. Since the modifications we want to make are small changes to improve fit, I am confident that if we wait to print them until the console arm is complete, we will be okay. The plate fits much better on the rower now than the previous semester pulley plates. Thus, a second print is not required until the console arm is ready to be printed for proof of concept.

Action items: Modify CAD to improve fit on rower; go over design modifications with team; begin CAD for console arm; then complete second print.

10/19/2022 - Adjustments to Pulley Plate and Antler

Josh ANDREATTA - Oct 19, 2022, 3:21 PM CDT

Title: 10/19/2022 - Adjustments to Pulley Plate and Antler

Date: 10/19/2022

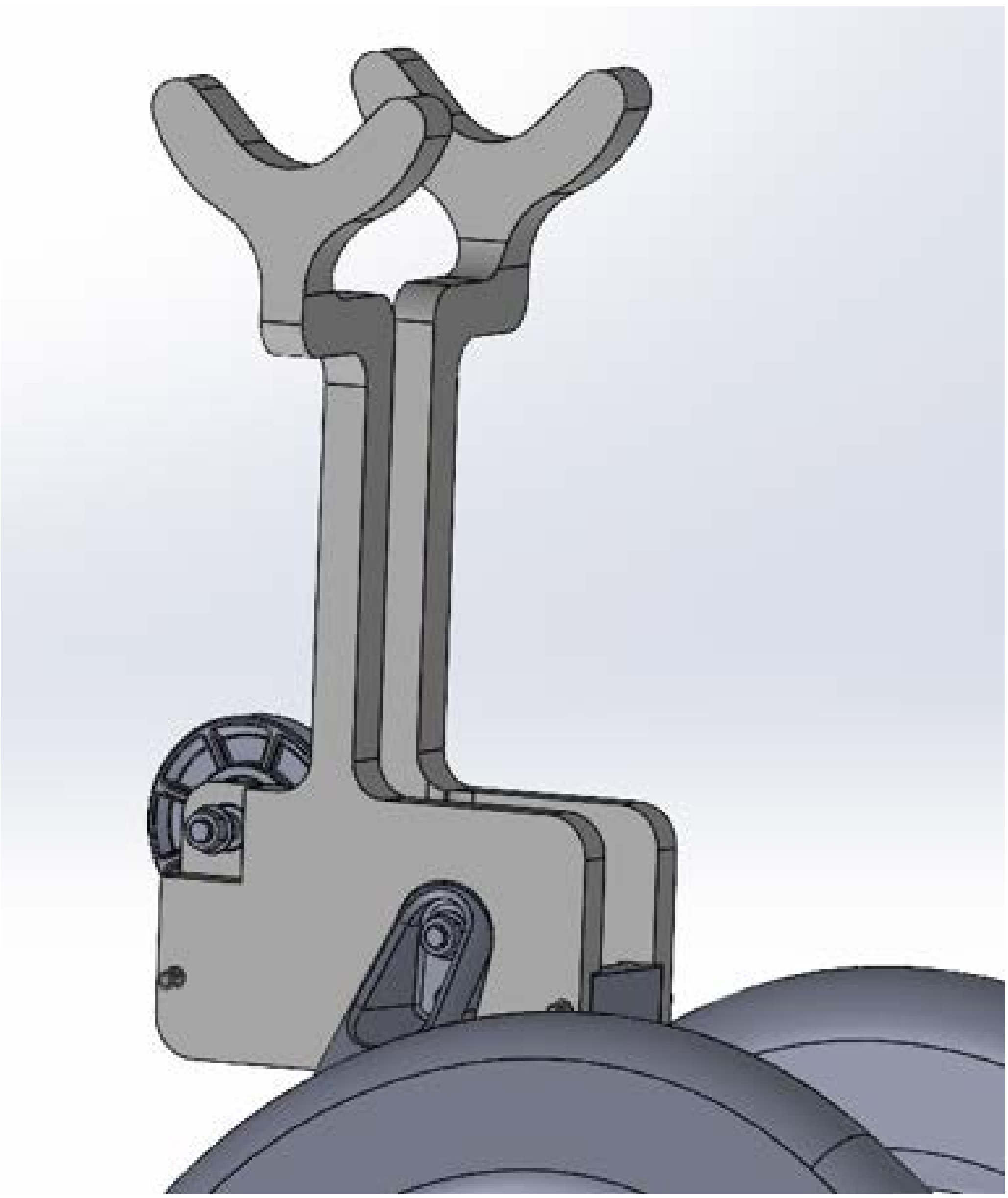
Content by: Josh Andreatta

Present: Josh Andreatta

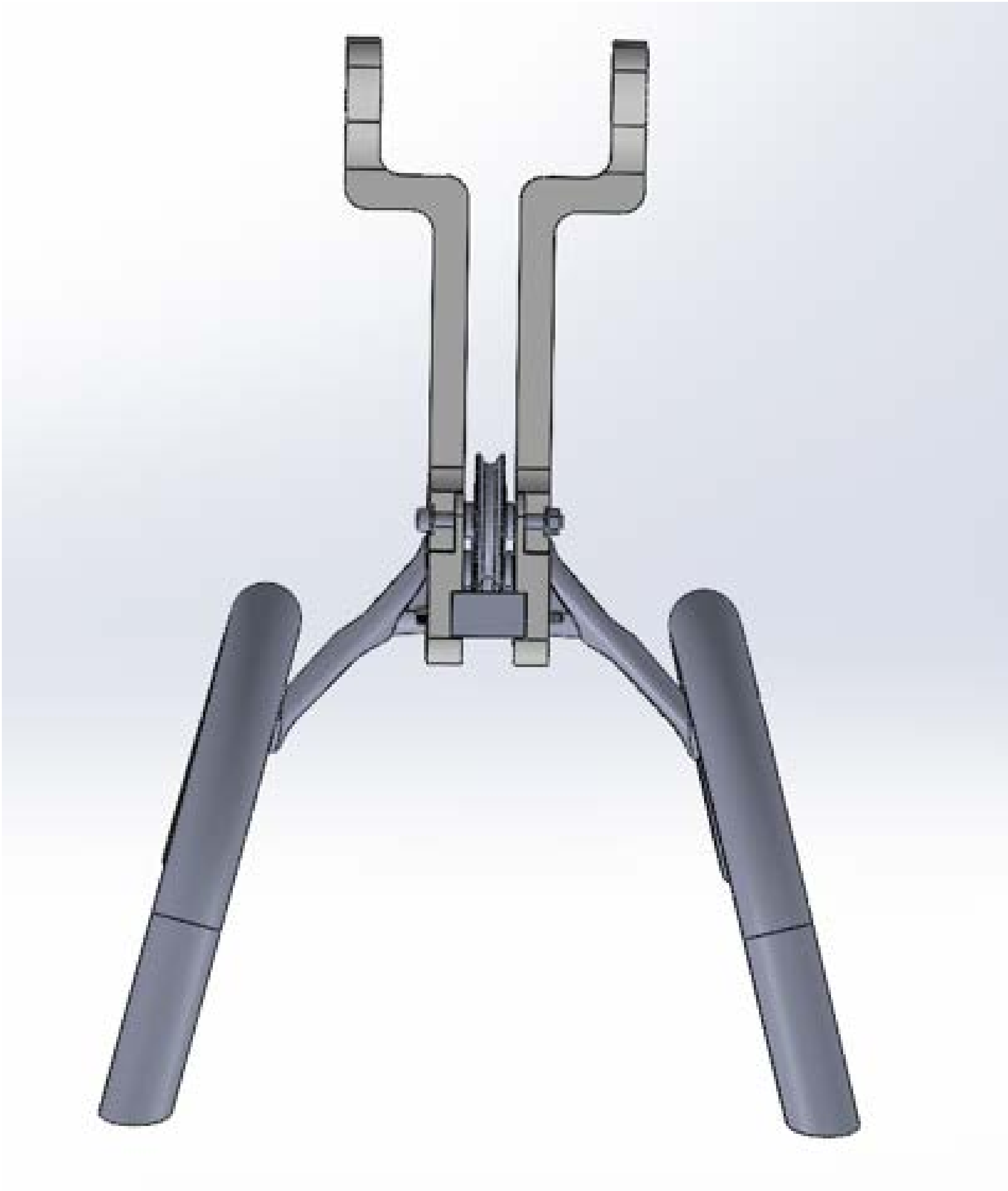
Goals: Modify CAD of pulley plate and antler

Content:

I modified the pulley plate and antler design to fix the following four issues: (1) Increase holder diameter for handlebar, (2) increase height of antler from pulley plate, (3) add chamfer to handlebar holder so users can roll handlebar out rather than lifting straight up first, (4) increased separation block cavities to add clearance. For (1), I increased the diameter from 1.5inches to 2.25 inches so now it should fit much better. For (2), there is now 6.33 inches from the top of the pulley plate to the underside of the arm that sticks sideways outward on the antler. We will discuss as a team the best plan for adding the console arm because the part is getting to tall to print at the maker space, even on their biggest printers. Currently, the part has a height of 13.84 inches. For (3) I added a chamfer and 0.5inch fillet to make it easier to slip the handlebar in and out of the holder. For (4) I added 5 thou of clearance to both sides of the separation block cavities to ensure that we can slip them in easier. Below are pictures of the update antlers.

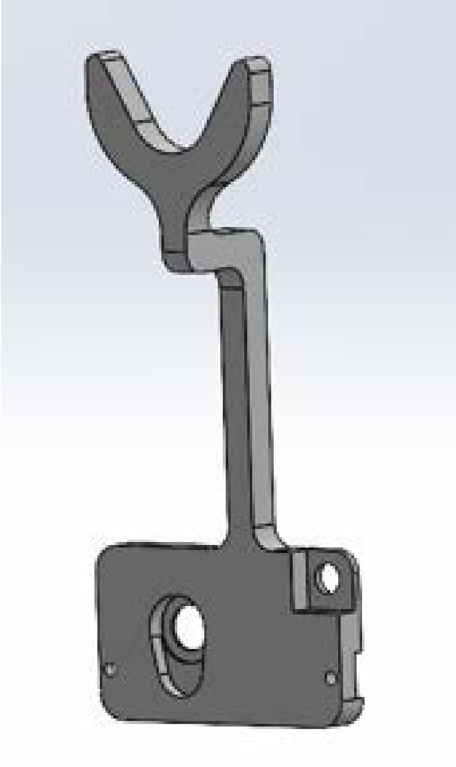


The above image shows the new antlers with a wider holder and chamfered holder edge.



The above image shows the front view with the increased height of the antlers.

I also came up with the idea of increasing the height of the side of the holders - this makes the user have to lift up more, but it does keep a more sturdy hold on the handlebar while it is resting.



The above image shows how the sides of the holder cavity are taller than above. I will discuss all of these design changes with the team to get feedback.

References: n/a

Conclusions:

I think that this CAD address the issues that were hindering the first pulley plate and antler print. In the above CAD, the following changes were made: (1) Increase holder diameter for handlebar, (2) increase height of antler from pulley plate, (3) add chamfer to handlebar holder so users can roll handlebar out rather than lifting straight up first, (4) increased separation block cavities to add clearance.

Action items: Go over CAD design changes on Friday with team; begin to develop console arm CAD; then complete second print with everything

Josh ANDREATTA - Oct 19, 2022, 3:14 PM CDT

Download

Left_Pulley_Support_Plate_Antler.SLDPRT (368 kB)

Josh ANDREATTA - Oct 19, 2022, 3:14 PM CDT

Download

Matrix_Rower_with_Separated_Assemblies.SLDASM (4.54 MB)

Josh ANDREATTA - Oct 19, 2022, 3:14 PM CDT

Download

Right_Pulley_Support_Plate_Antler.SLDPRT (192 kB)

10/25/2022 - Initial Electronics Housing SolidWorks Design

Josh ANDREATTA - Oct 25, 2022, 11:57 PM CDT

Title: 10/25/2022 - Initial Electronics Housing SolidWorks Design

Date: 10/25/2022

Content by: Josh Andreatta

Present: Josh Andreatta, Annabel Frake

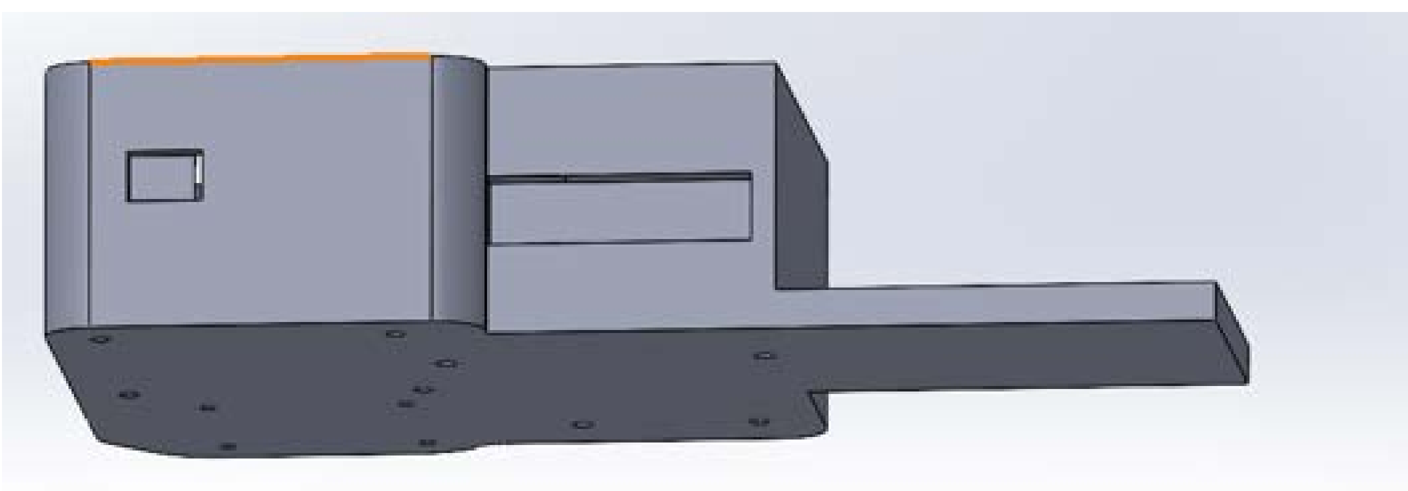
Goals: Develop an initial model of the housing chamber for the electrical components

Content:

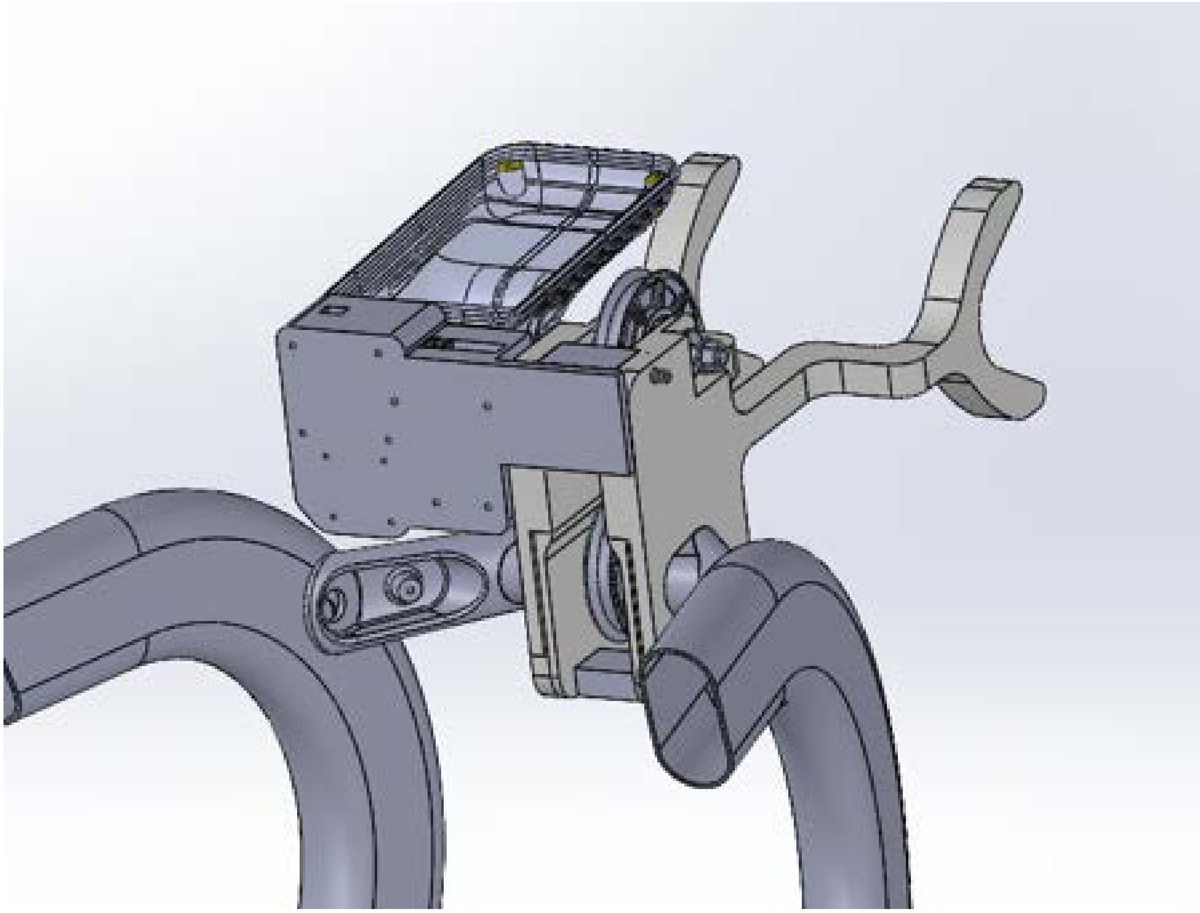
Today I worked on developing a SolidWorks model for the housing chamber that will end up holding all of our electronics. The design is essentially a "box" of sorts that has sections specifically shaped to hold either the stepper motor, motor controller, and arudino uno. I made sure that for these sections, each had a little bit of clearance so that the components can fit in easily. I made the mounting holes for each component an extruded cut through the entire box, which will allows us to just screw them in place from the bottom of the box (we just need to determine the screws each needs and grab them from TEAMLab). The console was placed such that it did not run into the portion of the antlers that holds the handlebar, and so that when it rotates, it can rotate out and around the antler to face the opposite direction. The electronics were then placed around the console and using the cavity feature, the box was made. I then made a large series of cuts to shape the windows, and remove interior barriers until it looked how I wanted. I talked with Annabel a few times while I was making the box to ensure that I was leaving enough room for the wires to travel in the locations that they will be traveling in within the box. I think the design below will be a great starting point for us to see how well it holds all of the components, and see if the motor is able to rotate the console or not. The next steps for the design will be to run it by our team and client for further feedback. Then I will make a simple lid to sit on top. After this, I will complete the first 3D print and see how well everything fits and how well the motor functions. Then I will make adjustments as needed for a more final print. One additional note is that the box actually has the screw for the front separation block going through it. I think this will actually help stabilize the box because it will provide another screw anchor point. To further secure the box in place, I think the easiest way to do this is to use a plate (or an extension of the box) and screw it in to the underside of the pulley plates. This extension cannot extend so far back that it runs into the rope as it runs upward between the two pulleys, thus I gave it a width of only 2 inches. For the first print, I am NOT going to put in screw holes, because I want to see how everything else fits first. Then, once the fixation method is agreed upon, screw holes are easy and quick to add to the model for the final print.

*Note: To attach the console to the motor, I made a cavity that is the same size as the motor shaft and we will press fit it into place. Additionally, I slightly altered the pulley plate height so it is 11.83 inches tall, allowing it to be printed in 1 piece on the largest printer at the Makerspace.

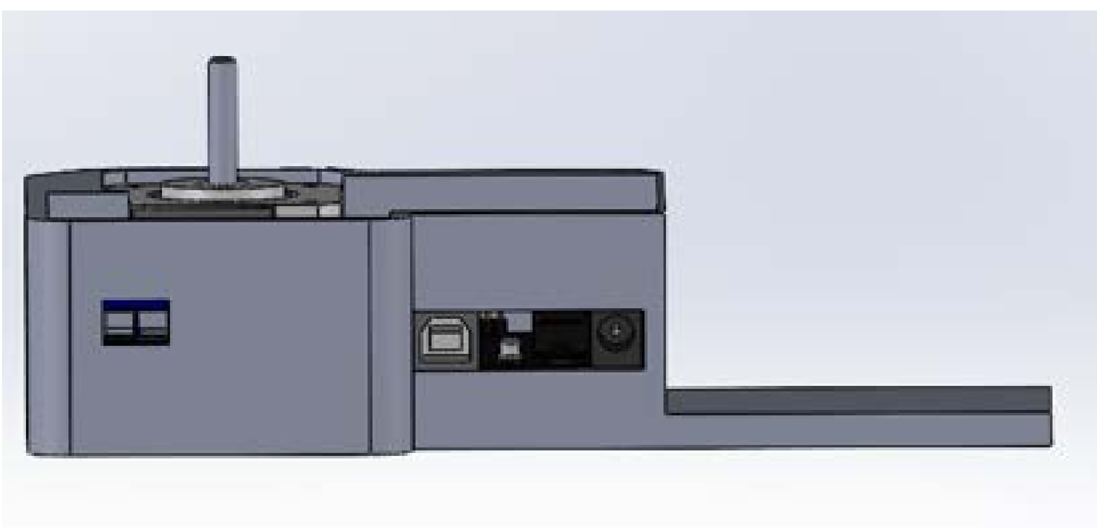
Please see pictures below!



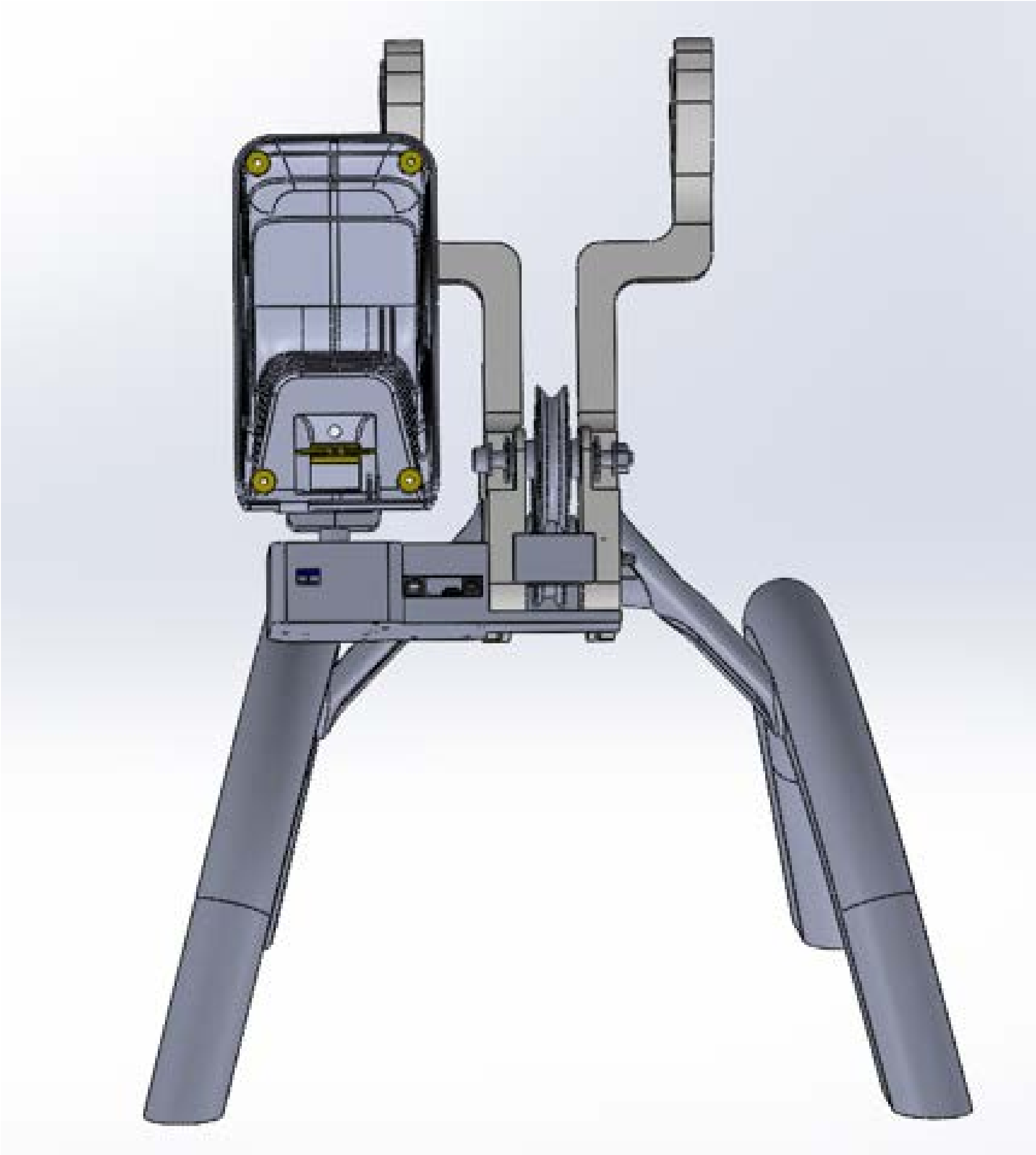
The above image shows a bottom/front view of the box. On the bottom are holes to screw the components into place. On the forward face are two windows for us to access the power supply to the motor controller and the USB plug in for the arduino uno. The extension on the right will go under the pulley plates to stabilize the box once screwed in.



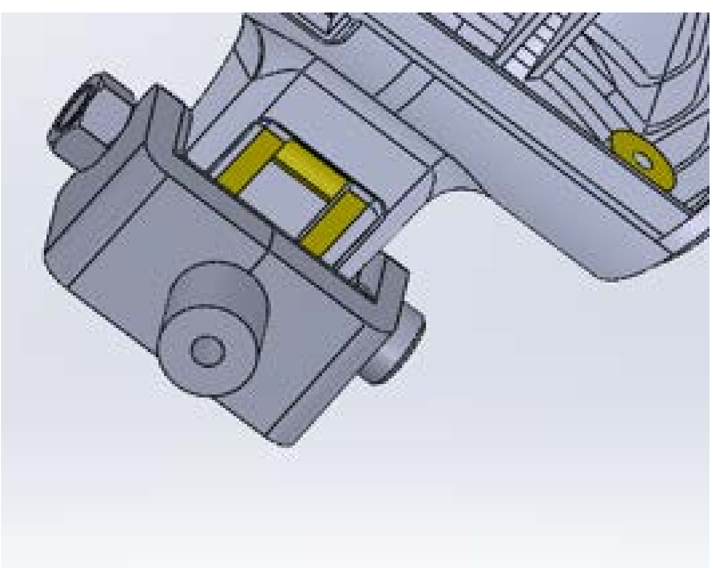
The above image shows the entire assembly from the bottom, showing how the extension will fit onto the bottom face of the two pulley plates.



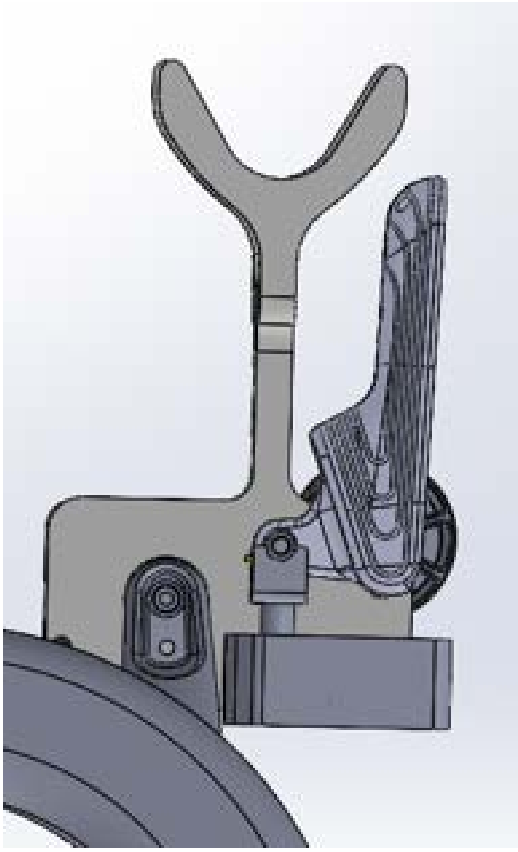
The above image shows the motor box with the electronics so that we can see where the windows give us access to power and USB ports.



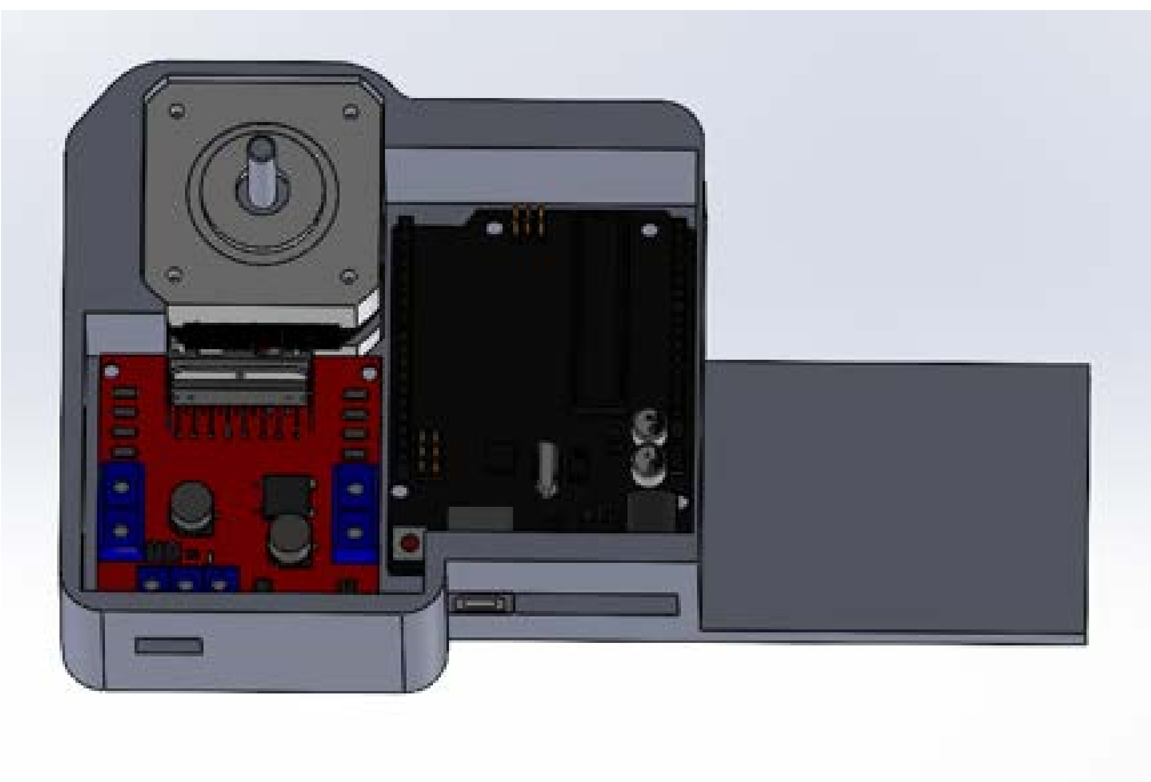
The above image is a front view of the entire rower assembly.



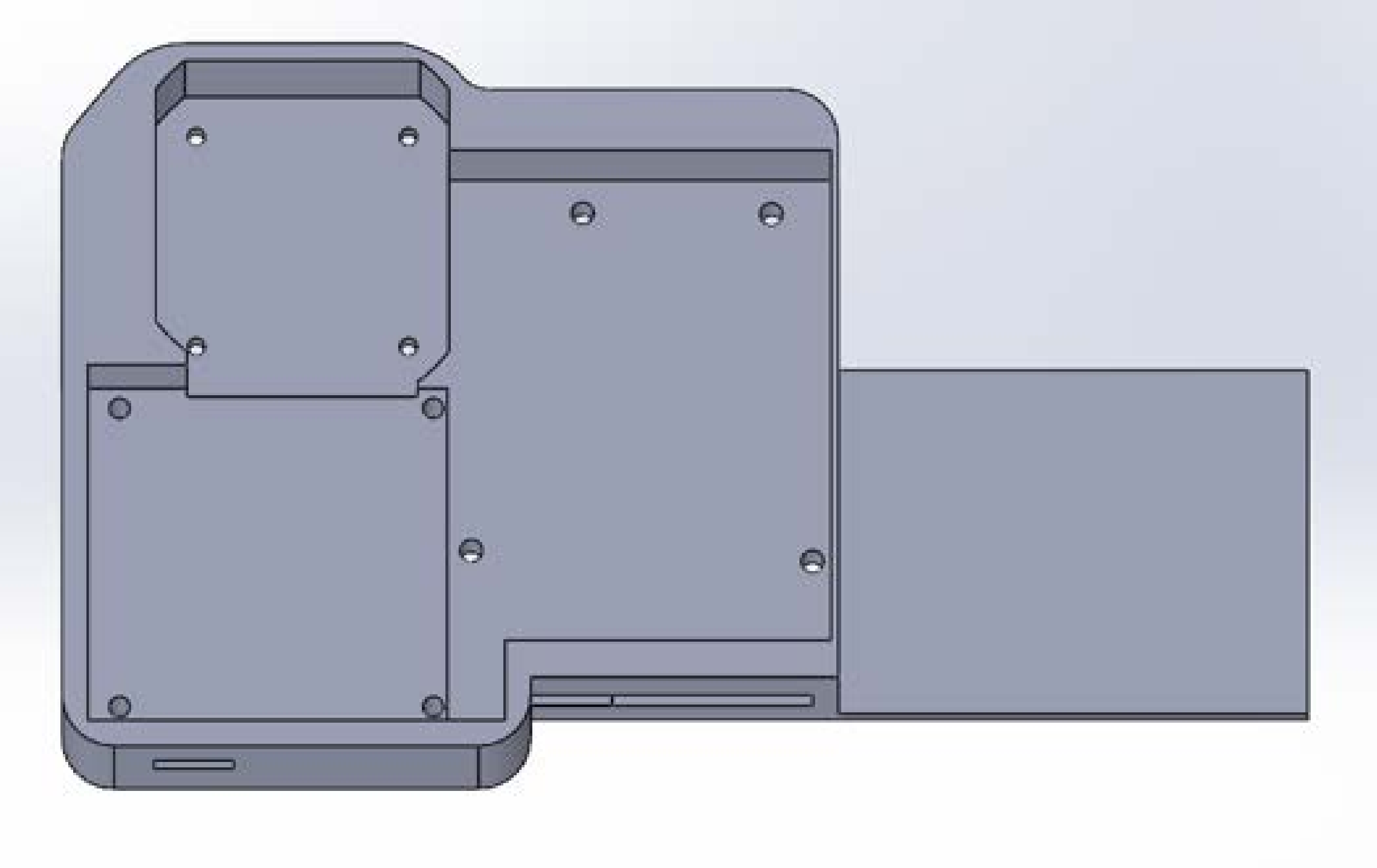
The above image shows the press fit for the console onto the motor shaft.



The above image shows a side view of the assembly. Note how the console does not hit the antler and will not hit it during rotation.



The above image is a top view of the box with electronics inside. The gray is the stepper motor, red is motor controller, and black is arduino uno.



The above image is the top view of the box, showing the sections for each electrical component and their respective through holes for screwing into place.

References: n/a

Conclusions:

Overall I think this is a really good starting point for our design! It has spaces to hold the stepper motor, motor controller, and arduino uno with clearance for the components and for the wires to travel throughout the internal parts of the chambers as well. The part has an attachment to the pulley plates via the underside of the plates where it will most likely be screwed in. I will go over the design with the team to get feedback, make adjustments, and then print.

Action items: Go over design with entire team to get feedback. Then, make small adjustments. Once complete, make lid for structure and print an initial 3D print of the housing chamber and lid. After the initial print, test to see how well everything fits and if motor can spin with console on top. Brainstorm how to add structure to hold power supply/battery. Make adjustments and print again.

Josh ANDREATTA - Oct 25, 2022, 11:58 PM CDT

Download

Arduino_Uno.SLDPRT (13.8 MB)

Josh ANDREATTA - Oct 25, 2022, 11:58 PM CDT

Download

Motor_Arm_Assembly.SLDASM (6.47 MB)

Josh ANDREATTA - Oct 25, 2022, 11:58 PM CDT

Download

Motor_Arm_Box.SLDPRT (9.96 MB)

Josh ANDREATTA - Oct 25, 2022, 11:58 PM CDT

Download

Motor_Controller.SLDPRT (1.81 MB)

Josh ANDREATTA - Oct 25, 2022, 11:58 PM CDT

Download

Stepper_Motor.sldprt (269 kB)

Josh ANDREATTA - Oct 25, 2022, 11:58 PM CDT

Download

Full_Swivel_Assembly.SLDASM (1.48 MB)

10/31/2022 - Update to Motor Box, Pulley Plates, and Items to Print

Josh ANDREATTA - Oct 31, 2022, 10:35 AM CDT

Title: 10/31/2022 - Update to Motor Box, Pulley Plates, and Items to Print

Date: 10/31/2022

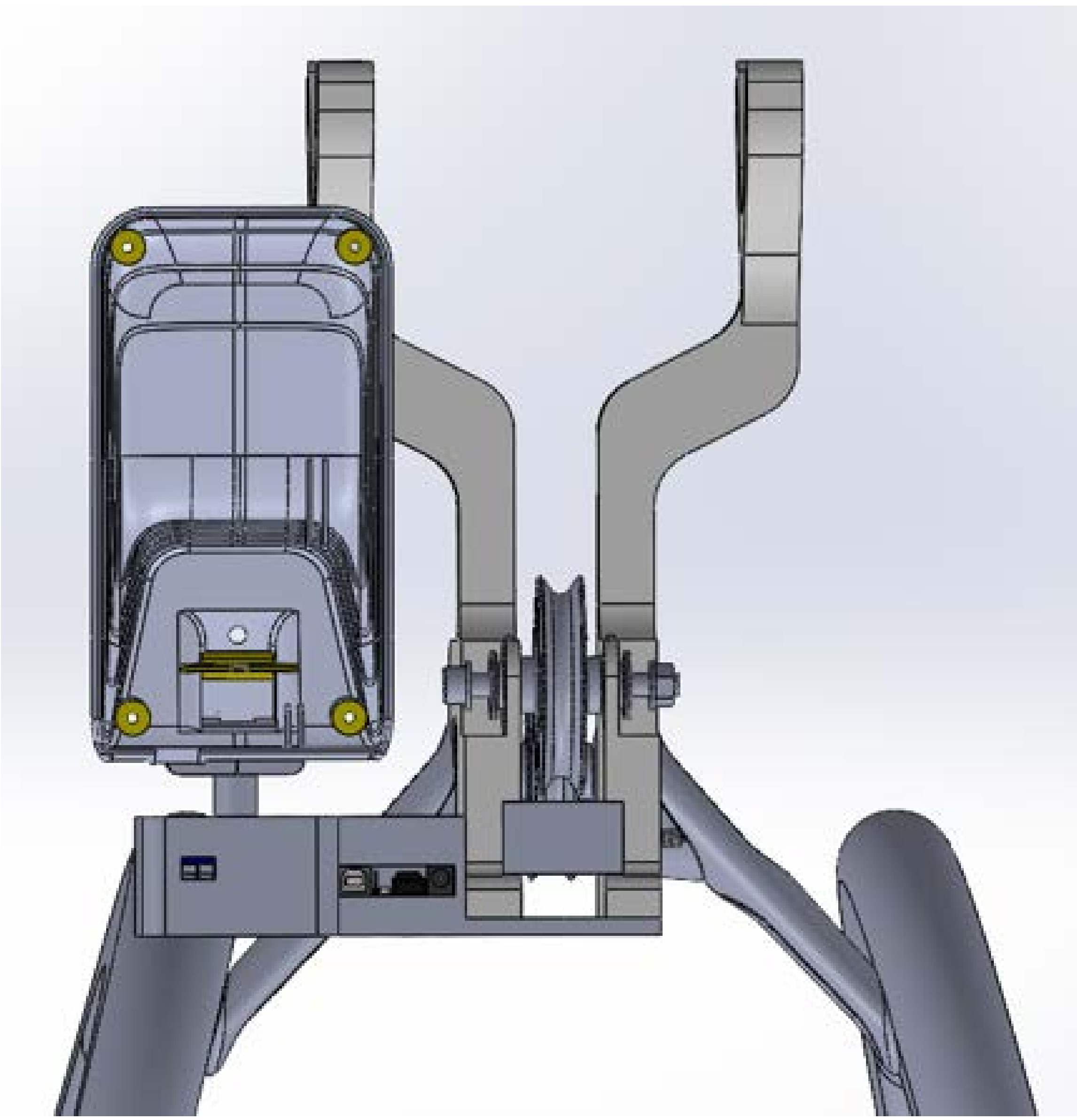
Content by: Josh Andreatta

Present: Josh Andreatta

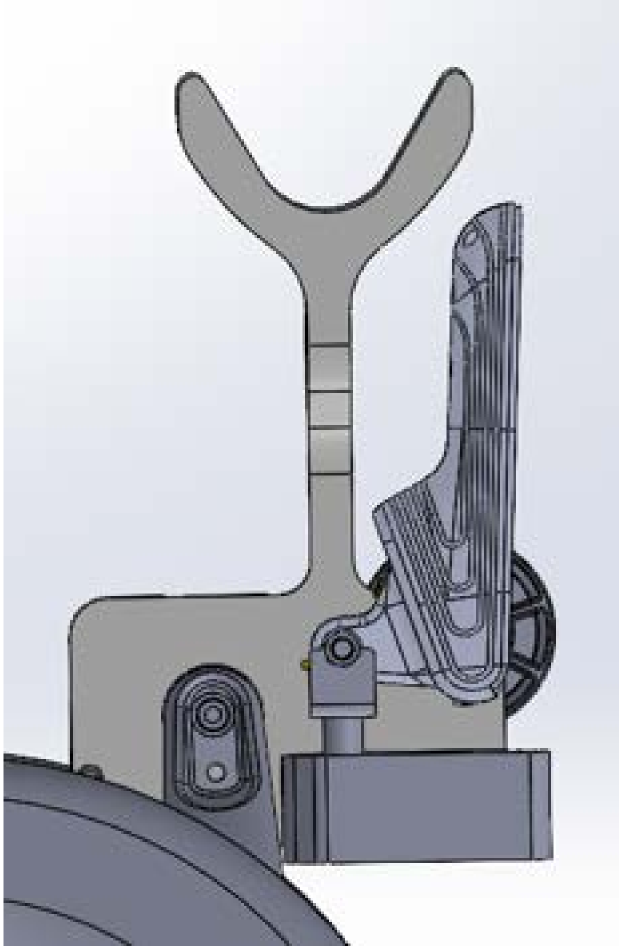
Goals: Update CAD models for second print

Content:

Today I updated all of our SolidWorks designs to reflect changes we discussed making in our Friday meeting. First, staci suggested that our antler arms extend upward at an angle, rather than directly out and then up at right angles. She said she typically tries to avoid the right angles because they are more susceptible to failure due to bending. The angled antlers were simple to modify and do not impede the ability for the console to rotate.

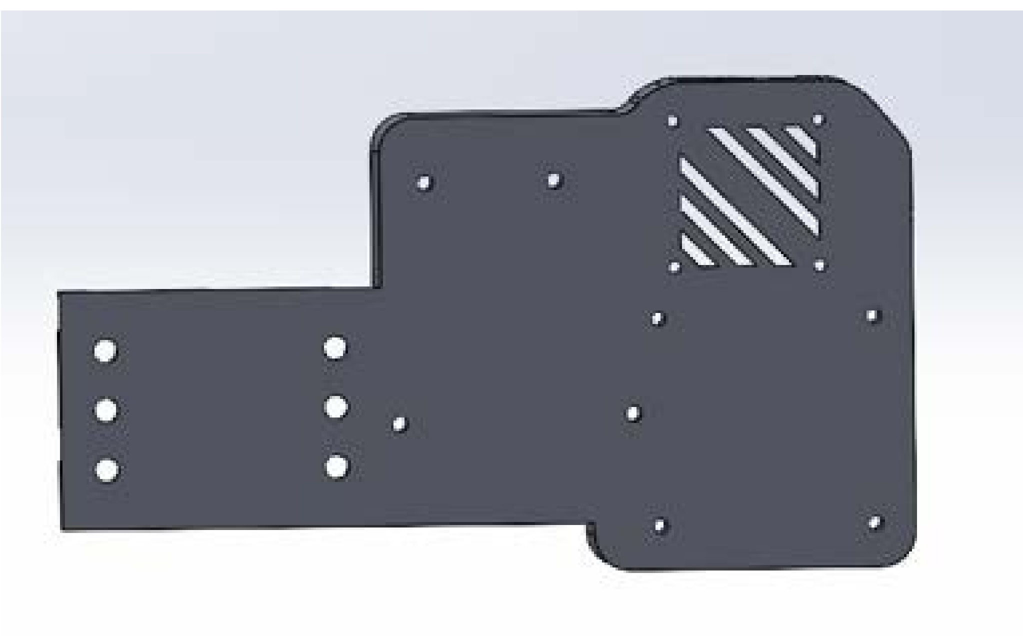


The above image shows the antlers now extending upward at an angle, and with that angled support being thicker than the previous iteration.

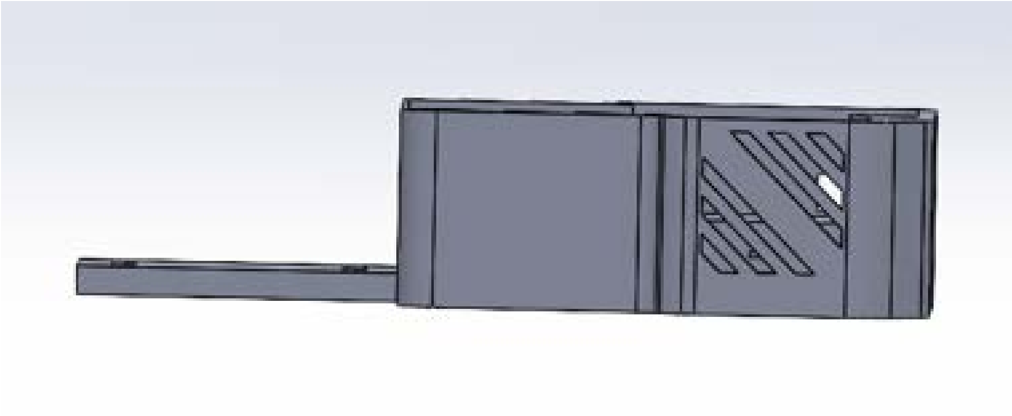


The above image shows that the console will still be able to rotate around the motor shaft without hitting the pulley plate or the antler.

Next, I modified the motor electronics box. Annabel noticed during her testing that the motor would heat up quite a bit so we talked about adding some form of ventilation to help the motor cool down when it runs. To achieve this, I added grating to the backside and underside of the motor. This will allow for excess heated air to escape into the surrounding environment rather than sitting around the motor and increasing its internal temperature. The grating is thin enough that it should not affect the structural integrity of this corner of the motor box. Per a note from Staci, Annabel is going to investigate if the motor is heating up due to excess Amperage and not excess voltage. If the motor is still heating up with ventilation and proper amperage, we will add a fan to blow on the motor to further cool it down.

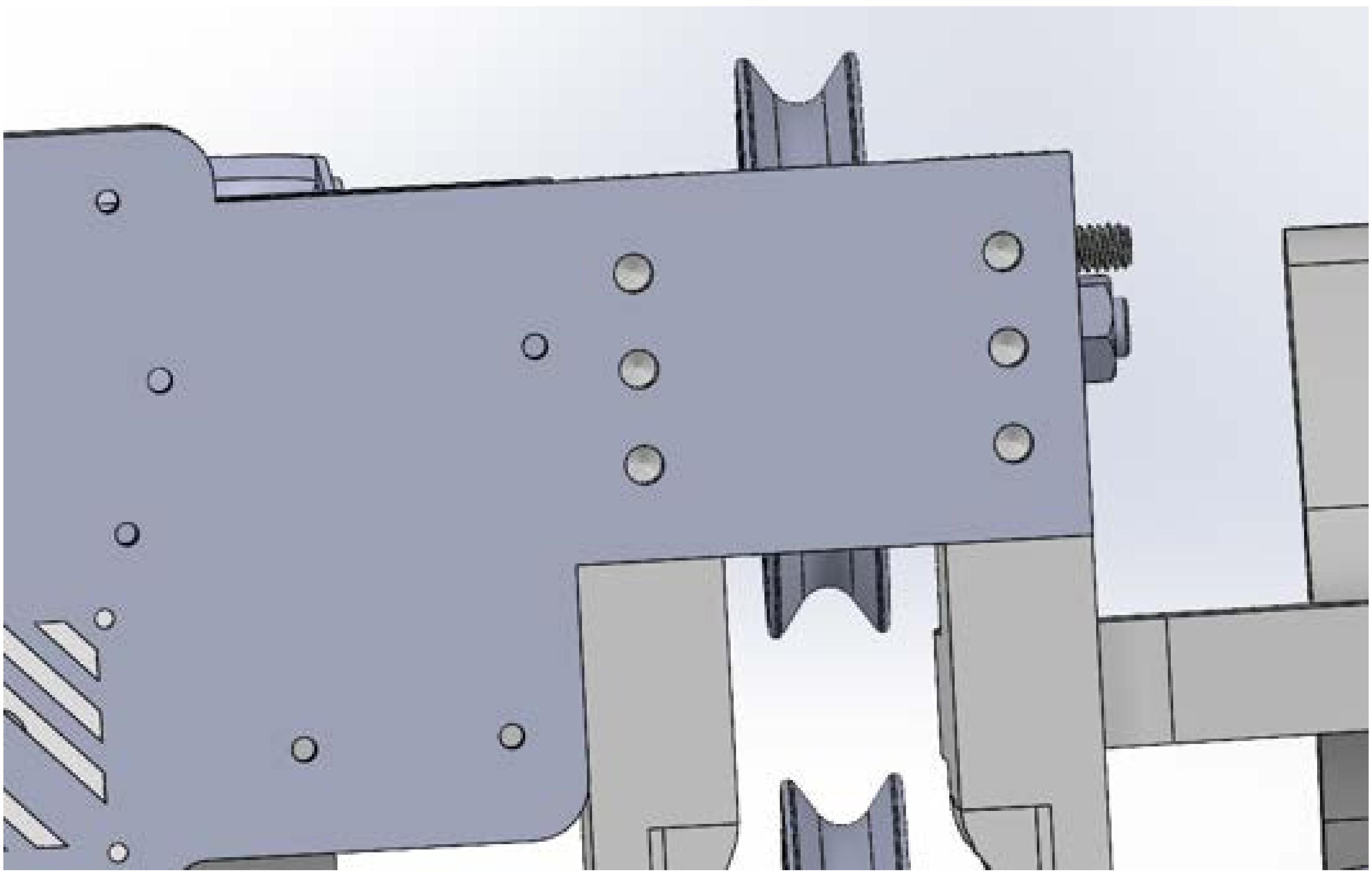


The above image shows the bottom motor grating for venting.



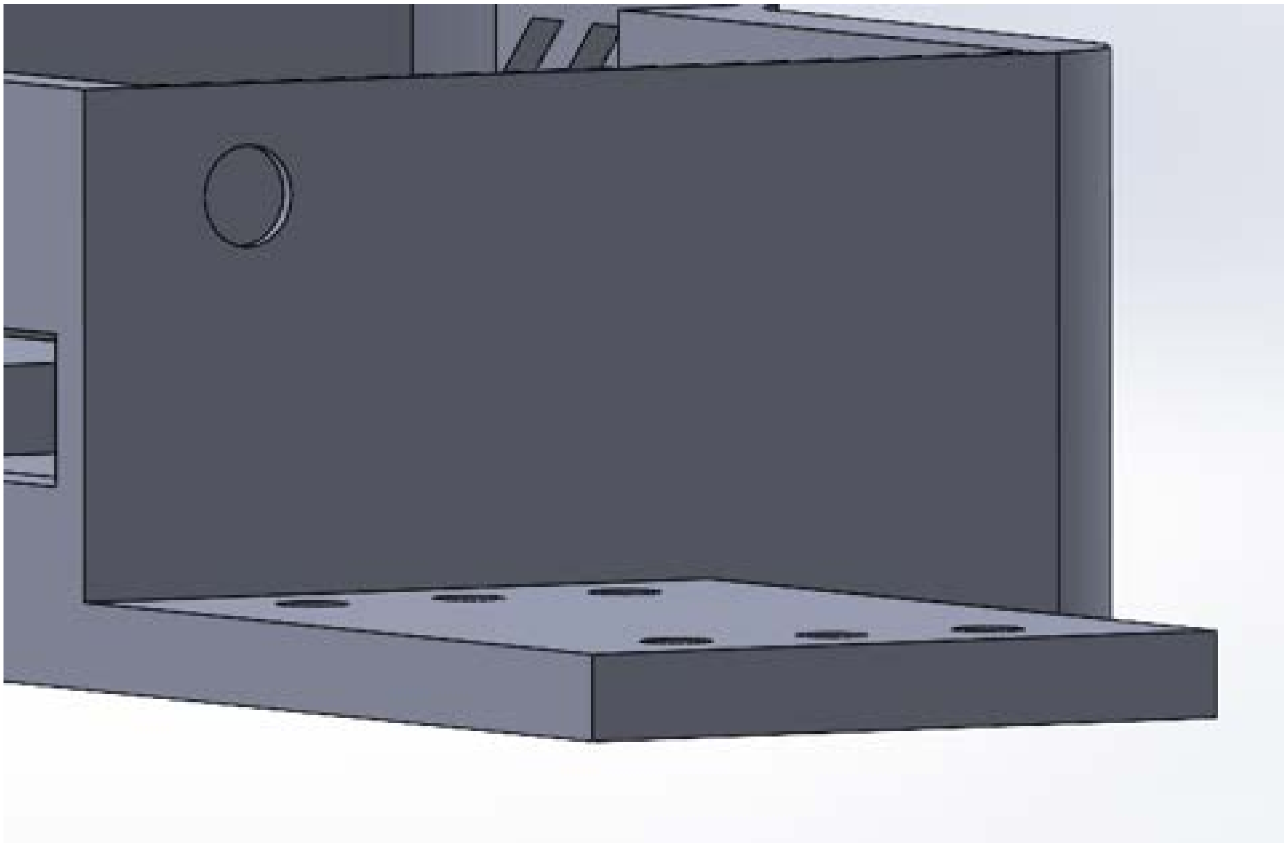
The above image shows the side grating of the motor for ventilation.

Next, I also needed to put in the holes that will allow us to mount the motor box to the pulley plates. I made 3 tapped holes for 1/4-20 screws to connect between each pulley plate and the motor.



The above image shows where the 6 screws will secure the motor box to the pulley plates.

Lastly, the screw for the front separator block goes through where the motor box contacts the side of the left pulley plate. So, I made a hole that will allow it to fit through. This will also act as a little bit of side support to support the motor box against the side of the pulley plate.



The above image shows the through hole for the screw for the front pulley plate separation block.

These changes should address all of the concerns our team and Staci had about our designs. Before printing, I will discuss with annabel to make sure the motor box looks good for what she plans to include with the electronics. Then I will print, assess, adjust, and complete a final print (after making the motor box lid and collecting all necessary screws). I will also complete the solidworks simulation tests and all of this will be done prior to thanksgiving break.

References: n/a

Conclusions:

Overall, I think the changes I made will help to improve our designs. By modifying the antlers so that they come up at angles and not straight out at right angles should reduce the stresses and bending moments that take place there. The change does not inhibit the rotation of the console. Additionally, adding the grating to the motor box should help some air escape to allow the stepper motor to cool down. If necessary, we will add a fan to blow cool air on the motor, but we do not think that this will be necessary. Once the pulley plates and motor box have been printed for the final time, I will make a record of the different number and types of screws that we will need to screw everything in place. I will then get these from the TEAMLab to allow us to fully assembly everything. Prior to thanksgiving, the 3D printed components should be printed, assembled, and have SolidWorks simulation tests ran and analyzed. This will allow for Annabel and Roxi to complete the integration and testing of the electronic circuit. Then after thanksgiving, we will only have to finish analysis and work on final deliverables and help out with the stabilization frame.

Action items: First, I will meet this afternoon with Annabel to double check my edits. Then I will print the below items to see if they fit nicely. Based off of this print, I will make necessary adjustments and print a final version OR send the CAD to staci for her lab to fabricate (TBD). The print taking place tomorrow (Tuesday) will have what we will show at Show and Tell on Friday. Once the motor box is finalized, a simple lid will be modeled and 3D printed to cover the electronics. I will NOT model this until the box is finished and we know what the outline of the top of the box looks like. The lid will be simple to model so this will be okay and fit our timeline.

Print:

- **Motor Box**
- **Updated Console Field Goal Post (Both Parts)**
- **Sectioned off antler of handlebar holder cavity**
- **Sectioned off RIGHT antler of right side rower neck support layered cavity**
-

Josh ANDREATTA - Oct 31, 2022, 10:18 AM CDT

Download

Left_Pulley_Support_Plate_Antler.SLDPRT (442 kB)

Josh ANDREATTA - Oct 31, 2022, 10:18 AM CDT

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Right_Pulley_Support_Plate_Antler.SLDPRT (208 kB)

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Motor_Arm_Assembly.SLDASM (6.51 MB)

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Motor_Arm_Box.SLDPRT (10.1 MB)

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Field_Goal_for_Console_Display_LEFTLEFT_Part.SLDPRT (229 kB)

Josh ANDREATTA - Oct 31, 2022, 10:18 AM CDT

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Field_Goal_for_Console_Display_Right_Part.SLDPRT (184 kB)

Josh ANDREATTA - Oct 31, 2022, 10:18 AM CDT

Download

Full_Swivel_Assembly.SLDASM (1.48 MB)

10/31/2022 - Post Talk with Annabel on Motor Box Design

Josh ANDREATTA - Oct 31, 2022, 7:06 PM CDT

Title: 10/31/2022 - Post Talk with Annabel on Motor Box Design

Date: 10/31/2022

Content by: Josh Andreatta

Present: Josh Andreatta, Annabel Frake

Goals: Update CAD models for second print from Annabel's feedback

Content:

I met with Annabel and she said that the changes I made looked good to go. She discussed that the Makerspace helped her figure out that we also need to include a relay module into the circuit to prevent the motor from heating up. Since the box is already limited on space, we brainstormed that the most efficient place to put this module is to screw it into the underside of the lid and hang it upside down above the arduino uno. This location is the place within the interior of the box where we have the most room to fit the relay module. First, however, we are going to print the box without the lid to make sure everything else fits properly. Then we will print the lid and add screw holes for the relay. I also added a small flag on the support that the console is attached to to act as a pusher to push the limit switches. The exact placement of this flag will be finalized after Staci gives us the exact limit switches we will be using. Future CAD changes should be minimal from here on out, as the bulk of the design is now complete. Below are the stls I will print tomorrow morning.

*Note: Staci said her fabrication lab is not able to make the pulley plates for us so we are okay to print them this semester. When we visit JHT on this friday, we will brainstorm with her on ways in which we can separate the part into components that would be easier for her lab to fabricate for next semester.

References: n/a

Conclusions:

Overall, I think the changes I made will help to improve our designs. By modifying the antlers so that they come up at angles and not straight out at right angles should reduce the stresses and bending moments that take place there. The change does not inhibit the rotation of the console. Additionally, adding the grating to the motor box should help some air escape to allow the stepper motor to cool down. If necessary, we will add a fan to blow cool air on the motor, but we do not think that this will be necessary. Once the pulley plates and motor box have been printed for the final time, I will make a record of the different number and types of screws that we will need to screw everything in place. I will then get these from the TEAMLab to allow us to fully assembly everything. Prior to thanksgiving, the 3D printed components should be printed, assembled, and have SolidWorks simulation tests ran and analyzed. This will allow for Annabel and Roxi to complete the integration and testing of the electronic circuit. Then after thanksgiving, we will only have to finish analysis and work on final deliverables and help out with the stabilization frame.

Action items: First, I will print the below items to see if they fit nicely. Based off of this print, I will make necessary adjustments and print a final version. The print taking place tomorrow (Tuesday) will have what we will show at Show and Tell on Friday. Once the motor box is finalized, a simple lid will be modeled and 3D printed to cover the electronics. I will NOT model this until the box is finished and we know what the outline of the top of the box looks like. The lid will be simple to model so this will be okay and fit our timeline.

Print:

- **Motor Box**
- **Updated Console Field Goal Post (Both Parts)**
- **Sectioned off antler of handlebar holder cavity**
- **Sectioned off RIGHT antler of right side rower neck support layered cavity**

Josh ANDREATTA - Oct 31, 2022, 7:05 PM CDT

Download

Antler_Cavity_Improvement.STL (22.7 kB)

Josh ANDREATTA - Oct 31, 2022, 7:05 PM CDT

Download

Field_Goal_for_Console_Display_LEFT_Part.STL (120 kB)

Josh ANDREATTA - Oct 31, 2022, 7:05 PM CDT

Download

Field_Goal_for_Console_Display_Right_Part.STL (104 kB)

Josh ANDREATTA - Oct 31, 2022, 7:05 PM CDT

Download

Motor_Arm_Box.STL (228 kB)

Josh ANDREATTA - Oct 31, 2022, 7:05 PM CDT

Download

Right_Pulley_Support_Plate_Fit_Check.STL (22.7 kB)

11/2/2022 - Initial Motor Box and Updated Antler Print

Josh ANDREATTA - Nov 02, 2022, 3:29 PM CDT

Title: 11/2/2022 - Initial Motor Box and Updated Antler Print

Date: 11/2/2022

Content by: Josh Andreatta

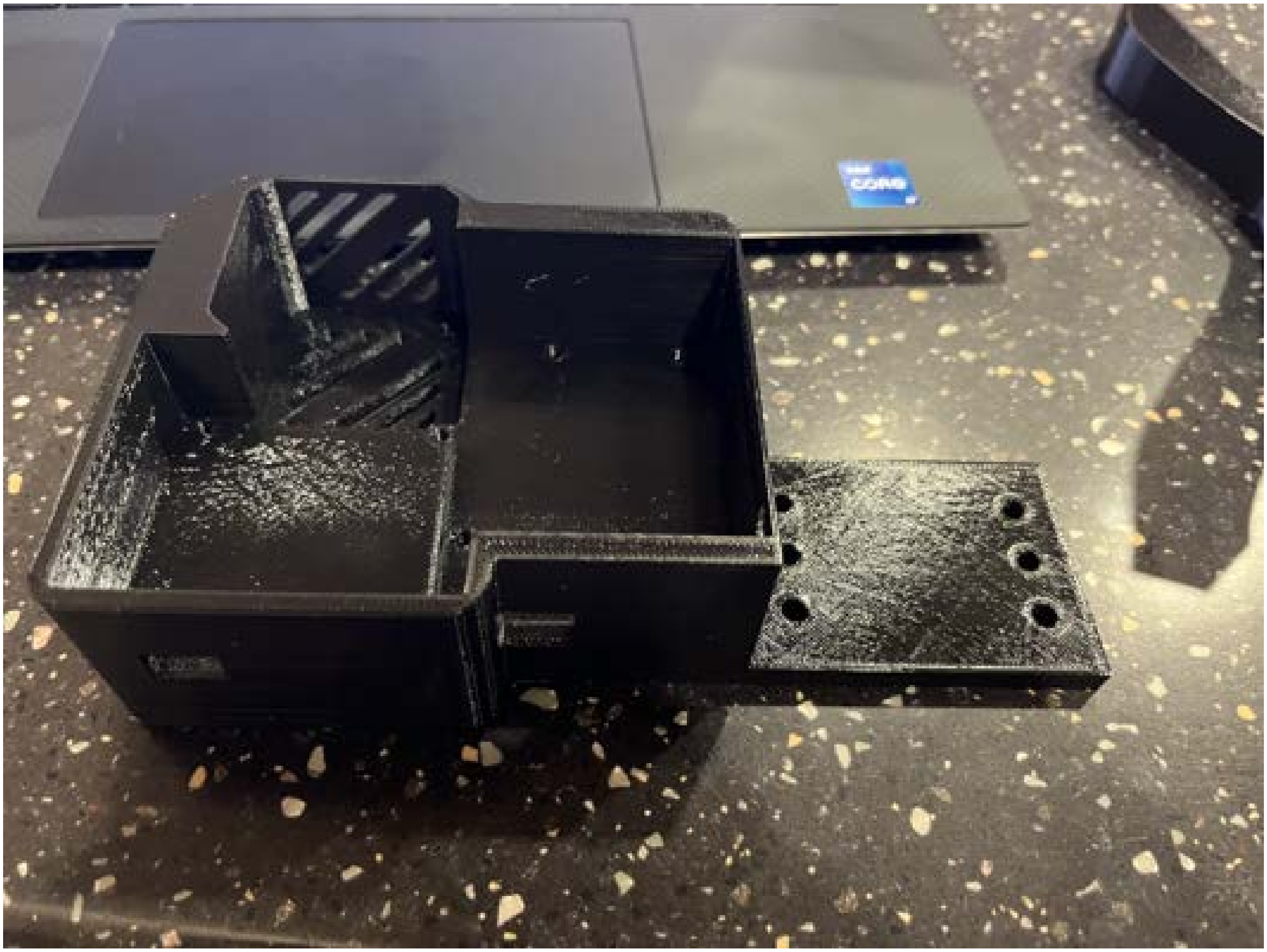
Present: Josh Andreatta

Goals: See how the prints fit

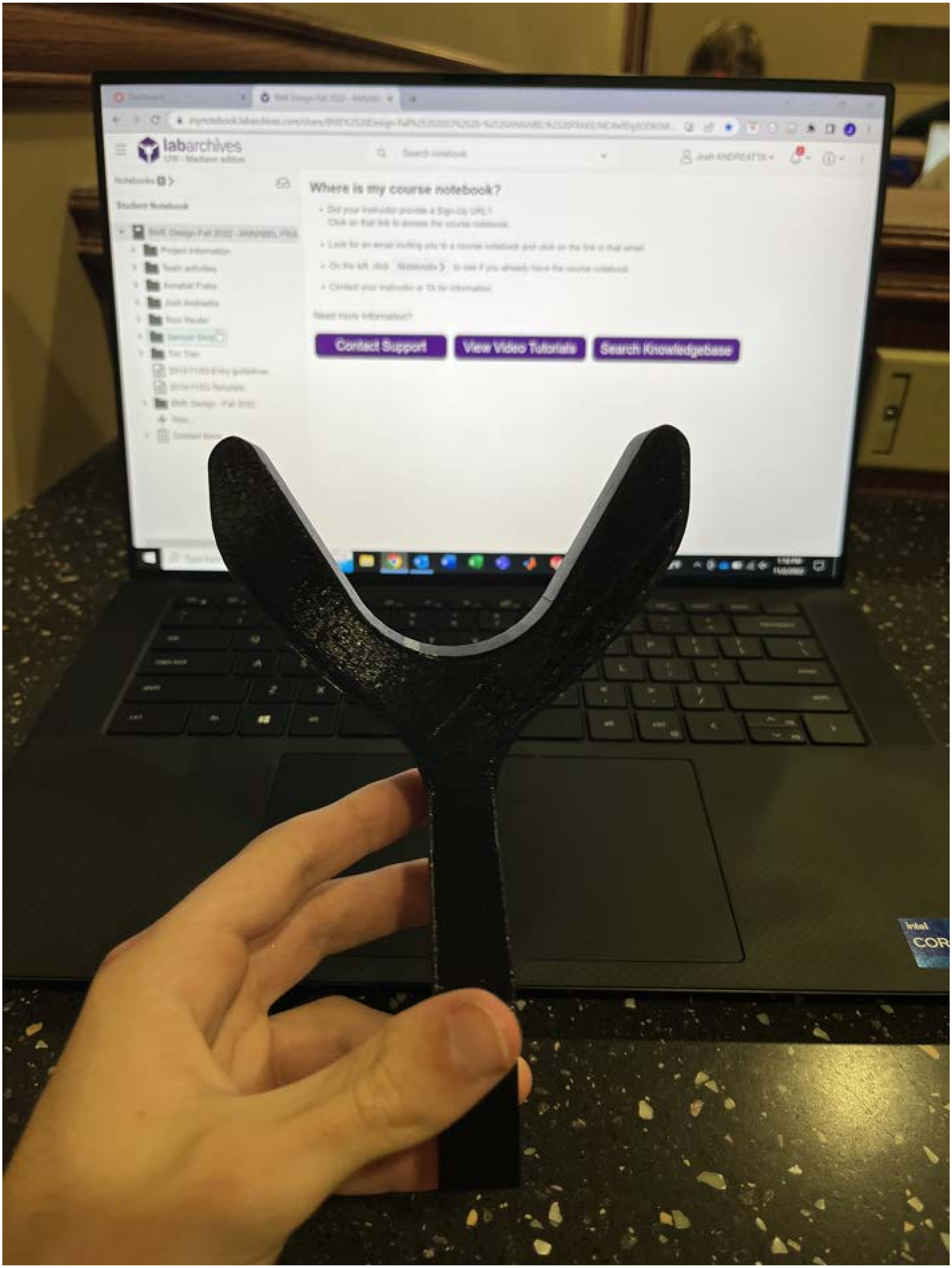
Content:

Today I picked up the initial prints from the MakerSpace and they all came out very well. The pulley plate cavity fits tightly around the right rower neck support arm and the wider handlebar cavity definitely makes it easier to fit the handlebar within. I may trim down the top of the cavity so that it doesnt stick super far above the handlebar (I can take off around an inch of material). The motor box came out very clean and Annabel will assemble the electronics within it to see how well everything fits together.

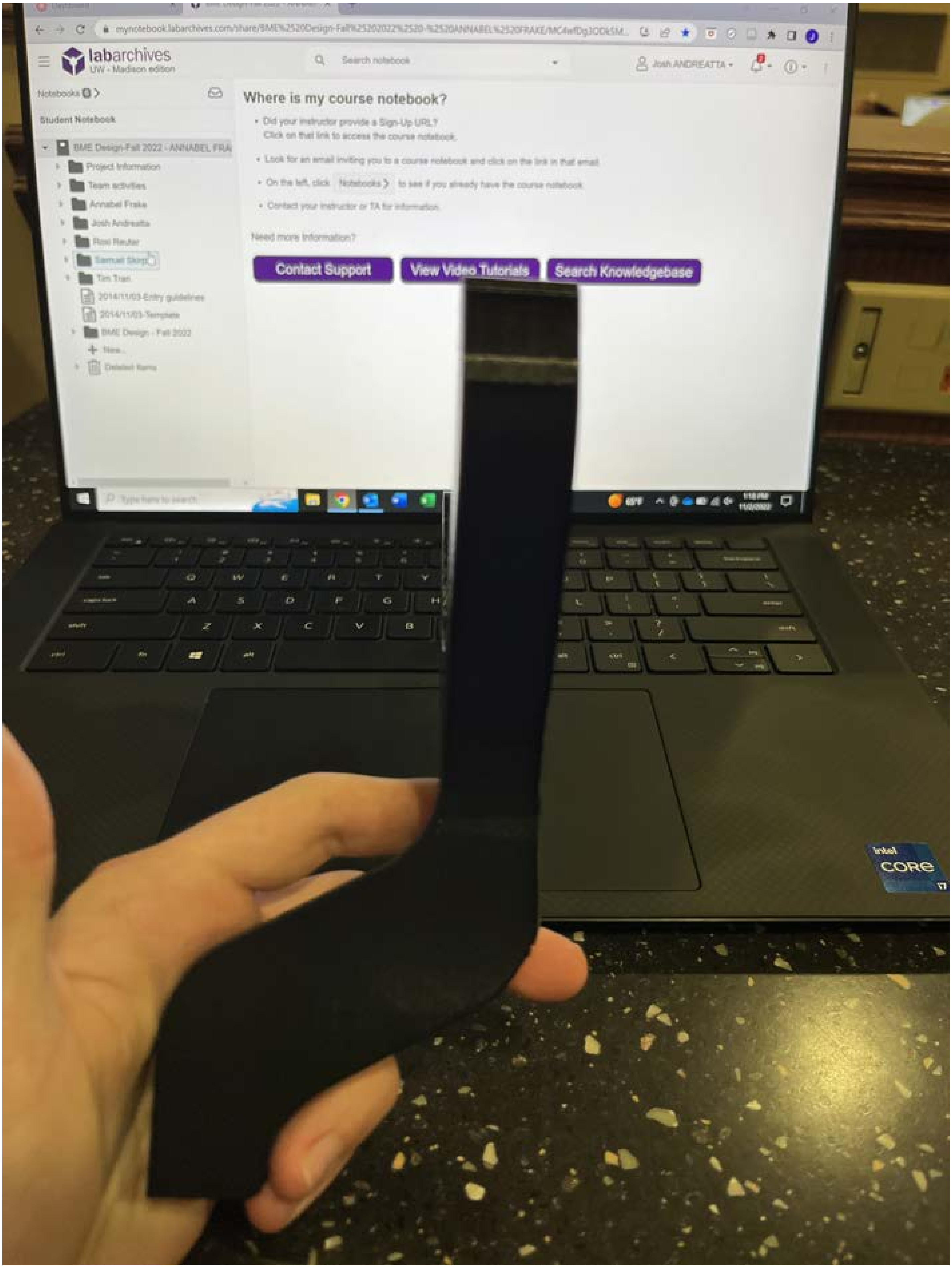
The above image shows a top view of the motor box with spaces for all the electrical components.



The above image shows the front angled view of the motor box.



The above image shows the increased and angled cavity for the handle bar on the new antler.


labarchives
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Josh ANDREATTA
Notebooks
Student Notebook
BME Design-Fall 2022 - ANNABEL FRA
Project Information
Team activities
Annabel Frake
Josh Andreatta
Rosi Reuter
Tim Tran
2014/11/03-Entry guidelines
2014/11/03-Template
BME Design - Fall 2022
Deleted Items
Where is my course notebook?
Did your instructor provide a Sign-Up URL?
Click on that link to access the course notebook.
Look for an email inviting you to a course notebook and click on the link in that email
On the left, click Notebooks to see if you already have the course notebook.
Contact your instructor or TA for information.
Need more information?
Contact Support
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The above image shows the side view of the updated antler which is now angled instead of a right angle.

The above image shows the updated console field goal post with a flag to hit the limit switches during rotation.

Potential Changes needed in SolidWorks:

- Adjustments to motor box
- Increase length of limit switch flag
- Shorten height of handlebar cavity
- Possibly make insert into console cavity thicker?

References: n/a

Conclusions:

The parts printed very clean and fit very nicely on the rower. Based off of annabel's feedback, I will make adjustments to the motor box and also adjust the height of the handlebar cavity. Once these adjustments are made and confirmed with the team, I should be able to go ahead and print the final version of the box and pulley plate antlers. Then I will construct and print the lid for the motor box.

Action items: Make adjustments, confirm changes, print final iteration

11/9/2022 - Update to Antlers and Motor Box

Josh ANDREATTA - Nov 09, 2022, 10:54 PM CST

Title: 11/9/2022 - Update to Antlers and Motor Box

Date: 11/9/2022

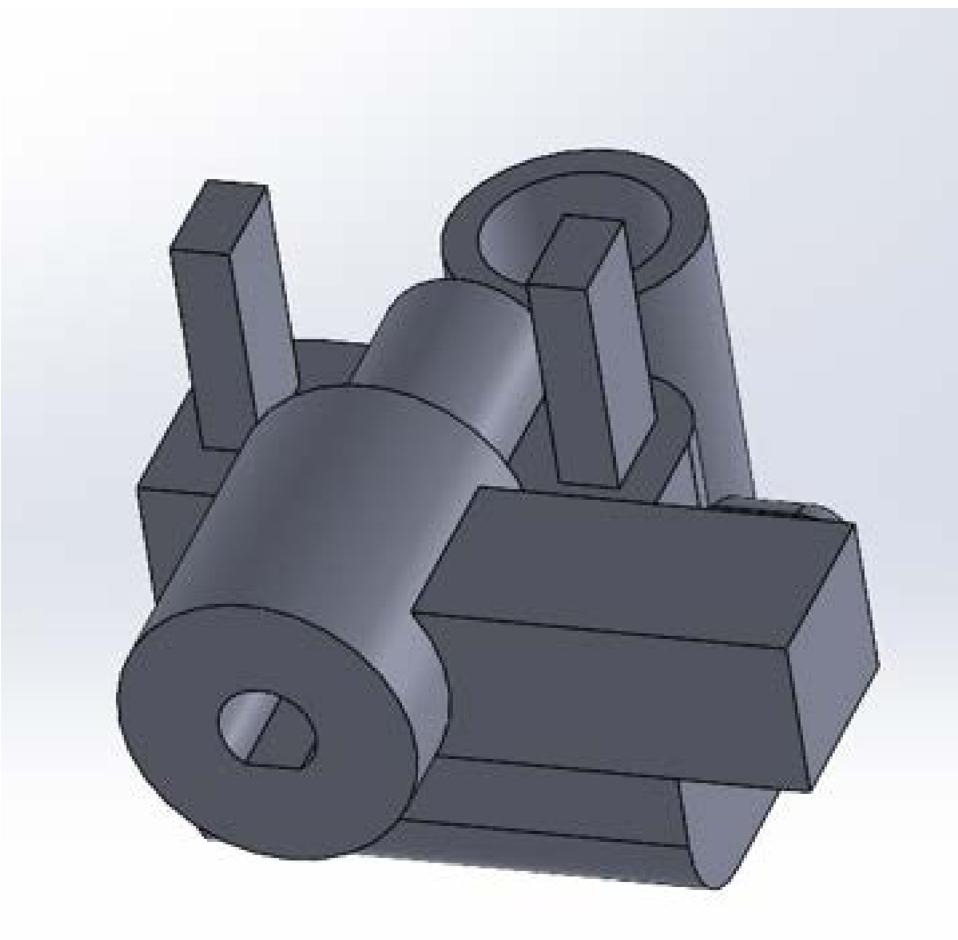
Content by: Josh Andreatta

Present: Josh Andreatta

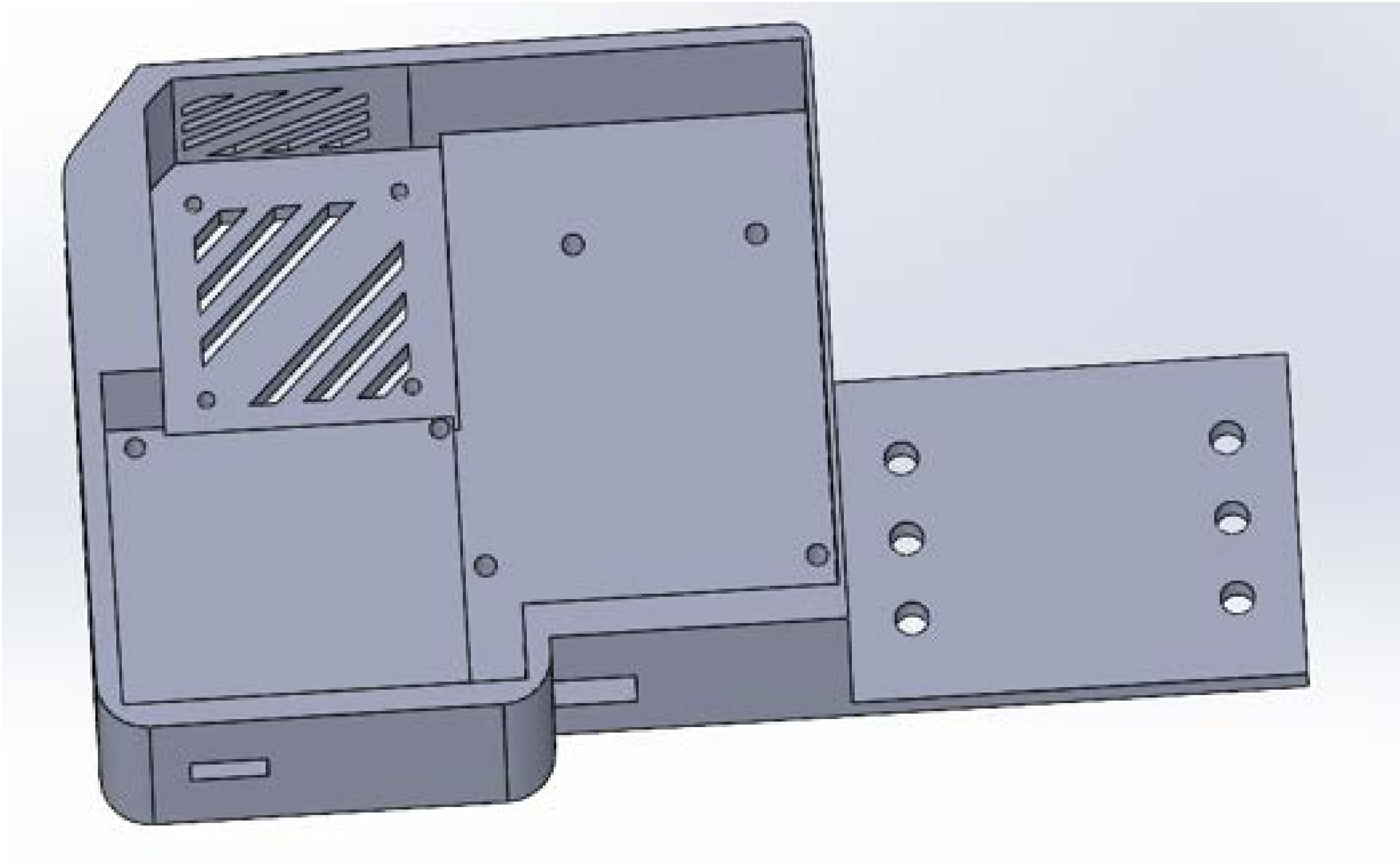
Goals: Make slight modifications to CAD design to reflect necessary changes

Content:

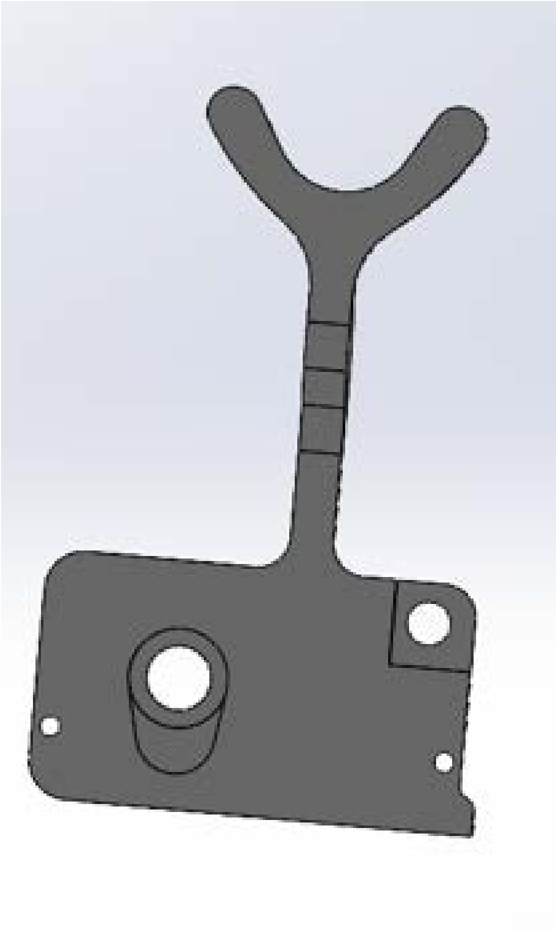
Today I made some changes to the solidworks models of the motor box, console field goal posts, and antlers to reflect changes we discussed about making after show and tell. To start, I trimmed the top of the antler cavity so that it did not hang up and over the handlebar as much - this makes it easier for the user to pull the handle bar out and replace it back into the cavity. Additionally, I added in the D-Shaft stepper motor that we are going to use instead of the cylindrical shaft stepper motor. I then made a new press fit cavity for this D-shaped shaft in the console field goal post, since Staci said that these work better than cylindrical ones. I also made the flag that hits the limit switches wider and longer so it is stronger. Finally, I adjusted the motor box by adding a little more clearance around the area where the stepper motor will sit. I also made sure to align the screw holes for the new stepper motor with the holes in the motor box floor. I also added space behind the arduino so that it can be slid into place. This was an issue before because the USB port needs to slide in a window, but the previous version didn't account for the fact that it will need to be slide into place, but now it does. These changes will help improve the overall fit and functionality of the motor box. Annabel is going to test the circuit with the console on friday to confirm all components. Once she does this, I will measure the exact widths and hole spacings for the arduino uno, motor controller and solder board, and relay and reflect these dimensions in the motor box. Then, I will make a lid to screw on top of the box. A preliminary final box will be printed to ensure all components fit, and then a final box and lid will be printed. When the final box and lid are printed, I will also print the final antlers and pulley plates. These are complete and should not require any further changes. Once they are printed, I will gather the necessary screws, and connect everything together and to the rower. Then I will complete SolidWorks stress simulations on the antlers and pulley plates and the motor box. This will then complete the SolidWorks portion of this semester's work for the motor box and pulley plate and antlers designs.



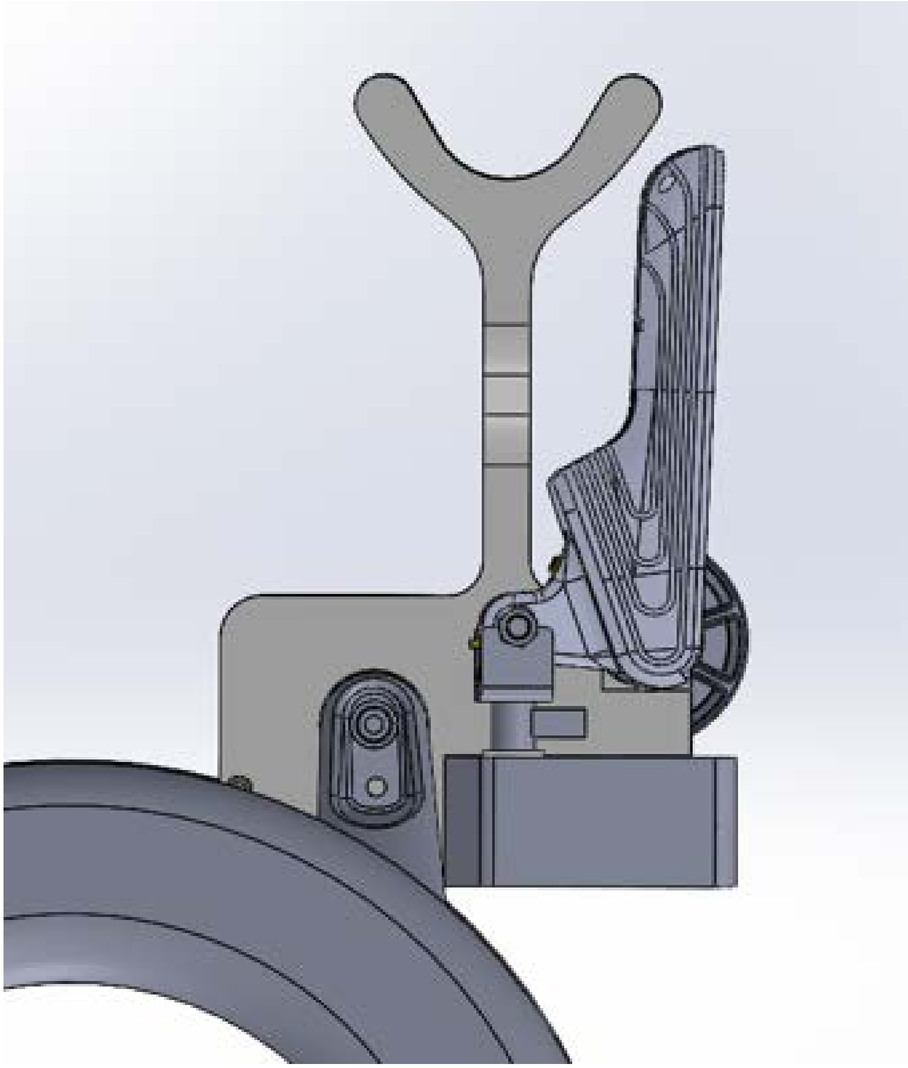
The above image shows the D-Shaft cavity and larger flag on the console field goal post.



The above image shows the updated motor box with the larger gap for the stepper motor, and space for the arduino uno to be slid in. Other changes will be coming soon.



The above image shows the shortened cavity antler tops.



The above image shows the side view of the assembly showing that the console does not hit the antlers during rotation.

References: n/a

Conclusions:

I will go over these changes with the team on friday, although they should already be aware of the modifications that I am making since we talked about them last friday after show and tell. These changes made today will improve the functionality of the antler design and improve the fit of the motor box. Further modifications for the motor controller + solder board and arduino uno will be made over the weekend once annabel confirms parts.

Action items:

-Print Left and Right Console Field Goal Post segments tomorrow so Annabel can test on Friday with them

-Once Annabel confirms motor controller, I will measure the widths and dimensions of the screw holes for the motor controller and arduino uno and relay. I will then add these into the motor box and make sure that the new motor controller + solder board fit along with the relay.

-Once these changes are confirmed with Annabel, I will print another version of the motor box

-Once the final motor box is ready, I will make a lid to screw on to the top and print the final version of both the lid and motor box. At this time I will also print the final version of the pulley prints, which should be completed now.

Josh ANDREATTA - Nov 09, 2022, 10:55 PM CST

Download

D_Shaft_Stepper_Motor.SLDASM (202 kB)

Josh ANDREATTA - Nov 09, 2022, 10:55 PM CST

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Motor_Arm_Assembly.SLDASM (6.63 MB)

Josh ANDREATTA - Nov 09, 2022, 10:55 PM CST

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Motor_Arm_Box.SLDPRT (10.1 MB)

Josh ANDREATTA - Nov 09, 2022, 10:55 PM CST

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Field_Goal_for_Console_Display_LEFTLEFT_Part.SLDPRT (206 kB)

Josh ANDREATTA - Nov 09, 2022, 10:55 PM CST

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Field_Goal_for_Console_Display_Right_Part.SLDPRT (184 kB)

11/11/2022 - Moving the Pulley Up & More Motor Box Modifications

Josh ANDREATTA - Nov 11, 2022, 5:42 PM CST

Title: Moving the Pulley Up & More Motor Box Modifications

Date: 11/11/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Update the CAD to include the most recent team changes

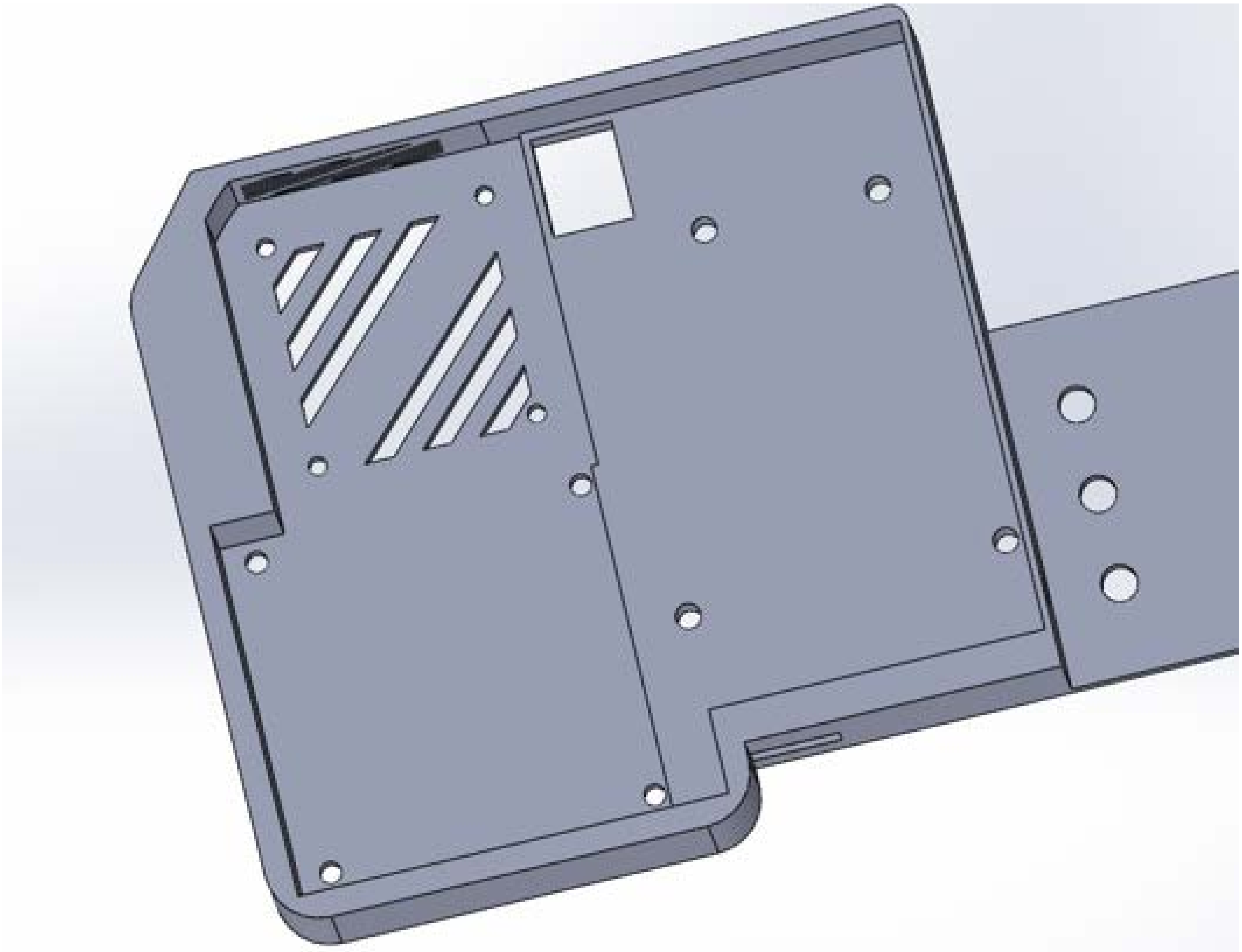
Content:

Today we met as a team and tried out the newest 3D prints and came up with some slight tweaks to continue to improve the design. First, the console field goal posts were a little too tight to fit into the console. The previous print was done at a low infill with the original diameter, and they were loose. For this print, I made them a 0.51in diameter instead of a 0.49 inch diameter, and printed on a higher infill, but this combined larger diameter and more infill made them too wide to fit. So, I changed it back to 0.49inch diameter and will just print that at 100% infill next time. Next, the D-Shaft cavity was a little to tight so here I widened it by 5% to make it tight but not so tight where we can't put it on the motor. These were the changes for the console.

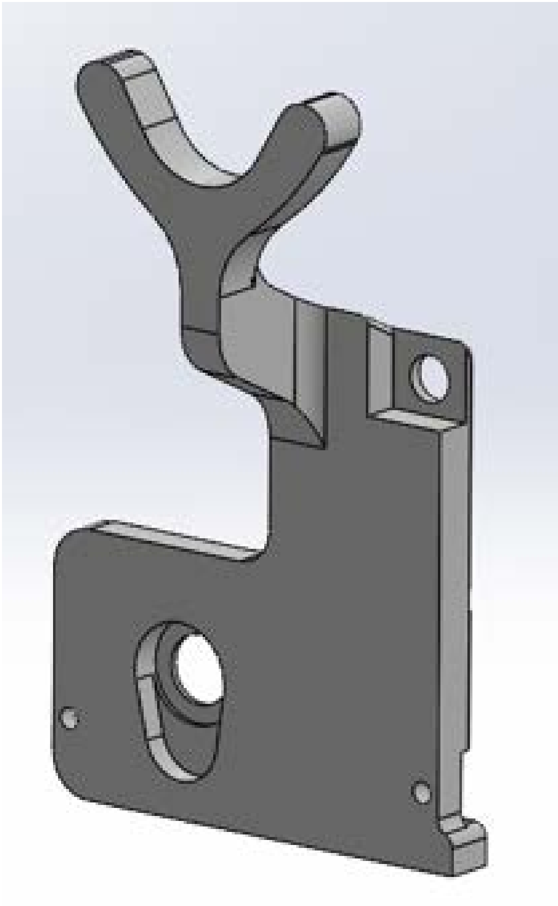
For the motor box, I measured the width of the power supply plug and moved the window for this plug to the bottom back of the motor box. This makes it more aesthetically pleasing because the cord just comes out of the bottom of the box and not the front. The user just has to plug it in from the bottom, and the gap is the size to allow for the plug. Next, I measured the arduino uno hole locations with a caliper and replicated those dimensions in the motor box to make the holes lines up. I will need to double check these with annabel again before printing just to make sure and not waste material on prints. Annabel is emailing staci and talking to the makerspace about getting a 2x2inch solder board or cutting one to that size. Once they do, I will measure where the screw holes are and adjust those in the motor box as well. These were the changes for the motor box.

The team was brainstorming and thinking that it may be easier to design the stabilization frame to bend down onto the users lap if the second pulley were placed vertically higher than it currently is. To reflect this, I made a change in the pulley plates that shifts the pulley up by about 4 inches. This can be undone incase we decide we dont want to do this, and I wont print the final plates until we make a decision. But for now, the change has been modeled so we can look at it and see what we think! These were the only changes for the pulley plate.

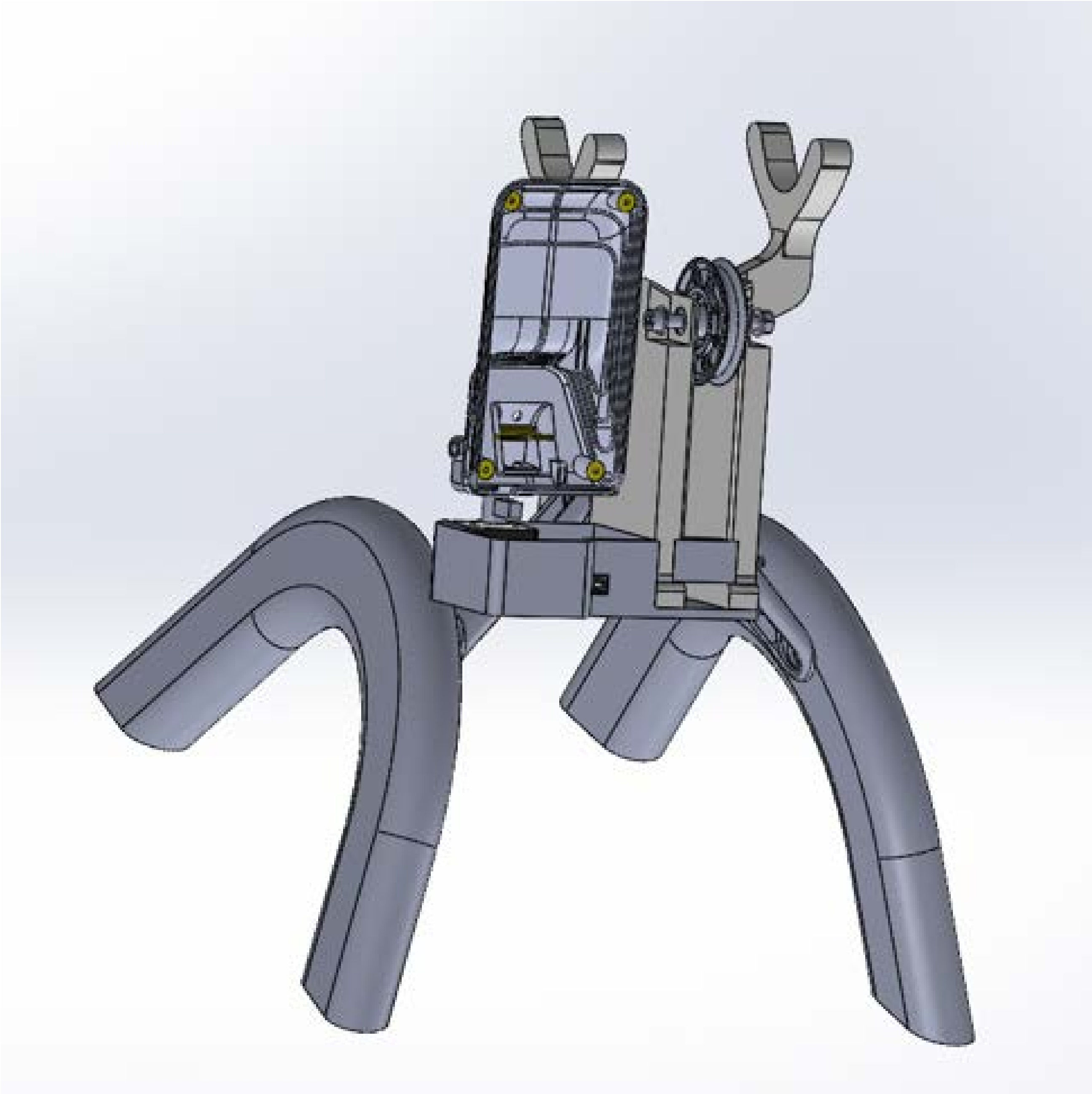
Please see below for images!



The above image shows the new motor box with newly placed arduino uno holes, the bottom back space for the power supply plug, and the space where the holes will be adjusted for the solder board.



The above image shows the pulley plate with the higher placed pulley.



The above image shows the front view of the entire assembly with both updated pulley plates and the newly placed pulley.

Once sam finishes his model of the stabilization frame, I will combine it with this model to ensure that it does not interfere with the second pulley or pulley plates while rowing.

References: n/a

Conclusions:

These changes allow for the ability to move the pulley vertically up to allow for more leverage when pulling the stabilization down if need be. Additionally, the changes should improve the fit of the arduino uno within the motor box.

Action items:

-Once sam sends me his stabilization frame file, I will combine it with my full assembly file to have one assembly of every component

-Confirm arduino measurements with Annabel Monday

-Confirm solder board measurements with Annabel Monday

-Print low in fill of motor box and new console field goal posts

-Make adjustments, then print final motor box, console field goal posts, and pulley plates.

-Make lid and find way to attach limit switches

-Me or Annabel to gather screws for motor box

Josh ANDREATTA - Nov 11, 2022, 5:43 PM CST

Download

Motor_Arm_Assembly.SLDASM (6.59 MB)

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Motor_Arm_Box.SLDPRT (10.1 MB)

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Field_Goal_for_Console_Display_LEFTLEFT_Part.SLDPRT (211 kB)

Josh ANDREATTA - Nov 11, 2022, 5:43 PM CST

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Field_Goal_for_Console_Display_Right_Part.SLDPRT (182 kB)

Josh ANDREATTA - Nov 11, 2022, 5:43 PM CST

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Left_Pulley_Support_Plate_Antler.SLDPRT (519 kB)

11/14/2022 - Initial Print of Motor Box Lid and Updates to Motor Box

Josh ANDREATTA - Nov 14, 2022, 4:51 PM CST

Title: Initial Print of Motor Box Lid and Updates to Motor Box

Date: 11/14/2022

Content by: Josh Andreatta

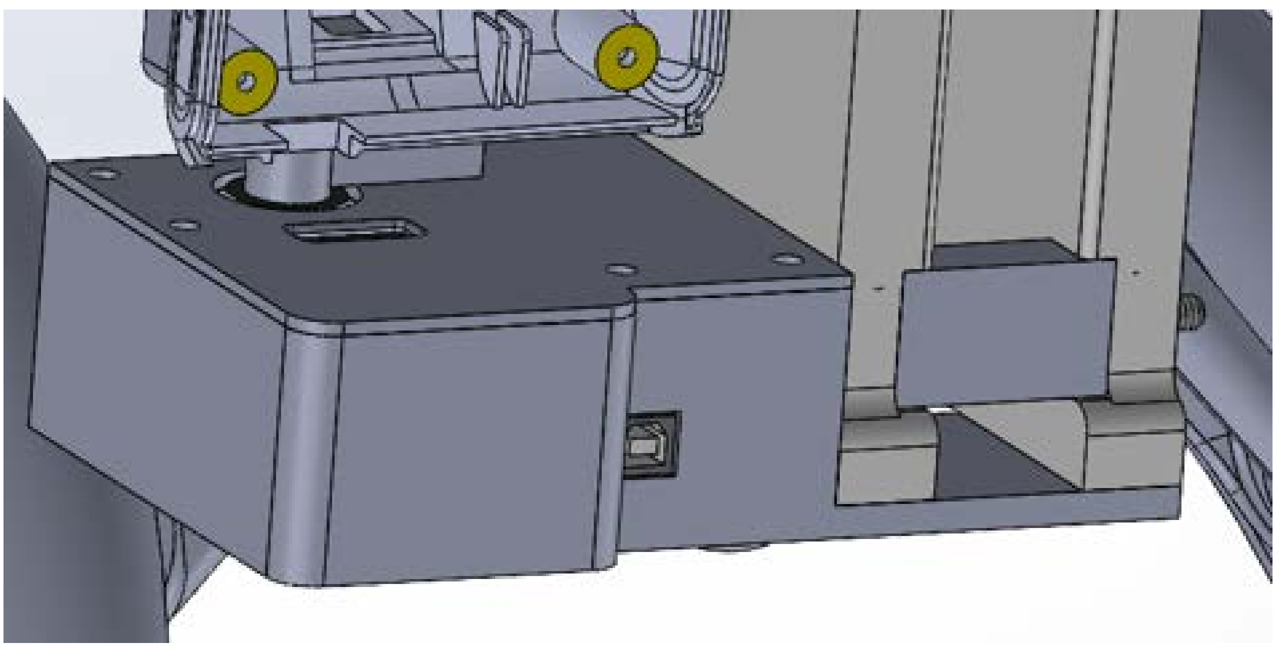
Present: Josh Andreatta

Goals: Make updates to motor box and develop initial motor lid

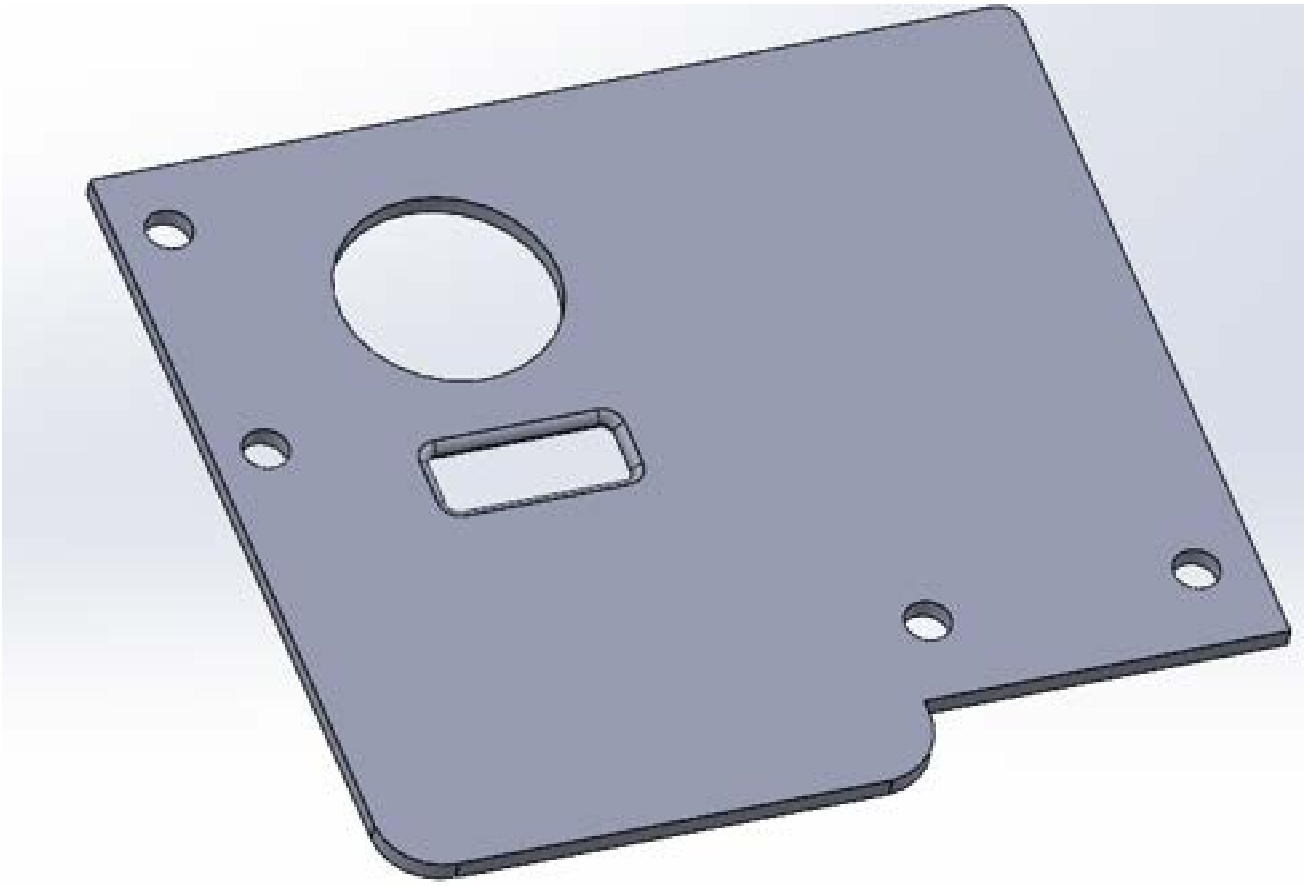
Content:

Today I met with annabel to confirm the placement that I had for the holes for the arduino uno and solder board. We used a caliper to double check the measurements and the dimensions that I made the holes in the model. I made all of the screw holes 1mm larger in diameter than they actually are to avoid having to tap the material, so now the screw should slide nicely through and hold everything rigidly in place. I then developed the initial lid for our motor box. This lid has 4 holes that screw into the motor box using 1/4-20 screws. It also has a hole for the motor shaft lift to fit in that way the console can fit snugly into this hole to rotate with the motor. I also made a square hole in the lid for the wires from the limit switches to enter into the motor box to connect to the solder board and the arduino uno. I printed these at the makerspace today and will be able to pick them up tomorrow. Hopefully, the lid will fit properly over the box and all of the electrical components will fit within the box and align with their screw holes. I will check this with annabel at the end of this week, and then make any final adjustments to screw hole placement. Hopefully I wont have to make any since I widened the screw holes slightly to allow for some slight inconsistent measurements. Once these final adjustments are made, I will complete the final 100% infill print of the motor box, motor box lid, and both pulley plates (with the pulley now lifted up higher). The only holes that will need to be tapped are the holes in the motor box for the motor box lid, and the holes in the bottom of the pulley plates for attaching the motor box. This will complete the solidworks modeling portion of this semester, and the final step will be to complete the solidworks simulation tests during thanksgiving.

Please see below for images.



The above image is the assembly with the covered motor box, concealing our electrical components.



The above image shows the motor box lid with the screw holes, motor shaft hole, and limit switch wire holes.

References: n/a

Conclusions:

These prints should hopefully allow all of the electronics to fit within the box. Once the print is complete, I will assess how everything fits and make final adjustments until the print is ready for the final version.

Action items:

-Pick up print on Tuesday

-Organize and pick up screws on thursday

-Meet with Annabel Thursday or Friday to assess fit of electronic components

Josh ANDREATTA - Nov 14, 2022, 4:52 PM CST

Download

Motor_Arm_Assembly.SLDASM (6.62 MB)

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Download

Motor_Arm_Box.SLDPRT (10.4 MB)

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Motor_Box_Lid.SLDPRT (301 kB)

Josh ANDREATTA - Nov 14, 2022, 4:52 PM CST

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Field_Goal_for_Console_Display_LEFTLEFT_Part.SLDPRT (209 kB)

Josh ANDREATTA - Nov 14, 2022, 4:52 PM CST

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Field_Goal_for_Console_Display_Right_Part.SLDPRT (182 kB)

11/22/2022 - List of Needed Screws

Josh ANDREATTA - Nov 22, 2022, 4:47 PM CST

Title: 11/22/2022 - List of Needed Screws

Date: 11/22/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: List needed screws to fabricate motor box

Content:

Motor Box Lid:

- 4 1/4-20 x 0.8in

Solder Board:

- 2 #5 x .6in

Arduino Uno:

- 4 #5 x .6in

Pulley Plate:

- 6 1/4-20 x 0.75in

Separation Blocks:

- 2 1/4-20 x 3 inch

Stepper Motor: Already have

Limit Switches: TBD - ask Annabel

References: n/a

Conclusions:

These screws are needed to assemble everything. I will get these from the TEAMLab on Monday after thanksgiving and use my red pass to tap and drill out any holes that are needed for assembly.

Action items:

-Get screws

-Tap/drill out necessary holes

-Assemble

11/28/2022 - Integration of 3D prints with Rower

Josh ANDREATTA - Nov 28, 2022, 8:32 PM CST

Title: 11/28/2022 - Integration of 3D prints with Rower

Date: 11/28/2022

Content by: Josh Andreatta

Present: Josh, Sam, Annabel

Goals: Assemble 3D prints on rower

Content:

Today I met with Sam and Annabel to assemble the 3D prints with the rowing machine. To do this, I used a tap to tap all of the necessary holes out of the motor box, motor box lid, and pulley plates. Then, I gathered all the needed screws from the TEAMLab (which was free because it was under $5). Then, we assembled. The pulley plates fit well onto the rower neck arm supports. I was able to insert the back separation block (which is closer to the standard side) and tighten it to help push the plates apart. Next, we screwed in all of the electronic components to the motor box. For some reason, Annabel's arduino wasn't working with the one we ordered, so we are using her personal one in the mean time. Since it has different screw holes, we are waiting to drill and tap the holes for the arduino until this issue is fixed. For now, we are just going to tape the arduino in place and do the holes later next semester. I was able to attach the motor box to the bottom of the pulley plates. There is still a slight gap and a slight bending of this support surface of the motor box, likely due to some inconsistencies in the tapping of the holes between the motor box and the pulley plate. Due to this gap, I was unable to insert the screw for the front separation block. However, I do not think this is a big deal for us because the pulley plates are already very secure due to the back separation block and being tightened in general around the original pulley. Lastly, we are deciding to just hot glue the limit switches in place this semester. This is because the flag on the motor hits the screw heads that screw the lid into place, and the limit switch won't fit. Thus, we will eventually need to find a better place to screw in the lid so that it doesn't impede the ability to contact the limit switches. Additionally, the console field goal post still is not tight enough within the console so I made it thicker and will reprint it tomorrow morning until we get the proper fit/tightness to hold the console upright statically and dynamically. The handlebars fit very nicely in the antlers and are easy to grab from both sides of the rower. Below is a list of issues we are dealing with this semester, and what we will fix for next semester at the start.

Items we are dealing with this semester:

-Taping the arduino in place

-Taping the motor box lid close, because they motor flag hits the screw heads where the limit switches need to be pressed

-Hot gluing the limit switches in place

-Slight gap between motor box and pulley plate = no front separation block

-Extremely slight forward rotation of pulley plates when rowing

To fix at start of spring semester:

-Correct arduino issue. Then tap, drill, and screw in arduino to motor box.

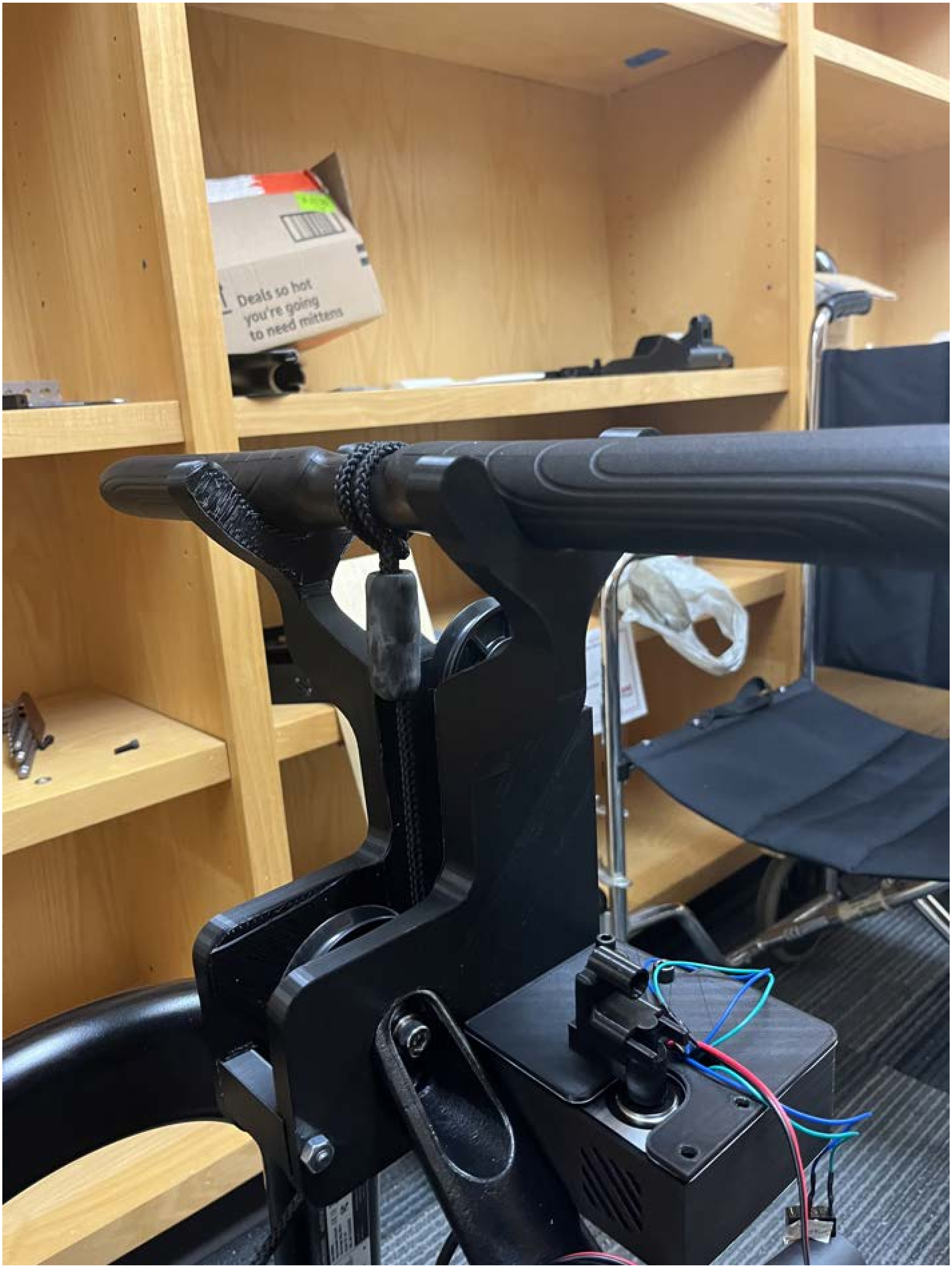
-Modify motor box/motor box lid to screw in place in a different location. so the flag doesn't hit the screws as its trying to hit the limit switches.

-Once above done, screw in limit switches.

-Possibly improve gap between motor box and pulley plates, but not absolutely necessary.

-Drill a second hole in pulley plates (carefully measure first) to help limit forward rotations while rowing.

The above image shows the front view of the assembled rower, with the handlebar in the antlers, and the motor box secured to the pulley plates.



The above image shows the back view of the assembly, showing the back separation block, and the back view of the motor box.

References: n/a

Conclusions:

The 3D prints work very well together. They integrated smoothly into the rest of the rowing machine. Although there are still some final areas for improvement, the current prints will be able to function for this semester and we will target to fix the final issues at the start of next semester, since they don't hinder performance - they would only improve it.

Action items:

-Print console field goal posts tomorrow morning and until they fit correctly

-Meet with team Thursday at 3pm to test motion capture of stabilization frame and circuit

-Assign final report and poster sections thursday at meeting

-Work on report/poster over weekend

-At start of spring semester: Fix above 3D print issues, complete physical testing of motor box and antlers, and then work on resistance dial.

11/19/2022 - Pulley Plate, Antler, and Motor Box Simulation Testing

Josh ANDREATTA - Nov 19, 2022, 11:23 AM CST

Title: 11/19/2022 - Pulley Plate, Antler, and Motor Box Simulation Testing

Date: 11/19/2022

Content by: Josh Andreatta

Present: Josh Andreatta

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

Content:

A solidworks simulation was conducted to analyze the stresses and displacements acquired due to a maximum, worst case load. In order to properly test the strength and geometry of the pulley support plates, the plates were modeled as Tough PLA in SolidWorks. This was done by creating a new material and altering the mechanical properties as shown in **Figure #**. This ensured that the stress and displacement data that was acquired was representative of the material that the plates were printed in. To test the strength of the pulley support plates, a maximum load of 1050 N was applied to the inner circular cavity on each plate where the pulley is connected to the plates. According to the PDS in **Appendix #**, this would be the maximum load applied to the additional pulley under maximum rowing effort. Ideally, this load would be transmitted equally to each pulley plate. Thus, this load has a safety factor of two, and represents the maximum loading of the plates [source from zotero]. To model a worst case scenario, the load was applied directly downward onto this cavity. This is where the plate sits on the additional pulley bearing. Thus, if any force were directed onto the pulley plates, it would be transmitted to this inner cavity surface. During a typical rowing motion, tension in the rope follows along a path parallel to the floor. Thus, the worst case scenario was modeled as the maximum load placed on the plates perpendicular to the floor. The cavity that sits on the rower neck support arms and the two faces in which the front and back separator blocks are rigidly screwed into the pulley plates were held fixed during the simulation to model the plates when sitting on these support arms and being pushed apart by the separator blocks, as they should not move. Testing of the stresses and displacements that develop revealed the strength and rigidity of the chosen material and geometry of the support plates, which in turn revealed how well the plates stabilized the additional pulley under typical rowing conditions.

Next, another solidworks simulation was conducted to analyze the stresses and displacements acquired due to a maximum, worst case load on the new antlers added to the pulley plates. To simulate this worst case loading, the same 1050N load (with a safety factor of two) was applied to two locations. First, this load was applied to the slanted edge of the inner surface of the handlebar cavity on the standard side of the rower directed towards the standard side of the rower. Next, the load was applied to the slanted edge of the inner surface of the handlebar cavity on the adaptive side of the rower directed towards the adaptive side of the rower. The plates were again held rigidly fixed at the two faces in which the plates contact the separator blocks and the cavity where the plate sits on the rower neck support arm. This loading simulates the worst case scenario of a user pulling directly on the handlebar while it is still sitting within the antler handlebar cavity. By placing the loads on either side of this cavity and directing the load to either the standard or adaptive side, this simulation will predict how the antlers will react to an excessive load being applied from either the standard or adaptive side of the rower.

Lastly, a final solidworks simulation was conducted to analyze the stresses and displacements due to a maximum, worst case load on the motor box. To simulate this worst case loading, a 50N force was directed downward on the bottom surface of the motor box. This simulates any weight from the electronics, console, or the user slightly pressing down on the box to be directed directly down on the box. The box was held rigidly fixed where it is screwed into the two pulley plates. A 50N force was arbitrarily chosen because the motor box is not expected to experience more than 5lbs of weight being placed on it at any time. Thus, by applying a 50N force (11.24 lbs), the box was tested with a safety factor of 2.25 to ensure its strength and rigidity under both normal and extreme loads. The box was also modeled as Tough PLA to mimic the actual material properties of the material it will be 3D printed out of.

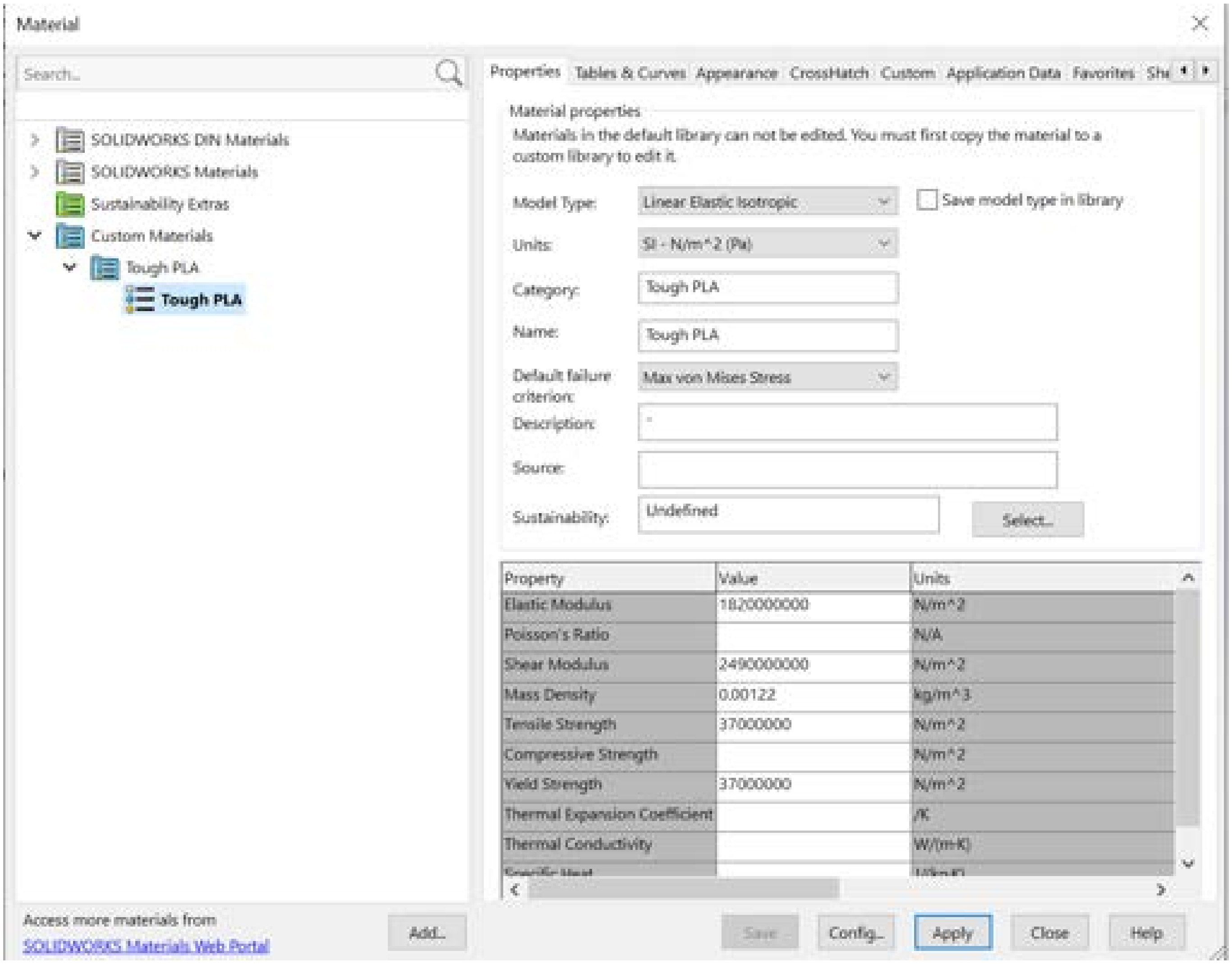


Figure #. Tough PLA. The above image shows the material specifications used to try to mimic Tough PLA according to the Ultimaker Technical Data Sheet for Tough PLA.

To further enhance the rigidity of these plates, when printing, I will use a 100% infill so that the plates are entirely solid Tough PLA, with little gaps between the layers. This will improve the performance under high loading conditions, and greatly reduce the deformations predicted by the solidworks simulations.

Simulation testing for the pulley plates was only conducted on the Left Pulley Plate because the left and right plates are exact mirror images of each other and will thus perform identically. After completing the SolidWorks simulation testing on the pulley plates, the resulting stresses and displacements were analyzed to determine the strength of the Tough PLA material and the designed geometries. After applying a 1050 N load to the inner bearing surface of the pulley plates, a maximum displacement of 1.757 mm occurred at the top of the antler handlebar cavity (**Figure #**). This was expected because the region in which the load was applied is thin. However, since this cavity is supported by a thick base of Tough PLA material below it, the cavity itself did not deflect excessively. Rather, the less supported antler deflected more because it has the least amount of structural integrity, and this is why the tips of the handlebar cavity deflected the most. This displacement is incredibly small, and will likely be even less during actual load bearing, due to the metal pulley bearing being inserted into this cavity and accepting some of the applied load. Throughout the rest of the plate, displacements were also less than 1.757 mm, proving that the geometry for both plates will be strong enough to withstand typical rowing loads. Additionally, the maximum stress that developed under this maximum load was only 18.36 MPa (**Figure #**). This is much less than the yield strength of Tough PLA of 37 MPa [12]. This maximum stress developed along the inner surface of the bearing cavity where the load was directly applied. This was expected because when the load is applied, the cavity would want to fold in on itself. Loading with a safety factor of two shows that both pulley support plates will be able to withstand loads well under this maximum, like the loads experienced during typical rowing, and thus should hold the additional pulley stable.

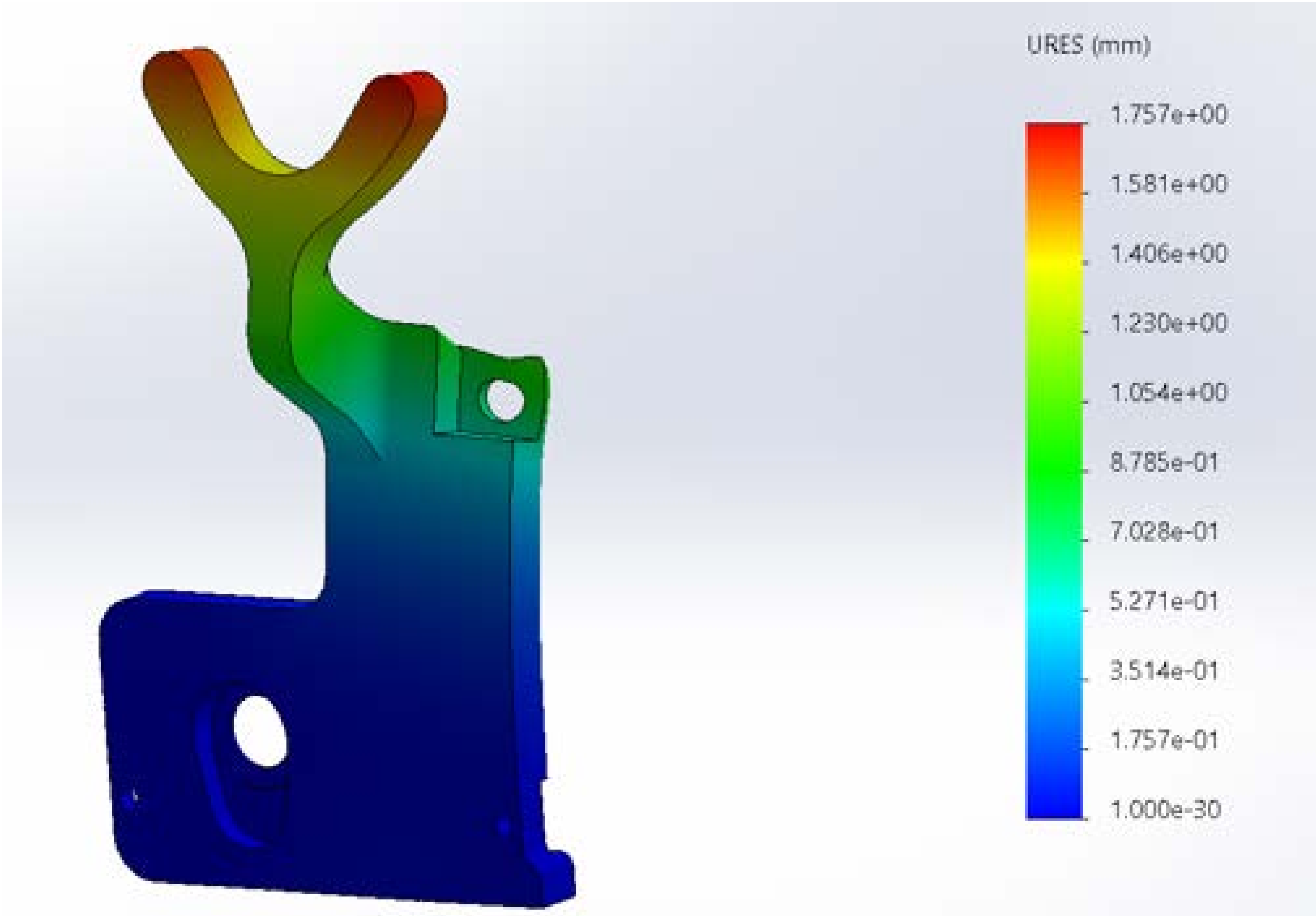


Figure #. Pulley Plate Deformation. The pulley plate deforms the most at the tips of the antler handlebar cavity due to having the least amount of structural integrity.

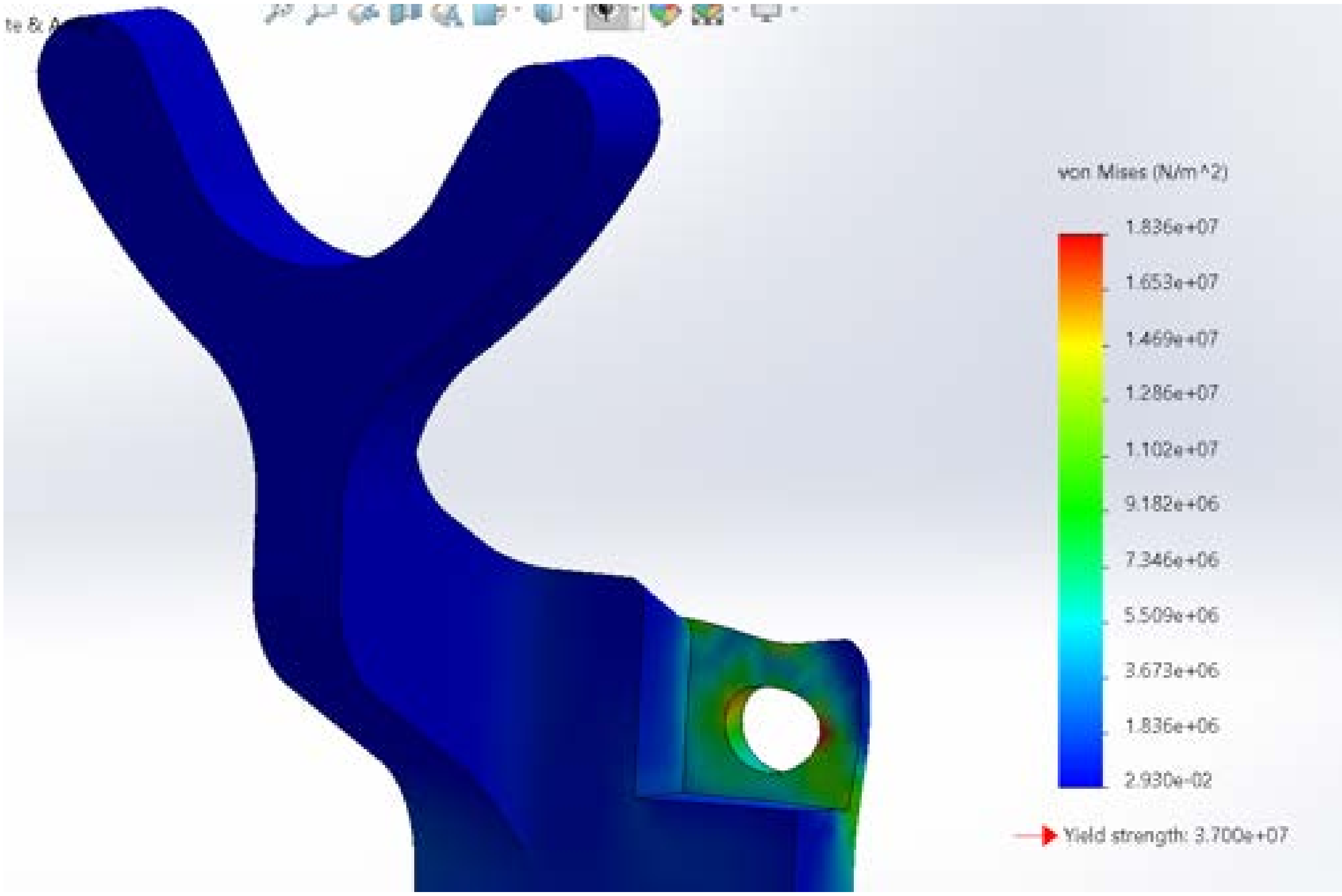


Figure #. Pulley Plate Stress. The pulley plate develops the largest stress concentration at the outer edge of the center of the cavity in which the load was applied due to the cavity wanting to fold in on itself.

After completing the SolidWorks simulation testing on the antlers, the resulting stresses and displacements were analyzed to determine the strength of the Tough PLA material and the designed geometries. After applying a 1050 N load to the slanted edge of the inner surface of the handlebar cavity on the standard side of the rower directed towards the standard side of the rower, a maximum displacement of 29.46 mm occurred at the top of the antler handlebar cavity (**Figure #**). This was expected because the region in which the load was applied has a relatively weak structural integrity when compared with the rest of the pulley plate. Thus, when an excessive load such as 1050N is applied, this region will be likely to fail. Throughout the rest of the antler, displacements were greater than 6mm. However, since the antler will be printed out of a completely solid Tough PLA structure, the actual deformation of the handlebar cavity is likely to be much less than predicted. Additionally, the maximum stress that developed under this maximum load was 110.7 MPa (**Figure #**). This is much greater than the yield strength of Tough PLA of 37 MPa [zotero]. This maximum stress developed along the slanted surface of the antler which supports the handlebar cavity. This was expected because when the load is applied, the antler arm would want to bend away from the plate and fracture.

After applying a 1050 N load to the slanted edge of the inner surface of the handlebar cavity on the adaptive side of the rower directed towards the adaptive side of the rower, a maximum displacement of 29.57 mm occurred at the top of the antler handlebar cavity (**Figure #**). This was expected because the region in which the load was applied has a relatively weak structural integrity when compared with the rest of the pulley plate. Thus, when an excessive load such as 1050N is applied, this region will be likely to fail. Throughout the rest of the antler, displacements were greater than 6mm. However, since the antler will be printed out of a completely solid Tough PLA structure, the actual deformation of the handlebar cavity is likely to be much less than predicted. Additionally, the maximum stress that developed under this maximum load was 111.5 MPa (**Figure #**). This is much greater than the yield strength of Tough PLA of 37 MPa [zotero]. This maximum stress developed along the slanted surface of the antler which supports the handlebar cavity. This was expected because when the load is applied, the antler arm would want to bend away from the plate and fracture.

Thus, the predicted stresses and loadings for both loading conditions of the antlers are very similar to one another. Despite the excessive deformations and stresses that the simulation predicts, the antlers are likely to actually experience a much smaller magnitude of force, which would greatly reduce their deformations and stresses. This is because users are not likely to being rowing with the handlebar still placed in the cavity. Rather, users are more likely to pull strongly on the handlebar by accident, which would be a force much less tha 1050N. Finally, the antlers will be made out of a 100% infill structure of Tough PLA. This extra infill will greatly increase the structures rigidity and therefore reduce the experienced deformations and stress concentrations. The antlers are predicted and likely to perform as intended under typical loading conditions, but are likely to fail under very extreme loading scenarios. Due to the limitations of simulating worst case loadings and accurately representing material properties, future testing will include physical failure tests to record the actual failure force required to fracture the antlers.

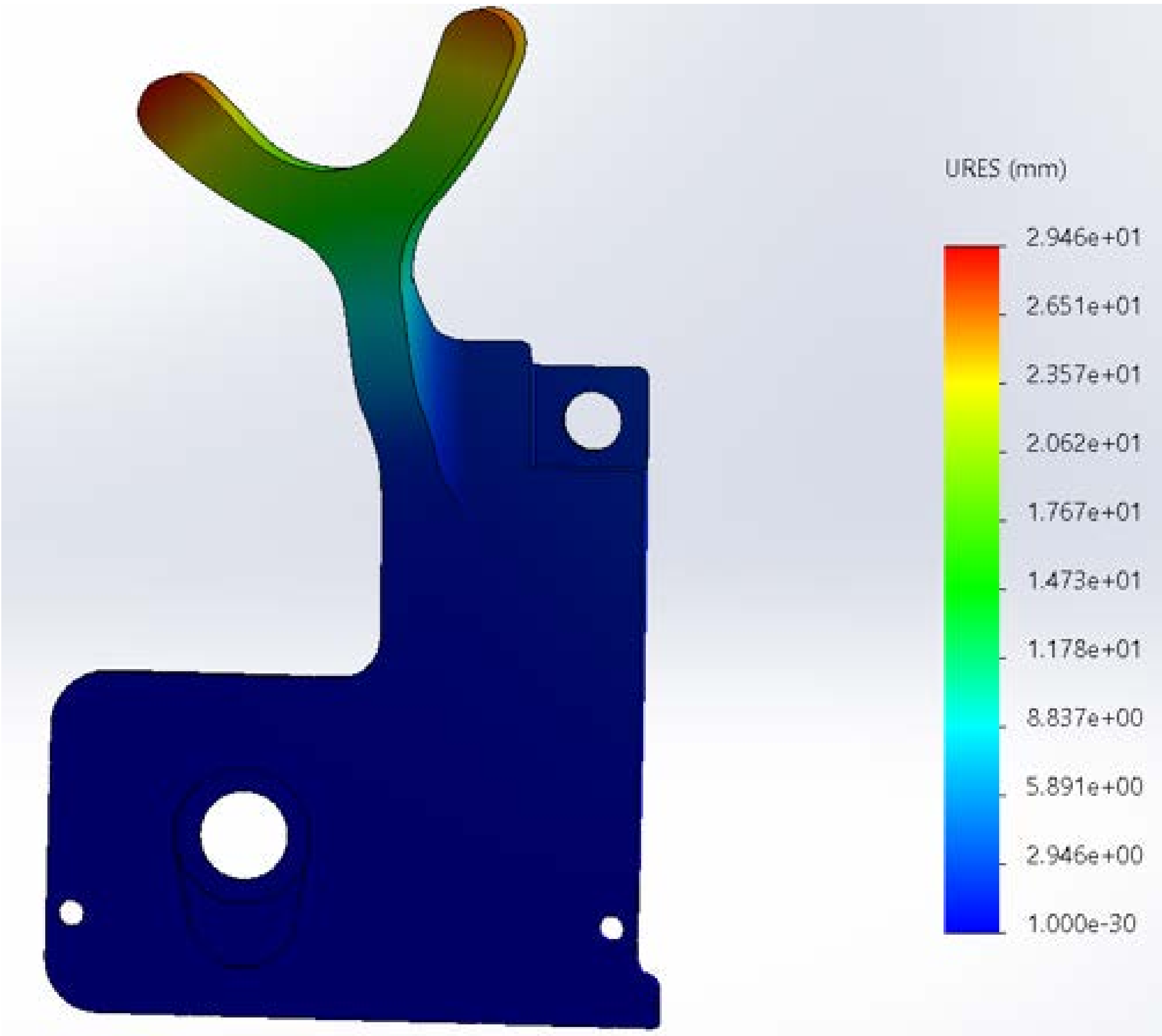


Figure #. Antler Standard Side Deformation. The antler deflects almost 30mm towards the standard side of the rower when subject to a very high and extreme load.

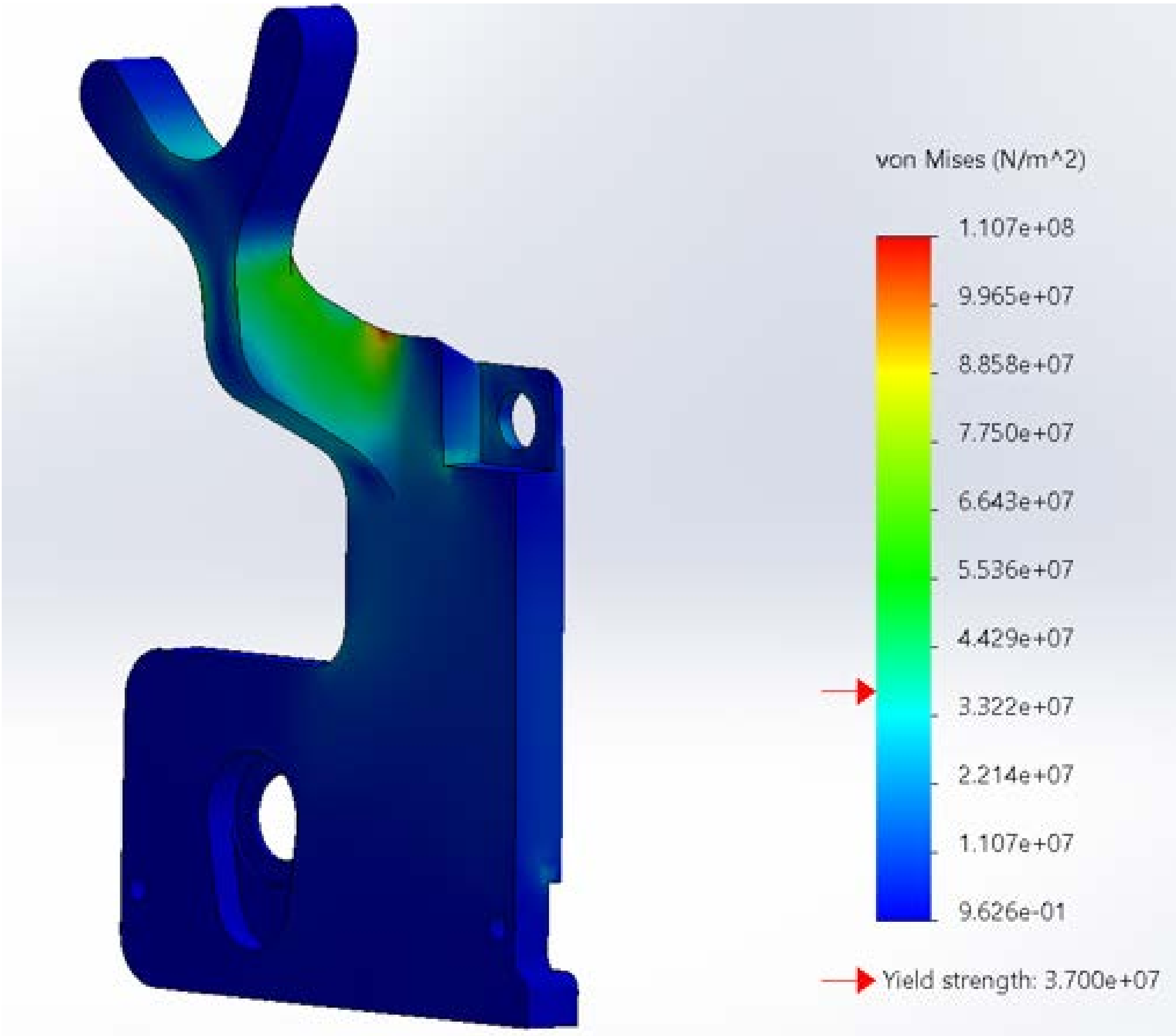


Figure #. Antler Standard Side Max Stress. The antler develops significant stress in the arm of the antler support under extremely high and excessive loading, causing the structure to fail under this given loading scenario.

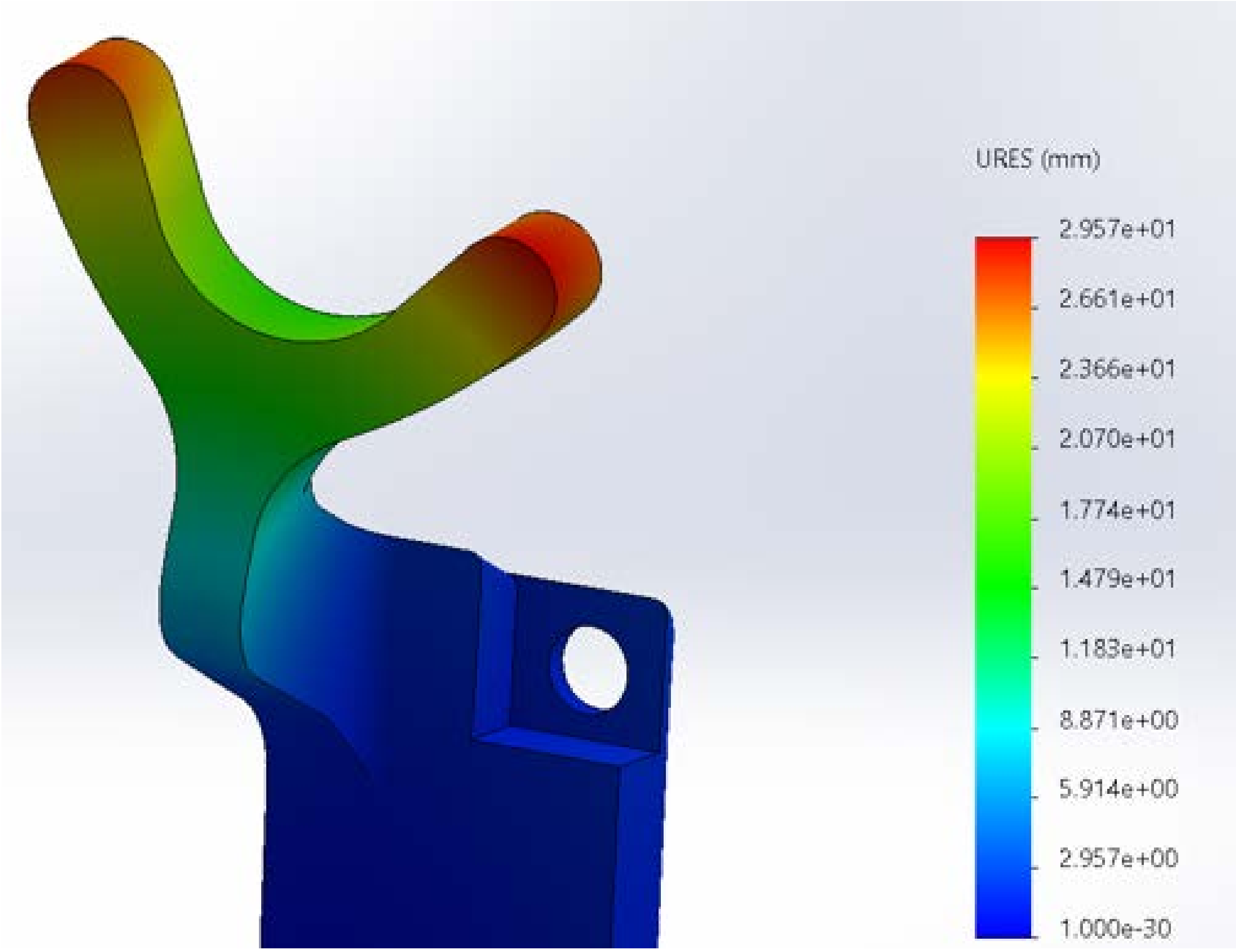


Figure #. Antler Adaptive Side Deformation. The antler deflects almost 30mm towards the adaptive side of the rower when subject to a very high and extreme load.

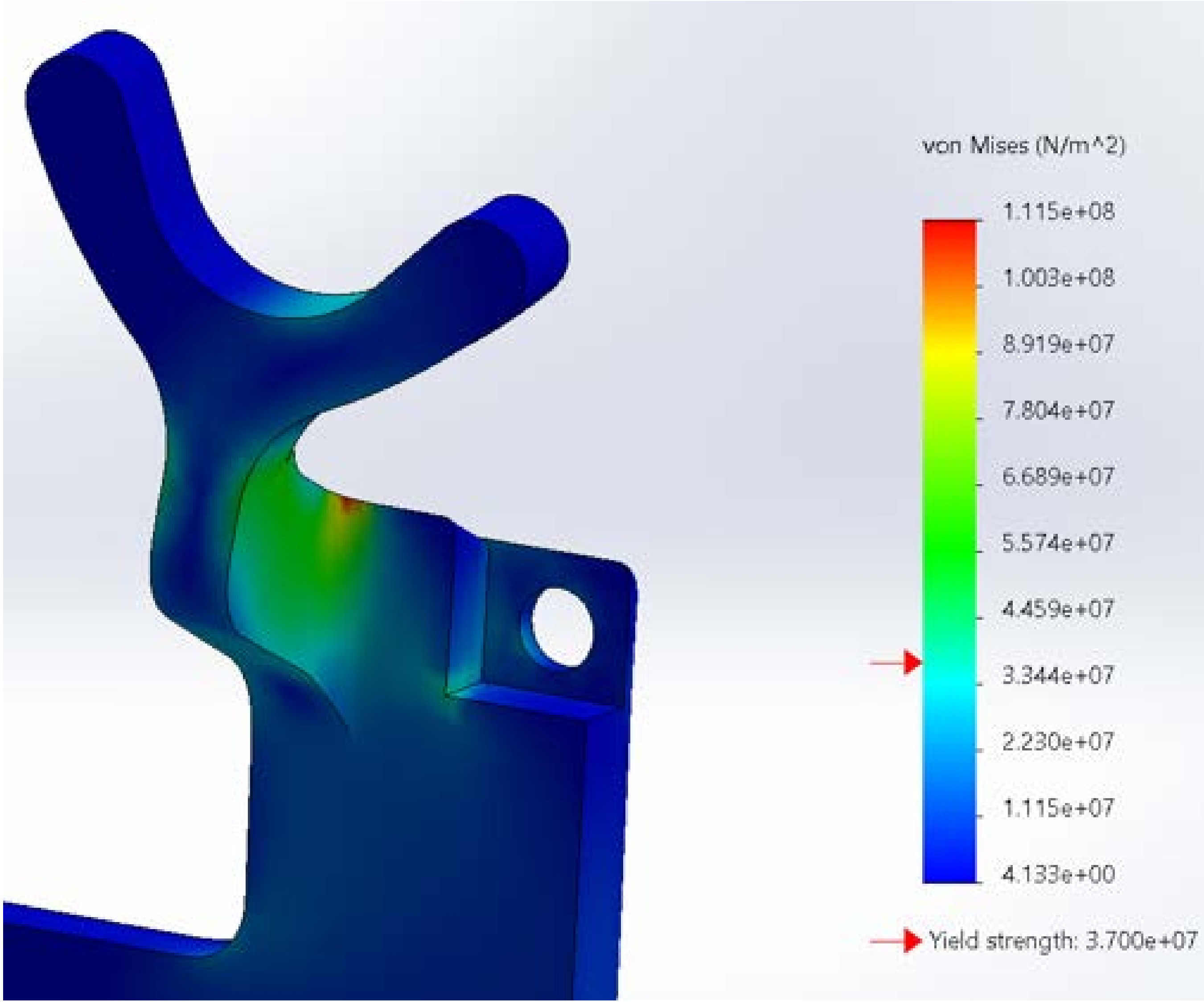


Figure #. Antler Adaptive Side Max Stress. The antler develops significant stress in the arm of the antler support under extremely high and excessive loading, causing the structure to fail under this given loading scenario.

After completing the SolidWorks simulation testing on the motor box, the resulting stresses and displacements were analyzed to determine the strength of the Tough PLA material and the designed geometries. After applying a 50 N load to the bottom surface of the box, a maximum displacement of 0.9422 mm occurred at the left side of the box (**Figure #**). This was expected because since the box is rigidly connected to the underside of the pulley plates, it is likely to bend more the further the material is away from this fixed location. Thus, the left side of the box deflected the most. Throughout the rest of the plate, displacements were also less than 0.9422 mm, proving that the geometry for the box will be strong enough to withstand typical external loads. Additionally, the maximum stress that developed under this maximum load was only 5.559 MPa (**Figure #**). This is much less than the yield strength of Tough PLA of 37 MPa [12]. This maximum stress developed along the edge where the structure first is able to bend from where it is rigidly connected to the underside of the pulley plates. This was expected because when the load is applied, the box will begin to kink at this location. Loading with a safety factor of 2.25 shows that the motor box will be able to withstand loads of the console, electronics, and extra downward directed forces, such as from the user pressing down slightly on the console when pressing a button, without fracturing or deforming excessively.

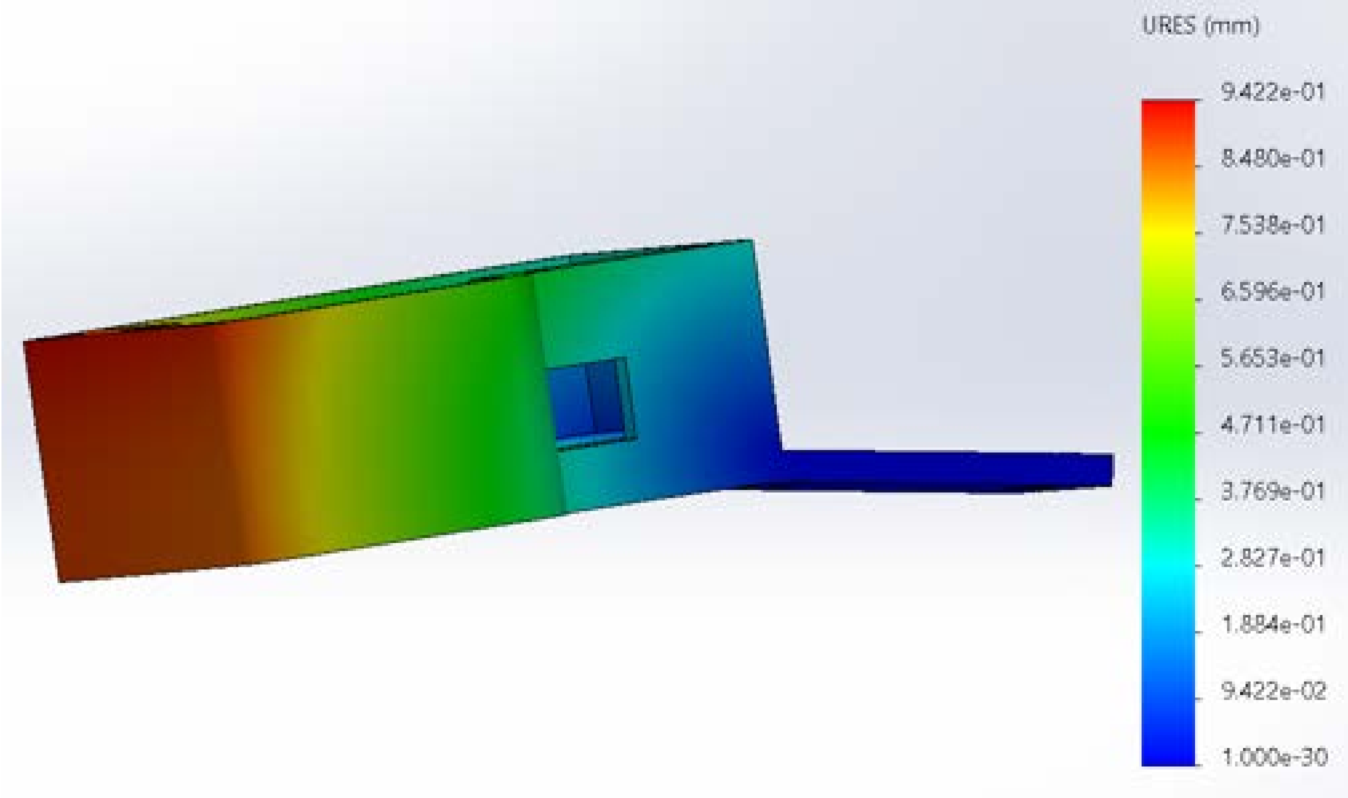


Figure #. Motor Box Deformation. The motor box deflects less than 1mm under a worst case loading, proving it is likely to succeed in holding the weight of our designed circuit.

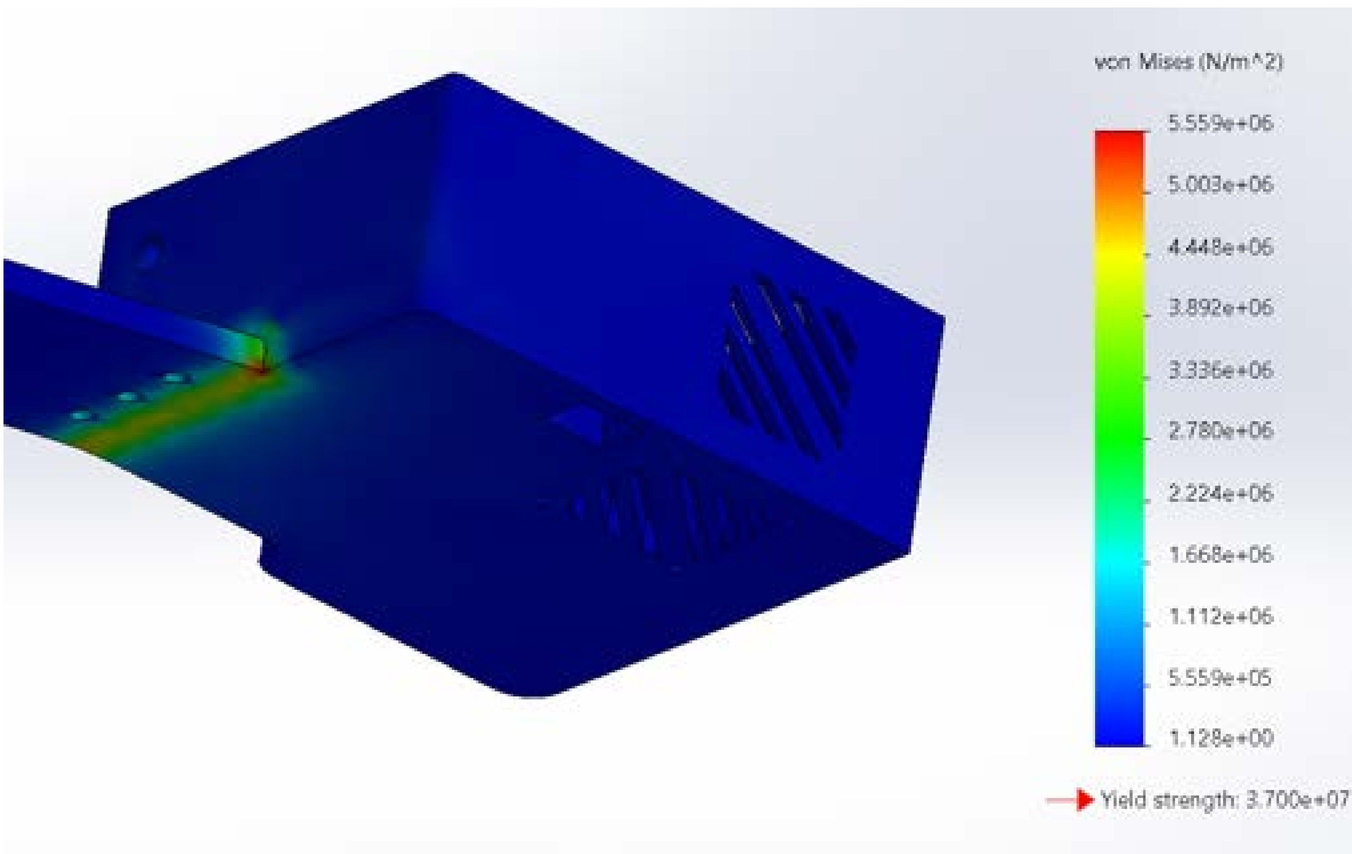


Figure #. Motor Box Max Stress. The motor box has a higher likelihood to fail right at the location where it begins to bend and is no longer rigidly connected to the underside of the pulleys. However, these developed stresses are much less than the yield stress of Tough PLA so the box is not predicted to actually fracture.

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

Conclusion:

The team is confident that all of the structures will perform better than predicted by simulation due to the inability to simulate a 100% infill, and the fact that the material properties of Tough PLA are hard to correctly simulate in solidworks.

Action Items:

-Pick up Print of motor box and lid, separation blocks, and console field goal posts monday

-Begin print of pulley plates and antlers

-Gather screws and connect everything with Annabel

Josh ANDREATTA - Nov 19, 2022, 10:18 AM CST


Technical data sheet Tough PLA

Ultimaker

Filament specifications

Color information

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:

09/13/2022 Onboarding Notes

Roxi Reuter - Sep 13, 2022, 9:17 PM CDT

Title: Project Onboarding Notes

Date: 09/13/2022

Content by: Roxi Reuter

Present: –

Goals:

- Further familiarize myself with the project through reports and additional documents on the team's website from last semester

Content:

Design Website:

- Overarching goal of the project: adapt exercise equipment (in this case, a Matrix rowing machine) to accommodate wheelchair users
  - The design should secure the wheelchair through a mechanism which prevents movement and tipping of the wheelchair during use
  - User safety is of utmost importance

Preliminary Presentation:

- Wheelchair users utilize their upper body very frequently, and shoulder pain is a very common occurrence
  - Regularly exercising the upper body is key to strengthen the upper body region and prevent pain
- Competing design: Adaptive Rowing Machine (AROW)
- The team came up with designs and decision matrices for both the safety/securing mechanism for the rower and the design which allows wheelchair users to utilize the rower (adaptive mechanism)

PDS Summary and Overview of Important Points:

- Mainly autonomous use design (minimal assistance to use the adaptive rower)
  - "Should allow individuals in wheelchairs to easily fit into the machine and use it properly" and should be adjustable for use by non-wheelchair users, as well
- Durable to last at least 10 years/8 million meters with daily use
- Preserve normal rowing motion
  - No added complexity or form adjustment when rowing
- Design should be built into the rowing machine, not simply an attachment
- Ensure tipping is prevented and that the user does not have high safety risks while using the design
  - No sharp edges or components
- Adjustable design such that both wheelchair users and non-wheelchair users can row with the device
- Originally - $200 research and development budget

Preliminary Report:

- Gap in the market for adaptive rowing machines, with very few competitors. The competing designs that do exist do not provide an experience with little outside help; either wheelchair transfer assistance or rower modification (such as removing and replacing parts to transition a regular rower to an adaptive rower) is necessary.
- Minimal outside assistance desired
- Two pulley, one rope design with slit (utilized):
  - Added another pulley next to the existing one to which the cable can be transferred in order to transition the regular rowing machine to an adapted one.
  - Required a slit in the side of the rowing machine to move the cable

A. Pulley Design 1: 2 Pulleys with Slit

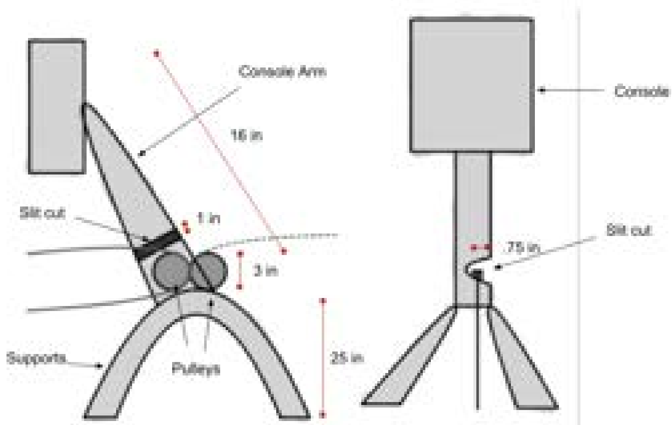
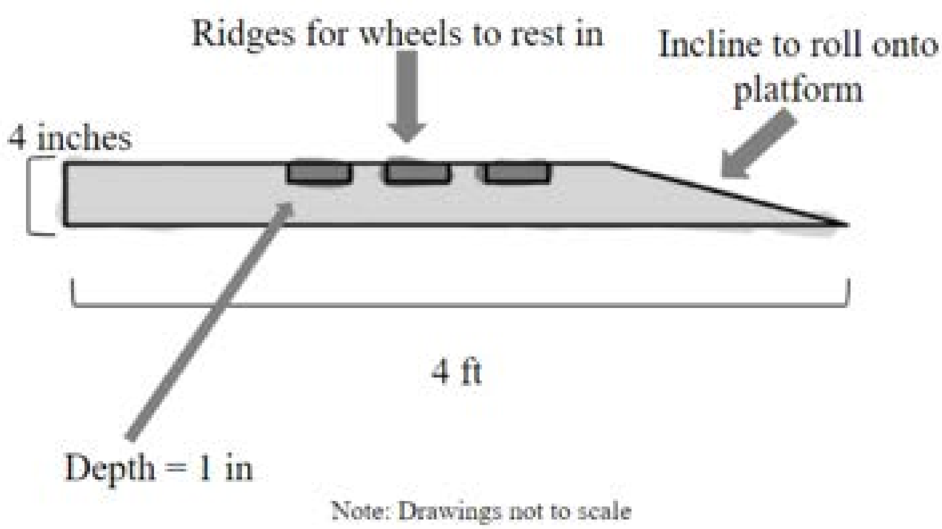


Figure 3. Visual Representation of 2 Pulleys with Slit Design. The 2 Pulleys with Slit design consists of two pulleys that are at the same height. The rope can be transferred from one pulley to the other to switch from traditional to adaptive rowing. A slit cut will be made in the console arm to allow for this to happen.

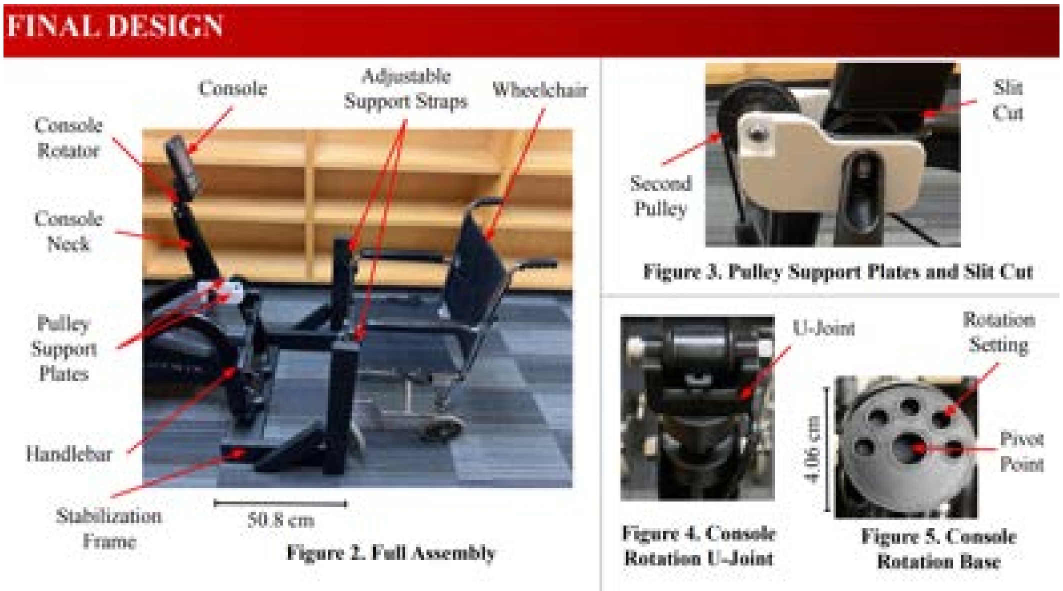
- Stability design utilized: Highway Ridges



  - This platform contains ridges or indentations in which the wheelchair wills will rest to minimize chair movement and to provide safety and stability to the user of the rowing machine.
- Possible future work:
  - A lever or other similar mechanism which allows the user to change the resistance from the adaptive side

Final Poster and Final Report:

- Progress from last semester: “In order to increase the accessibility of the standard rowing machine, an additional pulley was attached to the rower on the opposite side of the standard rowing side via mirroring support plates, and a cut was made in the rower neck to allow for the user to transition the rope and handle to the adaptive side. A wooden frame attached the wheelchair to the rower frame in order to stabilize the user and wheelchair during rowing. Testing of the pulley support plates and wooden frame revealed that all added components can withstand typical loads experienced during rowing while properly stabilizing the user, and showed that users can still achieve varying workout intensities from the adapted side.



- Achievements:
    - Rowing machine can be converted to adaptive use by wheelchair users
    - Wheelchair users can autonomously navigate to the stabilization frame and secure themselves with minimal movement during exercise.
- Areas of improvement for the design:
    - Make the wheelchair frame from a more durable material and make it adjustable
        - Another issue: Lifts during use
    - Outside help is needed to take tension off of the cable to transition the handlebar to the adaptive side
    - Fabrication of parts out of more durable materials (such as steel)
    - Creation of a chest restraint or abdomen support to prevent the user from moving in the chair while rowing.
    - Belt buckle straps used to secure wheelchair
        - There may be a better method - work for this semester?

Conclusions/action items:

Reviewing the previous semester's reports and design work on the BME website familiarized me with the team's thought process, design challenges and successes, and gave me a general idea of the design. Areas of improvement include material used for fabrication, finding a better method for rotation of the console, a mechanism to take tension off of the rowing cable, and more (mentioned above and in the initial client meeting). Along with brainstorming ideas and researching ways in which the design can be improved and perfected, I am interested in researching AROW to become more familiar with competing designs.

Additionally, the team will be meeting tomorrow (09/14) to have an onboarding meeting and see the design and a demonstration of the rowing machine in person. I think this will be very beneficial to the team and ensure all team members understand the design, areas of improvement, work for the semester, and that everyone is on the same page.

09/25/2022 Muscle Activation in Rowing

Roxi Reuter - Sep 25, 2022, 1:08 PM CDT

Title: Muscle Activation in Rowing

Date: 09/25/2022

Content by: Roxi Reuter

Present: –

Goals:

- Look into muscles exercised while using a rowing machine and take this information into consideration while moving forward with design ideas and creating design matrices

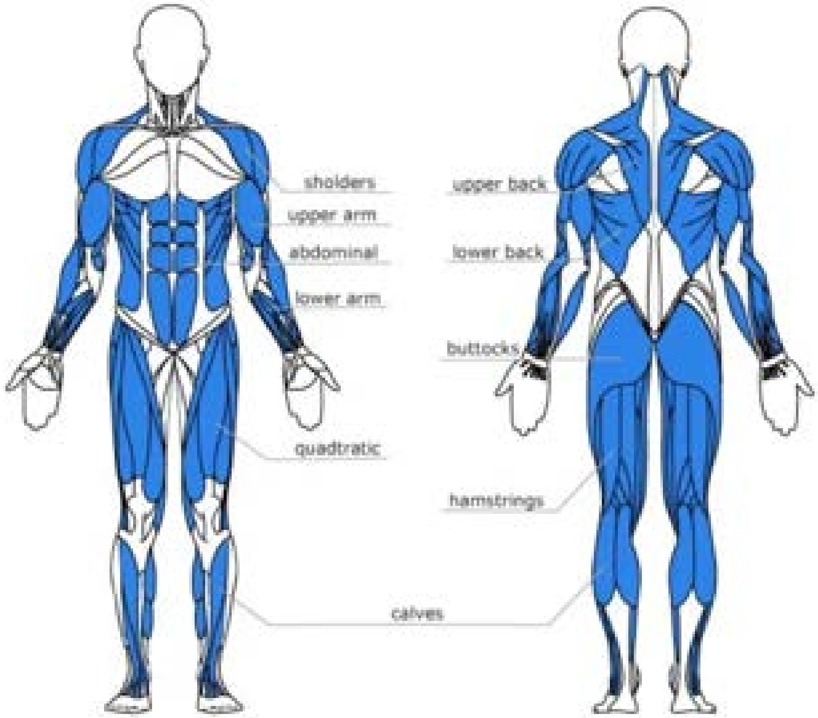
Content:

Source: https://www.rowingmachineking.com/rowing-machine-muscles-used/

Citation:

Edwin, “Rowing Machine Muscles Used,” Rowing Machine King, 19-Jul-2022. [Online]. Available: https://www.rowingmachineking.com/rowing-machine-muscles-used/. [Accessed: 25-Sep-2022].

- Rowing machines exercise an astounding 84% of the muscles in the human body
    - Classified as a full body workout machine because they “exercise every major muscle group and proved a fantastic cardiovascular workout”
- The machine is also considered “low impact” and can be a great workout for people with knee problems or other types of injuries
- Muscles targeted:
    - Quads
    - Hamstrings
    - Glutes
    - Lats
    - Core
    - Shoulders
    - Triceps
    - Back
    - Biceps



- Four rowing phases (each phase activates a different set of muscles):

  - Catch **-** “is the beginning of your stroke where your knees are bent, shins are vertical, arms are straight, and body leaning slightly forward”
    - Triceps
    - Deltoids
    - Traps
    - Calves
    - Hamstring
    - Abdominal
    - Lower Back
  - Drive **-** ‘begins with pushing off with your legs, then swinging your back through the vertical position, and then pulling with your arms”
    - Leg emphasis:
      - Deltoids
      - Traps
      - Upper Back
      - Glutes
      - Hamstring
      - Quads
      - Calves
    - Body swing emphasis:
      - Biceps
      - Forearms

- Middle Back
- Calves
- Hamstring
- Abdominal
- Glutes
- Quads
- Arm pull through emphasis:
  - Biceps
  - Forearms
  - Delts
  - Traps
  - Lats
  - Quads
- Finish **-** 'is where your upper body is leaned slightly back, legs are extended, and the handle is pulled to your lower chest."
  - Traps
  - Delts
  - Biceps
  - Forearms
  - Lats
  - Glutes
  - Quads
- Recovery **-** "is the reverse order of everything just performed. You begin by extending your arms, leaning from your hips forward, and then begin bending your knees until you are back in the catch position."
  - Traps
  - Hamstring
  - Calves
  - Delts
  - Triceps
  - Forearms
  - Abdominal

- The cores is a key part of the body used in rowing to stabilize the rest of the body.

Conclusions/action items:

This research session made me aware of the vast amounts of muscles exercised while rowing! Muscle groups are important to consider for our design, as we want to be sure the normal side of the rower maintains normal rowing form, and the adaptive side mimics a similar motion, although not all the same muscle groups will be used since the individual will be stationary in their wheelchair. With that being said, stationary individuals should exercise all the same muscles except the lower body since the seat stays in one place throughout the entire exercise. Compensation for the lower body movements will likely occur in the core and prevent the user from being ejected from their chair (also supported by some sort of wheelchair stabilizing frame or lap support).

09/18/2022 AROW Background Research

Roxi Reuter - Sep 18, 2022, 11:48 AM CDT

Title: AROW Backgrou9nd Research

Date: 09/18/2022

Content by: Roxi Reuter

Present: –

Goals:

- Take away key design concepts behind an existing adaptive rower
- Think about ways that this device can be improved and how similar ideas can be incorporate into my team's adaptive rower project

Content:

Source: https://adaptederg.commons.bcit.ca/

Citation:

"Introducing the Adapted Rowing Machine (AROW)," Adapted Rowing Machine AROW. [Online]. Available: https://adaptederg.commons.bcit.ca/. [Accessed: 18-Sep-2022].

- AROW stands for "Adapted Rowing Machine" and is a project in collaboration between SFU, UBC, BCIT, and ICORD
    - Funding by the Craig H. Neilsen foundation
- Overall, rowing machines are ideal for cardio and strength training; however, standard machines on the market do not consider the needs of mobily impaired individuals, such as wheelchair users.
    - Both "seating and positioning needs" must be taken into consideration
- AROW specifically addresses these needs by designing adaptations for commercially available rowers
- The team of designers interviewed wheelchair users on challenges faced while rowing and things that they learned and were applied to the design concept:
    - Future research: https://adaptederg.commons.bcit.ca/results/
- They also provided resources to find "commercially available products [that] may be helpful for adapted rowing":
    - Future research: https://adaptederg.commons.bcit.ca/resources/
- The team is also giving others access to the design plans so that people can build their own adapters
- For more information on the design and the design process, they provided the following link:
    - Future research: https://rowingbc.ca/para-rowing/

Conclusions/action items:

This research gave me an idea of the process behind the AROW design. Although the source didn't discuss the adapter in detail, it proved to be a very informed and educated design process since research on the physiology of rowing was carried out, as well as interviews about rowing with individuals that have mobility issues. The site provided a variety of links to additional adapted rowing design information, which I will be looking into and taking inspiration from for this semester's design.

09/18/2022 AROW Design Information

Roxi Reuter - Sep 18, 2022, 12:14 PM CDT

Title: AROW Design Information

Date: 09/18/2022

Content by: Roxi Reuter

Present: –

Goals:

- Read results acquired from AROW rowing interviews and apply what I learn to this semester's design project, whether that be a modification to the current design or taking the design in a completely new direction.

Content:

Source: https://adaptederg.commons.bcit.ca/results/

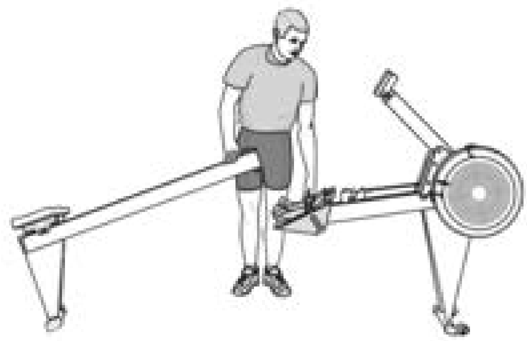
Citation:

"AROW Design Results," Adapted Rowing Machine AROW. [Online]. Available: https://adaptederg.commons.bcit.ca/results/. [Accessed: 18-Sep-2022].

- The AROW team interviewed a wide range of individuals (avid rowers, rowing coaches, and those with mobility limitations which could benefit from an adapted rowing machine design) for feedback on the preliminary design and current solutions.
- Takeaways from interviews:
    - Fixed Seat - clamps to the bar on which the normal seat usually slides on

        - Pros:
            - Accurately mimics the motion of rowing in a boat, so it serves as an ideal way to practice rowing on land before actually doing so in the water (safety).
        - Cons:
            - Wheelchair transfer is required
            - Clamping the seat on may be difficult for the wheelchair user and may require outside assistance
            - Controls are out of reach when in the chair (fixed location)

- Splitting the rowing ergometer:



  - Pros:
    - No transfer needed (rowing occurs while in the wheelchair)
    - Close to controls
    - No additional equipment is needed
  - Cons:
    - Setup can be difficult and may require outside assistance
    - The machine may move while rowing (although weights can be placed on the feet of the machine to prevent this)
    - “The abdominal binder provides limited trunks stability”

- The design solution from the AROW team following interviews, research, prototyping, and testing:

  - “The final design includes an adapted that mounts to the Concept 2 split erg.”
  - The “lever-controlled lap pad” gives the user support and stability
    - The user can also opt for more support from the “abdominal binder or chest pad add-on”
  - Adjustable design for a variety of users

Conclusions/action items:

This research session was very informative and gave me inspiration for brainstorming current design ideas. I enjoyed reading about the pros and cons of each design idea, all of which have crossed my team’s mind at one point or another. The feedback from different users and coaches was valuable in assessing each design and giving me an idea of what will and will not work for an adapted rower design.

I will continue to look into information provided by AROW (especially the available products on the market which can be used for adapted rowing) and incorporate this information into a brainstorming session which I will be doing later today. I think the stabilization methods used in this design may be worth looking into and incorporating into our design instead of a wheelchair frame which was used last semester.

11/14/2022 Roller Coaster Restraints

Roxi Reuter - Nov 14, 2022, 4:27 PM CST

Title: Roller Coaster Restraints

Date: 11/14/2022

Content by: Roxi Reuter

Present: —

Goals:

- Research roller coaster restraints for inspiration and ideas while beginning sketches for stabilization frames using similar concepts

Source: https://coasterforce.com/trains/

Content:

- This source introduces a few different stabilization designs:
    - Lap bar ("Buzz bar") **-** "prevents riders from standing up"
    - Over the shoulder restraints (OTSR) **-** "secures a rider into their seat, preventing them from falling out on slow inversions or high-negative-G moments"
    - Locking lap bar **-** "the locking lap bar secures riders into their seat via a locking mechanism and prevents them from falling out"
    - T-bar **-** "consists of a bar with a cushioned lap bar with two handles for riders to hold on to"

Lap bar or "Buzz" bar

The lab bar prevents riders from standing up.

Over the shoulder restraints (OTSR)

The OTSR secures a rider into their seat, preventing them from falling out on slow inversions or high-negative-G moments.

Locking lap bar

The locking lap bar secures riders into their seat via a locking mechanism and prevents them from falling out.

T-bar

All B&M hyper and giga coasters use a type of restraint called a "T-bar" restraint, which consists of bar with a cushioned lap bar with two handles for riders to hold on to.

- The designs that would work best for our project application would be similar to the T-bar, locking lap bar, or "buzz" bar designs
    - We will need a lap bar with a lap pad that will come up from below and secure a user by locking a lap pad close to their body

Conclusions/action items:

In this research session, I looked into four common types of restraints used for roller coasters, three of them having a design concept similar to lap pad stabilization frame designs that the team has been brainstorming. Next, I will begin sketching these ideas on the rower.

09/15/2022 Standard Wheelchair Dimensions (Manual)

Roxi Reuter - Sep 15, 2022, 10:18 PM CDT

Title: Standard Wheelchair Dimensions (Manual)

Date: 09/15/2022

Content by: Roxi Reuter

Present: –

Goals:

- Research standard wheelchair dimensions to get an idea of a general range which will be helpful in determining measurements for the adjustable wheelchair stabilization frame as the team improves its design this semester

Content:

Source: https://www.avacaremedical.com/blog/wheelchair-dimensions-need-know.html

Citation:

"Wheelchair dimensions you need to know," Avacare Medical Blog, 30-Mar-2022. [Online]. Available: https://www.avacaremedical.com/blog/wheelchair-dimensions-need-know.html. [Accessed: 15-Sep-2022].

- Note: This article takes into consideration manual wheelchairs, not powered chairs. Additional research will need to be done in order to get a range of measurements for electric wheelchairs.
- The article covers a variety of wheelchair measurements, but we are most interested in the height of the wheelchair (from the floor to approximately the arm rests) and the width of the wheelchair (distance from one wheel to the other)
- Seat to floor height:
    - Some wheelchairs are what is called "hemi-height adjustable" which means that the height can be adjusted by the user for ideal fit
    - Typical ranges are 18"-20"
    - Additional area of research from the sizing tip: "The seat to floor height should reflect the length of the user's lower leg, from the back of the knee to the heel", so common calf area measurements could also be looked into for this measurement
- Overall width:
    - For manual wheelchairs, the overall width is typically between 23" to 39"; however, transport chairs can start from 18.5" in width
- Armrest height:
    - Some wheelchairs have adjustable armrests
    - Typically, this distance should be the same as the distance measured from the user's elbow to the seat when their arm is bent at a right angle

Conclusions/action items:

Although this article provided a general idea of wheelchair dimensions, more research is needed to verify the findings before starting the design of an adjustable wheelchair base for the adaptive rower. For our application, the dimensions most important to the design include the height from the floor to the arm rest of the wheelchair (where the chair will be secured for movement) and the width of the wheelchair (from one wheel to the other) so that the chair fits within the frame.

Overall, a standard manual wheelchair has a width between 23” and 39” [58.42 cm to 99.06 cm] but can be as little as 18.5” [47 cm] in width. The height from the floor to armrest was not provided; however, the measurement from the ground to the seat is usually in the range of 18” to 20” [45.72 cm to 50.8 cm]. The distance from the armrest to the seat is generally the measurement from the user’s elbow to the seat when their arm is bent 90º.

This article only took into consideration manual wheelchairs, so additional research will be needed for electric wheelchairs, but this research provided a great starting point for ballpark dimensions. I will do more research on this topic and compare my findings with my team as we move forward with the design process.

09/15/2022 Standard Wheelchair Dimensions (Powered)

Roxi Reuter - Sep 15, 2022, 10:39 PM CDT

Title: Standard Wheelchair Dimensions (Powered)

Date: 09/15/2022

Content by: Roxi Reuter

Present: —

Goals:

- Research general dimensions for powered wheelchairs, which will be used in the design of an adjustable wheelchair base used in tandem with the adaptive Matrix rowing machine.

Content:

Source: https://www.redmanpowerchair.com/can-a-wheelchair-fit-through-a-30-inch-door/

Citation:

Redmanpowerdev, “Can a wheelchair fit through a 30-inch door? by Redman Power Chair,” Redman Power Chair, 23-Sep-2021. [Online]. Available: https://www.redmanpowerchair.com/can-a-wheelchair-fit-through-a-30-inch-door/. [Accessed: 15-Sep-2022].

- The article starts by stating that most wheelchairs are 25” to 36” [63.5 cm to 91.44 cm] in width, which is fairly consistent with my previous research entry on manual wheelchair dimensions.
- Powered wheelchairs can start from 23” [58.42 cm] in width
- ADA (Americans with Disabilities Act) states that a width of 32” [81.28 cm] for a door frame is recommended for wheelchair users to comfortably pass through; however, a 30” [76.2 cm] is usually fine for standard wheelchairs.
- “Most wheelchairs in production are 25” [63.5 cm] wide, but you have to account for room to their hands and arms to propel the chair through the door openings when using a standard wheelchair, so that surely adds a few inches”
    - May need to take into account the extra space needed to actually wheel into the frame for chair stabilization unless there are handles or the design allows the user to grab onto the “arms” of the frame to properly roll the chair into place since there most likely will not be enough space to manually wheel in with hands.

Conclusions/action items:

This article was fairly consistent with my previous research on wheelchair dimensions in regard to standard wheelchair width for the typical manual wheelchair. Powered wheelchairs have a similar range. Most chairs fit in the range of 25” to 36” [63.5 cm to 91.44 cm], but powered wheelchairs can start at 23” [58.42 cm] wide. The majority of chairs fit through a 32” [81.28 cm] door frame per ADA.

No information was included on wheelchair height, so that is something that I will need to do additional research on. This was a productive research session in terms of finding a range of dimensions which are necessary for designing the adjustable wheelchair frame with which the wheelchair user will secure their chair while using the adaptive rower.

Next steps include reporting these findings to the team and verifying both height and width ranges with team members or other online sources. Additionally, I would like to begin looking into adjustment methods used by Matrix gym equipment or other exercise machines to get an idea of materials and designs currently utilized. Then, I will brainstorm design ideas on my own and with the team.

09/18/2022 Available Adapter Products

Roxi Reuter - Sep 18, 2022, 12:34 PM CDT

Title: Available Adapter Products

Date: 09/18/2022

Content by: Roxi Reuter

Present: –

Goals:

- Become familiar with commercially available adapter products (links provided by the AROW design team that design an adapted rower)
- Think about how these products can improve our design and/or brainstorm similar concepts which can be utilized to enhance my team's current adaptive rower design

Content:

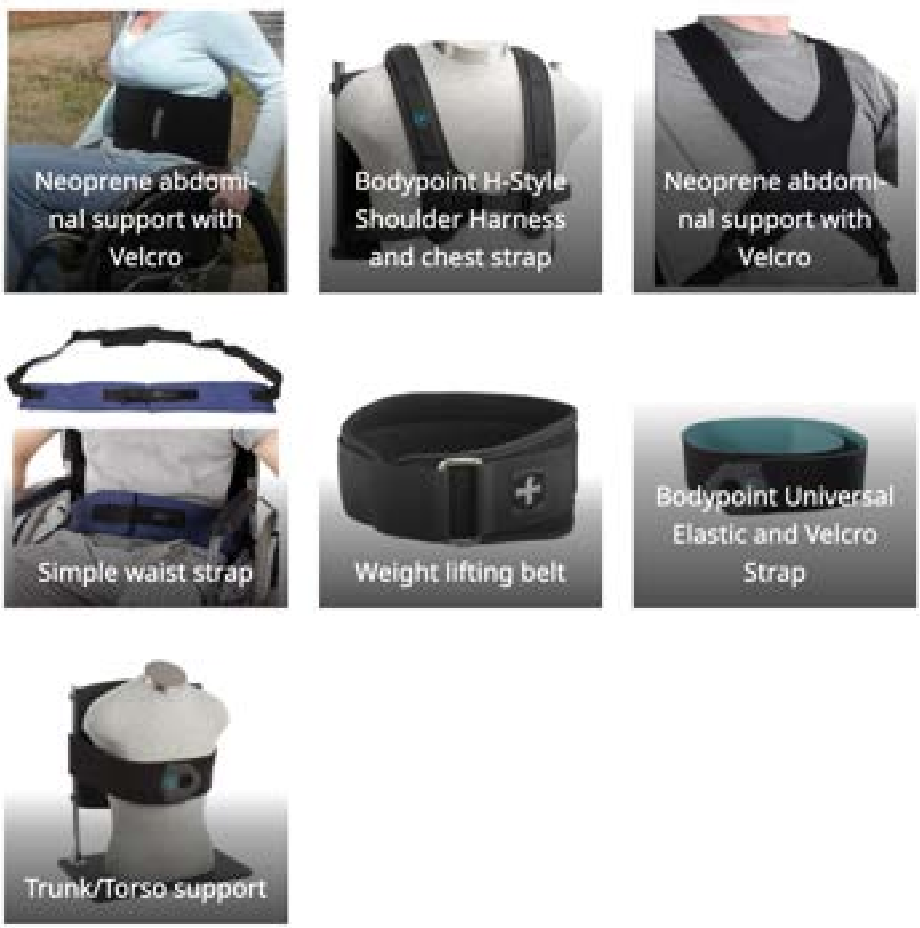
Source: https://adaptederg.commons.bcit.ca/resources/

Citation:

"AROW Adapter Resources," Adapted Rowing Machine AROW. [Online]. Available: https://adaptederg.commons.bcit.ca/resources/. [Accessed: 18-Sep-2022].

- The AROW team provided a range of products which may be helpful in making your own adapter for a rowing machine
- Categories for these products include:
  - Harnesses and Binders
  - Gloves
  - Handles and Grips
- I think the harnesses and binders will be the most applicable to our design, as securing the wheelchair user while rowing is still a work in progress
- A harness or waist strap could hook around the user's own chair for stabilizing the user; however, this may require outside assistance
  - Velcro straps or a buckle strap may be good options since they can withstand lots of force while also easily being able to be manipulated by the user when desired
  - This may be something that we can test in the manual wheelchair which has been used with the current design
  - May pose issues with powered wheelchairs due to different wheelchair designs (a belt may not fit (properly) around a powered chair
    - Something to look into

Harnesses and Binders



Conclusions/action items:

This design session gave me even more inspiration for my brainstorming session which I will carry out later today (09/18/2022). I think we need to come up with a better solution for the wheelchair support and stabilization mechanism in the design, both in terms of adjustability for varying wheelchair dimensions and a more reliable system to prevent movement.

More research on this topic will be carried out if necessary after the brainstorming session.

09/25/2022 Standard Gym Equipment Materials

Roxi Reuter - Sep 25, 2022, 1:27 PM CDT

Title: Standard Exercise Equipment Materials

Date: 09/25/2022

Content by: Roxi Reuter

Present: –

Goals:

- Research typical materials used to fabricate gym equipment

Content:

Source: https://fitneset.com/how-was-the-gym-equipment-made-and-what-are-they-made-of/

Citation:

J. roberts and N. *, “How was the gym equipment made? And what are they made of?,” Fitneset, 22-Jun-2021. [Online]. Available: https://fitneset.com/how-was-the-gym-equipment-made-and-what-are-they-made-of/. [Accessed: 25-Sep-2022].

- Since the team has a pretty well-developed design idea, Tracy recommended looking into fabrication and materials, so I will start out this research process by looking at materials used in standard exercise equipment.
- Gym equipment is usually composed primarily of one of the following metals:
    - Aluminum
    - Carbon steel
    - Other metal alloys
- These materials are frequently used due to their light weight and durable properties
- For example, in fabricating an exercise bike, a company would…
    - 1. Construct the bike frame from a metal
    - 2. Pain and powder-coat the frame for appearance and longevity
    - 3. Make injection molding (metal, plastic, or rubber parts)
    - 4. Connect the drive belts, wheels, cranks, etc.
        - Adhesives (like epoxy) or metal brackets/bolts are generally used in this stage
- Free weights are typically made of iron, steel, or hard rubber
    - Bar - generally iron

Conclusions/action items:

Although this source didn’t provide a great quantity of information on gym equipment materials, it did give me a basic idea of typical materials used in exercise equipment and a starting point for this research. Most often, gym equipment (like an exercise bike) is composed primarily of a metal or metal alloy due to its lightweight nature and durability. This must be taken into account while fabrication our handle bars and adapted stabilization support.

A few things to think about while deciding on a material:

1. Is there a weight limit for this component (i.e., will the user have to lift of move this)?
2. Will the component be in direct contact with the user?
3. What other properties do we want this part to have (durability, longevity, etc.)?
4. How easy is it to work with this material?
5. Material cost compared to allowed budget.

I will move forward with this research by looking specifically at materials used in Matrix gym equipment, since that is the brand of the rowing machine we are using to model our design. Ideally, we would like our design to match the finish and material (if possible) of the original machine.

09/27/2022 Stepper and Servo Motors

Roxi Reuter - Sep 27, 2022, 10:12 PM CDT

Title: Servo vs. Stepper Motors Research

Date: 09/27/2022

Content by: Roxi Reuter

Present: –

Goals:

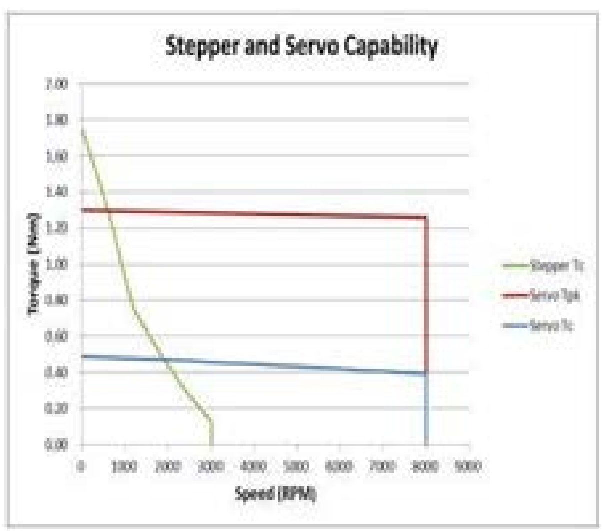
- Do background research on both servo and stepper motors since we will be adding bioinstrumentation to the project by automating the console transition from the adapted to standard side (and vice versa) of the rower.

Content:

Source: https://www.machinedesign.com/mechanical-motion-systems/article/21836868/whats-the-difference-between-servo-and-stepper-motors

Citation:

"What's the difference between Servo and Stepper Motors?" [Online]. Available: https://www.machinedesign.com/mechanical-motion-systems/article/21836868/whats-the-difference-between-servo-and-stepper-motors. [Accessed: 28-Sep-2022].



- Both servo and stepper motors are commonly used in engineering projects, and with proper use, can be effective and reliable power for a design
- The main differences between a servo and stepper motor are speed, acceleration, and price
- Stepper motor:
    - "Stepper motors consist of a rotor with permanent magnets and a stationary stator that carries the windings."
    - The stepper motor turns in a series of "steps"

    - Typically, it runs open-loop, which diminishes the necessity of an accompanying encoder or resolver (**more economical**)
    - “The high pole count allows them to generate very **high torque at zero speed**”
        - However, torque decreases with increasing speed
        - Torque ranges typically max out at 1,000-2,000 ounce inches for available motors
    - Compact size
    - **Lower speed** motor as compared to a servo motor
    - “Generally run best at 1,200 RPM or lower
    - Margin of a few percent in error of distance turned (can add an encoder to help increase the accuracy, but this will not fix the problem)
- Servo motor:
    - Torque is relatively constant throughout operation
    - Much lower pole count as compared to stepper motors and must be run closed-loop
    - Overall, servo motors are more complex than their stepper motor counterpart
    - Run at **faster speeds** than stepper motors
    - Also can deliver higher torque at higher speeds (don’t drop off in torque as speed increases as the stepper motor does)
    - “**With closed-loop feedback, servo motors deliver high accuracy positioning coupled with better speed and acceleration than stepper motors. The trade-off is increased cost, size, and complexity**.”
    - Due to speed and torque properties, servo motor provides better acceleration than stepper motors, as well as better positioning due to their closed-loop circuit

Conclusions/action items:

Overall, the differences between servo and stepper motors come down to cost, acceleration, and torque factors. Although we are not sure of the torque in turning the console 180º on our project (which is something we will need to calculate soon), it seems like both motors could potentially serve our intended purpose.

Our next step will be determining the torque necessary for the console transition. Once that is known, we can determine which specific motors will work for our application and look into cost, which may be the ultimate deciding factor in our motor decision. We will then proceed by ordering necessary components and starting circuit and coding designs.

09/28/2022 Torque Calculation Refresher

Roxi Reuter - Sep 28, 2022, 11:56 AM CDT

Title: Torque Calculations

Date: 09/28/2022

Content by: Roxi Reuter

Present: —

Goals:

- Since a key factor between deciding between a servo and stepper motor is the amount of torque required to turn the console in our design, we must know how to calculate this value. This research session will give me a refresher on torque calculations.

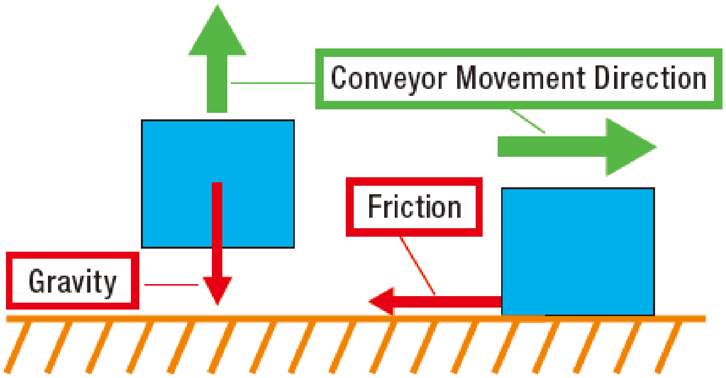
Content:

Source: https://blog.orientalmotor.com/motor-sizing-basics-part-1-load-torque#:~:text=To%20calculate%20load%20torque%2C%20multiply,x%200.05%20m%20%3D%201%20Nm.

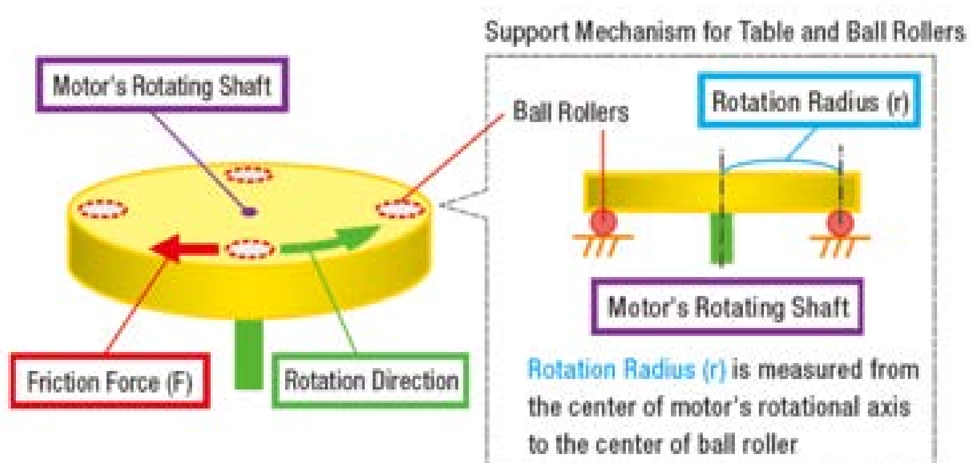
Citation:

J. Tang, “Motor sizing basics part 1: How to calculate load torque,” Engineering Notes. [Online]. Available: https://blog.orientalmotor.com/motor-sizing-basics-part-1-load-torque#:~:text=To%20calculate%20load%20torque%2C%20multiply,x%200.05%20m%20%3D%201%20Nm. [Accessed: 28-Sep-2022].

- From my motor research, I found that:
    - Stepper motors have a higher holding torque than servo motors but are cheaper. As speed increases, torque decreases.
    - Servo motors are typically more expensive but are able to apply a relatively constant torque at higher speeds.
    - Most likely, servo motors will have higher torque than stepper motors at the speed we are operating at; however, we have yet to determine how much torque will be needed.
- In determining motor size, we must meet criteria for torque, load, inertia, and speed
    - Torque definition: “rotational force at a distance from the rotational axis”, “the capacity to do work”
        - Two types of torque:
            - Load torque: “the amount of torque constantly required for application and includes friction load and gravitational load”
            - Acceleration torque: “torque is the torque required just for the maximum acceleration and deceleration rate for the load”
- The torque needed to turn the console should be calculated with the following information:
    - The forces below all play a part in torque calculation



- Load torque is the "sum of both friction and gravitational loads", where the gravitational load takes into account the weight of the object (mass * acceleration)
    - This calculation is different for various applications
    - In general, torque = Force (F) x rotational radius (r)
        - In our case, F would be the weight of the console
            - How much torque would be required if we were to place the console directly above the motor?
                - Distance from rotational axis to frictional force
            - This formula works with frictional load or without
- The application most fitting to our project is the "Rotary Index Table" example



- Formula below should be used but in a slightly different approach than the belt drive example
    - Note that:
        - μ - friction coefficient
        - F - friction force
        - m - mass of the object
        - r - radius (distance from the center of the motor shaft to point of friction)
    - Friction occurs between the ball rollers and the table make contact (our frictional force will look slightly different and will likely be the frictional force between the motor and the console - or any intermediate components

integrated into the design)

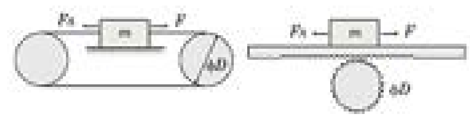
- Take into consideration safety factor

F : Force of moving direction [N]
F_0 : Preload [N] ($\fallingdotseq \frac{1}{3}F$)
μ_0 : Internal friction coefficient of preload nut (0.1~0.3)
η : Efficiency (0.85~0.95)
i : Gear ratio (This is the gear ratio of the mechanism -and not the gear ratio of an Oriental Motor's gearhead.)
P_B : Ball screw lead [m/rev]
F_A : External force [N]
F_B : Force when main shaft begins to rotate [N] (F_B = Spring balance value [kg] × g [m/s²])
m : Total mass of table and load [kg]
μ : Friction coefficient of sliding surface
θ : Inclination angle [°]
D : Final pulley diameter [m]
g : Gravitational acceleration [m/s²] (9.807)

◇Wire and Belt Drive, Rack-and-Pinion Drive

$$T_L = \frac{F}{2\pi\cdot\eta}\cdot\frac{\pi\cdot D}{i} = \frac{F\cdot D}{2\cdot\eta\cdot i} \text{ [N·m]} \quad ——— ④$$

$$F = F_A + m\cdot g(\sin\theta + \mu\cdot\cos\theta) \text{ [N]} \quad ——— ⑤$$



Conclusions/action items:

This was a good refresher of calculating torque. It is a little more complex than what we learned in statics, so I will have to do more research or consult the appropriate person to better learn how to calculate this value. The closest example given in the source involved a rotary index table; however, our application still varies slightly from this, so I will need to do more research. Additionally, according to the oriental motor website, the total torque is a sum of the acceleration torque and load torque, so I will have to do more investigation on how that would be calculated, as well.

10/19/2022 Stepper Motor Coding and Circuitry Refresher

Roxi Reuter - Oct 19, 2022, 12:50 AM CDT

Title: Stepper Motor Research

Date: 10/19/2022

Content by: Roxi Reuter

Present: –

Goals:

- Get a refresher on coding and working with a stepper motor (this was the type of motor used in a previous project of mine)

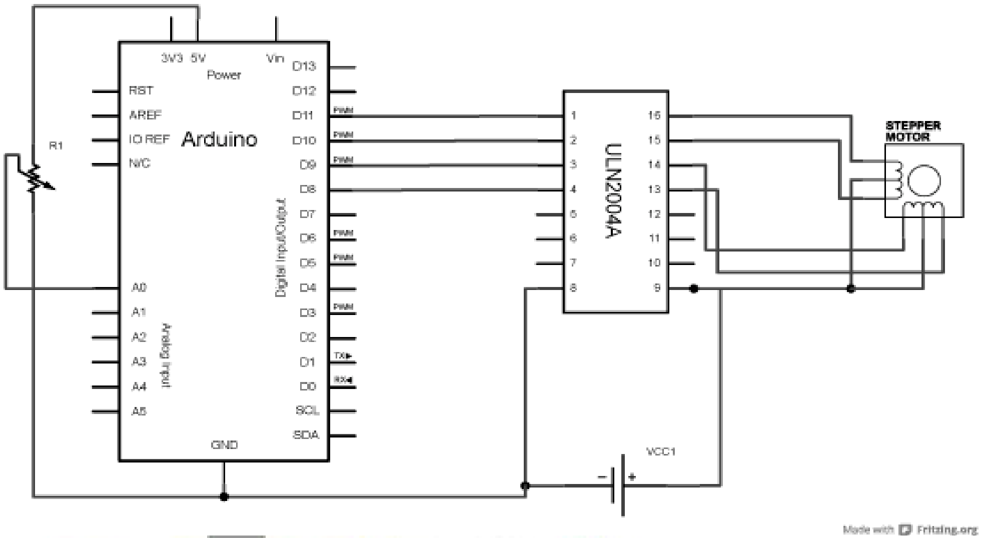
Source: https://docs.arduino.cc/learn/electronics/stepper-motors

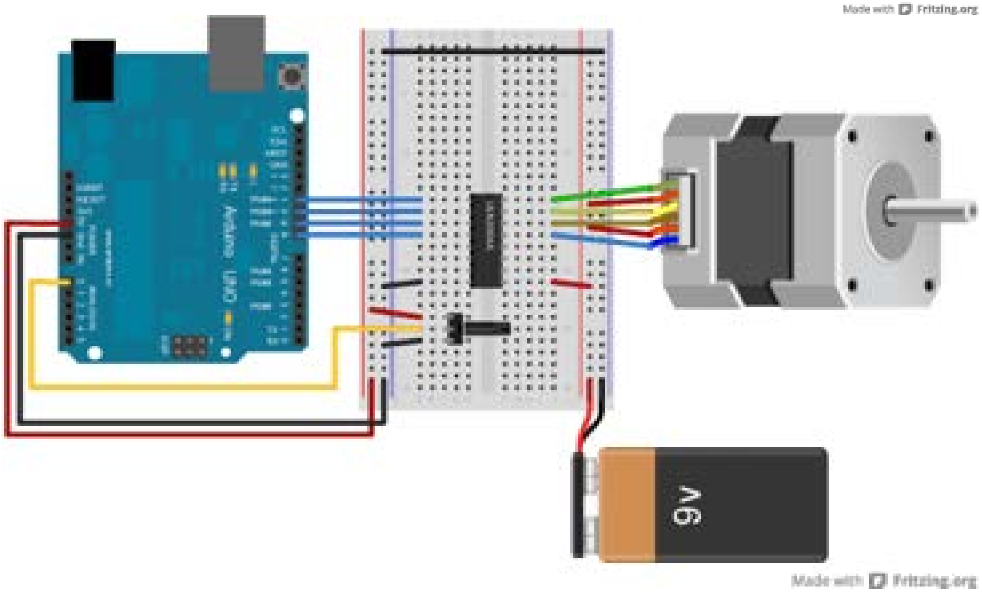
Citation:

T. A. Team, "Arduino and Stepper Motor Configurations: Arduino documentation," *Arduino Documentation | Arduino Documentation*. [Online]. Available: https://docs.arduino.cc/learn/electronics/stepper-motors. [Accessed: 19-Oct-2022].

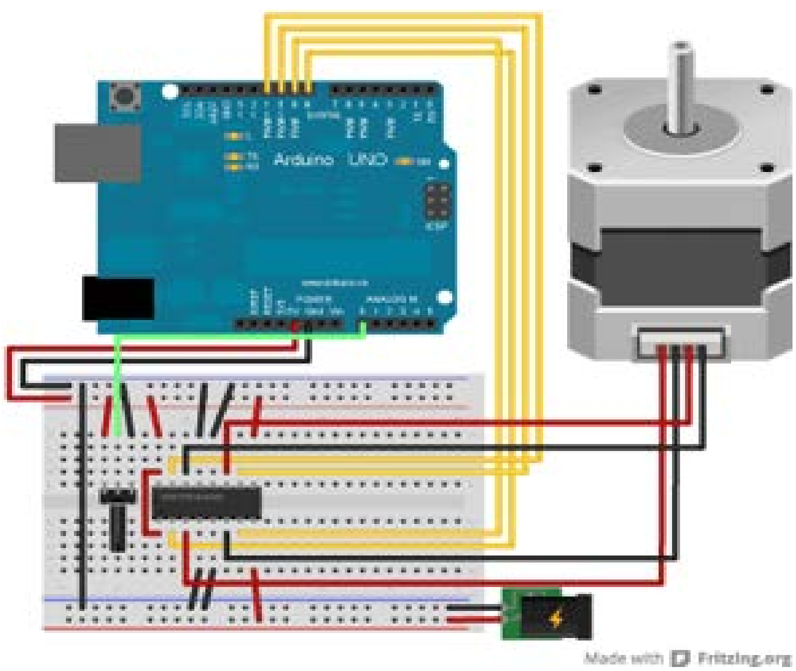
Content:

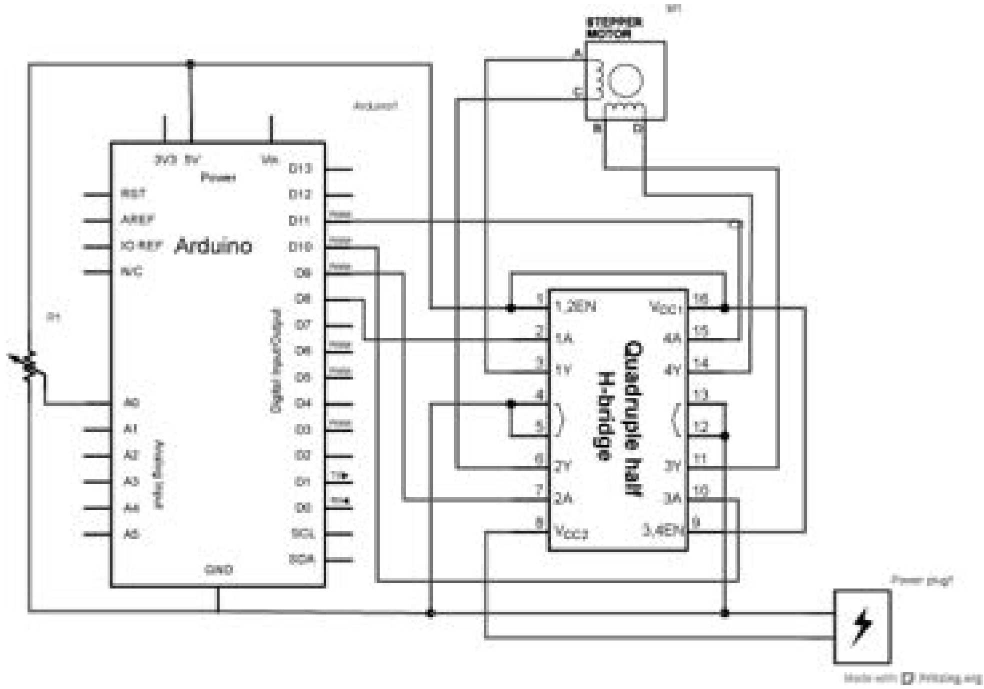
- Stepper motors can be precisely controlled because magnets within the motor's shaft control the movement in increments of tiny steps
- Two types of steppers:
  - Unipolar
  - Bipolar
- Each of the two types of motors requires a different circuit
- Control either type of stepper with pins 8, 9, 10, and 11
- Required components for programming and operating the stepper motor:
  - Arduino Board
  - Stepper motor (bipolar or unipolar)
  - U2004 Darlington Array (if using a unipolar stepper)
  - SN754410ne H-Bridge (if using a bipolar stepper)
  - Power supply appropriate for your particular stepper
  - Hook-up wires
  - Breadboard
- The source notes that powering the motor externally is better than compared to powering the motor with the Arduino
- Circuit examples:
  - 1. Unipolar circuit schematic





- 2. Bipolar circuit schematic





Additionally, included in the source are some example codes: “Motorknob”, StepperOneRevolution”, StepperOneStepAtATime”, “StepperSpeedControl”

- I think our code would be most similar to the “StepperOneRevolution”, except we have to factor in a button to cause the rotation, and the rotation should only result in half of a revolution.

Conclusions/action items:

This was a good refreshed on coding stepper motors and their required components. The team is still deciding on which motor to move forward with (stepper or servo motor). Annabel has been working on coding a little bit, and I will be meeting up with her today (10/19) in order to make a final decision on a motor and test code.

10/19/2022 Servo Motor Circuitry and Programming Research

Roxi Reuter - Oct 19, 2022, 1:06 AM CDT

Title: Servo Motor Research

Date: 10/19/2022

Content by: Roxi Reuter

Present: –

Goals:

- Learn more about servo motors, programming them, and their required circuitry

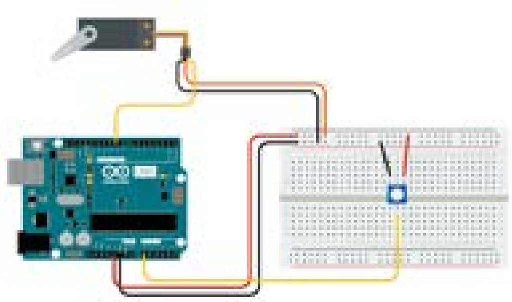
Source: https://docs.arduino.cc/learn/electronics/servo-motors

Citation:

T. A. Team, "Servo Motor Basics with Arduino: Arduino documentation," Arduino Documentation | Arduino Documentation. [Online]. Available: https://docs.arduino.cc/learn/electronics/servo-motors. [Accessed: 19-Oct-2022].

Content:

- There is a servo library provided for programming and controlling servo motors: https://www.arduino.cc/reference/en/libraries/servo/?_gl=1*y7a1xt*_ga*ODA0Njk3NzgzLjE2NjQ2NTQxOTE.*_ga_NEXN8H46L5*MTY2NjE1NzE3Ni4yMS4xLjE2NjYxNTg2NDAuMC4wLjA.
- Required components:
  - Arduino Board
  - Servo Motor
  - 10k ohm potentiometer
  - hook-up wires
- Three wires on a servo motor: power, ground, and signal
  - Power to 5V pin on Arduino board
  - Ground wire to GND pin on Arduino board
  - Signal wire should connect to a PWM pin
- Circuitry example 1: Knob circuit - potentiometer controls position of the servo



- Circuitry example 2: Sweep Circuit - "Sweeps the shaft of an RC servo motor back and forth across 180 degrees."

Conclusions/action items:

This was a nice introduction into servo motor capabilities and circuitry. I feel as though I need to do more research on this topic if this is the motor that Annabel and I decide to move forward with for the console swivel design.

It seems as though the functionality of a stepper motor and a servo motor are about the same. Most likely, both will work for our application, so I am thinking that the deciding factor may be the price of the motor. I will discuss this with Annabel during our meeting today (10/19).

11/02/2022 Lap Pad Sourcing

Title: Lap Pad Search

Date: 11/02/2022

Content by: Roxi Reuter

Present: —

Goals:

- Source possible lap pads which can be used in the fabrication of our stabilization frame for user comfort

Content:

- We are looking for a standard exercise equipment lap pad for the stabilization frame. Below are a few options which may work for our application:
  - https://www.amazon.com/Rollers-Exercise-Machines-Equipments-Replacements/dp/B08FBP3RRG/ref=asc_df_B08FBP3RRG/?tag=hyprod-20&linkCode=df0&hvadid=475825838768&hvpos=&hvnetw=g&hvrand=11897939033285904023&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&1020446640642&psc=1#customerReviews
  - https://www.amazon.com/dp/B094D5ZJXK/ref=sspa_dk_detail_2?psc=1&pd_rd_i=B094D5ZJXK&pd_rd_w=5mp84&content-id=amzn1.sym.88097cb9-5(abfacbc1c44b&pf_rd_p=88097cb9-5064-44ef-891b-abfacbc1c44b&pf_rd_r=F69K0QTQFD57WKF7ATWG&pd_rd_wg=3YoRv&pd_rd_r=06eba430-182bedc04236510d&s=hpc&sp_csd=d2lkZ2V0TmFtZT1zcF9kZXRhaWw&smid=A21ZSLGXXFHYVZ
  - https://www.amazon.com/dp/B08QFGF694/ref=sspa_dk_detail_5?psc=1&pd_rd_i=B08QFGF694&pd_rd_w=5mp84&content-id=amzn1.sym.88097cb9-50abfacbc1c44b&pf_rd_p=88097cb9-5064-44ef-891b-abfacbc1c44b&pf_rd_r=F69K0QTQFD57WKF7ATWG&pd_rd_wg=3YoRv&pd_rd_r=06eba430-182bedc04236510d&s=hpc&sp_csd=d2lkZ2V0TmFtZT1zcF9kZXRhaWw
    - This option is a barbell pad but may work for since it is basically one long, connected pad

Conclusions/action items:

This is a start for sourcing a lap pad which will be used for the stabilization frame on the adaptive side of the rower. I will share my findings with the stabilization subteam, more sound plan for fabricating the frame. This may occur after our JHT visit this Friday (11/04).

12/05/2022 Wheelchair Statistics - Gyms

Roxi Reuter - Dec 05, 2022, 4:31 PM CST

Title: Wheelchair Statistics - Gyms

Date: 12/05/2022

Content by: Roxi Reuter

Present: —

Goals:

- Improve the background section of deliverables by informing readers/listeners of statistical studies carried out about wheelchair users in gyms

Source:

https://www.marketingdive.com/news/degree-presses-fitness-industry-as-81-of-disabled-people-feel-left-out/606835/

Citation:

P. Adams, “Degree presses fitness industry as 81% of disabled people feel left out,” Marketing Dive, 20-Sep-2021. [Online]. Available: https://www.marketingdive.com/news/degree-presses-fitness-industry-as-81-of-disabled-people-feel-left-out/606835/. [Accessed: 05-Dec-2022].

Content:

- A MarketingDive article talks about the pressure that the deodorant brand, Degree, put on the fitness industry for its little accommodation to users with disabilities in gyms
    - This article is from 2021
- A study carried out supported this claim with the statistic that “81% of people with disabilities do not feel comfortable in fitness spaces”
    - Wheelchair users fall into this category, although they do not make up the entire 81%
- Degree is looking to help solve this issue by providing a resource which lists “trainers and coaches with disabilities who are ready for employment”
- To be clear, this is referencing physical disabilities

Conclusions/action items:

Degree has challenged the fitness industry in the area of inclusivity by pressuring them to be more inclusive to individuals with disabilities. This 2021 article revealed that 81% of people with (physical) disabilities do not feel comfortable in gyms. This statistic is important because it justifies the gap in the market and the need for adaptive exercise equipment in modern day fitness centers.

09/23/2022 PDS Modifications

Roxi Reuter - Sep 25, 2022, 3:42 PM CDT

Title: Individual PDS Work

Date: 09/23/2022

Content by: Roxi Reuter

Present: –-

Goals:

- Document my individual work for the PDS

Content:

- The team reviewed the PDS from last semester and noted areas which needed updates and modifications
- I was assigned the performance requirements section to accurately reflect our current design needs:
    - *Performance Requirements:*
        - The modified rower will enable people in wheelchairs to use the machine. The user will be able to easily secure/unsecure themselves to/from the modified rower. The attachment to the rowing machine should keep the wheelchair from tipping over backwards and will prevent unnecessary chair movement during the rowing motion.
        - The modifications made, to allow for attachment of the user/wheelchair, should remain intact and not break with repeated use of the rowing machine.
            - The modifications used for the attachment should be able to resist and endure stresses caused by a pulling force up to 1050 N [2].
            - The modifications made to the machine should be able to endure the fatigue due to the repetitive rowing cycle.
        - The user will grip the handlebars to complete rowing movements. The wheelchair and the adaptive rower machine will remain stationary during rowing.
        - The device will be used daily.
        - The transition of the handle and rope from the normal to the adapted side should be easily carried out by all users, including those in wheelchairs.

[2] N. Découfour, F. Barbier, P. Pudlo, and P. Gorce, “Forces Applied on Rowing Ergometer Concept2®: a Kinetic Approach for Development (P94),” p. 8.

- In addition, I looked over the PDS and edited as a whole both individually and with the rest of the team

Conclusions/action items:

This notebook entry serves the purpose of documenting my personal work on the PDS. Although I edited the PDS on my own and with the team, my main job was updating the performance requirements section. This included primarily noting ease of transition of the rower bar, along with a few other modifications.

09/30/2022 Console Design Matrix

Roxi Reuter - Sep 30, 2022, 11:49 AM CDT

Title: Console Design Matrix Work

Date: 09/30/2022

Content by: Roxi Reuter

Present: Josh, Annabel

Goals:

- Complete the design matrix for the console design

Content:

- Josh, Annabel, and I met to finish up the console design matrix after reviewing it with the entire team and scoring each design
- While meeting in our subgroup, we split the final design paragraph into individual sections after discussing the content for each
- Below were the sections assigned to me (safety and cost)
  - “Although no design poses significant risk to the user, the Motor design scored the lowest (3/5) due to added electrical components (i.e., the motor and accompanying circuitry) that could potentially put the user at risk (i.e., electrocution or fire hazards). The 2 Pivot Points and 1 Pivot Point designs were comparable in regard to safety since they add only mechanical mechanisms (and no electrical elements) to the design. However, the 2 Pivot Points design has an extra point of rotation about the base of the antler, increasing the chance of pinching the user’s extremities. Therefore, the 2 Pivot Points design and the 1 Pivot Point design scored a 4/5 and 5/5, respectively.”
  - “Finally, the team compared the cost of the three design ideas. None of the preliminary designs are expected to exceed the $200 limit given for this portion of the design project; however, some designs are more cost-effective than others. The 1 Pivot Point and 2 Pivot Points designs only differ in the number of rotation points for the console. The fabrication costs would be almost identical for both designs due to the similarity in the quantity and types of materials needed for fabrication. The Motor design, however, will be more expensive due to the addition of a motor, Arduino, and other circuit components. Accordingly, the 1 Pivot Point and 2 Pivot Points designs both scored 5/5, whereas the Motor design received a 4/5.”

Conclusions/action items:

Annabel, Josh, and I had a very productive meeting wrapping up the console design matrix. We wrote the final design paragraph and edited it together. Now that this document is complete, we are ready to send it out with our progress report and turn it in to our advisor, Tracy. On Friday, I will have meetings from 12-2PM (BPAG, team, advisor, and client), and the team will discuss assignments for the preliminary design presentation which will take place on 10/07. This weekend, I will work on my sections of the preliminary design presentation.

10/06/2022 Preliminary Presentation

Roxi Reuter - Oct 06, 2022, 8:55 PM CDT

Title: Preliminary Presentation Slides

Date: 10/06/2022

Content by: Roxi Reuter

Present: —

Goals:

- Work on preliminary presentation slides assigned (document individual work which will be presented)

Content:

- I was assigned the pulley plate and antler design slides (see slides attached to this entry for further details)
- I plan on touching on the following topics during the design presentation:
- Pulley plate:
    - The previous design which allowed transition between the adapted and standard side of the rowing machine involved the addition of a second pulley directly in line with the rower's original pulley. Additionally, two pulley plates 3D-printed of tough PLA were attached to the rower to support the second pulley. The team had Johnson Health Tech. cut a slit in the neck of the rower (the support which holds the console) to allow users to move the cable through the slit and transition the handle bar from one side to another, which allows wheelchair users to utilize the device.
    - The overall concept of the design was well thought out, but some issues were encountered in terms of ease-of-use as the functionality of the design was tested last semester. Two areas which our team will be addressing this semester include:
    - The welds on the rowing machine (which were not taken into consideration during the designing of the pulley plates on the solidworks design and caused there to be some fitting issues between the pulley plates and the rower).
    - In order to transition the handle bar and use the adapted and/or standard side, the user must remove the tension in the cable by first getting some slack in the rope and then moving the bar through the slit to the appropriate side, which makes the design less user-friendly.
- Antler design:
    - To address these issues and improve the overall design, the team is moving forward with an improved "antler" design which involves the removal of the rower neck since its only role is holding the console.
    - Instead, there will be two "antler"-like structures connected to the pulley plates (one per pulley plate) to hold the handle bar directly above the set of pulleys. Specifically, the bar will be located directly between the pulleys such that the tension from the cable acts directly downward. This will solve the tension removal problem, as the user will simply need to lift up the handle bar and pull it towards their respective side, and this will also eliminate previous alignment problems between with the cable and pulleys.
    - Annabel will be up next to talk about the console design and relocation.

Conclusions/action items:

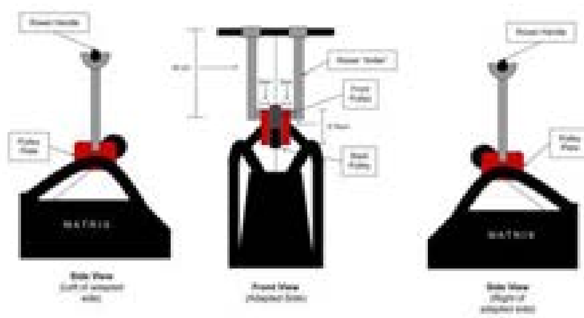
I have completed my individual parts of the presentation, and I will be practicing both individually and with the team before giving the presentation on Friday (10/07). Following the presentation, I will turn my focus to the preliminary report which is due the coming week.

Roxi Reuter - Oct 06, 2022, 8:55 PM CDT

Download

Preliminary_Presentation_Roxi.pdf (312 kB)

Roxi Reuter - Oct 08, 2022, 11:01 AM CDT



Download

Antler_Design_Sketch_No_Console_.jpg (63.2 kB) An updated design sketch that I did, as well, for the presentation. (Antler design)

10/11/2022 Preliminary Report Work

Roxi Reuter - Oct 08, 2022, 12:27 PM CDT

Title: Individual Preliminary Report Work

Date: 10/08/2022

Content by: Roxi Reuter

Present: –

Goals:

- Work on the preliminary report sections assigned to me

Content:

- I was assigned the sections for the antler design description and fabrication in the report. The following were the parts I added:
- Antler design description:
    - The previously implemented Two Pulleys with Slit design (Appendix B) requires the user to first remove tension in the rope in order to transition the handle bar between the standard and adaptive sides of the rowing machine, which decreases the functionality of the design for wheelchair users. As a result, the team created the antler design to mechanically solve the tension-removal issue present in the prior semester's design.
    - Similar to the Two Pulleys with Slit design, the antler design (Figure x) features two pulley plates which hold an added pulley that is directly in line with the rower's original pulley. However, the rower neck will be removed, and two antler-like structures will be attached to the pulley plates to hold the rower handle bar. The antlers will be placed such that the bar is held directly in the line of action between the two pulleys; thus, the only force acting on the bar will be directly downward (Figure x). This design solves the tension removal issue, as placing the handle bar in a more central location only requires the user to pull up against the downward tensile force on the bar and to move the handle bar toward themselves to begin the rowing motion. The transition of the handle bar between the standard and adaptive sides is more user-friendly and ergonomic.
- Antler design fabrication:
    - As part of the fabrication process, the team will be modeling the antler design on SolidWorks and adjusting dimensions as needed. Last semester, the rower welds were not taken into consideration in the CAD model of the rower that the team was given, which inhibited proper fitting of the pulley plates to the rowing machine. This semester, the team will be taking the rower welds into account as the plate designs are modified to ensure a tight fit.
    - Once dimensions are verified and the design is completely modeled on SolidWorks, the CAD model will be 3D-printed out of tough PLA at the MakerSpace for proof of concept. The team will test the functionality of the printed design and adjust dimensions as needed before fabricating the antler design with a more durable material. Gym equipment is typically composed of aluminum, carbon steel, or other metal alloys due to their lightweight nature and durability. [x]. Therefore, the team will most likely be welding with a durable metal to fabricate the antler design; however, more research of materials will need to be carried out before a final decision is made.
- Please note that figure numbers are not yet decided, as the report is still a work in progress. I will add an updated version of my section of the report into my design notebook when final edits are made.

Conclusions/action items:

I will be meeting with the team on Monday to finish editing the preliminary report as a team. In the meantime, I will continue working on research of materials and fabrication as we move into the fabrication phase of the design process. Testing procedures are also something to keep in mind, as well as the outreach activity that is required for BME 400.

Roxi Reuter - Oct 11, 2022, 5:11 PM CDT

Individual work on preliminary report:

Antler Design

The previously implemented Two Pulleys with Slit design (**Appendix B**) requires the user to remove tension in the rope in order to transition the rower handle between the standard and adaptive sides of the rowing machine. This decreases the functionality of the design for wheelchair users since outside assistance will most likely be required to transition the rower handle. As a result, the team created the antler design to mechanically solve the tension-removal issue present in the prior semester's design.

Similar to the Two Pulleys with Slit design, the antler design (**Figure 10**) features two pulley plates that hold an added pulley directly in line with the rower's original pulley. In this design, the rower neck will be removed, and two antler-like structures will attach to the pulley plates for the purpose of holding the rower handle when the machine is not in use. The antlers will be placed such that the rower handle is held directly between the two pulleys; thus, the only force acting on the bar will be directly downward (**Figure 11**). This design solves the tension removal issue by placing the handlebar in a more central location that only requires the user to pull up against the downward tensile force on the bar and move the rower handle toward themselves to begin the rowing motion. This transition of the rower handle between the standard and adaptive sides is more user-friendly and ergonomic.

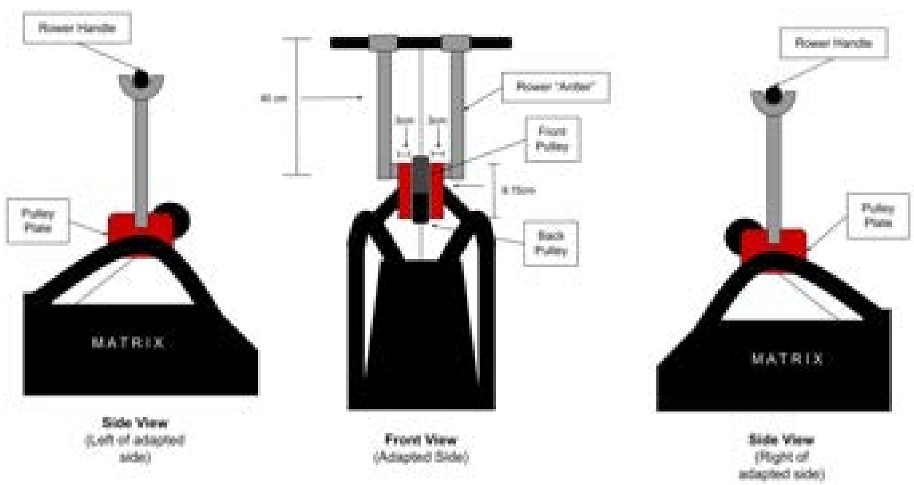


Figure 10. Antler Design. This design relocates the handle bar of the rower to a more central location and allows the user to row from the adaptive or standard side of the rower without needing to remove rope tension before transitioning the bar.

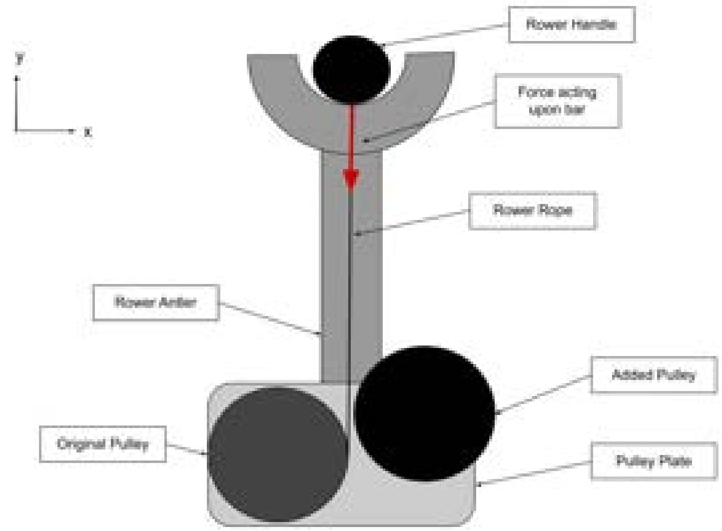


Figure 11. Tension on HandleBar of Antler Design. As part of the antler design, the handlebar is relocated such that it lies directly in between the two pulleys on the rower. Therefore, the net tension acting upon the bar is directly downward.

Fabrication:

Antler Design

As part of the fabrication process, the team will be modeling the antler design in SolidWorks and adjusting dimensions as needed. Last semester, the rower welds were not taken into consideration in the CAD model of the rower given to the team by Johnson Health Tech, which inhibited proper fitting of the pulley plates to the rowing machine. This semester, the team will take the rower welds into account while modifying the plate designs to ensure a tight fit.

Once dimensions are verified and the design is completely modeled in SolidWorks, the CAD model will be 3D-printed out of tough PLA at the MakerSpace for proof of concept. The team will test the functionality of the printed design and adjust dimensions as needed before fabricating the antler design with a more durable material. Gym equipment is typically fabricated out of aluminum, carbon steel, or other metal alloys due to their lightweight nature and durability [13]. Therefore, the team will most likely be welding with a steel or aluminum to fabricate the antler design.

10/28/2022 Gantt Chart

Roxi Reuter - Oct 28, 2022, 10:28 AM CDT

Title: Gantt Chart

Date: 10/28/2022

Content by: Roxi Reuter

Present: –

Goals:

- Create the team Gantt chart based on project tasks and deadlines that were discussed in last week's team meeting (10/21)

Content:

- This week, one of my responsibilities was to create the team Gantt chart
- In last week's meetings, we planned many of the tasks and deadlines for the project this semester
- I provided a template to the team, and Sam filled in the section for the stabilization frame. Then, I made a few changes to that section and added the rest of the information in the chart.
- The dates in the chart are subject to change based on surrounding circumstances with our project; however, we will try to follow this schedule as closely as possible.
- After I finished the Gantt chart, I approved it with the rest of the team, and it was sent out along with our progress report this week.

Conclusions/action items:

Please see the attached Gantt chart to view project dates and deadlines. The team plans on following this schedule as closely as possible to stay on track with project goals this semester; however, dates are subject to change if needed.

Roxi Reuter - Oct 28, 2022, 10:29 AM CDT

Download

JHT_Gantt_Chart_-_Team_Gantt_Chart.pdf (45.3 kB)

12/04/2022 Individual Poster Work

Roxi Reuter - Dec 05, 2022, 4:39 PM CST

Title: Poster Presentation Individual Work

Date: 12/04/2022

Content by: Roxi Reuter

Present: —

Goals:

- Complete/update my sections of the poster (abstract, background & motivation, problem statement)

Content:

- Please see images below for individual work on the poster
- This is before team editing

ABSTRACT

Exercise is essential to maintain a healthy lifestyle. Fitness centers offer a wide variety of workout equipment to strengthen and exercise different muscle groups within the body. However, the majority of these exercise machines are not accessible to individuals with disabilities or injuries that require a wheelchair. For example, standard rowers require external modifications to accommodate individuals in wheelchairs. The previous Johnson Health Tech Adaptive Rower design utilized an additional pulley on the adaptive side, held in place by mirroring support plates, as well as a wooden stabilization frame to secure the user. Throughout the Fall 2022 semester, the design was improved to increase its accessibility and enhance user experience while rowing. In place of the wooden stabilization frame, an adjustable lap pad support mechanism was integrated to prevent the user from tipping backwards and sliding out of their wheelchair. The Matrix neck was removed and replaced by two antlers extending from the pulley plates that hold the handlebar directly above the pulleys. As a result, the console was relocated to a slightly off-center position beside one of the pulley plates. The console automatically rotates between the standard and adaptive sides via a stepper motor using feedback from three limit switches. Final testing of the design examined the ability of the pulley support plates and support mechanism to withstand excessive loads experienced during rowing, as well as the displacement of the stabilization and wheelchair during exercise. Although the device can be improved, this unique and convertible design enables easy access to a rowing machine for wheelchair bound individuals and helps improve their quality of life through exercise.

BACKGROUND & MOTIVATION

Background:

- Rowing exercise targets shoulder, back, and oblique muscle groups [1]

Motivation:

- 5.5 million wheelchair users in the U.S. [2]
- Consistent upper body exercise can alleviate shoulder pain, which is common amongst wheelchair users [3]
- Lack of adaptations for rowing machines on the market
- Existing devices permanently change functionality of the rower (AROW) [4]
- Increase exercise options for wheelchair users

Figure 1. AROW Rowing Machine [4]

Conclusions/action items:

I completed my individual sections of the poster (see images above) and also completed individual editing of the entire poster. The team will be meeting on 12/05 from 7:30-8:30PM on Teams to do final edits of the poster and will get advisor feedback on Wednesday 12/07 during office hours.

12/05/2022 Individual Poster Editing

Roxi Reuter - Dec 05, 2022, 4:43 PM CST

Title: Individual Poster Editing

Date: 12/05/2022

Content by: Roxi Reuter

Present: —

Goals:

- Look over the team poster before the group editing session

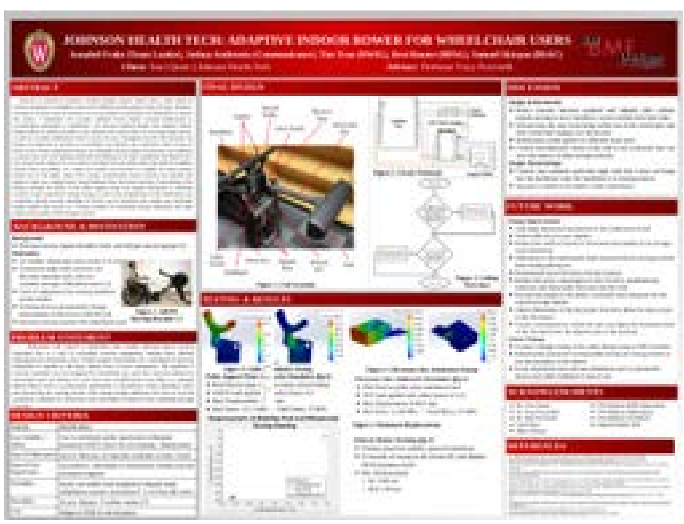
Content:

- Overall, the poster is fairly complete
- There are some places that are missing quantitative information and a few spots which need to be corrected for grammatical or stylistic errors, but this seems to be very minor
- Please see attached file of the poster with comments

Conclusions/action items:

The poster is in very good shape! There are a few minor fixes, but the team will be meeting today (12/05) at 7:30PM via Teams to make final team poster edits.

Roxi Reuter - Dec 05, 2022, 4:47 PM CST



Download

Final_Poster_-_Adaptive_Rower_Fall_2022.pptx (6.32 MB) Please note that you may need to download this file to view the comments.

12/13/2022 Final Report Work

Roxi Reuter - Dec 13, 2022, 3:31 PM CST

Title: Final Report Work

Date: 12/13/2022

Content by: Roxi Reuter

Present: –

Goals:

- Document final report individual work

Content:

- In the report, I updated the abstract (used on the poster but, ultimately, did not need for the poster, so we pasted it in the report and made updates where necessary), motivation and background information, wrote the discussion, updated the cost information, and added sketch edits where necessary
- I also made other changes where I found necessary and help update figures, sketches, and sources.
- The bulk of my work was in the abstract, motivation and background, and discussion, although I helped out in other areas, too. Below are the final versions of the parts which I was assigned. Please note that in some sections (such as competing devices) I added information, so not all the work is originally mine.

I. Introduction

A. Problem Statement

Individuals with injuries or disabilities have difficulty utilizing typical workout machines due to a lack of accessibility to exercise equipment. Among these affected individuals are wheelchair users. 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. To solve this issue, modifications must be made to current manufactured machines. A standard Matrix rowing machine will be adapted to accommodate wheelchair users while retaining its original functionality for non-wheelchair users [1]. The Adaptive Rower will secure the wheelchair/user to the rowing machine, preventing the user from both tipping backwards and falling forwards out of the wheelchair during the workout. This modified design will increase the accessibility and ease of use of the rowing machine, ensure the proper rowing form is maintained, and ultimately help to improve the overall well-being of wheelchair users through exercise.

B. Motivation

Wheelchair users make up a significant proportion of the world's population. In the United States alone, 5.5 million people require a wheelchair to perform daily tasks [2]. Currently, there is a lack of wheelchair accessible workout equipment in fitness centers, and a reported 81% of physically disabled individuals stated that they felt uncomfortable in gym settings due to this lack of accommodating exercise equipment [3]. In 2021, Planet Fitness, a major fitness center company, announced its goal to create a more inclusive gym environment by adding adaptive equipment to its new and existing locations; however, very few adaptive machines were added, and several other major gym companies have yet to add inclusive equipment to their gym space [4]. This proves the gap in the market for adaptive gym equipment.

Additionally, all current adaptations to fitness equipment are fabricated by the consumer or third-party services. Most fitness equipment manufacturers do not offer machines intended for users with physical disabilities. Common complaints among the wheelchair community include a lack of space between equipment for wheelchair access and an overall lack of adaptive equipment at fitness centers. In addition, wheelchair users reported a concern about needing or requesting assistance [5]. Even if all of these criteria are met, there is still a need for external assistance. Requests for additional stability measures that are not present at fitness centers include velcro to improve grip, straps for securement to the wheelchair, and elimination of the need to continuously leave the wheelchair for particular exercises [5]. These requests are not unreasonable and should be provided at every fitness center. Proper exercise leads to a healthier life; therefore, wheelchair users should not be denied this right due to a lack of equipment. To combat this, more adaptable equipment that satisfies the aforementioned criteria needs to be made. The creation of an adaptive rowing machine will allow wheelchair users to remain stable throughout their workout and offer gyms a solution to increase the accessibility of their facilities.

C. Existing Devices and Competition

Many rowing ergometers do not have disability design considerations, and exercise machines in general are not designed specifically for individuals in wheelchairs. Most adaptive products are third-party and will void the warranty of the machines [6]. The two most common methods to accommodate rowing for wheelchair users are replacing the sliding seat with a fixed seat, or removing the sliding rail altogether [7]. The fixed seat method requires the user to transfer themselves from their wheelchair to the fixed seat on the rower which is often not possible without outside assistance [8]. However, this method does allow a quick transition between the adaptive and non-adaptive forms as the seats are easily screwed on and off. Alternatively, removing the sliding rail allows the wheelchair users to operate the rowing ergometer directly from their wheelchair. This method makes the rowing machine more accessible, however, it is likely that disabled individuals will require assistance to remove the sliding rail. It is unlikely that this method would be employed at fitness facilities due to the need to maximize space and usage of the machines.

Researchers at the British Columbia Institute of Technology designed the Adaptive Rowing Machine (AROW). The design and fabrication instructions are free on their website [7]. The adaptations, which can be seen in **Figure 1**, were designed specifically for the Concept 2 rowing ergometer. The design involves removing the sliding rail so that operation of the rowing machine can be completed directly from the wheelchair. The adaptations to the Concept 2 include permanently attaching an aluminum truss onto the frame of the rowing machine and securing a plate at the base of the rower. The ends of the aluminum bar are enclosed in padding to support the user's lower body, and there is an optional bar to support the upper body. The bars are screw adjustable to accommodate different body sizes. The plate at the base of the machine extends to the front wheels of the wheelchair and under the rowing machine to prevent the translation of the ergometer during intensive activity. A shortcoming of the AROW design is the permanent transformation of the rower, which voids the warranty and prohibits standard use of the machine. Additionally, the adaptation requires extensive fabrication instructions, which take a significant amount of time to follow. Lastly, the permanently attached chest bar prohibits the user from interacting with the resistance setting and console during the workout. Despite these advancements in adaptive rowing machines, a gap in the market remains for a convertible rowing machine that allows for both standard and adaptive use, along with easy access to the interface for workout settings.

Figure 1. AROW adaptations to Concept 2. Adaptations for the Concept 2 include a support bar extending to the user's chest and a rigid attachment to the frame of the rower [7].

Adapt2Row is another adaptive rower on the market which allows for standard and adaptive wheelchair use on the Concept2 rowing machine and can be seen in **Figure 2** [6]. During adaptive use, the user is able to row directly from their wheelchair, which eliminates assistance to transfer the wheelchair user to/from a fixed seat on the rower. However, this design does not completely remove the need for outside assistance, as a wheelchair user will likely need assistance to transition the Concept2 rower for adaptive use. Additionally, Adapt2Row is only compatible with the Concept2 rowing machine and the Adapt2Row design is solely shipped in the EU, limiting the accessibility of the device. Due to the need for outside assistance and the difficulty of obtaining Adapt2Row within the U.S., there remains a need for an adaptive rower which does not require outside assistance and allows both standard and adaptive rowing on the same machine.

Figure 2. Adapt2Row on a Concept2 Rowing Machine. Adapt2Row allows for both standard and adaptive rowing on the Concept2 rowing machine but still requires outside assistance to transition between both states [9].

VII. Discussion

This semester, substantial progress was made on the adaptive rower design. Successful integration of the antler and pulley plate, console, and stabilization frame designs was completed to constitute a working prototype. Entering the Fall 2022 semester, three main goals were established. First, the ease of transition of the handlebar between the standard and adaptive sides should be improved. Second, a more durable and effective stabilization frame should be incorporated into the adaptive rowing machine to secure the user and their wheelchair on the adaptive side. This frame should be adjustable to accommodate more individuals and their varying wheelchair dimensions. Lastly, a mechanism to allow the swivel of the console between both sides of the rower should be designed.

Fortunately, all of these goals were accomplished. First, the antler and pulley plate design gives the handlebar a neutral resting location which can be easily accessed from both sides of the rower and eliminates the rope tension issue from the Spring 2022 design (**Appendix B)**. Second, a durable metal stabilization frame with a lap pad was fabricated using materials supplied by Johnson Health Tech. Additionally, this semester's design was able to target a larger audience because the frame allows for height adjustment, fitting more users and wheelchairs. Finally, through the use of electronics and strategically-placed limit switches, the console automatically rotates between the standard and adaptive sides based on the position of the lap bar. This means that the user can view their workout information while rowing without having to worry about manually swiveling the console before getting set in the rowing position, improving the ease of use of the rower. The console rotation passed all of its functionality tests, as it rotated to the correct side of the rower when placed in several different edge cases.

Load and displacement testing revealed successful functionality of the pulley support plates and the electronics box but predicted failure for the antler feature on the pulley plates. SolidWorks simulations used for extreme loading cases on the 3D-printed pulley plates and electronics box indicated no signs of failure because the maximum displacements for each component were lower than the tolerance specified in the PDS, and the maximum stresses that developed were less than the yield strength of the Tough PLA material. This proved that the pulley plates and electronics box are able to withstand loads with at least a safety factor of two. The antlers were predicted to develop stresses beyond the yield strength of the Tough PLA material and develop displacements larger than specified in the PDS under extreme loading. To address this failure, the geometry will be improved, and the material will be upgraded to metal (see **Section IX.A.**). Although the antlers are likely to never experience these worst case loads, it is important for this feature to withstand worst case loading.

The stabilization frame also proved its design durability during user testing because the motion capture recorded minimal displacement of the lap bar and the wheelchair on the highest and lowest resistance settings. The wheelchair experienced greater displacement during the lower resistance trial, and the lap pad sustained greater displacement during the higher resistance trial. These results can be explained by the differing tensions developed in the rope while rowing. For the lower resistance trial, less tension develops in the rope, which allows the user to reach a higher backward velocity during the pulling phase. This faster recoil of the body impacts the wheelchair backrest and causes the wheelchair to tip and translate backwards slightly. For the higher resistance trial, a greater tensile force develops in the rope when compared with the lower resistance trial. This larger force pulls the users forward out of the wheelchair. To counteract this, the user braces themselves against the lap pad with a larger force, which ultimately moves the lap pad a greater distance. For the lower resistance trial, the user does not have to brace against the lap pad with as large of a force. This results in the lap pad not moving as much during the lower resistance trial. The updated stability frame yielded improved displacement values compared to the previous wooden stabilization frame. Wheelchair displacement was reduced from 4.09 cm in the x direction down to 2.06 cm, and the stabilization frame's displacement was reduced from 1.86 cm in the x direction to 0.58. In comparison with the previous wooden stabilization frame, this was a major improvement. During the testing of the stabilization frame, it was important to ensure the safety of the test subject.

Potential sources of error during testing could have skewed the results. During motion capture testing, potential error sources include inaccurate dimension calibration in Kinovea and movement of the recording device (phone) between takes such that it did not rest in the same spot for both resistance trials. Inaccurate placement of the calibration line in the Kinovea analysis could have also led to an unreliable displacement reading created during either rowing intensity trial. Furthermore, although users were instructed not to use their legs while rowing on the adaptive side, there was no way to completely ensure this standard was followed. Any lower extremity muscular effort by the test participant during rowing could have skewed the results of the Kinovea tests. However, since the previous Kinovea test was conducted with the same procedures, the improvements seen in the updated stabilization frame indicate a true improvement of the stabilization frame's ability to limit movement while rowing as compared to the previously built wooden structure from Spring 2022.

Additionally, although the Fall 2022 adaptive rower design can accommodate a wider variety of wheelchair dimensions as compared to the Spring 2022 design, the stabilization frame still does not allow access to wheelchairs with narrower widths. Since the stabilization pad is too wide to fit in between the armrests of the average wheelchair, only users with wider wheelchairs can use the rower. Furthermore, users with shorter arm lengths may experience difficulty reaching the handlebar as the stabilization pad is not able to retract. These considerations must be accounted for to improve the inclusivity of the device. By catering to a larger demographic of wheelchair users, the final design will offer a more welcoming and accessible experience to the wheelchair community in comparison to the products that are currently offered.

Conclusions/action items:

This concludes the final edits of the report! Each team member will read over the report and make any necessary changes before turning it in. Overall, it has been a fun semester working on this project, and I am excited to continue working on the project with this group next semester! Please see the full final report in the team LabArchives folder.

10/26/2022 Outreach Activity Ideas and Research

Roxi Reuter - Oct 26, 2022, 11:41 PM CDT

Title: Outreach Activity Research

Date: 10/26/2022

Content by: Roxi Reuter

Present: –

Goals:

- Begin thinking and planning the outreach activity requirement for BME 400/402

Source: https://engineering.jhu.edu/outreach/activities/

Content:

- Johns Hopkins School of Engineering provides several outreach activities which can be filtered by grade level or subject
    - Options include: Science, Math, Engineering, Technology, Elementary, Middle, High
- A few examples I looked at:
    - Potato Power (45 minutes, grades 3-5) - teach kids simple circuits and how batteries work (light up an LED using potatoes)
    - Pepper and Soap Experiment (Grade 2) - have children learn about the surface tension of water and why soap is necessary when washing hands
    - Inventing a Backscratcher from Everyday Materials (45 minutes, Grades K-2) - introduce a problem and guide students to designing a device/apparatus to solve the problem

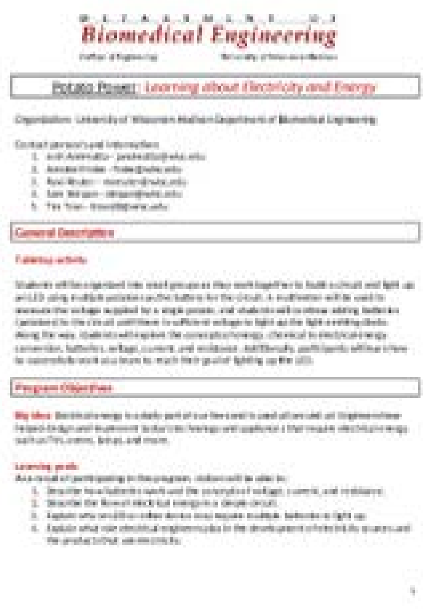
Conclusions/action items:

Although there are many other options for outreach activities on the Johns Hopkins website which I included above, I looked at a few engineering and science outreach projects which are targeted for a younger audience and are around 45 minutes each. These activities are engaging and fun yet help teach student basic but important concepts in science and engineering.

I will discuss my research with the team and start making arrangements for the outreach activity.

11/30/2022 Activity Outline

Roxi Reuter - Nov 30, 2022, 7:26 PM CST


Biomedical Engineering

Potato Power: Learning about Electricity and Energy

General Description

Program Objectives

Download

BME400_Outreach.docx (53.5 kB)

11/02/2022 IRB Exemption Categories

Roxi Reuter - Nov 02, 2022, 12:43 PM CDT

Title: IRB Research

Date: 11/01/2022

Content by: Roxi Reuter

Present: —

Goals:

- Look at IRB information since we will have human subjects testing our device (need approval)

Sources: https://irb.wisc.edu/ , https://kb.wisc.edu/sbsedirbs/page.php?id=90518 ,

Content:

- “The Minimal Risk Research IRB: Reviews research protocols that present minimal risk to subjects, including medical interventions or procedures requiring medical expertise or knowledge of the health care setting and human participants research occurring within the social and behavioral sciences.”
- Must submit an IRB research application for research exemption with human subjects (obviously must have minimal safety risk)
    - “If a study is determined to be exempt from review, it is not subject to continuing review or other rules governing human research, such as rules on obtaining written consent.”
- Exemption categories implemented at this time:
    - Category 1: “Research conducted in established or commonly accepted educational practices that are not likely to adversely impact students’ opportunity to learn required educational content or the assessment of educators who provide instruction. This includes most research on regular and special education instructional strategies and research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods”
    - Category 2: “Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior (including visual or auditory recording).”
        - Could get an exemption if we demonstrate or show the device without having others (such as wheelchair users) actually test the device and just conduct a survey with
    - Category 3: “Research involving benign behavioral interventions (i.e., brief in duration, harmless, painless, not physically invasive, not likely to have a significant adverse lasting impact on or be offensive or embarrassing to the subjects) with adult subjects who prospectively agree to the intervention and collection of information through verbal or written responses (including data entry) or audiovisual recording.”
        - This would most likely be the category (“benign behavioral intervention”) we would request exemption in
    - Category 4: “Secondary research uses of identifiable private information or identifiable biospecimens.”
    - Category 5: “Research and demonstration projects that are conducted or supported by a Federal department or agency, or otherwise subject to the approval of the department or agency heads, that are designed to study, evaluate, or otherwise examine:
        - procedures for obtaining benefits or services under those programs;
        - possible changes in or alternatives to those programs or procedures; or

        - possible changes in methods or levels of payment for benefits or services under those programs."
    - Category 6: "Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approve by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture (45 CFR 46.101 (b)(6) and 21 CFR 56.104 (d)."
- UW institutional policy requires a consent process for exemptions, so an information sheet or an oral consent script are needed
- Category 3 exemption considerations:
    - Must have a detailed consent document for participants, and the participants "must be made aware of research procedures".
    - Participants must be notified of audio or video recordings in the consent form if applicable.

Conclusions/action items:

In this research session, I looked into the IRB department at UW-Madison and their exemption categories. Tracy said we will need to submit an IRB exemption application if we want to carry out testing as we had planned (by allowing other individuals to actually test our rowing design after safety has been ensured). I will share this information with the team and continue looking into the application process.

11/09/2022 IRB Exemption Application Process

Roxi Reuter - Nov 09, 2022, 11:17 PM CST

Title: IRB Exemption Application Research

Date: 11/09/2022

Content by: Roxi Reuter

Present: —

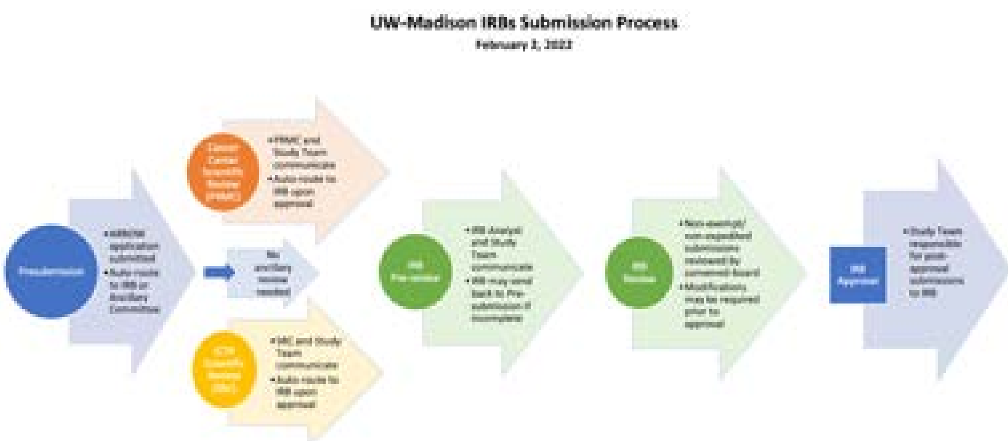
Goals:

- Continue researching the exemption process for IRB that will be needed if we intend to actually have one or more users testing the rower

Source: https://irb.wisc.edu/how-to-submit/new-study/

Content:

- “Federal regulations allow some kinds of research which pose very minimal risk to subjects to be exempt from IRB review. However, UW policy states that the IRB office, not the investigator, must make this determination”
- Below is the application submission process:



- Since we are looking for an exemption, we will be submitting a new study categorized as Non-Protocol Based Application (nPBA)

Conclusions/action items:

After looking into the application process, I realize that we should get this process started soon in order to request an exemption for our project testing. I believe that we will be submitting an nPBA; however, this is something to ask Tracy about at our meeting this Friday (11/11).

11/29/2022 IRB Application Progress and Questions

Roxi Reuter - Nov 29, 2022, 11:03 PM CST

Title: IRB Application Process and Questions

Date: 11/29/2022

Content by: Roxi Reuter

Present: —

Goals:

- Make more progress on the IRB application
- Note any questions that I have for Tracy

Content:

- Questions for Tracy:
  - PI Appointment #4 - " Is this an investigator-initiated study?"
  - Do we need to upload a form for the "Request To Serve As PI" section?
  - Funding section - "Do you have pending or approved funding NOT listed on this page?"
    - I said "Yes" (the other funding is RSP or Business Services funding)
  - Scientific Review section - are any of the options true for our project?
  - ClinicalTrials.gov Information section - need help answering both questions listed.
- Questions for team:
  - Study Team section - Who do we want to list as points of contact for the study (up to four total, and I am already listed)? You can read and edit the application.
    - We can also just list everyone else as "Study Team Personnel", which allows members to read the application but not edit it. You cannot be listed as both. So far everyone is listed as "Study Team Personnel"
  - Assign specific roles for "Study Team Details"? Right now I have everyone listed for all topics ("Identify or Recruit Subjects", "Obtain Informed Consent", and "Interact with Subjects")
  - BE SURE TO LET TEAM MEMBERS KNOW THAT WE MUST EACH SUBMIT AN OAR (Outside Activities Report)
    - This is because we're all listed as participants on human subject protocols
    - https://research.wisc.edu/compliance-policy/outside-activities-reporting/
  - Conflict of Interest section: How should I answer this question? We don't have patent for any of our designs, but is there anything we could/would potentially patent? - "Do any study team members involved in the design or conduct of the research (including their spouses and dependent children) own intellectual property that will be used in the study or project?"

Conclusions/action items:

In this session, I was able to complete the "General Study Information" section of the IRB ARROW application. I do have some questions which I noted above and will be asking Tracy and/or the team when we get the chance to go over this. Answering these questions may have to wait until break since we only have a little over a week until final poster presentations, and the team will be focusing on integration, testing, and final deliverable in the meantime. I also need to remind the team that everyone must fill out an OAR (outside activities report).

09/18/2022 Adjustable Wheelchair Stabilization Ideas

Roxi Reuter - Sep 19, 2022, 12:23 AM CDT

Title: Design Brainstorming Session

Date: 09/18/2022

Content by: Roxi Reuter

Present: –

Goals:

- Describe and/or illustrate design ideas to meet our project goals and improve the current adapted rower design

Content:

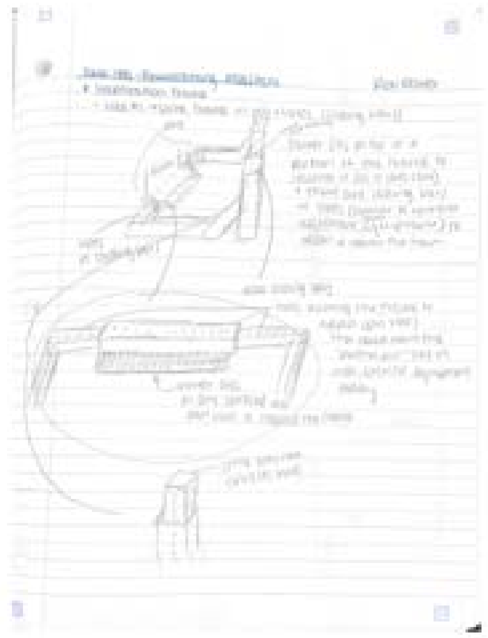
- There are a variety of design ideas which my teammates and/or I have discussed or thought out, including the following:
  - Moving the console and allowing the bar and cable to rest in a more neutral location between the normal and adapted sides of the rower, removing the need for a tension removal mechanism
  - Motor or linear actuator which would help remove the tension from the rope while being transitioned between the adapted and normal sides of the rower
  - A horizontal pin design for rotating the console, which is more durable than the current design and will be more easily manipulated
  - An adjustable frame for wheelchair stabilization
  - Control of the resistance from the adapted side
- The design that I will work out right now involves the wheelchair stabilization frame. A few issues right now:
  - 1. Material is not as durable as we would like, which allows more movement than desired
  - 2. The straps which "secure" the user's chair do not hold the wheelchair very steady during the rowing motion
  - 3. It is not adjustable, so it does not accommodate most wheelchair dimensions, just the one which was tested with the rower
- Two possible design ideas that came to mind:
  - 1. Building the same frame as currently used out of metal but (similar to normal adjustable exercise equipment) having a sliding bar design with holes in the horizontal bars and vertical bars which allow the user to adjust both the width and height of the frame)
    - Possible issues: ease of adjustability - may require outside help and be heavy
      - Could add some sort of pneumatic or hydraulic assist or possibly automate the movement of the frame?
- See attached document for design ideas and explanations

Conclusions/action items:

In this brainstorming session, I came up with three design ideas for an adjustable or more accommodating wheelchair stabilizer frame. The first design idea included using the current frame built out of a more durable material with sliding bars in the vertical and horizontal directions which allow the user to adjust the height and width of the frame with a pin. The second design just involved adding a foot rest and lap/chest pad to the design, which would be adjustable in height. This would eliminate the need for the frame. Finally, the third design involved a combination of the two ideas: keeping the frame (built out of metal) but attaching a chest and lap support onto the frame on a sliding bar for adjustments.

These ideas aren't 100% functional yet, as there may need to be tweaks in placement; however, I will contribute these ideas to the team brainstorming session tomorrow (09/19) and hopefully get feedback on how to improve these design ideas if they are implemented.

Roxi Reuter - Sep 19, 2022, 12:23 AM CDT



Download

BME400_Brainstorming091822.pdf (748 kB)

09/20/2022 Design Ideas Recap

Roxi Reuter - Sep 20, 2022, 10:22 PM CDT

Title: Brainstorming Ideas

Date: 09/20/2022

Content by: Roxi Reuter

Present: –

Goals:

- Brainstorm ideas for the two main areas of improvement for our project, including recycling some ideas that we discussed in our team meeting yesterday (09/19)
  - 1. Tension removal mechanism
  - 2. Wheelchair and user stabilization

Content:

- Tension removal mechanism:
  - Annabel's idea of using "antlers" to hold the rowing bar in a central location between the two pulleys
  - The trick would be relocating the console…
    - Attach to one side and allow to rotate?
- Stabilization:
  - Lap pad
    - Connect to a base board?
    - Connect to current wooden frame (but build out of a more durable material)?
    - Connect to rower itself?
    - Use in combination with a chest pad?
    - Must prevent user from being launched forward out of their chair while rowing and prevent the chair from tipping backward
    - Adjustability?

Conclusions/action items:

After recapping some initial thoughts on design solutions to improve our project, I will proceed to brainstorm and create sketches for each of the two areas individually.

09/20/2022 Tension Removal Design

Roxi Reuter - Sep 20, 2022, 11:24 PM CDT

Title: Tension Removal Mechanism Design Ideas

Date: 09/20/2022

Content by: Roxi Reuter

Present: –

Goals:

- Further develop and sketch design ideas discussed in previous meetings, as well as add own design elements if necessary

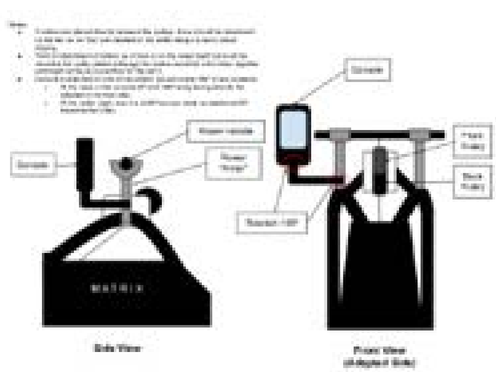
Content:

- Tension removal mechanism idea:
    - Two “antlers” which hold the bar neutral between the two pulleys
        - Will attach to the side of the rower
    - Actual antlers - rounded, square, or triangular?
        - See attachment for analysis on these (any will work)
- See attached PDF for digital drawing and notes of the antler design on the rower for tension removal

Conclusions/action items:

In this brainstorming session, I was able to sketch up both a front and side view of the antler design to solve the team’s tension removal mechanism issue. I used Annabel’s original idea and built off of it to relocate both the bar and the console. I will show this to the team during the design meeting tomorrow (09/21) and continue brainstorming ideas for the wheelchair stabilizing mechanism.

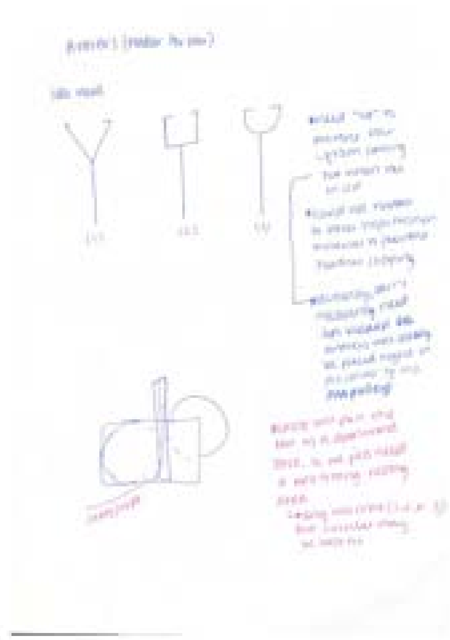
Roxi Reuter - Sep 20, 2022, 11:27 PM CDT



[Download](#)

Antler_Design.pdf (50.2 kB)

Roxi Reuter - Sep 20, 2022, 11:27 PM CDT



Download

Antler_Shape.pdf (182 kB)

09/21/2022 User Stabilization Design

Roxi Reuter - Sep 21, 2022, 12:00 AM CDT

Title: Wheelchair Stabilization Design

Date: 09/21/2022

Content by: Roxi Reuter

Present: –

Goals:

- Sketch up and elaborate on design possibilities which allow stabilization of the user and chair (preventing tipping and preventing the individual from being launched out of their wheelchair) during rowing. The design should be adjustable to accommodate varying wheelchair dimensions.

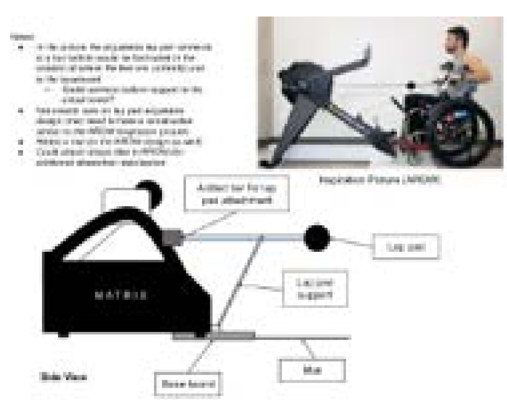
Content:

- As I suggested in the last team meeting on Monday (09/19), having a simple and adjustable lap pad may be the best solution for accommodating various wheelchair users and their chair dimensions
    - This was inspired by the AROW design (see attachments for more details and citation information)
- Still uncertain of exactly how and/or where the lap pad would connect, but that is a topic for discussion with the team
- See attached drawing for more design information and notes

Conclusions/action items:

Overall, I came up with a relatively simple solution for stabilizing the wheelchair and its occupant during adapted rowing. Although the design is not fully planned out, I will show it to my team during our brainstorming and design meeting today (09/21) for feedback.

Roxi Reuter - Sep 21, 2022, 12:00 AM CDT



Download

User_Stabilization.pdf (97.4 kB)

Roxi Reuter - Sep 21, 2022, 12:00 AM CDT

Download

AROW-instructions-set-up.pdf (1.16 MB) AROW Instructions Source: https://adaptederg.commons.bcit.ca/ Citation: “Introducing the Adapted Rowing Machine (AROW),” Adapted Rowing Machine AROW. [Online]. Available: https://adaptederg.commons.bcit.ca/. [Accessed: 18-Sep-2022].

09/25/2022 Updated Design Sketches (Antler)

Roxi Reuter - Sep 25, 2022, 12:40 PM CDT

Title: Updated Design Sketches (Antler)

Date: 09/25/2022

Content by: Roxi Reuter

Present: —

Goals:

- Update sketches for design matrix based on team feedback and discussion, due Friday (09/30)

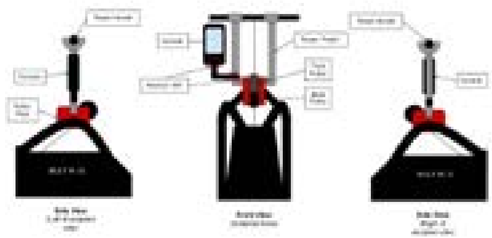
Content:

- At the team meeting on Friday (09/23), I showed the team the sketches I had come up with for the antler and tension-removal designs
    - The team decided they were very professional-looking, and we will be using them as templates and slightly modifying them to use in the design matrix, preliminary presentation, and the report
- Antler design:
    - After team conversation, I modified the current sketch such that the handle bars ("antlers") are higher than the display console. That way, the console is closer to its old location and is less offset from the center of the rower.
    - Changed the pulley plate colors to be more visible with a white background
    - Added additional labels and a second side view so that the design idea is more clear
- I added two variations of this design to the team drive:
    - One has a single rotation point directly under the console
    - The second has two points of rotation: one under the console (as in the aforementioned design) and a second point of rotation where the arm bar holding the console connects to the rower's "antler"
        - See attached images for more details
    - Annabel will be using this template for the stepper motor design, which will be scored in the design matrix
- I also added a copy of my lap support design to the drive, which Tim and Sam will be modifying as part of their work as the stabilization subgroup

Conclusions/action items:

I will confirm that the changes I made to the designs were what the team was looking for. Today (09/25), I will be meeting with my tension removal subgroup to work on creating our design matrix criteria, definition, and weights. We will also review our individual design sketches and work on scoring the design matrices with the entire team on Tuesday (09/27) from 4-5:30PM.

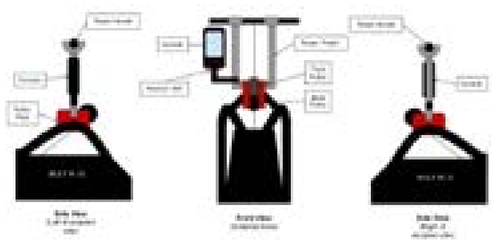
Roxi Reuter - Sep 25, 2022, 12:37 PM CDT



Download

Antler_Design_Two_points_of_rotation_.pdf (48.1 kB) Updated antler designs which will be used in team deliverables.

Roxi Reuter - Sep 25, 2022, 12:37 PM CDT



Download

Antler_Design_One_point_of_rotation_.pdf (48 kB) Updated antler designs which will be used in team deliverables.

09/28/2022 Preliminary Design Edits

Roxi Reuter - Sep 28, 2022, 10:55 AM CDT

Title: Design Sketches Updates (Dimensions)

Date: 09/29/2022

Content by: Roxi Reuter

Present: —

Goals:

- Make necessary adjustments to design sketches based on feedback
- Add dimensions to the designs

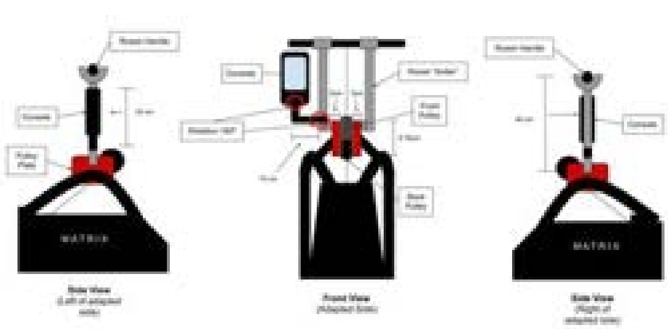
Content:

- Josh mentioned that adding ballpark dimensions to our design sketches for the design matrix is important
  - This will better-orient the reader to the rower size and the scale of the added design components
- I referenced the team's final report from Spring 2022 to acquire the most accurate dimensions possible
  - Pulley plate dimensions were listed in terms of length and height (9.75 cm and 16.88 cm). Width was not specifically mentioned, but we would like a thicker plate design to increase strength and durability, so 3 cm was chosen as a starting point.
- No other dimensions applicable to the console design were included in the final report, so the team estimated that the antler height will be approximately 40 cm and the console with the vertical section of the mechanical arm/motor would total 30 cm.
- The horizontal component of the mechanical arm should extend approximately 10 cm to allow the console to be closer to the midline but still fit next to the antler

Conclusions/action items:

I was tasked with updating the design sketches with dimensions, so I referred to last semester's documentation for the most accurate measurements of already existing components. The other dimensions were rough estimations that I made which were then modified slightly after team discussion. Please see the attached updated design sketches for exact dimensions added. Moving forward, we will adjust the dimensions as seen fit.

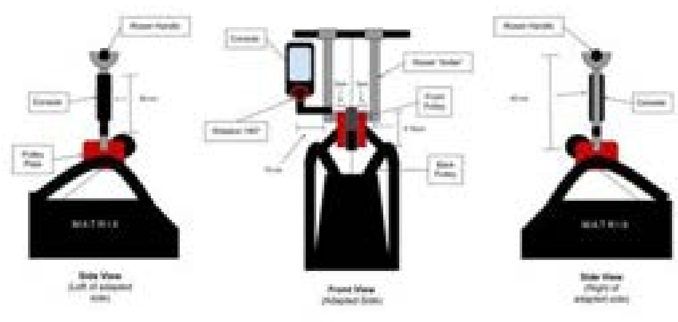
Roxi Reuter - Sep 28, 2022, 10:56 AM CDT



Download

Antler_Design_Two_points_of_rotation_2_.jpg (72.9 kB)

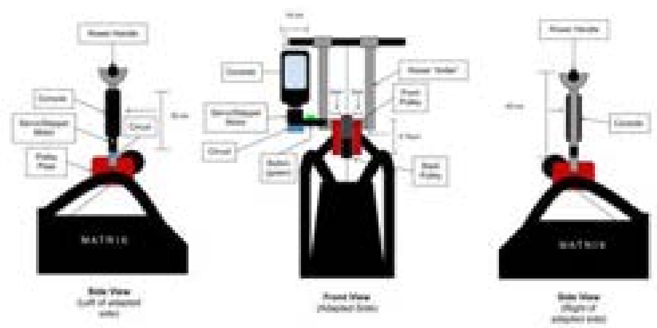
Roxi Reuter - Sep 28, 2022, 10:56 AM CDT



Download

Antler_Design_One_point_of_rotation_3_.jpg (72.6 kB)

Roxi Reuter - Sep 28, 2022, 10:56 AM CDT



Download

Console_with_Servo_Stepper_Motor_Rotation.jpg (79.4 kB)

09/30/2022 Lap Pad Angle Adjustments

Roxi Reuter - Oct 06, 2022, 9:13 PM CDT

Title: Brainstorming and Updated Lap Pad Sketch

Date: 09/30/2022

Content by: Roxi Reuter

Present: —

Goals:

- Brainstorm an adjustment mechanism for the lap pad
- Create a sketch of the new lap pad design that I come up with

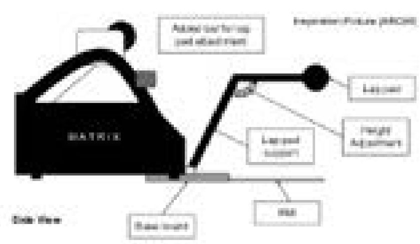
Content:

- As the team was discussing the current vertical adjustment mechanism for the lap bar stabilization mechanism, I thought of a design idea which may make the fabrication process easier, as well as increase the ease of use for the user
- My design involves moving the point of adjustment between the two supporting bars for the lap pad
    - This angle adjustment between the two bars will utilize a pin and hole locking mechanism to lock the bar into the correct vertical position
    - This is similar to current adjustment mechanisms in gym equipment
- ** See attached design sketch for more details.

Conclusions/action items:

The team is planning on moving forward with this lap pad adjustment mechanism design after discussing the design and talking with the client. This sketch will be modified and used in the preliminary presentation and report.

Roxi Reuter - Oct 06, 2022, 9:13 PM CDT



Download

New_User_Stabilization_Sketch.pdf (40.9 kB)

10/03/2022 Brainstorming Lap Pad Adjustments with Staci's Ideas

Roxi Reuter - Oct 03, 2022, 6:07 PM CDT

Title: Brainstorming with Staci's Stabilization Ideas

Date: 10/03/2022

Content by: Roxi Reuter

Present: –

Goals:

- Take ideas from Staci's PowerPoint and current user stabilization frames at JHT to brainstorm adjustment mechanisms for the lap support

Content:

- Staci sent us a presentation with pin-in-plate commercial strength frames at JHT (see attachment)
- She suggested moving the pivot point for adjusting the lap pad to the section where the lap support bars meet and using a similar pin-in-plate design mechanism
    - This is very similar to the design idea I sketched on Friday (09/30) and discussed with the team
    - Staci also suggested a vertical (and not diagonal) support bar which attaches to the base board of the rowing machine that we will be adding
        - This may be easier in terms of fabrication, as we do not know specifically what the angle should be between the rower base board and the support that attaches to it
        - Additionally, the welding task may be simpler if we weld two components orthogonal to each other as compared to any other reference angle

Conclusions/action items:

In this brainstorming session, I looked through Staci's presentation that was sent to us for adjustable locking mechanisms on current JHT devices. Her design is very similar to the one which I brainstormed on (09/30/2022) but suggests folding the lap bar down for storage. This may be less user-friendly than our current design, as the user must pick up the lap support from the ground, maneuver their wheelchair under the support, and then adjust it to lock themselves into a secure position.

This is a topic which will need to be addressed with the team in addition to the angle of the bar supports for the lap bar.

In the meantime, I will continue brainstorming design ideas, work on the preliminary presentation, and do necessary research to support my brainstorming design decisions.

Roxi Reuter - Oct 03, 2022, 6:08 PM CDT

Download

Adaptive_Rower_Stabilization_Design_Suggestion_.pptx (4.2 MB) The PowerPoint presentation sent by Staci to the team with the following information in the email: "Hi Team, As promised, I investigated the commercial strength frames today while in the office. I have discovered that the adjustments do not use a cable but are pin in plate assemblies that use linkages. I have come up with a suggestion for the stabilization design that will simplify it. Please see attached for images of the pin in plate linkage designs as well as my suggestion. The suggestion moves the pivot from the baseboard to the angle portion of the arm. If the pad pivots around this new location the height and length of the pad's position are adjusted according to the pivot arc. This will change the user's adjustment points from 3 to 1. This would also let the arm fold when not in use. Let me know if you would like to talk through this at all this week or if you have any questions Thanks, Staci Quam"

10/06/2022 Prelim Presentation Antler Sketch Modifications

Roxi Reuter - Oct 08, 2022, 11:30 AM CDT

Title: Antler Design Sketch Update (Presentation)

Date: 10/06/2022

Content by: Roxi Reuter

Present: –

Goals:

- Update the antler design sketch for the preliminary presentation

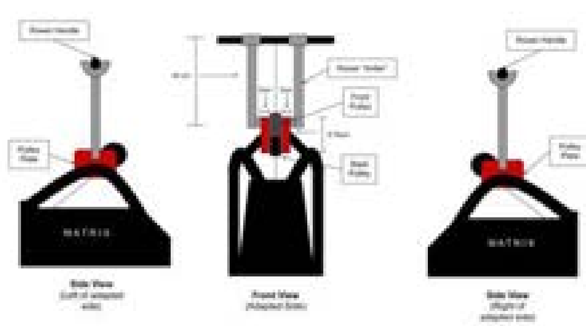
Content:

- See attachment for design sketch update
- I was able to modify the combined antler and console sketch such that only the antler design was focused on and reflected
  - We split up the presentation so that the antler and console designs were talked about separately

Conclusions/action items:

I will finish my parts of the presentation, edit the presentation with the team, practice, and deliver the preliminary presentation on 10/07. Following this, I will modify sketches as needed and work on the preliminary report, as well as PDS updates.

Roxi Reuter - Oct 08, 2022, 11:30 AM CDT



Download

Antler_Design_Sketch_No_Console_.jpg (63.2 kB) Antler Design Modifications (Prelim Presentation)

10/08/2022 Antler Design Handle Bar Forces Sketch

Roxi Reuter - Oct 08, 2022, 11:36 AM CDT

Title: Forces on Handle Bar (Antler Sketch)

Date: 10/08/2022

Content by: Roxi Reuter

Present: –

Goals:

- Create an FBD (or similar sketch) to represent the forces acting upon the handle bars of the rower

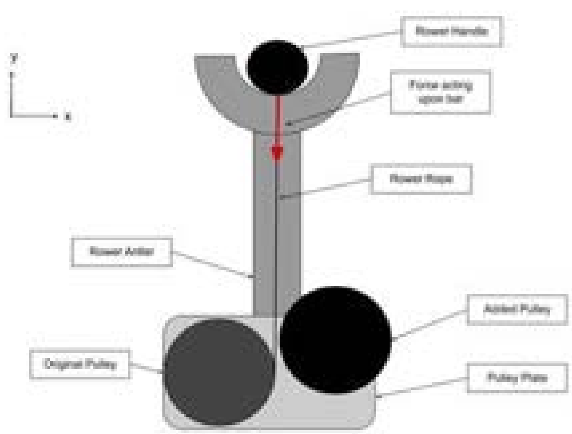
Content:

- Please see attachment for details of design sketch
- I created a sketch to represent the forces acting on the rower handle bar as we relocate the bar in the antler design, solving the tension-removal issue from the previous team's design
- As part of the antler design, the handle bar is relocated between the two pulleys such that it lies directly in between the two pulleys on the rower. Therefore, the only forces acting upon the bar are directly downward and result from the weight of the handle bar, as well as the rope tension.

Conclusions/action items:

I will show this sketch to the team and add the description above, as well as the sketch, to the preliminary report's antler design section to further explain the concept of the antler design. Additionally, I will begin work on the fabrication section of the antler design.

Roxi Reuter - Oct 08, 2022, 11:36 AM CDT



Download

Forces_on_Handle_Bar.jpg (36.7 kB) Sketch of forces on handle bar for the antler design.

10/14/2022 Suggestions from Staci

Roxi Reuter - Oct 14, 2022, 12:05 AM CDT

Title: Brainstorming per Staci's Email

Date: 10/14/2022

Content by: Roxi Reuter

Present: –

Goals:

- Put thought into Staci's email suggestions (see email content below)

Content:

- We received an email from Staci after sending her our preliminary deliverables, and she suggested thinking about the following ideas:
    - I have three things I would like you to think about before Friday:
        - 1. Order of operation for the user; If you were in a wheelchair and rolled up to this rower, what order would you do the adjustments? This is important for evaluating the usability of the adjustments as they stand or if linkages must be designed to make them more reachable.
        - 2. What is the "not in use" position and why?; When there is no user, is the intent to have the stabilization frame straight up, folded down or sticking out? This will affect the logic for your limit switch because the limit switch needs to know that the stabilization bar is at different angles for different user heights. I do have an opinion, but I can be swayed by your decision points if you have a different opinion than me.
        - 3. I know that the coding flowchart is not the final, but I did want to let you know that you have extra conditional blocks. The conditional block of "Limit switch depressed?" should be the only conditional block you need because from there you will know if the console needs to more 180deg or not. The other logic question I have is, are you planning on using poling or interrupt for reading the limit switch state?
- My thoughts:
    - 1. I would adjust the horizontal bar first, and then I would lower or raise the lap pad to secure me. We may need to make a long lever (or similar link as Staci suggested) to allow the user to adjust the vertical position of the lap pad from the location where they would be stationary during rowing.
    - 2. This was something that was up for discussion and debate; however, we decided the "unused" position is an elevated position. This is what was taken into consideration in the console automation coding flowchart (verify with Annabel who came up with this flowchart and discuss with team).
    - 3. I discussed this with Annabel - this depends on which motor we end up using (topic for discussion during the team meeting).

Conclusions/action items:

Staci sent us some great things to keep in mind and think about as we move forward with the design process. These ideas will be discussed in this week's meetings.

11/09/2022 Stabilization Sketches

Roxi Reuter - Nov 09, 2022, 10:57 PM CST

Title: Stabilization Frame Sketches

Date: 11/09/2022

Content by: Roxi Reuter

Present: –-

Goals:

- Sketch some stabilization frame ideas after visiting JHT last Friday (11/04)

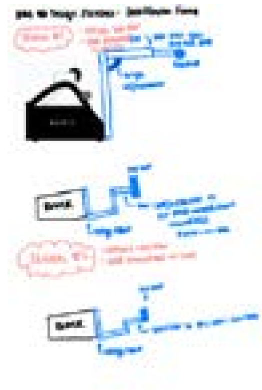
Content:

- See the attached images for fabrication ideas carried out at JHT last week and new sketches (rough drafts) that I drew to help with some of the issues we ran into
- Issues include:
    - Attachment of lap pad (most available lap pads attach via the side of the pad, so we might need to cut a hole in the center of one)
    - Placement of angle hinge for vertical adjustment which cannot interfere with the rower handle or cable
- I also attached images of our fabrication from JHT

Conclusions/action items:

Discuss these ideas with the team as we move forward with the fabrication process for the stabilization frame. Eventually, create a fabrication plan and help obtain materials.

Roxi Reuter - Nov 09, 2022, 10:57 PM CST



Download

StabilizationFrame_FabricationSketches.pdf (309 kB)

Roxi Reuter - Nov 09, 2022, 10:58 PM CST

Download

IMG_2895.heic (3.48 MB) Images of fabrication from JHT on 11/04/2022

Roxi Reuter - Nov 09, 2022, 10:58 PM CST

Download

IMG_2894.heic (3.47 MB) Images of fabrication from JHT on 11/04/2022

Roxi Reuter - Nov 09, 2022, 10:58 PM CST

Download

IMG_2556.HEIC (1.96 MB) Images of fabrication from JHT on 11/04/2022

Roxi Reuter - Nov 09, 2022, 10:58 PM CST

Download

IMG_2555.HEIC (1.94 MB) Images of fabrication from JHT on 11/04/2022

Roxi Reuter - Nov 09, 2022, 10:58 PM CST

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IMG_2554.HEIC (1.9 MB) Images of fabrication from JHT on 11/04/2022

Roxi Reuter - Nov 09, 2022, 10:58 PM CST

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IMG_2553.HEIC (1.8 MB) Images of fabrication from JHT on 11/04/2022

Roxi Reuter - Nov 09, 2022, 10:58 PM CST

Download

IMG_2552.HEIC (1.46 MB) Images of fabrication from JHT on 11/04/2022

Roxi Reuter - Nov 09, 2022, 10:58 PM CST

Download

IMG_2551.HEIC (1.63 MB) Images of fabrication from JHT on 11/04/2022

11/16/2022 Roller Coaster Stabilization Frame Sketches

Roxi Reuter - Nov 16, 2022, 5:59 PM CST

Title: Stabilization Roller Coaster Sketches

Date: 11/16/2022

Content by: Roxi Reuter

Present: —

Goals:

- Sketch some preliminary stabilization frame ideas after looking into roller coaster restraints. This may be one of the better options for the team, as there were issues with the previous stabilization designs inhibiting the rowing motion.

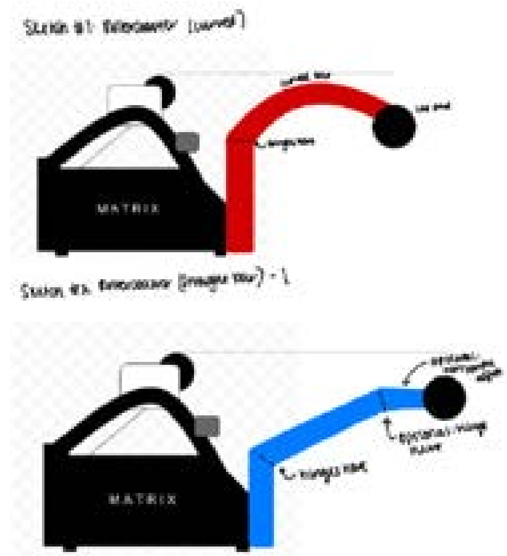
Content:

- See the attached sketches for more details.
- I have not put dimensions on the sketches yet since they are rough drafts and I do not yet have the dimensions of the rower.
- All these designs are based on roller coaster restraints, which I looked into this week. The designs are very similar, but each has a slight variation.
    - Each design is intended to be centered on the adaptive side of the rower.
- Sketch #1:
    - This design features a curved bar which provides a downward force on the user's lap.
        - This may be difficult to fabricate, as JHT does not do much bar bending.
    - There is a hinge where the vertical support bar meets the curved lap pad bar. This hinge has not been designed in detail yet but could use a mechanism similar to the pin and hole mechanism on other exercise equipment (and what we had planned for the previous stabilization frame designs).
- Sketch #2:
    - The second design is similar to the first design but does not need a curved bar. The vertical bar (present in design 1) is connected to an angled bar (connection point 1 with a hinge), which connects to a horizontal bar holding the lap pad.
    - The design has two optional features:
        - 1. A second hinge point where the horizontal lap pad bar and the diagonal bar connect (better adjustability)
        - 2. A bar in bar sliding adjustment mechanism for the horizontal lap pad bar.
- Sketch #3:
    - This design is almost identical to design #2 except there is no horizontal bar which holds the lap pad. Instead, the lap pad connects directly to the diagonal bar, and the adjustment occurs at the hinge where the vertical bar meets the diagonal bar.
- Sketch #4:
    - The fourth design is similar to #3 except features a curved bar.
    - I am not sure if this will be easier to use and more comfortable than a diagonal bar, but it does seem to provide more leverage due to the force applied downwards upon the user's lap.

Conclusions/action items:

I will share these sketches with the team and continue doing research and designing (including adding dimensions) if we decide to move forward with the roller coaster stabilization design. The overall goal is to integrate the console/antler and stabilization designs by Thanksgiving; however, given that there is still a lot to do in terms of fabricating the stabilization frame, this may happen the week after Thanksgiving.

Roxi Reuter - Nov 16, 2022, 6:00 PM CST

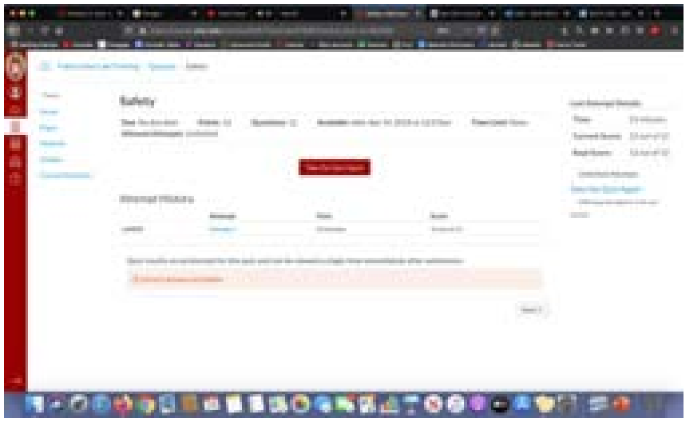


Download

BME_400-stabilization_Sketches.pdf (449 kB)

Red Permit

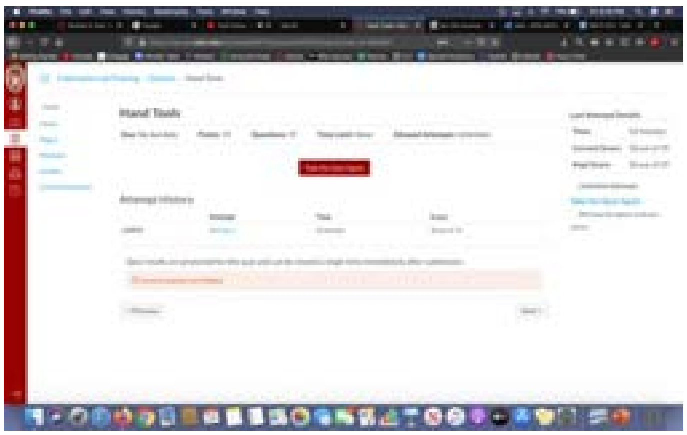
Roxi Reuter - Jan 24, 2020, 10:37 PM CST



Download

Screen_Shot_2020-01-24_at_3.10.25_PM.png (847 kB) Module 1: Safety Quiz

Roxi Reuter - Jan 24, 2020, 10:38 PM CST



Download

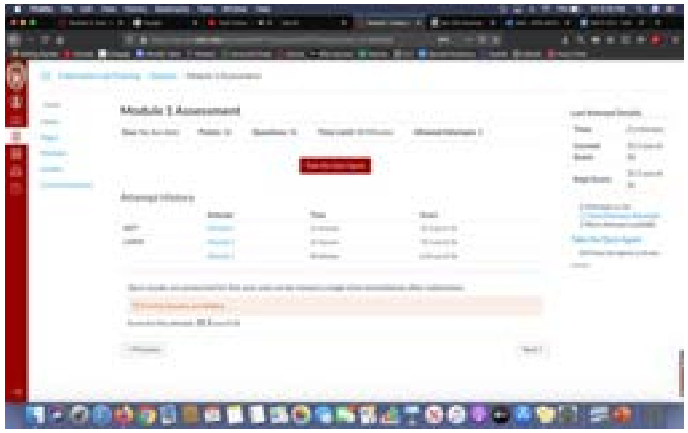
Screen_Shot_2020-01-24_at_3.10.38_PM.png (941 kB) Module 1: Hand Tools Quiz

Roxi Reuter - Jan 24, 2020, 10:38 PM CST

Download

Screen_Shot_2020-01-24_at_3.10.44_PM.png (974 kB) Module 1: Power Tools Quiz

Roxi Reuter - Jan 24, 2020, 10:38 PM CST



Download

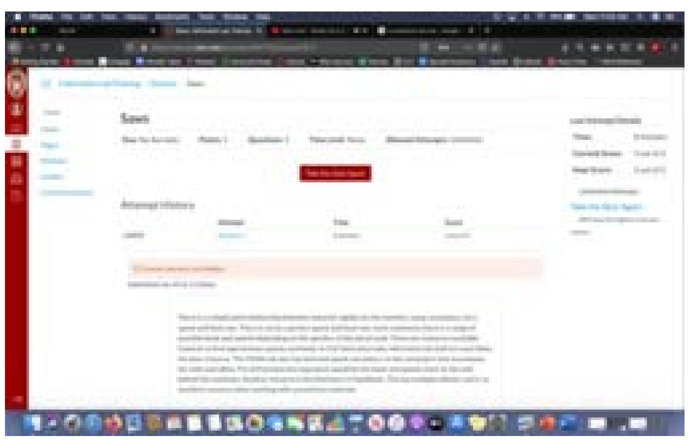
Screen_Shot_2020-01-24_at_3.10.50_PM.png (1.02 MB) Module 1: Assessment

Roxi Reuter - Jan 28, 2020, 10:16 PM CST

Download

Screen_Shot_2020-01-28_at_10.14.38_PM.png (620 kB) Red Permit Module 2: Drill Presses

Roxi Reuter - Jan 29, 2020, 11:04 AM CST



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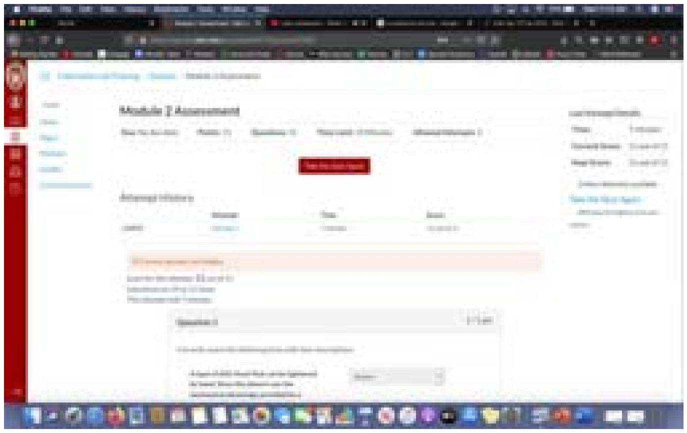
Screen_Shot_2020-01-29_at_11.03.15_AM.png (1.07 MB) Red Permit Module 2: Saws

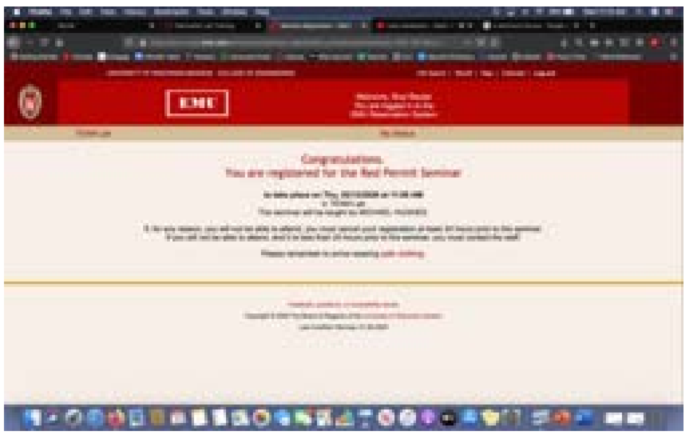
Roxi Reuter - Jan 29, 2020, 11:14 AM CST



Download

Screen_Shot_2020-01-29_at_11.13.37_AM.png (1.01 MB) Red Permit Module 2 Assessment

Roxi Reuter - Jan 30, 2020, 5:39 PM CST

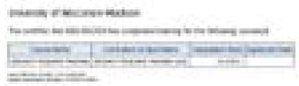


Download

Screen_Shot_2020-01-29_at_11.15.11_AM.png (978 kB) Red Permit: Seminar Registration

Biosafety Training

Roxi Reuter - Mar 13, 2021, 10:28 AM CST



Download

Biosafety_Training.pdf (119 kB) Attached is my Biosafety Training Certificate Completed on 3/13/21

Chemical Safety Training

Roxi Reuter - Mar 28, 2021, 10:22 AM CDT

Download

Chemical_Safety_Training_Proof.pdf (146 kB) Proof of both Biosafety training and Chemical Safety training

09/09/2022 Initial Advisor Meeting

Roxi Reuter - Sep 12, 2022, 2:07 PM CDT

Title: Initial Advisor Meeting

Date: 09/09/2022

Content by: Roxi Reuter

Present: Sam, Josh, Tim, Annabel, and Roxi

Goals:

- Initial advisor and team introductions
- Discuss project plan and semester goals and schedule

Content:

- Dr. Tracy Jane Puccinelli is the advisor for our continuing adaptive rower project
- This semester, there will be a new change in grading: notebooks will be checked weekly to make sure everyone is keeping up with their own work
    - Dr. Puccinelli requested feedback from students on this new evaluation process since this is the first time it is being put in place
- Next steps following this short meeting:
    - Contact our client Ms. Staci Quam and set up a meeting with her
    - Assign team roles
    - Set up the team notebook in LabArchives
    - Complete first day activities (swapping enrollment is especially important)
    - Set up weekly team and advisor meeting times

Conclusions/action items:

Following this short introductory meeting, I will be meeting with my team to discuss when we will be meeting regularly throughout the semester, as well as next steps in the project. Additionally, we will all be completing the first day activities listed in the Canvas course homepage.

09/09/2022 Initial Team Meeting

Roxi Reuter - Sep 12, 2022, 2:07 PM CDT

Title: Initial Team Meeting

Date: 09/09/2022

Content by: Roxi Reuter

Present: Entire team (Sam, Josh, Tim, Annabel, and Roxi)

Goals:

- Assign roles and responsibilities
- Set up weekly meetings with advisor and among team members
- Contact Staci Quam, our client, about a kickoff meeting for the project
- Project introduction/onboarding

Content:

- We started by assigning team roles, since we have already met and know each other:
    - Tim - BWIG
    - Josh - Communicator
    - Annabel - Team Leader
    - Roxi - BPAG
    - Sam - BSAC
- We want to set up an initial client meeting next week with Staci to go over expectations and project improvements
    - Josh will be contacting Staci about meeting Monday afternoon and Tracy about meeting weekly during the 12-2PM time slot on Fridays
- Wednesday afternoon 2:15 to 3:13PM, we will be meeting in ECB for an "onboarding session"
    - This is mainly for Annabel and me, as the other team members are continuing this project and are very familiar with the design and both its problems to fix and goals
- After the meeting, Sam showed Annabel and I the adaptive rower design since the project was still in ECB
    - Potential areas for improvement/ideas for the semester that we discussed:
        - Making the wheelchair securing frame adjustable for various wheelchairs and changing the material to something more durable (right now it is wooden)
        - Creating some sort of mechanism to take the tension off of the cable when moving the rower handle from one side to another
            - Potential area to incorporate bioinstrumentation for Annabel - possibly some sort of motor
            - Creating a better mechanism for turning the screen (180º turning needed)

Conclusions/action items:

Today, the team assigned roles. We should continue completing first day tasks (due tonight, 09/09 at 11:59PM).

Josh has already contacted Staci for an initial meeting, hopefully on Monday afternoon, and he emailed Dr. P our availability for advisor meetings.

Moving into next week, the team should start brainstorming project goals and areas of improvement for the design this semester. Additionally, Annabel and I should look at the previous semester's work on the BME website, including reports and presentations.

Next Wednesday, we will meet as a team for our first "onboarding" session from 2:15-3:15 PM with the goal in mind of discussing work for the semester and allowing Annabel and I to get caught up with project information since we are both new to the team.

09/12/2022 Initial Client Meeting

Roxi Reuter - Sep 12, 2022, 2:07 PM CDT

Title: Initial Client Meeting

Date: 09/12/2022

Content by: Roxi Reuter

Present: Entire Team

Goals:

- Talk to our client, Ms. Staci Quam, about project goals and expectations for this semester and the next
- Discuss modifications and additional features for the design
- Brainstorm ways we can meet these goals and expectations throughout the year following the meeting

Content:

- We started out with team introductions and met another client which we will be working with, Ruby, a BME undergraduate student at UW-Madison who is interning part-time at JHT.
  - Staci noted that if we email the Biomechanics lab email, Ruby will be the person in charge of running the account and responding.
- Feedback from Staci on the past semester's projects:
  - Great progress and the team learned a lot
  - Think of material strength (discussed the neck piece)
  - She really loved how the bar sat nicely on the feet while in the wheelchair user design
  - Think about challenges - Staci stated that if we decide we want to go down a different design path, that is definitely fine since she can get us more parts.
    - For example, right now the console is up higher on the matrix rower, but Staci suggested possibly moving the console down lower which may help with the rope tension issue.
- Wheelchair support/stabilization design:
  - Make out of a more durable material and make adjustable
  - JHT can help us out with fabrication of the
    - Square tube or rec tube - very easy for JHT to get
    - Fab lab welding would be a great experience and was suggested by Staci even if it doesn't turn out well and we have to turn to JHT to finish welding components for us
  - Before actually welding, we will set up a meeting with Staci to do a design review
- Josh described an initial build for the stabilization design, and Staci recommended not using 80/20 for a final design but would be fine for an initial design
  - Great idea for sliding tubes and adjustability - take a look at Matrix products at UW-Madison gym (the Nicholas Recreation Center)
  - Can also look at seat adjustments and slide designs; however, for this weight-bearing design, we DO want a pin and hole design.
- Budget for the project: should be the same as last year but is flexible
- Team improvement ideas:
  - 1. Improve bracket which turns the display console and electronics added into the design (for example, attaching it to an automated bearing)
  - 2. Mechanism to take off the tension in the rope (maybe with a motor)
  - 3. Wheelchair base - making it more accessible and adjustable
  - 4. Being able to adjust the resistance level from the adaptive side (linkage system which turns the resistance dial)
  - 5. Chest support or resistance
  - 6. Pulley plate design which fits more snug on the shorter arms within the rower

        - Staci suggested maybe foam insulation to create a mold but might be a little more complicated than anticipated
        - SolidWorks model adjustment may be easiest
        - Rotating in a different area may also solve several of these issues
            - Rotation of the base without taking the tension off of the rope
            - Second pulley wouldn't really be necessary
            - Put more thought into this
- Meetings with Staci every other week to start with

Conclusions/action items:

Today's client meeting cleared up some of the general questions that the team had, such as budget for the year and goals/expectations, while also fruiting some new design ideas which the team will ponder and discuss this week. As for action items, I will continue onboarding research and brainstorming design ideas or improvements which were mentioned in previous meetings. The team onboarding meeting in which a demonstration and explanation of the current adaptive rower design will happen Wednesday (09/14) from 2:15-3:15 PM.

09/14/2022 Team Meeting

Roxi Reuter - Sep 14, 2022, 3:41 PM CDT

Title: Team Meeting

Date: 09/14/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss meeting with Staci and talk about goals for the project
- Set up a meeting time to work on the PDS and future team meetings

Content:

- PDS due next Friday - need to add this semester's work to it
- We discussed talking to Tracy about her bi-weekly evaluation expectations
- Possible future work:
    - Changing material of wheelchair frame stabilization
        - Also: research how we can make that adjustable and look at adjustable (Matrix) gym equipment at the Nick
    - Lowering the console per Staci's suggestion and fixing the swivel mechanism for durability and ease of use
        - After evaluating the situation, we would just mainly cut the arm holding the console and move the console to the lower hole already drilled into the arm (As of now, the console is bolted into the top hole).
        - Fix the swivel mechanism - a combination of Annabel's and my ideas include using a horizontal pin and connecting all the holes in the current design into one big slit which the console could swivel in 180º.
    - Designing a mechanism to take the tension off of the rope when the cable is moved from one pulley to the other
        - Multiple design ideas, including both electronic and mechanical concepts. For example:
            - Clamping the rope manually (using rubber or a similar material on the ends of the clamp to ensure that the rope does not fray) and then using a linear actuator to move the rope a set distance
                - This especially interests Annabel because it would involve bioinstrumentation. Both Annabel and I have worked with linear actuators in the past.
            - Fully mechanical design with the use of a lever and manual clamp
            - Fully automated design with a motor or linear actuator and automated clamps
                - This might be a little more complicated than we're looking for
    - Other similar improvements were discussed, including moving the location of the bar while at rest on the normal side of the rower; however, most of these design ideas were of lower priority and should be addressed once the main improvements have been made.
- Main areas of improvement include:
    - 1. Making the wheelchair stabilization frame adjustable and out of a more durable material
    - 2. Designing a method to take the tension off of the cable during the transition from the normal to adaptive sides of the rower (and vice versa)
- We are interested in splitting the team up into two subgroups to address these design challenges after the advisor meeting on 09/16.

Conclusions/action items:

Before meeting as a group on Friday (team meeting at 12:30 on Zoom and advisor meeting at 1:05 on Zoom), the team should do a little research on the design ideas we came up with during this meeting and add an entry to the LabArchives notebook. Additionally, we have our first progress report due tomorrow (09/15), so each individual needs to fill out their project contributions for this week.

Josh will be contacting Staci about biweekly meeting times and verifying the project budget.

09/15/2022 Team Meeting

Roxi Reuter - Sep 16, 2022, 1:52 PM CDT

Title: Team Meeting

Date: 09/16/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Schedule meeting to review PDS
- Check in on brainstorming ideas and research found this past week
- Set up meetings for brainstorming next week

Content:

- We decided to schedule a meeting for Wednesday (09/21) to go over the PDS from 2:15-3:15 PM
    - Everyone should come with their portion of the PDS completed
- We went through the PDS and noted areas that need to be updated
- PDS assignments:
    - Roxi - Performance requirements
    - Sam - Materials / Aesthetics
    - Annabel - Safety
    - Josh - Client Requirements
    - Tim - Ergonomics
- A brainstorming meeting is planned for Monday afternoon, either virtually or in person
    - Do individual brainstorming sessions before then and document it in LabArchives
    - Waiting on scheduling a specific time because Sam may have a conflict

Conclusions/action items:

This short team meeting allowed us to touch base with each other and look at upcoming project deadlines. The PDS is due next Friday (09/23), and we discussed a plan of action to complete that assignment: individually assigning components after reviewing the PDS as a team, and we will meet next Wednesday (09/21) to edit the document before turning it in.

Additionally, we want to get straight into designing and completing necessary research so that our design is finished and in the hands of the client by the end of BME 402. We scheduled a brainstorming meeting for Monday afternoon; however, each member should brainstorm ideas individually before then.

09/15/2022 Advisor Meeting

Roxi Reuter - Sep 16, 2022, 2:08 PM CDT

Title: Advisor Meeting

Date: 09/15/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss project goals with our advisor, Tracy
- Explain the previous semester's progress and get general feedback on design ideas
- Talk about grading changes (notebook checks)

Content:

- Josh started off by giving a brief overview of the progress last semester
- Then, we discussed budget with Tracy
    - As of now, Staci gave us a $200 budget that is flexible
    - If we need further funds (other than the $200 provided), Tracy recommended sending the funding request form to our client
- Tracy mentioned possibly having a specific person interested in this device. If so, we should gear the design towards their specific wheelchair dimensions.
- Most people with disabilities use powered wheelchairs?
    - Look into research on this since it may affect the adjustable frame dimensions
- We went through notebooks with Tracy and discussed future meeting plans
    - Weekly Friday meeting sat 1 PM either on Zoom, in-person, or alternating
- Next week: BME Outreach Meeting from 12:05 to 1:30 PM, with short advising meeting (about 10 minutes) to follow.
    - Possibly going to ECB with Tracy to view the rower

Conclusions/action items:

During this advisor meeting, we introduced the project to Tracy and discussed progress that was made last semester. Areas of improvement were also mentioned, and client budget was a topic included in this discussion. If a larger budget is needed, BME offers a funding request form which can be sent to the client. Each team member went through their individual notebook and presented their progress from this week and last.

For the coming week, Tracy suggested each team member do individual brainstorming and document the design ideas in LabArchives before meeting as a team to discuss these ideas so that everyone can contribute. The BME outreach meeting is happening next Friday (09/23) and conflicts with normal advising meeting times. We will meet with Tracy following the meeting (approximately 20 minutes afterwards) for 10 minutes and possibly walk over to ECB to see the rower in-person. Additionally, the PDS is due next Friday, so that is something the team should be working on, as well.

09/19/2022 Team Brainstorming Meeting

Roxi Reuter - Sep 19, 2022, 3:03 PM CDT

Title: Brainstorming Meeting

Date: 09/19/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss ideas that we brainstormed for the adapted rower design
- Talk about response from Staci (meeting times and budget)

Content:

- Staci emailed us back this morning to let us know that she was approved for a $500 budget
    - Josh will be emailing her back to clarify if that budget is for the year or just the semester
        - Update: $500 for the whole year; however, Staci can get approved for further funding if needed
- Meeting times with Staci will be bi-weekly to start from 1:30-2PM
    - We will begin meeting next Friday (09/30)
- Annabel's tension removal idea:
    - Placing the handle just above the pulley, with an antler-like design that is open in the middle. This way, the hand bar is in a neutral position and doesn't require any slack when using the rower on the normal or adapted side.
    - Possible issue: console placement (not centered), but we can slightly offset the console so that it is still easy to view and access, and it pivots to be viewed from either side. The current console support bar would be removed
- Other ideas:
    - From Roxi: Just using a lap pad / lap support instead of an entire adjustable frame (inspiration from AROW competing design)
        - An adjustable frame may be hard to manipulate by the wheelchair user alone and can get heavy
        - A lap bar would allow for more variation in size of wheelchairs and prevents tipping

Conclusions/action items:

The team took time to discuss design ideas which would work towards meeting our client's wants and needs, while also brainstorming new ideas while viewing the rowing machine. The team will be meeting Wednesday virtually to conclude the PDS edits and begin working on design matrices. Before then, each member should dedicate time to additional brainstorming and sketching some of the concepts talked about today.

09/21/2022 PDS Edits

Roxi Reuter - Sep 21, 2022, 3:27 PM CDT

Title: PDS Editing and Brainstorming Meeting

Date: 09/21/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Edit the PDS as a team (following individual read-throughs and updates)
- Discuss brainstorming ideas from Monday's meeting and show sketches that we created

Content:

- The team went through the entire PDS together and made edits
- We are setting up a Zotero folder to keep track of all of our citations and make citing much easier in reports
- Sources were fixed manually in the document until we all have Zotero figured out

Conclusions/action items:

The team finished up the PDS together during the one-hour meeting. Although there was not enough time to go through design ideas and sketches, this will be done after the advisor meeting on Friday (09/23).

09/23/2022 Advisor Meeting

Roxi Reuter - Sep 23, 2022, 6:24 PM CDT

Title: Advisor Meeting

Date: 09/23/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Ask questions that we have about design matrices (due next Friday), as well as the preliminary presentation (in two weeks)
- Explain our design changes and get feedback from Tracy about them

Content:

- Tracy, our advisor, suggested that we research the areas of the project areas we're planning to change (not spending as much time doing background research on physiology, for example, if it won't contribute to the progress we're hoping to make this semester
- Tracy suggested thinking about how we will actually make this design
    - We have put thought into this already - separator block between plates, making pulley plates thicker with absence of console neck, using extra screw hole on rower neck to create additional stabilization of the plates
    - Adding antlers onto the pulley plates
- She encouraged us to switch research to fabrication techniques and materials moving forward
- In meeting with Staci next week, we should present our designs as if they are preliminary designs
- For the presentation in two weeks (preliminary), clearly state that this is a continuing project

Conclusions/action items:

This brief meeting with Tracy answered some of our questions about notebook expectations and where to focus our research moving forward. Tracy was able to get an understanding of our design changes through sketches that I drew up, as well as further verbal explanations. We will move forward with the project by creating design matrices which will be due next Friday (09/30). In the meantime, each individual is responsible for research and meeting with their subgroup for design matrices.

09/23/2022 Team Meeting

Roxi Reuter - Sep 23, 2022, 6:32 PM CDT

Title: Team Meeting

Date: 09/23/2022

Content by: Roxi Reuter

Present: Team

Goals:

- Discuss work for design matrices
- Start thinking about preliminary presentation and report

Content:

- We discussed the main areas of design change this semester:
    - Stabilization mechanism
        - Lap pad
        - Adjustable frame
    - Tension removal
        - Antler
        - Linear actuator
    - Rotation of console
        - Rotation at one point
        - Rotation at two points
        - Stepper motor
- These design changes will be tackled in subgroups: the stabilization team (Tim and Sam) Within those subgroups, we will create two design matrices:
    - Stabilization
    - Tension Removal and Console
- We will have an entire team meeting on Tuesday (09/27) to discuss scoring the design matrices (4-5:30PM, virtual)
    - For Tuesday:
        - Have design matrices built with criteria, descriptions, sketches, and weights so that all that is left to do is score the designs as a team
- The tension team will be meeting Sunday (2-3PM virtually)
    - Have sketches done before then
    - Move antlers to attach to pulley plate
- Roxi:
    - Move antlers to pulley plate in design sketch
        - Keep one sketch with one rotation point (right under console)
        - Keep another sketch with both rotation points
            - Both of these will be used in the design matrix

Conclusions/action items:

Today, the team met very quickly after the outreach seminar to discuss brainstorming ideas and plan both meetings and tasks for the coming week. Each design subgroup (tension team and stabilization team) will meet to work on design sketches and set up their respective design matrix with the criteria, explanations, and weight of each criteria. On Tuesday afternoon, we will meet from 4-5:25PM to finish up the design matrices.

09/23/2022 Outreach Seminar Notes

Roxi Reuter - Sep 23, 2022, 6:36 PM CDT

Title: Outreach Seminar Notes

Date: 09/23/2022

Content by: Roxi Reuter

Present: —

Goals:

- Learn about the outreach requirement for BME 400 and note anything of utter importance

Content:

- Can put BME outreach on CV - highly sought after by employers
- Outreach is important to educate others about what BMEs do, to create a diverse engineering environment, and much more
- Cultural awareness is also very important in interviews
- Important things to keep in mind about BME outreach:
    - Age-appropriate content
    - Plan in advance and be organized
    - Do a practice run of the activity (and leave extra time since we are working with kids)
    - Arrive extra early to allow plenty of time to set up
    - Be ready for a background check for visitors if working with a school
- Encouraged to seek out locations with underrepresented minority groups (URMs)
- Higher percentage of minority - Tracy can pay for outreach materials
    - Otherwise, can get funding (more limited and need to apply)
- Actual requirements for outreach online:
    - Teams of up to 5 but can do individually
    - Deliverables:
        - Presentation: Intro, definition of BME, and activity (10 minutes)
        - Activity: hands-on activity with clear learning objectives (20-40 minutes)
            - Don't need to come up with your own activity. Can recycle or modify existing activities.
                - Cite sources!
        - Report with pictures
            - Need release form for any children in picture (unless cannot be identified in photo
        - Teacher/Leader evaluation form (whoever is helping with or organizing the event needs one)
- Submit everything online
    - Activity guide (or mentor plan) due on Wednesday, December 14, 2022
    - Final outreach deliverables due Friday, April 21, 2023
        - Mentor program list will be sent out (satisfies this outreach requirement)
- Set up meeting with Tracy once we feel the activity is all planned and ready
- Always wrap up the outreach activity with a post-activity discussion
- We carried out the helmet activity

Conclusions/action items:

Today's outreach seminar was very fun! We learned about the outreach requirements for capstone BME design and did an outreach activity of our own (designing "helmets" with a water balloon inside to simulate a helmet for concussion prevention). I will be working with my 400/402 team for this outreach activity and will think of ways in which we can fulfill this requirement as we progress with our design project.

09/25/2022 Console Design Subgroup Meeting

Roxi Reuter - Sep 25, 2022, 3:32 PM CDT

Title: Console Design Subgroup Meeting

Date: 09/25/2022

Content by: Roxi Reuter

Present: Josh, Annabel, Roxi

Goals:

- Share design sketches for the design matrix and give feedback on them
    - Make modifications if necessary
- Create the criteria, descriptions, and weights of the tension removal design matrix
- Write design descriptions and add figures for each design and

Content:

- We modified the design matrix criteria to accurately reflect the design characteristics for our console design
- We debated on design weights (see the attachment)
- Josh updated the CAD model for the swivel mechanism
- We each went through the design matrix document and wrote out descriptions for the design criteria. Then, we edited those definitions together.
- Following design criteria definitions, Annabel and I added our design sketches to the design matrix, and Josh showed us his modifications to the CAD in SolidWorks for the console rotation mechanism
- We wrote descriptions for each design in consideration and ended the meeting by reviewing them
- **Please see attached design matrix outline for further details on meeting work

Conclusions/action items:

This was a very productive meeting for the tension subgroup. Together, we completed our design matrix (excluding the scoring of the designs, which will occur at our meeting on 09/27). This included reviewing design sketches, changing design criteria, defining and weighting the design criteria, writing design descriptions, and editing the document as a team.

Moving forward, I will think about how I would score these designs such that on Tuesday (09/27), I have already put some thought into the criteria and designs as a whole while discussing this as a team.

On Tuesday, we will meet to score the criteria for each design and write the final design paragraph.

Roxi Reuter - Sep 25, 2022, 3:32 PM CDT

Design Matrix Criteria

Download

Console_Design_Matrix.pdf (1.07 MB)

09/27/2022 Design Matrix Scoring

Roxi Reuter - Sep 27, 2022, 9:09 PM CDT

Title: Design Matrix Scoring

Date: 09/27/222

Content by: Roxi Reuter

Present: Team

Goals:

- Discuss design matrices as a group, make necessary adjustments based on feedback, and score each design

Content:

- The team began the meeting by reading over both of the design matrices, which were done in subgroups
- For the console design matrix:
    - The team combined the “Position/Orientation” and “Ease of Use/Ergonomics” sections into one “Ergonomics” section
    - We changed “Versatility” to “Ease of Use”
    - Then, we scored the competing designs. The motor design won and will be the one which we will be moving forward with.
- For the stabilization mechanism design matrix:
    - Added criteria for “Ease of Use” (attaching/detaching to/from the rower when desired)
    - Following discussions on design pros and cons, we scored each design and ended up with the bar in bar lap pad design winning by a good amount.

Conclusions/action items:

We still have a bit left to finish the design matrices, due Friday (09/30). Tomorrow morning (09/28), my subgroup (console design matrix team) will be meeting on Teams to write the final design paragraph. Sam and Tim (on the stabilization team) will meet to write their final design paragraph, as well, and we will proofread and discuss the design matrices one last time before submitting them.

By Thursday, each person must fill out progress report, and on Friday we will have team, advisor, and client meetings. Additionally, I will be having a BPAG meeting.

If there is time, we should add dimensions to design sketches before the subgroup meetings for the final design paragraphs.

09/28/2022 Completing Console Design Matrix

Roxi Reuter - Sep 28, 2022, 10:01 AM CDT

Title: Completing Console Design Matrix

Date: 09/28/2022

Content by: Roxi Reuter

Present: Josh, Annabel

Goals:

- Write the final design paragraph and make final edits on the console design matrix

Content:

- Josh, Annabel, and I met in the morning on Teams to make any necessary changes to the console design matrix based on team feedback
- We then wrote and edited the final design justification, ultimately deciding on the Motor design, by explaining the scores for each design by criteria
    - This is what we spent most of the meeting completing
- Once finished, we did a final reading and made a few modifications to the justification portion of the design matrix

Conclusions/action items:

Today's subgroup meeting was primarily focused on writing the final design justification for the console design matrix; however, we also made edits to the overall design matrix document. Overall, we decided to proceed with the Motor design because it scored the highest of the three designs, and we believe it will be the easiest for the user to interact with.

Before sending the design matrix to our client and advisor, I will be updating the dimensions and replacing all the sketches in the document. By tomorrow (09/29), each member should fill out the progress report and continue research applicable to the project. On Friday (09/30), I will have a BPAG meeting, a team meeting advisor meeting, and client meeting.

Roxi Reuter - Sep 28, 2022, 10:04 AM CDT

Download

Console_Design_Matrix_1_.pdf (1.07 MB)

09/30/2022 BPAG Meeting

Roxi Reuter - Sep 30, 2022, 8:12 PM CDT

Title: BPAG Meeting

Date: 09/30/2022

Content by: Roxi Reuter

Present: BPAG Students

Goals:

- Review BPAG guidelines

Content:

- Much easier for client to buy for you, rather than buying and getting reimbursed later in the semester
- Approve purchases with client beforehand
- Keep track of all purchases (original detailed receipts) in LabArchives
    - Also update in progress and final reports
- My project: UW affiliation NOT BME and not UW Funds
    - Anything is fair game (work with client for reimbursement at the end of the semester)
- Makerspace purchases:
    - We are responsible for UW shop fee ($50 for both TEAMLab and Makerspace)
        - Clients can set up funding account to pay (see link in slides)
        - Otherwise, can pay personally
- TEAMLab
    - Can meet with TEAMLab staff for consultations to figure out how to fabricate CAD design or other design ideas
    - Can borrow tools from here, as well
- Only BPAG will be reimbursed by the client
- Seek reimbursement within 90 days of purchase
    - Seek reimbursement before the poster session
- UW clients can do e-reimbursement
- Non-reimbursable expenses
    - LabArchives notebook
    - $50 shop/makerspace team
    - Poster printing (about $50 per team)
- Make sure table with purchasing information is clean
    - Can use hyperlinks on text if links are too long
- Slides posted on BME design website for future reference

Conclusions/action items:

In this meeting, all the BPAG students were reminded of their roles and responsibilities as purchasing and accounting members of their team. In short, it is best for the client to purchase items if possible; however, if that is not possible, the BPAG (and only the BPAG) can get reimbursement from the client. All original receipts must be documented, and reimbursement must be sought out within 90 days of purchasing. Since my team's project is not using UW funds and is not affiliated with the UW-Madison BME department, supplies can be purchased from anywhere, as long as the client approves of those purchases in advance.

09/30/2022 Team Meeting

Roxi Reuter - Sep 30, 2022, 8:16 PM CDT

Title: Team Meeting

Date: 09/30/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss preliminary presentation and report

Content:

- We have questions for Tracy about the structure of our preliminary report since we are on a continuing project
- Need slides for:
    - Design matrices
    - Explanation slide for each design
        - Three console designs
        - Two stabilization designs
    - Summary of last year's work
    - Antler design explanation
    - Update PDS slide
- Splits:
    - 1st person: intro, client, problem statement, motivation, physiology (slides 1-7)
        - Tim
    - 2nd: competing design, last semester, PDS (slides 8-10)
        - Josh
    - 3rd: antler design, console design matrix (slides 11-16)
        - Roxi
    - 4th: stabilization design matrix (slides 17-20)
        - Sam
    - 5th: testing, prelim design, future work (slides 21-24)
        - Annabel
- Have slides done by: Wednesday (meeting on Teams from 2:15-3:15PM to edit it)
- Meeting on Thursday to practice (from 4-5PM in ECB)
- After our advisor and client meetings, the team decided to take a slightly different approach to preliminary design presentation: explaining last semester's design in detail and giving an explanation of areas of weakness, how we will be improving the design.

Conclusions/action items:

The team took this meeting time to further develop design ideas (such as the points of adjustment for the lap pad) and structure the preliminary presentation. Each individual, in addition to necessary project research, has assigned slides which must be finished for the Wednesday meeting for presentation edits.

Next week, the team will be meeting Wednesday (10/05) from 2:15-3:15PM on Teams to edit preliminary slides and Thursday from 4-5PM in ECB for presentation practice.

09/30/2022 Advisor Meeting

Roxi Reuter - Sep 30, 2022, 8:13 PM CDT

Title: Advisor Meeting

Date: 09/30/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss design matrices and the preliminary design

Content:

- We discussed the design matrices with Tracy
  - For the design sketches on the console, manipulate the images since it's a little difficult to tell the difference between them
  - Stabilization design matrix
- Up to us if we want to include the design matrices
  - Don't need to include stabilization design matrix for improvements
- Next week: electronics workshop in the Makerspace on motors
  - In general, work with the Makerspace to determine motor requirements
- PDS feedback next week
- Tracy is offering an office hour next week 2-3PM if we want any feedback on our presentations
- On report
  - Summary paragraph for previous work and reference it as needed
  - Focus on what we're doing this semester in the report
- Preliminary design presentations in the Tong lecture hall

Conclusions/action items:

During this meeting, the team explained design ideas to Tracy and asked questions about the preliminary presentation. The team has a better understanding of how to format the preliminary presentation since this is a continuing project and not all the same requirements apply to the project. The team will be working on the prelim presentation through next week and present it on Friday. Additionally, we will be receiving PDS feedback early next week, which the team will be using to improve the document before preliminary deliverables are due.

09/30/2022 Client Meeting

Roxi Reuter - Sep 30, 2022, 8:13 PM CDT

Title: Client Meeting

Date: 09/30/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Talk through design matrices and address any of Staci's questions about the designs

Content:

- Staci wanted a design explanation of the rower antlers, so Josh explained the design idea to her and was able to show where they would be located on the rowing machine
- Staci wanted to know if there was any way the console could be centered
    - As a team, we were not able to come up with a design that does this without excess material and a bulky design
- Staci wanted to challenge us with the following:
    - Move the button to the adapted side for accessibility
        - Annabel suggested methods for one button or two buttons
    - Hinge design for stabilization design?
        - Hinge for lap bar could trigger the turning of the console
            - Limit switch could help this
- Staci offered 80/20 material if we needed to experiment with it
    - Might be easier to go straight to the metal
- Tim asked about materials for changing the design of the diagonal bar for the bar-in-bar stabilization
    - Staci will review products at JHT for this, but we might need to buy or fabricate some yourself
- Staci will be sending us a presentation of ideas on locking mechanisms from current JHT equipment

Conclusions/action items:

Staci gave us some great ideas for our designs, and she will be sending us information on locking mechanism ideas that she mentioned (common to other JHT products). The team will be moving forward with the design concepts chosen in the design matrices and will work on the preliminary presentation over the next several days, as it will take place in one week.

10/05/2022 Team Meeting

Roxi Reuter - Oct 05, 2022, 3:32 PM CDT

Title: Team Meeting

Date: 10/04/2022

Content by: Roxi Reuter

Present: Sam, Roxi, Annabel, and Josh

Goals:

- Edit the preliminary presentation as a team
- Discuss the preliminary report due next week

Content:

- We went through the presentation slide-by-slide
- We also talked about the PDS comments and updated the suggestions from Tracy based on her feedback
- As the team continued editing, Sam got feedback from Tracy during her office hours, so we revisited the slides with her suggestions and made edits
    - Mainly more quantitative additions or modifications to the design slides
- Look at BME 402 evaluation form for better idea of grading

Conclusions/action items:

Make necessary modifications to the presentation slides and look at the BME 402 evaluations forms in preparation for the presentation on Friday (10/07). Fill out the progress report by tomorrow (10/06) and attend the team meeting in-person tomorrow (10/06) from 4-5PM in ECB to practice the presentation.

10/06/2022 Preliminary Presentation Practice

Roxi Reuter - Oct 06, 2022, 8:33 PM CDT

Title: Preliminary Presentation Practice

Date: 10/06/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Run through the preliminary presentation to make sure we fall within the time limit and are comfortable with our individual parts
- Submit the presentation on Canvas
- Upload the presentation to the website
- Divide the report and edits for the PDS

Content:

- The team met in the Tong lecture hall to practice the preliminary presentation
- We also discussed the report
  - Past testing, fabrication, and analysis work will be put in an appendix
- Report/PDS divisions:
  - Everyone - update abstract, discussion, conclusion
  - Roxi - antler design and antler + console fabrication
  - Josh - testing plans and
  - Annabel - console design and console electronics
  - Sam - PDS updates and update the introduction/problem statement in report
  - Tim - stabilization frame and future work
- Report due next Wednesday (10/12) at 4PM
- We are meeting on Monday (10/10) from 2:30 - 4:30 PM for report edits
  - Everyone should read and edit the report before the meeting on Monday and have report sections done by Sunday night
  - Contingency Tuesday meeting at 3PM on Tuesday

Conclusions/action items:

Tomorrow (10/07), the team will be giving the preliminary presentation and plans to meet 15 minutes before the start of presentations. Following the preliminary presentation, the team will be working on the preliminary report and will be meeting the coming week to finish that up, as it is due on Wednesday, October 12.

10/10/2022 Preliminary Report Editing

Roxi Reuter - Oct 11, 2022, 5:15 PM CDT

Title: Team Preliminary Report Meeting

Date: 10/10/2022

Content by: Roxi Reuter

Present: Entire Team

Goals:

- Edit preliminary report and turn in once complete

Content:

****Please see the preliminary report, as well as other team files, in the "Project Files" folder in LabArchives.**

- The team members individually read the report before the meeting and made comments to address as a whole
- The team went through comments one-by-one and had modified the report
- Together, the members added the discussion and conclusion, and they adjusted the abstract
- Tim also showed everyone how to use Zotero to make report citations much more simple
- Final updates to report:
    - Table of Contents
    - Edit and reformat appendix
        - Fix figures
        - References
        - Call-outs to sections in old report (fix)

Conclusions/action items:

Today's long meeting was a productive one; the team spent 3 hours working on the preliminary report!

Individually, each person should read through the report one last time. Then, the report will be uploaded to Canvas and the project website. \

As a reminder, preliminary notebooks are due Wed. (10/12), and peer/self evaluations are due by midnight on Friday (10/14).

10/14/2022 Team Meeting

Roxi Reuter - Oct 21, 2022, 1:46 PM CDT

Title: Team Meeting

Date: 10/14/2022

Content by: Roxi Reuter

Present: Entire Team

Goals:

- Discuss Staci's email ideas
- Plan fabrication and testing procedures

Content:

- During today's meeting with Staci we'll remind her of the final presentation date
- Discussing Staci's comments:
    - Order of adjusting the lap pad:
        - Debated but most agreed horizontal adjustment first and then vertical to secure the things of the user in the most
            - This sparked debate for adding a hook (or some other mechanism to hold the bar while the user is making adjustments to the lap pad so that the bar is within reach - will this be needed? Or be an issue?)
        - We also decided that having the support bars completely vertical and horizontal
    - Resting/storing position of bar:
        - Upwards - pull pin and adjust placement on side rail, and it could be stepped down
        - This will affect the limit switch design
            - Override button for the console design? Topic of discussion that was very debated, as not every user would store the lap pad upright, which would affect the console position
            - Overall - we want to keep the limit switch but possibly add an override button (could also maybe press the limit switch button to change position or
                - Plan - let's get the limit switch working first and add a button later if needed
    - Console code:
        - We discussed this as a team and think that Annabel's flowchart is correct
            - This depends on the type of motor (stepper motor rotates continuously for x amount of time), whereas a servo motor rotates a certain amount of degrees
            - We interpreted Staci's suggestion as continuously rotating the console in the same direction, which isn't feasible due to the cords
        - Code ideas: interrupt vs. poling (check button state in a continuous loop (void loop))
            - Poling, or continuously checking the button state, may use more power
                - Can we test the power consumption somehow?
        - We found that you can do interrupts while the Arduino is in sleep mode
            - This may be the way to go

Conclusions/action items:

During this team meeting, we discussed Staci's comments in her last email. We will bring up these topics in our client meeting with her today.

10/14/2022 Advisor Meeting

Roxi Reuter - Oct 21, 2022, 1:46 PM CDT

Title: Advisor Meeting

Date: 10/14/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss the preliminary presentation and steps moving forward in the design process

Content:

- Tracy will be uploading the evaluations for the preliminary presentation
  - We received almost a perfect score
  - Tracy really enjoyed our presentation
  - Could have had a little bit more on background
- We showed our notebooks to Tracy
- Personal research ideas:
  - Lap pad materials
  - Welding
  - Arduino coding
- We are still discussing where we will fabricate the design
  - JHT or TEAMLab
  - We could do a combination of both
- Tracy suggested visiting Johnson Health Tech again to see
- Mock up a prototype
  - What size of prototype? (Full scale or smaller scale) **-** Initial idea was to go full size originally
  - Tracie said it was up to us
    - She offered to pick up materials and bring them to campus if we need them since she lives close to JHT in Cottage Grove

Conclusions/action items:

In this meeting, we

10/14/2022 Client Meeting

Roxi Reuter - Oct 21, 2022, 1:47 PM CDT

Title: Client Meeting

Date: 10/14/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss Staci's email ideas

Content:

- Position of bar when not in use:
    - Vertical (easier for user to position themselves by pulling bar down)
        - Staci recommended all the way up (easier for limit switch)
    - As for storage, Staci thought instructions would suffice for the user to place the lap pad back up after use
- Sequence of stabilization securement:
    - Most agreed that horizontal adjustment would occur first and then vertical (angle) adjustment
    - Another question from Staci: do we even need horizontal adjustment?
        - We think it is necessary to have an adjustment to accommodate more users
            - Staci's thoughts: good thing to test in prototypes and then make a decision
- In terms of materials, Staci has a variety of material available for us to use. We can use the steel with holes for pins already fabricated
- Thoughts on fabrication:
    - Work on prototype as a team with materials provided by Staci and JHT (prototype)
    - Then, we will hand it over to JHT professionals to make it look more professional (polished model)
- Before actually fabricating, we will need to polish up the drawings and then send out the final drawings attached in a progress report email
- Arduino code:
    - The logic discussed in the 10/14 team meeting is correct
        - Flow chart - written as poling with a stepper
        - Annabel will be attending a MakerSpace workshop today to help decide on a specific motor
- Monday - Staci will be sending us a picture of things that have been fabricated out of the bars that are available to us.

Conclusions/action items:

We will be finalizing the design sketches such that we have a better, more concrete plan of action for fabrication and testing. We are planning on setting up a visit to JHT in Cottage Grove in the coming weeks so that we can work on the fabrication process and become familiar with materials that are available.

We will include the final presentation date in next week's email to Staci as a reminder since she asked for it.

In the coming week, I will be meeting with both Annabel and Josh to work on CAD designs and Arduino motor coding.

Personally (ideas for work to do in coming ..,weeks):

- Research on materials for lap pad
- Arduino coding research
- Think about outreach activity planning
- Reflection for peer and self evaluation due Wed.
- Start thinking about testing plans and the outreach project.

10/19/2022 Motor Meeting with Annabel

Roxi Reuter - Oct 21, 2022, 1:49 PM CDT

Title: Servo/Stepper Motor Meeting

Date: 10/19/2022

Content by: Roxi Reuter

Present: Annabel and Roxi

Goals:

- Discuss servo vs. stepper motor and look at coding

Content:

- Annabel demonstrated her servo and stepper motor circuits that she has been working on
  - The code is working with polling and interrupts are a work in progress
- She went to the MakerSpace on Friday (10/14) for recommendations on which motor would be best for our application, but she received mixed feedback
- We believe that either motor would probably work, so we estimated the weight of the console and used a similarly-weighted object to test with the stepper motor
  - This method worked with the stepper motor, so we believe that the stepper motor would be a good option for the console swivel mechanism
  - It also worked with the servo motor (did not expect this)
- We have proof of concept of both motors
- We plan on showing everyone else on Friday what they think
  - We are inclined to believe that the servo motor would wear down faster than the stepper motor since it is smaller and the shaft is much smaller and weaker than that of the stepper
- Another thing to think about: server operates on 5V and stepper operates on 12V
  - Size and cost will be a factor
- Ask Staci at the client meeting; Should we be worried about battery longevity? Will the power for the console swiveling be incorporated into the rower's power?
  - Does she just want proof of concept of the idea?
- Factors to consider:
  - Shaft **-** we think the servo is better in terms of notches, but the stepper is better in terms of dimensions and durability
    - Which connection point is the most sturdy?
  - Battery **-** servo only needs 9V which also powers Arduino (may need to be switched sooner); stepper we need 12V and 9V (cost and size difference)
  - Size of the motors **-** servo is smaller in stepper but both feasible
  - Cost of the circuit **-** servo requires fewer components than stepper circuit (motor controller and 12V added)
  - Motor longevity **-** it appears that servo will wear down faster than stepper
- Annabel thinks the stepper is more accurate in terms of position
- We are thinking of testing these motors with the actual console. To do so, we need an external 12V power supply for the stepper motor.

- This is an option that my group used last year to power our stepper motor: https://www.amazon.com/gp/product/B07GFFG1BQ/ref=ppx_yo_dt_b_asin_title_o08_s00?ie=UTF8&th=1
- In terms of securing both motors, the stepper might be able to be screwed into the lid of the housing. The servo has a case which it can sit in.
    - We also figured out that the stepper motor has bolts which can be removed, so we can attach supports straight through it if needed.

Please see attached videos and photos for the functionality testing we did using an object similar in weight to the console.

Conclusions/action items:

Discuss the topics of today's meeting with the team and plan on testing the stepper and servo with the actual console soon. In Friday's team meeting, we will try to make a final decision on which motor to use so that we can have a discussion with Staci and purchase the correct components for our project.

We will be meeting from 12-1PM on Friday as a team.

Personally, I plan on trying to look into any of the following areas before Friday:

- Testing plans
- Stepper motor integration from previous project
- Outreach project.

10/21/2022 Team Meeting

Roxi Reuter - Oct 21, 2022, 1:44 PM CDT

Title: Team Meeting

Date: 10/21/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss topics from motor meeting
- Gantt chart planning

Content:

- Josh explained his 3D print of the antler design
    - He printed out of regular PLA with a lower infill
    - Fit is good against the rower
    - Plan on adjusting height and the geometry of the resting area
- Annabel and I explained the motor pros and cons
    - The consensus was to go with the stepper motor, although it may be a little more complex (not very strong argument though because Annabel and I already ran and tested the code)
    - We will be moving forward with the stepper motor
        - Possibly using a press fit design to attach the console to the motor
- Annabel and I will be discussing purchasing motor components
- Stabilization updates from Tim and Sam:
    - Sam got his welding pass and made some general updates to the stabilization design sketches
    - Stabilization bar is now vertical
    - Changed lever design to adjustable pin design like in other Matrix machines
    - Unsure of stabilization from solely base board, so he added two other supports to aid in stability and prevent tipping or failure
        - Sam believes that we should fabricate and test without the added supports and then decide if the supports are necessary
        - Need to consider height of vertical bar for rowing (do not want interference)
- I added a copy of a Gantt chart template to the shared team drive
    - We want to integrate the project before Thanksgiving

Conclusions/action items:

The team played a lot of catch-up today. Each subteam shared their progress with the other subgroup and received design feedback. The team discussed a project timeline and plans on completing a Gantt chart before next Thursday. Additionally, Josh will be emailing Staci to set up a time to go to Johnson Health Tech in Cottage Grove for a meeting.

The team will be meeting next week on Friday. I will be collecting dates for project dates and deadlines and creating the Gantt chart for the team.

10/28/2022 Team Meeting

Roxi Reuter - Oct 28, 2022, 3:18 PM CDT

Title: Team Meeting

Date: 10/28/2022

Content by: Roxi Reuter

Present: Entire Team

Goals:

- Discuss plans for the show and tell next week
- Talk about design progress

Content:

- We discussed the show and tell
    - Possible questions to ask other groups:
        - Suggestions for changing the resistance of the rowing machine from the adaptive side
        - Any better methods to attach the stabilization frame
    - What will we be showing at the show and tell?
        - Have rower with us
        - Show 3D prints
        - Paper sketch of stabilization frame and photos of materials if possible
- For the 3D print of the motor housing, Annabel suggested adding venting (such as a fan, slits, or both) to the design
    - Might be able to place the fan underneath the motor since we have more room in that direction; however, placing it on the side is optimal (although we don't have as much room there)
    - Also - 12V will be able to power both Arduino and stepper motor, so the 9V battery is no longer needed
- Research possible fans that could be used to motor ventilation
    - Motor heats up even when not rotating (just based on when Annabel has been playing around with it, but will this still occur when the motor is used in
- Box for housing estimated under $10 to print
    - Current project cost is around $94
    - Should only have to do one to two more prints with the pulley plate - still need to approve the 3D print (instead of metal) idea with Staci
- Josh estimated approximately $60 for the printing of both pulley plates out of tough PLA and high density
- We will plan on adding slits for ventilation as of now and not using the fan at the moment

Conclusions/action items:

The team will continue working on the design and testing plans. Josh will be modifying the current CAD designs, and the team will prepare for show and tell next Friday (11/04).

10/28/2022 Advisor Meeting

Roxi Reuter - Oct 28, 2022, 3:17 PM CDT

Title: Advisor Meeting

Date: 10/28/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss project progress and show and tell

Content:

- Show and tell next Friday in Tong lecture hall
- Think of questions for show and tell
- Run elevator pitch by Tracy if we would like
    - Put BME 400 as subject for email (with space)
- A few comments on preliminary report, so take a look at that
- Testing plans (preliminary):
    - SolidWorks **-** tensile testing to identify the weakest points (and if possible do this in person, otherwise we will do it next semester if we don't get to it this semester)
    - Stabilization frame **-** making sure pad prevents from falling forward or tipping backwards, ensuring brakes from wheelchair are sufficient to prevent backward motion of wheelchair
        - Use motion sensors but may need to be careful with human subjects for testing (look into IRB **-** institutional review board)
            - Start this process now!! Need to make sure this process is exempt before we can proceed
            - Can be a tedious process so might be good to start over winter break
            - Tracy will help us with this (she's our PI in this case)

Conclusions/action items:

During this advisor meeting, the team discussed show and tell, as well as a bit on the preliminary report. Additionally, the team updated Tracy on design progress and prints.

10/28/2022 Client Meeting

Roxi Reuter - Oct 28, 2022, 3:17 PM CDT

Title: Client Meeting

Date: 10/28/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Update Staci on project progress
- Confirm a meeting date at JHT

Content:

- Meeting date at JHT: next Friday 11/4 after show and tell (around 3-4:30PM)
  - Can do a little tour of the facility
- Josh showed Staci the pulley plate design and asked about printing at higher infill out of tough PLA instead of welding with metal due to complex design
  - Staci can talk to model shop guys to see if we could fabricate it with plastic (milling it with plastic)
  - Staci suggested changing the geometry slightly of the antler arm (diagonal member instead of L-shaped design)
- Josh also explained and showed the motor housing on SolidWorks
  - Staci didn't think that a fan would be necessary
  - Overheating issue: 12V power supply may be causing this (Staci suggested maybe looking to make sure we aren't supplying too much power in terms of volts and amperage)
- Tim has a document with estimated bar lengths, so Staci will be going through the materials at JHT to streamline our time there a little bit
- Staci also has limit switches which we can use, and she will be showing those to us when we go to JHT on Friday 11/04.

Conclusions/action items:

During the client meeting, the team updated Staci on the project progress and money that has been spent this far. The team will be going to JHT next week (Friday 11/04) following show and tell to tour the JHT facility in Cottage Grove and to start fabricating the stabilization frame.

11/11/2022 Team Meeting

Roxi Reuter - Nov 11, 2022, 5:46 PM CST

Title: Team Meeting

Date: 11/11/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss when integration of designs will occur
- Plan for next steps in the design process

Content:

- Annabel showed the updated circuit with a D-shaft motor and a new motor controller instead of a relay
- Stabilization frame updates:
    - Sam is working on a SolidWorks design
    - Deadline for CAD model is next Friday (send to Staci so she can talk to the model shop people)
    - We are still running into some issues with the geometry (don't want the stabilization frame to interfere with the rowing motion)
    - We are still looking into a bending bar (like what is used on a rollercoaster)
- Josh updated the CAD designs for the circuit/motor box and the antlers. He plans on printing these new prototypes mid next week
- We still need to purchase a new motor with a D-shaft (right now we are using Annabel's personal one)
- The team took some time to look at the rower and brainstorm ideas for the stabilization frame
- The stepper motor, circuitry, and 3D-printed console bracket were integrated and tested for functionality
    - This worked! See attached video for console rotation

Conclusions/action items:

During this meeting, each team member shared their weekly update. The team also tested the design components that have been worked on throughout the semester and successfully rotated the console. In the coming weeks, the team will be designing and fabricating the stabilization frame, as well as integrating all design components and carrying out testing.

Roxi Reuter - Nov 11, 2022, 5:48 PM CST

Download

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Roxi Reuter - Nov 11, 2022, 5:51 PM CST

Download

IMG_2633.MOV (9.84 MB)

11/11/2022 Advisor Meeting

Roxi Reuter - Nov 11, 2022, 6:18 PM CST

Title: Advisor Meeting

Date: 11/11/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Talk about show and tell
- Discuss project updates

Content:

- We discussed updates on the stabilization frame
  - We have the current design which was built at JHT last week and are now looking at a stabilization mechanism which folds up (like a rollercoaster securing mechanism)
  - Tracy recommended somehow testing both (like PVC)
    - There is a lot of material available already at UW-Madison (scraps)
- Josh gave updates on the 3D prints
- IRB:
  - Start with ARROW
  - Submit protocol-based test
  - List Tracy as PI
  - Identify all areas of safety concern
    - Pinch points
    - Electronics

Conclusions/action items:

In this short advisor meeting, the team updated Tracy on project progress. Tracy suggested getting started as soon as possible on the IRB exemption application process and beginning low-fidelity prototyping of various stabilization designs. The team will continue working on each individual project component and incorporate the overall design around Thanksgiving week.

11/18/2022 Team Meeting

Roxi Reuter - Nov 18, 2022, 2:09 PM CST

Title: Team Meeting

Date: 11/18/2022

Content by: Roxi Reuter

Present: Josh, Tim, Annabel, and Roxi

Goals:

- Update each other on project progress
- Plan integration and activities before/after Thanksgiving

Content:

- Josh and Annabel shared their 3D printing updates on the console/motor housing designs
- Tim and I discussed the stabilization frame
  - As of now we are giving Staci bar dimensions for the stabilization frame which sits in the middle of the rower
  - Next week, we are planning on fabricating the stabilization frame
- In terms of outreach, I will be planning the outreach activity outline
  - We will ask Tracy when she will have time to meet for the outreach activity
- As for the IRB application, I will continue working on that and
- Josh will be printing all the final 3D prints today and will have the testing simulations done over Thanksgiving break
- After Thanksgiving, we will be integrating the console and 3D printed components with the rower and the stabilization frame
- Next week, the team will try to meet to fabricate the stabilization frame.
  - No welding will be done by the team initially
- No meeting next week
- Following Thanksgiving break, we will be keeping our schedules open and flexible to pick up materials and fabricate the stabilization frame.
  - Following stabilization frame fabrication, we will be carrying out testing and working on final deliverables.

Conclusions/action items:

The team has made great progress so far with the project this semester. Josh will be printing final prints today, and Tim is planning on sending Staci drawings of the materials which we need from JHT. I will be dedicating time to the IRB exemption application and the outreach activity planning. When we get back from Thanksgiving break, we will be picking up materials from JHT and begin fabricating the stabilization frame, integrating project components, complete testing, and start final deliverables.

11/18/2022 Advisor Meeting

Roxi Reuter - Nov 18, 2022, 1:31 PM CST

Title: Advisor Meeting

Date: 11/18/2022

Content by: Roxi Reuter

Present: Tim, Josh, Annabel, and Roxi

Goals:

- Talk about design progress and updates
- Ask about outreach activity

Content:

- Tracy encouraged us to explore the rollercoaster design for the stabilization frame
- Josh showed Tracy the new SolidWorks pulley design (the second pulley is moved up)
  - He informed her that he will be doing final prints at 100% infill
- Annabel talked about the motor vibration issues; however, this is not present anymore since we purchased the new D-shaft motor
- Activity guide: what we're thinking about
  - Middle schoolers
  - Potato/battery activity
  - Turn in activity guide template explaining
- I updated Tracy on the IRB ARROW application
  - I plan on slowly working through that throughout the remainder of the semester, and we will do the bulk of it over winter break
  - Tracy said if anything comes up, I can
- In terms of testing, we can focus on what we changed this semester. Testing data from last semester is still valid for tension testing.
  - We will focus on testing the frame and the circuit design.
- Tracy recommended taking a look at preliminary report comments again because the final report will be due soon

Conclusions/action items:

Tracy received project updates from the team. She told us to reach out for help if we need anything in terms of testing as we continue working on that after Thanksgiving break.

11/18/2022 Client Meeting

Roxi Reuter - Nov 18, 2022, 1:59 PM CST

Title: Advisor Meeting

Date: 11/18/2022

Content by: Roxi Reuter

Present: Tim, Josh, Annabel, and Roxi

Goals:

- Discuss project progress
- Ask about stabilization materials and fabrication

Content:

- Josh showed Staci the new SolidWorks pulley plate design (moved up the location of the added pulley so the stabilization frame can fit)
    - Josh is printing the final models today out of tough PLA at 100% (or highest possible) infill
- Annabel showed Staci her circuit updates
    - Added solder board
- Stabilization frames:
    - Feedback from Staci on Sam's SolidWorks stabilization design (roller coaster edition) - the thickness of the bar may need to be increased
    - Screws and bolts dimensions - we can use the size that we used at JHT or we can drill out the holes to be bigger if needed
        - JHT pretty much has all sizes that we will need for bolts (M6, M8 is best bet but could probably go up to M10)
    - Lap pad from JHT - all one piece
    - Width of bars used for stabilization frame - Staci can give us feedback on what widths we decide on
        - Staci suggested FEA (this will help narrow down the size options)
    - Angle adjustment - not standard pieces. We will need to design this angle adjustment mechanism and design it at the fabrication shop at JHT.
    - Materials list - usually does not take too long to get materials (usually within a day or two after signature from Staci's boss if needed
        - Gas assist - for future semester
        - Can make drawings for materials (page with picture of bars and dimensions)

Conclusions/action items:

During this client meeting, we gave Staci a quick project update. Tim will be sending Staci the materials list and drawings. Since there will be a time delay for obtaining materials (approval and cutting) and next week is a short week due to Thanksgiving, we told Staci we would like to pick up the materials by the Monday after Thanksgiving (11/28).

12/01/2022 Design Integration and Testing

Roxi Reuter - Dec 01, 2022, 6:20 PM CST

Title: Testing and Design Integration

Date: 12/01/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Integrate all design components with each other and the rower
- Perform testing
- Divide up the final presentation and report

Content:

- The team met in ECB to work on integration and testing
- Some areas of improvement for next semester include:
    - Redesign the lid for the circuit and motor box so that the screws do not impede movement of the console
    - Add a flat piece instead of a bolt as the backstop (we can also glue or somehow attach the limit switch on this so it is better attached)
    - Implement pin-angle adjustment instead of tightening a bolt
    - Add in the gas assist
    - Get a smaller lap pad (in width) to accommodate the standard range of wheelchair widths - or cut the current lap pad
    - We also need to increase the height of the antlers because the console is just barely running into the handle bar.
    - Add wedges or some sort of support to prevent the rower from rocking when used on the adaptive side
- Divisions for the final poster presentation (editing):
    - Abstract - Roxi
    - Background and motivation - Roxi
    - Problem statement (alter slightly) - Roxi
    - Design criteria - Tim
    - Final design - Annabel (electronics) & Sam (rest of the design)
    - Testing and results
        - Motor and pulley plate simulation - Josh
        - Stabilization frame - Tim
    - Discussion - Sam
    - Future work - Annabel & Josh
    - Acknowledgements - All
- Divisions for the final poster presentation (presenting):
    - Abstract - Not presented
    - Background and motivation - Tim
    - Problem statement - Tim
    - Design criteria - Annabel
    - Final design - Annabel
    - Testing and results - Josh

  - Discussion - Roxi
  - Future work - Sam
  - Acknowledgements - Sam
- We ran into slight issues with the console turning back to the adaptive side once it reached the standard side (unnecessary turning); however this was fixed with wire placement
- Meeting to edit poster on Monday 12/05 (virtually) at 7:30PM
  - 45-ish minute meeting
  - Try to have parts done by Sunday night and look over poster before team meeting
  - Assign report sections if time during this meeting
- Printing poster on Wednesday (12/07)
- Practicing on Thursday for final poster presentation next Friday (12/09)

Conclusions/action items:

The team successfully completed integration of the different design components with each other and with the rower. Testing of the displacement of both the wheelchair and the stabilization frame were carried out with motion capture on Kinovea in the extreme cases (resistance of 1- lowest resistance - and resistance of 10 - highest resistance). The team will analyze these results and work on the final deliverables.

12/02/2022 Advisor Meeting

Roxi Reuter - Dec 02, 2022, 4:27 PM CST

Title: Advisor Meeting

Date: 12/02/2022

Content by: Roxi Reuter

Present: Sam, Roxi, Josh

Goals:

- Look over outreach activity outline
- Show Tracy the rower and demonstrate how it works
- Discuss testing that we performed (verify that we tested all the necessary resistance testing cases)

Content:

- Outreach activity is good to go
    - Turn in with final deliverables this semester
- We described our integration and testing process to Tracy
- Then, we visited the rower in the green room
- Josh demonstrated rowing from the adaptive side and the turning of the console
- We confirmed with Tracy that we did motion capture testing for all the necessary cases (extreme resistances: 1 and 10), and since there was no significant movement in either case, Tracy said we do not need to test any middle cases
- Tracy will be available Wednesday (12/07) to give feedback on the poster via Zoom
    - As many team members should attend this as possible

Conclusions/action items:

The team has a working design and carried out testing this week! Tracy loved the design. The team plans on working on the poster over the weekend and meeting on Monday (12/05) to edit the poster. Practice for the final poster presentation will take place on Thursday (12/08).

12/05/2022 Team Poster Editing

Roxi Reuter - Dec 05, 2022, 9:16 PM CST

Title: Team Poster Editing

Date: 12/05/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Edit the team poster

Content:

- The team took a look at the poster which each member worked on over the weekend
- Questions for Tracy's office hours on Wednesday:
  - Font size of abstract section? Is it OK that it is not the same as the other sections?
  - Any other quantitative data that should be included?
- The team made the design specifications and future work more quantitative to sound less vague and give a better idea of what we actually intend(ed) to do with our design
- We added a table to clean up the data in the testing results for the Kinovea testing
- Josh is emailing Tracy about meeting at 2PM to go over the poster
- Plan for 4PM on Thursday to practice the poster presentation
  - Sam is going to try to reserve a room
- We will plan on meeting slightly before the presentation on Friday to set everything up
- We also assigned report sections
  - I have…
    - 1. Adding sources to the introduction (statistic from today of 81%..., competing design from Annabel, etc.)
      - Competing design from Annabel: "Adapt2Row: rowing on a Concept2 rowing machine from your wheelchair," *Gerofitness*. https://gerofitness.nl/export/406-adapt2row.html (accessed Sep. 26, 2022).
    - Discussion
- We are planning on meeting both Sunday and Monday (1 hour each day) to edit the report
  - 7:30PM on Monday (1-1.5 hours)
  - 4PM on Sunday (2 hours)

Conclusions/action items:

The team spent this meeting editing and discussing the poster content together. We have a busy couple weeks finishing up the design semester but have planned out how we will successfully tackle the end of the semester.

12/11/2022 Report Editing I

Roxi Reuter - Dec 11, 2022, 7:04 PM CST

Title: Report Editing I

Date: 12/11/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Start editing report (address comments from individual editing, as well as preliminary report)
- Write conclusion and abstract together

Content:

- The team addressed both comments from team members from individual editing and from our advisor, Tracy, in the preliminary report
- Final meeting with Tracy:
  - Monday or Tuesday (12/19 or 12/20) during the morning

Conclusions/action items:

During this long meeting, the team spent time editing the final report together. Although the team did not completely finish edits, a final editing meeting will take place tomorrow (12/12) from 7:30-9PM on Teams. A copy of the final report after edits will be added to the team notebook.

12/12/2022 Report Editing II

Roxi Reuter - Dec 13, 2022, 3:20 PM CST

Title: Report Editing II

Date: 12/12/2022

Content by: Roxi Reuter

Present: Entire team

Goals:

- Finish editing report

Content:

- In this report editing session, we focused on revising the following sections
  - Discussion
  - Future Work
  - Conclusion
- We finished making all edits and will read the report individually before turning it in

Conclusions/action items:

The report is almost complete! We made the rest of our final group edits today and will be reading the report again individually before turning it in. Additionally, we will finish up other final deliverables, such as peer and self reviews, as well as the outreach plan for Wednesday (12/14).

Adjustable Mechanism for Support Base and Material Research 9/15/22

SAMUEL SKIRPAN - Sep 15, 2022, 4:29 PM CDT

Title: Research on Adjustable Mechanism for Support Base

Date: 9/15/22

Content by: Sam

Present: Sam

Goals: Look for exercise equipment that uses adjustable mechanisms to change sizes.

Content:

Article: Life Fitness

Citation: "Adjustable bench," *Hammer Strength*. [Online]. Available: https://www.lifefitness.com/en-us/catalog/strength-training/benches-racks/hammer-strength/adjustable-bench. [Accessed: 15-Sep-2022].

- Notes:
  - After looking on the Life Fitness website through a lot of their equipment, I came upon the adjustable bench
  - This uses a bar-in-bar mechanism where a larger bar encases a smaller bar which is able to slide freely within the larger bar
  - A pin is used to stop the smaller bar from sliding within the larger bar at discrete locations along the length of the small bar. This pin can be placed in different holes along the smaller bar.
    - The pin is spring loaded so that it is always forced to lock into one of the wholes and maintain its position

  -
    - In this picture, the multiple holes along the smaller bar allow for the pin to be placed at different locations. Subsequently, the length of the two bars together changes as the pin location is changed. This allows for the shrinking and enlargement of the bar
      - NOTE: this mechanism could be used to increase the width, heigh, and length of our base support mechanism. We would need two sets of bars (one larger and one smaller) so that the smaller bar rests within the larger bar.

2. Stainless steel in sports and leisure equipment

Citation: "Stainless steel in sports and Leisure Equipment." [Online]. Available: https://www.worldstainless.org/Files/issf/non-image-files/PDF/ISSF_Stainless_Steel_in_Sports_and_Leisure_Equipment.pdf. [Accessed: 15-Sep-2022].

- Notes:
  - Stainless steel us often used for many pieces of gym equipment, both outdoor and indoor
  - Stainless steel provides a long service life and is very resistant to corrosion
  - Stainless steel and aluminum have a very high strength
    - NOTE: significant strength will be needed for the support base to make sure that the wheelchair used is supported substantially while completing the pull-motion

Conclusions/action items:

Overall, by looking at some other pieces of gym and exercise equipment, the bar-in-bar mechanism along with the pin appear to be great at creating adjustable parts for machines. With one bar sliding within the other and a pin used to lock each in place, with respect to one another, this mechanism could be used for our adjustable support base. This could allow for the change in height, width, and length. Additionally, stainless steel and aluminum appear to be common materials used for exercise equipment due to their high strength.

Action items: meet with team to discuss PDS sections. Meet with advisor to discuss lab notebook expectations. Continue to research/brainstorm ideas for support base.

Typical Wheelchair Dimensions 9/15/22

SAMUEL SKIRPAN - Sep 15, 2022, 4:01 PM CDT

Title: Typical Wheelchair Dimensions

Date: 9/15/22

Content by: Sam

Present: Sam

Goals: Determine the typical dimensions of standard wheelchairs.

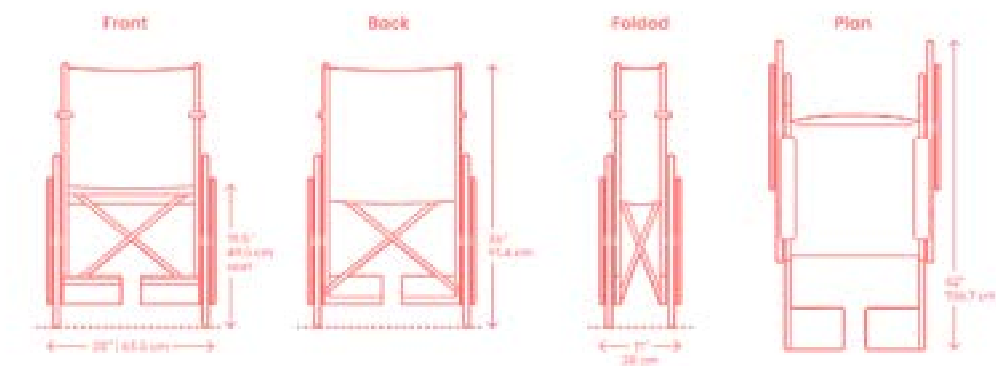
Content:

1. Are There Standard Wheelchair Dimensions

- Citation: O. Badge, “Wheelchair dimensions: Average width, height & standard size,” *Orange Badge Mobility Solutions*, 16-Feb-2022. [Online]. Available: https://orangebadge.co.uk/blog/are-there-standard-wheelchair dimensions/#:~:text=Much%20like%20a%20piece%20of,wide%20and%2032%20inches%20long. [Accessed: 15-Sep-2022].
- Notes:
    - Typical wheelchair is around 36 inches tall, 25 inches wide, and 32 inches long
    - NOTE: Our design should be centered around the typical size of a wheelchair and allow for some variability in both the smaller and larger directions.

2. Wheelchairs Dimensions and Drawings

- Citation: “Wheelchairs Dimensions & Drawings,” *RSS*. [Online]. Available: https://www.dimensions.com/element/wheelchairs. [Accessed: 15-Sep-2022].
- Notes:
    - Standardized dimensions and related clearances for wheelchairs directly impact the built environment by establishing required widths and turning radii mandated in an effort to make public buildings accessible for all people
    - Wheelchairs come in differently shapes and sizes based on types of technology, methods of propulsion, and other specific uses
    - Typical dimensions of ordinary wheelchair:
        - length = 42 inches
        - height = 36 inches
        - seat height = 19.5 inches
        - width = 25 inches



        -
            - This pictures shows the front, back, folded, and plan view of a typical wheelchair. It also denotes the different dimensions associated with each characteristic.

Conclusions/action items:

It appears the the standard height of a wheelchair is around 36 inches, width around 25 inches, and length around 32-42 inches. With these measurements in mind, the base that we create will have to be adjustable to fit different sized wheelchairs. These base measurements will be used to center the size of the base. Variability will be accounted for on both the smaller and larger side of each centered measurement to account for both bigger and smaller sized wheelchairs.

Action items: Discuss these measurements with team. Research potential materials and adjustable mechanisms for the base.

Common Exercise Equipment Materials 9/20/22

SAMUEL SKIRPAN - Sep 20, 2022, 7:17 PM CDT

Title: Common Exercise Equipment Materials

Date: 9/20/22

Content by: Sam

Present: Sam

Goals: Research common exercise equipment materials typically used.

Content:

Article: How was the gym equipment made? And what are they made of?

Citation: J. Roberts, “How was the gym equipment made? and what are they made of?,” *Fitneset*, 22-Jun-2021. [Online]. Available: https://fitneset.com/how-was-the-gym-equipment-made-and-what-are-they-made-of/. [Accessed: 20-Sep-2022].

Link: https://fitneset.com/how-was-the-gym-equipment-made-and-what-are-they-made-of/

Notes:

- Aluminum, carbon steel, or any other metal alloy is the primary materials used in fitness-gym equipment
    - These have low weight characteristics and high durability
- In terms of finishing, frames can be powder-coated and painted to give a long-lasting, appealing appearance
    - NOTE: we could do this with the frame we create, including the pad
- For free weights, iron, steel, and hard rubber are typically used
    - Iron, Kevlar, or a metal alloy typically increase a product's longevity and straightness
    - These are typically used in high-end home gyms

Conclusions/action items:

Similar to a previous article that I read, aluminum and steel are typically used in commercial gym equipment. However, other metal alloys, iron, or potentially kevlar are also sometimes used to increase a product's longevity. For our base and pad support system, we should consider using these materials to make sure they match the strength characteristics of the existing frame.

Action items: meet with team to discuss PDS. Complete another design iteration of support base.

UW-Madison Fabrication Capabilities 9/26/22

SAMUEL SKIRPAN - Sep 26, 2022, 4:37 PM CDT

Title: UW-Madison Fabrication Capabilities

Date: 9/26/22

Content by: Sam

Present: Sam

Goals: Find out fabrication capabilities and methods available at UW Madison in Team Lab.

Content:

TEAM Lab

- 3 types of welding passes available at TEAM Lab
    - Welding 1 Upgrade (MIG)
        - Allows for use of MIG welder
        - Need to have red or green permit
        - Need to apply for the upgrade
        - Need to complete Canvas quiz and attend a seminar
    - Welding 2 Upgrade (TIG)
        - Same requirements as 1, but need to already have the welding 1 upgrade
        - Instead of 1 seminar, it will have two seminars
    - Welding 3 Upgrade (MIG Aluminum)
        - Same requirements as 1, but already need to have the welding 1 upgrade
- Link to website: https://teamlab.engr.wisc.edu/training/permit-upgrades-2

Conclusions/action items:

At the TEAM Lab, they have 3 different welding upgrades available. I already have my Red pass, so I could apply for these upgrades. Initially, I think only the welding 1 upgrade will be needed to complete the welding we need for our support mechanism.

Action items: Determine if MIG welder will be sufficient for our welding purposes. Meet with team to discuss design matrixes.

MIG Welding Process Parameters 9/28/22

SAMUEL SKIRPAN - Sep 28, 2022, 8:56 AM CDT

Title: MIG Welding Process Parameters

Date: 9/28/22

Content by: Sam

Present: Sam

Goals: Determine basics of MIG welding.

Content:

Article: Optimization of Synchropulsed MIG Welding Process Parameters for Welding of AW 5083 Sheets

Citation: L. Maglić, D. Marić, T. Šolić, and I. Samardžić, “Optimization of synchropulsed mig welding process parameters for welding of AW 5083 Sheets,” *Materials*, vol. 15, no. 9, p. 3078, 2022.

Notes:

- Metal inert gas (MIG) welding is one of the processes most commonly used for joining metals
    - Typical for joining aluminum and its alloys
    - Can also be used for stainless steel
- Application of pulsed current in an electric arc allows better controllability of the molten droplets and the art transition
    - This leads to better joints of better quality
- Biggest parameters for welding aluminum alloys include:
    - Delta wired feed
    - Frequency
    - Duty cycle
- Common output variables associated with MIG welding:
    - Throat thickness, weld penetration, weld width
        - These all have particular ranges that can be set by the user
        - Want to try to have enough strength within the weld without it looking poor
- Welding is one of the most common processes of joining metals, but its definition is complex because it involves several scientific disciplines
    - Metallurgy, electrical engineering, technical materials, thermodynamics, etc.
- Throat thickness

Conclusions/action items:

From this article, I learned that MIG stands for metal inert gas. Additionally, MIG welding can be used for aluminum and its alloys in addition to steel, which is perfect for this project since that is what we want to make our stabilization mechanism out of (commonly used in exercise equipment). While welding, it is important to have the right balance of strength/durability and appearance. For our purposes, we would probably care more about the strength and durability sections as long as it meets a minimum appearance requirement for use.

Action items: Continue to research MIG welding. Meet with advisor and client on Friday.

MIG Welding TEAM Lab Guide 10/4/22

SAMUEL SKIRPAN - Oct 04, 2022, 4:09 PM CDT

Title: MIG Welding TEAM Lab Guide

Date: 10/4/22

Content by: Sam

Present: Sam

Goals: Take notes on MIG welding from TEAM lab guide.

Content:

- Safety
    - Welding creates heat, sparks of molten metal, bright light
    - Have to wear protective eyewear
    - Have to wear leather capes, sleeves, and gloves
    - Weight leather boots or shoes
    - Wear a helmet with welding lenses
- Make sure to keep equipment safe
    - Make sure electrical connections are tight and secure
    - Make sure there are no frayed cables
- Don't use oxygen to blow off equipment or clothing
- Proper ventilation of workspace is super important
- Be careful where you place the gun since it can be really hot
- MIG process can weld steel, aluminum, and stainless steel alloys
- The travel speed and deposition rates in MIG welding make the process much faster and more efficient
- MIG welding is used when speed, efficiency, and cleanliness are important
- The electrode wire and shielding gas can be matched to the weld material
- MIG system components
    - Power source, wire feeding mechanism, shielding gas cylinder, regulator, MIG gun, and a work clamp
- An inert shielding gas is used to protect the electrode and weld pool from contamination and to enhance the welding capabilities of the electrical arc
- MIG Gun function
    - The trigger on the MIG gun activates the wire feeding system, gas delivery, and weld power
    - A nozzle in the gun directs shielding gas around the arc and weld pool
    - The contact tip at the front of the MIG gun transfers electrical current to the electrode wire
- A work clamp will be clamped to the work piece to complete the weld circuit and enable the current to flow
- Stickout is the amount of wire sticking out of the end of the contact tip
    - Maintain a .25 to .375 inch stickout while welding

Conclusions/action items:

I read through the welding 1 guide provided by the COE workshops. The guide went through the basic principles of welding in addition to the safety procedures needed to remain safe during the experience. Also, it went through the different components of the welding process. I will use these notes to be successful on the canvas quiz.

Action item: Pass welding 1 canvas quiz. Sign up for welding 1 seminar. Meet with team to edit preliminary presentation.

TEAM Lab Available Materials 10/5/22

SAMUEL SKIRPAN - Oct 05, 2022, 1:54 PM CDT

Title: TEAM Lab Available Materials

Date: 10/5/22

Content by: Sam

Present: Sam

Goals: Determine materials available at team lab for the stabilization frame.

Content:

- Link: https://teamlab.engr.wisc.edu/services/stock-hardware
- I went on the TEAM Lab website to find out what materials we could potentially use for the stabilization mechanism
- They mention that they have raw materials for the machine shop such as aluminum, steel, and stainless steel
- These materials are the forms of bars, rods, and sheets
    - NOTE: this could be perfect for us - we just need to determine what form of metal will be best for us (or combo of forms)
- Additionally, they list out a bunch of metal suppliers around the Madison region where we could order metal from
    - For metal stock:
        - Cincinnati Tool Steel
        - Liebovich
        - Thyssenkrupp Materials NA
        - Wiedenbeck
        - MSC
    - NOTE: we can also check at Menards or Home Depot if we would like to
- They mention on the website that it may be cheaper to go through one of the suppliers than through the TEAM Lab, so that is something we can keep in mind while finding the right material to use

Conclusions/action items:

I completed research on the available materials at the TEAM Lab that we could potentially use for the stabilization mechanism. They have some aluminum and steel in the form of bars, rods, and sheets. However, it may be cheaper to get it through one of their suppliers.

Action items: Determine where we could get pad from. Create further detailed design of stabilization mechanism. Meet with team to discuss preliminary presentation.

Pad Considerations and Research 10/11/22

Title: Pad Considerations and Research

Date: 10/11/22

Content by: Sam

Present: Sam

Goals: Note considerations for how we will source pad along with completing some research for potential pads to use.

Content:

- Considerations:
  - We could potentially get a pad from JHT from one of the machines they aren't using
    - This way we know it meets standards and would feel comfortable for users
    - Also would allow for easier attachment to our pad support mechanism
    - Would need to ask Stacy about this if it is possible
  - If we don't get a pad from JHT, we could start by getting a prototype pad to see if the design concept works
    - Wouldn't need to be very expensive or nice to start out with
  - Then will get a final pad which will be very comfortable and effective for user
  - The pad will have to be comfortable for the user, but firm enough that it doesn't move much when the user is in the stabilization mechanism
- Research on pads:
  - Link: https://www.amazon.com/Oodles-Noodles-Foot-Black-Padding/dp/B09CLGBVHZ/ref=pd_lpo_3?pd_rd_i=B09CLGBVHZ&psc=1
  - Notes:

    -
      - This picture shows potential pads we could use to make our prototype
    - Although these pads aren't the nicest one's in the world, they could be functional and easily slip onto the pad support design
    - These only cost $29.99 for these 4, so if we needed extra, there are multiple in this pack and it is not very expensive
    - The central hole could fit around a bar at the end of the horizontal support
  - Link: https://www.amazon.com/Elevation-Non-slip-Removable-Comfort-Home/dp/B07BVF9827/ref=sxin_15_pa_sp_search_thematic_sspa?content-id=amzn1.sym.6b029eb3-7d4 69fe835e098d&crid=3836G8Y1IPSB3&cv_ct_cx=thigh+exercise+pillow&keywords=thigh+exercise+pillow&pd_rd_i=B07BVF9827&pd_rd_r=1775f4c7-90a3-438f-877b-2e62113b 69fe835e098d&pf_rd_r=XNGPAEQT193TTVC2YWVT&qid=1665496845&qu=eyJxc2MiOiIwLjAwIiwicXNhIjoiMC4wMCIsInFzcCI6IjAuMDAifQ%3D%3D&sprefix=thigh+excercise- spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEySFBJU000U1k3RUFJJmVuY3J5cHRlZElkPUEwNTY4NjQzMVU4STdBWjExMkpGQSZlbmNyeXB0ZWRBZElkPUEw
  - Notes:

-
    - This picture is of the half moon pillow
    - This pad is originally used to elevate someones knees when they are lying down, but could be used for our design if we face it downwards
    - It will feel comfortable on the person's legs and will give them support while in the mechanism
        - However, it could potentially not be firm enough, which would mean the user could be insecure while rowing

Conclusions/action items:

For the pad we use for our stabilization mechanism, we could potentially source one from JHT. If not, there are many options available on Amazon and other stores. These two pads above cou
a high level of firmness so the user doesn't move much during the rowing exercise.

Action items: turn in preliminary deliverables. Meet with team on Friday to discuss next steps of project. Complete welding seminar.

Substantial Pad Supports 10/19/22

SAMUEL SKIRPAN - Oct 19, 2022, 1:17 PM CDT

Title: Substantial Pad Supports

Date: 10/19/22

Content by: Sam

Present: Sam

Goals: Research pads that could potentially be used for our final product and pads that Matrix may have available.

Content:

- Link: https://www.johnsonfitness.com/Body-Solid-Pro-Dual-Leg-Extension-Curl-Machine-P553.aspx
    - Notes:
        - 

            - This is a picture of the leg extension machine that Matrix (JHT) makes
        - This machine utilizes two 9 inch diameter leg pads to both secure the user and allow them to complete their exercise of leg extensions
            - The leg pad provides comfort and proper alignment of both legs during the curls and extensions
        - Note: Staci may have one of these leg pads that we could use for our prototype/final design, so that is something we can ask her about
    - This pad would require the bar to come in from the side, unless there was a way to adjust it so that our bar would come right down the center
        - If we made our bar come right down the center, the pad would not be able to rotate freely like it does with this machine

- 
  - This picture is of another pad that Matrix uses for one of their machines
  - This pad is more focused on the downward force to support a user from being pulled out of the machine, so it could be very applicable to our project
    - NOTE: we can ask Staci about this pads availability when we meet with her next
  - In addition to the pad in this picture, you can also see the angle adjustability mechanism on the right side
    - When this yellow lever is pressed inwards, the pad is able to adjust heights
    - Note: we can also ask Staci about using one of these for our design

Conclusions/action items:

I focused my research in this entry specifically on Matrix machines and the pads they use to support users. I found two examples of pads: one that is a cylindrical softer pad and one that is a semi-cylindrical more firm pad. In addition to the pads, there also is a combined lever and angle-adjustability mechanism used on the second machine to change the height of the pad.

Action items: Ask Staci if we could potentially use these pads for our prototype if they have some extra at JHT. Complete welding seminar.

Welding Seminar 10/19/22

SAMUEL SKIRPAN - Oct 19, 2022, 8:50 PM CDT

Title: Welding Seminar

Date: 10/19/22

Content by: Sam

Present: TEAM Lab Staff and Sam

Goals: Complete welding seminar to earn Welding 1 upgrade.

Content:

- Today, from 5-7PM, I earned the welding upgrade by completing the welding 1 seminar
- The contents of the seminar were as follows:
  - We got keys for lockers to put on the coat, gloves, and the welding helmet
  - We went into the welding room
  - Went over major safety protocols of the welding room and welding in general
  - Got a tour of the welding room as well as an introduction to the MIG welder
  - The instructor demonstrated 3 types of welds
  - We then got to practice doing the 3 welds
- Thoughts on experience:
  - I really enjoyed learning how to weld today!
  - At first, I was nervous about actually doing the welding, but after the first weld I completed, felt fine
  - At first, I my skills were very poor
  - However, my skills significantly got better as time and practice went on
  - Things I need to improve upon:
    - Correct arc length
    - Pace of creating weld
    - How far to go forward on weld and then backward
      - 2 steps forward, 1 backward
    - How close to place gun from the desired weld location and the angle of the gun

Conclusions/action items:

Overall, I had a terrific experience learning how to weld. There are many things I need to improve upon, such as the correct arc length and the pace, but that will come with practice. I will be able to use these skills whenever we create our final design.

Action items: share experience with team. Meet with team and advisor on Friday.

Wheelie Base Design 9/19/22

SAMUEL SKIRPAN - Sep 19, 2022, 11:30 AM CDT

Title: Wheelie Base Design

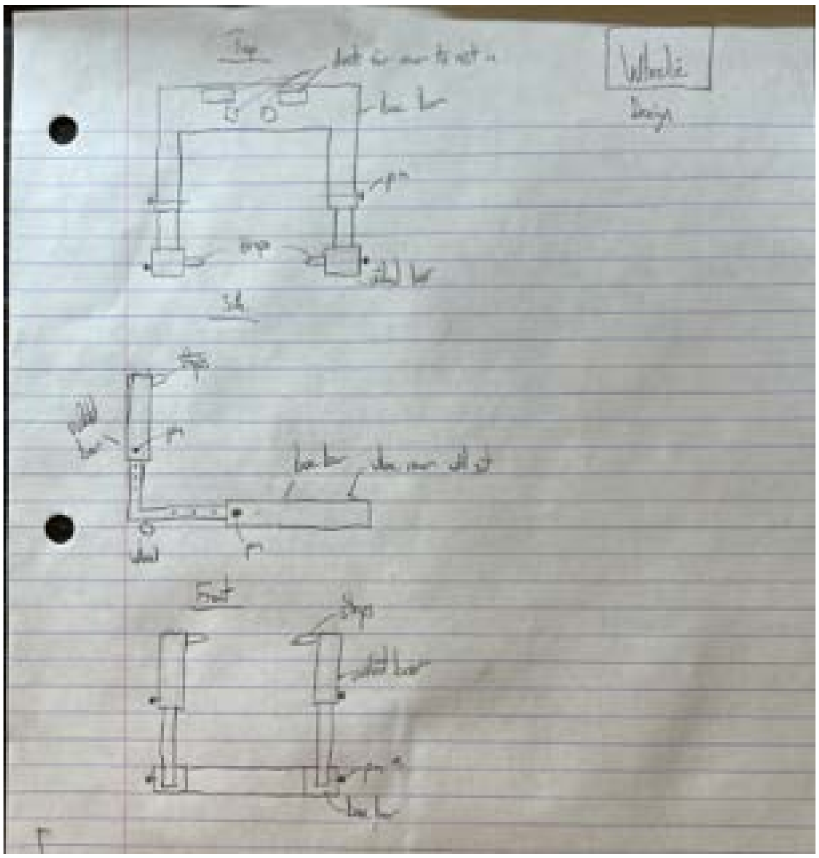
Date: 9/19/22

Content by: Sam

Present: Sam

Goals: Enter "Wheelie" design into notebook.

Content:

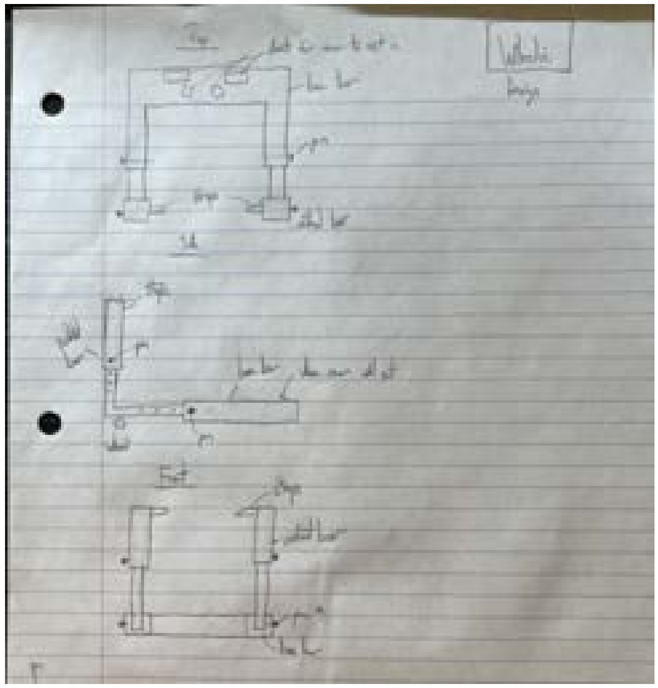
- 
    - This picture is the "Wheelie" design that I came up with for the base
    - The design includes:
        - A base portion that rests under the rowing machine with divots for the rower supports
        - 2 base bars that rest along the floor and jut out towards the wheelchair
            - These bars are larger in diameter
            - These have 1 hole where a pin will rest on each side
        - 2 smaller base bars that rest in the larger base bars
            - The smaller base bars can slide in and out of the larger bars
            - They have wholes along them that allow for adjustability
        - Pins on each side
        - 2 smaller vertical bars that reach up towards the arm rests of the wheelchair
            - These also rest within the larger vertical bars
            - These have holes along them that allow for vertical adjustability
        - 2 larger vertical bars that sit on top of the smaller vertical bars
            - These each have 1 hole where a pin rests
        - 2 straps (1 on each side) that connect to the wheelchair
        - 1 wheel on each smaller base bar that allows for the smaller base bar to roll smoothly when adjusting it

Conclusions/action items:

This "Wheelie" design incorporates an adjustable bar-in-bar feature of many adjustable workout machines. The wheel on the smaller base bars allows for the length of design to be adjusted easily. A pin features allows for both the vertical and length bars to be adjusted to fit different sized wheelchairs. Straps are used to secure the wheelchair to the design.

Action items: Discuss this design with the team during our brainstorm session.

SAMUEL SKIRPAN - Sep 19, 2022, 11:27 AM CDT



Download

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Bar-in-bar Pad Support 9/21/22

SAMUEL SKIRPAN - Sep 21, 2022, 8:58 AM CDT

Title: Bar-in-bar Pad Support

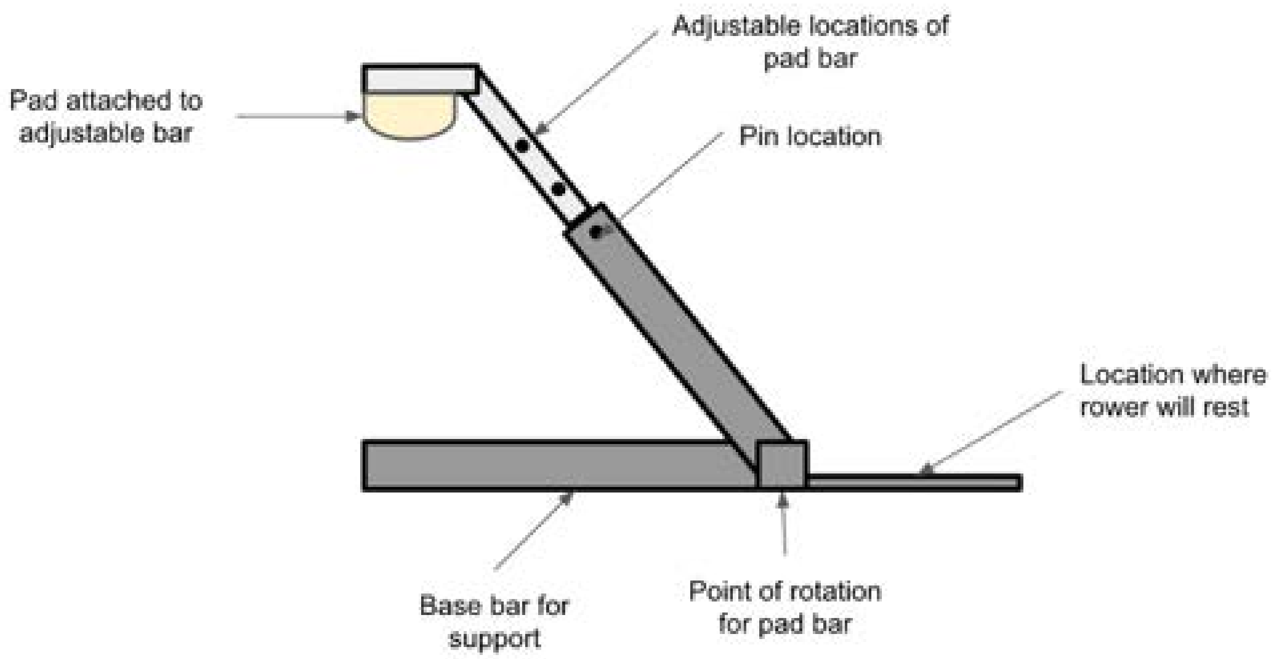
Date: 9/21/22

Content by: Sam

Present: Sam

Goals: Enter bar-in-bar pad support design into lab notebook.

Content:



-
    - This picture is of the bar-in-bar pad support design that I came up with to secure the user to the machine
    - This design counts on the wheelchair locking its wheels so that it does not move backwards while the user is rowing
    - In order to stop tipping from occurring, this design provides a downward reaction force from the pad onto the users thighs
    - Design specs:
        - Has pad attached to adjustable bar that will rest on users thighs
        - Has smaller bar that has many holes indicating locations where the pad can be adjusted to
        - Has larger bar that involves pin
            - The smaller bar rests within the larger bar
        - Has point of rotation where the base bar and larger adjustable bar meet
            - Only the larger adjustable bar can rotate
        - Has base bars that provides support for the design during rowing
            - Note: this base bar acts like the supports a crane shoots out to prevent it from tipping during use
        - Lastly, has a flat piece of metal where the rower will rest on to secure the design to the rowing machine

Conclusions/action items:

This design accounts for different sized wheelchairs (both height and length). Width is not take into consideration other than placing the two base bars far enough apart that a very wide wheelchair could fit in between them. The adjustable pad support bar will use a bar-in-bar mechanism similar to what is used by many pieces of gym equipment.

Action items: Meet with team to discuss PDS edits. Share this design with team. Create FBD of rxn force created by the pad support bar.

FBD for Bar-in-Bar Pad Support Design 9/28/22

SAMUEL SKIRPAN - Sep 28, 2022, 12:15 AM CDT

Title: FBD for Bar-in-Bar Pad Support Design

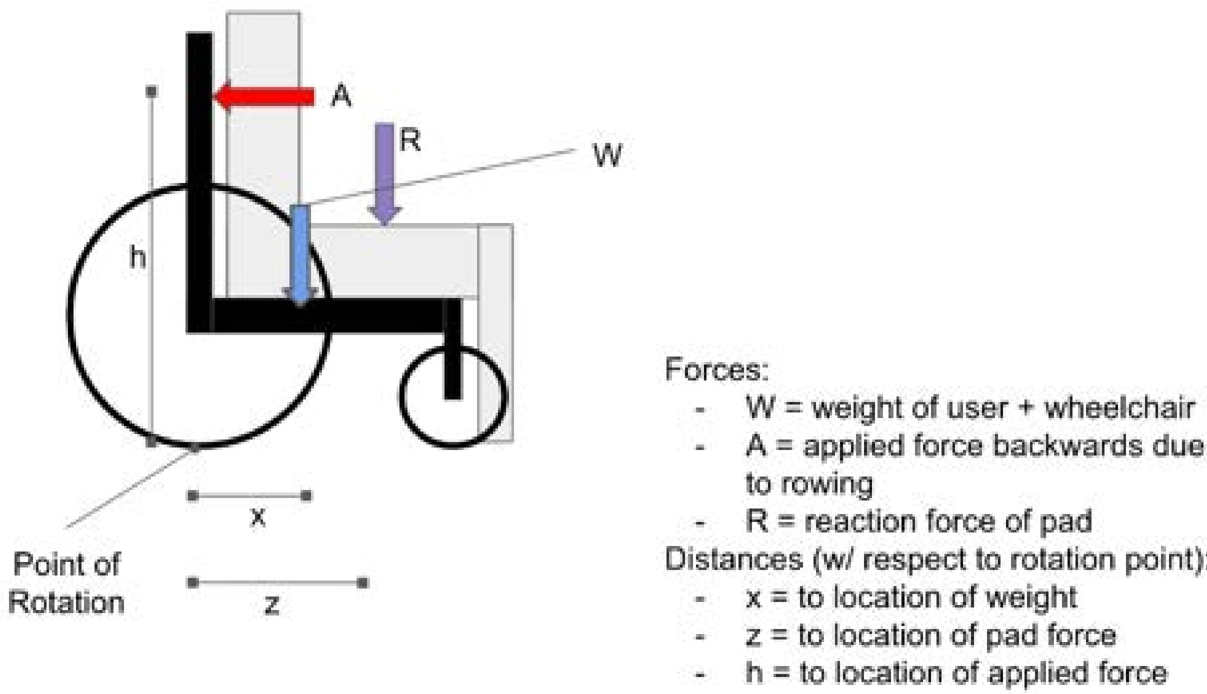
Date: 9/28/22

Content by: Sam

Present: Sam

Goals: Create FBD for Bar-in-Bar Pad Support design to note considerations for design.

Content:



-
    - This pictures includes the the FBD I created for my bar-in-bar pad support design
    - This design relies on a downward reaction force provided by the pad to prevent the user from tipping backwards
        - Assumption: the locking of the wheels will prevent the wheelchair from moving backwards during use
    - Forces included:
        - W = weight of user and wheelchair combinded
        - A = applied force backwards due to rowing exercise
            - Assumed to be maximum of 1050 N
        - R = reaction force necessary for pad
    - Distances included:
        - x = location of center of mass from bottom of large wheel
        - z = location of pad force from bottom of wheel
        - h = location of applied rowing force from bottom of wheel
    - Sum of moments will equal zero if there is to be no tipping of the wheelchair:
        - Counter-clockwise is positive direction
        - Sum of moments: A*h = W*x + R*z
            - R*z = A*h - W*x
            - R = (A*h - W*x) / z
    - Note: this equation shows that the closer the lap pad is towards the persons knee and the further it is from their hip, the smaller the reaction force required to keep the user from tipping over
        - This would correspond to a lesser pressure felt on the user's legs during the rowing exercise

Conclusions/action items:

The required reaction force needed by the pad to prevent the user from tipping is equal to the following expression: R = (A*h - W*x) / z. This means that this reaction force depends on the various lengths mentioned above in addition to the applied force magnitude as well as the total weight of the wheelchair and user. Our team can use this equation to determine the location at which we want to place the thigh pad to prevent tipping.

Action items: Research the MIG welding technique. Write final design paragraph for the stabilization mechanism design matrix.

Pad Support Second Iteration 10/16/22

SAMUEL SKIRPAN - Oct 16, 2022, 4:43 PM CDT

Title: Pad Support Second Iteration

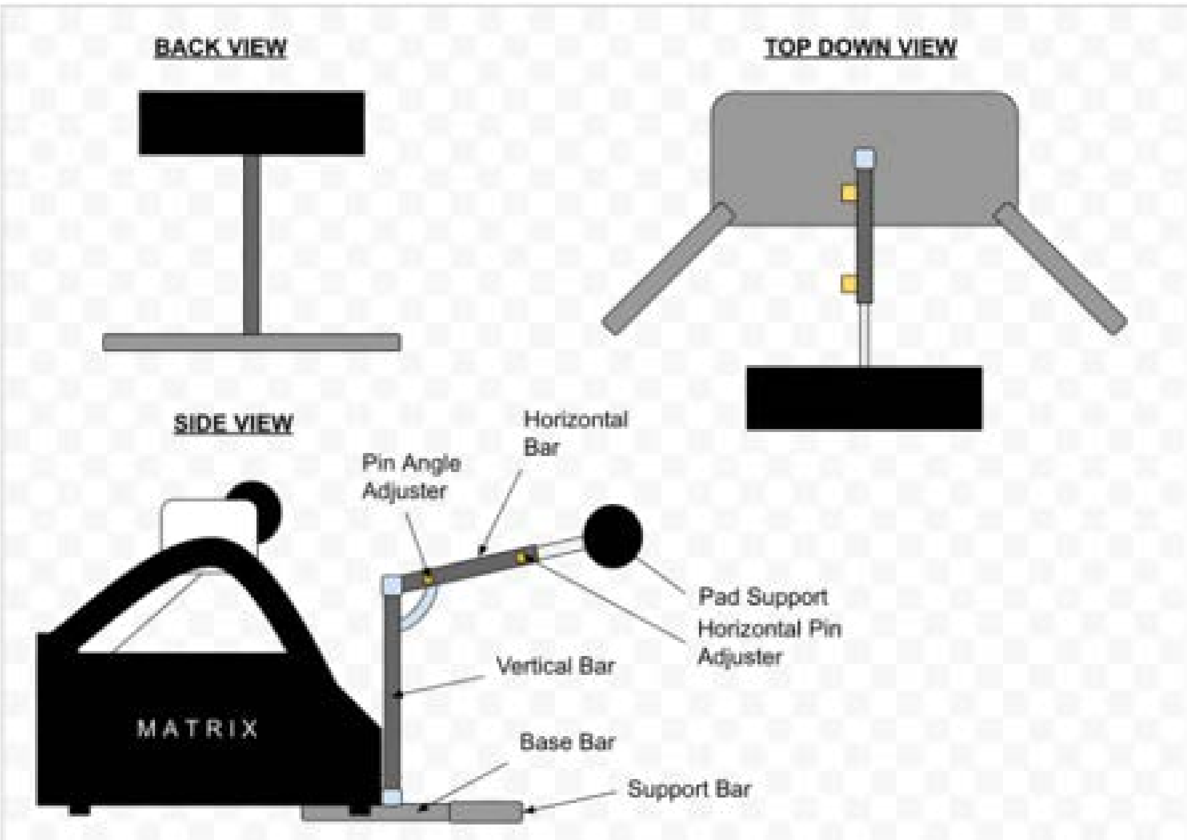
Date: 10/16/22

Content by: Sam

Present: Sam

Goals: Complete a second iteration of the Pad Support Design.

Content:

- I created a second iteration of the Pad Support design in my sketches
- 

    - Here is the picture of the second iteration that I created
    - The main features of this iteration:
        - I made the vertical bar completely vertical instead of diagonal
            - This will allow for the user to have more space to wheel up before hitting there knees against the stabilization mechanism
        - I added in a support bar on each side that flails our from the base board
            - These support bars will further stabilize the stabilization mechanism from tipping over and for stabilizing the user
        - I created a back view and top down view of the mechanism
        - I changed the lever horizontal adjustability mechanism to a pin adjustability mechanism
            - I did this because Staci said they may have some pre-built pin adjustability mechanisms that we could potentially use, which would save us a lot of time and make fabrication a lot easier for us
- Items that still need to be considered/discussed:
    - If the base board mechanism is the best way to attach stabilization mechanism to the rowing machine
        - There are 4 screws on the back side of the rower that we may be able to use if need be for attachment of the stabilization mechanism

        - However, we will probably try with this type of connecting mechanism first and testing will reveal if it is suitable
    - How tall we need to make the vertical support bar
        - We want it to be high enough that it is not hitting the user's knees in the resting position, but not too tall such that it impedes the rowing motion and location of the rope and handlebar

Conclusions/action items:

Today, I made a second design iteration for the pad support mechanism. The main new features I included are new views of the design, 2 support bars as the base, a pin adjustability mechanism for the horizontal bar, and the vertical bar being completely vertical instead of diagonal.

Action items: discuss these changes with the team. Complete welding seminar.

Third Iteration Pad Support 11/2/22

SAMUEL SKIRPAN - Nov 02, 2022, 11:31 PM CDT

Title: Third Iteration Pad Support

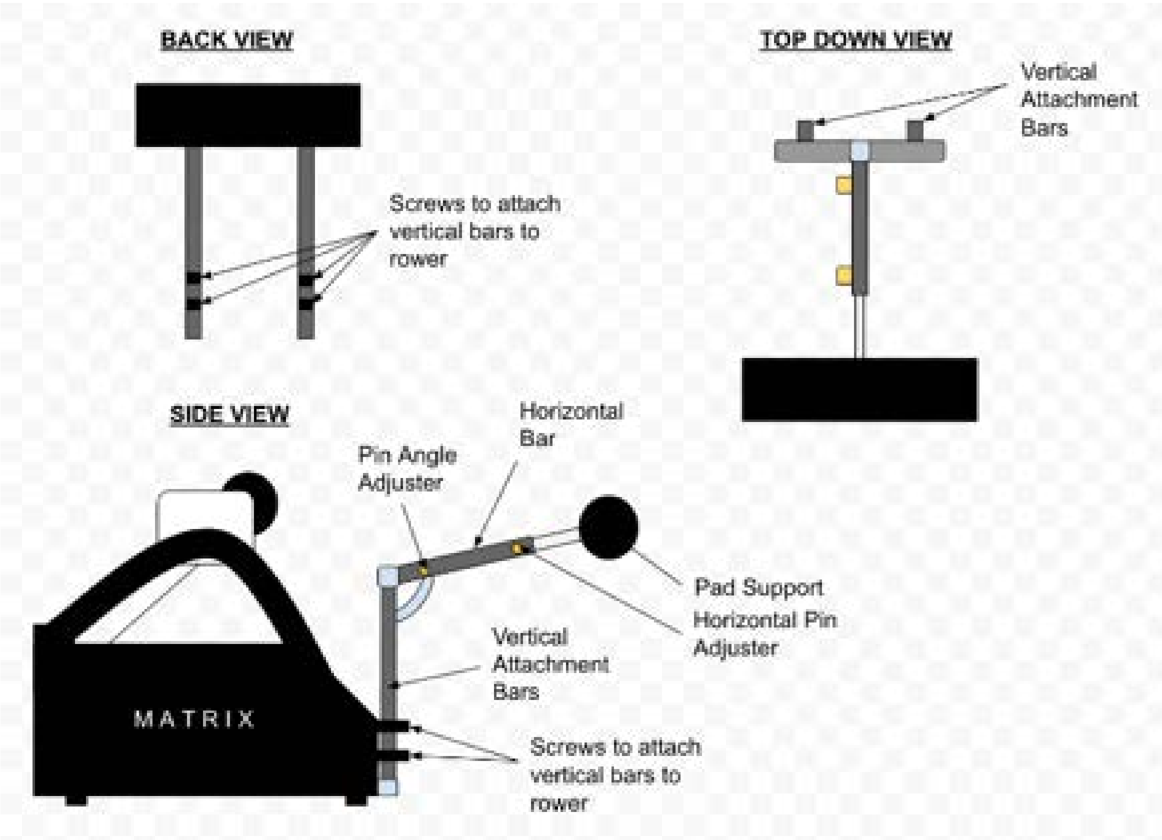
Date: 11/2/22

Content by: Sam

Present: Sam

Goals: Create third iteration of pad support

Content:

- The third iteration of the pad support is very similar to the second iteration
- However, the main difference involves the attachment style to the rower
    - This third iteration connects to the rowing machine via the screws and attachment points on the back of the rower
- The other main difference includes there being two vertical attachment bars rather than just one
    - This is so the bars can attach on both sides
- 

    - The picture shows the main adjustments from the side, top, and back views
    - As can be seen, screws will be used to secure the vertical attachment bars to the rowing machine
    - There are also now two vertical bars instead of one vertical bar
    - Also, the base board and the stabilization bars have been removed

Conclusions/action items:

The third iteration of the device includes the stabilization mechanism being attached to the rower via screws and two vertical attachment bars. This replaces the base board and stabilization bars. This willl make the attachment of the stabilization frame much more secure.

Action items: Present at show and tell. Go to JHT to fabricate this stabilization frame prototype.

Laser Permit and Red Permit Verification

SAMUEL SKIRPAN - Sep 29, 2020, 12:00 PM CDT

Title: Laser and Red Permit Verification

Content:

See attached documentation below.

Conclusions/action items:

This documentation serves as verification that I have both the Laser Permit and the Red Permit, which I obtained in the Spring of 2020.

Welding 1 Permit

SAMUEL SKIRPAN - Oct 28, 2022, 12:55 PM CDT

Title: Welding 1 Verification

Content:

See attached documentation below.

You have the following permits and upgrades:

Name	Date
Red Permit	02/11/2020
Welding 1	10/19/2022
Laser 1	02/18/2020

Conclusions/action items:

This documentation serves as verification that I have both the Welding 1 upgrade, which I obtained in the Fall of 2022.

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.

Client Meeting Questions 9/12/22

SAMUEL SKIRPAN - Sep 12, 2022, 1:08 PM CDT

Title: Client Meeting Questions

Date: 9/12/22

Content by: Sam

Present: Sam

Goals: Come up with questions for meeting with Staci.

Content:

- Do you have any general/specific feedback on our design from last semester? Any things you really liked? Any things you would like for us to change?
- For iteration of frame made out of durable metal, would JHT be able to fabricate that for us?
- Any other improvements not listed on the project description that you would like us to make over the course of this year?

Conclusions/action items:

During our meeting this afternoon with Staci, I will ask these specific questions to get her take on our design from last semester as well as some additional improvements we can make this year. Additionally, for fabrication, we will ask if JHT will be able to fabricate the support base since that will require a lot of welding/material.

Action Items: Meet with Staci and ask questions. Meet with team to complete onboarding process for adaptive rowing machine on Wednesday. Brainstorm improvements/designs for rowing machine.

Support Base Considerations 9/21/22

SAMUEL SKIRPAN - Sep 21, 2022, 12:43 PM CDT

Title: Support Base Considerations

Date: 9/21/22

Content by: Sam

Present: Sam

Goals: Note some considerations/specs that will need to be made for creation of support base/pad system.

Content:

- Considerations:
    - Best way to attach to the rowing machine
        - Idea: could potentially connect to the screws used for the support pads
        - Idea: use weight of rowing machine to rest on top of metal plate
        - Idea: create clamping system to back side of rower
    - Whether base supports are needed regarding bar-in-bar pad system
        - Originally in place to stop pad mechanism from tipping over towards where wheelchair would be located
    - If pad support will be enough to secure wheelchair in place and stop it from moving backwards. and tipping
        - Idea: potentially using gripping mat to wheel onto to provide higher friction surface

Conclusions/action items:

As we get closer to actually creating the support mechanism, I wanted to note some ideas regarding the specifics that will need to be considered before fabrication. First off, we will need to figure out an efficient way to attach the support mechanism / locking mechanism to the rowing machine. Also, will the base support bars be needed regarding the bar-in-bar design? Lastly, as a team, we will discuss whether the pad supports will be enough to stop the wheelchair from moving during the rowing motion.

Action items: Meet with team to discuss PDS. Create FBD with bar-in-bar support mechanism.

Work For Design Matrix 9/26/22

SAMUEL SKIRPAN - Sep 26, 2022, 3:27 PM CDT

Title: Work For Design Matrix

Date: 9/26/22

Content by: Sam

Present: Sam

Goals: Enter work completed on design matrix into notebook.

Content:

- Tim and I were assigned to create the design matrix for the stabilization mechanism
- For design criteria, I came up with the ideas to include safety/security, adjustability, ease of fabrication/installation, and cost
    - I weighted safety as highest, followed by adjustability, fabrication, then cost
        - The following are the descriptions that I wrote for each of these:
            - **Safety / Security:** The support mechanism prevents the user and wheelchair from tipping over backwards during use. Additionally, the user is secure and their wheelchair will not move during the rowing exercise.
            - **Ease of Fabrication:** The fabrication of the design will not be overly complicated and will only require use of fabrication methods a team member is currently skilled in / has plans to learn. Comparatively, a design that would require less intensive fabrication steps/methods would receive a higher score than a design that requires more intensive fabrication steps/methods.
            - **Adjustability:** The ability for the support mechanism to accommodate different sized wheelchairs. The mechanism should be able to fit wheelchairs that are different heights, widths, and lengths. A design that is able to accommodate a greater number of wheelchair sizes will receive a higher score.
            - **Cost:** The materials to make the mechanism fall within a $100 budget. A design that has a lower cost than others will receive a higher score.
    - Note: Tim also wanted to add ease of removal, so we switched ease of fabrication/installation to just ease of fabrication and then created another criteria called ease of installation/removal
- I wrote the majority of the description for the Bar-in-Bar Support Pad design
    - Note: Tim and I decided to combine our designs to include both vertical and horizontal adjustability, so Tim also added in a few sentences on his horizontal adjustability component
- I wrote the design description for the previous Base Stabilization Frame design as well
- I also entered the pictures for both Roxi's design and the previous design from last semester into the design matrix folder

Conclusions/action items:

Before meeting with Tim to discuss the design matrix for the support mechanism, I came up with 4 criteria to compare each design. I then discussed these with Tim and we agreed upon 5 total criteria. After entering pictures for the designs into the matrix, I wrote the design descriptions for both the Bar-in-Bar design and the Base Stabilization Frame design.

Action items: Meet with team to score designs in design matrix. Research fabrication methods for stabilization mechanism.

Design Matrix Discussion 9/28/22

SAMUEL SKIRPAN - S

Title: Design Matrix Discussion

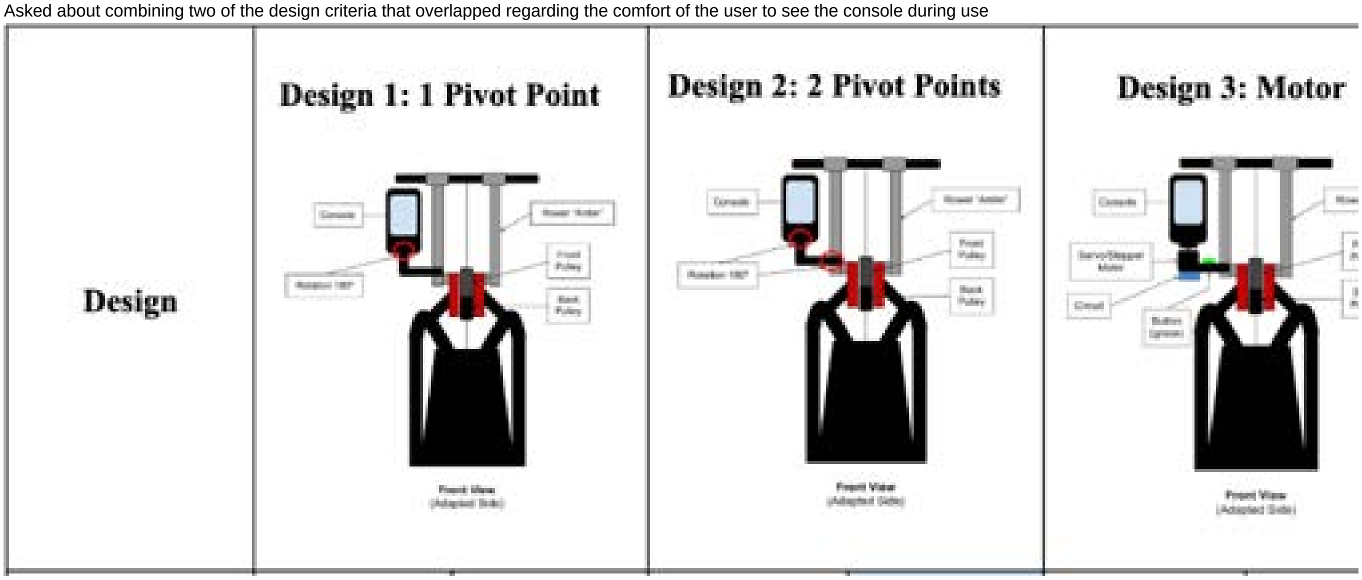
Date: 9/28/22

Content by: Sam

Present: Sam, Annabel, Josh, Roxi, Tim

Goals: Note my contributions within the Design Matrix discussions.

Content:

- For stabilization mechanism:
  - I explained the key features of the bar-in-bar design to the group
    - Noted how you could adjust it both vertically and horizontally
  - I told the team that for each design criteria, I wrote an example sentence for each
    - These examples said "A design that scores high in ___ criteria would have ___ components/functionalities"
      - I used this general methodology, but switched up the wording frequently
    - I told the team I did this so that the reader could get a better feel for why a high score was awarded for a particular design for a given criteria
- For console
  - Asked about combining two of the design criteria that overlapped regarding the comfort of the user to see the console during use
  - 

    - In my opinion, the first design would be the best design for this project since it is the most simple and still scored high on many of the other criteria listed
      - However, for our team, we would like to include some instrumentation component so that Annabel is able to use her skillset within this project
      - My only worry is that we are making a simple process complex, which will increase cost and time spent creating the console holder
- I am excited that we are going with the Bar-in-bar pad support design for the stability mechanism and just have a few worries about the design for the console holder
  - However, Annabel and Josh told me that the electric console holder should not be too complex, so I trust them with that

Conclusions/action items:

We had a very successful discussion yesterday about both design matrixes. We are going with Design 3 for the console mechanism and the Bar-in-bar pad support for the stabilization mechar working on the stabilization mechanism with Tim. Throughout the process of fabrication, we will continually look for areas that we can improve and potential additions we could make to make t

Action items: Write final design paragraph for the stability mechanism design matrix. Meet with client and advisor on Friday.

Work On Stabilization Mechanism Design Matrix Final Design 9/28/22

SAMUEL SKIRPAN - Sep 28, 2022, 1:19 PM CDT

Title: Work On Stabilization Mechanism Design Matrix Final Design

Date: 9/28/22

Content by: Sam

Present: Sam

Goals: Write opening paragraph on why we chose the winning design and then denote scoring of each stability mechanism for safety/security, ease of fabrication, and adjustability.

Content:

- Here are the paragraphs that I wrote for the final design section of the Stabilization Mechanism Design Matrix
    - The team compared the Bar-in-Bar Pad Support design to the previous Base Stabilization Frame design on the criteria of safety/security, adjustability, ease of fabrication, ease of use, cost, and integration to environment (Table 1). Overall, the Bar-in-Bar Pad Support design finished with the higher score, receiving an 84/100. This design includes both a vertical and horizontal adjustability to secure users and wheelchairs of varying sizes. A pad at the end of the horizontal support will rest against the user's thighs as they are completing the rowing exercise. The reaction force provided by the pad will prevent the user from tipping during the exercise. The user can secure themselves to the device by pulling the bar and pad down towards their lap and locking it into place with the ratchet mechanism.

      The Bar-in-Bar Pad Support design scored highest in the most heavily weighted criteria, safety/security, receiving a 5/5. This high score was awarded due to the design including a thigh pad that both prevents the user from tipping backward and from falling forward out of the wheelchair. In comparison, the Base Stabilization Frame design only prevents the wheelchair from tipping backwards during use; the design does not prevent the user from falling out of the wheelchair. For this reason, the Base Stabilization Frame design received a 3/5 for the safety/security criteria.

      Adjustability was the second highest weighted criteria. The Bar-in-Bar Pad Support design scored a 5/5 for adjustability due to being able to accommodate both different heights and arm lengths of users. This design features a pin-in-hole mechanism for vertical adjustability and a lever mechanism for horizontal adjustability. The Base Stabilization Frame received a low score of 1/5 for adjustability since the frame was unable to be adjusted. Additionally, the Base Stabilization Frame could only fit wheelchairs up to 66 cm wide due to the constraint within the base support separations. Since the Bar-in-Bar Pad Support design does not have base supports, there is no restriction for how wide a wheelchair can fit within the mechanism.

      For ease of fabrication, the Bar-in-Bar Pad Support design scored a 2/5 due to the complexity involved with creating the pin and lever adjustability mechanisms. For the pin mechanism, one smaller bar will slide within a larger bar encasement. The drilling of holes in both the larger and smaller bar add complexity to the fabrication of the design. Additionally, installing the lever mechanism to the horizontal bar for adjustability will be difficult but necessary to accommodate various arm lengths. For the Base Stabilization Frame design, there are not any fabrication complexities associated with incorporating adjustable mechanisms. Both designs will require the use of welding to connect the support segments to one another, which will add a level of complexity. Since the Base Stabilization Frame design only requires the use of welding and no other complex methods, it received a higher score of 4/5 for ease of fabrication.
- Tim was assigned to write sections on the last 3 design criteria
- We will then proofread each other's sections

Conclusions/action items:

I was assigned to write the final design description and reasoning for the stabilization design matrix. I wrote the opening paragraph on why we chose the bar-in-bar pad support design over our current base stabilization frame design. I discussed the differences in scores for safety/security, adjustability, and ease of fabrication for each design as shown in my paragraphs above. I am excited to start planning fabrication methods for the stabilization mechanism.

Action items: Meet with advisor and client on Friday. Research MIG welding methods.

Work on Preliminary Presentation 10/2/22

SAMUEL SKIRPAN - Oct 02, 2022, 2:18 PM CDT

Title: Work on Preliminary Presentation

Date: 10/22/22

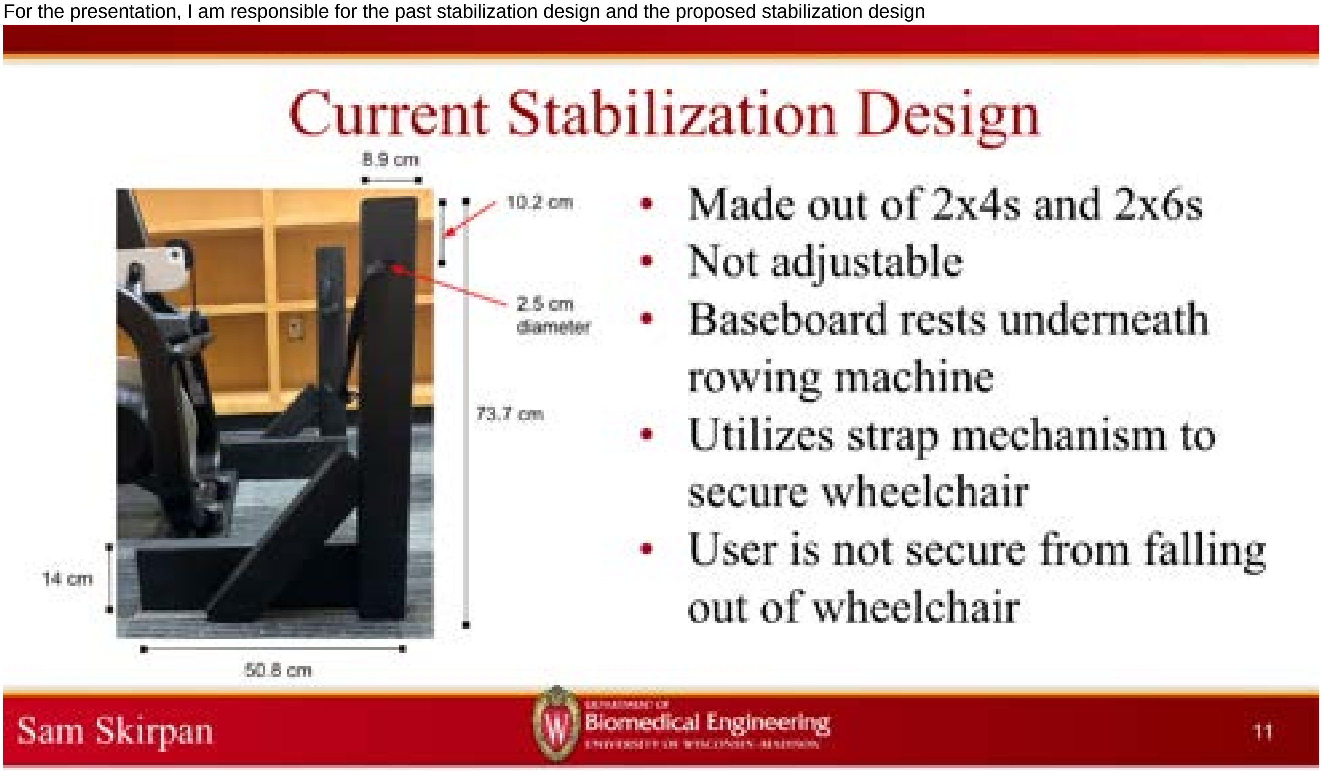
Content by: Sam

Present: Sam

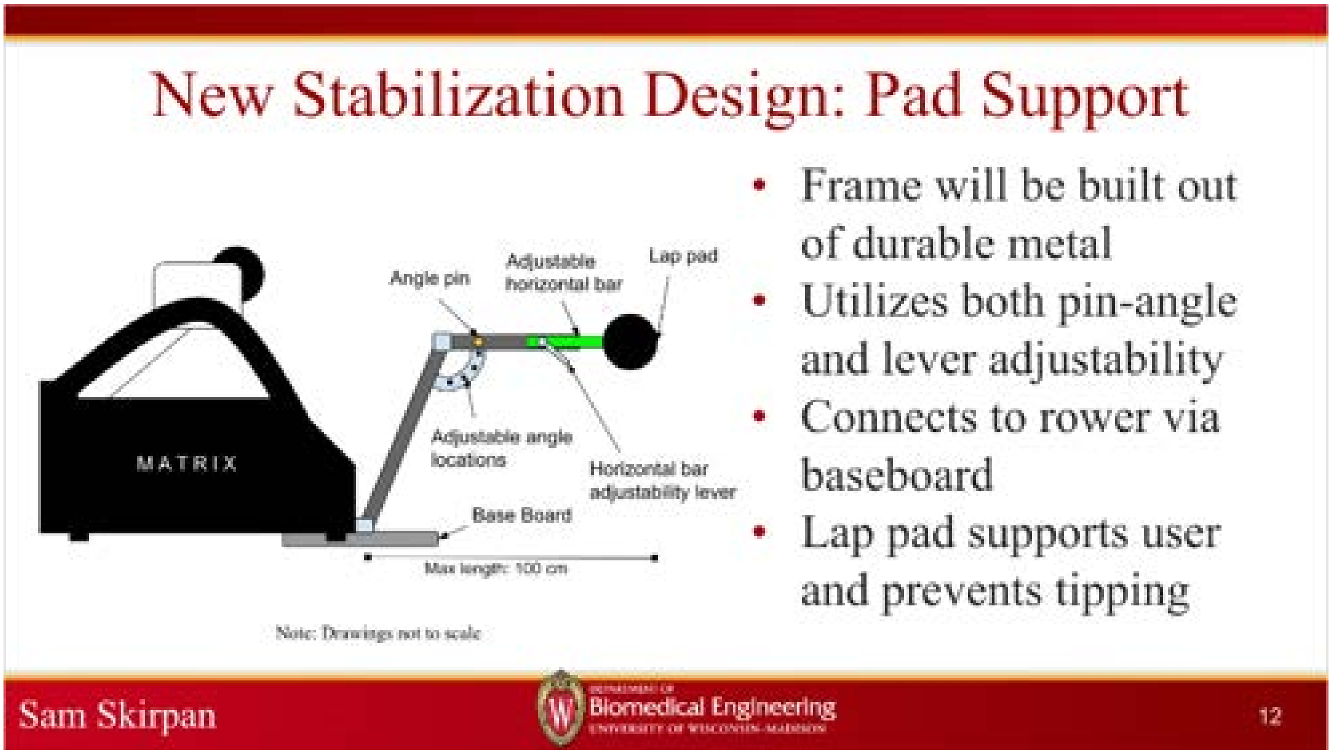
Goals: Enter work I completed for preliminary presentation into notebook.

Content:

- For the presentation, I am responsible for the past stabilization design and the proposed stabilization design



-
  - This picture is of the slide I made for the current stabilization design
  - The key points I will talk about for this slide include:
    - How the current design was made out of wood, but eventually would be made out of some durable metal
    - Was lacking in the fact that it was not adjustable for different sized wheelchairs and users
    - Connected to the rower by having a baseboard that rested underneath the rower
    - Connected to the wheelchair by use of adjustable straps on the side
    - These straps prevented the wheelchair from tipping over backwards, but there was a lot of forward and backward movement with the wheelchair when we tested it
    - Also, this design did not secure the user from falling forward out of the wheelchair, so that needs to be addressed

- 

    - This is a picture of the slide I made for the new/proposed stabilization design
    - The main things I will discuss regarding the new design include:
        - The frame will be built out of a durable metal like aluminum or stainless steel
            - These are also able to be welded using the MIG welder, which we plan on getting the upgrade for
        - Includes two ways for adjustability: vertical and horizontal
            - For the vertical adjustability, there is an pin-angle device in which you can swing the horizontal arm up and down
            - For horizontal adjustability, there is a lever which changes the length of the horizontal arm inward and outward
        - The design has a baseboard that rests underneath the rowing machine
        - The lap pad provides a downward reaction force on the user, which prevents the wheelchair from tipping backwards
            - The user will lock the wheels of their wheelchair to prevent themselves from going backwards

Conclusions/action items:

For the preliminary presentation, I am going to be responsible for presenting the stabilization current and new designs. I will address the key differences of each, such as the adjustability features. Additionally, I'll discuss how the lap pad will be both comfortable for the user as well as keeping them safe from tipping over.

Action items: Meet with team to edit preliminary presentation. Deliver preliminary presentation.

Welding 1 Canvas Quiz 10/4/22

SAMUEL SKIRPAN - Oct 04, 2022, 9:30 PM CDT

Title: Welding 1 Canvas Quiz

Date: 10/4/22

Content by: Sam

Present: Sam

Goals: Enter notes from work put in so far to get Welding 1 upgrade.

Content:

- So far, I had to both apply for the Welding 1 upgrade in addition to getting an 11/11 on the welding 1 canvas quiz.
- On my first try, I got a 10.33/11 and only missed one question partially
- On my second attempt, I got an 11/11, so I am now able to attend a seminar for the welding 1 upgrade
- Canvas quiz takeaways:
    - Important to know what the wire feeder and the power source are responsible
    - Important to know why MIG welding is efficient and effective
    - Important to know why inert gas is used in the MIG welding process
- Currently, it doesn't look like they are offering any seminars in the near future
- I will have to reach out to someone in the TEAM lab or COE shop department to ask about Tim and I being able to attend a seminar so we can get the upgrade

Conclusions/action items:

Today, I completed the canvas quiz for the welding 1 upgrade. I had to score an 11/11 on the quiz, and I did so on my second try. Now that I have completed this and applied for the permit, I have to attend a seminar, so I will have to reach out to someone from the TEAM Lab about this.

Action items: reach out to TEAM Lab about welding seminar for Tim and me. Meet with team to edit preliminary presentation.

Points to Address for Prelim Presentation Stabilization Design Slides 10/5/22

SAMUEL SKIRPAN - Oct 05, 2022, 11:34 AM CDT

Title: Points to Address for Prelim Presentation Stabilization Design Slides

Date: 10/5/22

Content by: Sam

Present: Sam

Goals: Create script/notes that I would like to address for my slides for preliminary presentation.

Content:

For current design:

- Thanks Josh. Our current stabilization design is from the previous frame we made last semester. This design was prototyped out of pine 2 by 4s and 2 by 6's, and the original goal was to fabricate it out of a durable metal. This design is also not adjustable as it only fits wheelchairs that fit within the horizontal base supports. In order for the user to secure themselves and their wheelchair to the frame, they use these adjustable straps on the side. These straps prevent the wheelchair from tipping backwards. However, testing revealed that the wheelchair still moved significantly even when the straps were attached. Additionally, testing also revealed that the user gets pulled forward out of their wheelchair with this current stabilization design. These shortcomings are a few of the main things we wanted to address with our new design.

For new design:

- Our team came up with the new Pad Support stabilization design to address many of the shortcomings of the previous design. First off, this design will eventually be made out of durable metal like aluminum or steel. Additionally, to address the adjustability of the device, there are two main components. First, we have the angle adjustability, which changes the height of the horizontal bar. Next, we have a lever on the horizontal bar that allows it to slide in and out to accommodate different reaches for users. This design has a pad at the end of the horizontal bar that rests on the users lap during use. This pad provides a downward reaction for while the user is rowing, which keeps the user from tipping over backwards. Additionally, we wanted to address the user being pulled out of their wheelchair during use, so this pad also provides a backwards reaction force that prevents the user from moving forward. This design is similar to the previous design in the way that it connects to the rowing machine.

Conclusions/action items:

Above are a few of the key points that I would like to address for each of the slides that I am presenting for the preliminary presentation. After meeting with the team today and tomorrow, I will edit this if necessary base on their comments and feedback.

Action items: meet with team to edit preliminary presentation. Deliver preliminary presentation on Friday.

Work on Preliminary Report 10/8/22

SAMUEL SKIRPAN - Oct 08, 2022, 2:41 PM CDT

Title: Work on Preliminary Report

Date: 10/8/22

Content by: Sam

Present: Sam

Goals: Enter work completed for Preliminary Report into notebook.

Content:

- For the preliminary report, I was assigned the sections of making proposed changes to the PDS document and writing about the stabilizations design sections
- For the PDS:
  - I changed the problems statement to include the following:
    - Ability of device to be used for traditional rowing
    - Keep user from being pulled out of wheelchair
  - I added in ability for stabilization mechanism to withstand 1050 N max force with safety factor of 2
  - Added in ability for user to receive 100-350 N workout per pull during their rowing exercise
- For the preliminary report, here are the paragraphs I wrote:
  - For the Base Stabilization Frame explanation:
    - The Base Stabilization Frame is the current support mechanism the Adaptive Rower uses to secure the wheelchair during the rowing exercise (Figure X). The design features a non-adjustable frame which only can accommodate a limited range of user/wheelchair sizes. To secure the wheelchair to the rower, the Base Stabilization Frame includes adjustable straps located on the vertical support bars. When attached to the front bars on the wheelchair, these straps provide a forward reaction force on the wheelchair's front bars to prevent the wheelchair from both tipping and rolling backwards during the rowing exercise. The Base Stabilization Frame includes a base board that rests underneath the rowing machine. The rubber supports on the bottom of the rower rest within divots cut out from the base board. The weight of the rowing machine resting on the base board prevents the Base Stabilization Frame from moving during use.
    - Then I added in a figure with a picture of the design:

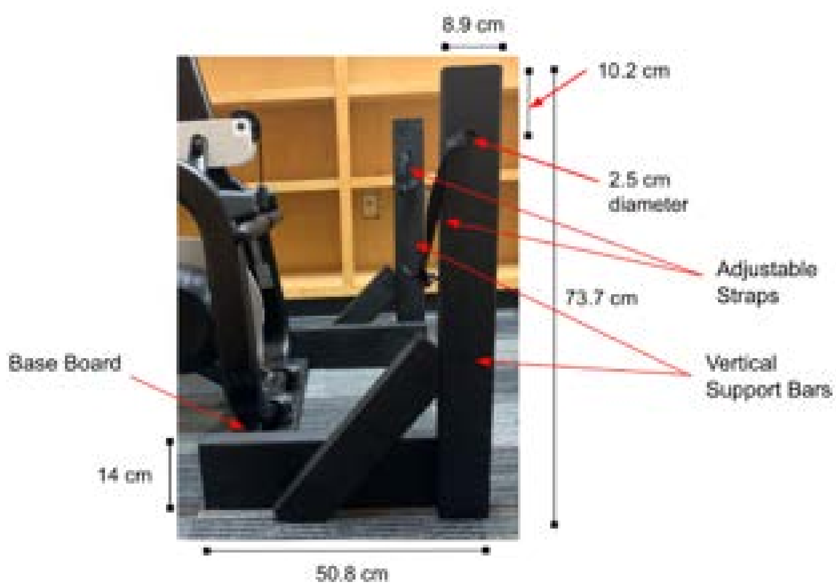
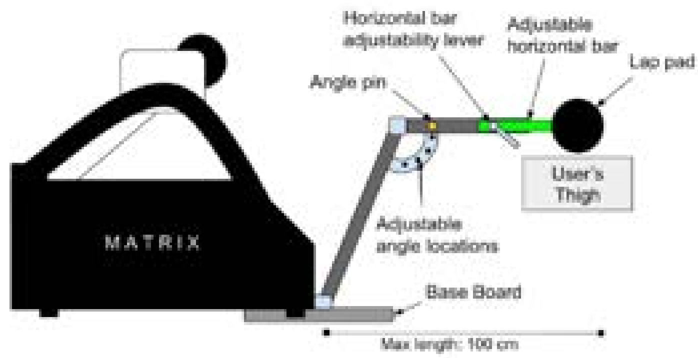


Figure X. Base Stabilization Frame. The Base Stabilization Frame prevents the user/wheelchair from tipping over backwards due to the forward reaction force provided by the adjustable straps on the front bars of the wheelchair. Since the frame is not adjustable, it can only fit a limited size range of users and wheelchairs.

-
- Here is the picture I added in to show the current design. I also created the picture caption.

  - For the pad support explanation:
    -

The Pad Support design features a pad attached at the end of a horizontal bar to secure the user and wheelchair in place during the rowing exercise (Figure X). This pad provides a downward reaction force on the user's thighs to prevent the wheelchair from tipping backwards. Additionally, the pad also provides a backward reaction force at hip during the drive portion of the rowing motion, prohibiting the user from being pulled out of the wheelchair. To accommodate for different sized users and wheelchairs, the Pad Support design includes two mechanisms for adjustability: the angle-pin mechanism and the lever mechanism. The angle-pin mechanism allows for the user to adjust the height of the horizontal bar with the pad on the end. By rotating the horizontal bar and locking the pin at various points, the Pad Support design can accommodate users/wheelchairs of varying heights. To accommodate for users with different arm lengths, a lever mechanism is incorporated into the Pad Support design to adjust the length of the horizontal bar. The horizontal bar section is made up of two separate bars, one which rests inside the other. By pressing the lever in, the position of the smaller bar within the larger bar can be adjusted to make the pad closer or further from the rower. Similar to the Base Stabilization Frame, the Pad Support design connects to the rowing machine via a base board. The supports at the base of the rowing machine will rest in cut-out grooves on the base board. With the weight of the rowing machine resting on the baseboard, the Pad Support design will be secured to the rower. This design does not intentionally secure the user from moving backwards. Rather, the prevention of backward movement would come from the user locking the wheels of their wheelchair.



*Note: Drawings not to scale

Figure X. Pad Support Design. The Pad Support design prevents the user from tipping over backwards by providing a downward reaction force on the user's thighs. The design also incorporates both angle-pin and lever adjustability mechanisms to account for different heights and reaches of users, respectively.

- Here is a picture of the picture and figure caption I added for the pad support design.

- I also was responsible for writing the paragraph for the stabilization design criteria. Here is what I wrote:

  - The stabilization frame design criteria include safety/security (30%), adjustability (25%), ease of fabrication (15%), ease of use (15%), cost (10%), and integration to environment (5%). Safety/security is the most important design criteria for the stabilization frame. The stabilization mechanism should prevent the user and wheelchair from tipping over backwards during use. While the rower is completing the drive phase of the rowing motion, the support mechanism should prevent the user from being pulled forward out of the wheelchair. Adjustability accounts for the support mechanism accommodating different sized users and wheelchairs. The mechanism should be able to fit users with varying heights, widths, and reaches. A design that accounts for more degrees of adjustability will receive a higher score.

    Ease of fabrication indicates how strenuous the fabrication process will be for a given design. Designs with less intensive fabrication methods will score higher than more complicated designs. Ease of use is determined by how easily the user can secure/detach themselves to/from the stabilization mechanism. Additionally, a design that can be adjusted with minimal effort will receive a higher score than a design that requires more effort to adjust. For the cost criteria, the materials used to construct the mechanism must fall within the $200 budget. A design that has a lower cost will receive a higher score. Lastly, the integration to environment criteria denotes how much space the design will occupy while in use. A design that occupies less space will receive a higher score

- I also added in the design matrix for the stabilization mechanism
- Lastly, I used the paragraphs Tim and I wrote on the design matrix discussion and proposed final design while making a lot of edits to make it more professional

Conclusions/action items:

For the preliminary presentation, I was responsible for fixing the PDS with edits proposed by Dr. TJ P and writing the sections on the stabilization design.

Action items: Meet with team to edit prelim report. Research materials to be used for the stabilization mechanism (lever and pad)

Editing of Preliminary Report 10/10/22

SAMUEL SKIRPAN - Oct 10, 2022, 9:43 PM CDT

Title: Editing of Preliminary Report

Date: 10/10/22

Content by: Sam

Present: Sam, Josh, Tim, Annabel, Roxi

Goals: Edit preliminary report.

Content:

- Before we met as a team to edit the preliminary report, I read through it and made some edits on my own
  - The majority of these edits were wording changes along with some grammatical edits
- Then, we met together as a team for 3 hours to edit the report in full
  - We went through section by section and addressed anyones questions along with making grammatical changes
  - I was responsible for making sure the resources aligned within the appendixes at the end of our editing session
- I helped with some of the clarification points regarding the stabilization frame since that is the section that I wrote
- I also updated some of the problem statement along with the discussion and conclusion with the team

Conclusions/action items:

Today, I read through the report to suggest edits we could make as a team. After that, we met as a team to go through everyone's suggestions and this editing took about 3 hours to get through.

Action items: Read through report one more time to make sure it is set. Complete research for pad to use.

Considerations for Staci's Design Questions 10/14/22

SAMUEL SKIRPAN - Oct 14, 2022, 11:15 AM CDT

Title: Considerations for Stacy's Design Questions

Date: 10/14/22

Content by: Sam

Present: Sam

Goals: Note ideas and considerations for questions proposed by Stacy for our preliminary design.

Content:

Below I have her questions listed out. I will note my thoughts and responses below each question.

1. Order of operation for the user; If you were in a wheelchair and rolled up to this rower, what order would you do the adjustments? This is important for evaluating the usability of the adjustments as they stand or if linkages must be designed to make them more reachable.

- I image the horizontal bar will be adjusted and then the pin-angle height adjustor will be used
    - Changing the horizontal bar first will allow for the user to get the preferred distance from the rower for their reach
    - Then they can adjust to their correct height or thigh height
    - If necessary, they can then further adjust the horizontal bar

2. What is the “not in use” position and why?; When there is no user, is the intent to have the stabilization frame straight up, folded down or sticking out? This will affect the logic for your limit switch because the limit switch needs to know that the stabilization bar is at different angles for different user heights. I do have an opinion, but I can be swayed by your decision points if you have a different opinion than me.

- Originally, I was thinking the not in use position would be upwards, but I now think it might be a better idea space wise to have it face downward
    - Not quite sure how this will affect the logic of the limit switch, but its possible the limit switch will be placed closer to the base so it will be pressed when the pad bar is all the way down
    - The user may have to flip the bar upward from its down resting position, and then bring it down on their thigh
        - This may be more difficult for the user as compared to if the resting position was in the upward direction

3. I know that the coding flowchart is not the final, but I did want to let you know that you have extra conditional blocks. The conditional block of “Limit switch depressed?” should be the only conditional block you need because from there you will know if the console needs to more 180deg or not. The other logic question I have is, are you planning on using poling or interrupt for reading the limit switch state?

- I am not very familiar with the logic related to the limit switch, but I think the only necessary question would be: Is the bar in the resting position?
    - If yes, then the console will face the traditional direction
    - If no, then the console should face the adaptive direction

Conclusions/action items:

Staci proposed these questions after we turned in our preliminary deliverables. For the resting position of the pad bar, there are downsides to both locations, but it may be easier for user if it is up in the air. Additionally, the adjustability should be as easy as possible for the user. I imagine the horizontal bar being adjusted first, and then the pin-angle changed next.

Action items: Discuss limit switch location with team. Meet with client to discuss thoughts for these questions.

Work Creating Stabilization Mechanism Gantt Chart 10/25/22

SAMUEL SKIRPAN - Oct 25, 2022, 5:43

Title: Work Creating Stabilization Mechanism Gantt Chart

Date: 10/25/22

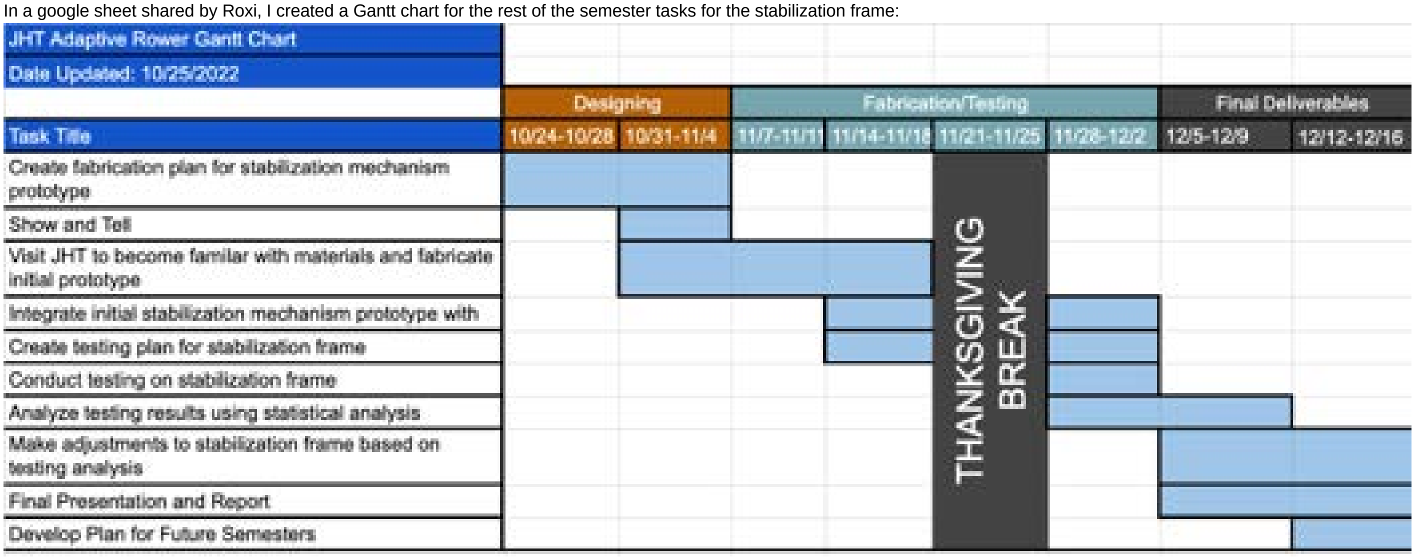
Content by: Sam

Present: Sam

Goals: Plan out rest of semester tasks for the stabilization frame.

Content:

- In a google sheet shared by Roxi, I created a Gantt chart for the rest of the semester tasks for the stabilization frame:



-
    - This is a picture of the gantt chart that I created for the stabilization mechanism
    - The main tasks on this gantt chart have to deal with the following:
        - Creating a fabrication plan
        - Going to JHT to fabricate
        - Eventually integrating all materials together with other sub-team
        - Creating and using a testing plan for the frame
        - Analyzing data
        - Making improvements after data analysis while working on final deliverables
- Our team will follow this gantt chart as a rough guideline as to when we want to complete certain tasks
    - Our goal is to finish fabrication before Thanksgiving of the stabilization prototype so we can test it whenever we get back

Conclusions/action items:

This Gantt chart that I created for the stabilization mechanism includes a set of tasks we need to complete to have the stabilization fabricated and tested before final deliverables. Our team wil to track our progress for the rest of the semester. We are hoping that when we go to JHT to fabricate that it will only take a week or two, but we have built in the possibility of it taking three wee case. Before we go to JHT, we will have a fabrication plan that will allow our efforts to be guided when we are there.

Action items: meet with team and advisor on Friday. Prepare for show and tell.

Show and Tell Ideas 11/2/22

SAMUEL SKIRPAN - Nov 02, 2022, 10:07 PM CDT

Title: Show and Tell Ideas

Date: 11/2/22

Content by: Sam

Present: Sam

Goals: Note ideas that are important to consider for show and tell.

Content:

- First want to give a short run down on the entire project
    - Potentially demo how the wheelchair user will be seated behind the rowing machine and how they will have to grab the handle bar from the antlers
    - We will have to bring the rower to our location (Tong room)
- Have one person from the antler design group discuss the progress made on the antlers and discuss how the console will rotate
    - Be able to discuss the electronics and limit switches and how the horizontal bar of the stabilization mechanism being in certain locations will cause the console to rotate a particular way
        - Discuss the purpose of the three limit switches
- Have a picture of our design of the stabilization mechanism
    - Discuss how we are going to JHT to fabricate the prototype
    - Also discuss how we will now plan on connecting the stabilization mechanism to the rower by using the screw locations on the back
- Potential questions to ask:
    - Are there any other ways you think might be efficient for attaching the stabilization frame?
    - If we were to try and create a mechanism that allowed for the resistance to be changed from the adaptive side, what would that look like?
    - With our current design, what are some potential downfalls you could see in terms of user-interaction?

Conclusions/action items:

For show and tell on Friday, we will display the progress we have made with the rower and the antlers design + electronics over the last few weeks. In addition to this, we will talk about our future plans for fabricating the stabilization mechanism at JHT. Lastly, we will have a question (which we will decide upon as a team) to ask other groups for help with our design.

Action items: confirm what question we would like to ask. Participate in show and tell. Go to JHT to fabricate stabilization frame.

Plan for Stabilization Frame Solidworks Modeling 11/7/22

SAMUEL SKIRPAN - Nov 07, 2022, 8:52 AM CST

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items:

Determining Dimensions for Stabilization Frame 11/15/22

SAMUEL SKIRPAN - Nov 15, 2022, 7:39 PM CST

Title: Determining Dimensions for Stabilization Frame

Date: 11/15/22

Content by: Sam

Present: Sam and Tim

Goals: Determine dimension of all bars for stabilization mechanism using scrap materials from the Makerspace.

Content:

- Tim and I met today at ECB for about an hour to dimension all of the bars for the stabilization mechanism
- We utilized some scrap material from the Makerspace, such as wood board, to see the determine some of the various dimensions of the stabilization frame
    - 
    - 
    - These pictures show the use of wood board to display how the horizontal bar will be extendable for users with different reaches
- We measured many of the dimensions using a tape measure
- The dimensions are as follows:

Dimensions of all bars:

- Large horizontal bar: 40 cm long
    - 3 cm width
- Small horizontal bar: 40 cm long
    - One size under 3 cm width (to be able to fit in large horizontal bar)
- Vertical bar: 68 cm long
    - 3 cm width
- Upper support bar: 40 cm long
    - 3 cm width
    - Note: screw's centers are 30 cm apart
- Lower support bar: 30 cm long
    - 3 cm width
    - Note: screw's centers are 20 cm apart
- Pad diameter: 10-15 cm
    - Note: 10 cm is used in the model for diameter

- I incorporated all of these measurements into the SolidWorks model
- Note: the only things not included in the model are the adjustability of the horizontal bar and the pin adjustability mechanism

Conclusions/action items:

Tim and I met at ECB today to finalize the measurements of the stabilization frame. I incorporated all of the new measurements into the SolidWorks model. These will be the dimensions for the bars that JHT and Staci will cut for us.

Action items: share the SolidWorks model with Staci on Friday. Develop materials list for Staci.

SolidWorks Drawings for Stabilization Frame 11/22/22

SAMUEL SKIRPAN - Nov 22, 2022, 8:46 AM CST

Title: SolidWorks Drawings for Stabilization Frame

Date: 11/22/22

Content by: Sam

Present: Sam

Goals: Create drawings for all SolidWorks pieces for stabilization frame. Also include the smaller horizontal bar in the assembly.

Content:

- Yesterday, I spent approximately 3 hours working through some technical difficulties with SolidWorks as I tried to create the full assembly and drawings for the stabilization parts.
- Eventually, I went to Engineering hall to work on one of the computers there and it worked a lot better
- My work:
    - I created drawings of each bar for the stabilization frame to label all of the lengths of bars
        - This will help JHT with the cutting process for each bar
        - I sent these drawings to Staci so she can send them to the model shop at JHT to be cut
    - I incorporated the smaller horizontal bar into the assembly
        - Now, there are both the large and small horizontal bar
            - This gives a better view of how the horizontal bars will be able to slide with respect to one another
        - There were many mating problems that occurred whenever I did this, so this took a lot of time to resolve
        - However, I was able to get it to work after about an hour or two of troubleshooting
    - I sent an email to Staci with the zip folder of the assembly, parts, and drawings together
        - I also included our plans for the fabrication of the device and waiting till next semester to build the angle adjustability part
        - I also included our plans for how we will incorporate the limit switch to the design

Conclusions/action items:

Yesterday, I worked on the SolidWorks assembly for the stabilization frame. I added the smaller horizontal bar to the assembly and also made drawings of all of the parts. Then, I created a zip of all the files and sent them to Staci so she can cut them at JHT.

Action items: pick up materials from JHT once they are ready. Create testing protocol for stabilization frame.

Work on Final Poster 12/5/22

SAMUEL SKIRPAN - Dec 05, 2022, 9:28 AM CST

Title: Work on Final Poster

Date: 12/5/22

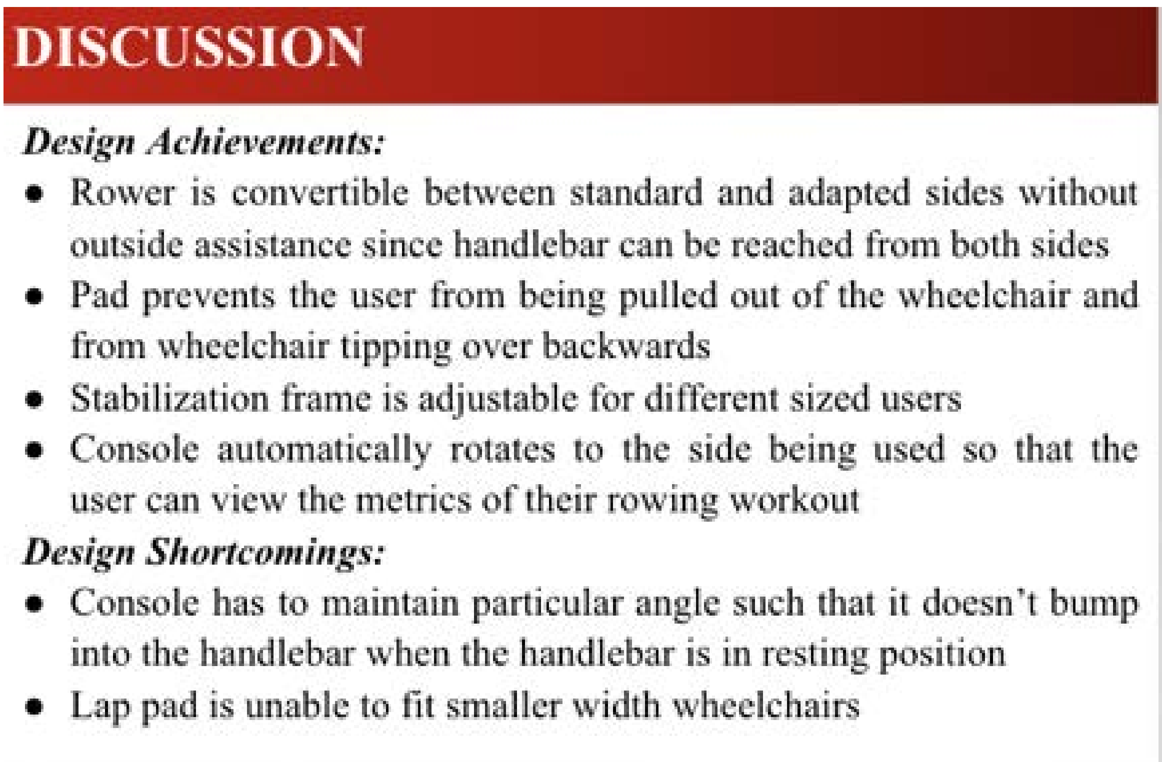
Content by: Sam

Present: Sam

Goals: Finish discussion and overall final design for poster

Content:

- For the poster, I was assigned the sections of discussion and creating a labeled image of the overall final design
- For discussion, this is what I created:



- For the pictures of the overall final design:

- 

Figure 1. Full Assembly
  - I labeled all of the relevant parts of the final design
- I had to go to ECB to capture a picture of the rower from multiple angles so I could create this slide above
- I communicated with Annabel to discuss the best possible layouts for the whole final design section
  - She used the other half to talk about the electronics and logic of the code we utilized

Conclusions/action items:

I was assigned the sections of discussion and final overalll design for the poster creation. My work is shown above.

Action items: Meet with team to edit poster. Work on Final report.

Script for Final Poster 12/8/22

SAMUEL SKIRPAN - Dec 08, 2022, 8:46 AM CST

Title: Script for Final Poster

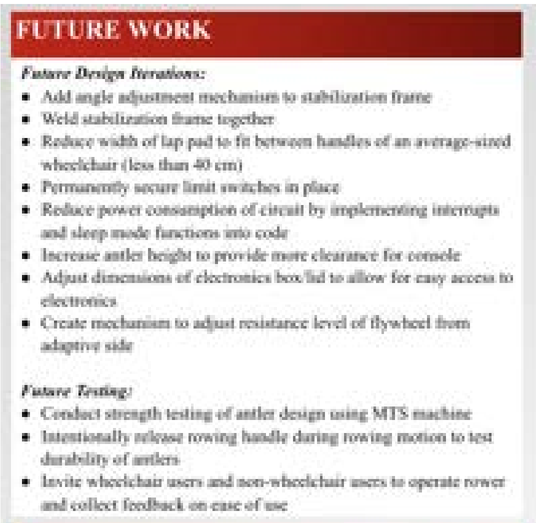
Date: 12/8/22

Content by: Sam

Present: Sam

Goals: Write notes on what I want to say for Future Work section.

Content:



- So here we have our future work, including both future design iterations and testing
- For design iterations, we plan on incorporating an angle adjustment mechanism that locks the horizontal lap pad in place at discrete angles to account for various sized users
- Additionally, we plan on welding all portions of the stabilization frame together
- To allow for smaller width wheelchairs to use the adaptive rower, we plan to decrease the width of the lap pad such that it can fit in between the arm rests of smaller wheelchairs
- The limit switches will also be permanently secured to the design rather than being place with hot glue like they are now
- We will also try to reduce power consumption of the electronics by implementing both interrupt and sleep mode functions to our code
- To allow the console to rotate freely without bumping into the handlebar, we will increase the height of both antlers to provide more clearance
- Additionally, The electronics box and lid will be adjusted to allow for easier access to the electronics
- Lastly, we will try to incorporate a mechanism that allows for the resistance of the flywheel to be adjusted from the adaptive side

- For future testing, we first plan to conduct a strength test on the antlers using an MTS machine to determine the max load they are able to withstand
- We will also conduct a test in which we remove the console and anything valualbes that could potentially be damaged and then pull the handlebar back from the rower and release it to determine the durability of the antlers

- Lastly, before completing this durability test, we will try to complete testing with actual wheelchair users in order to collect the most representative data possible

- We would like to give a special thanks to our client Ms. Staci Quam, our Advisor Dr. Tracy Jane Puccinelle, Johnson Health Tech, and a few others for their help with this project
- Thank you very much for listening and now we can open it up for any questions!

Conclusions/action items:

Here, I have outlined the thoughts I would like to mention during our poster presentation for the future work section.

Action items: rehearse this with the team today in ECB. Deliver successful poster presentation tomorrow!

Work on Final Report 12/10/22

SAMUEL SKIRPAN - Dec 10, 2022, 5:52 PM CST

Title: Work on Final Report

Date: 12/10/22

Content by: Sam

Present: Sam

Goals: Complete future work and stabilization frame fabrication parts of the final report.

Content:

- Below is the work that I put forward for the final report

Fabrication of Stabilization Frame

The stabilization frame is located on the opposite side of the rowing machine from the sliding seat. The purpose of the stabilization frame is to secure wheelchair users in place while they are rowing such that the wheelchair and user do not tip over backwards during use. Additionally, the stabilization frame prevents the user from being pulled forward out of the wheelchair due to the tension in the rope while rowing. In order to withstand the 1050 N maximum force that can develop while rowing, steel bars were used due to their high strength and durability properties [13].

Prior to sourcing materials from Johnson Health Tech, the Pad Support design from **Section III.A.b** was modeled in SolidWorks to determine the correct dimensions of each of the bars (**Figure X**). A few adjustments were made to the preliminary Pad Support design. In order to make the connection to the rowing machine more sturdy, nuts and bolts were used to attach the frame to the rowing machine instead of the base board. Additionally, the horizontal adjustment mechanism was removed for the design.

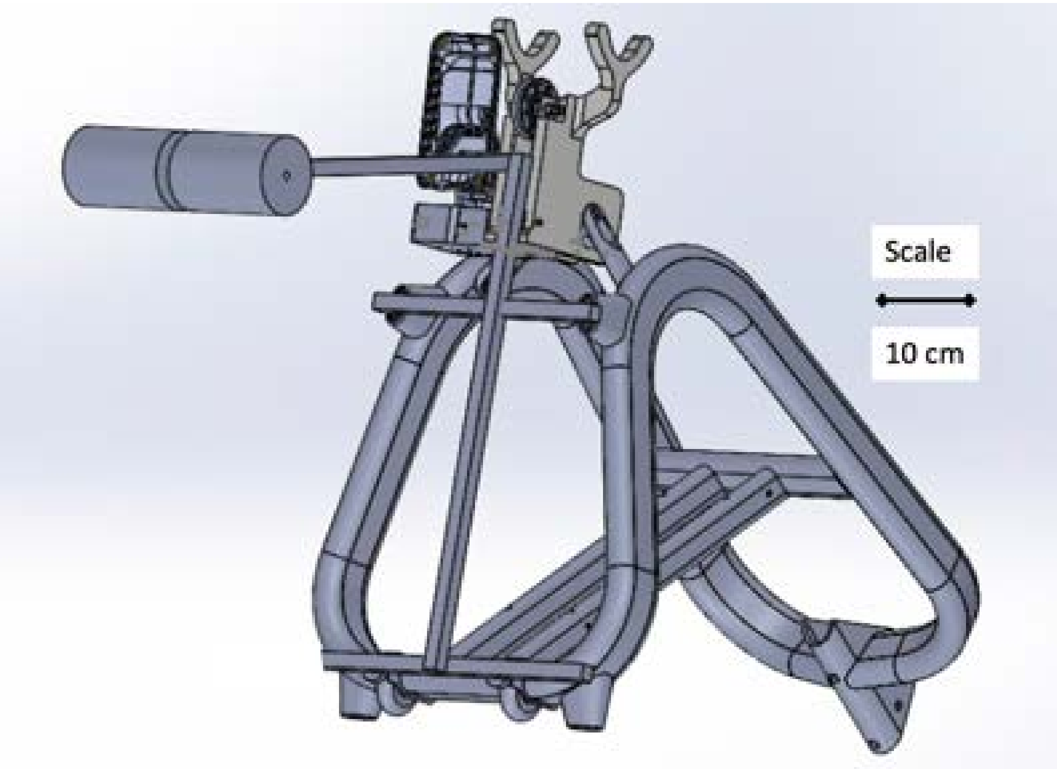


Figure X. SolidWorks Model of Stabilization Frame. Before sourcing the steel bars from Johnson Health Tech, the stabilization frame was modeled in SolidWorks to determine each bar's dimensions.

The stabilization frame includes two support bars (one 40 cm long top bar and one 30 cm long bottom bar), a vertical bar (68 cm long), a horizontal bar (40 cm long), and a pad (**Figure X)**. All bolts were tightened using a hexagon wrenchThe fabrication of the frame began with the two support bars being attached to the back side of the rowing machine. The 30 cm bottom support bar was lined up in the center of the rowing machine with the holes on the back side. Two M-5 50 mm bolts, two M-6 washers, and a M-5 hexagon wrench were used to secure the bottom support bar to the rowing machine. The same materials were used to secure the 40 cm top bar to the back side of the rowing machine. After both support bars were attached to the rowing machine, the vertical bar was incorporated. The vertical bar was aligned perpendicular to both the lower and upper support bars and was offset to the right from the centerline of the rowing machine by one hole. One M-10 nut and 80 mm bolt pair was used to attach the vertical bar to each support bar. A M-10 hexagon wrench was used to secure the bolts. One M-10 90 mm bolt was attached to the top hole of the vertical bar such that the bolt faced toward the centerline of the rowing machine. This bolt was secured using two M-10 nuts and a hexagon wrench. Three holes down from the top of the vertical bar, an L-bracket was attached such that the open section of the bracket was perpendicular to the ground and facing the centerline of the rowing machine. The L-bracket was secured using a M-10 nut and 50 mm bolt. On the side of the L-bracket that faced, the horizontal bar was attached at one end using a M-10 nut and 50 mm bolt.

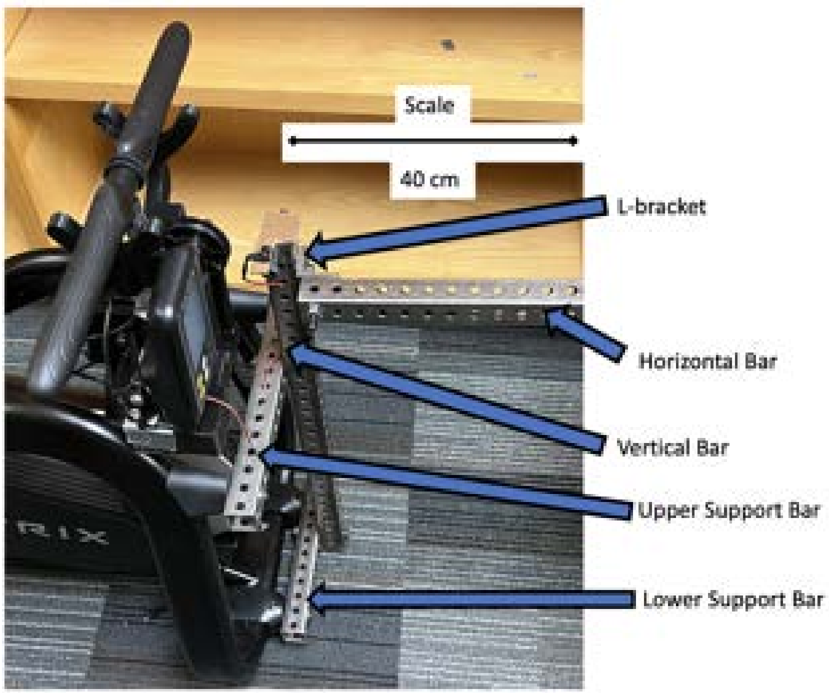


Figure X. Stabilization Frame Components. The stabilization frame is attached to the backside of the rowing machine. It is made up of two support bars, a vertical bar, and a horizontal bar.

The lap pad was secured to the open end of the horizontal bar using two smaller perforated bars and two triangular braces (**Figure X**). In order to secure the lap pad to the horizontal bar, two smaller perforated bars were first connected to the lap pad using two M-10 50 mm bolts. A 3.5 cm gap was left between the two smaller perforated bars so that the horizontal bar could fit in between. The horizontal bar was placed between the two smaller perforated bars such that it faced perpendicular to the pad. Four M-10 nut and 50 mm bolt pairs were used to secure the two triangular braces to the smaller perforated bars and the horizontal bar (one triangular brace on each side).

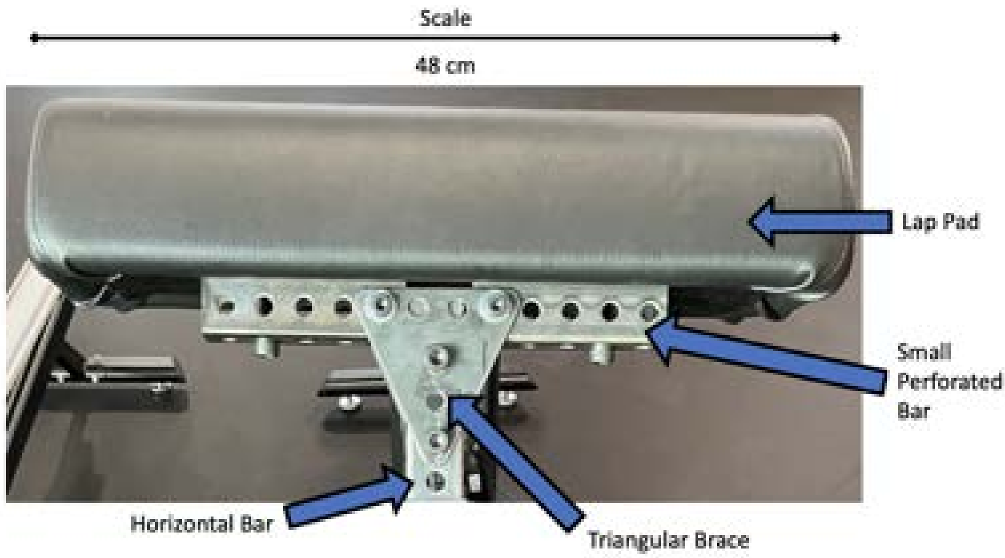


Figure X. Pad Attachment to Horizontal Bar. The pad was attached to the horizontal bar using two smaller perforated bars, two triangular braces, and M-10 nuts and bolts.

Future Work:

1. Design Iterations

For future design iterations, a few adjustments and modifications will be made to the stabilization frame. First, an angle adjustment mechanism will be incorporated between the pivot point of the vertical and horizontal bars. This mechanism will allow for the locking of the lap pad in discrete positions to secure the user and wheelchair in place during the rowing exercise. An adjustable strap will also be included to connect the stabilization frame to the wheelchair. This strap will prevent the wheelchair from moving backward while the user is rowing. Additionally, the lap pad will be cut to a smaller width such that it fits between the armrests of smaller wheelchairs. This will increase the number of users who are able to access the adaptive rowing machine. As part of the stabilization frame, a mechanism that allows for the adjustment of the resistance will be incorporated. This will allow wheelchair users to alter the resistance of the rowing machine from the adaptive side rather than having to wheel over to the traditional side. After all the necessary modifications are made to the stabilization frame, the bars of the stabilization frame will be welded together in the TEAMLab to strengthen the connections between each of the bars.

In addition to the stabilization frame, a few adjustments will be made to the 3D printed materials and electronics. The height of the antlers will be increased to make sure that the console does not bump into the handlebars when it is rotating from one side to the other. Since the MakerSpace does not have a 3D printer large enough to print these antlers in one piece, the antler design will be split up into multiple smaller pieces that can be attached to one another via screws. Additionally, the dimensions of the electronics box and lid will be adjusted such that accessing the electronic components will be easier if any modifications need to be made. In order to permanently attach the limit switches to the adaptive rower, screws will be used. Lastly, sleep and interrupt functions will be incorporated in the coding of the console rotation setup to reduce the power consumption of the electronics.

2. Testing

For future testing, a strength test of the antler design will be conducted using an MTS machine. Although SolidWorks simulations have already been conducted to determine the durability of the antlers, completing the strength test will deliver more accurate results. In addition to an MTS test, another test will be conducted to simulate a more extreme scenario for the antler design. Sometimes, rowing machine users forgot to place the handlebar in the resting position after use and let go of the handlebar. In order to test the durability of the antler design, the handlebar will be pulled back from the resting position. Then, the handlebar will be let go and will crash into the antlers. This test will reveal if the antlers are sturdy enough to endure this extreme case. Lastly, both wheelchair and non-wheelchair users will be invited to use the adaptive rowing machine from the adaptive and traditional sides, respectively. Data will be collected to determine the experience and ease of use of the participants. After analyzing this data, modifications will be made to the rowing machine to improve the user experience.

Conclusions/action items:

I was assigned the fabrication of stabilization frame and future work sections of the final report. Above is the work that I put in for each section.

Future work: meet with team to edit report.

Thoughts on Fall Semester and Plans for Spring Semester 12/12/22

SAMUEL SKIRPAN - Dec 12, 2022, 8:53 AM CST

Title: Thoughts on Fall Semester and Plans for Spring Semester

Date: 12/12/22

Content by: Sam

Present: Sam

Goals: Note thoughts on the progress we made this semester and the plans we should have for next semester.

Content:

Progress made this semester:

- Really happy that we were able to get the stabilization frame built and prove that it was successful at stopping users from tipping over backwards
  - I took the lead on the stabilization frame, so it was very nice seeing it fabricated and used successfully
- I was excited that the electronics ended up working
  - At first, I was very hesitant about including electronics in our design because I have very little background knowledge on electronics
    - However, Annabel taking point and putting a lot of time into that design made me feel more comfortable and confident that it would work properly
- Utilizing the antler design ended up working perfectly to allow for the tension to be removed from the rope to transition from the standard side to the adaptive side
- Josh did an amazing job with all of the 3D printing for all of the SolidWorks parts this semester

Plans for next semester:

- For the electronics, we will need to find a way to make sure the console is completely rotated each way when it is on the adaptive or standard side
- We will have to weld the bars of the stabilization frame together, which will probably be my job
  - I am not the greatest at welding, but I will be very happy if we can get welds that at least work well on the bars, even if they do not look the best
- Trying to build the resistance adjustor will be very difficult in my opinion
  - This is the one task that I think we will try our hardest to complete and hope that we are able to complete something
  - I hope this does not include electronics because I think that will be further complicating things
- Additionally, trying to have wheelchair users come in and use our design will also be difficult simply because it will be difficult to find them when they are available
- I am very excited to complete the outreach activity because I love working with kids and eventually want to become a teacher some day

Conclusions/action items:

I have listed out the things that I am proud of us accomplishing this semester in addition to my thoughts on the things we need to do next semester.

Action items: finish editing final report and turn it in.

Prototype Fabrication Protocol 10/27/22

SAMUEL SKIRPAN - Oct 27, 2022, 12:11 PM CDT

Title: Prototype Fabrication Protocol

Date: 10/27/22

Content by: Sam

Present: Sam

Goals: Create preliminary fabrication protocol for when we visit JHT for stabilization mechanism.

Content:

NOTE: This protocol is based on ideal conditions. Exact protocol followed will vary depending on what materials JHT has available in their shop. The protocol will be adjusted as necessary.

Fabrication Protocol

1. Create base board that will rest underneath rower
    1. The baseboard should be a rectangular piece with the capability of attaching stabilizers on each side
    2. Also should include an attachable portion for the vertical bar to be attached
2. Attach stabilizers to the base board on diagonals
3. Attach vertical bar to the base board
4. From the vertical bar, attach angle-pin adjustment mechanism that will allow for the horizontal bar to be moved up and down
5. Attach first horizontal bar to the angle-pin mechanism
6. Place bar-in-bar pin adjustability mechanism on exposed end of first horizontal bar
7. Attach second horizontal bar to the pin-adjustability mechanism
    1. The second bar should be able to slide within the first horizontal bar
8. Attach pad to the end of the second horizontal bar so that it rests underneath
    1. This pad will make contact with the user's thighs while the rowing workout is being completed

Considerations:

- Determine if baseboard is sturdy enough to hold weight of vertical bar and horizontal bars
    - If not, consider using screws to attach stabilization mechanism to the rower (which are located on the back side)
- Use screws to make all attachments of bars and perforated metal sheets
- If adjustability mechanism are unable to be used for initial fabrication, consider make the device stationary (not dynamic) for first iteration for proof of concept

Conclusions/action items:

We will follow this general fabrication protocol whenever we go to JHT to fabricate the stabilization frame. We do not yet know what materials and tools they have available, so we will adjust the protocol once we actually get there to the capabilities they have available. We will also need to consider whether the base board will be sufficient for securing the frame, or if we will need to use screws to attach to the rowing machine.

Action items: prepare for show and tell. Go to JHT to fabricate stabilization mechanism.

Stabilization Frame Preliminary Fabrication Protocol 11/4/22

SAMUEL SKIRPAN - Nov 05, 2022, 9:46 AM CDT

Title: Stabilization Frame Preliminary Fabrication Protocol

Date: 11/4/22

Content by: Sam

Present: Sam

Goals: Create fabrication protocol for stabilization frame that we created at JHT.

Content:

Fabrication Protocol

1. Mount two horizontal base bars to attachment points on backside of rowing machine
    1. Use 5 mm screws (4 total) and nuts (4 total)
    2. If necessary, use 5 mm washers
    3. Horizontal base bars = approximately 30-40 cm
2. Mount vertical bar to right side of both horizontal base bars
    1. Vertical bar = approximately 60 cm
    2. Use 6 mm screws (2 total) and nuts (2 total)
    3. Use 6 mm washers
3. Mount horizontal extension bar on to vertical bar such that it comes directly out towards adaptive side
    1. Horizontal extension bar = approximately 20 cm
    2. Use one 10 mm screw and nut
4. From horizontal extension bar, mount centering bar to so that it reaches toward midline of rowing machine
    1. Centering bar = approximately 20 cm
    2. Use one 10 mm screw and nut
5. From centering bar, mount large horizontal bar so that it comes directly out towards adaptive side
    1. Large horizontal bar = approximately 30 cm
    2. Use one 10 mm screw and nut
6. Inside of large horizontal bar, place small horizontal bar so that it is able to slide forwards and backwards. To lock the small horizontal bar in place, use pin mechanism for adjustment of small horizontal bar within the large horizontal bar.
    1. Small horizontal bar will be smaller gauge than large horizontal bar
7. At end of small horizontal bar, attach pad

Conclusions/action items:

This entry includes the fabrication protocol for the stabilization mechanism we made at JHT yesterday. For the last step, we were unable to use an actual pad. However, Staci said that she will be able to get us one in the future.

Action items: Model stabilization frame in SolidWorks.

SOLIDWORKS Modeling of Stabilization Frame 11/9/22

SAMUEL SKIRPAN - Nov 09, 2022, 10:12 PM CST

Title: SOLIDWORKS Modeling of Stabilization Frame

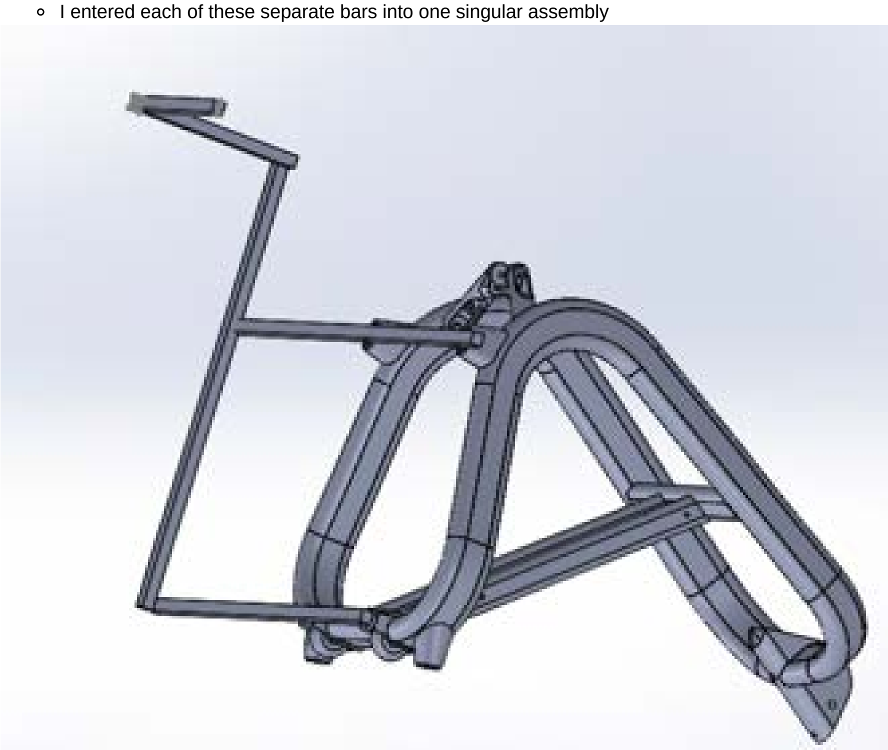
Date: 11/9/22

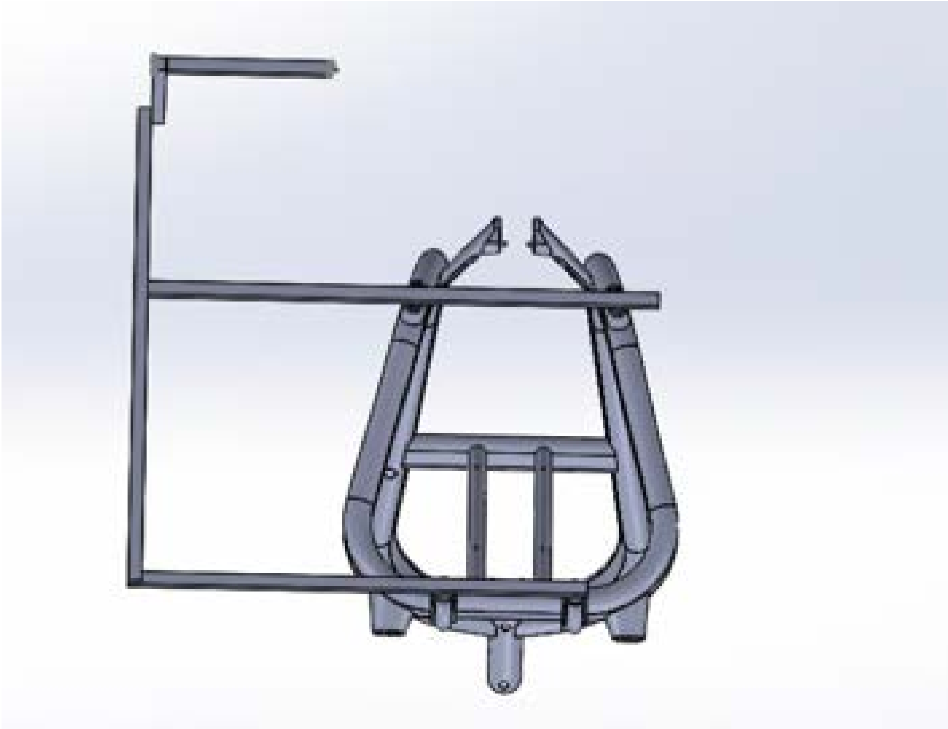
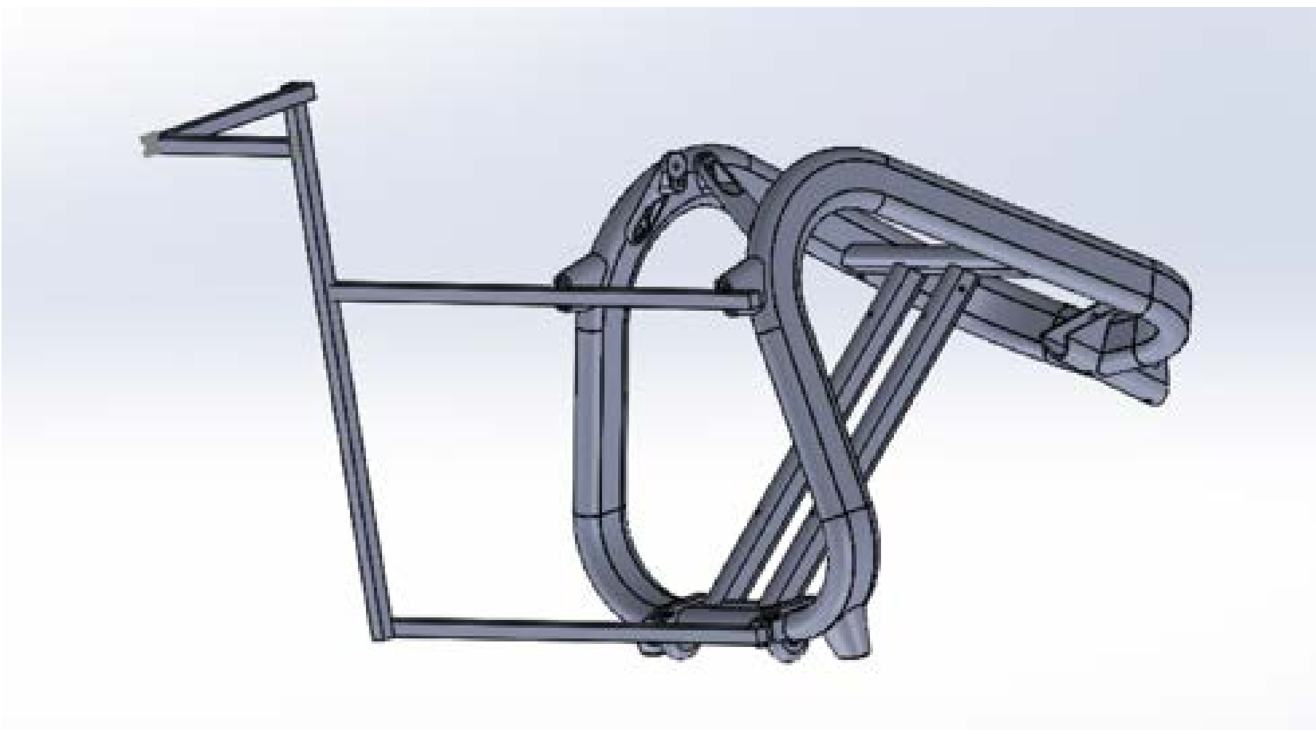
Content by: Sam

Present: Sam

Goals: Model part of stabilization frame in SolidWorks.

Content:

- I am not the best at SolidWorks, but I tried very hard to make a similar representation of what we made at JHT in SolidWorks
- The work that I have completed this far has gotten to horizontal extension bar
  - I will finish the rest of the model this upcoming week
- First, I had to create many different length bars to attach the assembly that Staci sent to us
  - For each of these bars, I made them 20 mm by 20 mm in terms of width and height
    - They are various lengths
  - I entered each of these separate bars into one singular assembly
- 
  - Here is a picture from the front left of the rowing machine
    - The two base bars can be seen here in addition to the vertical bar and horizontal attachment bar
-
  - I mated the rectangular bars together using the mating feature in SolidWorks

- 
- 

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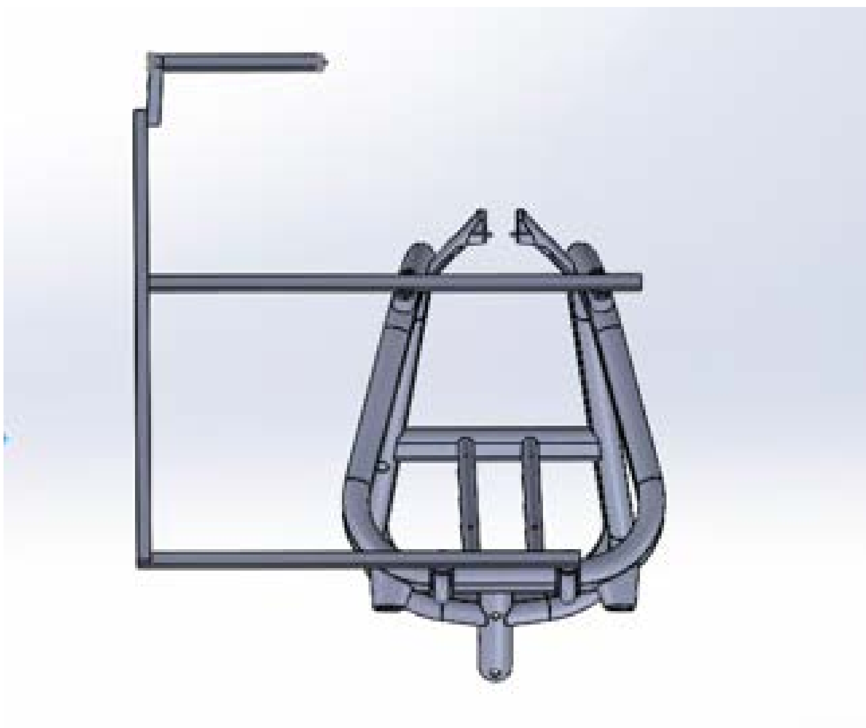


-
- Included, here I added many different angles of the work that I did in SolidWorks
- Overall, this work took me multiple hours due to my lacking skills in SolidWorks, but I definitely got a lot better as time went on

Conclusions/action items:

I started to model the stabilization frame in SolidWorks that we built at JHT. I am not the best at SolidWorks, but I got a lot better putting this model together. There is still work that needs to be done, in terms of adding the pad. The pictures above show different angles of the model that I created. We will use this model to get actual dimensions to eventually send to Staci.

Action item: share this model with the team and advisor. Finish the rest of the model.

SOLIDWORKS Modeling of Between the Legs Pad Support 11/13/22

SAMUEL SKIRPAN - Nov 13, 2022, 6:25 PM CST

Title: SOLIDWORKS Modeling of Between the Legs Pad Support

Date: 11/13/22

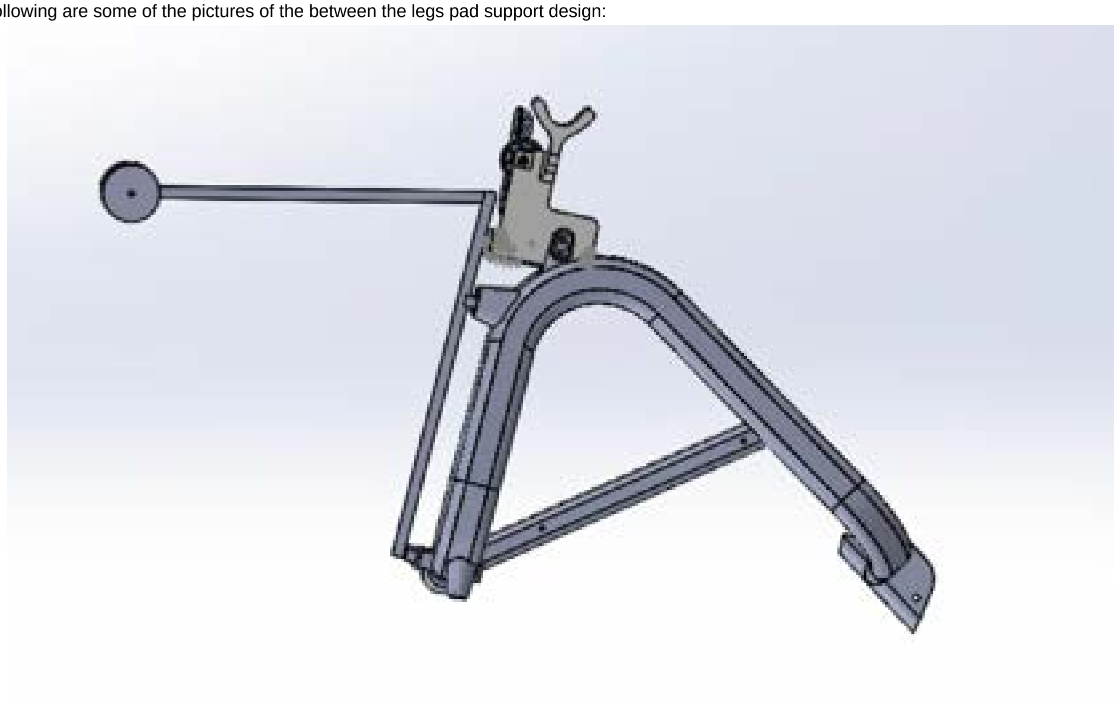
Content by: Sam

Present: Sam

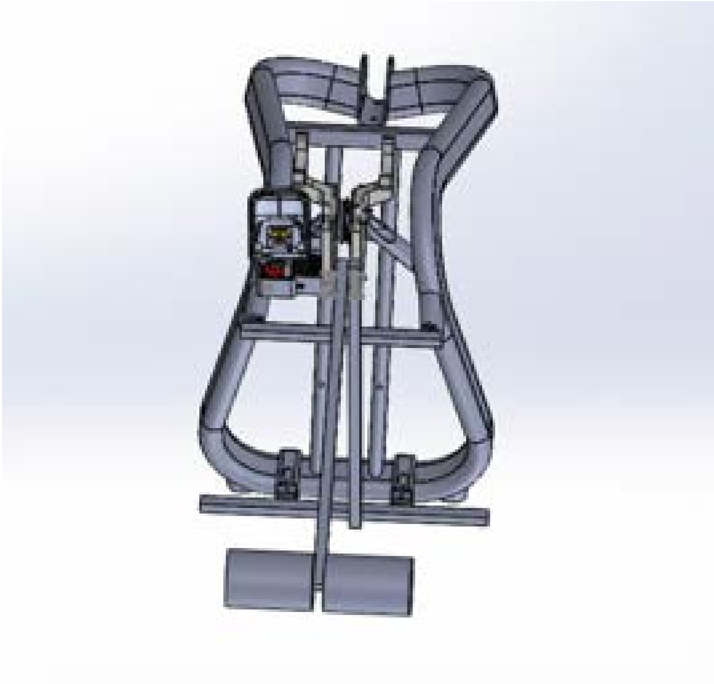
Goals: Model the between the legs pad support design in SolidWorks.

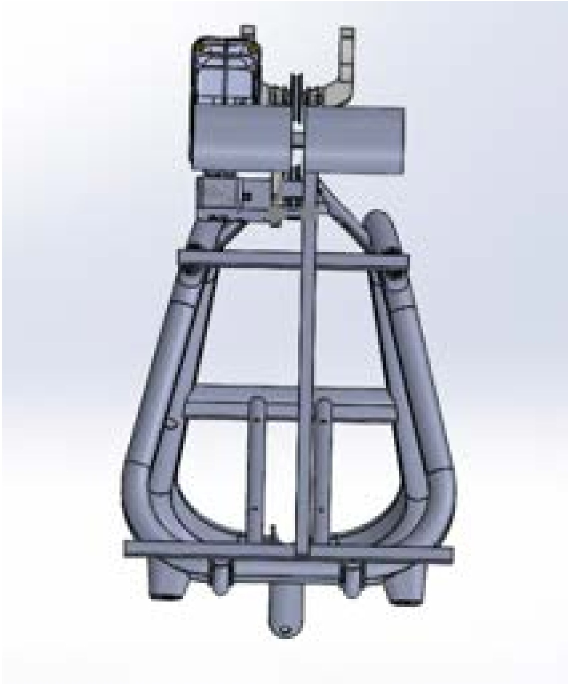
Content:

- After meeting with the team on Thursday and our advisor, we decided the want to try the between the legs pad support design
  - The other design that we created at JHT was very complex in terms of the orientation and geometries of the various bar
  - The between the legs design is much more straightforward and is what we ORIGINALLY were planning on doing
- One of the key edits made to make this design possible was the increasing the height of the second pulley within Josh's model
  - This allows for the vertical bar to be a little taller, so we can try to maintain downward leverage on the user's thighs for safety purposes and stability
- I spent multiple hours modeling the simpler design in SolidWorks and also included a pad to show how the pad looks with the design
- I also made the design able to rotate, like it will when the user brings the pad down on their thighs
  - The following are some of the pictures of the between the legs pad support design:

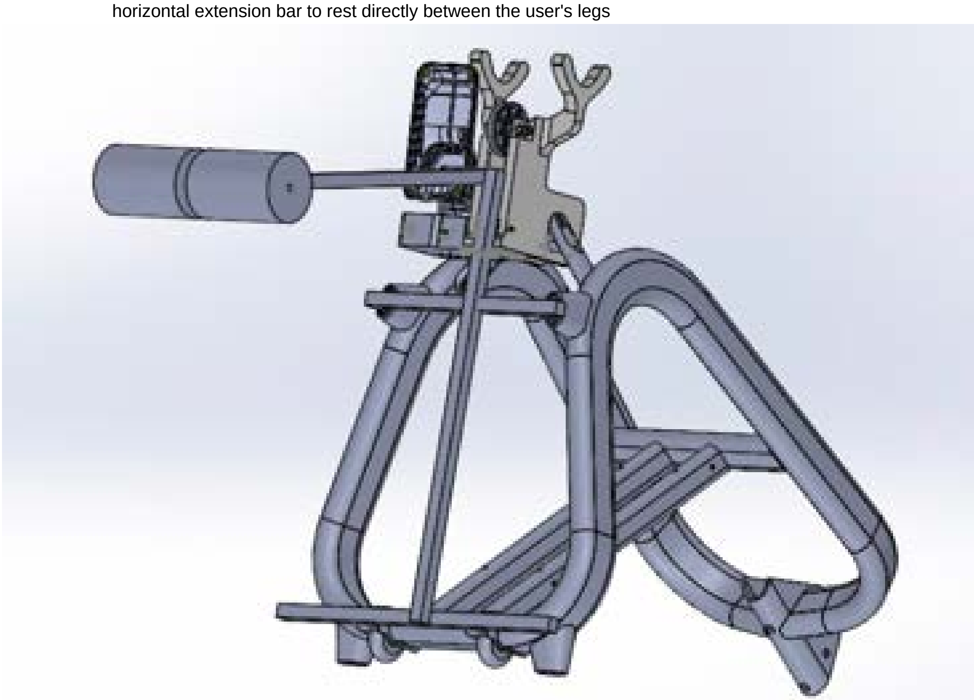


    - This is a view from the right side of the stabilization frame

- 
  - This is a top view of the design
- 
  - This is a view from the left side of the stabilization frame



- This is a front view of the stabilization frame
  - As can be seen in this picture, the vertical bar is placed away from the center line of the rower to allow for the horizontal extension bar to rest directly between the user's legs



- This is an overall picture of the design from a diagonal view
  - The horizontal bar that holds the pad (cylinder) will be able to rotate upward and downward

- Note: the pin adjustability mechanism is not included in this design, but will be whenever we fabricate
- The pad support piece of this stabilization mechanism will utilize two separate pads, similar to a few of Matrix's existing machines

Conclusions/action items:

I spent multiple hours today working on the stabilization design that we originally discussed in SolidWorks. This design is the original pad support design, and has the horizontal bar in between the user's legs. The pads were modeled using cylinders. The horizontal bar rotates upward and downward.

Action items: Discuss this model with Staci during this week's check in. Share model with Team.

Final Stabilization Frame Protocol for Assembly at JHT 11/30/22

SAMUEL SKIRPAN - Nov 30, 2022, 10:05 PM CST

Title: Final Stabilization Frame Protocol for Assembly at JHT

Date: 11/30/22

Content by: Sam

Present: Sam

Goals: Create finalized fabrication protocol for stabilization frame.

Content:

Below is the fabrication protocol created for the stabilization frame.

Fabrication Protocol To Connect Pad to Smaller Horizontal Bar

1. Connect two smaller perforated bars to holes within the semi-circular pad using two M-10 bolts that are 50 mm long. Leave 3-4 cm gap between both bars so that the smaller horizontal bar can fit between. Tighten bolts using M-10 hexagon wrench.
2. Place the smaller horizontal bar between the two smaller perforated bars so that it faces perpendicular to the pad. Secure the smaller horizontal bar to both smaller perforated bars with the triangular brace. Secure one triangular brace using 4 M-10 50 mm bolts and 4 M-10 nuts on each side. For the two bolts that attach to the two smaller perforated bars, use two M-6 washers (one on each smaller perforated bar). Tighten the bolts using a M-10 hexagon wrench.

Picture of pad attachment:

Fabrication Protocol for Overall Stabilization Frame

1. Place the lower support bar on the back of the rowing machine so it's holes overlap with the connection points on the lower part of the rower. Using two M-5 50 mm bolts and two M-6 washers, attach the lower support bar to the back of the rowing machine (one bolt and washer on each side). Tighten the bolts using a M-5 hexagon wrench.
2. Place the upper support bar on the back of the rowing machine so it's holes overlap with the connection points on the upper part of the rower. Using two M-5 50 mm bolts and two M-6 washers, attach the upper support bar to the back of the rowing machine (one bolt and washer on each side). Tighten the bolts using a M-5 hexagon wrench.
3. Place the vertical bar so that it is aligned perpendicular to both the lower and upper support bars. Offset the vertical bar one set of holes to the right from the center of the rowing machine (so that it is aligned on the right side of the

rowing machine). Use two M-10 80 mm bolts and two M-10 nuts to secure the vertical bar to both the lower and upper support bars. The base of the vertical bar should align with the bottom of the lower support bar. Tighten the bolts using a M-10 hexagon wrench.

4. 3 holes down from the top of the vertical bar, connect one L bracket to the back side of the vertical bar such that the other section of the L bracket is perpendicular to the floor and facing the centerline of the rower. Secure the one side of the L bracket using one M-10 50 mm bolt and one M-10 nut. Tighten the bolt using a M-10 hexagon wrench.
5. Attach one M-10 90 mm bolt to the top hole of the vertical bar such that bolt hangs out towards the centerline of the rower by about 3-4 cm. Use two M-10 nuts to connect the bolt to the vertical bar (one on the inside of the bar and one on the outside of the bar)
6. On the part of the L bracket that is facing towards the centerline of the rower, attach the large horizontal bar at the second hole from the end of the bar. Secure the larger horizontal bar to the L bracket using one M-10 50 mm bolt and one M-10 nut. The large horizontal bar should be tightened using a M-10 hexagon wrench, but not too tight since it should be able to rotate.
7. Place the open end of the smaller horizontal bar (the smaller horizontal bar has the pad attached at one end) in the open end of the larger horizontal bar. Use the JHT pin to lock both horizontal bars within one another.

Picture of full stabilization frame:

Conclusions/action items:

This is the fabrication protocol we followed for the fabrication of the stabilization frame and the pad connection.

Action items: create fabrication protocol for the limit switch incorporation.

Senior Outreach Seminar 9/23/22

SAMUEL SKIRPAN - Sep 23, 2022, 1:13 PM CDT

Title: Senior Outreach Seminar

Date: 9/23/22

Content by: Sam

Present: Senior BME Class

Goals: Take notes for BME outreach seminar.

Content:

- Started off talking about why we should do BME outreach
    - Encourage underrepresented groups to learn about engineering
- Talked about why diversity is important in engineering
    - Makes better teams for problem solving
    - Want to be inclusive for design concepts reaching all backgrounds
- Idea: having our outreach be about inclusive exercise equipment
- Lessons learned:
    - Be organized and plan in advance
    - Talk with teacher before doing it
    - Practice your presentation before
    - Arrive extra early to allow plenty of time to set up
- With our outreach, we want to try to conduct it at underrepresented minority groups
    - If we find population of students greater than 30%, UW will pay for our supplies
- TODO: submit a paragraph proposal for outreach materials and funds
    - Need to include table of materials and costs
- Boys and Girls Club
- Outreach requirements:
    - Deliverables:
        - Presentation
            - 10 minutes of introductions, define BME, and activity
        - Activity
            - 20-40 minutes of FUN hands-on activity
            - Must have clear learning objectives (4-5)
        - Report
            - Details date, students, percent underrepresented, how it went
                - Check online for this
            - Include pictures

            - Need photo release form if you include faces
            - Or pictures where you can't identify the child
        - Teacher/leader evaluation form
- We will submit everything online
    - Follow direction slisted
    - Activity guide due date: Dec 14, 2022
    - Final outreach deliverables due date: April 21, 2023
- OR can be a mentor!
- Once we think we know what to do, we should set up a meeting with Tracy
- Order:
    - Describe biomedical engineering with lots of pictures
    - Talk about our life as a student and as a biomedical engineer
    - Then get into background material on activity
    - Then have activity steps
    - Then have post-activity discussion
        - Problems with communication

Conclusions/action items:

Today, we listened to Dr. TP talk about the senior outreach requirements and the dates for activities. Also, we made water balloon helmets to represent the impact on a brain during a concussion.

9.27.22 Anthropometric Data

Tim TRAN - Sep 27, 2022, 8:36 PM CDT

Title: Anthropometric Data

Date: 9.27.22

Content by: Tim

Present: Tim

Goals: Present findings about anthropometric data.

Content:

According to anthropometric data for U.S adults from 2020, the 95th percentile for hip height for men was 38.78 inches.

Taking this number into account, and remembering the safe hypotenuse research from the lap support entry, the lap supports the team designs must be adjustable enough to prevent breaking the safety hypotenuse.

To ensure coverage of the majority of users, the team will add an extra 30% to the hip height number provided by the data. (49.114 inches = 124.75 cm)

Conclusions/action items:

The team now has a number to work around when determining dimensions for the stability support

Tim TRAN - Sep 27, 2022, 8:29 PM CDT

Download

Anthropometry-Summary-Table-2020.pdf (631 kB)

Linear Actuators

Tim TRAN - Sep 16, 2022, 2:58 AM CDT

Title: Linear Actuators

Date: 9//16/22

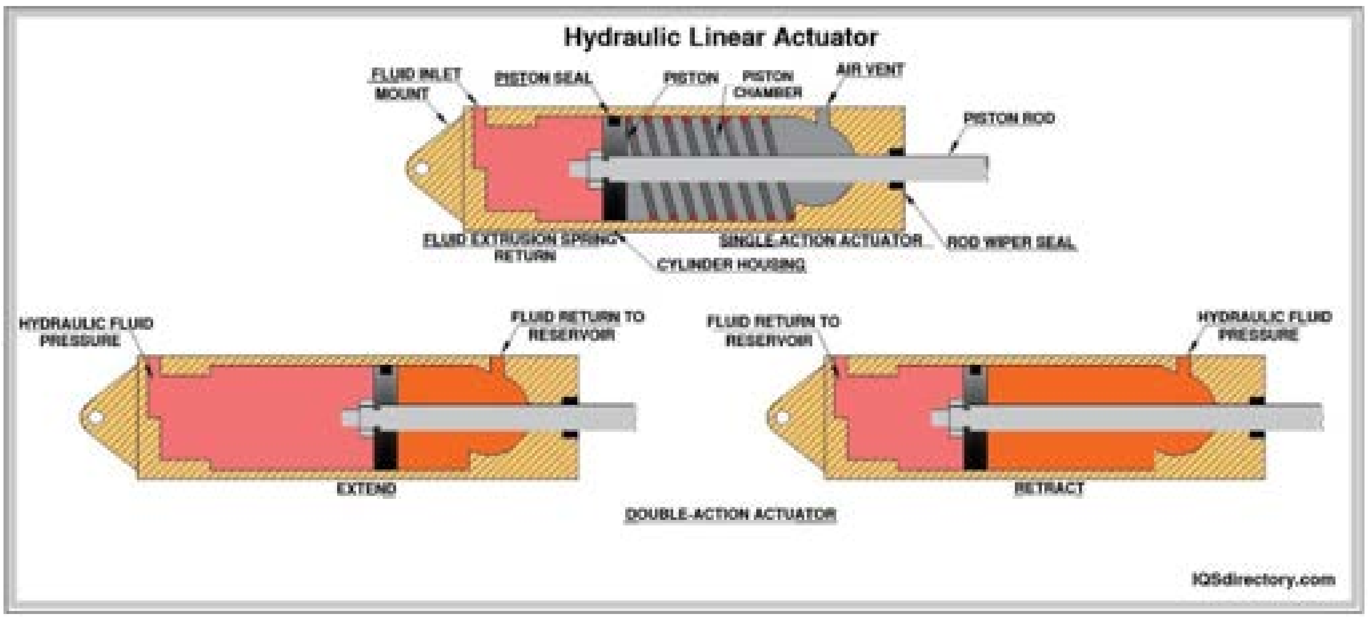
Content by: Tim

Present: Tim

Goals: Familiarize myself with linear actuators and how they work

Content:

- Converts rotational motion into linear motion
  - safe and clean motion control
- Use DC or AC motor
  - series of gears and lead screw to push the main rod shaft
  - motor sizes range from 12v DC to 48v DC
- Static and dynamic loads
- Types
  - mechanical actuators
    - rotational motion into linear motion
  - Hydraulic actuators
    - cylinders with a piston that uses incompressible liquid to produce pressure gradient --> linear displacement



- Types continued
  - Pneumatic actuators
    - uses compressed air to generate linear motion
    - low to medium force
  - Piezoelectric actuators
  - Coiled actuators
    - employ the use of magnets to produce a current that moves a coil which in turn causes motion in the shaft.
    - more current = more force
  - Electromechanical
    - programable force and motion
- Maintaining life span of actuator
  - minimize side load - actuators are meant to push and pull, so it is weaker when resisting shear stress, Internal friction will wear out the internal components

    - applying the correct voltage
    - using the appropriate actuator for the amount of force
- Things to consider when choosing actuators
    - energy availability
    - level of precision
    - force required
    - movement
        - actuators have a different stroke length
        - must measure how much movement is required to remove adequate tension from the rope.
    - Mounting
    - Space
        - telescoping actuators can fit in tight spaces

“Linear Actuator: What Is It? How Does It Work? Types Of.” https://www.iqsdirectory.com/articles/linear-actuator.html (accessed Sep. 16, 2022).

Conclusions/action items:

After researching linear actuators, they seem like a plausible solution to removing the rope tension without outside assistance. Electrical-mechanical actuators sound the most useful for our problem, as their force can be programmed. While transitioning the rope from the adaptive side to the standard side and vice versa, the team noticed that the force applied is different going from one side to the other.

The next steps will be to brainstorm possible mounting orientations of the linear actuator, as well as measure the distance and force needed to remove tension allowing the rope to be transitioned easily.

9.24.22 Roller Coaster Lap Support Mechanisms / Safety

Tim TRAN - Sep 24, 2022, 3:35 PM CDT

Title: Roller Coaster Lap Support Mechanisms

Date: 9.24.22

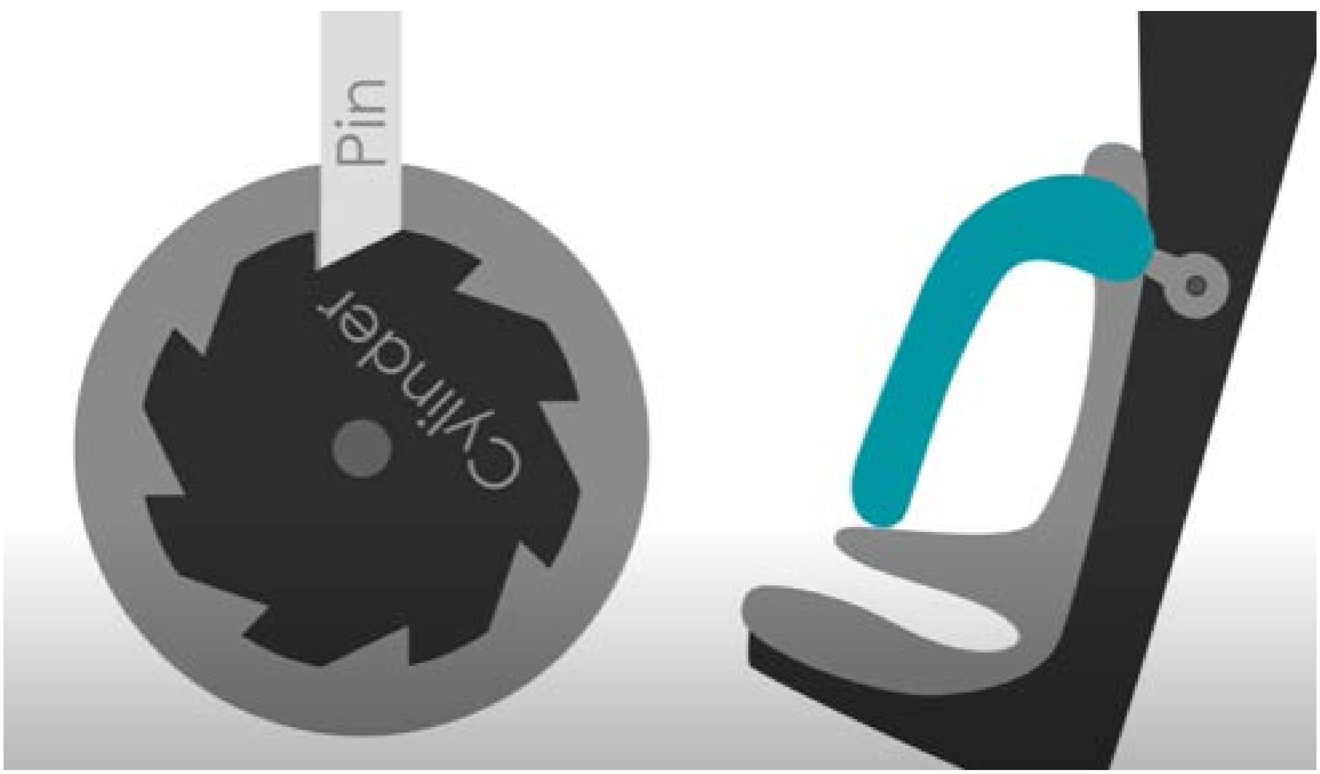
Content by: Tim

Present: Tim

Goals: Present key points about the mechanisms behind lap supports used in roller coasters to apply to the lap support design for the adapted rower.

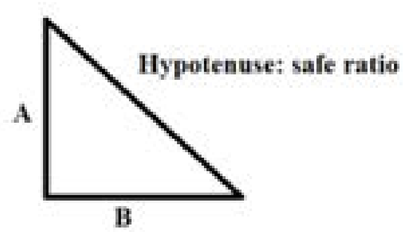
Content:

- 2 main categories of restraint mechanisms
  - Ratchet
  - Hydraulic
- Ratchet mechanism
  - Composed of serrated gear and a pin (prawl)
  - The gear is fabricated in such a way that the pin only allows the gear to rotate in one direction. If the gear is rotated in the opposite direction, the pin hits the wall of the serrated gear and locks the gear into place.
    - The gear is rotated as the roller coaster restraint is lowered into its orientation and is locked into place once the rider is comfortable with the fit.
  - To release the restraint, a lever, typically activated by the operator's foot, lifts the pin to allow the gear to rotate in the opposite direction
  - Backlash
    - because the backward rotation of the gear is restricted through the contact of the pin and the back wall of the gear, there will be some wiggle room or "play" that the restraint/lap support arm will have.
    - the maximum amount of distance / largest angle of rotation prior to resistance
    - Dependant on the spacing of the teeth in the gears
  - Limited adjustability
    - Ratchet mechanisms have a finite number of orientations
      - limited by the number of teeth in the gear and the spacing of such teeth



- Considering if a lap restraint is safe to use

- The safe hypotenuse
    - measurement A = height of lap bar from the seat
    - measurement B = distance between lap bar and back of the seat
    - if the hypotenuse created between these two measurements is greater than the length of a person's straightened legs, the person is no longer safely secured by the lap bar



[1] C. M. Staff, “All About Ratchets.” https://www.creativemechanisms.com/blog/all-about-ratchets-design-and-engineering-firm (accessed Sep. 24, 2022).
[2] A. D. Kaplan and P. A. Hancock, “Design of a Roller Coaster Restraint System to Make Lap Bar Restraints More Inclusive for People with Lower-Body Limb Differences,” p. 7.
[3] *Roller Coaster Restraints: Explained*, (Sep. 15, 2019). Accessed: Sep. 24, 2022. [Online Video]. Available: https://www.youtube.com/watch?v=oFsLdM7miUc

Conclusions/action items:

After researching how roller coaster restraints function, I have concluded that implementing a ratchet mechanism to the lap support bar would be easy and allow an element of adjustability to the lap support bar.

The next steps would be to

9.24.22 Lap Support Material Ideas / Research

Tim TRAN - Sep 24, 2022, 3:11 PM CDT

Title: Lap Support Material Ideas / Research

Date: 9.24.22

Content by: Tim

Present: Tim

Goals: Present ideas and research on possible materials for the lap support bar

Content:

Taking inspiration from a similar production AROW, their lap bar is constructed out of 80 20, which are aluminum bars that are modular and can be connected to each other via brackets, eliminating the need for welding. 80 20 have "tracks" in the bars which could allow the team to implement a locking lever mechanism to adjust the length of the support bar.

Aluminum is a good material to consider because of its lower weight and well as affordability.

[1] "Adapted Rowing Machine (AROW) – BCIT REDLab." https://adaptederg.commons.bcit.ca/ (accessed Sep. 24, 2022).
[2] "80/20 Aluminum T-slot Building Systems|80/20 Aluminum Extrusions." https://8020.net/# (accessed Sep. 24, 2022).

Conclusions/action items:

The next step would be to implement the form factor of 80 20 into the design sketches.

UW Team Labs welding training research + Welding Research

Tim TRAN - Oct 05, 2022, 11:39 PM CDT

Title: Welding Training Research

Date: 10.5.22

Content by: Tim

Present: Tim

Goals: provide a summary of the research on welding training offered by TEAM labs

Content:

TEAM labs offer 3 seminars on welding, each seminar builds off on the other, and are prerequisites for each subsequent one.

The first seminar (welding 1) trains on MIG welding steel. Welding 2 focuses on TIG welding, and lastly welding 3 teaches students the techniques of MIG welding aluminum.

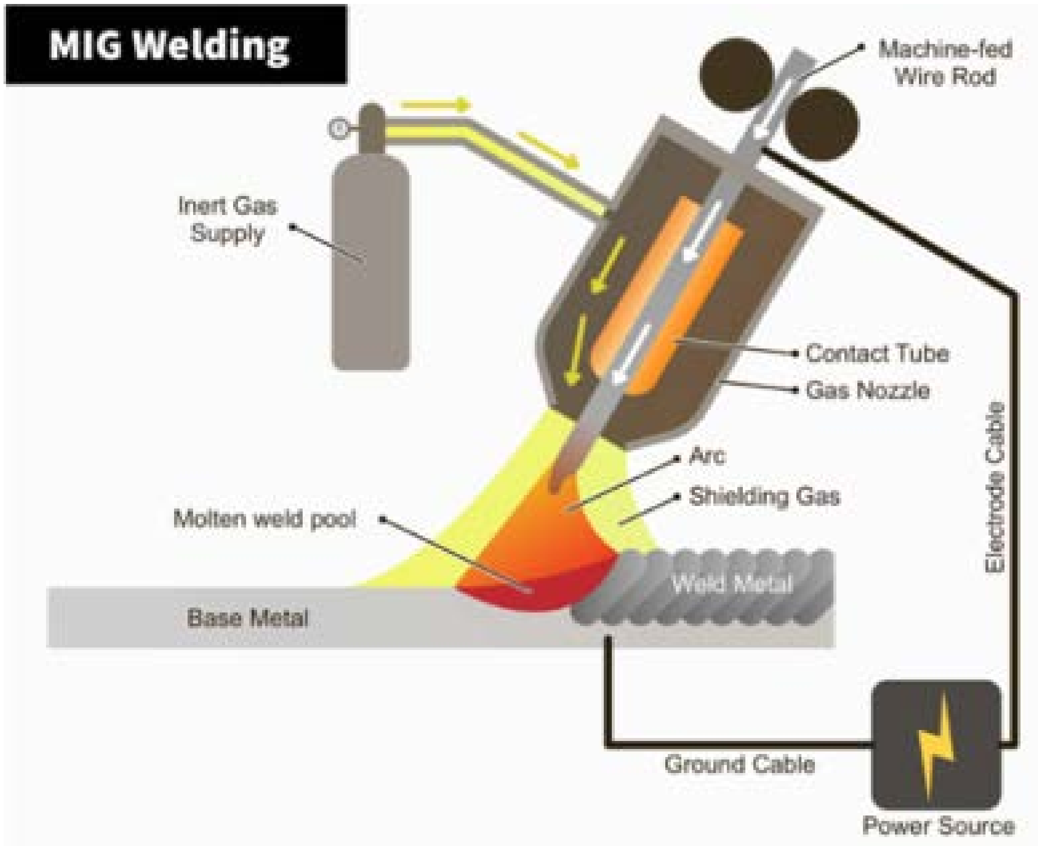
If the team decided aluminum is the best material to use for the support bar, Sam and I would need to take all three courses.

This is a problem as the TEAM labs have put the seminars on hold due to a lack of instructors. The trainings are now on a case-by-case basis, and this could take months to get all three trainings.

After communications with the staff of the TEAM labs, I was told that they are in the process of setting up more seminars for at least the first training. The first seminar offered is on the 19th, however, this has already filled up.

Welding

- process of joining two metals together via melting
- types
    - arc
        - MIG: metal inert gas
            - most common type
    - friction
    - electron beam
    - laser
    - resistance welding
- MIG
    - arc melts metals
        - formed between surface and continuously fed filler electrode
    - Uses shielding gas to protect the melted metal from reacting with elements in the atmosphere
    - employs the use of reverse polarity
    - features
        - parent metal: metal to be joined
        - filler metal: metal added to join the parent metal
        - weld metal: all metal is melted and retained during the weld formation
        - heat affected zone: areas of the parent metal that has properties affected by heating, but aren't melted
        - fusion line: boundary between HAZ and weld metal
    - process



TIG welding: another type of arc welding. Also employs the use of shielding gas. Uses a consumable tungsten electrode instead of an electrode wire in MIG welding.

TIG welding is preferred for thinner materials or more delicate jobs. TIG welding allows for more precision and increases aesthetic, however, it is slower and more expensive

[1] "MIG vs TIG Welding (What is the Difference between Them?)." https://www.twi-global.com/technical-knowledge/faqs/mig-vs-tig-welding.aspx (accessed Oct. 05, 2022).
[2] "What Is MIG Welding – Understanding It Thoroughly - Welding Headquarters," Mar. 23, 2020. https://weldingheadquarters.com/what-is-mig-welding/ (accessed Oct. 05, 2022).

Conclusions/action items:

I have hopefully put my name on the email list to be notified of any upcoming seminars.

11.10.22 Institutional Review Board

Tim TRAN - Nov 11, 2022, 1:55 AM CST

Title: Institutional Review Board at UW-Madison

Date: 11.10.22

Content by: Tim

Present: Tim

Goals: Present information about the IRB and the process of gaining approval for human subject testing

Content:

There are two IRB's on campus

- The Health Sciences IRB
    - reviews research protocols involving medical interventions or procedures
- The Minimal Risk Research IRB
    - reviews research protocols that present minimal risk to subjects

The IRB reviews all activities that meet the federal definition of human research.

New applications must be submitted through ARROW.

There are 4 application types

- non-protocol base application
    - used for minimal-risk research
- Protocol-based application
    - clinical trials
    - biomedical studies with multiple physical interventions
    - studies investigating a drug or device
- SIRB application
    - studies with two or more sites
- ceded application
    - requests to rely on external IRB (external from UW Madison)

Since our proposed human subject testing poses a low amount of risk, our IRB application will be of the non-protocol base variety.

The ARROW application is very streamlined and clearly defines everything one would need to submit a successful IRB application.

Conclusions/action items:

10.5.22 talking points for prelim presentation

Tim TRAN - Oct 06, 2022, 2:54 AM CDT

Title: talking points for prelim presentation

Date: 10.5.22

Content by: Tim

Present: Tim

Goals: provide talking points for the prelim presentation

Content:

Problem statement:

The majority of exercise machines are not designed for wheelchair use, and thus exercise options for wheelchair users are limited. To fill this need, our client Ms. Quam has tasked our team with modifying a Matrix rower to accommodate wheelchair users. The design will retain the functionality of the rower for standard use as well as allow users to switch between adaptive rowing and standard rowing easily.

Motivation:

This product is important to create because of the large number of potential consumers. It is estimated that there are 5.5 million wheelchair users in the U.S alone. Exercise machines at gyms lack adaptive equipment, and the adaptive equipment that is available requires the user to transfer out of their wheelchair. Existing modified rowers remove the standard rowing function, which our device will retain. And lastly, upper body pain is a common complaint amongst this demographic.

Physiological research:

Research has shown that the upper body pain reported by wheelchair users can be alleviated with consistent exercise. The rowing exercise targets the triceps. biceps, abdominal, and back muscles. The four phases of rowing are depicted in the diagram in the lower right,

I will now pass it off to Josh who will be talking about competing designs, what the team accomplished last semester, and the product design specifications

Potential places to recruit wheelchair users to test final product

Tim TRAN - Nov 17, 2022, 2:27 AM CST

Title: Places to reach out to for wheelchair user testing

Date: 11.17.22

Content by: Tim

Present: Tim

Goals: Present list of places that the team can reach out to in search of wheelchair users willing to test out our final product

Content:

- Mad City Wheelchair Sports
    - Mad City Wheelchair Sports is a nonprofit that provides youth with physical disabilities to stay active.
    - The Mad City Badgers is an organized youth wheelchair basketball team
        - this group would be the perfect candidate to test out our rower.
        - The team is active, going on tournaments often and they seem to have a very dedicated coach.
    - https://www.madcitybadgers.org/about-us.html
    - https://www.facebook.com/madcitywheelchairsports/

Conclusions/action items:

9.19.22 - Tension Removal Idea 1

Tim TRAN - Sep 19, 2022, 1:04 AM CDT

Title: Tension Removal Design Idea 1

Date: 9.19.22

Content by: Tim

Present: Tim

Goals: Provide a plausible idea to remove tension with minimal effort.

Content:

"Rower – Matrix Fitness." https://matrixhomefitness.com/products/rower (accessed Sep. 19, 2022).

The overall arching idea to remove tension was to create a housing for both a linear actuator and Arduino that would be welded to the side support beam of the rower. In this early prototype, the Arduino can be externally powered, however, in the final design, the Arduino would be wired into the rower, so the power created by the rower that powers the console would also power the Arduino.

The linear actuator would be translating a horizontal bar that is attached to some grips. These grips will be removable so that when individuals are rowing, the activity is not impeded.

For the grips, something adjustable similar to the ones pictured above would work well. However, the ones above would require a lot of hand dexterity to continually screw the grips until they are tight on the cable.

Designing a similar grip to the one pictured on the right with the same locking lever mechanism would alleviate the hand dexterity problem and would be more reliable over time. One problem with the grip pictured on the right is that it is non-removable.

The grips we design could be one solid piece with a horizontal bar to increase strength and lower the number of moving parts.

S. | M. Products, "Nylon Adjustable Tube Clamp," *SeaSense | Marine Products*. https://seasense.com/products/nylon-adjustable-tube-clamp (accessed Sep. 19, 2022).

"LC-2-Replacement Locking Clamp for 2'' Diameter Adjustable U," *Pipe And Drape Online*. https://www.pipeanddrapeonline.com/Replacement-Locking-Clamp-for-2-Diameter-Adjustable-Upright_p_468.html (accessed Sep. 19, 2022)

Conclusions/action items:

The next steps will be to meet with the team to discuss our different ideas, hopefully combining elements from each of our ideas and start prototyping solutions.

If we carry on with the linear actuator solution, before the team purchases a linear actuator, the team must test to see the minimum displacement and force needed from the cable to remove adequate tension.

Lap Support Idea

Tim TRAN - Sep 21, 2022, 1:47 AM CDT

Title: Lap Support Idea

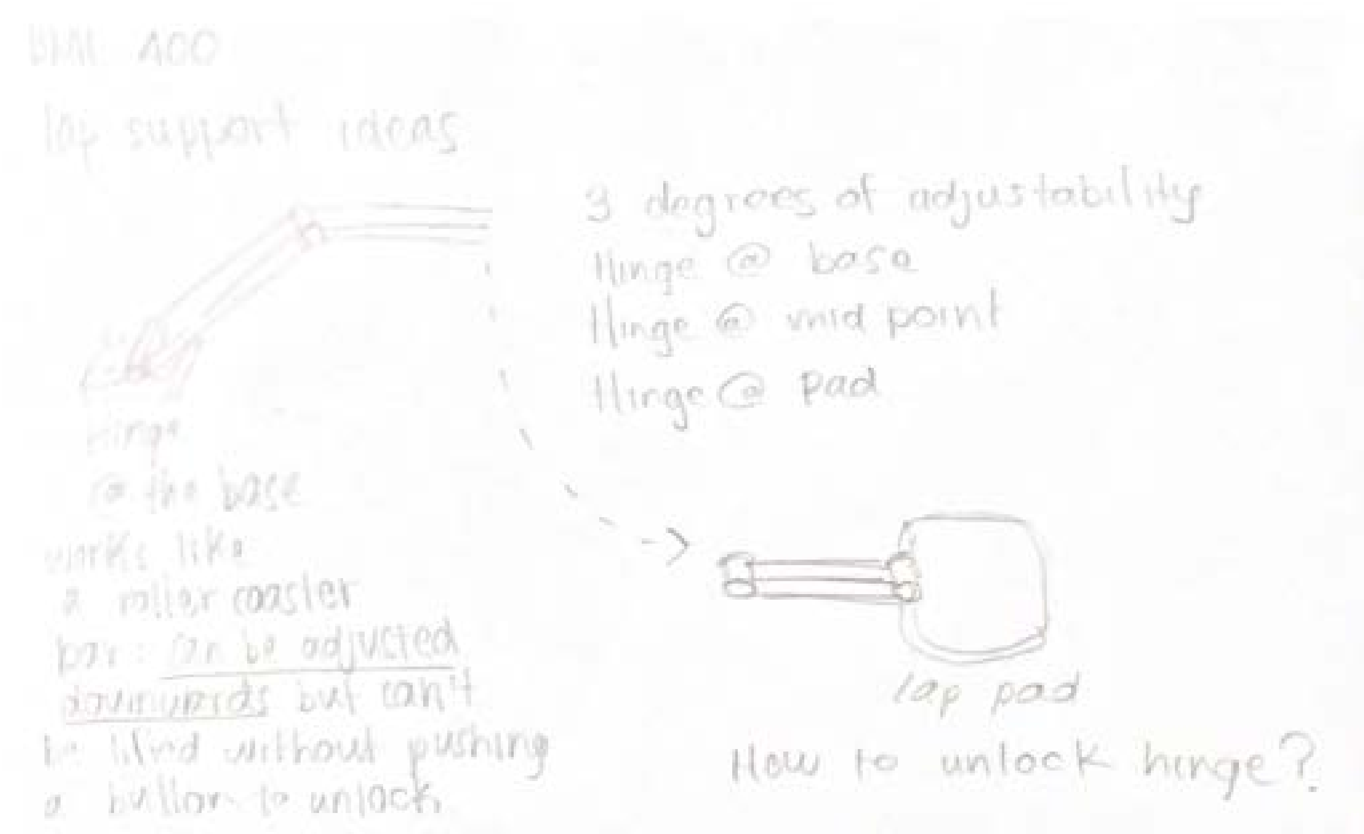
Date: 9/20/21

Content by: Tim

Present: Tim

Goals: Present prelim idea for lap support

Content:



For adjusting the hinge, a lever system that is located within arm length, ideally 12 inches from the individuals would be the most accessible

Conclusions/action items:

Brainstorm how to adjust the hinges on the lap support. Test how stable the pad will be during rowing for the subject

Floor Support + Lap Support

Tim TRAN - Sep 21, 2022, 1:50 AM CDT

Title: Floor support and lap support idea

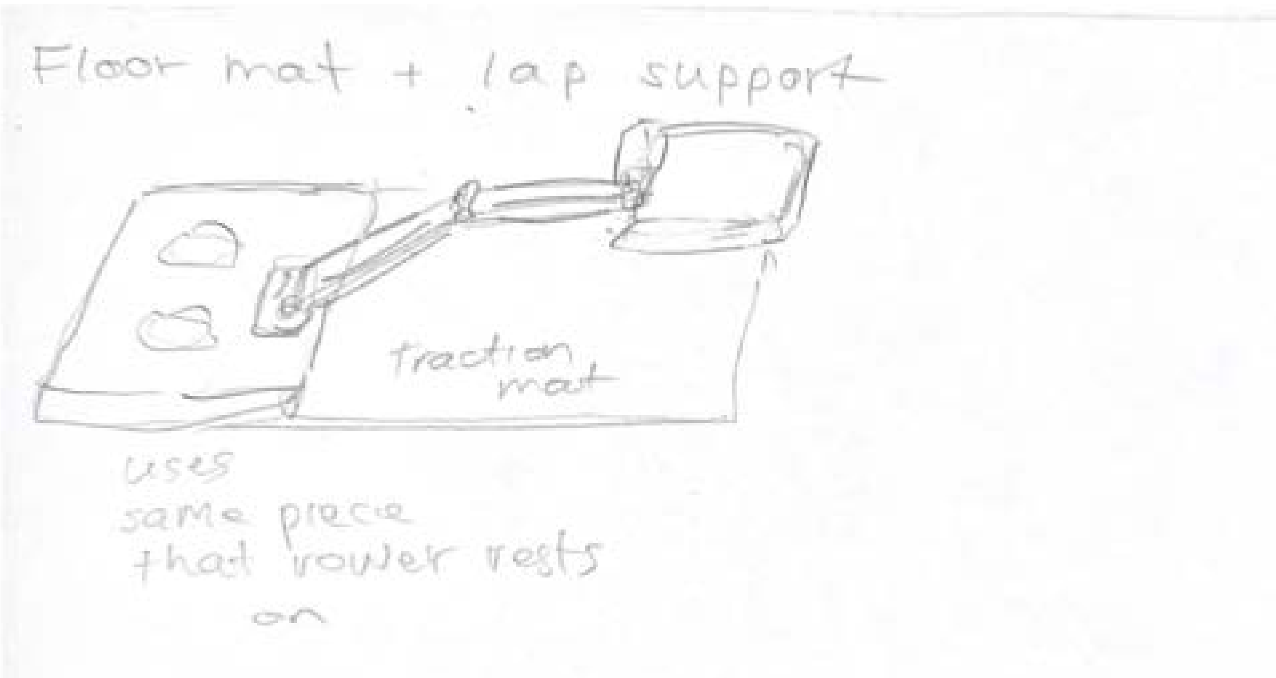
Date: 9.21.22

Content by: Tim

Present: Tim

Goals: present an idea that combines both floor support and lap support

Content:



Conclusions/action items:

Research possible materials that have enough friction coefficient to ensure wheelchair wheels do not slip during activity.

9.24.22 Lap Support Idea 2.0

Tim TRAN - Sep 24, 2022, 4:05 PM CDT

Title: Lap Support Idea refined

Date: 9.24.22

Content by: Tim

Present: Tim

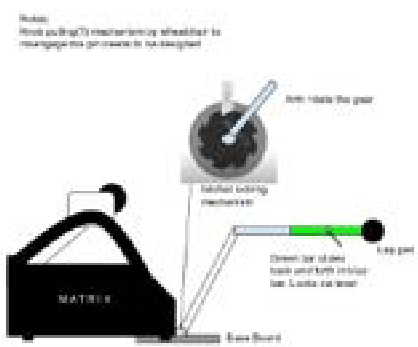
Goals: present idea for lap support and the mechanisms used

Content:

See attached PDF

This design implements a ratchet mechanism to lower and raise the lap support bar.

Tim TRAN - Sep 24, 2022, 4:06 PM CDT



Download

Tim_s_Lap_Support_Sketch_.pdf (41 kB)

9.27.22 Lap Support 3.0

Tim TRAN - Sep 27, 2022, 8:51 PM CDT

Title: Lap Support 3.0

Date: 9.27.22

Content by: Tim

Present: Tim

Goals: provide context/explanations to updates to design as well as dimensions

Content:

Look at the PDF for the updated sketch.

The tentative dimension for the diagonal bar is 100 cm. This number was decided upon after looking at the anthropometric data and typically wheelchair dimensions.

An extra 30% was added to each dimension to ensure the majority of users would be able to use the rower.

wheelchair seat height: 19.5 inches. 19.5 *1.3 = 25.35 inches

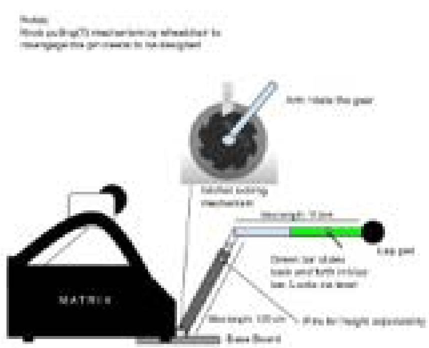
95th percentile for thigh clearance for males = 8.15 inches. 8.15 * 1.3 = 10.6 inches

23.35 + 10.6 --> convert to cm = 86 cm (rounded up). Keeping in mind this number is the hypotenuse, not the height, I tentatively set the length as 100 cm as the angle will not be held constant.

The max length of the horizontal bar will be 112 cm. This number was decided upon after looking at the anthropometric data for arm length (33.58 inches)

33.58 * 1.3 --> convert to cm --> 112 cm (rounded up)

Tim TRAN - Sep 27, 2022, 8:51 PM CDT



Download

Tim_and_Sam_s_Combined_Lap_Support_Sketch_2_.pdf (43.5 kB)

10.5.22 Staci's Stabilization Idea

Tim TRAN - Oct 05, 2022, 10:35 PM CDT

Title: Staci's Stabilization Idea

Date: 10.5.22

Content by: Tim

Present: Tim

Goals: Provide main takeaways from Staci's presentation on current adjustability mechanisms available at Johnson Health Tech

Content:

- Staci has suggested shifting from 3 adjustment points to 2 adjustment points
  - this is achieved by removing the ratchet mechanism and height adjustment of the diagonal bar and replacing it with a pivot point between the diagonal bar and the horizontal bar
- The pivot mechanism will employ the use of a spring-loaded lever and a plate with holes in which a pin can fit to lock the bar.
  - Having just the pivot mechanism would reduce the number of things to adjust for the user
  - Additionally, the height adjustment and the ratchet mechanism are redundant in their functions.
- The main concern I have about this design is having a set number and location of holes will limit the adjustability of the lap bar.
  - This is a problem that my design has as well, but the gear for the ratchet can be machined in a way that provides a finer level of adjustment than a plate with holes. The holes need to have adequate material between each hole to be durable
- Staci suggested having the horizontal bar fold down when the device is not in use to save space, however, this would bring trouble for the user as they set it up. This orientation would prevent the user from wheeling into the position that they would want to row as when they go to pull the bar up, it would collide with their wheelchair or leg.
- Implementing Staci's suggestions would make the fabrication easier, and if the product enters the market, Johnson Health Tech would have to do less design as we are using their already existing technology.

Conclusions/action items.

The team will go forwards with implementing Staci's 1 pivot point suggestion as the benefits outweigh the benefits of the other design.

Ideally, Johnson Health Tech can provide the team with a lever pin pivot mechanism already professionally fabricated.

Tim TRAN - Oct 05, 2022, 10:33 PM CDT

Download

Adaptive_Rower_Stabilization_Design_Suggestion_.pptx (4.2 MB)

10.11.22 Lever Mechanism brainstorming

Tim TRAN - Oct 11, 2022, 6:50 PM CD

Title: Lever mechanism ideas

Date: 10.11.22

Content by: Tim

Present: Tim

Goals: present ideas about how the lever mechanism will function

Content:

Instead of what is depicted in the picture for the Bar in Bar Lap support, the extending bar will have to be bigger than the horizontal bar.

The horizontal bar will need a groove on both the left and right sides of the bar. The bigger bar will have two holes drilled and tapped in both left and right sides and a knob or lever with a rubbe cap at the end will be inserted into the holes and will slide in the grooves of the inside bar. The knob/lever will have thread that catches onto the tapped holes. To lock the horizontal extending bar, the user would twist the knob until the rubber compresses against the groove preventing horizontal translation.

Need to find a durable and high-friction rubber.

For the prototype, the inner bar will be 80 20 aluminum as small segments are very cheap and no fabrication is needed to construct the grooves.

I have the green pass from the TEAM labs so I will be able to mill holes into the outer piece as well as tap the holes.

levers like these were what I had in mind. At the end of the threads we would attach a rubber cap.

https://www.amazon.com/Mutai-Clamping-Ratchet-Adjustable-Threaded/dp/B0982R21JS/ref=asc_df_B0982R21JS/?tag=hyprod-20&linkCode=df0&hvadid=532324337176&hvpos=&hvnetw=g&hvrand=6198234007344794413&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1028057&hvtargid=p 1392435154549&psc=1

10.14.22 Staci's feedback 2.0

Tim TRAN - Oct 21, 2022, 1:32 AM CDT

Title: Answers to Staci's questions

Date: 10.14.22

Content by: Tim

Present: Tim

Goals: Provide answers to Staci's new questions about the function of our design.

Content:

What is the not-in-use position?

- The not-in-use position would be to have the horizontal bar pivot all the way vertical to be in line with the vertical bar. This would reduce the amount of space the stability bar takes. This orientation would increase the ease of use as users will be able to roll themselves into the position they want to row and then secure themselves with the bar. If the bar folded down at rest, the bar would collide with the user or the wheelchair as they pull up the bar to secure themselves.

What is the order of operation of the stability bar?

- The user would roll into place and adjust the angle of the stability bar first. Once the user is happy with the rough location of the horizontal bar, the user would then extend the horizontal bar to sit on their lap. They would then make final adjustments to the angle of the bar to ensure that they feel secure.

close up of stability bar joints and pivot mechanism

Tim TRAN - Oct 21, 2022, 1:35 AM CDT

Title: close up of stability bar joints and pivot mechanism

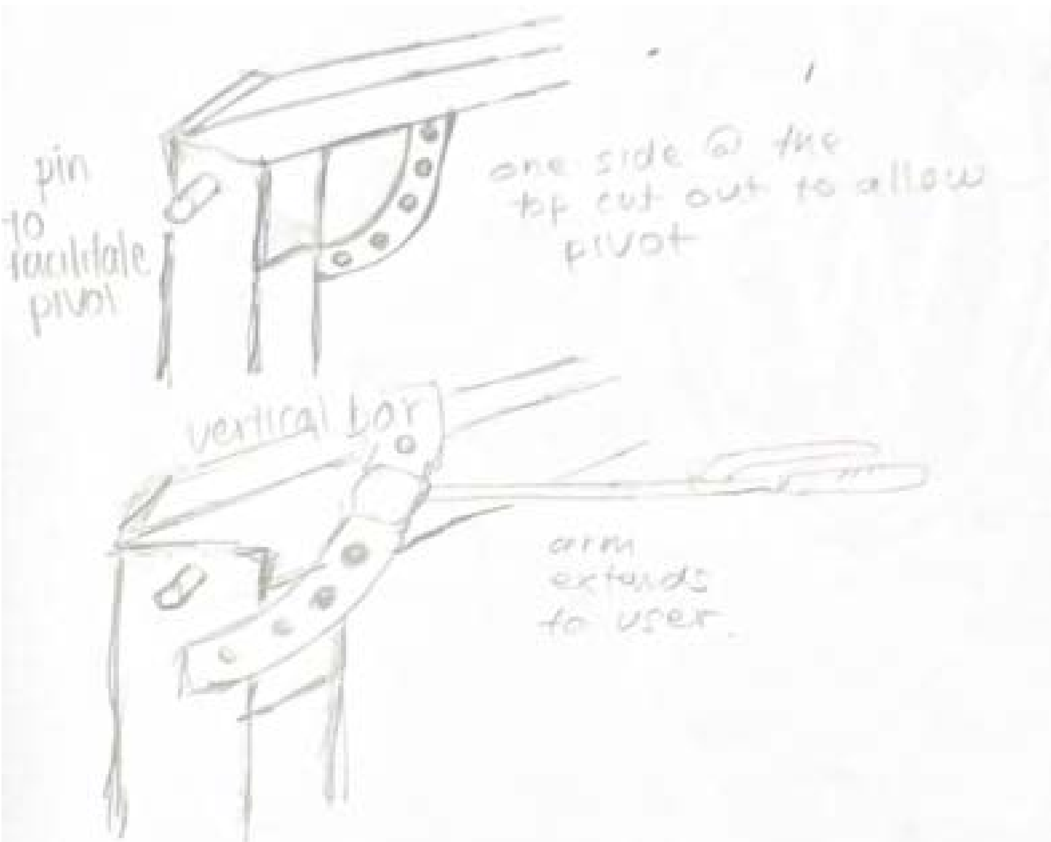
Date: 10.20.22

Content by: Tim

Present: Tim

Goals: present ideas on how the horizontal bar can pivot while remaining connected to the vertical bar

Content:



Conclusions/action items:

The next steps are to schedule a time to visit the fabrication lab at JHT and create a low-fidelity prototype of the stability bar.

10.27.22 Dimensions for Low Fidelity Prototype

Tim TRAN - Oct 28, 2022, 2:03 PM CDT

Title: Dimensions for Low-Fidelity Prototype

Date: 10.27.22

Content by: Tim

Present: Tim

Goals: Finalize dimensions of the stability bar in order to streamline fabrication during the visit to JHT

Content:

Length of vertical bar: max length would be 45 **cm.** 59 cm is the height of the rower, so the length of the bar may need to be lower than 59 cm to ensure the rowing handle or motion is impeded. This also ensures that the addition of the limit switch would not impede rowing.

Pin angle adjustment: Want the angle adjustment from straight vertical (0 degrees) to 150 degrees. We don't want the angle to go all the way down to 180 degrees as this could cause users to stow the bar at 180 degrees instead of 0 degrees vertical when they are done.

The max reach accommodated by the rower will be 90 cm

Non-adjustable horizontal bar (outer bar): for better stability, the horizontal bar will account for 50 percent of the max length: 45cm

Adjustable bar: 45 cm

The horizontal pin adjustment will be located at the leading edge of the outer bar: around 45 cm

Conclusions/action items:

Once the prototype has been built at JHT, adjustments will be made to the initial dimensions to increase the stability of the frame at full extension

11.3.22 Stability Bar Attachment To Rower

Tim TRAN - Nov 03, 2022, 7:18 PM CDT

Title: Stability Bar Attachment to Rower

Date: 11.3.22

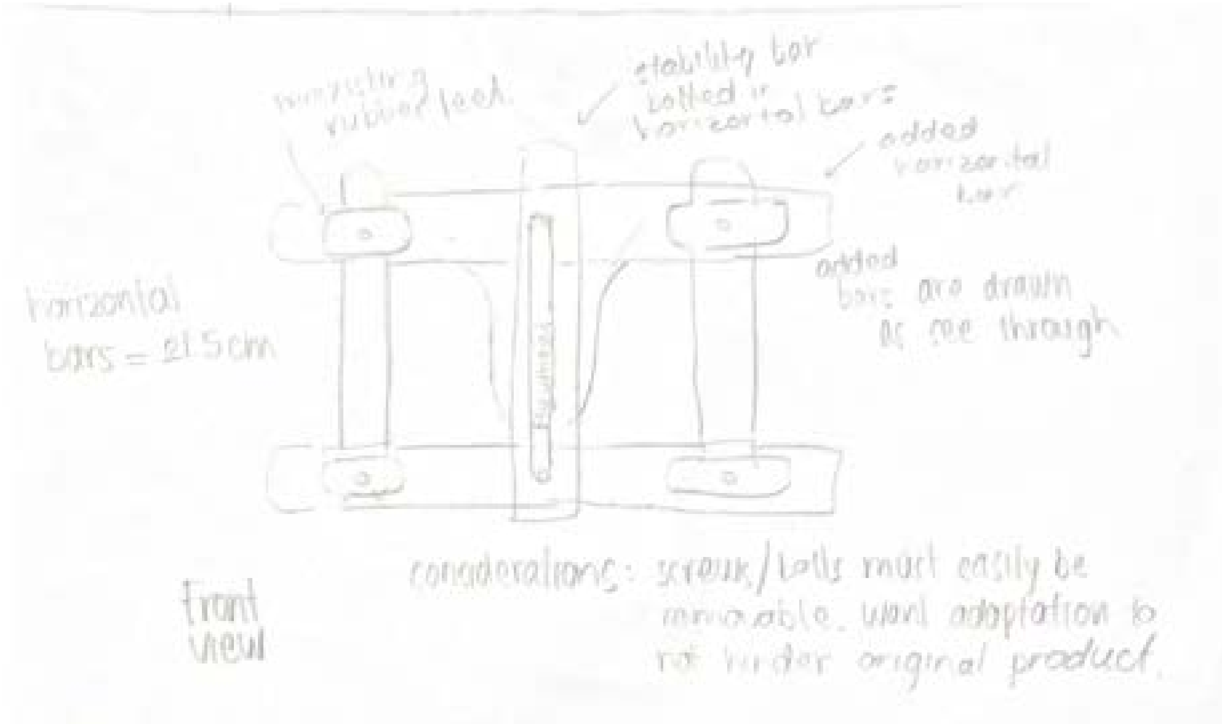
Content by: Tim

Present: Tim

Goals: Revisit how the stability bar is secured to the rower based on feedback from Staci

Content:

Staci suggested that instead of attaching the bar to a baseboard that sits under the rower, the stability bar could be secured to horizontal bars that are screwed into the holes initially intended for the rubber feet of the rower. The rubber feet are used when the rower is oriented vertically to stow away in storage.



Conclusions/action items:

The next steps are to build the low-fidelity prototype on Friday 11/4

11.17.22 Finalization of Dimensions for Stabilization Frame

Tim TRAN - Nov 17, 2022, 2:07 AM CST

Title: Determining Dimensions for Stabilization Frame

Date: 11/15/22

Content by: Tim

Present: Sam and Tim

Goals: Determine dimension of all bars for stabilization mechanism using scrap materials from the Makerspace.

Content:

- Sam and I utilized scrap material from MakerSpace to visualize how the stabilization frame would interact with the rower and wheelchair. The physical representation allowed us to finalize the final dimensions of the components that make up the stabilization frame.
  - 
  - 
  - These pictures show the use of wood board to display how the horizontal bar will be extendable for users with different reached
- The dimensions are as follows:

Dimensions of all bars:

- Large horizontal bar: 40 cm long
  - 3 cm width
- Small horizontal bar: 40 cm long
  - One size under 3 cm width (to be able to fit in large horizontal bar)
- Vertical bar: 68 cm long
  - 3 cm width
- Upper support bar: 40 cm long
  - 3 cm width
  - Note: screw's centers are 30 cm apart
- Lower support bar: 30 cm long
  - 3 cm width
  - Note: screw's centers are 20 cm apart
- Pad diameter: 10-15 cm
  - Note: 10 cm is used in the model for diameter

- The width of the bars has not been decided upon. This dimension depends on what is available at JHT.
- Note: the only things not included in the model are the adjustability of the horizontal bar and the pin adjustability mechanism

Conclusions/action items:

Sam has updated the SolidWorks model to reflect these dimension decisions.

Action items: share the SolidWorks model with Staci on Friday. Develop materials list for Staci.

Biosafety Training + Chemical Safety + Human Subject Research Training Documentation

Tim TRAN - Sep 19, 2022, 1:08 AM CDT

Title: Biosafety Training + Chemical Safety + Human Subject Research Training Documentation

Date: 9.19.22

Content by: Tim Tran

Present: Tim Tran

Goals: present training documentation

Content:

WISCONSIN
UNIVERSITY OF WISCONSIN-MADISON

This certifies that Tuong Tran has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety 102: Bloodborne Pathogens for Laboratory and Research	Biosafety 102: Bloodborne Pathogens Safety in Research Quiz 2021	2/23/2022	2/23/2023
Biosafety Required Training	Biosafety Required Training Quiz	3/13/2021	3/13/2026
Chemical Safety: The OSHA Lab Standard	Final Quiz	3/26/2021	
UW Biomedical Course	Basic/Refresher Course - Human Subjects Research	9/6/2021	9/5/2024

Green Pass Documentation

Tim TRAN - Sep 19, 2022, 1:13 AM CDT

Title: Green Pass Documentation

Date: 9.19.22

Content by: Tim Tran

Present: Tim Tran

Goals: provide green pass documentation

Content:

Welding 1 Upgrade

Tim TRAN - Nov 03, 2022, 6:47 PM CDT

Title: Welding 1 Upgrade

Date: 11/3/2022

Content by: Tim

Present: Tim

Goals: Present completion of welding 1 upgrade.

Content:

11/12022, I attended the welding 1 seminar at the TEAM Labs. After the 2-hour session, my welds and welding shop etiquette were deemed adequate.


here is a picture of something I've welded together out of the practice slabs of steel.


TEAMLab Green Shop Permit Makerspace
Name: Tim Tran
Woodworking 1: Woodworking2: Woodworking3:
Welding1: Welding 2: Welding 3:
CNC Mill 1: CNC Mill 2: CNC Mill 3: CNC Mill 4:
CNC Lathe 1: CNC Lathe 2: Haas1: Laser1:
Ironworker 1: Coldsaw1: CNC Router 1: CNC Plasma1:

9.23.22 Outreach Seminar

Tim TRAN - Sep 23, 2022, 12:27 PM CDT

Title: Outreach Seminar Presentation

Date:

Content by: tim

Present: Tim

Goals: Provide key points from the talk on BME outreach

Content:

- Enhance public understanding of BME
  - fundamental science related to engineering
    - more interest in BME
    - more funding opportunities
- Diversity in engineering
  - more skills / more ideas for solutions
  - designs applicable to more diverse demographics
- Outreach lessons
  - plan in advance - organization
  - content is age appropriate
  - practice run of activity
  - arrive early
- Connections
  - strongly recommended to hold outreach at locations with a high percentage of URMs
    - can receive funding
    - short proposal for materials and costs
- Requirements
  - Presentation - 10 mins
    - intro (personal story)
    - define BME
    - preface activity
  - Activity
    - 20-40 min fun hands-on activity
    - must have clear learning objectives
  - Report
  - Teacher/Leader Evaluation
- Submission
  - website
  - activity guide: Wednesday, Dec. 14th, 2022
  - Final Outreach Deliverables: Friday, April 21st, 2023

Conclusions/action items:

Tong Distinguished Entrepreneurship Lecture

Tim TRAN - Nov 11, 2022, 12:38 PM CST

Title: Tong Distinguished Entrepreneurship Lecture

Date: 11.11.22

Content by: Tim

Present: Tim

Goals: present key points from the tong distinguished entrepreneurship lecture

Content:

Entrepreneurial mindset (EM)

- collaboration
- leadership
- technical skills
- curiosity
- connect knowledge
- value creation

EM is effective when it is a habit

- passionately seek new opportunities
- pursue opportunities with discipline
- focus on execution - adaptive execution
- engage the energies of everyone in their domain

Innovation and Entrepreneurship (I&E)

- Schools are very slow to incorporate entrepreneurship into the engineering curriculum.
    - Most of the time, this incorporation is student-driven.
    - entrepreneurship training is rare for engineering faculty

Entrepreneurial mindset culture

- context both inside and outside the university is the key determinant of how successful the program is.
    - student perspective
        - many students hold a strong interest in an entrepreneurial career
        - research undertaken at universities is a source of knowledge that creates new opportunities

Approaches

- Internal
    - interactions with students and faculty in the university
- External
    - interactions with the surrounding community - raising awareness
- Operational
    - teaching
    - research
    - extracurricular

Technology Entrepreneurship Office (TEO)

- partnership among CDIS, L&S, COE
- purpose: accelerate the commercialization of UW-Madison advances

I-Corps at UW-Madison

- partner in a $15 million effort to commercialize more university advances
- 14 midwest universities in the great lakes I Corp hub

Conclusions/action items:

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:

BME Design - Spring 2021 - Notebook

ANNABEL FRAKE - Sep 09, 2022, 2:24 PM CDT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