BME Design-Spring 2023 - ANNABEL FRAKE
Complete Notebook

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Josh ANDREATTA

on

May 02, 2023 @09:47 PM CDT

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

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Project description

ANNABEL FRAKE - Jan 26, 2023, 9:55 PM CST

Course Number:

BME 402, 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.

01/27/23 JHT Visit

ANNABEL FRAKE - Jan 27, 2023, 2:59 PM CST

Title: 01/27/23 JHT Visit

Date: 01/27/23

Content by: Annabel Frake

Present: Annabel, Josh, Roxi, Sam, Tim, Staci, Alan (JHT)

Goals: learn about the resistance mechanism

Content:

- Alan took apart the rower for us
- there are 3 screws on each side of the plastic cover
  - remove to get to the internal mechanisms
- there is a plastic fixture that holds 2 magnets
- the magnets are positioned on either side of the flywheel and their relative position determines the resistance of the flywheel
- the orientation/rotation of the fixture is determined by the length of a cable that leads to the resistance dial
- when the cable is shorter, it pulls the fixture towards the flywheel and increases the resistance
- there is also a spring to ensure that the fixture moves away from the flywheel when the cable is lengthened
- we discussed 2 main ways to replace this mechanism
- Idea 1: keep the cable, but change the length of the cable with a stepper motor or linear actuator instead of the dial
  - pro: keeps most of the existing mechanism
  - con: may not have enough torque if the flywheel is in motion when the resistance is changed
  - we would need to measure the linear translation of the cable and then map that to rotations of the stepper/servo motor to move the magnet the correct distance to match the current design
- Idea 2: remove the cable and move the fixture directly
  - pro: could move the magnets anywhere if needed
    - con: hard to recalibrate resistance level?
  - pro: may not have torque/spring problem that idea 1 has
  - Sub-idea 1: use a rack and pinion similar to the setup on the Athena machine (see picture attachment)
  - Sub-idea 2: rotate the bolt the fixture is on directly with a motor (may need pulley and belt system)
- Josh and Sam each talked to Staci individually about updates to the antlers and stabilization frame, respectively for this semester
  - antlers: break into 2 pieces for metal machining, cut back on unnecessary material (now that we are using metal)
  - stabilization frame: JHT will weld and paint black after Sam/Tim update the SolidWorks design, not doing the gas assist mechanism for this semester

References: JHT

Conclusions:

Today, we went to JHT to take apart the resistance dial and learn more about the resistance mechanism. The dial changes the tension in a cable that adjusts the placement/overlap of a magnet relative to the flywheel. A spring keeps everything taunt. We talked about 2 main ways to go about interfacing with the existing system: 1. keep the cable and adjust its length using a stepper motor or linear actuator or 2. remove the cable and move the magnet directly using a stepper motor or rack and pinion. Each is discussed above within the content section of this entry. We are planning to meet and do a pros/cons list of each of the resistance dial ideas and then move forward.

Action items:

1. brainstorm solutions to interface with the existing resistance mechanism

ANNABEL FRAKE - Jan 27, 2023, 11:40 AM CST

Download

Magnet_Fixutre_Side_View.png (15.5 MB)

ANNABEL FRAKE - Jan 27, 2023, 11:40 AM CST

Download

Magnet_Fixture_Top_View.png (15.5 MB)

ANNABEL FRAKE - Jan 27, 2023, 11:40 AM CST

Download

Back_of_Resistance_Dial.png (13.6 MB)

ANNABEL FRAKE - Jan 27, 2023, 11:40 AM CST

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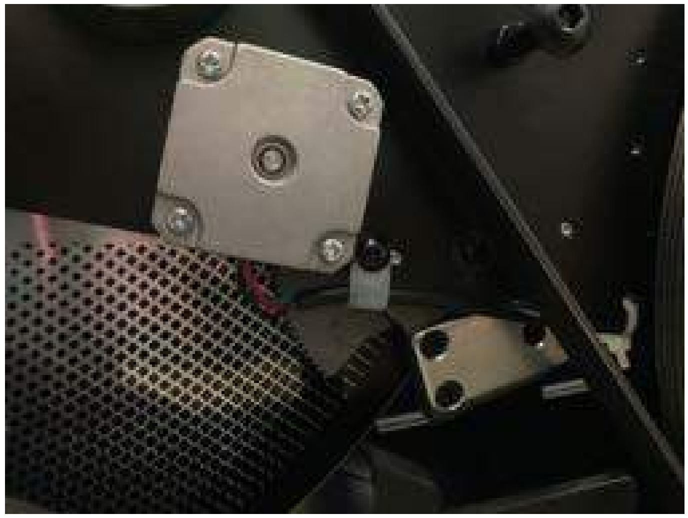
Stepper_motor_cable_concept_another_machine_.png (15 MB)

ANNABEL FRAKE - Jan 27, 2023, 11:40 AM CST



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Stepper_motor_rack_and_pinion_concept.png (15.5 MB)

2/24/2023 - Manufacturing Meeting

Josh ANDREATTA - Feb 25, 2023, 12:04 PM CST

Title: 2/24/2023 - Manufacturing Meeting

Date: 2/24/2023

Content by: Josh Andreatta

Present: Josh, Sam, Tim, Roxi

Goals: Discuss details for manufacturing of parts

Content:

- Staci confirmed that she got Sams email with parts for the pin mechanism for the stabilization frame
    - She has it open and will look at it this week
- Staci is not able to get us a smaller lap pad like she hoped so we will have to cut the seams, trim it, and re-sew the leather back on to make ours the size we need for our testing wheelchair
- Staci emailed us contact info for someone at JHT who has conducted wheelchair testing on other machines and we will reach out to her this upcoming week for advice and help
- Staci spent the rest of the meeting going over the changes that Josh should make to the pulley plate and antlers (see Josh's Entry on 2/25/2023 for these changes)
    - Staci now wants the plate and antler to be one piece again and be one uniform thickness of 12 gage metal (0.104 inches thick). She also had other suggestion for how to prevent rotation of the plate without having to wrap it around the rower neck support arms.
- For reimbursement, Staci said we should just pay for things ourselves and she will write us a personal check for reimbursement so we don't have to go through the BME treasury process

References: Staci, Tom (a machinist at JHT who helped staci explain the changes we should make)

Conclusions:

Josh will continue to make the changes the plate and antler pieces so that they are easily able to be fabricated at JHT for low cost while still maintaining their intended functions. Staci will look over Sam's work and give him feedback this week hopefully.

Action items:

-Write and Edit prelim report

-Josh to make SolidWorks Changes

03/10/2023 Fabrication Update

SAMUEL SKIRPAN - Mar 10, 2023, 2:32 PM CST

Title: Fabrication Update

Date: 3/10/23

Content by: Sam

Present: Everyone

Goals: Meet with Staci to discuss fabrication updates.

Content:

- Q's for Staci
    - The vertical bar height may need to be decreases slightly due to the rope contacting; or decrease the radius of the arc
        - However decreasing the arc may decrease number of adjustment points
    - Ask about wheelchair testing if they have EMG equipment we could potentially use?
- Stabilization frame:
    - Could do a quick geometry check
    - Lap pad is a little bit shorter now - Staci cut it for us
        - Lap pad is now functional
    - Staci was able to find another of the pins
- Pulley plate:
    - The assembly is now completed
    - It is painted black
    - Staci will send us a picture of it
    - 

- EMG
  - JHT does have EMG equipment
  - We should plan some extra time to relearn how to use the
  - We would have to take the rower apart a little bit
    - Might need to take two cars over to JHT
- Electronics holding / resistance mechanism:
  - Staci said that she can set up an account at the Makerspace
  - However, since we already have spent some money out of our own pockets, she said
  - Staci will also see if she can find some buttons for us to use for the interface
- Budget
  - We have around $100 of our budget left
  - We will be purchasing buttons as well for the resistance dial

Conclusions/action items:

- Action items:
  - Make sure that the rope will not contact the physical stop on the stabilization frame
  - Shift next meeting with Staci to the next week

01/27/23 Advisor Meeting

ANNABEL FRAKE - Jan 27, 2023, 2:53 PM CST

Title: 01/27/23 Advisor Meeting

Date: 01/27/23

Content by: Annabel Frake

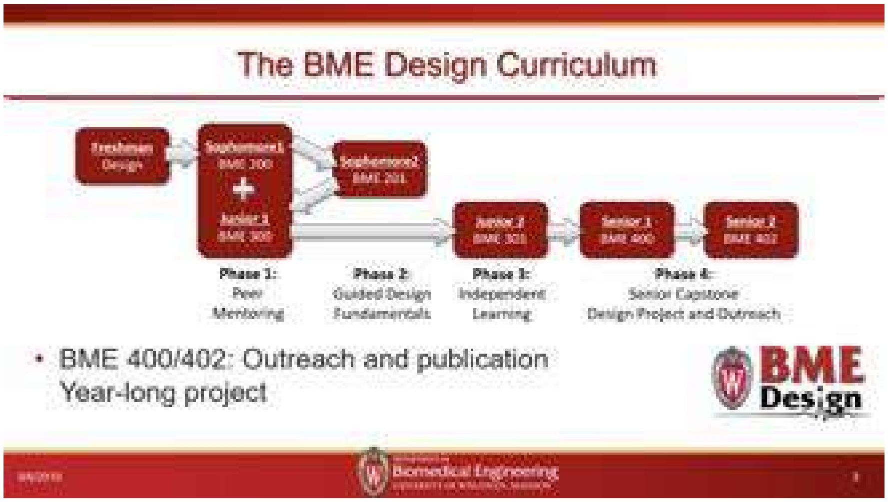
Present: Annabel, Josh, Tim, Roxi, Sam, Dr. Tracy Puccinelli

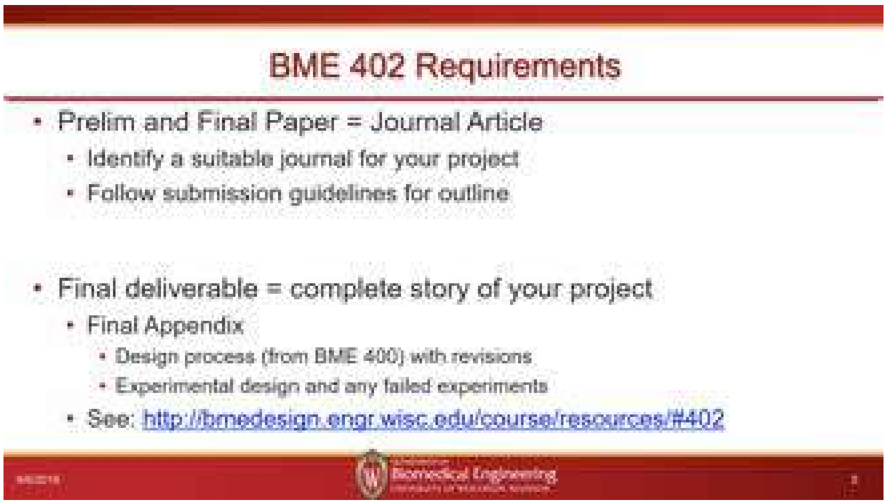
Goals: touch base with advisor

Content:

large group:

- advisor weekly meeting times
  - 1:05-1:35 pm for our group
- complete first day activities
- keep up with outreach project
- focus of this semester is on a journal article
  - set attainable goals
  - you can actually publish
  - try to keep things concise
  - still need Appendix of design process
  - don't repeat information
  - a lot of what we wrote will be condensed into 1-2 sentences
  - read some articles published in the journal to look at writing style
  - need an EXTREME amount of detail
  - needs to be repeatable
  - need exact product number, sometimes even location
    - will vary by journal
  - Appendix should be largely done based on work from last semester
    - only new thing would be stuff you did this semester and any results that are not in the journal article (ex: failed experiment)
- our prelim presentation will be on zoom
  - presenting a plan for the semester
  - most of time should be spend on plan and timeline for semester (one slide per month?)
- will have executive summary near end of semester





<u>Adaptive Rowing team:</u>

- respond to all EMG related email
- Outreach update
    - potato activity
    - Tim's contact
    - will go on some Friday (mid-march?)
    - Spring Harvard Middle School
    - go during a 'flex period'
    - probably 7th graders

- 40-50 min class periods
  - ok to make everything fit in that time frame
- make sure to spin it to teach about BME

- JHT visit this morning
  - antlers and pulley plates
    - split into 2 parts and make using metal (machined by JHT)
    - can make motor box out of metal too, but would need to insulate from wiring
    - testing
      - rerun SolidWorks simulation with updated material
      - Staci recommended not doing MTS failure testing
      - failure case with handle let go
  - stabilization frame
    - get new bars, not perforated, smaller gauge
    - same connection points to rowing machine
    - weld all other connections
    - Sam will remodel in SolidWorks by changing bars and making more sleek, add platform for limit switch (within next 2 weeks)
    - Staci will find us another pad that is smaller
    - JHT will weld it together and pain it black for us
  - resistance dial
    - 3 main options
      - use cable and wind it up with stepper motor (acts as resistance dial)
      - remove cable, rotate fixture directly
      - rack and pinion?
    - more proof of concept than the other aspects of the design
- Testing questions
  - EMG?
    - What is the point of collecting EMG data?
    - collect data with us (team members) rowing on both sides of the machine
    - 3 trials on each side with each person, compare single person's data
    - NOT for wheelchair users because can't use standard side, so nothing to adapt to
  - wheelchair users will only fill out survey
- keep our names on it somehow
  - JHT won't want us to file with WARF
  - talk to Staci about protecting our intellectual property
  - if they manufacture it, we should get a cut somehow
- IRB
  - drafts: surveys, protocols, consent form
    - will edit and send them to advisor
  - this week: work on device documentation
    - edit week and send it to advisor after that
- don't need to dress up for prelim presentation
  - encourage more formal presentation to Staci and her colleagues

References: none

Conclusions:

We met as a large advising group to go over expectations for BME 402. The major difference is the journal article and the private preliminary presentation. We also met with Dr. Tracy Puccinelli as an individual design group to update her on our IRB application and outreach progress. We also told her about our visit to JHT this morning, including the design updates to the antlers and stabilization frame, as well as the preliminary ideas for the resistance dial.

Action items:

1. meet with team and plan out semester

02/03/2023 Advisor Meeting

SAMUEL SKIRPAN - Feb 03, 2023, 1:40 PM CST

Title: Advisor Meeting

Date: 02/03/2023

Content by: Sam

Present: Sam, Josh, Tim, Roxi

Goals: Discuss various items about project.

Content:

- Notebook checks:
  - Will not be weekly
  - Will likely just be a check at the middle of the semester and at the end
- Discussion on the work each of us did this last week/plans for next week
  - A few of the main topics: brainstorming for resistance dial, IRB application review, Journal research
- Journals:
  - Try to narrow journals down and pick one
  - Look at impact factor to give a clue to how good our chances are
    - 2-3 is pretty doable
    - Can try for higher, but would require more effort on our part
  - Ask Staci if she would like to be on as an author for the journal article
    - Reach out to her before we meet
  - Staci might also have some journals we could do
- Outreach:
  - Will try to get list of supplies to Dr. P
  - Could use Amazon to purchase our materials
  - Other option would be to do a grocery pickup
  - Process:
    - Dr. P will buy the materials and pick it up for us
  - Doing outreach Friday March 24th
- Presentation for next week:
  - Aim for 10-15 mins
  - Will be done by 1:35
  - If we want to run by slides with her, we can set up a time
- IRB
  - Use person first language in all of them
  - For 1-5 scales, make sure the scale is the same throughout
    - High score should be the positive for all of them
  - Also, for scale, identify what each number means (1, 2, 3, 4, and 5)
  - Comparative survey:
    - Grammar for 1 (have you previously used a rowing machine)
    - Add who the participants are right after the title ("participants who do not use wheelchairs")
  - Testing protocols:
    - Try to have somebody use our protocol before we turn it in
  - Consent form:
    - Have IRB look at
    - Add that the data may be "published"

Conclusions/action items:

In our discussion with Dr. P, we first discussed the work we completed last week. Then we talked for the majority of the time about the IRB materials. See action items below.

Action items:

1. Try to pick a journal
2. Reach out to Staci about being an author for the journal article
3. Get list of supplies to Dr. P for outreach activity; confirm the date with Dr. P as well

4. Run slides for prelim presentation by Dr. P before Friday
5. Update IRB materials: scales, person first language, have somebody try out our protocols, consent form
6. Have IRB look at the consent form; send it to them to get feedback

02/08/2023 Preliminary Presentation Slide Deck Feedback

ANNABEL FRAKE - Feb 08, 2023, 12:08 PM CST

Title: 02/08/2023 Preliminary Presentation Slide Deck Feedback

Date: 02/08/2023

Content by: Annabel Frake

Present: Annabel, Josh, Tim, Dr. Puccinelli

Goals: receive feedback on our presentation slides for prelims

Content:

- IRB update
  - she will work on it during her office hour
  - she can usually get it approved in a day or 2
- looking at evaluation form
- need to include competing designs in this presentation
- walked her through our slides
- problem statement
  - needs editing, more specific for what we are working on this semester
  - add rowing distance to 8 million meters in PDS or just remove it
  - motivation is a little wordy, but don't have a lot of extraneous text, maybe don't need which is
  - person first language in motivation
- Competing design
  - make font smaller
  - try to get on one line
  - space between the bullets
- Accomplishments
  - make it pretty, add space
- Testing
  - make it 2 slides or animate it to come in halves
- Fabrication Plan
  - ok
- Testing Plan
  - ok
- Timeline
  - break up into 3 slides by month
- Device Documentation
  - vague, not useful

- need to include, but need to be more specific

- Budget
  - Did we talk to Staci about her doing the purchases?
  - Admin not happy about a reimbursement to Roxi

References: Dr. Tracy Puccinelli

Conclusions:

Tim, Josh, and I met with Dr. Tracy Pucinelli today to receive feedback on our prelim presentation slides. We made some edits as we went through them, but we have some more general improvements that need to be implemented later today/tomorrow (see action items). Overall, we need to improve the aesthetic appeal of the presentation and ensure easy digestion of information.

Action items:

1. implement her suggestions
   1. edit problem statement to be more specific
   2. motivation is wordy
   3. Break up testing with animations/multiple slides
   4. break up timeline into 3 slides (per month)
   5. device documentation needs to be more specific
   6. unify text (font style, amount of text, white space, etc.)
2. Talk to Staci about her purchasing materials this semester

02/17/2023 Advisor Meeting

SAMUEL SKIRPAN - Feb 17, 2023, 1:56 PM CST

Title: Advisor Meeting

Date: 2/17/23

Content by: Sam

Present: Sam, Josh, Annabel, Tim, Roxi

Goals: Update Dr. TJP on team accomplishments.

Content:

- Started off by showing/telling Dr. TJP about all of the work that we completed this past week
  - Showed her the SolidWorks models for the stabilization frame and the antler/pulley plates
  - Showed her the code/interface of counting from 1-10
  - Told her about IRB application updates
- Discussed how the resistance dial currently works in the rowing machine
- Journal article:
  - Josh asked question about including other stuff from the design process in the article
    - Dr. TJP said to include preliminary data in the appendix
    - Don't include simulation as part of journal article
      - Maybe just make it one sentence near end of introduction
    - Summarize preliminary material in the introduction
  - She would like to see:
    - Intro written in the style of article
      - Little more technical
    - Materials and methods section done
    - Put placeholders for other things
      - Results and discussion
    - Note: make sure to keep subtitles consistent between sections
  - Appendix:
    - All work from last semester plus information of stuff we do this semester
  - In journal article, just talk about final design specs, materials and methods, and testing
  - Write it in the format we would a regular report
  - Include title and authors
  - Length of journal article:
    - 4000-5000 words

Conclusions/action items:

See above.

Action items: NA

02/10/2023 Team, Client, Advisor Meeting

Roxi Reuter - Feb 10, 2023, 5:52 PM CST

Title: Team and Advisor Meeting

Date: 02/10/2023

Content by: Roxi Reuter

Present: Josh, Sam, Annabel, Tim, Roxi

Goals:

- Present preliminary presentation
- Discuss semester plans and plan of action

Content:

- The whole team presented the preliminary presentation to Dr. TJ Puccinelli via Zoom
- We then discussed:
    - Meeting agenda with Staci (asking her if she wants to be an author on our journal article, intellectual property questions, SolidWorks designs, semester plan)
    - Josh and Sam finished their SolidWorks
    - IRB application submission
- During the Client meeting:
    - Josh explained the modifications to the current pulley plate and antler design which is to be fabricated out of metal by JHT (including thinning the plates, adding permanent separation blocks, and increasing the height of the antlers to accommodate the height of the console)
        - Feedback from Staci: thickness looks good, but do not make block permanently attached to the plates (increased thickness too much), the fabrication will not have 90º angles (instead, there will be fillets),
        - Fabrication will be out of steel (exact details will come later from JHT on alloy so that can be accurately represented for simulation testing
    - Sam also shared his SolidWorks stabilization frame design. The only issue he ran into was the vertical and horizontal bar alignment (did not perfectly align, but the shop will account for this and make sure it works with our rower)
        - Feedback from Staci: think more about how we will implement pivot point adjustment of bar (we will need the user to be able to reach and adjust this from their wheelchair), add holes for lap pad before sending it to her
- Finally, we met with a COE writer (Tom Ziemer) so that he can write a story on our project

Conclusions/action items:

Today, we met as a team with Tracy, our advisor, to present our preliminary BME 402 presentation via Zoom. We also updated our client, Staci, on our current progress in the project and met with a COE write, Tom Ziemer to be featured in COE writing. This weekend, I will submit the IRB application and put together a list of outreach items and links. We will all continue working on the resistance dial mechanism throughout the week and reconvene next Friday (02/17/2023).

2/24/2023 - Advisor Meeting

Josh ANDREATTA - Feb 24, 2023, 1:34 PM CST

Title: 2/24/2023 - Advisor Meeting

Date: 2/24/2023

Content by: Josh

Present: Josh, Sam, Roxi, Rim

Goals: Take meeting notes

Content:

- We went over all of our accomplishments from the past week
- Tracy will check and confirm that people external to UW cannot setup a makerspace account - she likes the idea of a pre-paid card
- Tracy says we do not need clinical trials so we are okay to not mention the registry in the article draft
- One section for each test - put protocols in appendix
- Tracy OKs the outline

References: Dr. Puccinelli

Conclusions:

We will work on our preliminary report draft. We will meet Staci this afternoon to go over manufacturing questions.

Action items:

-Write prelim report

-Edit prelim report on Monday evening

03/10/2023 Advisor Meeting

SAMUEL SKIRPAN - Mar 10, 2023, 2:31 PM CST

Title: Advisor Meeting

Date: 3/10/23

Content by: Sam

Present: Sam, Josh, Roxi, Annabel, Tim

Goals: Meet with Tracy to discuss outreach and updates to project.

Content:

- Started by everyone going around and discussing their accomplishments and work for the last week
- Outreach:
  - If we can purchase anything from the Makerspace, we should
    - May be able to get alligator clips from them
  - Talked about pennies
    - Tracy may send a message out to the faculty
  - Multimeters
    - We are going to send an email to Dr. Nimunkar if we can use the multimeters
      - Need to make sure they don't have 201 or bioinstrumentation
    - If we needed to purchase
  - Traci will buy the potatoes on the Wednesday before we do the outreach activity
  - The materials will be placed in the BME copy room
    - NOTE: there may be a lot of materials in there
- EMG
  - We are waiting to hear back from Wille
  - If it is a no, we might talk with Dr. Nimunkar to create our own EMG
    - Wouldn't be super professional but would serve as a proxy
  - Tracy will also ask around if she can find information for EMG use
- Resistance mechanism
  - Annabel will be fabricating the electronics over break
- Preliminary report:
  - Traci left some comments for us
  - Eventually will want to share a google doc with
  - Some parts a little bit long
    - Don't need a section titled "relevant physiology"
  - Intro doesn't need subtitles
  - Don't need details on 4 phases of rowing motion

        - Scale this back a little bit
    - In figures, for adaptations we made, call them out on the image with letters
        - Then can refer to the specific areas
    - Include the surveys in the journal
        - When we introduce the surveys, that's where you put them
        - Since ours is long, we should put representative questions
            - Just state that the full survey is at the end or in supplemental information
        - Also, put the wording “Leikert scale” near the survey
    - References
        - Traci expected to see a few more
        - Want to see a lot of redundant citations
            - Include multiple sources for the same piece of information
    - Citation style:
        - Check the journal to see if there is a recommended style

Conclusions/action items:

- Action items:
    - Reach out to Dr. Nimunkar about multimeters
    - Reach out to Dr. P after spring break about a pickup time of outreach materials
    - Send Dr. P the journal requirements and include the full name of the journal
    - Make edits to the journal article listed above

03/23/2023 Advisor and Outreach Meeting

Roxi Reuter - Mar 23, 2023, 4:23 PM CDT

Title: Advisor and Outreach Meeting

Date: 03/23/2023

Content by: Roxi Reuter

Present: Josh, Annabel, Tim, Sam, Roxi

Goals:

- Discuss final outreach plans
- Talk about this week's progress on the rower

Content:

- We discussed outreach plans with Dr. TJ Puccinelli. We have all materials and will be testing after our advisor meeting today
- Josh completed some SolidWorks updates which he will be printing soon
- Tim contacted the wheelchair basketball team, but participants are anywhere from 7-18 years old. For our study they must be 18 or older. Because of this, we may have to look to other options.
- Josh emailed Staci back about picking up the stabilization frame (if it is ready).
- Tomorrow, we are meeting at Josh and Sam's apartment just before 12:30PM so that we can do an interview on our project, then go to outreach at Spring Harbor Middle School.
- Tim emailed Mr. Ropa to see if any of the photo release forms have been handed out and signed. Mr. Ropa responded that he handed out the forms and will send an email reminder to return those.
- We ran through the outreach presentation and made sure we had all the necessary outreach materials, including pennies.
- We also performed the activity ourselves with the materials to ensure it worked properly, and it did.
- Sam and Tim took the materials back to Sam and Josh's apartment so that it will all be there when we meet tomorrow and leave for the activity.

Conclusions/action items:

Today's one hour meeting was spent going over project updates with our advisor and ensuring we had all materials for the activity. We also completed the outreach as a team to make sure everything went smoothly and we had all materials before doing the activity tomorrow (03/24) in person at Spring Harbor Middle School.

04/07/2023 Advisor Meeting

SAMUEL SKIRPAN - Apr 07, 2023, 2:40 PM CDT

Title: Advisor Meeting

Date: 4/7/23

Content by: Sam

Present: Everyone

Goals: Ask Tracy about IRB questions and best course of action.

Content:

- Asked Tracy about taking EMG material out of the IRB application
    - AI: call the person reviewing our application to see if taking EMG out would be better for the application passing; or if we can do anything to speed up the process
        - Phone number : 608 265 9792
        - 3 main questions for her:
            - Will having Dr. Wille as a helper, given her credentials, help out with our application / be sufficient?
            - What is the timeline for this?
            - Would it be better fi we removed EMG and just focused on user testing?
            - WE DONT HAVE MUCH TIME
        - Leave a message if she doesn’t answer
    - For IRB application, mention that Willie is:
        - Physical therapist
        - Working on her PhD
            - In BME with emphasis on biomechanics
        - A DPT
            - Doctor of physical therapy
        - Has biomechanics focused undergraduate and PhD
        - AI: ask her what credentials we should list for IRB
- AI: list the specific equipment that we are using for the EMG machine
    - Also, not that Dr. Wille is the one that purchased this for her lab
    - Then say what her credentials are
- Updated Tracy on the new integration ideas with the rowing machine
- Worst case scenario, what do we put in our journal article and on poster?
    - We could do our own testing in wheelchair

Conclusions/action items:

We met with Tracy to discuss some of the feedback we got from IRB application. She gave us some advice regarding including Wille in the application and calling in order to speed up the review process.

Action items:

- Call the person reviewing our application to see if taking EMG out would be better for the application passing; or if we can do anything to speed up the process
- List the specific equipment that we are using for the EMG machine

4/21/23 - Advisor Meeting & Assign Report Sections

Josh ANDREATTA - Apr 21, 2023, 2:43 PM CDT

Title: 4/21/23 - Advisor Meeting & Assign Report Sections

Date: 4/21/23

Content by: Josh Andreatta

Present: Josh, Tim, Sam, Annabel, Roxi

Goals: Assign report sections

Content:

- We gave an update on our testing from EMG and survey results
- We tentatively planned to have our final advisor meeting at Tracy's house in May 5th in the afternoon
- We made our assignments for the final poster updates and scripts
  - Annabel: Final Design
  - Tim: Update protocols and add in lab archives (EMG and NO EMG)
  - Sam: Future Work
  - Roxi: Discussion
  - Josh: Testing
- We made our assignments for the design excellence pitch
  - Annabel: Electronics for Console and Resistance Mechanisms (3)
  - Tim: Demo (throughout)
  - Sam: Testing/Results & Future Work (4)
  - Roxi: Motivation & Problem Statement (1)
  - Josh: Antlers & Pulley Plates and Stabilization Frame (2)

References: n/a

Conclusions:

We are in a good place for finishing our final deliverables!

Action items:

-Make final poster, script, and script for design excellence pitch

-Finish final draft of journal article

-Finish poster by sunday night, edit monday, meet with tracy and print by wednesday

-Meet thursday from 9-10pm in ECB to practice scripts for poster and design excellence

04/26/2023 Advisor Poster Feedback

ANNABEL FRAKE - Apr 26, 2023, 2:41 PM CDT

Title: 04/26/2023 Advisor Poster Feedback

Date: 04/26/2023

Content by: Annabel Frake

Present: Annabel, Josh, Sam, Roxi, Dr. TJP

Goals: get feedback on our poster

Content:

- make sure to call out the SolidWorks section during the poster presentation
    - tell a story and make sure that story makes sense
- in final design, find a way to call out the things that we added to the rower
- all figures should have captions
    - bullet points treated as captions?
- remove graphs for EMG testing - difficult to understand
    - scales should match
    - would need to label x and y
    - Amplitude is not specific enough
        - but can't correlate number to muscle activation...
- Survey tables
    - add standard deviation
    - make sure they are at highest resolution
        - rule: view at 100% zoom from 3 feet away
    - tables need captions
    - make it more obvious which is standard and which is adaptive
    - Possible to do t test?
        - will be asked this - say too many variables
- discussion and future work are a lot of words, but ok
- make sure to sell it for design excellence
- make sure to mention iterations in regular presentation too

References: none

Conclusions:

We met with Dr. TJP to ask her opinion on our poster. She gave us feedback on content and formatting.

Action items:

1. implement changes

01/18/23 IRB Meeting

Roxi Reuter - Jan 28, 2023, 10:43 AM CST

Title: 18JAN2023 IRB Meeting

Date: 18JAN2023

Content by: Annabel Frake

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

Goals: ask our advisor questions about the IRB application; briefly discuss goals for the semester

Content:

Meeting with advisor:

-
- Generally speaking, you should have an N of 3, so we should aim to recruit at least 3 wheelchair users
- we still need to get IRB approval for team members who conduct testing
- General testing structure:
  - Have team members and Roxi's friend (who has rowing experience) row on both the standard and adaptive sides of the machine with EMG
  - Have 3+ wheelchair users row on the adaptive side
  - have all participants fill out a survey
- she recommends not collecting EMG data for wheelchair users
  - we may take some criticism for this, but she will back us up on it
- EMG for testing
  - ask Dr. Amit Nimunkar about equipment we could borrow and how best to use it in our testing
  - we will need to minimize noise
  - try to be consistent with protocol in terms of individual effort
    - we might want to have someone do it 3 times and check consistency levels
    - might need to take an average
- the protocol needs to be as detailed and specific as possible (including which EMG we are using)
- the IRB doesn't need to know about our analysis, only about how people interact with our device in testing
- How to recruit wheelchair users?
  - reach out to local physical therapists (within the UW health system) asking for wheelchair participants who have upper body strength and want to maintain it
  - reach out to Dr. Wille (PT herself), but leave her alone if she is too busy because she is currently trying to graduate
- Is the rower an approved machine or do our modifications make it unapproved?
  - email someone in IRB to ask
- we should have the IRB application submitted by our prelim oral presentation at the absolute latest
  - have her review it before submission

- we will need consent forms - typically a paragraph at the beginning
- we might need to be careful about where we store the data
  - might have to get CAE account
  - prepare for data governance
  - big push for this in the department right now
- make it clear how we are minimizing risk in our application
- Feedback on our 400 prelim report
  - plan for a 30 minute meeting after the large group meeting 1/27 for expectations in BME 402
  - overall, we need to be more technical and precise in our journal article

Team Discussion:

-
- Things that need to be done for IRB:
  - 2 protocols (Josh and Sam)
    - non-wheelchair users
    - wheelchair users
  - Consent Form (Roxi)
  - Survey (Annabel)
  - Device Documentation (Tim?)
    - need to email IRB because requirements change depending on if the rower is approved or unapproved
- Emails that need to be sent:
  - IRB - about device documentation
  - Nimunkar - about EMG devices we could use and tips for how best to use it in our testing
  - Wille - how best to use EMG data for our analysis + recruiting wheelchair users
  - Staci - see if we can visit 2/3 to look at inside of resistance dial + recruiting wheelchair users
- Best case scenario goal: start testing after spring break
- Outreach - should have Tim reach out to the school
- Make wording on survey vague about resistance dial in case we don't get to it / we don't know how it will look yet (sounds like it won't be in protocol)
- plan that the stabilization frame will have a strap to keep the wheelchair from moving backward
- have individual IRB assignments done by 1/26 and then review each others work to discuss 1/27

References: none

Conclusions:

We met with our advisor to ask questions about the IRB application. We assigned people to work on the protocols, consent forms, and survey. Josh will email the IRB to ask about the device documentation requirements for our submission.

Action items:

- Josh
  - send emails to IRB, Nimunkar, Wille, and Staci
  - IRB protocols with Sam
- Sam
  - IRB protocols with Josh
- Roxi
  - Consent Form
- Annabel
  - Survey
- Tim
  - email school about outreach
- All
  - fill out the outside activities report if you have not done so
  - have individual IRB assignments done by 1/26
  - review each others work for discussion on 1/27 before we send it to Dr. Tracy Puccinelli for review

- On 1/27, we will...
  - attend the large group meeting about expectations for BME 402 (look for an email from Dr. Tracy Puccinelli)
  - meet with Dr. Tracy Puccinelli to discuss our final report from last semester
  - discuss plans for the semester
  - potentially visit JHT to look at the internal mechanism of the resistance dial (pending Staci is available)

01/27/2023 Advisor and Team Meetings

Roxi Reuter - Jan 28, 2023, 4:37 PM CST

Title: Advisor and Team Meetings

Date: 01/27/2023

Content by: Roxi Reuter

Present: Entire team, Tracy

Goals:

- Talk about semester goals and testing plans
- Make an action plan to complete IRB application and appropriate documentation

Content:

- We will continue to meet with Tracy from 1:05-1:35PM each Friday for check-in meetings
- To-do:
  - Swap enrollment into Tracy's section
  - Decide on team roles. We do not need to keep the same roles as last semester.
  - First progress report is due next Thursday at 5PM
- Focus this semester is on a journal article.
  - Identify a suitable journal for our project; focus on something attainable. Follow submission guidelines for outline. Impact factor 1-3. Still need an appendix for this.
    - Failed experiments, raw data would be additions to appendix (most of the appendix is from last semester's report).
  - Read articles by journal of choice to get an idea of writing style and content. We will need a high level of detail in the notebook because we will need to reference this in the journal article.
- All deliverables are due Friday, April 21.
- Keep track of important dates on BME schedule
  - First important date: 02/10/2023 (Friday) we will be presenting a plan for the semester on Zoom just to Tracy
    - More information on design website (402 preliminary design presentations) - problem statement should be modified to cover what we are doing this semester
    - Try to be very specific with dates and tasks for a plan - in presentation, this should take up a few slides (possibly one slide per month)
- Team meeting
  - We switched a few team roles (BSAC conflicts)
  - Tasks for upcoming week
    - Sam - Solid
    - Roxi - intended use
    - Annabel - description of device
    - Tim - features that minimize risk
- Outreach - in contact with school, need to pick time and date to actually do the activity at Spring Harbor Middle School
- JHT update - Josh will be updating SolidWorks files to make the pulley plates and antlers into a few separate pieces so that they can be made out of metal and welded by the shop team at JHT
- Testing - no MTS, do the "let go" test of handlebar after the handlebars are made of metal
- Stabilization frame update - same setup as current design and will be screwed into the rower, but all other connection points will be welded together by JHT shop team, no perforated bars

- Resistance dial **-** main focus of the semester (allowing resistance adjustments from standard AND adaptive sides)
    - Possible ideas:
        - Puck and stepper motor casing (cheaper)?
        - Wire? No wire?
        - Athena bike model **-** rack and pinion?
        - Replace hinge point of magnets with stepper motor?
            - In whichever case, we will need to do math to get equivalent movement to resistance adjustments
- We will still do EMG testing (compare own data to own data) **-** see muscle activation on both sides of rower
- Start talking to Staci about protecting own intellectual property and WARF moving forward
- The team spent the remaining time editing IRB documents and dividing up work for the first week

Conclusions/action items:

The team had a very productive meeting today. We went to JHT and set project goals, as well as started brainstorming for resistance dial adjustments from the adaptive sides. In the coming week, we have the following tasks:

- Sam **-** stabilization frame SolidWorks
- Josh **-** pulley plates and antler modifications in SolidWorks, sending out emails to appropriate people on IRB application and client/advisor for weekly meetings
- Tim **-** IRB device documentation (features that minimize risks), ask about outreach school demographic for funding, respond to availability (March 24 or April 7), ask Tracy about funding for outreach activity (demographic)
- Roxi **-** IRB device documentation (intended use)
- Annabel **-** IRB device documentation (device description)
- All **-** brainstorm for resistance dial mechanism and first day activities
- Complete device documentation by February 4 for review at meeting on February 5.

We will be meeting as a team to catch up with each other next Friday (February 3) before or after our advisor and client meetings. In the meantime, we will be completing individual activities.

02/03/2023 Pre-Advisor Meeting

SAMUEL SKIRPAN - Feb 03, 2023, 1:05 PM CST

Title: Pre-Advisor Meeting

Date: 2/3/23

Content by: Sam

Present: Sam, Josh, Roxi, Tim

Goals:

Content:

- Items to discuss with Tracy during advisor meeting:
  - IRB related material
    - Ask if she has had the opportunity to read/review for feedback?
  - Asking about the journal article
  - Ask about the formalness of the preliminary presentation we are giving next week
    - Also what time the presentation will be finished so we can meet with the Writer (Tom)
- Other materials discussed during our meeting:
  - Outreach
    - How many kids will be in the classroom for materials purposes (20-25 kids)
  - Upcoming meeting to review the IRB application, brainstormed ideas for resistance dial
  - Discussion on journals
  - Potential of splitting up the resistance dial work into groups
    - One group would focus on the physical modeling of the design (SolidWorks, housing of the stepper motor)
    - The other group would focus on the electronics and user interface

Conclusions/action items:

We discussed some of the things that we would like to mention to Tracy during our advisor meeting. Also, we talked about a few other items, such as how we will split up the work for the resistance dial work and the different journals we can choose from.

2/5/2023 - Final edit of IRB materials; set up Prelim Presentation

Josh ANDREATTA - Feb 05, 2023, 4:22 PM CST

Title: 2/5/2023 - Final edit of IRB materials; set up Prelim Presentation

Date: 2/5/2023

Content by: Josh Andreatta

Present: Josh, Annabel, Sam, Tim, Roxi

Goals: Finish editing IRB documents and assign Prelim Presentation slides

Content:

- Goals for the meeting:
  - Edit Device Documentation
  - Edit Surveys
  - Edit Protocols
  - Submit IRB application
  - Assign Preliminary Presentation Slides
  - Set time to edit prelim presentation
  - Review thoughts on resistance dial mechanism brainstorm
- Device Documentation:
  - Started by editing device documentation addressing comments made by other teammates
  - will attach final BME 400 report with IRB application for further details and explanation
  - Good to acknowledge briefly previous testing and results done on the rower to prove its efficacy
  - mention to look at attached BME 400 final report for any other details
- Resistance Dial Mechanism Brainstorm:
  - Sam:
    - Cable-less concept to place pivot point of magnet at shaft of stepper motor
    - Motor sits within the flywheel casing
    - 2 connection points
    - Josh mentions that there might be more room to attach the stepper motor at the front of the flywheel closer to the base of the rower where the casing bulges outward slightly
    - Possibly would need a second arduino for two LCDs (one for the standard side and one for the adaptive side - number of digital pins is the limiting factor)
  - Roxi:
    - Same general idea as Sam
    - Rack and Pinion Idea is most complicated design idea JHT had
    - Puck and Motor would only require figuring out the puck size but the main issues are durability and space of the puck
    - The shaft of the stepper motor might be too narrow for the bolt hole so we would need to print something to fill that extra space in the gap to make sure it can rotate the magnet properly

    - Annabel:
        - Same ideas as above
        - New Idea: Mechanical solution where a bar goes across the flywheel and has handles to push or pull the magnet from each side of the rower
        - Wouldn't require electronics because it is purely mechanical, although this would require the need to re-do the calibration
        - Group agrees this might be a little taxing on the design and fabrication side and might stress the limits of the team along with doing testing and other component improvements
    - Move forward with common theme of placing motor in current hinge spot or somewhere along flywheel. We would like to use an LCD interface to display the current resistance level on each side of the rower. We will need to meet in person eventually to take apart the rower to measure and find the best place with the most amount of space to insert the stepper motor. Then, we can order a motor based on size constraints and begin to model supports.
    - Form subteams of electronics and motor placement/support modeling (Sam/Josh - motor stuff, Annabel/Roxi - electronics, Tim - floater between groups)
- Sam and Josh to send Staci SolidWorks models by Friday for updates
- Prelim Presentation Slide Assignments:
    - Set order of slides based on required layout instructions
    - Sam: Slides 12-13
    - Josh: Slides 10-11
    - Annabel: Slides 8-9
    - Tim: Slides 1-7
    - Roxi: Slides 14-end
- Finish editing IRB documents:
    - Added labels to each of the scale increments and made sure all scales went form 1 being worst to 5 being best
    - Added person first language
    - Added in EMG details into the protocols

References: n/a

Conclusions:

The team finished editing our IRB documents and will send them to our IRB contact for feedback prior to submitting the actual application. We also agreed on a plan for approaching the resistance dial mechanism. We assigned slides for the prelim presentation on this upcoming friday.

Action items:

-Everyone make their assigned slides and scripts for the prelim presentation

-Send IRB documents to IRB contact prior to actual submission

-Edit prelim presentation on ? Wait for response

-Josh email Tracy to see when is the best day to go over slides with her

2/9/2023 Pre Prelim Presentation Meeting

Tim TRAN - Feb 09, 2023, 6:53 PM CST

Title: Pre-Preliminary Presentation Meeting

Date: 2/9/2023

Content by: Tim

Present: Team

Goals: Record happenings of team meeting

Content:

- Fixes to the continuity of preliminary presentation slides
- Meet at 12:45 PM tomorrow in the closet with the rower
- Journal decision
    - between *Disability and Rehabilitation* and the *Journal of Science in Sport and Exercise*
    - impact factors are 2.44 and 3.34 respectively
    - the team is leaning towards *Disability and Rehabilitation* as we think our journal will align more with topics commonly published by this journal.
        - will ask Tracy for her thoughts
    - journal due March 1st
        - cut down from the final report?
- Preliminary report?
    - how long / involved
- Meeting with reporter
    - nothing need
    - Annabel will bring electronics box in case the console rotation fails.

Conclusions/action items:

Practice prelim scripts

Ask Tracy about the journal decision and preliminary report. Confirm that journal is just a cut-down version of the final report from last semester

02/17/2023 Pre-advisor Team Meeting

SAMUEL SKIRPAN - Feb 17, 2023, 1:55 PM CST

Title: Pre-advisor Team Meeting

Date: 2/17/23

Content by: Sam

Present: Sam, Josh, Annabel, Roxi, Tim

Goals: Meet as a team to discuss recent accomplishments and upcoming work.

Content:

- IRB
  - Got feedback from IRB that we should submit a “non-protocol” application
    - This would involve removing the one that we already submitted
    - AI: everyone read over the new IRB application so we can submit it by Monday
- Outreach:
  - We should potentially try out the activity before we do it
    - There were some small discrepancies in the kit
    - Make sure that everything is working out well
  - We need to make a presentation talking about BME for the students
    - AI: start working on this in about 2 weeks
- Resistance dial/mechanism:
  - Tim took the housing off of the rowing machine
  - As a team, we discussed potential placement points for the stepper motor
    - We are thinking we can place it at a different point to create a new point of rotation
- SolidWorks for pulley plates and stabilization frame:
  - Josh was able to send the pulley plates off to Staci
    - She made a few changes, but said that they would be able to fabricate it
    - This will be made out some Aluminum alloy
  - We won’t be exactly sure what will happen with the motor box until we design the resistance mechanism
  - Stabilization frame:
    - AI: will build out the pin-adjustment mechanism to include an upper “rest” position with a physical stop

Conclusions/action items:

- Action items:
  - everyone read over the new IRB application so we can submit it by Monday
  - start working on this in about 2 weeks for BME outreach presentation
  - will build out the pin-adjustment mechanism to include an upper “rest” position with a physical stop

02/17/2023 Electronics Team Meeting

Roxi Reuter - Feb 18, 2023, 8:08 PM CST

Title: Team and Advisor Meeting

Date: 02/17/2023

Content by: Roxi Reuter

Present: Tim, Annabel, Roxi

Goals:

- Discuss plan of action for electronics part of resistance dial design
- Review Annabel's code and ask questions

Content:

Electronics Meeting

- Annabel showed us the code for the resistance dial which she has so far
- We have a list of materials to purchase, but we need to weigh out pros and cons of using off-brand materials (cheaper) vs. name brand (like Arduino, but the downside is that these products are more expensive) for our project purposed
    - Last semester, we bought an off-brand Arduino to use for the electronics (console rotation), but the off-brand board ended up breaking, so we have to buy a new one
- In the coming weeks, we will schedule a time for Annabel, Tim, and me to meet to go over code, troubleshooting, and learn more about the electronics in general
    - Until then, we should compile a solid list of materials with purchasing links and figure out how we can make purchases through JHT

Conclusions/action items:

The resistance dial is still a work in progress, but the team has split into subgroups (motor placement and electronics) to tackle this design challenge. Today, we mainly looked through Annabel's code and asked questions where they came up since Tim and I are still learning the ins and outs of electronics. We also planned things we can do within the next few weeks, including thinking of edge cases that may or may not be addressed in the code and compiling a list of materials and sources. In the coming week, we will continue working on individual assignments, review the IRB application and outreach materials, and start working on the journal article. We will reconvene next week for our team, advisor, and client meetings.

02/21/2023 Brainstorming for Resistance Mechanism Stepper Motor

SAMUEL SKIRPAN - Feb 21, 2023, 2:53 PM CST

Title: Brainstorming for Resistance Mechanism Stepper Motor

Date: 2/21/23

Content by: Sam

Present: Sam and Josh

Goals: Examine the rowing machine for potential connection locations for the stepper motor

Content:

- What we did:
    - Brainstormed potential location of the stepper motor in the assembly for the resistance mechanism
    - Examined the taken apart rowing machine and looked for best place to place stepper motor
    - We can potentially use the existing connection mechanism for the magnets, but just move it to the base of the rowing machine
    - We can make the shaft of the stepper motor longer such that it can be placed a little bit further away from the centerline of the rowing machine

Conclusions/action items:

We beleive we will place the stepper motor at the front side/base of the rowing machine. This is where we have sufficient space to fit it.

Action items:

- Josh to email Staci to get the SolidWorks for the magnet piece
- Sam to measure the angle of the magnets turning for each dial turn
- Josh and Sam will begin drafting model for stepper motor at the base of the rowing machine
- Eventually figure out where we will put the arduino and other electronics

02/21/2023 Team Meeting

Roxi Reuter - Feb 21, 2023, 8:59 PM CST

Title: Team Meeting

Date: 02/21/2023

Content by: Roxi Reuter

Present: Sam, Tim, Josh, Annabel, Roxi

Goals:

- Divide up journal article
- Update team on progress of subteams (motor placement and electronics for resistance dial)

Content:

- Josh mentioned his updates to the pulley plate and antler SolidWorks model
  - He is in contact with Staci over modifications to the thickness of the design since the fabrication costs are expensive
- Sam is still working on his pin adjustment SolidWorks model
- Sam and Tim also did work on the motor placement for the resistance dial mechanism today (move the entire housing and screws to the opposite side of the wheel where there is more room)
- Tim, Annabel, and I cannot purchase our electronics materials for the resistance dial yet because we need JHT to purchase items for us this semester since the reimbursement process is a little different now
- The team also discussed the journal article. Annabel was kind enough to go ahead and make a section in our shared Google Drive with template information from our selected journal
  - After going through the journal sections, we have a number of clarification questions for the expectations for some sections
  - We will ask Tracy about these during our next advisor meeting on Friday (02/24).
  - Appendices will be super simplified (for example, one paragraph talking about work from BME 301)
- We divided up the journal article and have a plan to meet next Monday (02/27) after 7:30PM

Conclusions/action items:

The team met briefly to split up the journal article work. The preliminary article is due next Wednesday (03/01) at 11:59PM. Our next team meeting will be in person in ECB on Friday, February 24 at 12:45PM with advisor and client meetings to follow. In the meantime, each member should continue working on their assigned project tasks and start working on the journal article.

02/28/2023 Journal Article Editing Meeting

ANNABEL FRAKE - Feb 28, 2023, 9:59 PM CST

Title: 02/28/2023 Journal Article Editing Meeting

Date: 02/28/2023

Content by: Annabel Frake

Present: Annabel, Roxi, Josh, Sam, Tim

Goals:

- receive update on what I missed last Friday / project updates
- edit journal article and new appendices
- set up time to create outreach slides and practice experiment
- preliminary notebook, peer evals

Content:

- Team updates
    - Antlers
        - Josh met with Staci yesterday to finish editing antlers
        - Staci doesn't know when it will be done
    - Stabilization frame
        - Staci has it but hasn't looked at it yet
    - meetings went well last Friday
- edited journal article and appendices
- outreach project - things to do
    - need to get materials sorted out ASAP because Tracy can order them for us, but she doesn't have prime
    - confirm date for visit with school
    - outreach slides
        - shouldn't be too long because don't have that much time with them
    - confirm that outreach project works

References: none

Conclusions:

During tonight's meeting, the team updated me on the adivsor and client meetings I missed last Friday. We also shared brief updates on the SolidWorks portions of the design. The majority of the meeting was spent editing the preliminary journal article. Please see "Preliminary Journal Article" under the Project Files folder. We will meet on Friday to confirm details for the outreach project.

Action items:

1. Josh - download and upload preliminary journal article
2. Sam - upload preliminary journal article to website
3. All - feedback fruits peer evals (due Friday)

4. All - meet Friday at 12:30pm before advisor meeting (plan for outreach)

3/3/2023 Team / Advisor Meeting

Tim TRAN - Mar 03, 2023, 1:50 PM CST

Title: 3/3 Team Meeting

Date: 3/3/2023

Content by: Tim

Present: Team

Goals: Document team discussion

Content:

- Hashed out outreach logistics/materials
- Edits to IRB
- Will reach out to Dr. Willie again to talk about EMG and test participants

Advisor meeting

- Meeting next Friday will be on zoom
- Comments on IRB
    - Reformating consent form
    - Dr. P has resolved some comments
- Pulley plates done - official!
    - SolidWorks simulation oversaw by Staci
        - lowered max force threshold - took forces from BME 301 tension data
        - PDS updated
        - need safety factor higher than 1
    - Can pick up after spring break
    - one piece of sheet metal - laser cut
        - bent after the cut
    - Added truss to the antlers to add support
        - will be welded on
- Materials purchasing
    - Annabel and Roxi purchased Arduninos from MakerSpace
        - Check in with Staci before purchasing more
- Outreach
    - The sooner the better to confirm materials for Tracy to purchase
        - Team will meet next week to run through activity
    - Send photo release form to Mr. Ropa
        - photos for tracy to write report on outreach
            - photos of children doing the activity

Conclusions/action items:

TO DO

confirm materials and send to tracy

Outreach slides - finish over spring break / do together next Friday

Outreach practice - Monday 5:00 PM-5:30 PM. Before monday: look over outreach activity instructions

reach out to the wheelchair basketball team for test participants - early April testing

madcitywheelchairsports@gmail.com

03/06/2023 Outreach Practice

Roxi Reuter - Mar 06, 2023, 9:23 PM CST

Title: Outreach Activity Meeting

Date: 03/06/2023

Content by: Roxi Reuter

Present: Sam, Josh, Annabel, Tim, Roxi

Goals:

- Go through outreach activity and confirm material quantities

Content:

- We went over the outreach activity, and that did not take very much time
  - We ran into a slight issue since we only had about 1.5V of power from 3 potatoes, and the LED required 3V
- Conclusion:
  - Order 1.5V LEDs
  - Increase potatoes to 5/group
    - This also affects quantities of alligator clips, pennies, and nails

Conclusions/action items:

Today's meeting was very brief to get a feel for the outreach activity. We did not get the LED we had to light up because it was a 3V LED, but we found 1.5V LEDs online. We will be changing material quantities and sending the list to Dr. TJ Puccinelli today or tomorrow.

03/10/2023 Work on Outreach Slides

SAMUEL SKIRPAN - Mar 10, 2023, 2:30 PM CST

Title: Work on Outreach Slides

Date: 3/10/23

Content by: Sam

Present: Sam, Josh, Annabel, Roxi, Tim

Goals: Work on outreach slides.

Content:

- Everyone went around and shared updates
    - Roxi was able to resubmit the IRB application
    - Sam drove the lap pad to JHT for fabrication
    - All parts of been acquired for the resistance dial mechanism
        - Everything should be functioning by the end of spring break
- Resistance dial
    - How will we attach the buttons and where will the wires go?
        - We will first do our testing to make sure it works, functionally, then we will see where things can be placed space wise
- Outreach slides:
    - The team began working on the outreach slides
        - Background on BME
        - Overview of electronics
        - Overview of the potato activity
        - What materials and objectives are
        - Activity procedure
        - THANKS slide

Conclusions/action items:

The team met to work on the outreach slides and include detailed procedures for the kids to follow.

Action items:

- Action items:
    - Send a quick email to Dr. Nimunkar about using multimeters for outreach
    - Finish up the outreach slides
    - Reach out to 310 TAs for multimeters
    - Josh is working on the modeling of the Resistance Mechanism model
    - Everyone will try to collect pennies
    - Annabel will continue working on the circuit

03/14/2023 Resistance Mechanism Modeling

ANNABEL FRAKE - Mar 14, 2023, 11:40 AM CDT

Title: 03/14/2023 Resistance Mechanism Modeling

Date: 03/14/2023

Content by: Annabel Frake

Present: Annabel, Josh

Goals: talk through Josh's current model

Content:

- Josh showed me the current model
- using press fit for connection to motor again
- talked about the difference in shaft diameter and that the stepper motor had to be that far out to avoid hitting the metal frame
- he will add threads to end for nut
    - even if 3D printer doesn't do threads well, should be able to clear out threads when screwing nut on and/or MakerSpace or TeamLab may have a threader to do that for us
- Josh doesn't think that the fixture will fall in either direction when the power is off, but hard to tell until we have it all in place in person
    - will make stop block on backside that will also hold limit switch
- I showed Josh a picture of stepper motor bracket that I've used in the past in case it was helpful, but he thinks it will be easier to directly screw into the 3D printed electronics box
    - 
    - He will wait to do the electronics box until the placement of the fixture is confirmed
- goalposts need to have smaller diameter for piece that connects to console (was too loose last time) and smaller for press fit

References: none

Conclusions:

Josh asked to meet with me today to walk through his current modeling design for the resistance mechanism.

Action items:

1. Josh will print the resistance mechanism shaft and console goalposts after spring break

2. Josh will add a stop block to the resistance mechanism design so that the fixture can't fall back past resistance level 1 when the device is powered off (also convenient place to put limit switch)

03/21/2023 Team Meeting

ANNABEL FRAKE - Mar 21, 2023, 10:50 PM CDT

Title: 03/21/2023 Team Meeting

Date: 03/21/2023

Content by: Annabel Frake

Present: Annabel, Roxi, Josh, Sam, Tim

Goals:

Things to discuss:

- Outreach
  - Getting outreach materials from Tracy
  - Final run through of outreach project
  - Logistics of when and how we are getting to the school
- IRB
- Journal
- Integration
  - Antlers and frame from JHT
  - Purchase buttons?
- Testing
  - Where are we on participants?
- Executive Summary
- Ask Stacy about IP

Content:

- Spring break updates:
  - IRB Update
    - more comments
    - Roxi addressed them and resubmitted yesterday
    - reviewed sometime this week
  - design updates
    - Josh did 3D printing
    - had to reprint and chop off end so that it would screw on
    - stabilization frame delayed because higher priority project came up
      -
      - Staci will have update for us tomorrow
    - Staci still wants us to get antlers first in case we need to change something on it
  - journal article updates
    - Sam went through edits for prelim journal
      - some are bigger and need to be addressed as team
- Staci said she put enough money in MakerSpace account to pay for poster
  - not sure how to pay college library with money from MakerSpace?
- Outreach
  - Josh will drive on Friday

        - get there by 1:30 pm, leave from VP at 1:20pm
            - have meeting with Tracy at Josh and Sam's apartment before hand
            - also have Herald interview at 12:30pm?
    - slides
        - intro: each person introduce themselves
        - What is BME? (Annabel)
        - Activity Overview (Roxi)
        - Key term (Tim)
        - objectives and materials (Josh)
        - activity steps (Sam)
    - whenever we meet to go over activity once more, we should go through whole thing to make sure timing works
    - have kids answer worksheet questions on whiteboard?
- Testing
    - we need to set up time for wheelchair users to come in
    - Can we test it as long as it is functionally operational even if electronics box isn't done?
        - would that be something we need to note in journal article? Maybe ask Tracy
- Integration
    - need to order buttons
    - attachment site for buttons and display? Still thinking on this
    - we removed most of the cable mechanism, but have one more piece we can't get out at the moment
    - Josh tried the fit on his 3D prints and is going to make the proper adjustments
    - I showed everyone the circuit
    - we were able to get the stepper motor to move the magnet fixture (the shaft fit was too loose, so we had to tape it and it didn't work very well, but we did get the fixture to move)
- Interview with Badger Herald
    - ask to meet this Friday 12:30-1pm

References: none

Conclusions:

Today was a very productive meeting. We updated each other on the IRB status, logistics for the interview with Badger Herald, and spring break accomplishments. We figured out the logistics for the outreach activity this Friday in terms of when we are going and who is saying what. We started integrating the electronics and 3D prints, as well as thinking about final component positions. Based on our progress tonight, Josh thinks he can have the 3D designs printed by March 31st. We are waiting to hear back from JHT about when the stabilization frame will be done so that we can plan final testing and reply to the basketball team.

High Priority Action items:

1. Josh - 3D designs for resistance motor shaft, console goalposts, electronics box, and display encasements
2. Tim - email Rower team once we decide on a target week to test (waiting on reply from JHT)
3. Annabel - email Staci about buttons (if NO or NC and where they would be shipped)
4. Roxi - make outreach handout
5. All - put outreach presentation on flash drive before Friday and make sure to take photos of kids for Tracy

6. Get antlers from JHT

Low Priority Action items:

1. Sam, Tim, Roxi - discuss journal article comments
2. All - ask Staci about IP on March 31st
3. All - discuss Executive Summary on March 31st

Upcoming meetings:

- Friday, March 24th (meet at VP)
  - Interview with Badger Herald (12:30-1:00pm) - TENTATIVE
  - Meeting with Tracy (1:05pm-1:20pm) - TENTATIVE
  - Leave for outreach activity at 1:20pm

03/28/2023 Meeting Notes

ANNABEL FRAKE - Mar 28, 2023, 9:28 PM CDT

Title: 03/28/2023 Meeting Notes

Date: 03/28/2023

Content by: Annabel Frake

Present: Annabel, Roxi, Tim, Josh, Sam

Goals: touch base about post-outreach action items; work on design integration

Content:

- Post-Outreach action items
  - Tim - email Mr. Ropa the evaluation form
  - Josh & Tim - send pictures of outreach activity and outreach slides to Tracy
  - Sam - write reflection (let us know if you need help)
- Testing
  - Where are we going to get participants?
    - Tim - email basketball team to see if they know of other, similar organizations around Madison
    - Roxi - ask Prof Wille if she knows of anyone (reconnect with contacts that never responded)
    - Josh - email contact from JHT about testing participants
    - All - ask Tracy on Friday
- Integration
  - Stabilization frame TODO:
    - drill out holes for attachment (screws don't line up right)
    - add 1-2 more holes for pin angle adjustment
  - Antlers TODO:
    - all done
  - 3D printing TODO:
    - pick up lid
    - reprint resistance dial shaft with
    - drill out holes and attach electronics
  - Resistance Dial
    - drill holes in rower and attach
    - figure out where to place based on ImageJ
  - Electronics TODO:
    - cut wires to length

        - solder motor connection once wires cut to length

References: none

Conclusions:

Tonight, we touched base about action items for the upcoming week. We also worked on integrating the antlers and stabilization frame with the rower.

Action items:

1. Josh
    - email contact from JHT about testing participants
    - reprint resistance shaft press fit
    - collaborate with Sam to drill out holes in TeamLab (by weekend so Annabel can work on her stuff)
2. Josh & Tim - send pictures of outreach activity and outreach slides to Tracy
3. Tim
    - email Mr. Ropa the evaluation form (DONE)
    - email basketball team to see if they know of other, similar organizations around Madison (DONE)
4. Annabel
    - update code so resistance motor direction goes opposite way for initial resetting of resistance level (DONE)
    - cut wires to length and solder once final positions are determined
5. Sam
    - write outreach reflection (let us know if you need help)
    - collaborate with Josh to drill out holes in TeamLab
    - look at ImageJ files to figure out where we need to place the magnet fixture (by weekend so Annabel can work on her stuff)
6. Roxi
    - Ask Prof Wille if she knows of any potential participants (reconnect with contacts that never responded?)
7. All
    - Ask Tracy on Friday if she can send out a department wide email about testing participants (is that against IRB?)

ANNABEL FRAKE - Mar 28, 2023, 10:11 PM CDT

Download

IMG_7109.MOV (58.1 MB) Video of resistance dial working. Held in place by hand.

3/31/2023 Meeting Notes

Tim TRAN - Mar 31, 2023, 2:26 PM CDT

Title: Meeting Notes

Date: 3/31/2023

Content by: Tim

Present: Josh, Annabel, Roxi, Sam

Goals: Executive summary, integration

Content:

Motor housing is moved back to the original location. Need to correlate the resting position to resistance level one and make sure motor resistance level 10 matches up with the original level 10.

The stabilization frame has been secured onto the rower. The motor box has been secured onto the rower.

Staci will consult JHT's IP department.

Wheelchair participants - will email PT clinics referred to by Professor Wille. Staci will reach out to JHT's testing contact on Monday.

IRB requirements - EMG certifications/test subjects. Check with Dr. Wille to include her in the IRB application. Add her to the IRB application ASAP so she can read it over.

Do we need to wait for IRB approval to conduct testing? - **YES**

- What happens if testing stalls? Will get creative.
- Kinovea in case testing cannot get done in time.

Action items:

- Match up resistance levels
- Screw in motor for magnet housing
- Integrate electronics
- Test motor/magnet housing integrity when the flywheel is moving
- Attach block between antler and stabilization frame to reduce wobble

Conclusions/action items:

4/5/2023 - Team Fabrication of Resistance Dial Mechanism

Josh ANDREATTA - Apr 05, 2023, 12:29 AM CDT

Title: 4/5/2023 - Team Fabrication of Resistance Dial Mechanism

Date: 4/5/2023

Content by: Josh Andreatta

Present: Josh, Sam, Tim, Annabel

Goals: Fabricate Resistance Dial Mechanism

Content:

Today we met to work on the fabrication and integration of the resistance dial mechanism. We used the first press fit version of the motor-magnet connector and tried to hammer it onto the motor (the press fit was really tight, which is a good thing in the end, but it makes putting it on the motor difficult). We tried to get it just a little more on the motor shaft, and when we hit it one more time, it snapped. We used a heat gun to melt the plastic and then plied it off. Luckily, Josh had made a second copy of the connector piece incase the first one broke. The team very slowly and carefully hammered this one onto the motor shaft. Next, the motor-magnet assembly was screwed into the rower.

Once this was screwed in place, we tried to put on the 3D printed motor housing that we wanted to screw into the flat face on the rower as mentioned in a recent entry by Josh. However, the team realized that we would have slightly bend the structure to get it fit flush with that flat metal face. This would move the shaft of the motor slightly off center, so we came up with a different idea. Instead, we are going to utilize an existing hole on the magnet assembly to screw the housing into (see Josh/s 4/5/2023 entry for more detail). Josh will also order screws to attach the motor to the housing, since the TEAMLab does not have the right length of the screws that we need.

Next we tested the code to make sure that everything worked, and everything did! Even while rowing, the motor provided enough torque to keep the magnets from moving/slipping. We also tested the console rotation circuity and slightly adjusted the placement of the limit switches to make sure the console ended at a nice angle on each side of the rower. While testing, we noticed that sometimes, the motor would do really strange things, and sometimes the motor for the resistance mechanism would start to move, even though we weren't activating it. We figured out that the aligator clips attached to the console rotation motor would randomly touch while the circuit was on, causing a short circuit in the console rotation circuitry, which is why the motor was acting strangely at random times. We also realized that if enough of the aligator clips were touching the rower metal frame at one time, the metal frame was conducting the current and the resistance mechanism motor was using it to randomly turn on. This won't be an issue in the end because Annabel will solder the wires where the aligator clips are temporarily being used now. She will also add electrical insulation tape to ensure no short circuits can be made with the rower frame.

Overall, we were able to attach the resistance dial mechanism, come up with a plan for next steps for fabrication (fabrication and meeting to fabricate), and tested the electronics/code. We will meet again on Friday to attempt to finish fabrication, minus the soldering that Annabel will do over the weekend.

References: n/a

Conclusions:

Josh will work on adjusting the motor housing so that we no longer have to use the drill to drill into the metal rower frame. The team will meet again on Friday to attempt to finish fabrication using our new printed pieces, as well as find proper locations for the limit switches and buttons and secure them in place. We would like to have everything correctly attached, soldered, and organized by the end of the weekend.

Action items:

-Josh to adjust motor housing and print new motor housing, LCD display cover, and spare motor-magnet connector

-Josh to order M3 x 45mm screws to attach motor to housing

-Josh to assess fit and make adjustments if needed

-Meet friday to continue fabrication

-Annabel to solder and finish electronics integration over the weekend.

-Continue to wait to hear back from participants/IRB about testing plans.

04/07/2023 Fabrication of Motor Housing and Button and LCD placement

SAMUEL SKIRPAN - Apr 07, 2023, 3:51 PM CDT

Title: Fabrication of Motor Housing and Button and LCD placement

Date: 4/7/23

Content by: Sam

Present: Everyone

Goals: Continue fabrication of the final design and integration.

Content:

- Discussion on the IRB application
    - Might want to remove EMG material from the application and not do it overall because this seems to be an area where we have to continue updating and resubmitting
        - We can ask Tracy about this when we meet with her
- Team notebook
    - Need to add in survey and protocols to the team notebook
    - Also need to add in entries regarding the fabrication of the various design components
- Josh went down to the TEAM Lab to drill out some holes on the 3D printed parts
- As a team, we worked on the integration of the device
    - Attached the motor holder to the rowing machine
        - We ran into the problem of the stall torque of the motor not being large enough to keep the magnet housing in place
            - Possible solutions:
                - Change up our testing protocol such that users only row on one; but change the stroke rate to change difficulty
    - Brainstormed some ideas for the attachment of the buttons and the displays
        - Might drill out holes in the plastic for the placement of the buttons on the standard side
        - Will probably position the LCD displays on the antlers, back to back, with one facing each side
            - Talked about using a really long screw to hold them in place with respect to one another
            - Also would need to glue them to the antlers
                - Or potentially tape if necessary
- Annabel will then cut the wires to length over the weekend

Conclusions/action items:

As a team, we discussed some of the IRB to do items and were able to resubmit the application. Also, we were able to attach the LCD display to the rowing machine as well as figure out the location of the buttons. Annabel was able place all of the wires in their correct locations.

Action items:

- Cut wires to correct length
- Drill out plastic parts for placement of buttons

- Complete trainings (Josh, Sam, and Roxi)
- Brainstorm possible testing ideas if we do not get approval and ideas for the magnet housing movement

04/11/2023 Final Fabrication Meeting

Roxi Reuter - Apr 14, 2023, 1:05 PM CDT

Title: Final Fabrication Meeting

Date: 04/11/2023

Content by: Roxi Reuter

Present: Sam, Annabel, Roxi

Goals:

- Work on button placement and attempt to finish fabrication
- Troubleshoot the motor issue that we're running into

Content:

- Annabel has been working on checking connections and soldering wires. We have run into a slight issue with the motors, as sometimes we are having trouble with a faulty connection or something similar which causes the motors to improperly function.
- Sam brought out the drill that was checked out from the TEAM Lab to begin drilling holes for the buttons.
- We could not figure out the issue with the electronics and now an element is sparking, so Annabel might be redoing the whole board or working on a printed circuit board which will allow for more stable connections and (hopefully) fix the issue that we're running into
- Sam drilled holes for the buttons on the standard side buttons, and we attached those. The drilling process was a bit tedious since we should have used a medium-sized bit instead of going straight from a smaller bit to a larger one, and we had to file a little bit.
- When we drilled the holes on the adaptive side, the 3D-printed part by the antlers which has the motor box and connects to the console, the component cracked a little bit. We got the buttons attached, however, and we are going to add an extra support block so that no bending of the plastic component to which the adaptive buttons are connected occurs.
- Button wires were also attached (which connect back to the circuitry).

Conclusions/action items:

During this meeting, we got quite a bit of fabrication done! We drilled the holes for buttons and placed them, then interfaced them with the electronics. We are close to being completely done with fabrication. There are still a few issues with the electronics that Annabel is working on solving, but these will be fixed shortly before testing occurs.

04/14/2023 Team, Advisor, Client Meetings

Roxi Reuter - Apr 14, 2023, 2:42 PM CDT

Title: Team, Advisor, Client Meetings

Date: 04/14/2023

Content by: Roxi Reuter

Present: Sam, Josh, Tim, Annabel, Roxi

Goals:

- Finish up fabrication
- Work on finalizing testing plans

Content:

Team Meeting:

- We now have two wheelchair participants for testing!
- Annabel has been troubleshooting the electronics for a while, and she finally figured out the issues with the help of her lab mentor who has a PhD in electrical engineering.
    - The issues mainly came down to a broken wire and a broken jack on the power supply.
- We have been brainstorming ways to decrease movement of the magnets when rowing because there has been movement when rowing on increased resistance levels. Staci said that they use a similar motor for one of their bikes, and if we supply more current to the motor, there should be enough torque to prevent this rotation.
    - We tried this, but we were still seeing movement in the magnets when the stroke rate was higher while Sam was rowing.
    - To troubleshoot this problem, we have two springs which we'll attach to the magnet housing which will (hopefully) prevent this unwanted backward magnet movement during rowing.

Advisor Meeting:

- We have now IRB approval!! We do not have to resort our
    - Mention IRB approval in the executive summary, and add a brief summary of what the test participants are going to be doing.
    - For more executive summary space:
        - Put title in header
        - Change margin size
        - No space between paragraphs
- We updated Dr. Puccinelli on our spring idea for the magnet housing to prevent backward motion
- Josh updated Dr. Puccinelli on the
- Executive summary update: overall we are on track, but there are a few things that we need to take out.

Client Meeting:

- Staci explained the current idea with the motor and holding torque again. Although we tried this, we did not have much luck, so we are trying to add springs. Staci thinks that we will be fighting ourselves if we do this.
    - She said since we designed the system to work without the spring, there are adjustments that we will need to make to account for this change. She thinks that we will have issues on the low-resistance end.

- Staci said that they ran into this same issue on their indoor resistance bike at JHT, but it came down to the frequency that the electronic system checked the position of the motor and the current supplied to the motor. There had to be sufficient current supplied to the motor so that the maximum holding torque would be available.
- Staci said if we don't find a spring that works, don't worry about it. We are designing for the 80%, not the 20%.
- She suggested that we try rowing on the adaptive side to see if there is a similar movement issue.
    - There is not very much movement on the adaptive side because not enough force is generated without the use of legs.
    - The spring idea did not work.

Conclusions/action items:

Today's meeting was very productive! We finalized plans for testing now that we have IRB approval, and we will try to meet to do testing next week (both EMG with Dr. Wille and adaptive side testing). Final outreach activity materials are submitted, and we will be moving forward to executive summary changes, as well as final deliverables. We are excited to see what the remainder of the semester brings and for the future of this project.

4/17/23 Team Meeting With Professor Wille

Tim TRAN - Apr 18, 2023, 9:27 PM CDT

Title: Team Meeting With Professor Wille

Date: 4/17/23

Content by: Tim

Present: Team

Goals: Present ideas discussed by the team and Professor Wille

Content:

The first part of the meeting was dedicated to setting up the SpikerBox.

Professor Wille provided a resource for EMG lead placements. She ok'ed the team's idea of testing the bicep, latissimus dorsi, and deltoid, and recommended that we individually (using just 1 channel) test each muscle at resistance levels 1,4,7,10.

In order to compare EMG results between people, we would need to do a voluntary max contract to normalize the readings. Professor Wille added that we would make a box plot comparing maximum voltage peaks if we test multiple people, but also said it was ok to test 1 person.

Conclusions/action items:

Action item: conduct EMG testing on Tuesday 4/18

04/24/2023 Final Poster Work

SAMUEL SKIRPAN - Apr 24, 2023, 8:21 PM CDT

Title: Final Poster Work

Date: 4/24/23

Content by: Sam

Present: Everyone

Goals: Work final poster and check everyone's section.

Content:

- The team met today to discuss the poster and go through all of the comments that were left by one another
    - We all went through beforehand and left some comments for us to address as a team
- The main sections we spent time on improving were the problem statement, final design, testing, discussion, and future work
    - Improved person first language
    - Talked about the layout of the arrows for the final design section
    - Talked about the layout of the testing section
        - Include the number of participants for the testing
    - In discussion, called out things we needed to improve upon in positive light
    - Talked about specific things for improvement for future work
- Then did overall look over the poster as a team and individually for formatting and aesthetics

Conclusions/action items:

As a team, we met to work on the poster and go over the completed version. We addressed one another's comments and fixed up various portions of the poster.

Action Items:

- Meet with Tracy to go over the poster and to receive constructive criticism

4/27/23 Team Meeting

Tim TRAN - May 02, 2023, 5:52 PM CDT

Title: Team Meeting

Date: 4/27/23

Content by: Tim

Present: Team

Goals: Practice poster presentations

Content:

The team practiced their presentation script for both the 10-minute presentation and design excellence.

Conclusions/action items:

Action items: win design excellence!

05/01/2023 Journal Article Editing

Roxi Reuter - May 02, 2023, 7:46 PM CDT

Title: Final Journal Article Editing

Date: 05/01/2023

Content by: Roxi Reuter

Present: Josh, Tim, Sam, Annabel, Roxi

Goals:

- Make final edits to the journal article and submit it
- Contact Dr. TJ Puccinelli about setting up a time for our final advisor meeting

Content:

- We each edited the journal article individually, and we began addressing comments that we each made individually
    - This helped speed up the review process
- Things to-do:
    - Final peer and self reviews (Friday)
    - Look through feedback on poster presentation (Wednesday)
    - Update notebook (due Wednesday but update by tomorrow night)
        - Roxi - add updated consent form
        - Roxi - update with meeting notes and poster presentation work
    - Roxi - make invoice for JHT/Staci
- Josh will be emailing Staci to have a final meeting with her. We will talk about next steps for the project.
- We will also talk to Tracy about next steps for the journal article during our final advisor meeting, which we will work on setting up a time for with Dr. TJ Puccinelli.
    - We are aiming for Thursday evening (May 4, 2023).

Conclusions/action items:

We finished up our journal article during today's team meeting, and we turned it in. In terms of future work, we are waiting to discuss project continuation with Staci and Dr. TJ Puccinelli. We are working on scheduling final meetings with our client and advisor to have these discussions. In the meantime, we will finish reading poster reviews, finalize our team notebook, and complete peer and self evaluations. Additionally, I will be working on the invoice for JHT for reimbursement.

03/14/2023 Final Integrated Coding Flowchart

ANNABEL FRAKE - Mar 14, 2023, 7:23 PM CDT

Title: 03/14/2023 Final Integrated Coding Flowchart

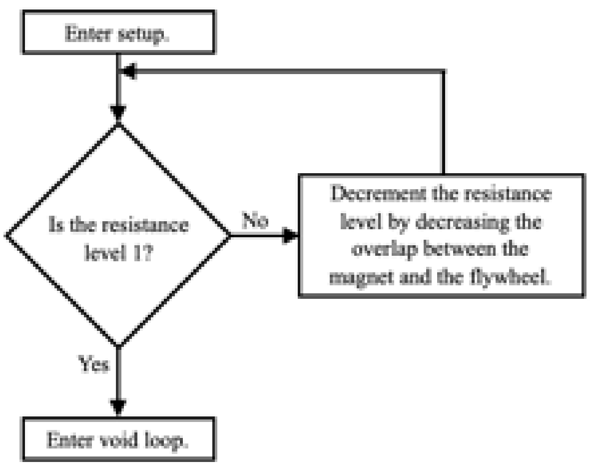
Date: 03/14/2023

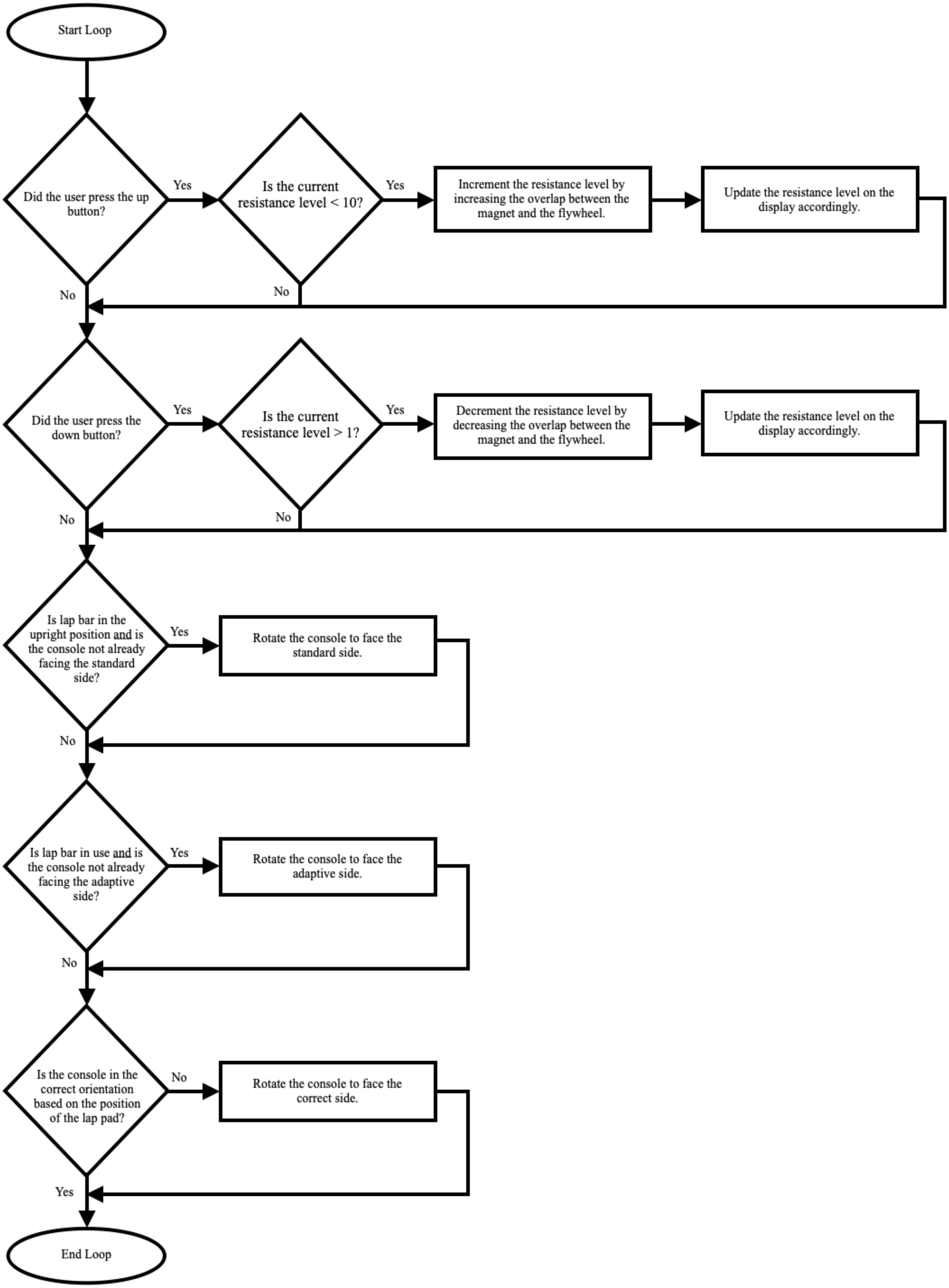
Content by: Annabel Frake

Present: Annabel Frake

Goals: integrate the console and resistance mechanism coding flowcharts

Content:




Start Loop
Did the user press the up button?
Yes
Is the current resistance level < 10?
Yes
Increment the resistance level by increasing the overlap between the magnet and the flywheel.
Update the resistance level on the display accordingly.
No
No
Did the user press the down button?
Yes
Is the current resistance level > 1?
Yes
Decrement the resistance level by decreasing the overlap between the magnet and the flywheel.
Update the resistance level on the display accordingly.
No
No
Is lap bar in the upright position and is the console not already facing the standard side?
Yes
Rotate the console to face the standard side.
No
Is lap bar in use and is the console not already facing the adaptive side?
Yes
Rotate the console to face the adaptive side.
No
Is the console in the correct orientation based on the position of the lap pad?
No
Rotate the console to face the correct side.
Yes
End Loop

References: none

Conclusions:

I integrated the coding flowcharts of the console mechanism and resistance dial mechanism. I also added the last decision diamond because it was not included in the console coding flowchart but is technically an if loop within void loop.

Action items:

1. include in the appendices of the journal article

03/14/2023 Final Integrated Circuit Schematic

ANNABEL FRAKE - Mar 14, 2023, 8:55 PM CDT

Title: 03/14/2023 Final Integrated Circuit Schematic

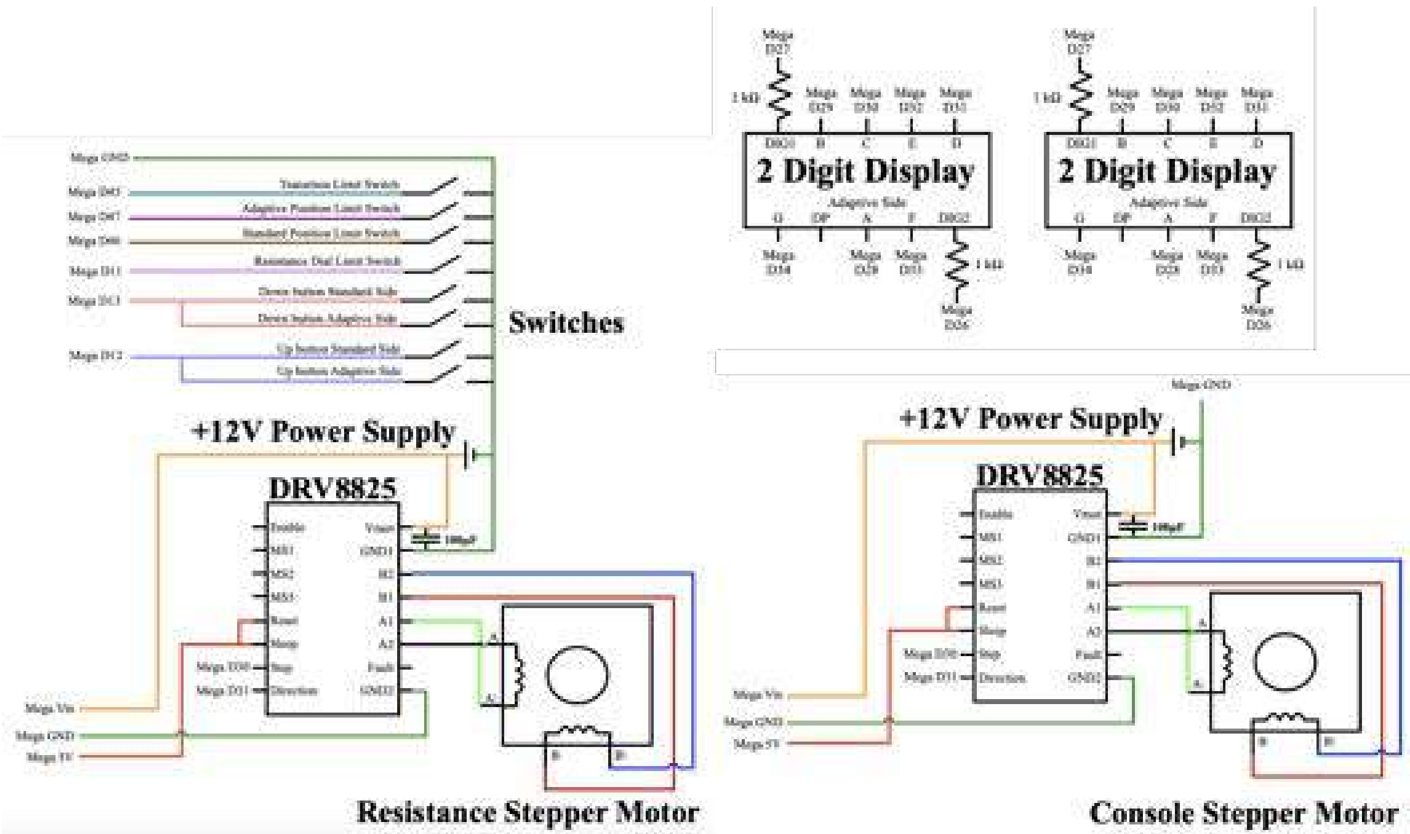
Date: 03/14/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: update the DRV8825 connections and integrate the console and resistance mechanism circuit schematics

Content:



Note: there is only one 12V power supply. It is drawn twice in the above schematic to make things more readable as apposed to crossing wires between motor circuits.

References: none

Conclusions:

I integrated the circuit schematics for the console and resistance dial mechanisms. I also updated the connections to the DRV8825.

Action items:

1. include in the appendices of the journal article

2. update any pins if necessary after final circuit fabrication

ANNABEL FRAKE - Mar 18, 2023, 4:08 PM CDT

Title: 03/18/2023 Updated Final Integrated Circuit Schematic

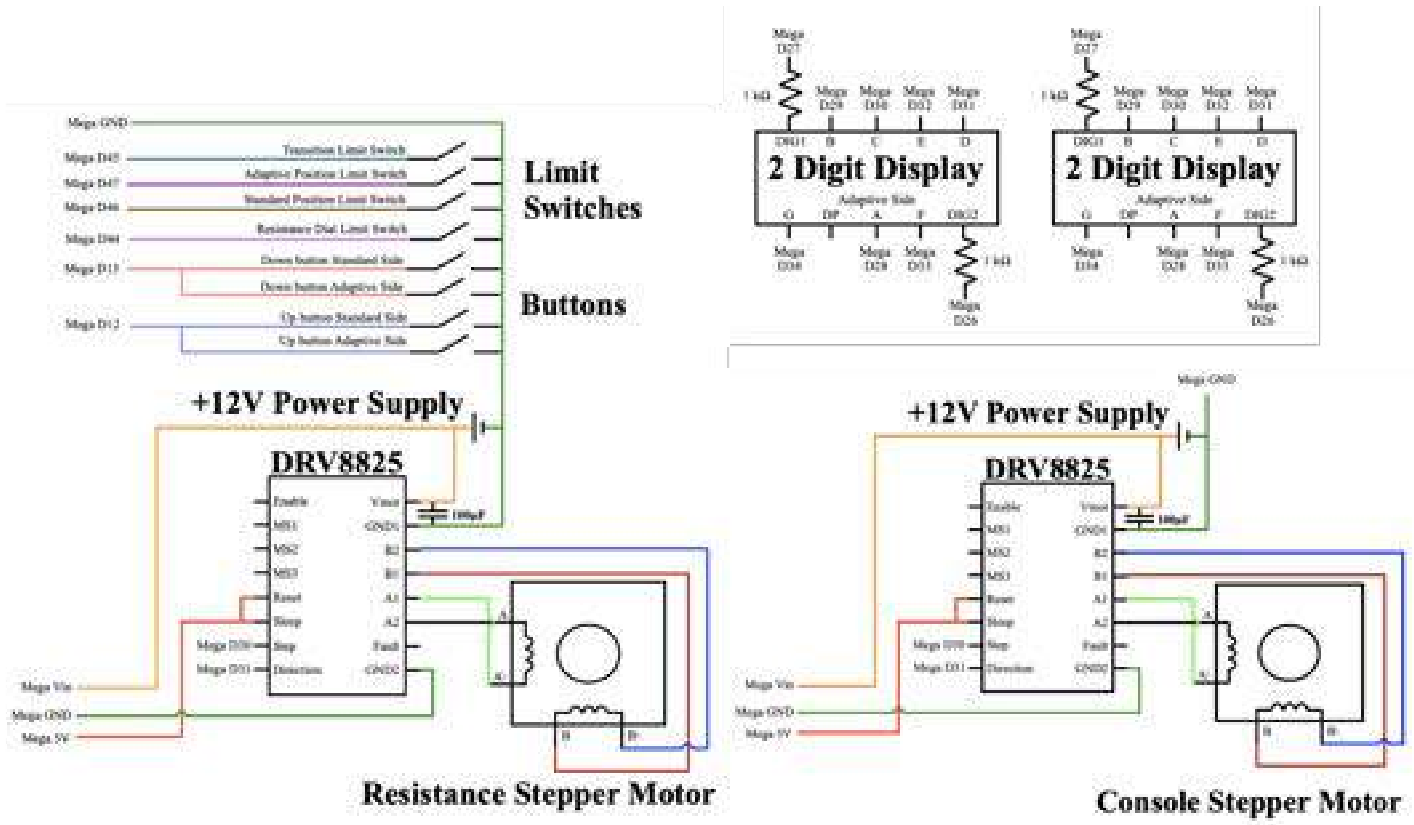
Date: 03/18/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: update the transition limit switch pin to D44 and change the "switches" label to "limit switches" and "buttons"

Content:



References: none

Conclusions:

I updated the circuit schematic to reflect changes I made during the fabrication process.

Action items: none

2/17/23 Material List for Resistance Dial Electronics

Tim TRAN - Feb 17, 2023, 11:22 AM CST

Title: Material List for Resistance Dial Electronics

Date: 2/17/23

Content by: Tim

Present: Tim

Goals: Compile materials needed to set up electronics for altering the resistance dial

Content:

Common anode 2 digit 7 segment: LINK

Common cathode 2 digit 7 segment: LINK

Up and down arrow buttons: not sure if these exist. We could buy big circular buttons and 3D print arrows that fit over the buttons.

Arduino Mega:

Budget board ($20): LINK

Official Arduino board ($49): LINK

Screw terminal block - fits on top of the Arduino mega with pins - should fit on the budget board as they are the same size and by the look of the pictures, same pin locations. LINK

Conclusions/action items:

The cost to purchase everything will be $88 (official board) or $59 (budget board)

Expense Sheet

Roxi Reuter - Apr 20, 2023, 3:48 PM CDT

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BPAG_Expense_Spreadsheet_Updated_04_19.xlsx (33.2 kB)

Receipts 2023

Roxi Reuter - Mar 29, 2023, 1:32 PM CDT

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Roxi Reuter - Apr 20, 2023, 3:47 PM CDT

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Final Schematic

ANNABEL FRAKE - Apr 05, 2023, 10:33 PM CDT

Note: Please navigate to "Annabel => Design Ideas => Adaptive Resistance Mechanism" for a full accounting of the circuit design process.

ANNABEL FRAKE - Apr 05, 2023, 10:32 PM CDT

Title: Final Schematic

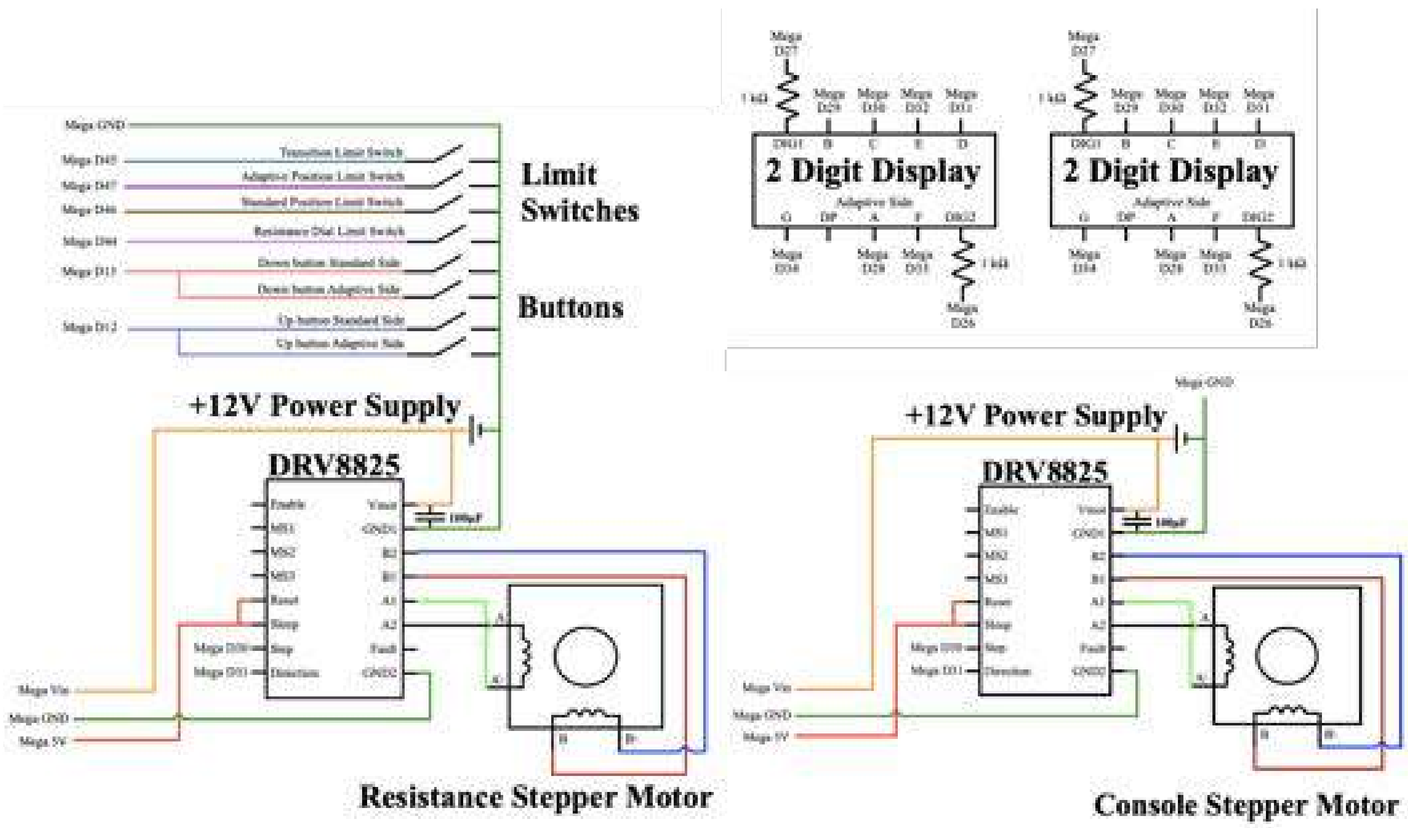
Date: 04/05/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: document final circuit schematic

Content:



References: none

Conclusions:

I created a final circuit diagram schematic using shapes within Pages (apple Word equivalent).

Action items:

1. include this in the journal article appendix

ANNABEL FRAKE - Apr 05, 2023, 10:33 PM CDT

Download

Integrated_Schematic.pages (574 kB)

Final Coding Flowchart

ANNABEL FRAKE - Apr 05, 2023, 10:37 PM CDT

Note: Please navigate to "Annabel => Design Ideas => Adaptive Resistance Mechanism" for a full accounting of the design process for the code.

ANNABEL FRAKE - Apr 05, 2023, 10:36 PM CDT

Title: Final Coding Flowchart

Date: 04/05/2023

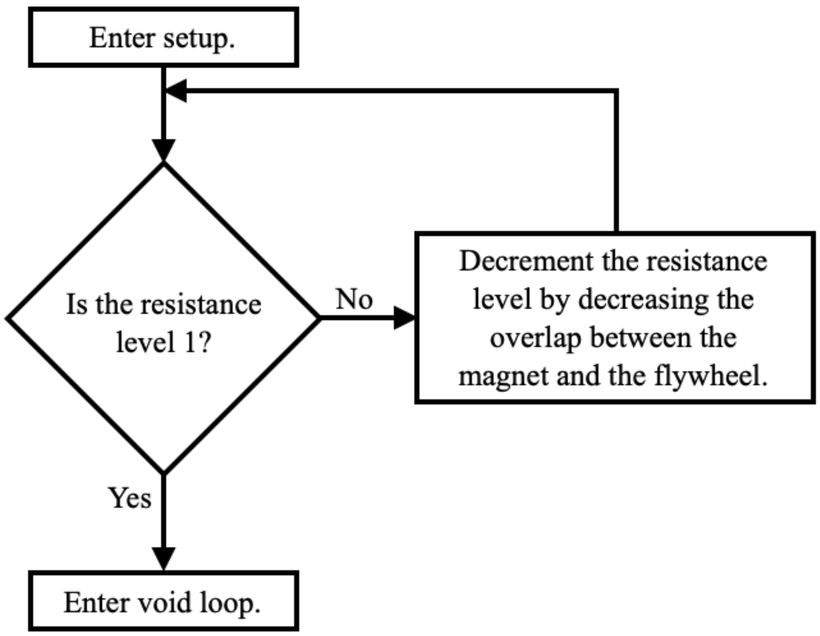
Content by: Annabel Frake

Present: Annabel Frake

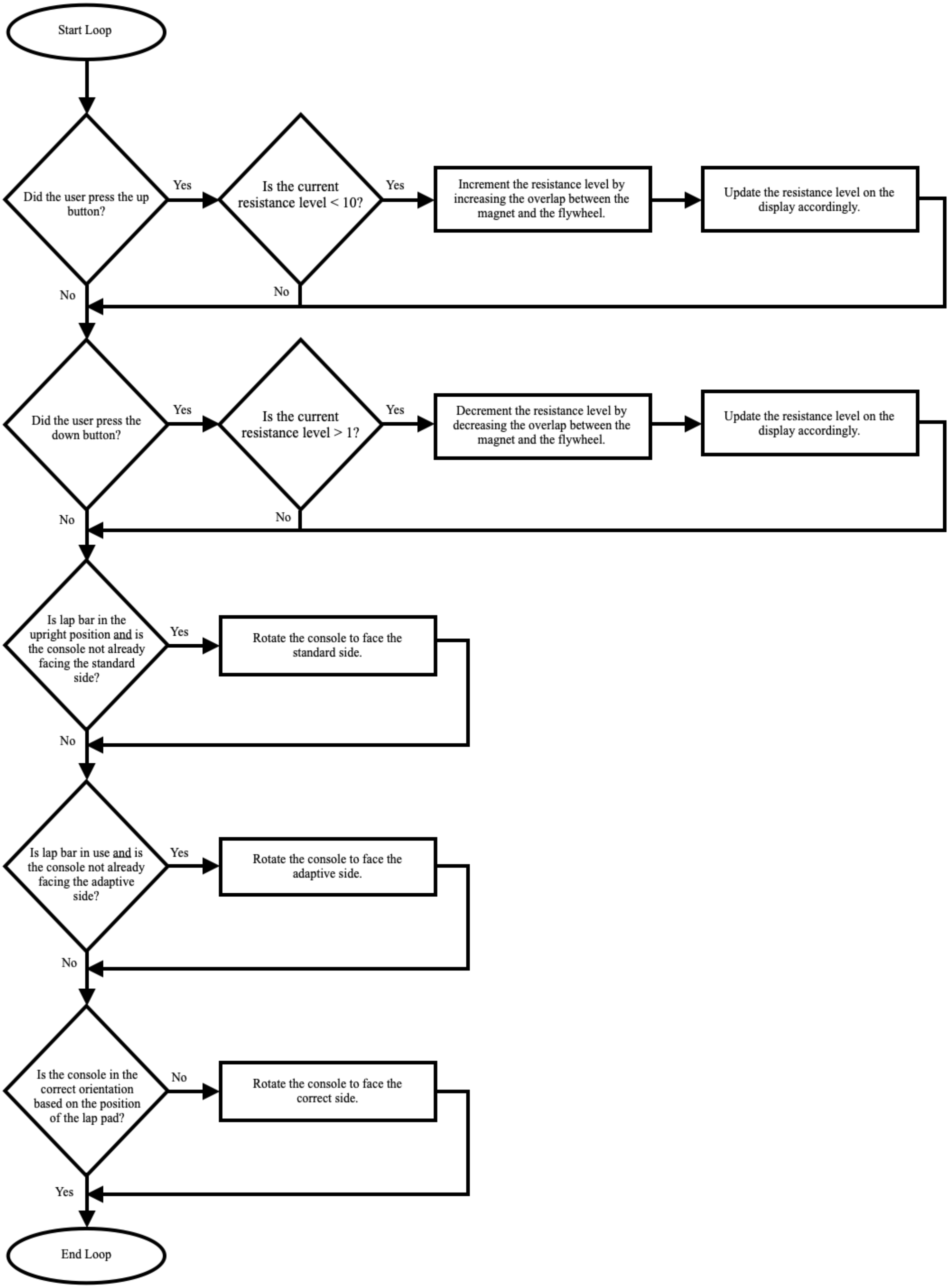
Goals: document the final coding flowchart

Content:

Setup Loop:



Void Loop:


Start Loop
Did the user press the up button?
Yes
Is the current resistance level < 10?
Yes
Increment the resistance level by increasing the overlap between the magnet and the flywheel.
Update the resistance level on the display accordingly.
No
No
Did the user press the down button?
Yes
Is the current resistance level > 1?
Yes
Decrement the resistance level by decreasing the overlap between the magnet and the flywheel.
Update the resistance level on the display accordingly.
No
No
Is lap bar in the upright position and is the console not already facing the standard side?
Yes
Rotate the console to face the standard side.
No
Is lap bar in use and is the console not already facing the adaptive side?
Yes
Rotate the console to face the adaptive side.
No
Is the console in the correct orientation based on the position of the lap pad?
No
Rotate the console to face the correct side.
Yes
End Loop

References: none

Conclusions:

I created a final coding flowchart schematic using shapes within Pages (apple Word equivalent).

Action items:

1. include this in the journal article appendix

Final Code

ANNABEL FRAKE - Apr 05, 2023, 10:36 PM CDT

Note: Please navigate to "Annabel => Design Ideas => Adaptive Resistance Mechanism" for a full accounting of the design process for the code.

ANNABEL FRAKE - Apr 05, 2023, 10:39 PM CDT

Title: Final Code

Date: 04/05/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: document the final code

Content:

```
// Written by:  Annabel Frake
// Class:       BME 402
// Purpose:     Rotate the console of a Matrix rowing machine between the standard and adaptive sides. Change the rowing resistance level (between 1 and 10) using up and down buttons. This change modifies the position of the magnet over the flywheel to change the rowing resistance level and updates identical 2 digit 7 segment displays that output the current resistance level.


// Include the necessary libraries.
#include "SevSeg.h"
#include <ezButton.h>;


// Declare digital pins for the up/down buttons. Note: there are two buttons for each, but they are tied to the same pin because their functionality is identical.
byte const upButtonPin = 12;
byte const downButtonPin = 13;


// Declare digital pins for the limit switches.
byte const resistanceLimitSwitchPin = 44; // This limit switch is placed near the magnet fixture such that, when it is depressed, the resistance level is 1.
byte const transitionSwitchPin = 45; // This limit switch is placed near the stabilization lap pad bar. When its state changes, the rower transitioned between adaptive and standard use or vice versa. When this limit switch is depressed, the console should be on the standard side and when it is not depressed, the console should be on the adaptive side.
byte const standardSwitchPin = 46; // This limit switch is placed near the console on the standard side. When it is pressed, the console is facing the standard user.
byte const adaptiveSwitchPin = 47; // This limit switch is placed near the console on the adaptive side. When it is pressed, the console is facing the wheelchair user.


// Define digital pins for the DIR and STEP features of the resistance mechanism stepper motor and console stepper motor.
byte const resistanceDirPin = 6;
byte const resistanceStepPin = 7;
byte const consoleDirPin = 8;
byte const consoleStepPin = 9;


// Create ezButton objects for the up and down buttons and the transition limit switch.
ezButton transitionSwitch(transitionSwitchPin);
ezButton upButton(upButtonPin);
ezButton downButton(downButtonPin);


// Create a SevSeg object for the display.
SevSeg sevseg;


// Define the number of steps for one increment of the stepper motor. Note: one rotation is achieved with 200 steps.
int stepsPerIncrement = 1; // Step - corresponds to roughly 3 degrees.
```

```
// Define the time delay for the manual PWM of the stepper motors.
int resistanceSpeedDelay = 30000; // microseconds
int consoleSpeedDelay = 30000; // microseconds


// Declare a variable for the resistance level. The resistance level is set to 1 at the beginning of
the program.
int resistanceLevel = 1;


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);


  // Set the stepper motor pinmodes to OUTPUT.
  pinMode(resistanceDirPin, OUTPUT);
  pinMode(resistanceStepPin, OUTPUT);
  pinMode(consoleDirPin, OUTPUT);
  pinMode(consoleStepPin, OUTPUT);


  // Set the limit switch pins to INPUT_PULLUP. Note: An internal pull-up 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(resistanceLimitSwitchPin, INPUT_PULLUP);
  pinMode(standardSwitchPin, INPUT_PULLUP);
  pinMode(adaptiveSwitchPin, INPUT_PULLUP);


  // Assign the up and down buttons and the transition limit switch with a debounce time of 50
milliseconds
  transitionSwitch.setDebounceTime(50);
  upButton.setDebounceTime(50);
  downButton.setDebounceTime(50);


  // Define pins for the two 2 digit 7 segment displays. Because they display the same output, they
are connected to the same digital out pins.
  byte numDigits = 2;
  byte digitPins[] = {27, 26}; // {D2, D1}
  byte segmentPins[] = {28, 29, 30, 31, 32, 33, 34}; // {A, B, C, D, E, F, G}


  // Define characteristics for the two 2 digit 7 segment displays.
  bool resistorsOnSegments = true;
  bool updateWithDelaysIn = true;
  byte hardwareConfig = COMMON_ANODE;
  sevseg.begin(hardwareConfig, numDigits, digitPins, segmentPins, resistorsOnSegments);
  sevseg.setBrightness(90);


  // Set the resistance level to 1.
  setResistance();
```

```
}


void loop()
{
  // Call the loop() function for the up and down buttons and the transition limit switch.
  upButton.loop();
  downButton.loop();
  transitionSwitch.loop();


  // If the up button is pressed and the resistance level is less than 10, increment the resistance
level. Note: .isReleased() must be used instead of .isPressed() or the code will implement twice.
  if (upButton.isReleased() && resistanceLevel < 10)
  {
    // Call the function that increments the position of the magnet over the flywheel.
    resistanceLevel = increment();


    Serial.print("Resistance level incremented to: ");
    Serial.println(resistanceLevel);
  }


  // If the down button is pressed and the resistance level is greater than 1, decrement the
resistance level. Note: .isReleased() must be used instead of .isPressed() or the code will
implement twice.
  if (downButton.isReleased() && resistanceLevel > 1)
  {
    // Call the function that decrements the position of the magnet over the flywheel.
    resistanceLevel = decrement();


    Serial.print("Resistance level decremented to: ");
    Serial.println(resistanceLevel);
  }


  // 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())
  {
    // Blank the displays so that they do not behave abnormally due to the delays within the motor
logic. Also signifies to the user that they cannot change the resistance during that time
    sevseg.blank();


    // 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())
```

```
  {
    // Blank the displays so that they do not behave abnormally due to the delays within the motor
logic. Also signifies to the user that they cannot change the resistance during that time
    sevseg.blank();


    // Call the function that rotates the console to face the adaptive side.
    rotateToAdaptive(adaptiveSwitchPin);
  }


  // If the transition limit switch state does not change, check the position of the console and
ensure it is in the correct orientation.
  else
  {
    //sevseg.blank();
    checkConsolePosition();
  }


  // Update the output of the display to accurately portray the current resistance level.
  sevseg.setNumber(resistanceLevel);
  sevseg.refreshDisplay(); // Refresh the display so that the change is registered.
}


// A function to rotate the magnet such that the resistance level is incremented once.
int increment()
{
  // Specify the direction the motor will rotate: counterclockwise.
  digitalWrite(resistanceDirPin, LOW);


  // Rotate the motor by stepsPerIncrement.
  for (int i = 0; i < stepsPerIncrement; i++)
  {
    // Manually perform PWM.
    digitalWrite(resistanceStepPin, HIGH);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
    digitalWrite(resistanceStepPin, LOW);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
  }


  // Increment the resistance level by one.
  return resistanceLevel += 1;
}


// A function to rotate the magnet such that the resistance level is decremented once.
int decrement()
{
  // Specify the direction the motor will rotate: clockwise.
  digitalWrite(resistanceDirPin, HIGH);
```

```
  // Rotate the motor by stepsPerIncrement.
  for (int i = 0; i < stepsPerIncrement; i++)
  {
    // Manually perform PWM.
    digitalWrite(resistanceStepPin, HIGH);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
    digitalWrite(resistanceStepPin, LOW);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
  }


  // Decrement the resistance level by one.
  return resistanceLevel -= 1;
}


// A function to set the resistance level to 1. Note: This code only implements once in void setup
to ensure that the resistance level is known when the program starts.
void setResistance()
{
  // Specify the direction the motor will rotate: clockwise.
  digitalWrite(resistanceDirPin, HIGH);


  // Rotate the motor in the specified direction until the limit switch is depressed, indicating a
resistance level of 1.
  while (digitalRead(resistanceLimitSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Manually perform PWM.
    digitalWrite(resistanceStepPin, HIGH);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
    digitalWrite(resistanceStepPin, LOW);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
  }


  Serial.println("Resistance Level Set to 1");


  // Update the output of the display to accurately portray the current resistance level.
  sevseg.setNumber(resistanceLevel);
  sevseg.refreshDisplay(); // Refresh the display so that the change is registered.
}


// 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(consoleDirPin, 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(consoleStepPin, HIGH);
    delayMicroseconds(consoleSpeedDelay); // Determines speed of stepper motor.
    digitalWrite(consoleStepPin, LOW);
    delayMicroseconds(consoleSpeedDelay); // Determines speed of stepper motor.
  }


  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(consoleDirPin, 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(consoleStepPin, HIGH);
    delayMicroseconds(consoleSpeedDelay); // Determines speed of stepper motor.
    digitalWrite(consoleStepPin, LOW);
    delayMicroseconds(consoleSpeedDelay); // Determines speed of stepper motor.
  }


  Serial.println("Console position: adaptive");
}


// A function that checks the current position of the console and corrects its orientation if a
discrepancy is detected.
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.
  {
    // Blank the displays so that they do not behave abnormally due to the delays within the motor
logic. Also signifies to the user that they cannot change the resistance during that time.
    sevseg.blank();


    // Call the function that rotates the console to face the standard side.
    rotateToStandard(standardSwitchPin);
  }
```

```
  // If the transition limit switch is 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.
  {
    // Blank the displays so that they do not behave abnormally due to the delays within the motor logic. Also signifies to the user that they cannot change the resistance during that time.
    sevseg.blank();


    // Call the function that rotates the console to face the adaptive side.
    rotateToAdaptive(adaptiveSwitchPin);
  }
}
```

References: none

Conclusions:

I used Arduino to generate the code for this project. This entry contains the final code implemented within the design.

Action items:

1. include this in the journal article appendix

ANNABEL FRAKE - Apr 05, 2023, 10:38 PM CDT

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final_code_spring_2023_bme_402.ino.ino (12.1 kB)

ANNABEL FRAKE - Apr 15, 2023, 11:29 AM CDT

Code updated on 04/13/2023 to change polarity of console motor after swapping out that component.

```
// Written by:  Annabel Frake
// Class:       BME 402
// Purpose:     Rotate the console of a Matrix rowing machine between the standard and adaptive
sides. Change the rowing resistance level (between 1 and 10) using up and down buttons. This change
modifies the position of the magnet over the flywheel to change the rowing resistance level and
updates identical 2 digit 7 segment displays that output the current resistance level.


// Include the necessary libraries.
#include "SevSeg.h"
#include <ezButton.h>;


// Declare digital pins for the up/down buttons. Note: there are two buttons for each, but they are
tied to the same pin because their functionality is identical.
byte const upButtonPin = 12;
byte const downButtonPin = 13;


// Declare digital pins for the limit switches.
byte const resistanceLimitSwitchPin = 44; // This limit switch is placed near the magnet fixture
such that, when it is depressed, the resistance level is 1.
byte const transitionSwitchPin = 45; // This limit switch is placed near the stabilization lap pad
bar. When its state changes, the rower transitioned between adaptive and standard use or vice versa.
When this limit switch is depressed, the console should be on the standard side and when it is not
depressed, the console should be on the adaptive side.
byte const standardSwitchPin = 46; // This limit switch is placed near the console on the standard
side. When it is pressed, the console is facing the standard user.
byte const adaptiveSwitchPin = 47; // This limit switch is placed near the console on the adaptive
side. When it is pressed, the console is facing the wheelchair user.


// Define digital pins for the DIR and STEP features of the resistance mechanism stepper motor and
console stepper motor.
byte const resistanceDirPin = 6;
byte const resistanceStepPin = 7;
byte const consoleDirPin = 8;
byte const consoleStepPin = 9;


// Create ezButton objects for the up and down buttons and the transition limit switch.
ezButton transitionSwitch(transitionSwitchPin);
ezButton upButton(upButtonPin);
ezButton downButton(downButtonPin);


// Create a SevSeg object for the display.
SevSeg sevseg;


// Define the number of steps for one increment of the stepper motor. Note: one rotation is achieved
with 200 steps.
int stepsPerIncrement = 1; // Step - corresponds to roughly 3 degrees.
```

```
// Define the time delay for the manual PWM of the stepper motors.
int resistanceSpeedDelay = 30000; // microseconds 30000
int consoleSpeedDelay = 30000; // microseconds


// Declare a variable for the resistance level. The resistance level is set to 1 at the beginning of the program.
int resistanceLevel = 1;


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);


  // Set the stepper motor pinmodes to OUTPUT.
  pinMode(resistanceDirPin, OUTPUT);
  pinMode(resistanceStepPin, OUTPUT);
  pinMode(consoleDirPin, OUTPUT);
  pinMode(consoleStepPin, OUTPUT);


  // Set the limit switch pins to INPUT_PULLUP. Note: An internal pull-up 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(resistanceLimitSwitchPin, INPUT_PULLUP);
  pinMode(standardSwitchPin, INPUT_PULLUP);
  pinMode(adaptiveSwitchPin, INPUT_PULLUP);


  // Assign the up and down buttons and the transition limit switch with a debounce time of 50 milliseconds
  transitionSwitch.setDebounceTime(50);
  upButton.setDebounceTime(50);
  downButton.setDebounceTime(50);


  // Define pins for the two 2 digit 7 segment displays. Because they display the same output, they are connected to the same digital out pins.
  byte numDigits = 2;
  byte digitPins[] = {27, 26}; // {D2, D1}
  byte segmentPins[] = {28, 29, 30, 31, 32, 33, 34}; // {A, B, C, D, E, F, G}


  // Define characteristics for the two 2 digit 7 segment displays.
  bool resistorsOnSegments = true;
  bool updateWithDelaysIn = true;
  byte hardwareConfig = COMMON_ANODE;
  sevseg.begin(hardwareConfig, numDigits, digitPins, segmentPins, resistorsOnSegments);
  sevseg.setBrightness(90);


  // Set the resistance level to 1.
```

```
  setResistance();
}


void loop()
{
  // Call the loop() function for the up and down buttons and the transition limit switch.
  upButton.loop();
  downButton.loop();
  transitionSwitch.loop();


  // If the up button is pressed and the resistance level is less than 10, increment the resistance
level. Note: .isReleased() must be used instead of .isPressed() or the code will implement twice.
  if (upButton.isReleased() && resistanceLevel < 10)
  {
    // Call the function that increments the position of the magnet over the flywheel.
    resistanceLevel = increment();


    Serial.print("Resistance level incremented to: ");
    Serial.println(resistanceLevel);
  }


  // If the down button is pressed and the resistance level is greater than 1, decrement the
resistance level. Note: .isReleased() must be used instead of .isPressed() or the code will
implement twice.
  if (downButton.isReleased() && resistanceLevel > 1)
  {
    // Call the function that decrements the position of the magnet over the flywheel.
    resistanceLevel = decrement();


    Serial.print("Resistance level decremented to: ");
    Serial.println(resistanceLevel);
  }


  // 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())
  {
    // Blank the displays so that they do not behave abnormally due to the delays within the motor
logic. Also signifies to the user that they cannot change the resistance during that time
    sevseg.blank();


    // 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())
  {
    // Blank the displays so that they do not behave abnormally due to the delays within the motor
logic. Also signifies to the user that they cannot change the resistance during that time
    sevseg.blank();


    // Call the function that rotates the console to face the adaptive side.
    rotateToAdaptive(adaptiveSwitchPin);
  }


  // If the transition limit switch state does not change, check the position of the console and
ensure it is in the correct orientation.
  else
  {
    //sevseg.blank();
    checkConsolePosition();
  }


  // Update the output of the display to accurately portray the current resistance level.
  sevseg.setNumber(resistanceLevel);
  sevseg.refreshDisplay(); // Refresh the display so that the change is registered.
}


// A function to rotate the magnet such that the resistance level is incremented once.
int increment()
{
  // Specify the direction the motor will rotate: counterclockwise.
  digitalWrite(resistanceDirPin, LOW);


  // Rotate the motor by stepsPerIncrement.
  for (int i = 0; i < stepsPerIncrement; i++)
  {
    // Manually perform PWM.
    digitalWrite(resistanceStepPin, HIGH);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
    digitalWrite(resistanceStepPin, LOW);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
  }


  // Increment the resistance level by one.
  return resistanceLevel += 1;
}


// A function to rotate the magnet such that the resistance level is decremented once.
int decrement()
{
  // Specify the direction the motor will rotate: clockwise.
  digitalWrite(resistanceDirPin, HIGH);
```

```
  // Rotate the motor by stepsPerIncrement.
  for (int i = 0; i < stepsPerIncrement; i++)
  {
    // Manually perform PWM.
    digitalWrite(resistanceStepPin, HIGH);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
    digitalWrite(resistanceStepPin, LOW);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
  }


  // Decrement the resistance level by one.
  return resistanceLevel -= 1;
}


// A function to set the resistance level to 1. Note: This code only implements once in void setup
to ensure that the resistance level is known when the program starts.
void setResistance()
{
  // Specify the direction the motor will rotate: clockwise.
  digitalWrite(resistanceDirPin, HIGH);


  // Rotate the motor in the specified direction until the limit switch is depressed, indicating a
resistance level of 1.
  while (digitalRead(resistanceLimitSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Manually perform PWM.
    digitalWrite(resistanceStepPin, HIGH);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
    digitalWrite(resistanceStepPin, LOW);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
  }


  Serial.println("Resistance Level Set to 1");


  // Update the output of the display to accurately portray the current resistance level.
  sevseg.setNumber(resistanceLevel);
  sevseg.refreshDisplay(); // Refresh the display so that the change is registered.
}


// 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(consoleDirPin, 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(consoleStepPin, HIGH);
    delayMicroseconds(consoleSpeedDelay); // Determines speed of stepper motor.
    digitalWrite(consoleStepPin, LOW);
    delayMicroseconds(consoleSpeedDelay); // Determines speed of stepper motor.
  }


  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(consoleDirPin, 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(consoleStepPin, HIGH);
    delayMicroseconds(consoleSpeedDelay); // Determines speed of stepper motor.
    digitalWrite(consoleStepPin, LOW);
    delayMicroseconds(consoleSpeedDelay); // Determines speed of stepper motor.
  }


  Serial.println("Console position: adaptive");
}


// A function that checks the current position of the console and corrects its orientation if a
discrepancy is detected.
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.
  {
    // Blank the displays so that they do not behave abnormally due to the delays within the motor
logic. Also signifies to the user that they cannot change the resistance during that time.
    sevseg.blank();


    // Call the function that rotates the console to face the standard side.
    rotateToStandard(standardSwitchPin);
```

```
  }


  // If the transition limit switch is 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.
  {
    // Blank the displays so that they do not behave abnormally due to the delays within the motor logic. Also signifies to the user that they cannot change the resistance during that time.
    sevseg.blank();


    // Call the function that rotates the console to face the adaptive side.
    rotateToAdaptive(adaptiveSwitchPin);
  }
}
```

ANNABEL FRAKE - Apr 15, 2023, 11:30 AM CDT

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Final Circuit Fabrication

ANNABEL FRAKE - Apr 05, 2023, 10:40 PM CDT

Note: Please navigate to "Annabel => Design Ideas => Adaptive Resistance Mechanism" for a full accounting of the fabrication process.

ANNABEL FRAKE - Apr 05, 2023, 11:18 PM CDT

Title: Final Circuit Fabrication

Date: 04/05/2023

Content by: Annabel Frake

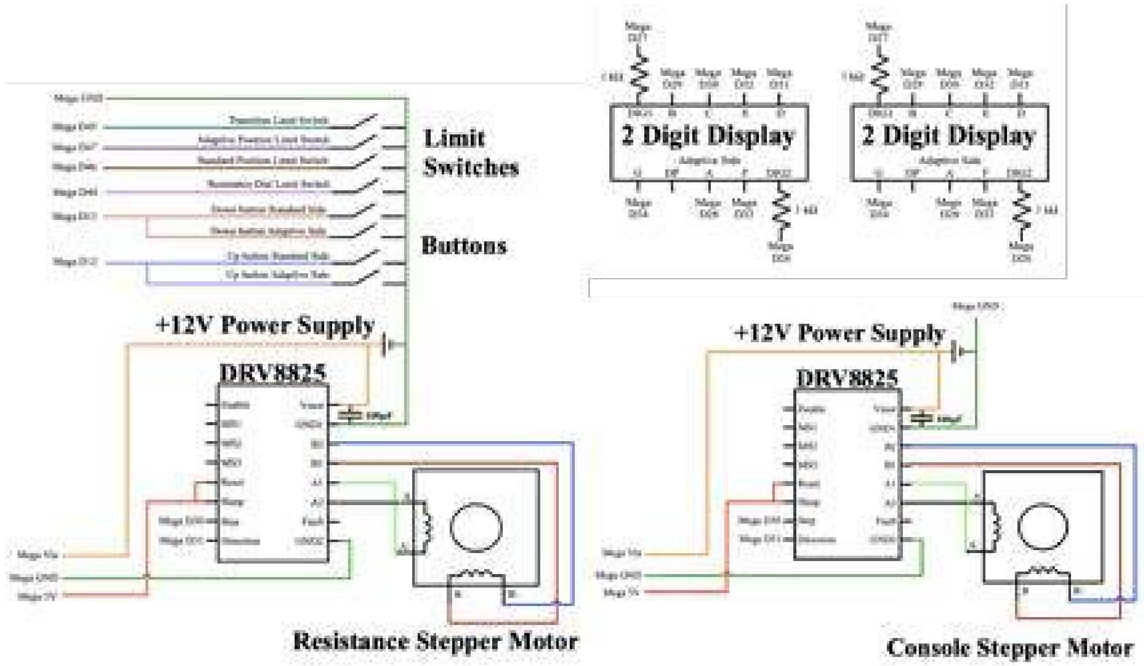
Present: Annabel Frake

Goals: describe the final circuit fabrication

Content:

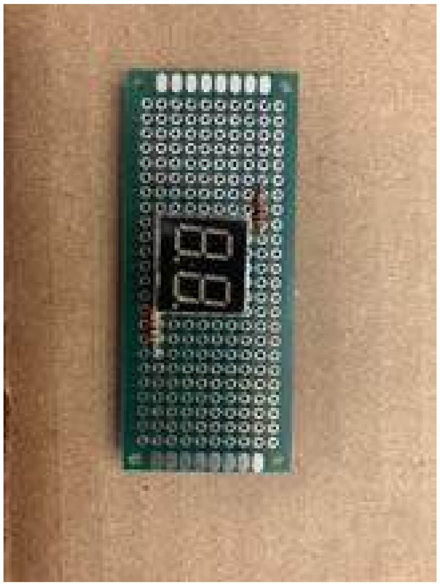
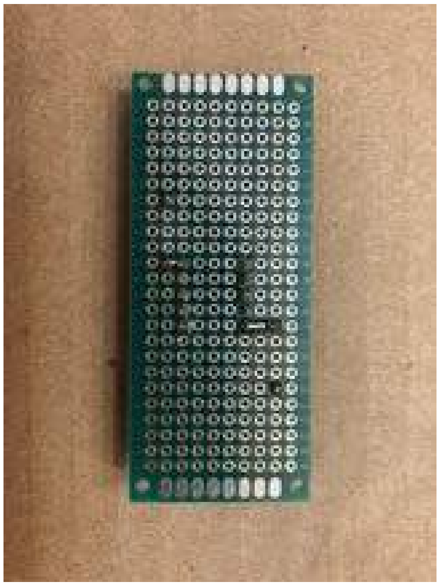
- Materials:
    1. Arduino Mega (sourced from MakerSpace)
    2. Arduino Mega screw terminal (https://www.amazon.com/Electronics-Salon-Prototype-Terminal-Arduino-MEGA-2560/dp/B00UT13YXA/?_encoding=UTF8&pd_rd_w=515re&content-id=amzn1.sym.08900ed4-dd64-49b1-bce7-2e717defb1aa&pf_rd_p=08900ed4-dd64-49b1-bce7-2e717defb1aa&pf_rd_r=E3NC4HWWT5XR5ET838K1&pd_rd_wg=7WWFP&pd_rd_r=6ea15391-f0d0-466a-9584-5be8ba7644bc&ref_=pd_gw_ci_mcx_mi)
    3. two DRV8825 (https://www.amazon.com/dp/B07XF2LYC8?psc=1&ref=ppx_yo2ov_dt_b_product_details)
    4. two NEMA 17 stepper motor (https://www.amazon.com/gp/product/B00PNEQI7W/ref=ppx_yo_dt_b_asin_title_o00_s00?ie=UTF8&psc=1)
    5. +12V power supply (https://www.amazon.com/gp/product/B07GFFG1BQ/ref=ppx_yo_dt_b_asin_title_o00_s00?ie=UTF8&psc=1)
    6. four NO limit switches (sourced from client)
    7. four push buttons (https://www.amazon.com/QCQIANG-Waterproof-Momentary-Mushroom-3V-220V/dp/B0B1PGMK9F/?_encoding=UTF8&pd_rd_w=515re&content-id=amzn1.sym.08900ed4-dd64-49b1-bce7-2e717defb1aa&pf_rd_p=08900ed4-dd64-49b1-bce7-2e717defb1aa&pf_rd_r=E3NC4HWWT5XR5ET838K1&pd_rd_wg=7WWFP&pd_rd_r=6ea15391-f0d0-466a-9584-5be8ba7644bc&ref_=pd_gw_ci_mcx_mi&th=1)
    8. two 2-digit 7-segment displays (https://www.amazon.com/uxcell-Common-Segment-Display-Digital/dp/B07GTQTD8S/?_encoding=UTF8&pd_rd_w=515re&content-id=amzn1.sym.08900ed4-dd64-49b1-bce7-2e717defb1aa&pf_rd_p=08900ed4-dd64-49b1-bce7-2e717defb1aa&pf_rd_r=E3NC4HWWT5XR5ET838K1&pd_rd_wg=7WWFP&pd_rd_r=6ea15391-f0d0-466a-9584-5be8ba7644bc&ref_=pd_gw_ci_mcx_mi&th=1)
    9. two 100 µFarad capacitors (sourced from BME spare materials room)
    10. four 1 kΩ resistors (sourced from BME spare materials room)
    11. three solder board (sourced from BME spare materials room and previous design projects)
    12. wires (sourced from MakerSpace)
    13. solder (sourced MakerSpace)
    14. heat shrink (sourced MakerSpace)
    15. electrical tape (personal stash)
- Tools:
    - Soldering iron
    - heat gun
    - wire strippers / cutters
    - small screw driver (flathead or Philips)

- USB cable

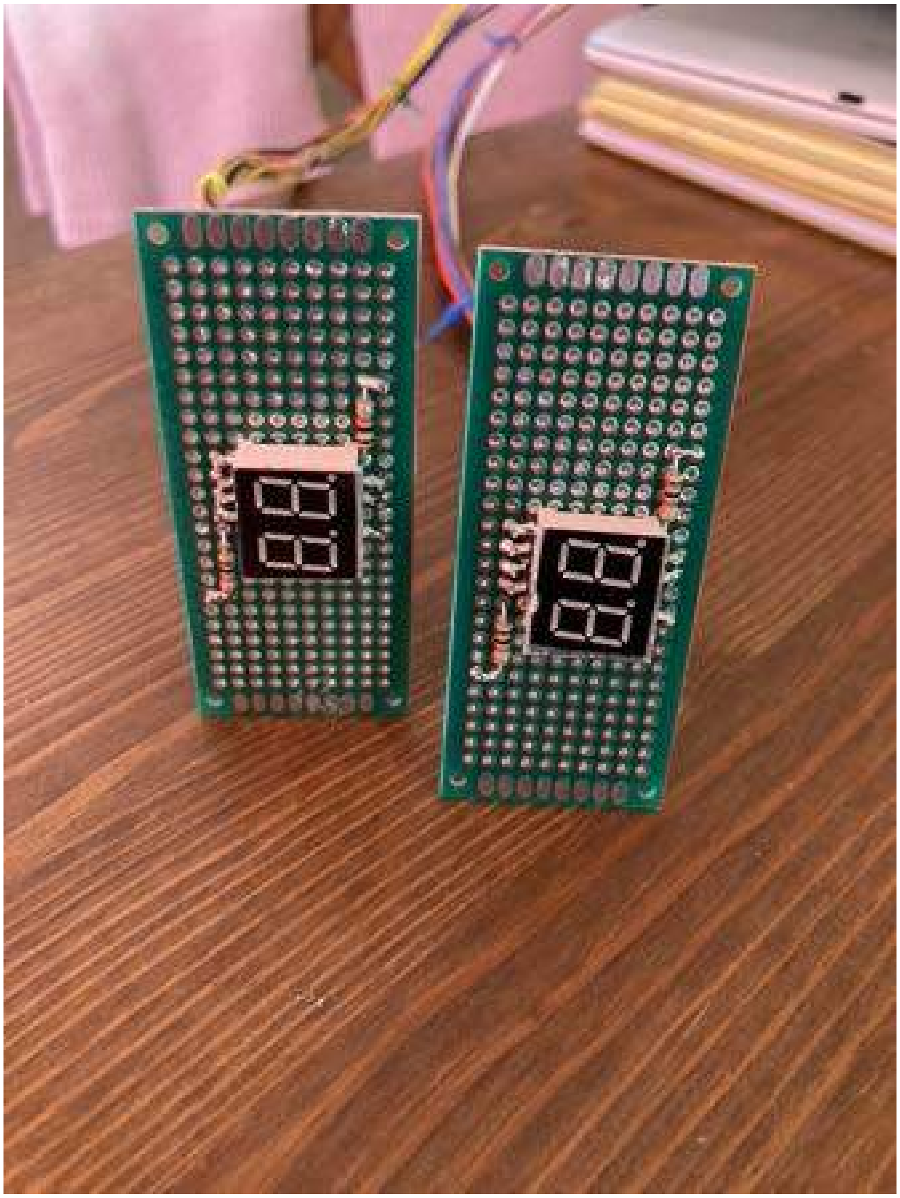
- Schematic:
  - 

- Procedure:
- ***Please refer to the schematic for specific wire connections and Mega pins***

1. Assemble the screw terminal fixture for the Mega
    1.  
2. Use two solder boards to create the connections for the 2-digit 7-segment displays
    1. Attach displays and resistors

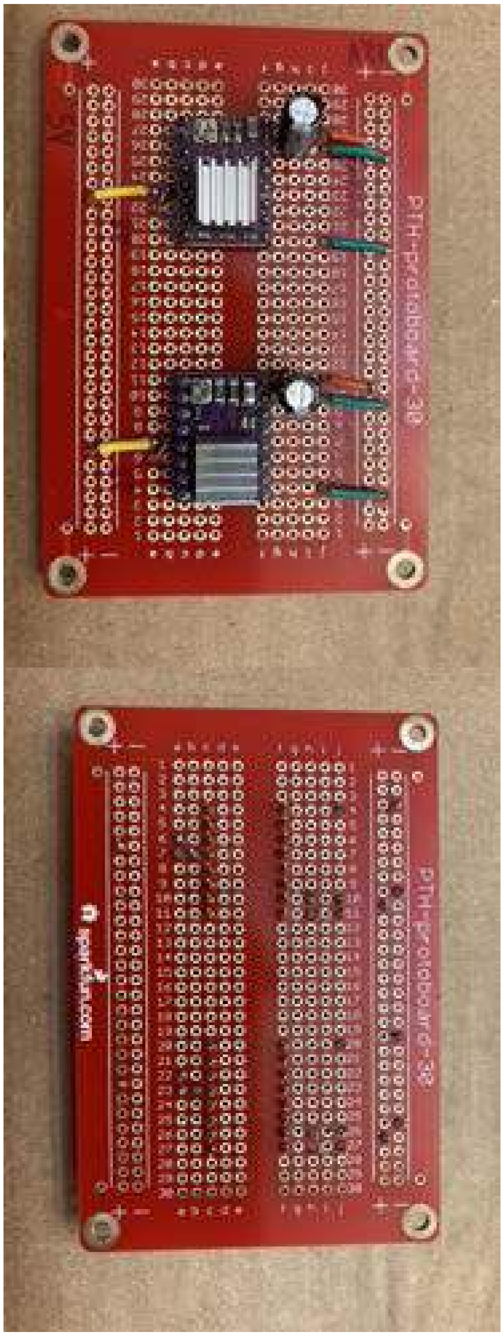
2.  

3. Attach wire connections to Mega

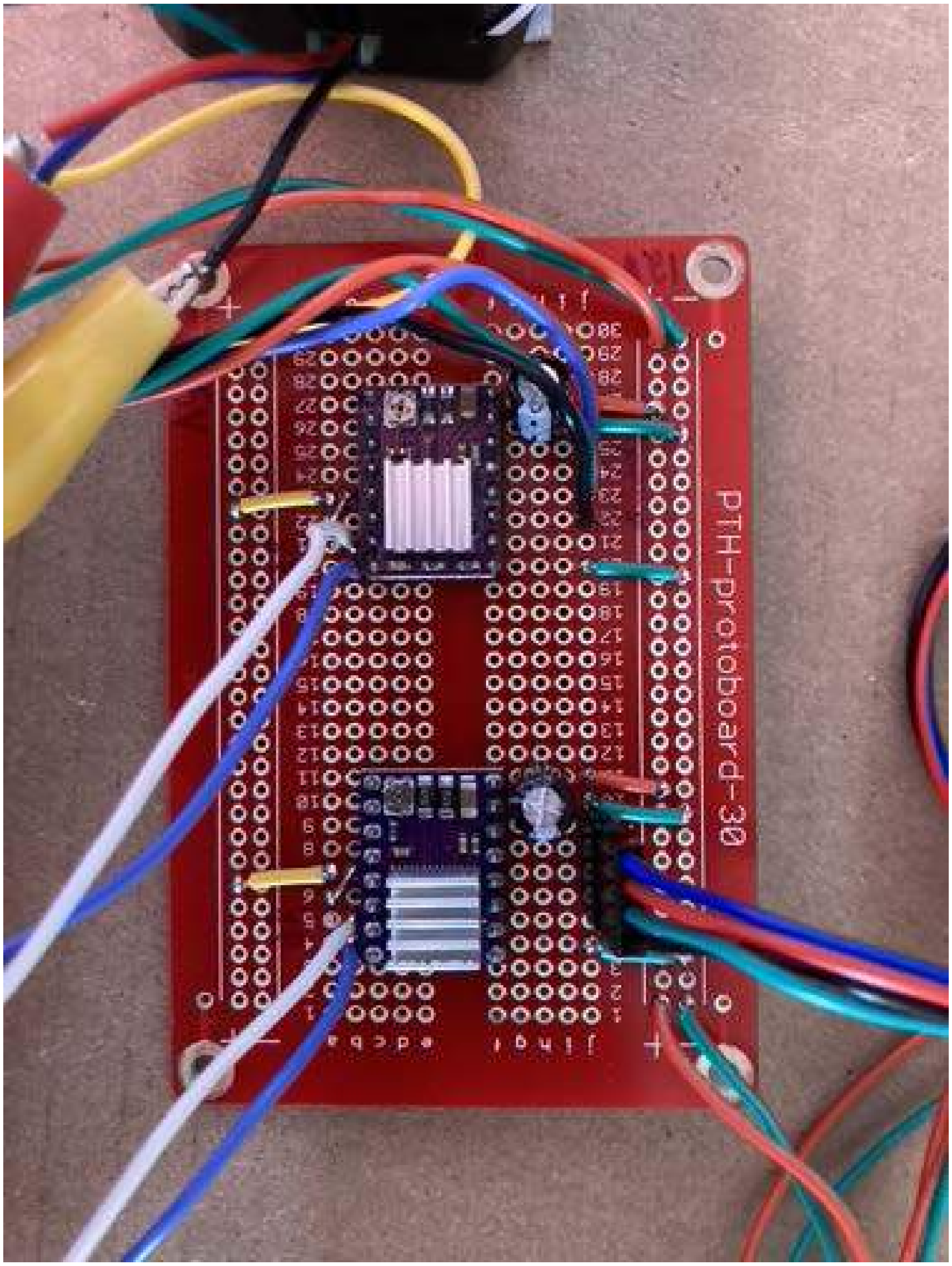
4. 

3. Use a solder board to create the connections for the DRV8825s

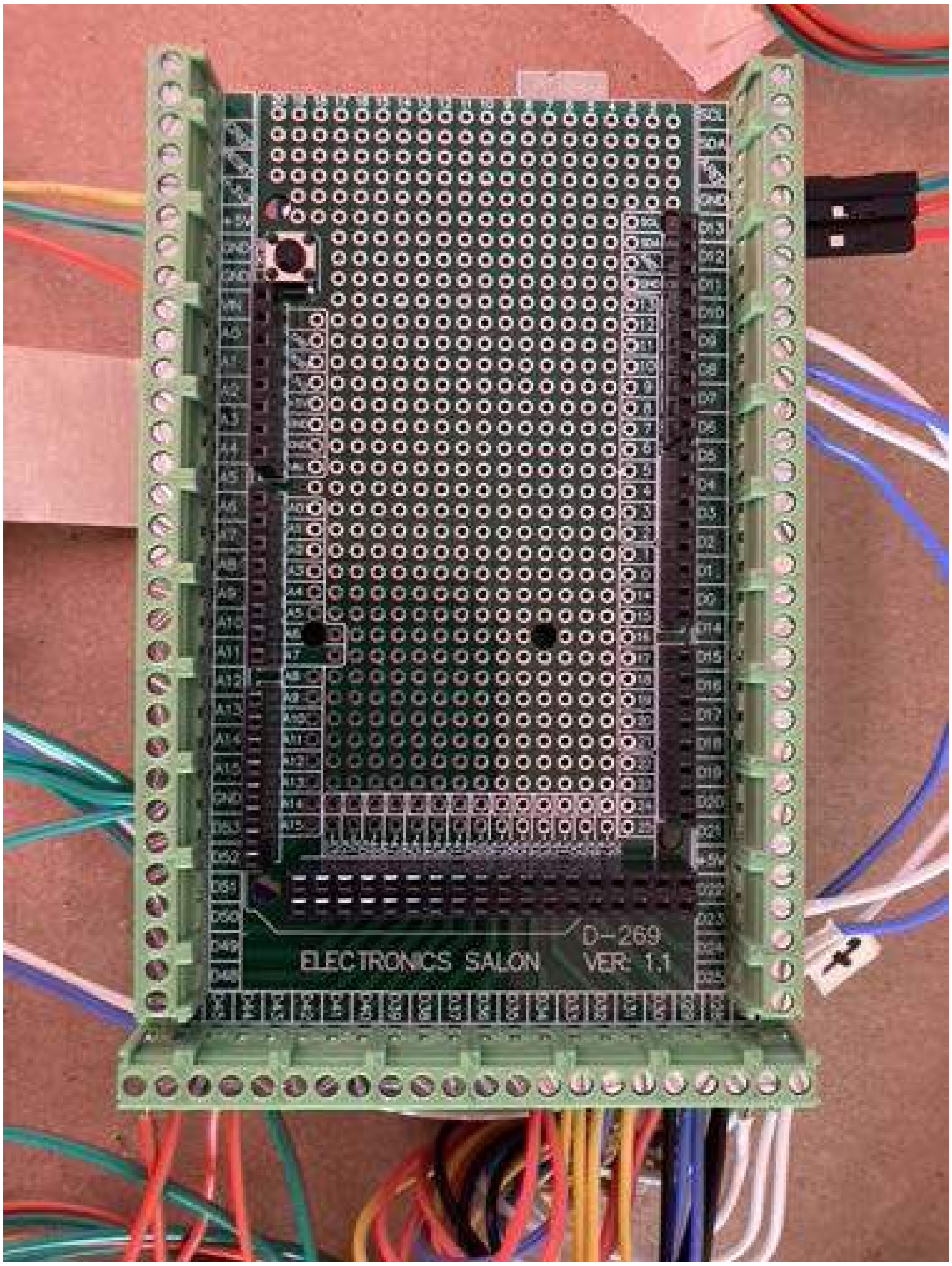
    1. Attach the DRV8825s and capacitors. Add on-board connections.

2. 

3. Add wire connections to Mega. Connect wires to stepper motors.

4. 

4. Make wire connections to Mega

1. 

5. Upload code.

References: none

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 > Adaptive Resistance Mechanism".

Action items:

1. conduct final circuit testing

ANNABEL FRAKE - Apr 15, 2023, 4:18 PM CDT

Title: Final Circuit Fabrication Update

Date: 04/15/2023

Content by: Annabel Frake

Present: Annabel Frake

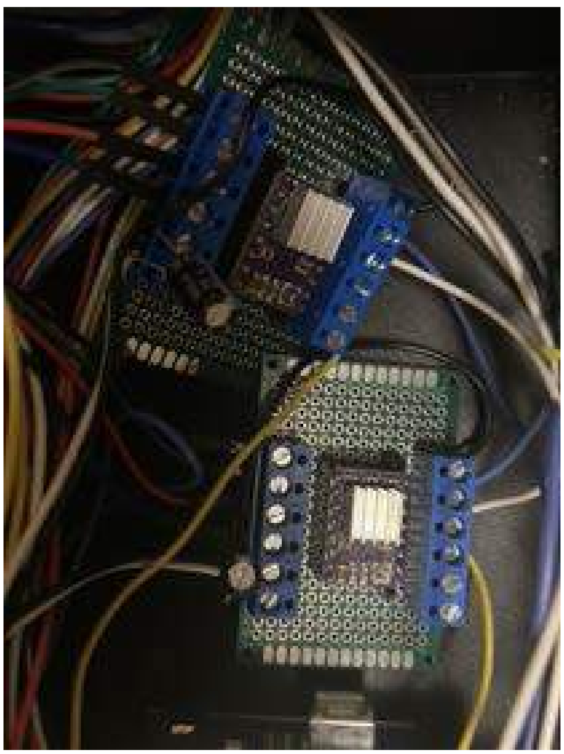
Goals: describe the updates made to the circuit

Content:

- Instead of using one solder board for the DRV8825s, I created breakout boards
  - 
  - 

- 

- All connections remain the same

- 

- 

References: none

Conclusions:

After the circuit failure, I improved the final circuit design by using breakout boards for the DRV8825s that allow easy replacement if the motor controller fails. Also, the wire connections are easier to connect/disconnect if necessary.

Action items:

1. test final system

Final Stabilization Frame

SAMUEL SKIRPAN - Apr 12, 2023, 9:36 AM CDT

Title: Final Stabilization Frame

Date: 4/12/23

Content by: Sam

Present: Sam

Goals: Note the process for attachment of the stabilization frame.

Content:

Materials:

- Stabilization frame created by JHT
  - 1 horizontal metal bar with two holes for attachment to the rower back
  - 1 plate with adjustable holes that holds lap pad in place
  - 1 lap pad

Steps:

1. I created CAD files of the stabilization frame in SolidWorks and sent them to Staci for fabrication at JHT
    1. Stacie ended up removing the lower half of my design and also create a smoother looking plate that would be stronger
    2. 
2. After picking up the stabilization from JHT, two more adjustable holes were added to the adjustability mechanism to allow for larger users to use the machine
    1. This was completed using 9/16ths inch drill bit that was checked out from the TEAMLab
3. The frame was then attached to the rowing machine using 2 3/4 inch M5 screws and washers

1. 

    1. This is a side/top view of the frame when it is attached to the rowing machine

2. 

    1. This is a top view of the frame when it is attached to the rowing machine

Conclusions/action items:

We were able to successfully attach the stabilization frame to the rowing machine after making two more adjustability holes in the plate.

4/14/2023 - Final Fabrication of 3D Printed Components & Antlers

Josh ANDREATTA - Apr 14, 2023, 5:03 PM CDT

Title: 4/14/2023 - Final Fabrication of 3D Printed Components & Antlers

Date: 4/14/2023

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show pictures of final fabrication of 3D printed components and antlers

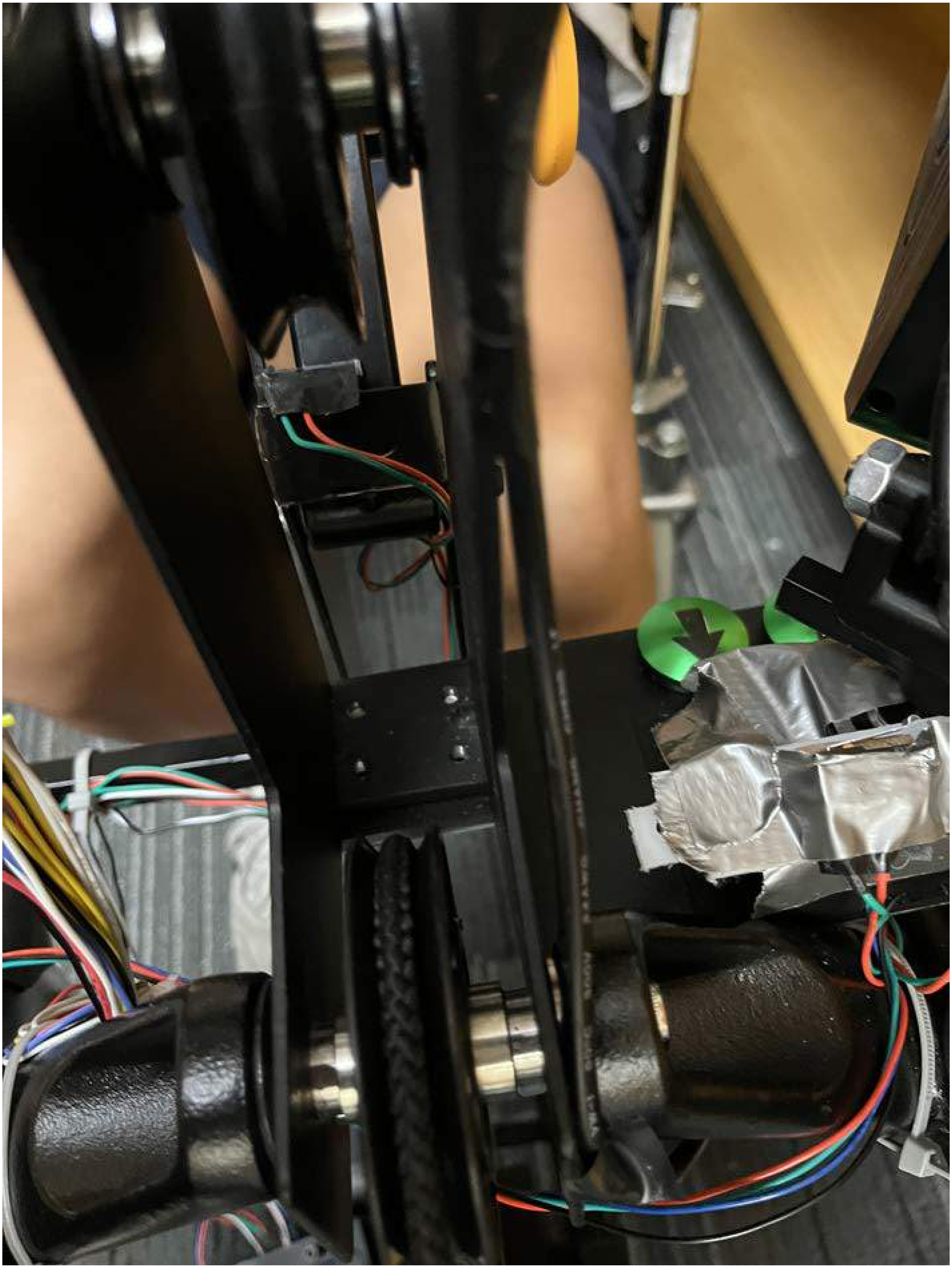
Content:

Materials:

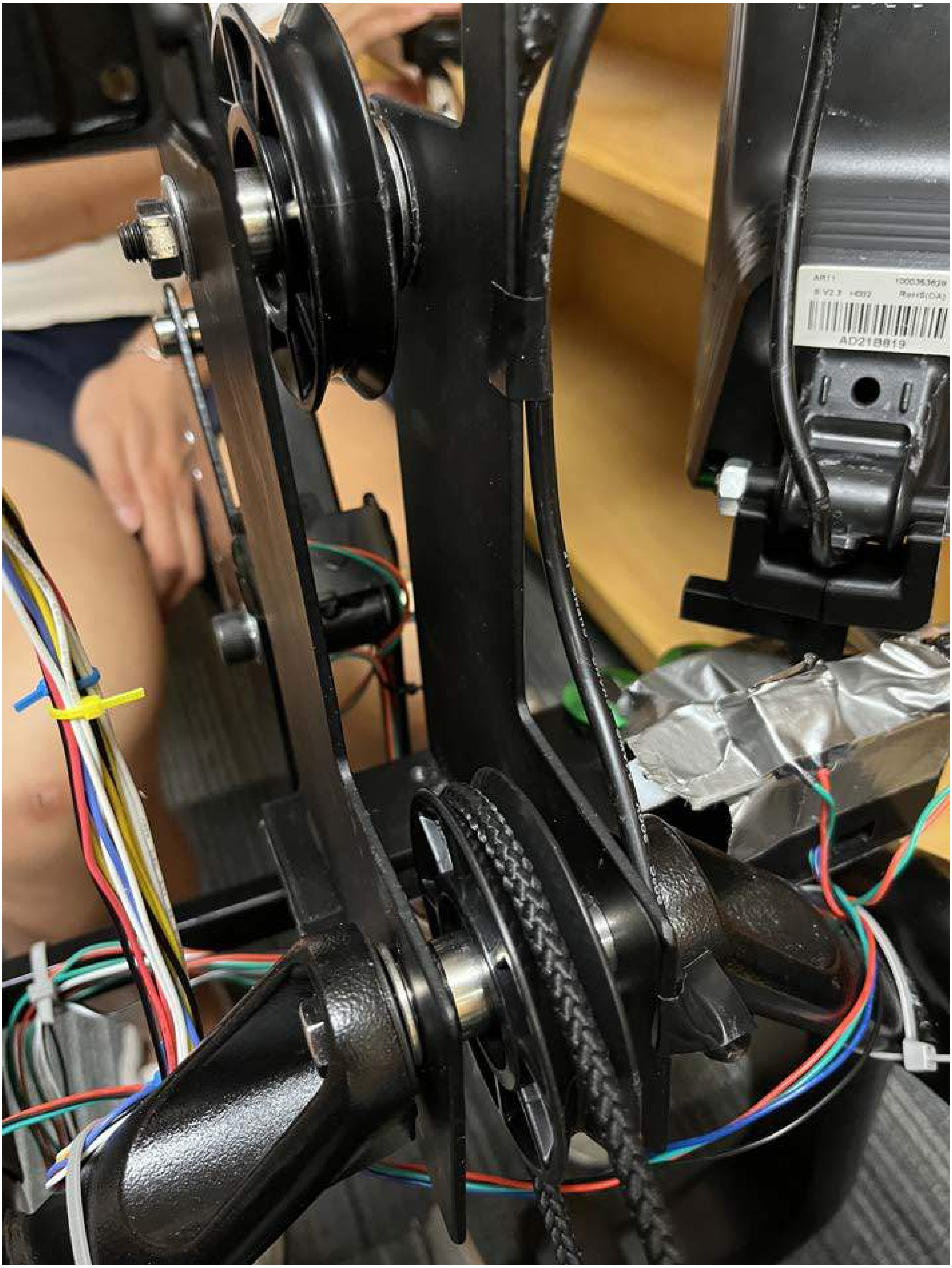
- 3D printed console field goal posts
- 3D printed console rotation box
- 3D printed resistance dial motor housing
- 3D printed electronics box and lid
- Machined pulley plates & antlers - made by JHT

Steps:

1. First I made SolidWorks models of all the 3D printed parts. These were iterated several times. See Josh's fabrication and design folders for details.
2. I collected all necessary screws and tools needed to connect everything as per their CAD models. Again, see Josh's fabrication and design folders for steps of these processes and a list of screws that were collected.
3. Some issues were encountered, such as only being able to use 2 holes to connect the console rotation box with the pulley plates. In the end, everything was able to be connected and everything fits such that the rower is completely functional.
4. For any more details, please see Josh's folders as he has described this entire design process throughout the semester in his entries.

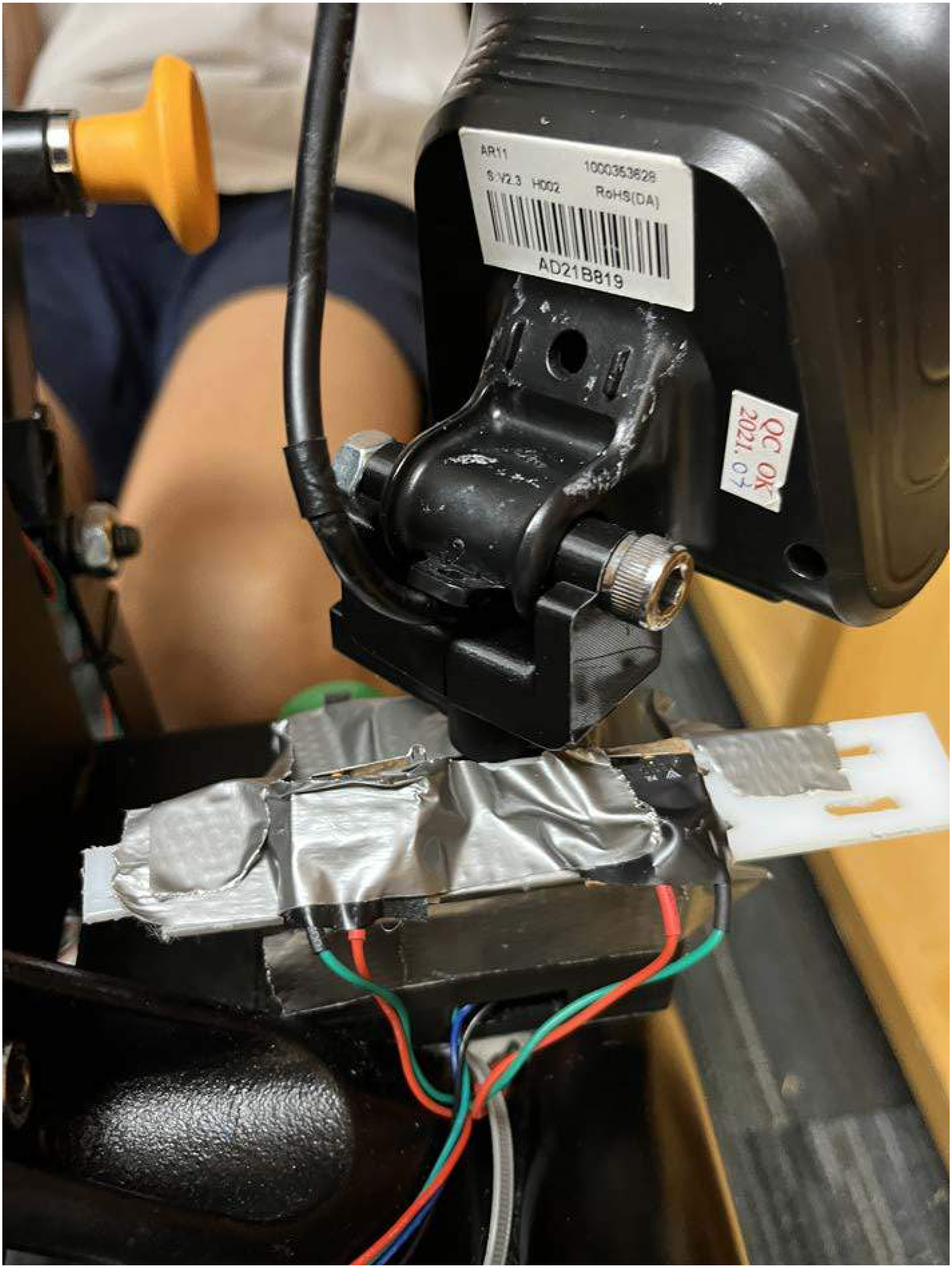


The above image shows the pulley inserted between the two pulley plates, as well as the screw hole locations that were used to attach the console rotation box to the pulley plates.



The above image shows how the pulley plates and both pulleys are connected.

The above image shows how the rower resistance mechanism is connected.



The above image shows the limit switches and console connected together.

References: n/a

Conclusions:

Please see Josh's folder for detailed descriptions of all 3D prints, iterations, and processes for connecting everything.

Action items:

-Test with EMG next week with Dr. Wille

-Test with wheelchair participants next week

Circuit & Code Functionality Testing Protocol

ANNABEL FRAKE - Apr 06, 2023, 9:07 PM CDT

Title: Circuit & Code Functionality Testing Protocol

Date: 04/06/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: expand on the testing protocol from last semester to include the adaptive resistance mechanism

Content:

Console Testing Protocol:

- To test the functionality of the console 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.
- Ignore the behavior of the resistance mechanism; that will be tested in the adaptive resistance mechanism testing protocol.
  - 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:

Adaptive Resistance Mechanism Testing Protocol:

- To test the functionality of the adaptive resistance mechanism circuit and code, induce the following edge cases and record the system's behavior. Record pass if the circuit operates according to the expected outcome. Otherwise, record fail. Repeat each edge case 3 times.
- Ignore the behavior of the console; that will be tested in the console protocol.
    - Edge Case 1:
        - Before power application: Manually rotate the magnet fixture such that the resistance level is greater than one (a.k.a. the adaptive resistance mechanism limit switch is not pressed).
        - Apply power.
        - Expected outcome: The magnet fixture rotates clockwise (relative to the motor side) until it triggers the adaptive resistance mechanism limit switch, at which point, the fixture stops moving. The display outputs a value of "1."
        - Recorded observation:
        - Pass/Fail:
    - Edge Case 2:
        - Before power application: Manually rotate the magnet fixture such that the resistance level is at one (a.k.a. the adaptive resistance mechanism limit switch is pressed).
        - Apply power.
        - Expected outcome: The magnet fixture remains stationary. The display outputs a value of "1."

        - Recorded observation:
        - Pass/Fail:
    - Edge Case 3:
        - Apply power.
        - After power application: Increment the resistance by pressing the up arrow on the standard side of the machine. Ensure that the display outputs values "1" through "10" and that the resistance cannot be incremented above a value of "10." Decrement the resistance by pressing the down arrow on the standard side of the machine. Ensure that the display outputs values "10" down to "1" and that the resistance cannot be incremented below a value of "1."
        - Expected outcome: The display outputs the following sequence: "1 2 3 4 5 6 7 8 9 10 9 8 7 6 5 4 3 2 1."
        - Recorded observation:
        - Pass/Fail:
    - Edge Case 4:
        - Apply power.
        - After power application: Increment the resistance by pressing the up arrow on the adaptive side of the machine. Ensure that the display outputs values "1" through "10" and that the resistance cannot be incremented above a value of "10." Decrement the resistance by pressing the down arrow on the adaptive side of the machine. Ensure that the display outputs values "10" down to "1" and that the resistance cannot be incremented below a value of "1."
        - Expected outcome: The display outputs the following sequence: "1 2 3 4 5 6 7 8 9 10 9 8 7 6 5 4 3 2 1."
        - Recorded observation:
        - Pass/Fail:
    - Edge Case 5:
        - Apply power.
        - After power application: Increment the resistance by pressing the up arrow on either the standard or adaptive side of the machine. Ensure that the magnet fixture rotates counterclockwise (relative to the motor side) by roughly 3 degrees each button press. Decrement the resistance by pressing the down arrow on either the standard or adaptive side of the machine. Ensure that the magnet fixture rotates clockwise (relative to the motor side) by roughly 3 degrees each button press.
        - Expected outcome: The motor rotates roughly 27 degrees (9 increments at 3 degrees each) clockwise. The motor then rotates roughly 27 degrees (9 increments at 3 degrees each) counterclockwise.
        - Recorded observation:
        - Pass/Fail:
    - Edge Case 6:
        - Apply power.
        - After power application: Increment/decrement the resistance by pressing the up arrow/down on either the standard or adaptive side of the machine while the flywheel is in motion.
        - Expected outcome: The motor rotates the appropriate amount (in degree increments) in the appropriate direction based on the input to the system regardless of whether the flywheel is in motion or not.
        - Recorded observation:
        - Pass/Fail:

<u>Combined Circuitry Testing Protocol:</u>

- To test the functionality of the overall circuit and code, induce the following edge cases and record the behavior of the system. Record pass if the circuit operates according to the expected outcome. Otherwise, record fail. Repeat each edge case 3 times.
- This protocol only tests the interaction between the console system and the adaptive resistance mechanism. To test the individual functionality of the independent systems, see the previous protocols.
    - Edge Case 1:
        - Apply power.
        - After power application: Increment/decrement the resistance by pressing the up arrow/down on either the standard or adaptive side of the machine. Immediately after an up/down button is pressed (assuming the button press is not outside the bounds of the system - i.e. 1 through 10), induce rotation of the console.
            - Note: It may be difficult to induce rotation of the console immediately after an up/down button press (ideally while the magnet fixture is still in motion) because the magnet fixture moves quickly. Try your best to achieve the ideal testing parameters, but this edge case is

unlikely to occur in standard use of the device, so it is not the most important edge case to study.

    - Expected outcome: The magnet fixture increments/decrements appropriately and the correct value is outputted on the displays. The console rotates appropriately based on the input to the system.
    - Recorded observation:
    - Pass/Fail:
  - Edge Case 2:
    - Apply power.
    - After power application: Induce rotation of the console and while it is rotating, try to change the resistance level.
    - Expected outcome: The displays are blank while the console is rotating. The magnet fixture remains stationary.
    - Recorded observation:
    - Pass/Fail:

References: none

Conclusions:

I created three testing protocols: one for the console system, one for the adaptive resistance mechanism, and a third for the overall combined system. Each testing protocol addresses edge cases of that system's functionality and ensures that the system behaves appropriately in response to various scenarios.

Action items:

1. after integration, complete the testing protocol

04/18/2023 EMG and Usability Testing Protocols

ANNABEL FRAKE - Apr 18, 2023, 7:58 PM CDT

Title: 04/18/2023 EMG and Usability Testing Protocols

Date: 04/18/2023

Content by: Annabel Frake

Present: Annabel, Roxi, Tim, Josh, Sam

Goals: include the EMG and usability protocols in the protocols team folder

Content:

- see attached pdf

References: none

Conclusions:

The protocols for EMG and usability testing are included in this entry.

Action items:

1. conduct testing

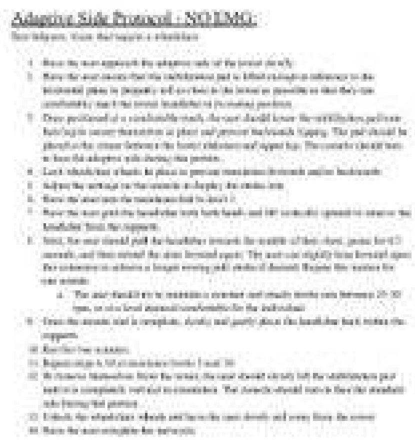
ANNABEL FRAKE - Apr 18, 2023, 7:56 PM CDT


Adaptive Side Protocol - EMG:

Download

Adaptive_Side_Protocol_-_EMG.pdf (39.5 kB)

ANNABEL FRAKE - Apr 18, 2023, 7:56 PM CDT


Adaptive Side Protocol - NO EMG:

Download

Adaptive_SIde_Protocol_-_NO_EMG.pdf (73.5 kB)

ANNABEL FRAKE - Apr 18, 2023, 7:56 PM CDT


Standard Side Protocol- EMG:

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Standard_Side_Protocol_-_EMG.pdf (38.3 kB)

ANNABEL FRAKE - Apr 18, 2023, 7:56 PM CDT


Standard Side Protocol - NO EMG:

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Standard_Side_Protocol_-_No_EMG_.pdf (35.7 kB)

04/18/2023 Testing Meeting

ANNABEL FRAKE - Apr 18, 2023, 9:22 PM CDT

Title: 04/18/2023 Testing Meeting

Date: 04/18/2023

Content by: Annabel Frake

Present: Annabel, Roxi, Josh, Sam, Tim

Goals: discuss testing plan for the week, conduct EMG testing, discuss executive summary

Content:

- I printed consent forms and surveys and put them in the rower room for everyone to use
- Outreach:
    - confirmed that this was done
- EMG Testing:
    - Sam conducted EMG testing as the testing participant
    - put electrodes on right arm (Sam's dominant arm)
    - muscle groups: biceps, rear deltoid, and latissimus dorsi
    - resistance levels: 1, 3, 5, 7, 9
        - cannot row at 10 because the magnet fixture jerks back due to eddy currents
        - will need to explain this in the final results/report
        - had to hold magnet in place for resistance level 7 and 9 in order to complete testing, otherwise magnet fixture popped back because of Eddy currents
            - this should be noted in our final report
    - use metronome to keep rate of 20 strokes/min
- Testing plan:
    - Whitewater (2 pm on Friday)
        - everyone
    - Jamaal Kemp (8 am on Friday)
        - Roxi, Josh, Sam, Tim
    - Friends, roommates, etc.
        - don't use metronome - row at comfortable pace (try to keep consistent by looking at monitor)
        - tell them to row normally, don't yank too hard
        - other than that, follow protocol to a T
        - Sam and Josh: bringing in 3
        - Roxi and I: bringing in 2 on Thursday
        - Tim: bringing in 6 roommates

        - resistance levels: 1, 5, 9

- Executive Summary:
    - poster number = 5
    - Josh, Roxi, and I wrote the rest of the executive summary while Tim and Sam conducted EMG testing
    - send to Prof TJP one last time
        - ask her opinion on whether or not it sounds too much like a Tong executive summary
        - ask her if it is ok to say that it accommodates "all" users
- Data Analysis
    - Tim and Sam: EMG
    - Roxi and Josh: surveys
    - Annabel: electrical (no analysis per say but will need to come in separately to complete electrical testing protocol)
- Final deliverables:
    - talk about on Friday
- Code explanation meeting?
    - based on peer eval feedback, people wanted to learn more about the code
    - so I suggested a time to explain how everything works
    - if we have time, I can explain things during Friday's meeting, otherwise we can go through the code when we meet to practice the poster presentation

References: none

Conclusions:

Tonight, we conducted the EMG testing. We could not row on resistance level 10 because the magnet fixture popped back due to the eddy currents. It eventually started happening with resistance levels 9 (and once at 7), so Josh held the fixture in place for the purposes of testing. We will need to include this in the final report as a deviation from the testing protocol. We also finished the executive summary and intend on sending it to Prof TJP one last time before submission. Finally, we touched base on who we plan to bring in for survey testing (ie roommates, friends, etc.).

Upcoming Meetings:

- Friday: meet starting at 12:30 pm

Action items:

1. Josh
    - get nuts to secure the console motor
    - email Tracy to ask about the executive summary and the consent forms (include in design notebook or not?)
2. Annabel
    - complete electrical testing protocol after Josh gets the nuts for the console motor securement
3. Tim and Sam: EMG analysis
4. Roxi and Josh: survey analysis
5. All:
    - bring people in to fill out the surveys (have them row at 1, 5, 9 and tell them to row at a comfortable pace) by/on Friday

ANNABEL FRAKE - Apr 18, 2023, 8:59 PM CDT

Download

IMG_7281.jpeg (3.52 MB) Electrode placement on the bicep.

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Download

IMG_7282.jpeg (3.47 MB) Electrode placement on the rear deltoid.

ANNABEL FRAKE - Apr 18, 2023, 9:01 PM CDT

Download

IMG_7283.jpeg (3.36 MB) Electrode placement on the latissimus dorsi.

04/20/2023 Usability Testing

ANNABEL FRAKE - Apr 20, 2023, 12:19 PM CDT

Title: 04/20/2023 Usability Testing

Date: 04/20/2023

Content by: Annabel Frake

Present: Annabel, Roxi, Lauren

Goals: have Lauren test the rower

Content:

- Lauren tested the machine and filled out a comparison survey
- the magnet fixture flipped back at resistance level 9 on the standard side, so she was not able to row at 9

References: none

Conclusions:

Roxi and I brought in one usability testing participant.

Action items:

1. analyze feedback

04/20/2023 Usability Testing - Josh

Josh ANDREATTA - Apr 20, 2023, 2:29 PM CDT

Title: 04/20/2023 Usability Testing

Date: 04/20/2023

Content by: Josh Andreatta

Present: Josh Andreatta, Bryce Sheedy

Goals: have Bryce test the rower

Content:

- Bryce tested the machine and filled out a comparison survey
- The magnets flipped backward at level 9 on the standard side, so only levels 1 and 5 could be tested on the standard side. Levels 1, 5, 9 all worked on the adaptive side.

References: none

Conclusions:

I brought in one usability testing participant (my roommate).

Action items:

1. analyze feedback over the weekend with roxi once all participants have completed their testing
2. The stabilization frame seemed a little loose, so we will need to tighten this prior to our demo

04/20/2023 Circuit & Code Functionality Testing

ANNABEL FRAKE - Apr 20, 2023, 5:39 PM CDT

Title: 04/20/2023 Circuit & Code Functionality Testing

Date: 04/20/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: test the circuit using the protocol I wrote

Content:

Console Testing Protocol:

- To test the functionality of the console 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.
- Ignore the behavior of the resistance mechanism; that will be tested in the adaptive resistance mechanism testing protocol.
    - 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 rotates 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 rotates 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 remains stationary until the lap bar is raised such that the transition limit switch is suppressed. Then the console rotates to standard side.
        - 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 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.
        - 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.
  - Apply power.
  - Expected outcome: The console rotates to standard side.
  - Recorded observation: The console rotates 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.
  - Apply power.
  - Expected outcome: The console rotates to adaptive side.
  - Recorded observation: The console rotates 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: *** Need to complete with the rest of the team ***
  - 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: 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.
  - Pass/Fail: Pass, Pass, Pass

<u>Adaptive Resistance Mechanism Testing Protocol:</u>

- To test the functionality of the adaptive resistance mechanism circuit and code, induce the following edge cases and record the system's behavior. Record pass if the circuit operates according to the expected outcome. Otherwise, record fail. Repeat each edge case 3 times.
- Ignore the behavior of the console; that will be tested in the console protocol.
  - Edge Case 1:
    - Before power application: Manually rotate the magnet fixture such that the resistance level is greater than one (a.k.a. the adaptive resistance mechanism limit switch is not pressed).
    - Apply power.
    - Expected outcome: The magnet fixture rotates clockwise (relative to the motor side) until it triggers the adaptive resistance mechanism limit switch, at which point, the fixture stops moving. The display outputs a value of "1."
    - Recorded observation: The magnet fixture rotates clockwise (relative to the motor side) until it triggers the adaptive resistance mechanism limit switch, at which point, the fixture stops moving. The display outputs a

value of "1."
    - Pass/Fail: Pass, Pass, Pass
- Edge Case 2:
    - Before power application: Manually rotate the magnet fixture such that the resistance level is at one (a.k.a. the adaptive resistance mechanism limit switch is pressed).
    - Apply power.
    - Expected outcome: The magnet fixture remains stationary. The display outputs a value of "1."
    - Recorded observation: The magnet fixture remains stationary. The display outputs a value of "1."
    - Pass/Fail: Pass, Pass, Pass
- Edge Case 3:
    - Apply power.
    - After power application: Increment the resistance by pressing the up arrow on the standard side of the machine. Ensure that the display outputs values "1" through "10" and that the resistance cannot be incremented above a value of "10." Decrement the resistance by pressing the down arrow on the standard side of the machine. Ensure that the display outputs values "10" down to "1" and that the resistance cannot be incremented below a value of "1."
    - Expected outcome: The display outputs the following sequence: "1 2 3 4 5 6 7 8 9 10 9 8 7 6 5 4 3 2 1."
    - Recorded observation: The display outputs the following sequence: "1 2 3 4 5 6 7 8 9 10 9 8 7 6 5 4 3 2 1." The display cannot increased passed 10 nor decrease passed 1.
    - Pass/Fail: Pass, Pass, Pass
- Edge Case 4:
    - Apply power.
    - After power application: Increment the resistance by pressing the up arrow on the adaptive side of the machine. Ensure that the display outputs values "1" through "10" and that the resistance cannot be incremented above a value of "10." Decrement the resistance by pressing the down arrow on the adaptive side of the machine. Ensure that the display outputs values "10" down to "1" and that the resistance cannot be incremented below a value of "1."
    - Expected outcome: The display outputs the following sequence: "1 2 3 4 5 6 7 8 9 10 9 8 7 6 5 4 3 2 1."
    - Recorded observation: The display outputs the following sequence: "1 2 3 4 5 6 7 8 9 10 9 8 7 6 5 4 3 2 1." The display cannot increased passed 10 nor decrease passed 1.
    - Pass/Fail: Pass, Pass, Pass
- Edge Case 5:
    - Apply power.
    - After power application: Increment the resistance by pressing the up arrow on either the standard or adaptive side of the machine. Ensure that the magnet fixture rotates counterclockwise (relative to the motor side) by roughly 3 degrees each button press. Decrement the resistance by pressing the down arrow on either the standard or adaptive side of the machine. Ensure that the magnet fixture rotates clockwise (relative to the motor side) by roughly 3 degrees each button press.
    - Expected outcome: The motor rotates roughly 27 degrees (9 increments at 3 degrees each) clockwise. The motor then rotates roughly 27 degrees (9 increments at 3 degrees each) counterclockwise.
    - Recorded observation: *** Need to complete with the rest of the team ***
    - Pass/Fail:
- Edge Case 6:
    - Apply power.
    - After power application: Increment/decrement the resistance by pressing the up arrow/down on either the standard or adaptive side of the machine while the flywheel is in motion.
    - Expected outcome: The motor rotates the appropriate amount (in degree increments) in the appropriate direction based on the input to the system regardless of whether the flywheel is in motion or not.
    - Recorded observation: *** Need to complete with the rest of the team ***
    - Pass/Fail:

<u>Combined Circuitry Testing Protocol:</u>

- To test the functionality of the overall circuit and code, induce the following edge cases and record the behavior of the system. Record pass if the circuit operates according to the expected outcome. Otherwise, record fail. Repeat each edge case 3 times.

- This protocol only tests the interaction between the console system and the adaptive resistance mechanism. To test the individual functionality of the independent systems, see the previous protocols.
    - Edge Case 1:
        - Apply power.
        - After power application: Increment/decrement the resistance by pressing the up arrow/down on either the standard or adaptive side of the machine. Immediately after an up/down button is pressed (assuming the button press is not outside the bounds of the system - i.e. 1 through 10), induce rotation of the console.
            - Note: It may be difficult to induce rotation of the console immediately after an up/down button press (ideally while the magnet fixture is still in motion) because the magnet fixture moves quickly. Try your best to achieve the ideal testing parameters, but this edge case is unlikely to occur in standard use of the device, so it is not the most important edge case to study.
        - Expected outcome: The magnet fixture increments/decrements appropriately and the correct value is outputted on the displays. The console rotates appropriately based on the input to the system.
        - Recorded observation: *** Need to complete with the rest of the team ***
        - Pass/Fail:
    - Edge Case 2:
        - Apply power.
        - After power application: Induce rotation of the console and while it is rotating, try to change the resistance level.
        - Expected outcome: The displays are blank while the console is rotating. The magnet fixture remains stationary.
        - Recorded observation: The displays are blank while the console is rotating. The magnet fixture remains stationary.
        - Pass/Fail: Pass, Pass, Pass

References: none

Conclusions:

I completed most of the edge case testing, but need to wait to do the rest of the testing when I have a second set of hands and a protractor. All the tests I ran today passed.

Action items:

1. finish testing with the rest of the team

04/20/2023 Usability Testing

ANNABEL FRAKE - Apr 20, 2023, 5:37 PM CDT

Title: 04/20/2023 Usability Testing

Date: 04/20/2023

Content by: Annabel Frake

Present: Annabel, Nesya

Goals: have Nesya test the rower

Content:

- Nesya tested the machine and filled out a comparison survey
- the magnet fixture did not pop during the testing
- The transition limit switch came off when she was done testing, so I had to re-glue that in place

References: none

Conclusions:

I brought in one usability testing participant.

Action items:

1. analyze feedback

04/20/2023 Usability Testing

SAMUEL SKIRPAN - Apr 21, 2023, 7:32 AM CDT

Title: 04/20/2023 Usability Testing

Date: 04/20/2023

Content by: Sam

Present: Sam, Ryan, Lauren

Goals: Have Lauren and Ryan test the rower

Content:

- Lauren and Ryan tested the machine and filled out a comparison survey

References: none

Conclusions:

I brought in two usability testing participants.

Action items:

1. analyze feedback

04/21/2023 Adaptive Side Testing 8AM

Roxi Reuter - Apr 21, 2023, 1:26 PM CDT

Title: Testing

Date: 04/21/2023

Content by: Roxi Reuter

Present: Sam, Josh, Roxi, Testing Participant (Jamaal)

Goals:

- Conduct testing on the adaptive side with a testing volunteer

Content:

- Josh, Sam, and I met with a testing participant, Jamaal, this morning at 8AM in ECB to test the adaptive side of the rower
- Complications/important notes:
    - The magnet popped up while using the adaptive side on resistance level 10

Conclusions/action items:

We had Jamaal test the adaptive side of the rower on resistance levels 1, 5, and 10 and following this use, fill out a survey on the usability. We will analyze the results of all surveys once we finish conducting testing with the adaptive side participants today.

4/20/2023 Usability Testing

Tim TRAN - Apr 21, 2023, 1:34 PM CDT

Title: Usability Testing

Date: 4/20/23

Content by: Tim

Present: Tim, Aidan, Nick

Goals: Have Nick and Aidan test the rower

Content:

- Nick and Aidan tested the machine and filled out the survey
- The magnet housing popped multiple times during the test even at resistance level 5.
    - I had to place my index finger on the housing to resist the pop.

Conclusions/action items:

analyze feedback

4/19/2023 Usability Testing

Tim TRAN - Apr 21, 2023, 1:36 PM CDT

Title: Usability Testing

Date: 4/19/2023

Content by: Tim

Present: Tim, Brody, Sam

Goals: Have Brody and Sam test the rower

Content:

- Brody and Sam tested the machine and filled out the survey
- The magnet housing popped at resistance level 10
    - I placed my finger on the housing to resist the pop

Conclusions/action items:

Analyze the feedback

04/21/2023 Circuit & Code Functionality Testing

ANNABEL FRAKE - Apr 21, 2023, 3:49 PM CDT

Title: 04/21/2023 Circuit & Code Functionality Testing

Date: 04/21/2023

Content by: Annabel Frake

Present: Annabel, Sam, Roxi, Josh

Goals: test the edge cases I couldn't do by myself

Content:

Console Testing Protocol:

- To test the functionality of the console 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.
- Ignore the behavior of the resistance mechanism; that will be tested in the adaptive resistance mechanism testing protocol.
  - 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 rotates 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 rotates 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 remains stationary until the lap bar is raised such that the transition limit switch is suppressed. Then the console rotates to standard side.
    - 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 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.
    - 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.
    - Apply power.
    - Expected outcome: The console rotates to standard side.
    - Recorded observation: The console rotates 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.
    - Apply power.
    - Expected outcome: The console rotates to adaptive side.
    - Recorded observation: The console rotates 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 rotates to the appropriate side of the rowing machine in accordance with the state of the transition limit switch when power is 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 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.
    - Pass/Fail: Pass, Pass, Pass

<u>Adaptive Resistance Mechanism Testing Protocol:</u>

- To test the functionality of the adaptive resistance mechanism circuit and code, induce the following edge cases and record the system's behavior. Record pass if the circuit operates according to the expected outcome. Otherwise, record fail. Repeat each edge case 3 times.
- Ignore the behavior of the console; that will be tested in the console protocol.
  - Edge Case 1:
    - Before power application: Manually rotate the magnet fixture such that the resistance level is greater than one (a.k.a. the adaptive resistance mechanism limit switch is not pressed).
    - Apply power.
    - Expected outcome: The magnet fixture rotates clockwise (relative to the motor side) until it triggers the adaptive resistance mechanism limit switch, at which point, the fixture stops moving. The display outputs a value of "1."

    - Recorded observation: The magnet fixture rotates clockwise (relative to the motor side) until it triggers the adaptive resistance mechanism limit switch, at which point, the fixture stops moving. The display outputs a value of "1."
    - Pass/Fail: Pass, Pass, Pass
- Edge Case 2:
    - Before power application: Manually rotate the magnet fixture such that the resistance level is at one (a.k.a. the adaptive resistance mechanism limit switch is pressed).
    - Apply power.
    - Expected outcome: The magnet fixture remains stationary. The display outputs a value of "1."
    - Recorded observation: The magnet fixture remains stationary. The display outputs a value of "1."
    - Pass/Fail: Pass, Pass, Pass
- Edge Case 3:
    - Apply power.
    - After power application: Increment the resistance by pressing the up arrow on the standard side of the machine. Ensure that the display outputs values "1" through "10" and that the resistance cannot be incremented above a value of "10." Decrement the resistance by pressing the down arrow on the standard side of the machine. Ensure that the display outputs values "10" down to "1" and that the resistance cannot be incremented below a value of "1."
    - Expected outcome: The display outputs the following sequence: "1 2 3 4 5 6 7 8 9 10 9 8 7 6 5 4 3 2 1."
    - Recorded observation: The display outputs the following sequence: "1 2 3 4 5 6 7 8 9 10 9 8 7 6 5 4 3 2 1." The display cannot increased passed 10 nor decrease passed 1.
    - Pass/Fail: Pass, Pass, Pass
- Edge Case 4:
    - Apply power.
    - After power application: Increment the resistance by pressing the up arrow on the adaptive side of the machine. Ensure that the display outputs values "1" through "10" and that the resistance cannot be incremented above a value of "10." Decrement the resistance by pressing the down arrow on the adaptive side of the machine. Ensure that the display outputs values "10" down to "1" and that the resistance cannot be incremented below a value of "1."
    - Expected outcome: The display outputs the following sequence: "1 2 3 4 5 6 7 8 9 10 9 8 7 6 5 4 3 2 1."
    - Recorded observation: The display outputs the following sequence: "1 2 3 4 5 6 7 8 9 10 9 8 7 6 5 4 3 2 1." The display cannot increased passed 10 nor decrease passed 1.
    - Pass/Fail: Pass, Pass, Pass
- Edge Case 5:
    - Apply power.
    - After power application: Increment the resistance by pressing the up arrow on either the standard or adaptive side of the machine. Ensure that the magnet fixture rotates counterclockwise (relative to the motor side) by roughly 3 degrees each button press. Decrement the resistance by pressing the down arrow on either the standard or adaptive side of the machine. Ensure that the magnet fixture rotates clockwise (relative to the motor side) by roughly 3 degrees each button press.
    - Expected outcome: The motor rotates roughly 27 degrees (9 increments at 3 degrees each) clockwise. The motor then rotates roughly 27 degrees (9 increments at 3 degrees each) counterclockwise.
    - Recorded observation: *** Waiting on analysis from Sam ***
    - Pass/Fail:
- Edge Case 6:
    - Apply power.
    - After power application: Increment/decrement the resistance by pressing the up arrow/down on either the standard or adaptive side of the machine while the flywheel is in motion.
    - Expected outcome: The motor rotates the appropriate amount (in degree increments) in the appropriate direction based on the input to the system regardless of whether the flywheel is in motion or not.
    - Recorded observation: N/A ** In hindsight, this is essentially the same as edge case 5, so we did not complete this edge case separately **
    - Pass/Fail: N/A ** In hindsight, this is essentially the same as edge case 5, so we did not complete this edge case separately **

<u>Combined Circuitry Testing Protocol:</u>

- To test the functionality of the overall circuit and code, induce the following edge cases and record the behavior of the system. Record pass if the circuit operates according to the expected outcome. Otherwise, record fail. Repeat each edge case 3 times.
- This protocol only tests the interaction between the console system and the adaptive resistance mechanism. To test the individual functionality of the independent systems, see the previous protocols.
    - Edge Case 1:
        - Apply power.
        - After power application: Increment/decrement the resistance by pressing the up arrow/down on either the standard or adaptive side of the machine. Immediately after an up/down button is pressed (assuming the button press is not outside the bounds of the system - i.e. 1 through 10), induce rotation of the console.
            - Note: It may be difficult to induce rotation of the console immediately after an up/down button press (ideally while the magnet fixture is still in motion) because the magnet fixture moves quickly. Try your best to achieve the ideal testing parameters, but this edge case is unlikely to occur in standard use of the device, so it is not the most important edge case to study.
        - Expected outcome: The magnet fixture increments/decrements appropriately and the correct value is outputted on the displays. The console rotates appropriately based on the input to the system.
        - Recorded observation: N/A **Unable to test because the motor moved too quickly for human reaction times **
        - Pass/Fail: N/A **Unable to test because the motor moved too quickly for human reaction times **
    - Edge Case 2:
        - Apply power.
        - After power application: Induce rotation of the console and while it is rotating, try to change the resistance level.
        - Expected outcome: The displays are blank while the console is rotating. The magnet fixture remains stationary.
        - Recorded observation: The displays are blank while the console is rotating. The magnet fixture remains stationary.
        - Pass/Fail: Pass, Pass, Pass

References: none

Conclusions:

Sam helped me finish some of the electronics testing. The last console test I needed to complete passed. I couldn't do the first combined test because the motor moved too quickly for human reaction times. Sam is going to analyze the angles in ImageJ for the remaining tests and let me know.

Action items:

1. finish testing with the rest of the team

ANNABEL FRAKE - Apr 22, 2023, 3:17 PM CDT

Title: 04/22/2023 Circuit & Code Functionality Testing

Date: 04/22/2023

Content by: Annabel Frake

Present: Annabel

Goals: analyze the ImageJ data Sam collected

Content:

Console Testing Protocol:

- To test the functionality of the console 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.
- Ignore the behavior of the resistance mechanism; that will be tested in the adaptive resistance mechanism testing protocol.
    - 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 rotates 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 rotates 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 remains stationary until the lap bar is raised such that the transition limit switch is suppressed. Then the console rotates to standard side.
        - 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 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.
        - 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.
    - Apply power.
    - Expected outcome: The console rotates to standard side.
    - Recorded observation: The console rotates 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.
    - Apply power.
    - Expected outcome: The console rotates to adaptive side.
    - Recorded observation: The console rotates 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 rotates to the appropriate side of the rowing machine in accordance with the state of the transition limit switch when power is 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 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.
    - Pass/Fail: Pass, Pass, Pass

<u>Adaptive Resistance Mechanism Testing Protocol:</u>

- To test the functionality of the adaptive resistance mechanism circuit and code, induce the following edge cases and record the system's behavior. Record pass if the circuit operates according to the expected outcome. Otherwise, record fail. Repeat each edge case 3 times.
- Ignore the behavior of the console; that will be tested in the console protocol.
  - Edge Case 1:
    - Before power application: Manually rotate the magnet fixture such that the resistance level is greater than one (a.k.a. the adaptive resistance mechanism limit switch is not pressed).
    - Apply power.
    - Expected outcome: The magnet fixture rotates clockwise (relative to the motor side) until it triggers the adaptive resistance mechanism limit switch, at which point, the fixture stops moving. The display outputs a value of "1."
    - Recorded observation: The magnet fixture rotates clockwise (relative to the motor side) until it triggers the adaptive resistance mechanism limit switch, at which point, the fixture stops moving. The display outputs a

value of "1."
    - Pass/Fail: Pass, Pass, Pass
- Edge Case 2:
    - Before power application: Manually rotate the magnet fixture such that the resistance level is at one (a.k.a. the adaptive resistance mechanism limit switch is pressed).
    - Apply power.
    - Expected outcome: The magnet fixture remains stationary. The display outputs a value of "1."
    - Recorded observation: The magnet fixture remains stationary. The display outputs a value of "1."
    - Pass/Fail: Pass, Pass, Pass
- Edge Case 3:
    - Apply power.
    - After power application: Increment the resistance by pressing the up arrow on the standard side of the machine. Ensure that the display outputs values "1" through "10" and that the resistance cannot be incremented above a value of "10." Decrement the resistance by pressing the down arrow on the standard side of the machine. Ensure that the display outputs values "10" down to "1" and that the resistance cannot be incremented below a value of "1."
    - Expected outcome: The display outputs the following sequence: "1 2 3 4 5 6 7 8 9 10 9 8 7 6 5 4 3 2 1."
    - Recorded observation: The display outputs the following sequence: "1 2 3 4 5 6 7 8 9 10 9 8 7 6 5 4 3 2 1." The display cannot increased passed 10 nor decrease passed 1.
    - Pass/Fail: Pass, Pass, Pass
- Edge Case 4:
    - Apply power.
    - After power application: Increment the resistance by pressing the up arrow on the adaptive side of the machine. Ensure that the display outputs values "1" through "10" and that the resistance cannot be incremented above a value of "10." Decrement the resistance by pressing the down arrow on the adaptive side of the machine. Ensure that the display outputs values "10" down to "1" and that the resistance cannot be incremented below a value of "1."
    - Expected outcome: The display outputs the following sequence: "1 2 3 4 5 6 7 8 9 10 9 8 7 6 5 4 3 2 1."
    - Recorded observation: The display outputs the following sequence: "1 2 3 4 5 6 7 8 9 10 9 8 7 6 5 4 3 2 1." The display cannot increased passed 10 nor decrease passed 1.
    - Pass/Fail: Pass, Pass, Pass
- Edge Case 5:
    - Apply power.
    - After power application: Increment the resistance by pressing the up arrow on either the standard or adaptive side of the machine. Ensure that the magnet fixture rotates counterclockwise (relative to the motor side) by roughly 3 degrees each button press. Decrement the resistance by pressing the down arrow on either the standard or adaptive side of the machine. Ensure that the magnet fixture rotates clockwise (relative to the motor side) by roughly 3 degrees each button press.
    - Expected outcome: The motor rotates roughly 27 degrees (9 increments at 3 degrees each) clockwise. The motor then rotates roughly 27 degrees (9 increments at 3 degrees each) counterclockwise.
    - Recorded observation:
        - resistance 1 to 2: incremented 1 degree
        - resistance 2 to 3: incremented 4 degrees
        - resistance 3 to 4: incremented 1 degree
        - resistance 4 to 5: incremented 2 degrees
        - resistance 5 to 6: incremented 1 degree
        - resistance 6 to 7: incremented 2 degrees
        - resistance 7 to 8: incremented 1 degree
        - resistance 8 to 9: incremented 2 degrees
        - resistance 9 to 10: incremented 2 degrees
        - average: 1.78 degrees
        - standard deviation: 0.97 degrees
    - Pass/Fail: Fail, Fail, Fail
    - *Note: Please see Sam's data analysis within his folder (Samuel Skirpan => Design Process Work/Ideas => 04/22/2023 Magnet Housing Angle Analysis).*

- Edge Case 6:
    - Apply power.
    - After power application: Increment/decrement the resistance by pressing the up arrow/down on either the standard or adaptive side of the machine while the flywheel is in motion.
    - Expected outcome: The motor rotates the appropriate amount (in degree increments) in the appropriate direction based on the input to the system regardless of whether the flywheel is in motion or not.
    - Recorded observation: N/A ** In hindsight, this is essentially the same as edge case 5, so we did not complete this edge case separately **
    - Pass/Fail: N/A ** In hindsight, this is essentially the same as edge case 5, so we did not complete this edge case separately **

<u>Combined Circuitry Testing Protocol:</u>

- To test the functionality of the overall circuit and code, induce the following edge cases and record the behavior of the system. Record pass if the circuit operates according to the expected outcome. Otherwise, record fail. Repeat each edge case 3 times.
- This protocol only tests the interaction between the console system and the adaptive resistance mechanism. To test the individual functionality of the independent systems, see the previous protocols.
    - Edge Case 1:
        - Apply power.
        - After power application: Increment/decrement the resistance by pressing the up arrow/down on either the standard or adaptive side of the machine. Immediately after an up/down button is pressed (assuming the button press is not outside the bounds of the system - i.e. 1 through 10), induce rotation of the console.
            - Note: It may be difficult to induce rotation of the console immediately after an up/down button press (ideally while the magnet fixture is still in motion) because the magnet fixture moves quickly. Try your best to achieve the ideal testing parameters, but this edge case is unlikely to occur in standard use of the device, so it is not the most important edge case to study.
        - Expected outcome: The magnet fixture increments/decrements appropriately and the correct value is outputted on the displays. The console rotates appropriately based on the input to the system.
        - Recorded observation: N/A **Unable to test because the motor moved too quickly for human reaction times **
        - Pass/Fail: N/A **Unable to test because the motor moved too quickly for human reaction times **
    - Edge Case 2:
        - Apply power.
        - After power application: Induce rotation of the console and while it is rotating, try to change the resistance level.
        - Expected outcome: The displays are blank while the console is rotating. The magnet fixture remains stationary.
        - Recorded observation: The displays are blank while the console is rotating. The magnet fixture remains stationary.
        - Pass/Fail: Pass, Pass, Pass

References: none

Conclusions:

Sam sent me the angle analysis for resistance mechanism edge case 5. The device failed this edge case because the magnet fixture consistently moved less than 3 degrees each increment. The 3 degree specification was determined by Sam earlier in the semester when he analyzed the original degree increments of the mechanical resistance mechanism. Overall, the design only failed the degree increment design criteria (when considering the design criteria covered by these edge cases - it should also be noted that the magnet fixture pops back at higher resistance levels with the application of sudden / high force by the user). To fix this issue in future iterations, I could try implementing the micro-stepping to allow for greater resolution and/or look for a different motor with more precise specifications. I am surprised that there was such variability between increments considering the fact that stepper motors are generally considered to have high accuracy of stepping, but perhaps the weight of the magnet fixture influences the stepping motion of the motor.

Action items: alter the design in future iterations so that it passes the edge case that it failed

04/21/2023 Adaptive Side Testing 1:30PM

Josh ANDREATTA - Apr 21, 2023, 3:12 PM CDT

Title: Testing

Date: 04/21/2023

Content by: Josh Andreatta

Present: Sam, Josh, Roxi, Annabel, Tim, 2 Testing Participants

Goals:

- Conduct testing on the adaptive side with a testing volunteer

Content:

- Two members of the mens wheelchair basketball team at UW-WhiteWater came in at 1:30PM in ECB to test the adaptive side of the rower
- Complications/important notes:
    - Users noted that they had to scoot back before being able to lower the lap pad far enough - this is because there aren't enough
    - holes towards the top of the frame and the holes are too wide to offer several stopping points

Conclusions/action items:

We had both participants test the adaptive side of the rower on resistance levels 1, 5, and 10 and following this use, fill out a survey on the usability. We will analyze the results of all surveys once we finish conducting testing with the adaptive side participants today.

4/21/2023 Usability Testing

Tim TRAN - Apr 23, 2023, 12:39 AM CDT

Title: Testing

Date: 4/21/2023

Content by: Tim

Present: Tim, Cole, Danny

Goals: Have Cole and Danny test the rower

Content:

Cole and Danny tested the rower and filled out the survey

The magnet housing popped at resistance level 10 for both participants

Conclusions/action items:

04/20/2023 EMG Testing Purpose and Data

SAMUEL SKIRPAN - Apr 20, 2023, 3:0

Title: EMG Testing Purpose and Data

Date: 4/20/23

Content by: Sam

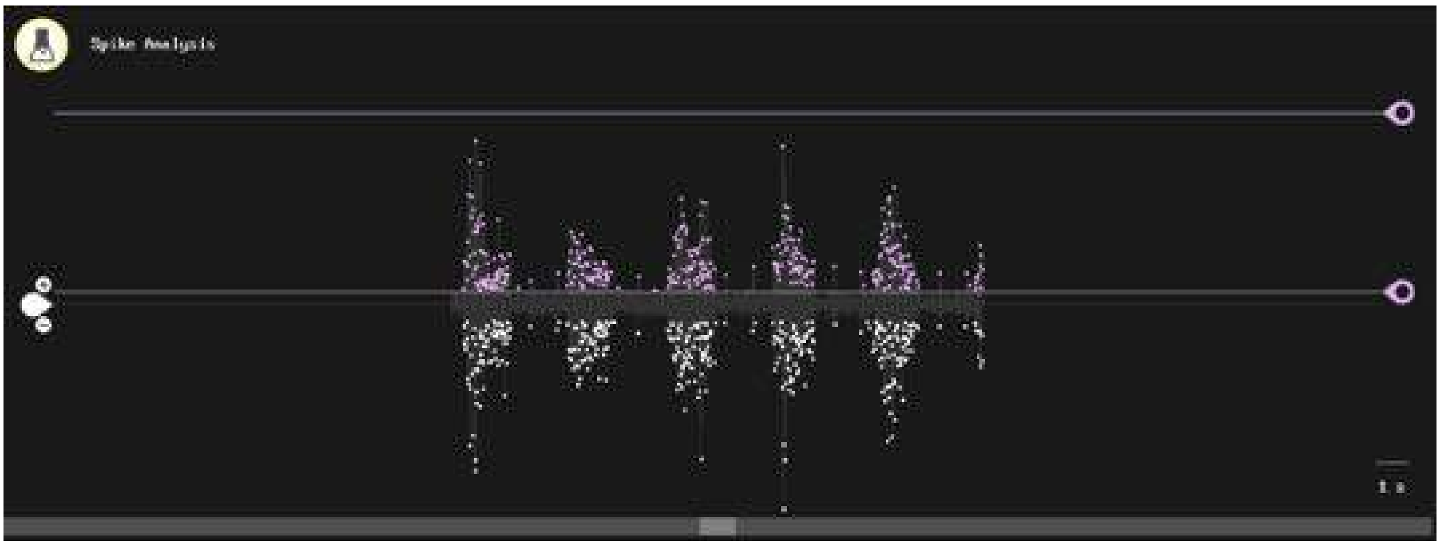
Present: Sam

Goals: Take screenshots of all of the average waveforms from the EMG data and organize it into one document. Also, measure the peak of each average waveform.

Content:

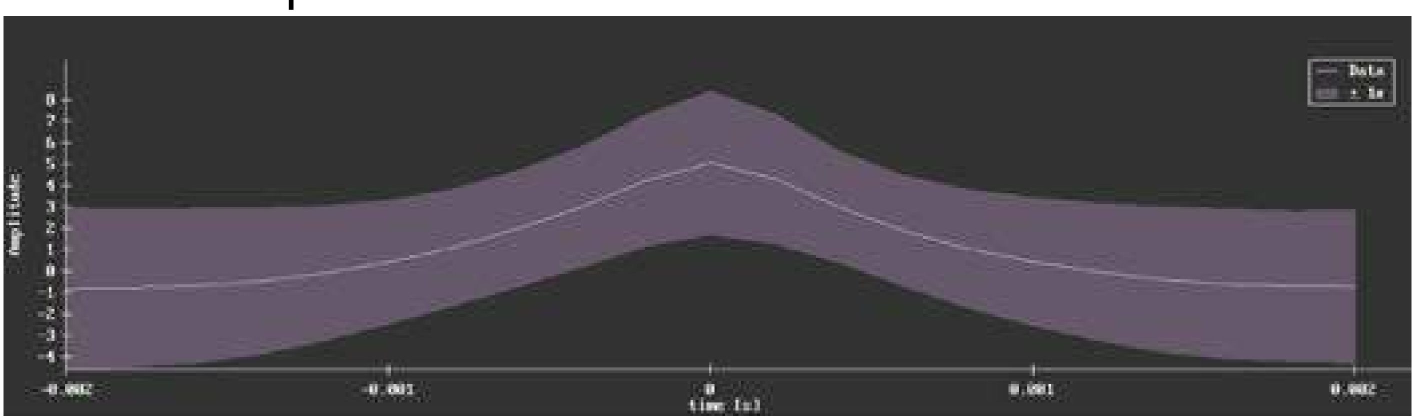
Purpose for EMG testing: For the EMG testing, 5 trials were captured for each condition. The different conditions were standard bicep, adaptive bicep, standard rear delt, adaptive rear delt, standard lat, and adaptive lat. Each of these conditions were tested on resistance levels of 1, 3, 5, 7, and 9 to determine if there would be a trend in the the respective muscle group activations for increases in resistance. After the data was collected, it was analyzed in SpikeRecorder using the analysis software.

Below is an example of one of the EMG graphs captured from the data collection. The filter was used to collect the desired signals for each muscle activation signal.

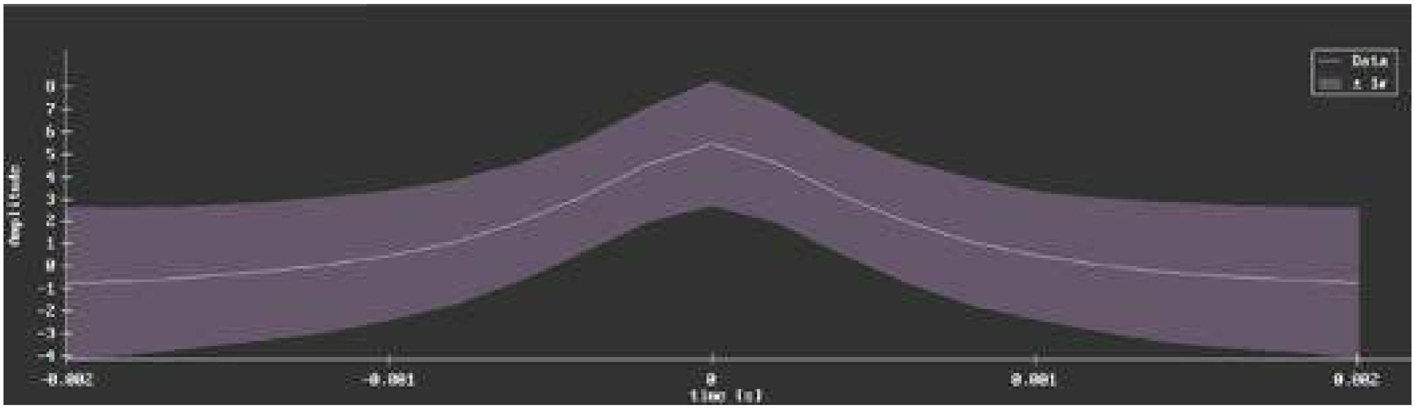


Below are the average waveforms computed for each trial.

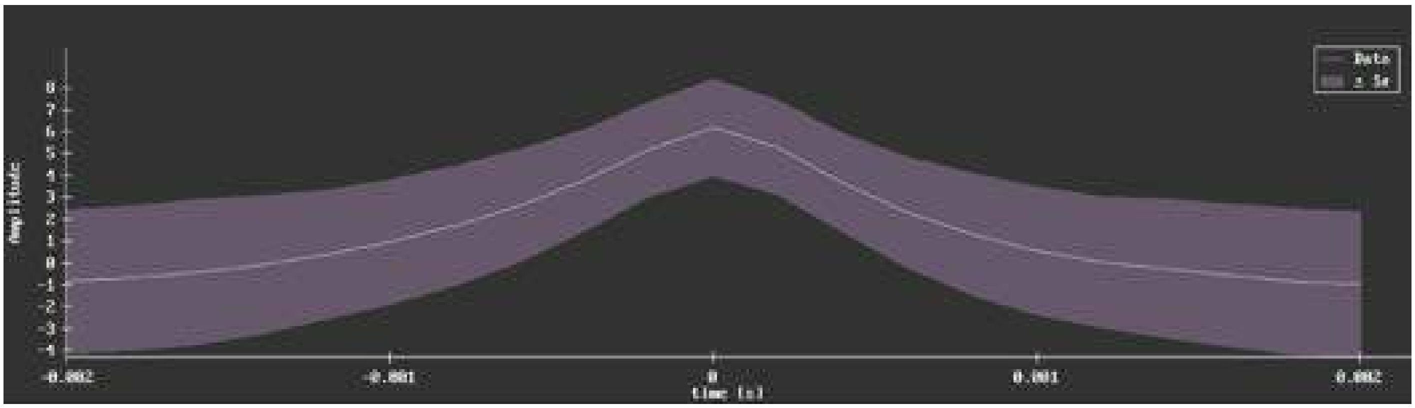
Standard Bicep

- 

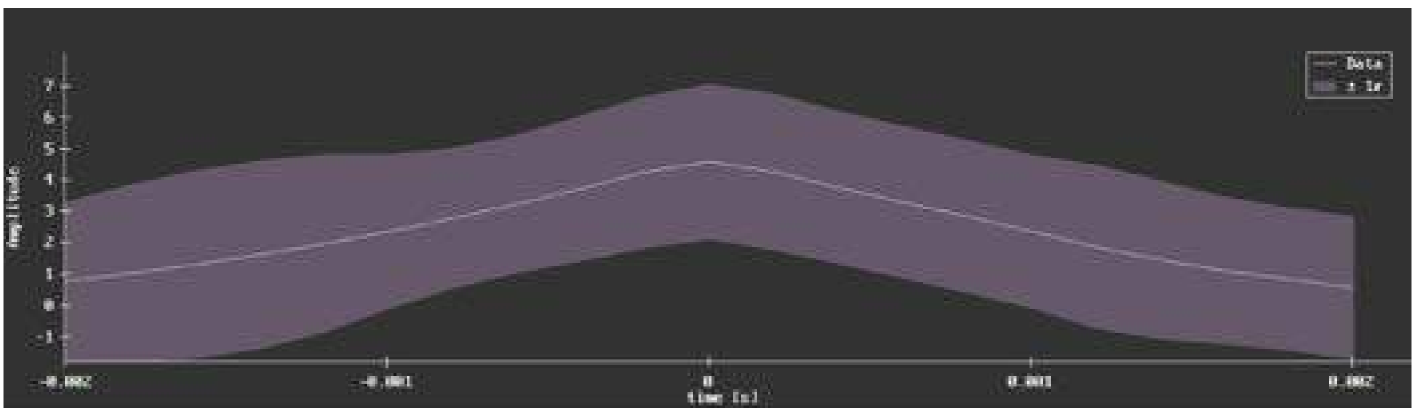
    - SSB1
        - Max around 5

- 

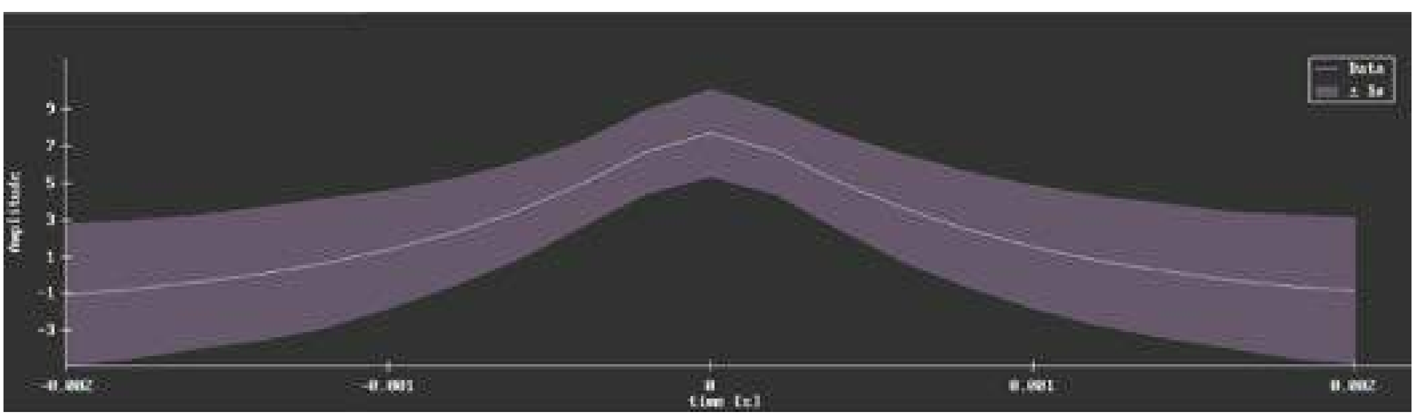
  - SSB3
    - Max around 5.5

- 

  - SSB5
    - Max around 6

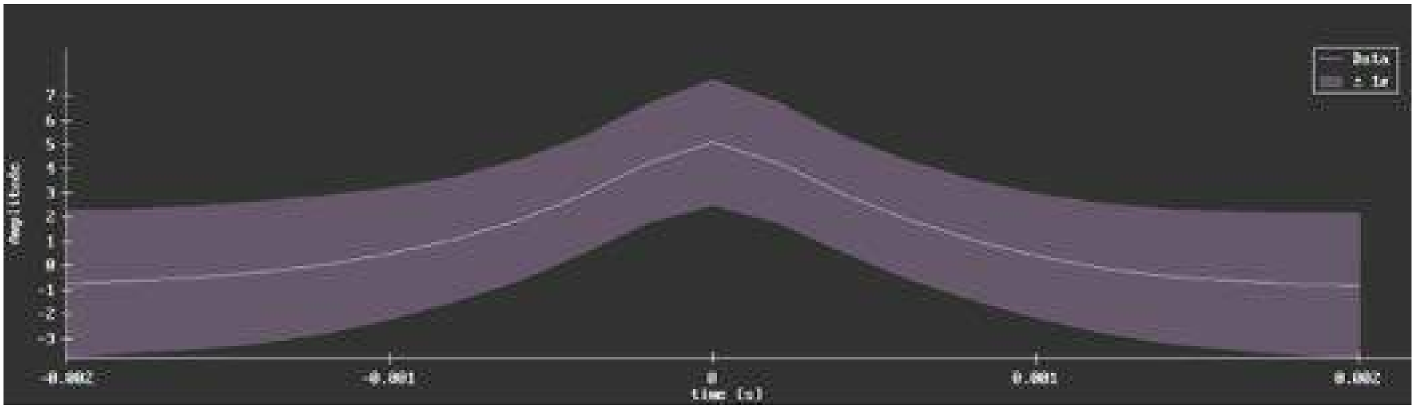
- 

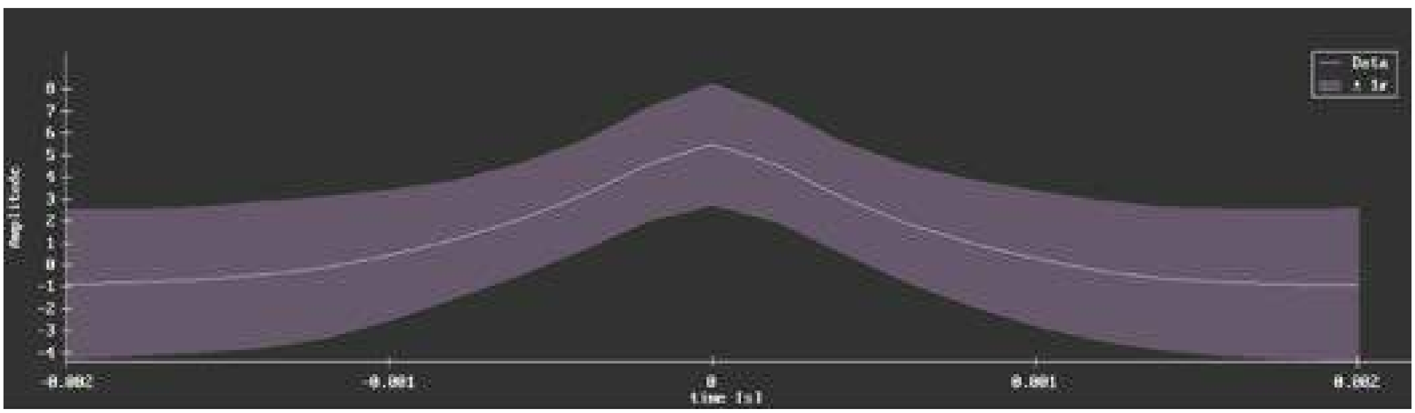
  - SSB7
    - Max around 7.5

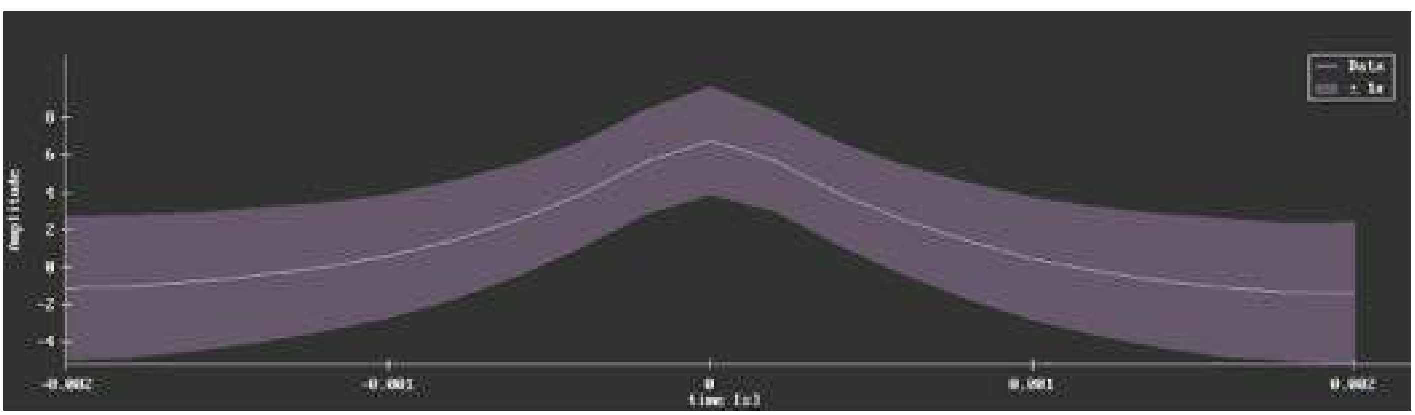
- 

- SSB9
  - Max around 8

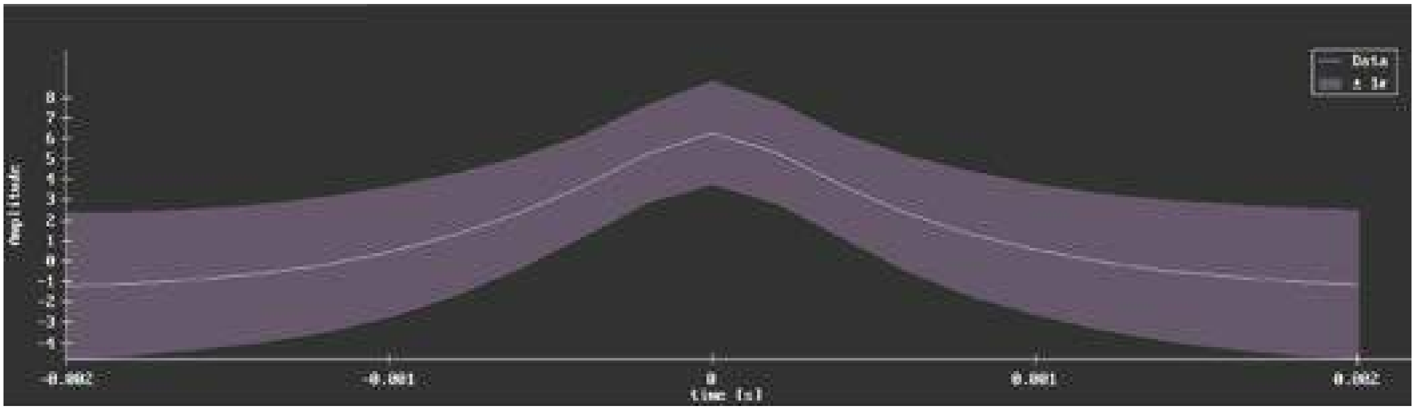
Adaptive Bicep

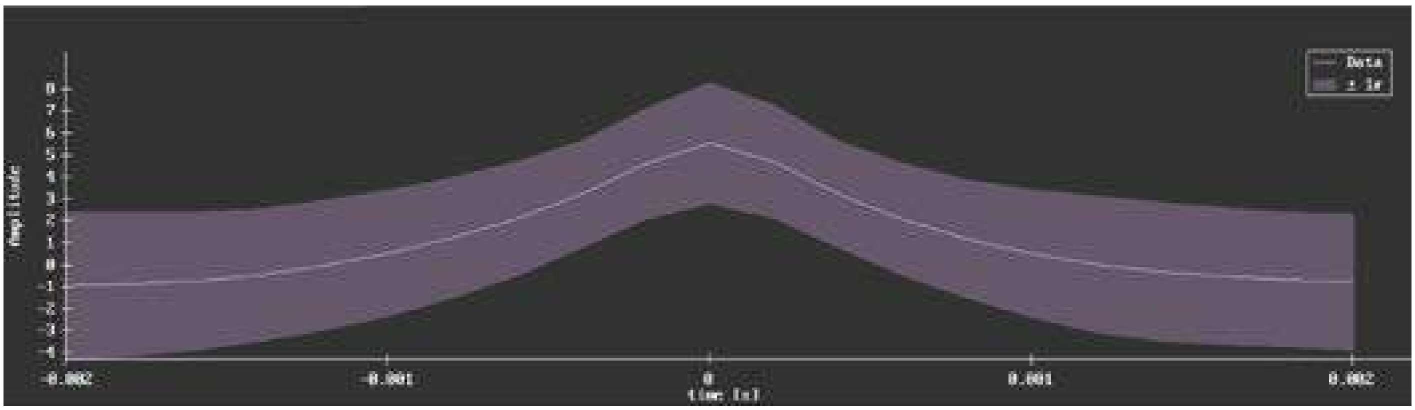
- 

  - ASB1
    - Max around 5
- 

  - ASB3
    - Max around 5.5
- 

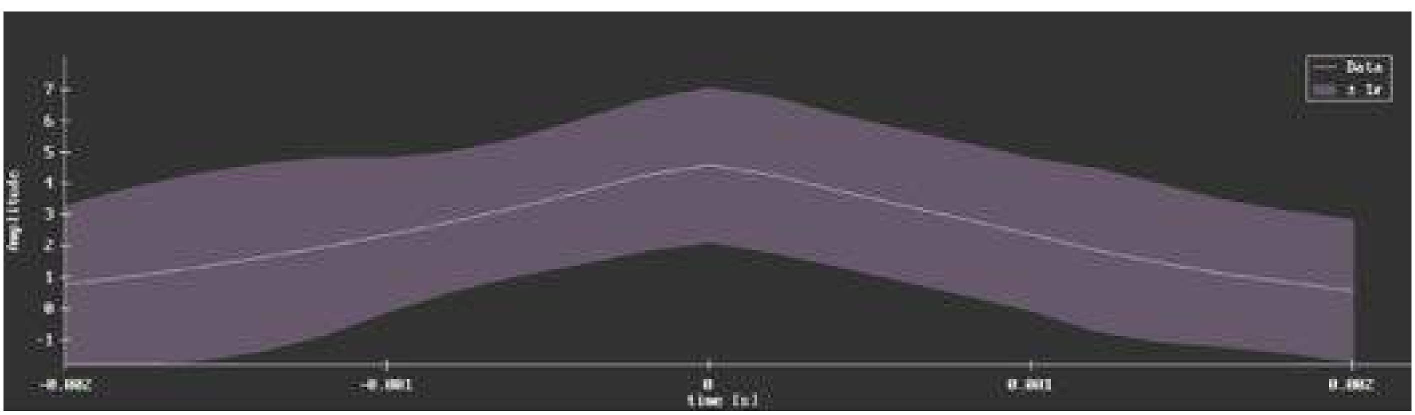
  - ASB5
    - Max around 7

- 

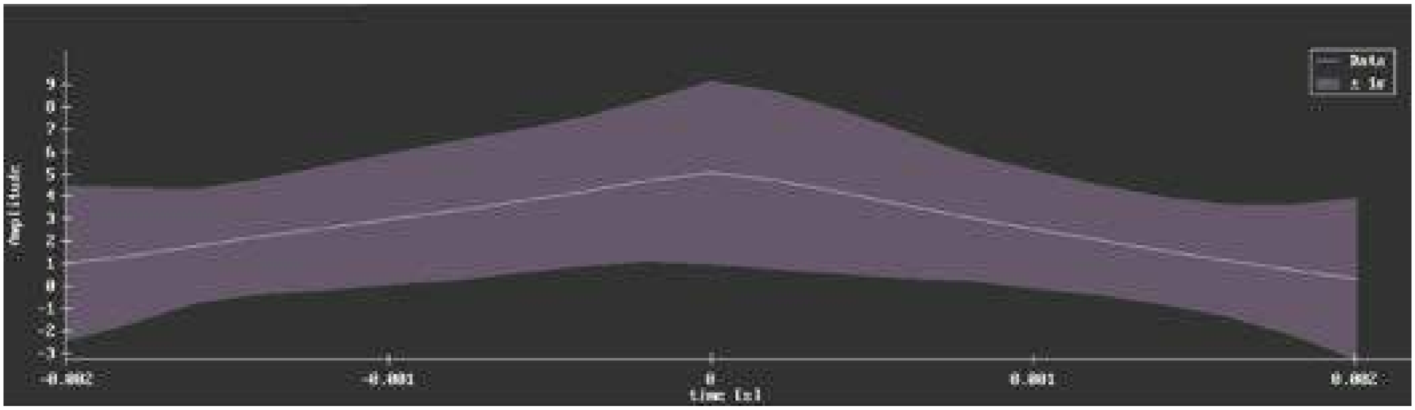
  - ASB7
    - Max around 6.5
- 

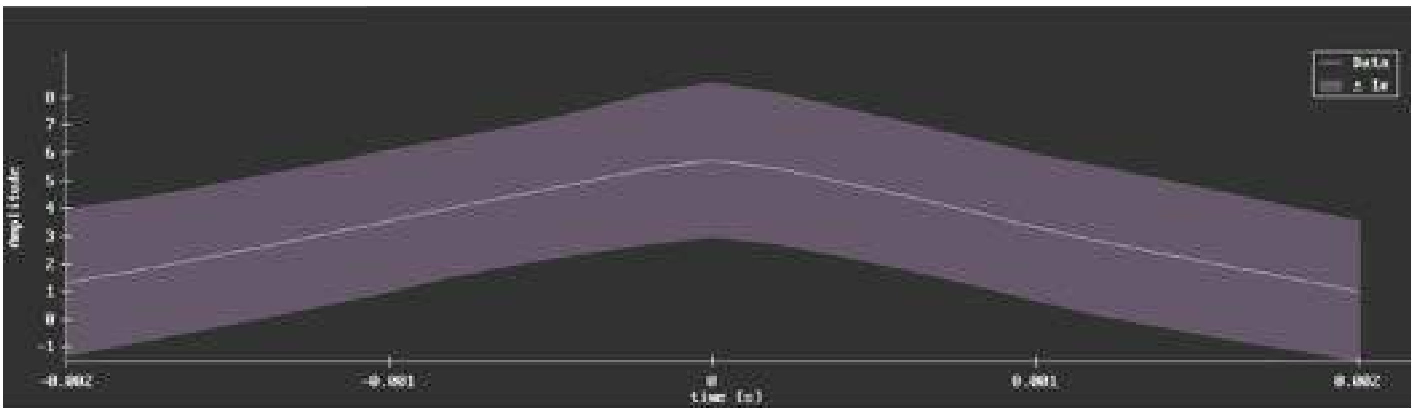
  - ASB9
    - Max around 6

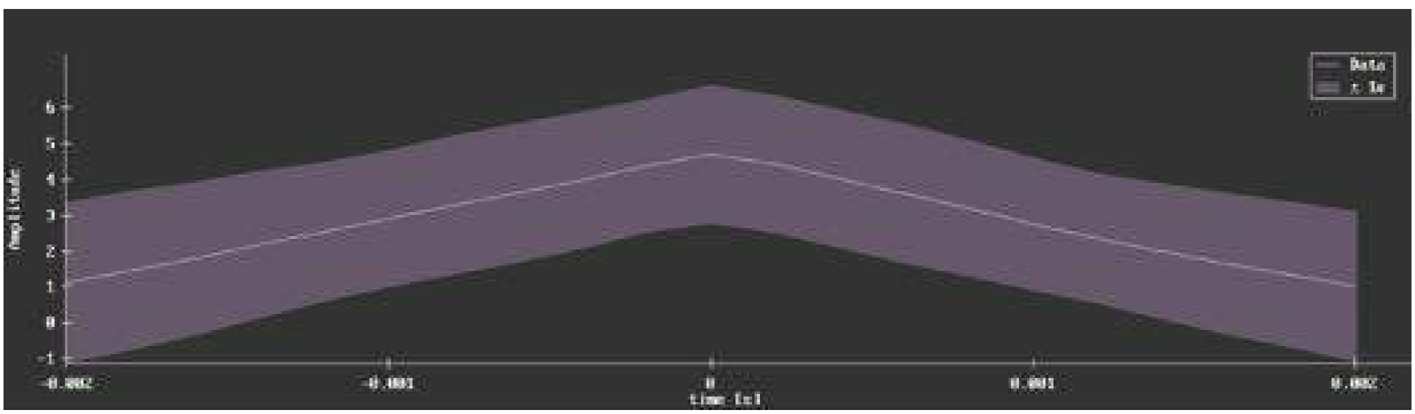
Standard Rear Deltoid

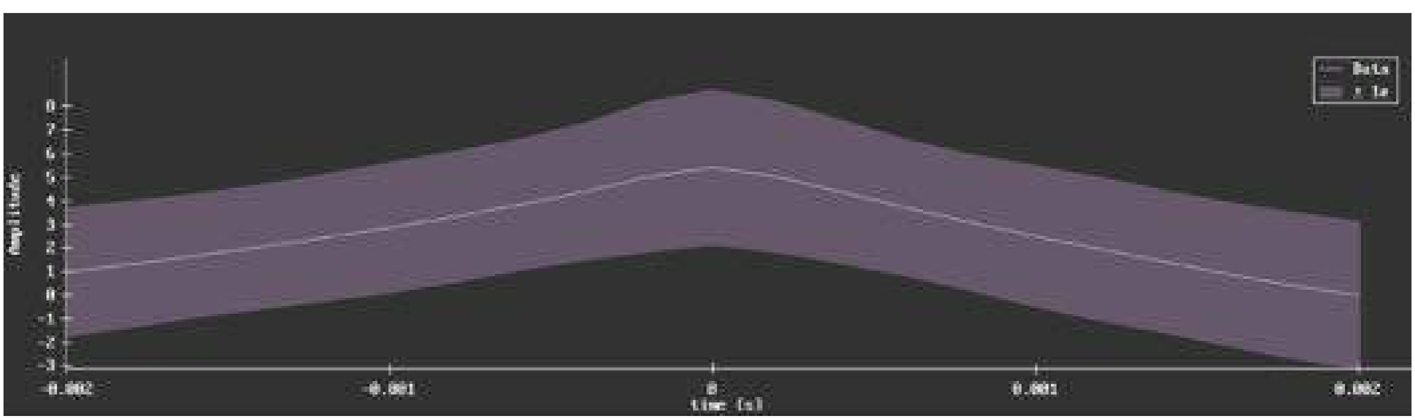
- 

  - SSD1
    - Max around 4.5

- 

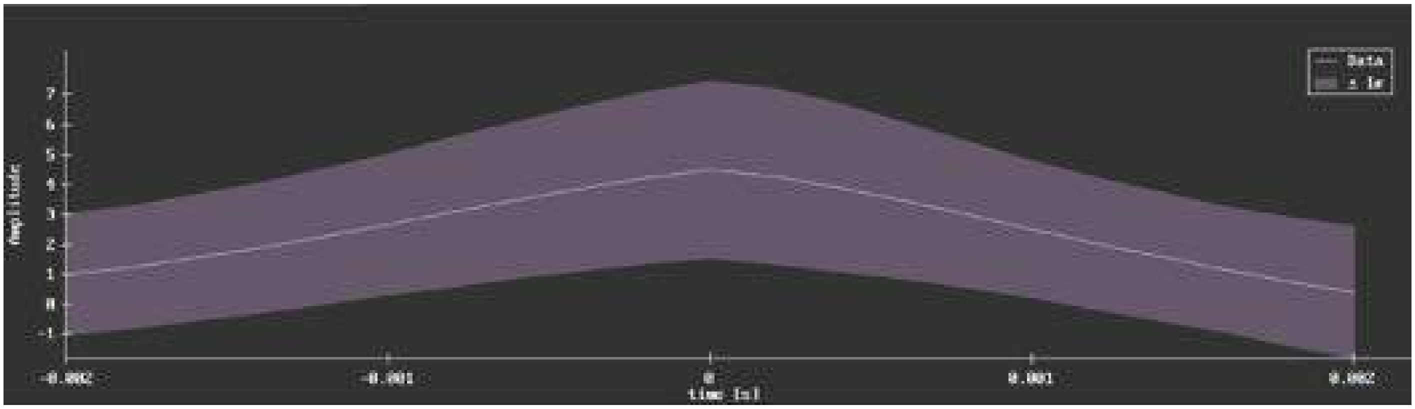
  - SSD3
    - Max around 5
- 

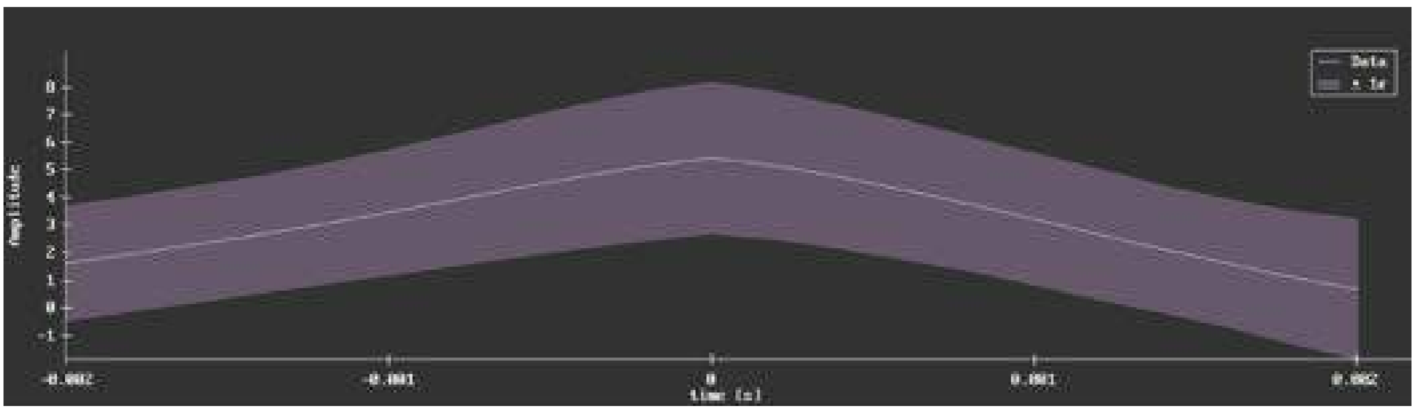
  - SSD5
    - Max around 6
- 

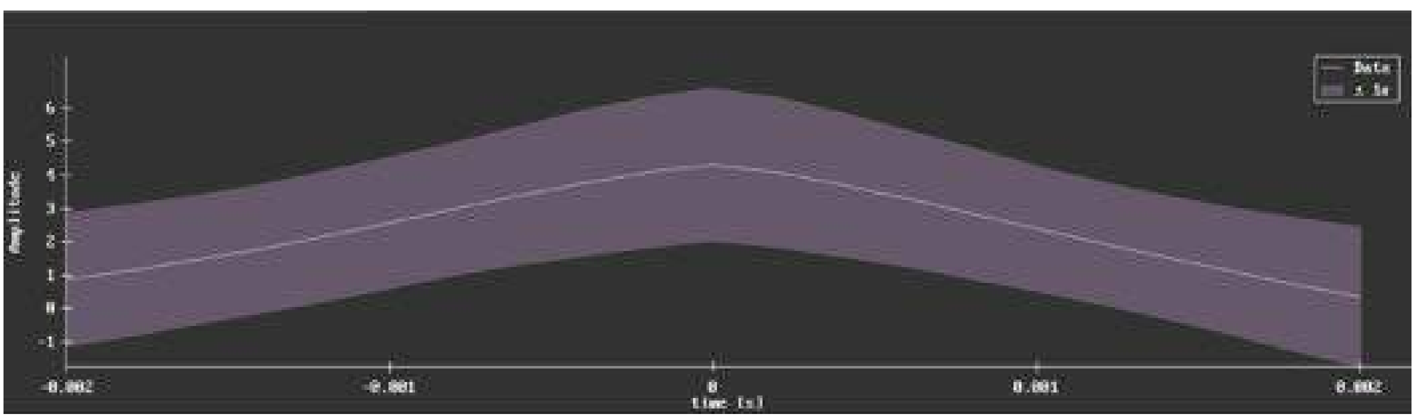
  - SSD7
    - Max around 5
- 

- SSD9
  - Max around 6

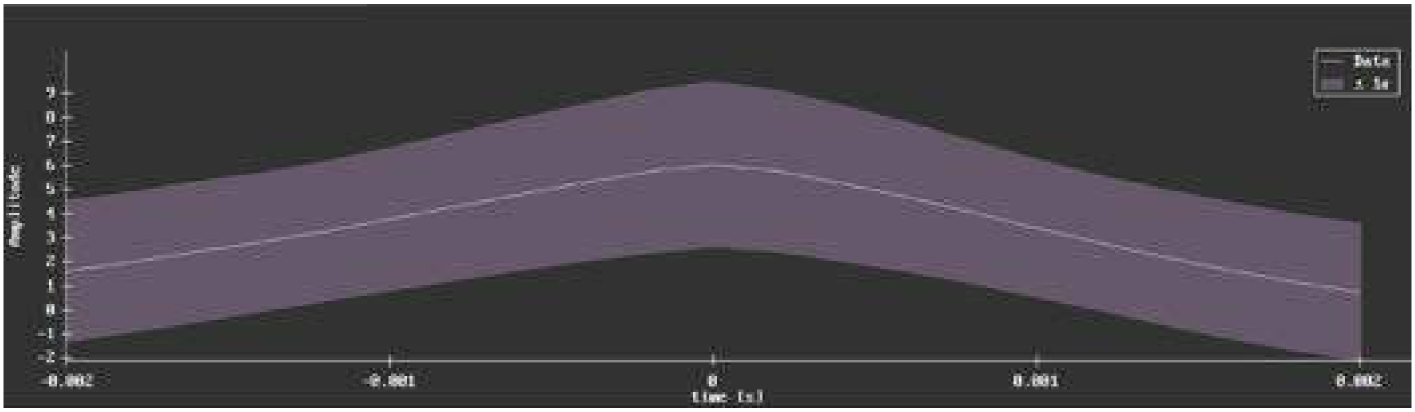
Adaptive Rear Deltoid

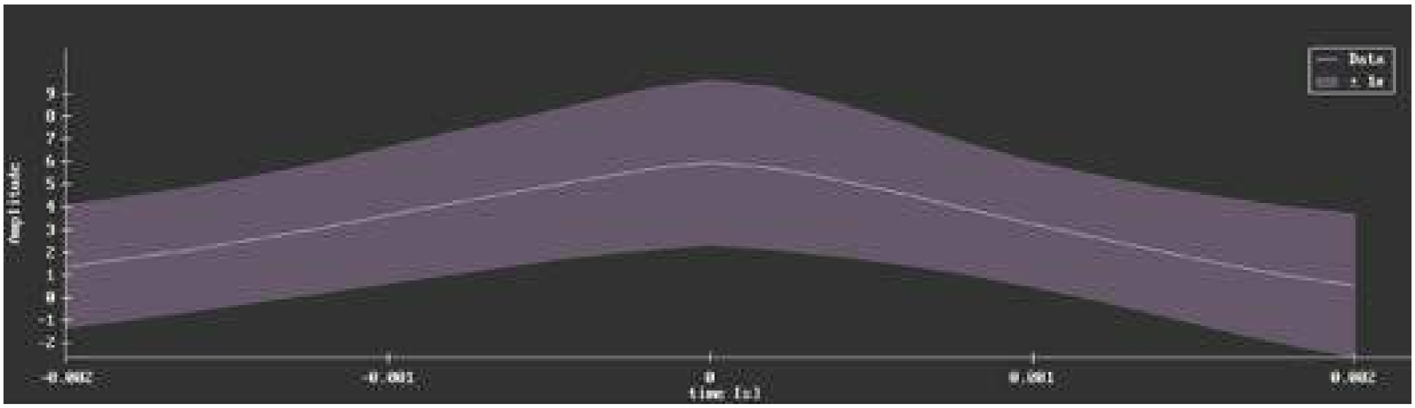
- 

  - ASD1
    - Max around 4.5
- 

  - ASD3
    - Max around 5.5
- 

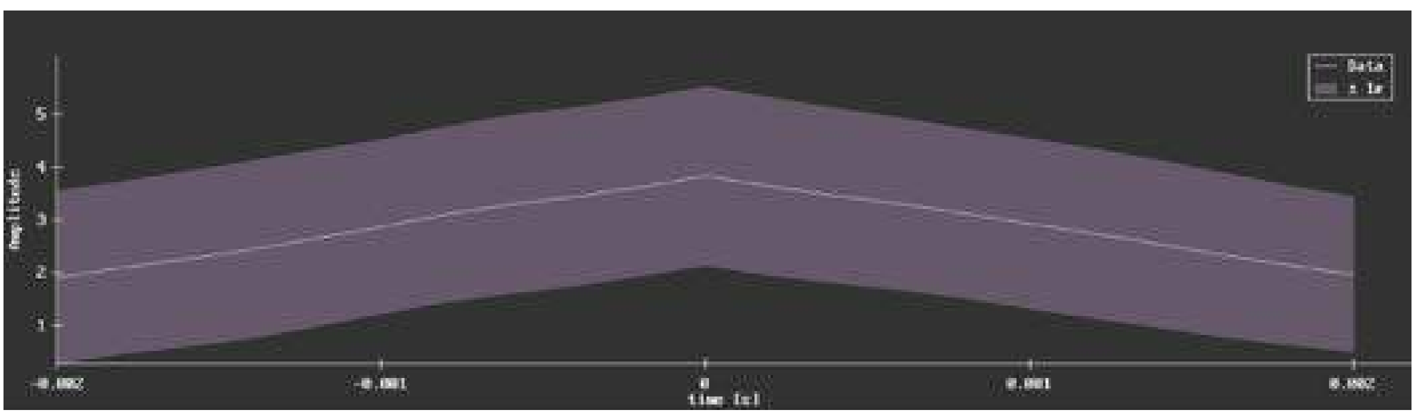
  - ASD5
    - Max around 4.5

- 

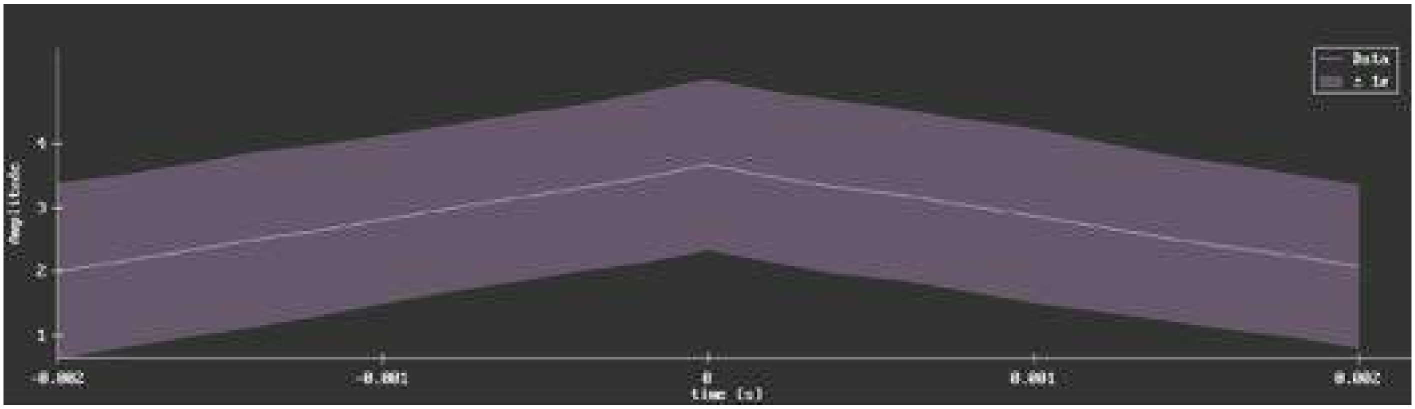
    - ASD7
        - Max around 6
- 

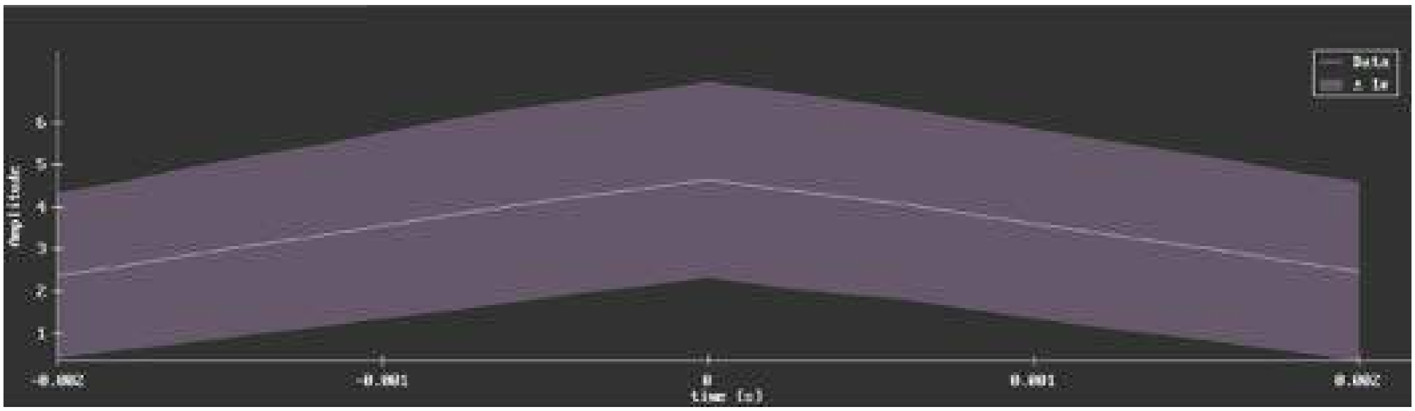
    - ASD9
        - Max around 6

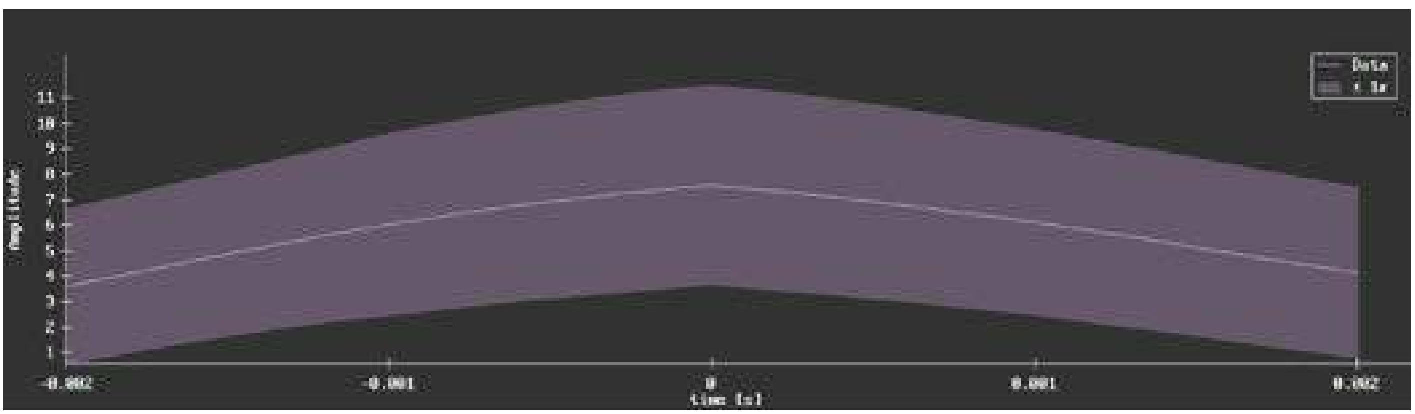
Standard Latissimus Dorsi

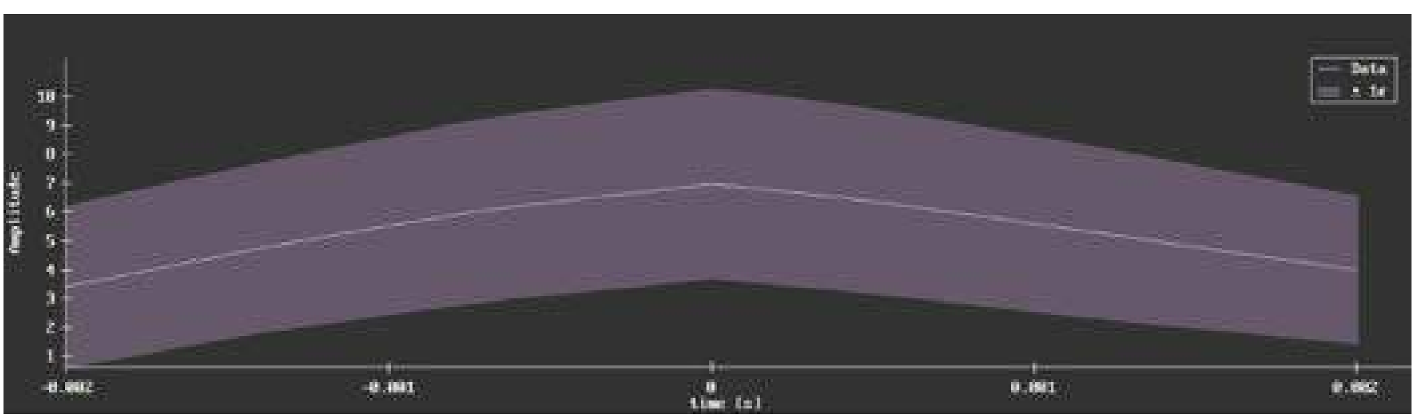
- 

    - SSL1
        - Max around 4

- 

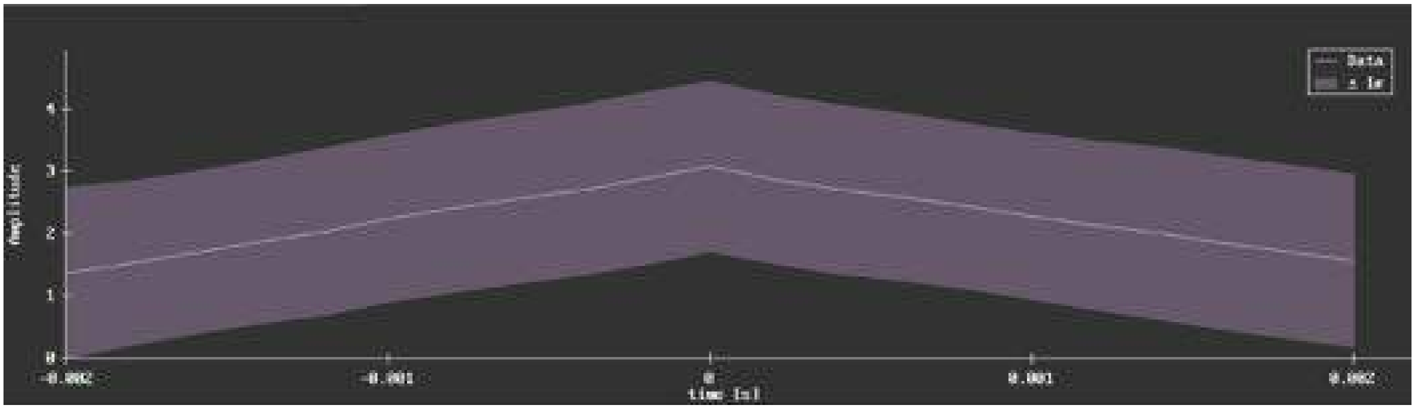
    - SSL3
        - Max around 3.5
- 

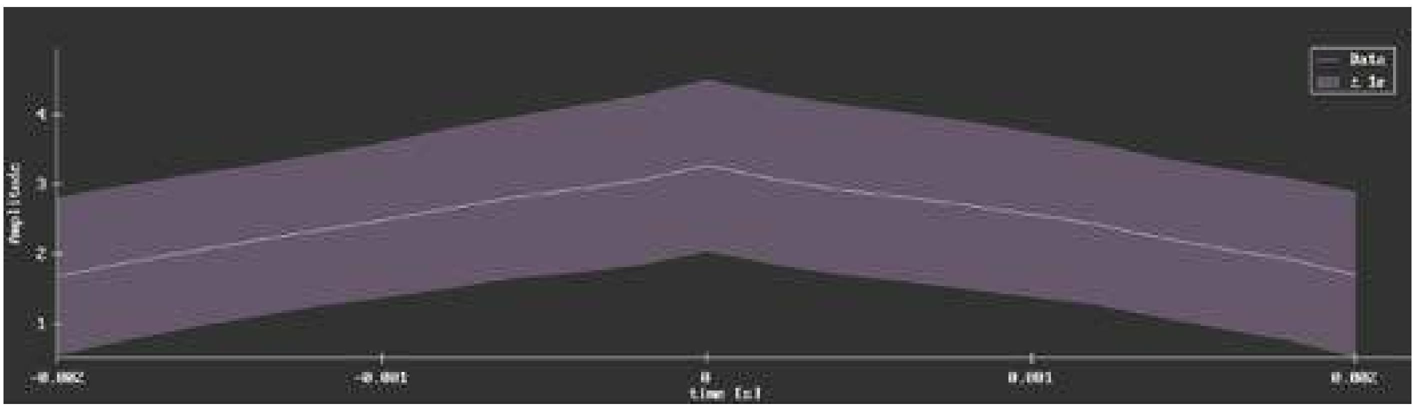
    - SSL5
        - Max around 4.5
- 

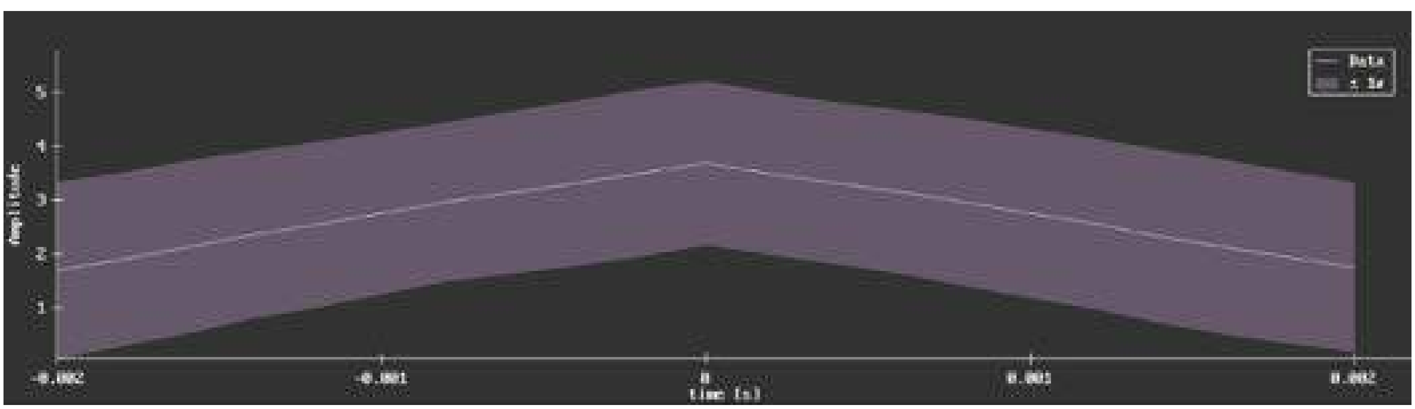
    - SSL7
        - Max around 7.5
- 

- SSL9
  - Max around 7.5

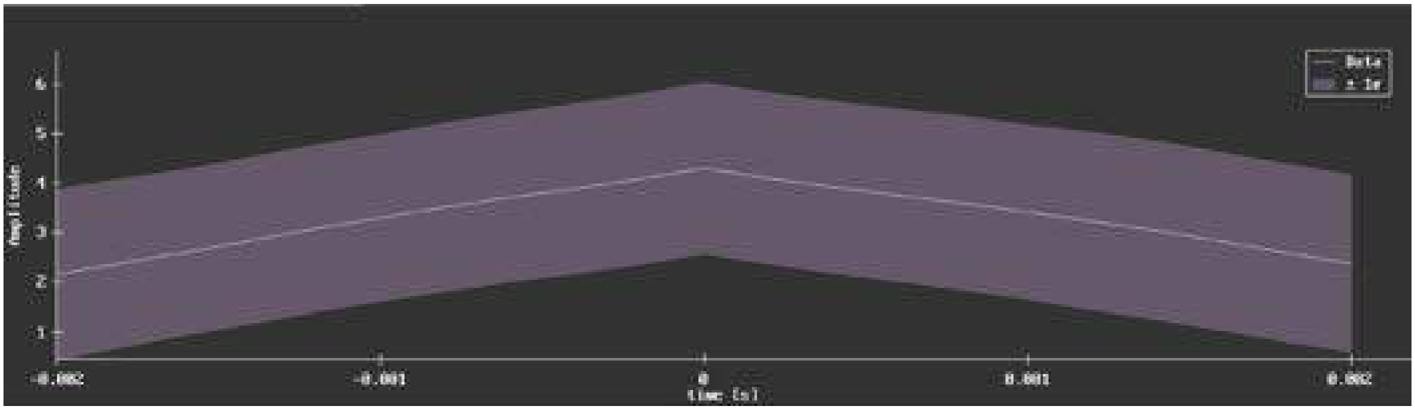
Adaptive Latissimus Dorsi

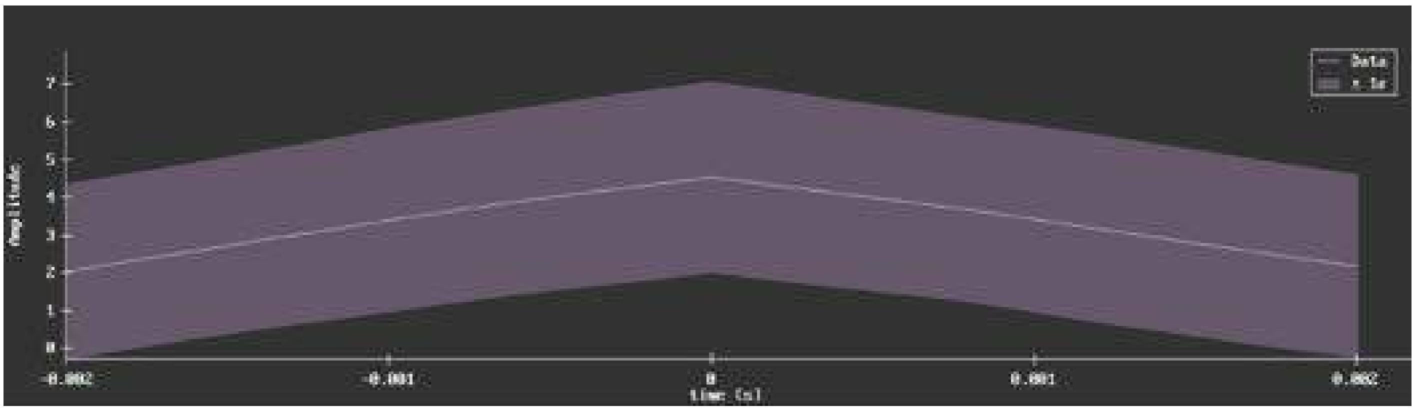
- 

  - ASL1
    - Max around 3
- 

  - ASL3
    - Max around 3
- 

  - ASL5
    - Max around 4

- 

    - ASL7
        - Max around 4.5
- 

    - ASL9
        - Max around 5

Conclusions/action items:

All of the average waveform graphs were captured and each maximum amplitude was noted for each trial. This data will be used for the analysis section of our EMG testing. Ultimately, we wa there are differences in activation between the standard and adaptive sides in addition to increases in activation for increases in resistance.

Action items:

- Analyze the EMG data and note trends

04/20/2023 EMG Testing Analysis and Results

SAMUEL SKIRPAN - Apr 20, 2023, 3:12 PM CDT

Title: EMG Testing Analysis and Results

Date: 4/20/23

Content by: Sam

Present: Sam

Goals: Analyze the collected EMG data.

Content:

Analysis of EMG testing data will focus on the general trends for each particular muscle with increases in resistance and from standard to adaptive side. Overall general trends in max amplitude of average waveform will be analyzed.

Standard Side

- Bicep
    - From R1 to R9: 5, 5.5, 6, 7.5, 8
- Rear Delt
    - From R1 to R9: 4.5, 5, 6, 5, 6
- Lat
    - From R1 to R9: 4, 3.5, 4.5, 7.5, 7.5

Adaptive Side

- Bicep
    - From R1 to R9: 5, 5.5, 7, 6.5, 6
- Rear Delt
    - From R1 to R9: 4.5, 5.5, 4.5, 6, 6
- Lat
    - From R1 to R9: 3, 3, 4, 4.5, 5

Analysis and trends:

- Standard side
    - Increasing resistance on standard side led to increase in activation for following muscles:
        - Bicep and lat
    - Not much of a correlation for increase in resistance on standard side to activation of rear delt
- Adaptive side
    - Not much of a correlation between increase in resistance and muscle activation for bicep
    - Small, weak correlation for increase in resistance and increase in muscle activation for rear delt and lat

- Comparison
    - Activation levels on standard side were higher for the lat than for the adaptive side
    - No strong difference between activation for bicep and rear delt between both sides

Conclusions:

- Difficult to draw overall conclusion between levels of activation when increasing resistance for different muscle groups. There was a fairly consistent increase in exertion for the following when increasing the resistance: standard side bicep, standard side latissimus dorsi, and adaptive side latissimus dorsi. Also, there was not much of a difference between the level of activation for respective muscle groups between the standard and adaptive sides. However, one notable difference between the standard and adaptive sides was the level of activation of the latissimus dorsi. The latissimus dorsi group had higher levels of activation on the standard side than on the adaptive side for each respective resistance level.

Limitations in testing:

- Only tested one individual, so having limited number of participants could lead to inaccuracy with results
- Data capture only lasted approximately 10-15 seconds per trial
- Inconsistency with rowing rate and exertion of the course of a given trial
    - Tried to use the metronome to keep this as constant as possible, but there still could have been some errors
- Improper setting of the frequency filters when using the EMG machine to capture results could have led to missing data points throughout the testing period

Ways to improve:

- Include more users in the EMG testing
- Have data capture last for a longer period of time to get consistency between rowing strokes
    - Would also help with the inconsistency of the rowing rate
- Use the same frequency cutoffs for each muscle group when completing the testing

Conclusions/action items:

I analyzed the results from the EMG data and noticed that there were not many distinct conclusions we can draw from our testing. One interesting conclusion we noticed was that we had higher levels of activation on the standard side than adaptive side for the latissimus dorsi trials.

Action items:

- Share these results with the team

4/22/23 - Comparison Survey Analysis

Josh ANDREATTA - Apr 22, 2023, 8:45 PM CDT

Title: 4/22/23 - Comparison Survey Analysis

Date: 4/22/23

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show initial results of surveys completed by people who compared the standard side to the adaptive side

Content:

Attached here is the initial analysis of the comparison survey results (which includes surveys for the standard side, adaptive side, and the comparison between the two sides), as well as a scanned PDF of all the surveys I collected. Roxi has the rest and will include her scans in a separate entry. There are a few things to note with this testing

1. Initially, we had thought we collected 11 comparison surveys. However, one team member accidentally handed out the wrong survey to a participant, so they filled out the adaptive side only survey instead of the longer comparison survey. Therefore, this survey was scrapped in data analysis leaving 10 total participants. Additionally, 2 other test subjects neglected to fill out the actual comparison portion of the survey, so they only filled out the standard and adaptive side surveys individually. Therefore, we have 10 participants to gather feedback from the individual standard and adaptive side surveys, but only 8 participants to gather data from the comparison survey.

Overall, the feedback we got was very positive. We received a majority of 4's and 5's as scores (which are on the more positive side of the spectrum). The main negative feedback was that participants thought the console and buttons were a little far away on the standard side. However, they are basically in the same relative position as they are in a standard un-modified rowing machine, so this is not something that knocks our design. 2 participants said the console and buttons were slightly out of reach from the adaptive side if they had shorter arms/wingspans. 1 participant suggested automating the lap pad to lower rather than having it be via pin mechanism. Personally, I don't think that is necessary. To improve it, I would rather add the gas-assist like we talked about with Staci at the beginning of the semester.

The data is summarized in the attached excel sheet. I made a histogram for each of the 3 sub-surveys with each question and their scores. This looks very busy in the graph, so to better present it on the poster and in the journal article, Roxi and I are going to create a summary table or 2 to better represent the average scores based on different categories of the design (stabilization frame, console, resistance, overall experience) for the comparison survey and for the adaptive side survey. This will give the casual viewer of our poster a better holistic understanding of what the subjects thought of our device as a whole.

References: n/a

Conclusions:

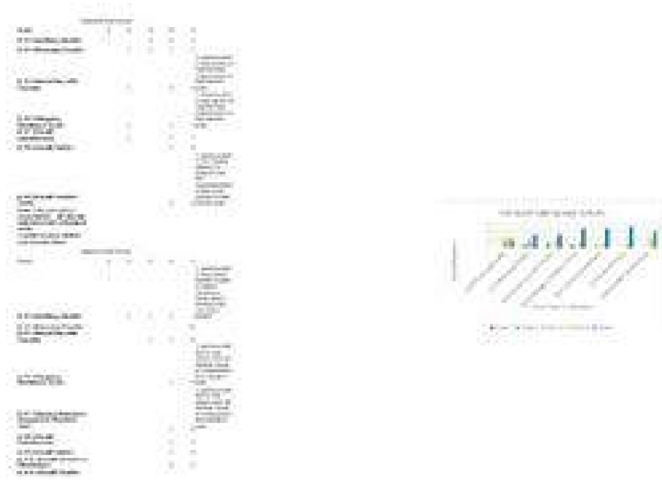
Overall, people really liked our design. The most common complaint was that the console/buttons were too far away on the standard side. Once roxi finishes her analysis of the adaptive side only surveys, we are going to pool our data and represent it in a table for the poster.

Action items:

-Work with roxi to make data summary table

-Make and Edit testing section of poster

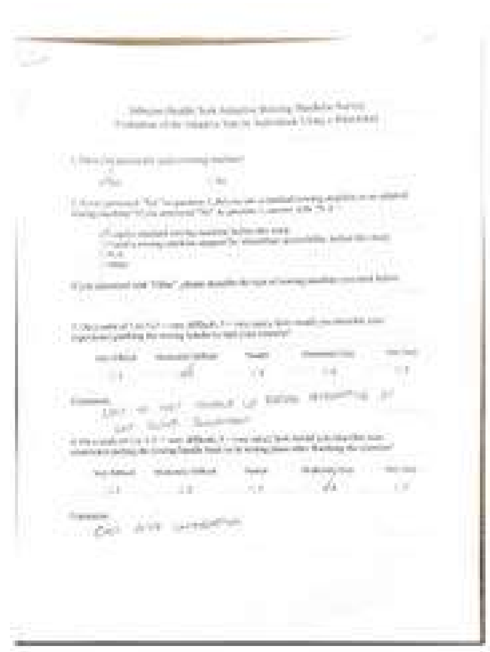
Josh ANDREATTA - Apr 22, 2023, 8:35 PM CDT



Download

Comparison_Survey_Analysis.xlsx (28.5 kB)

Josh ANDREATTA - Apr 22, 2023, 8:35 PM CDT



Download

Scanned_Surveys.pdf (23.2 MB)

04/23/2023 Survey Data Results

Roxi Reuter - Apr 23, 2023, 8:41 PM CDT

Title: Individual Poster Work

Date: 04/23/2023

Content by: Roxi Reuter

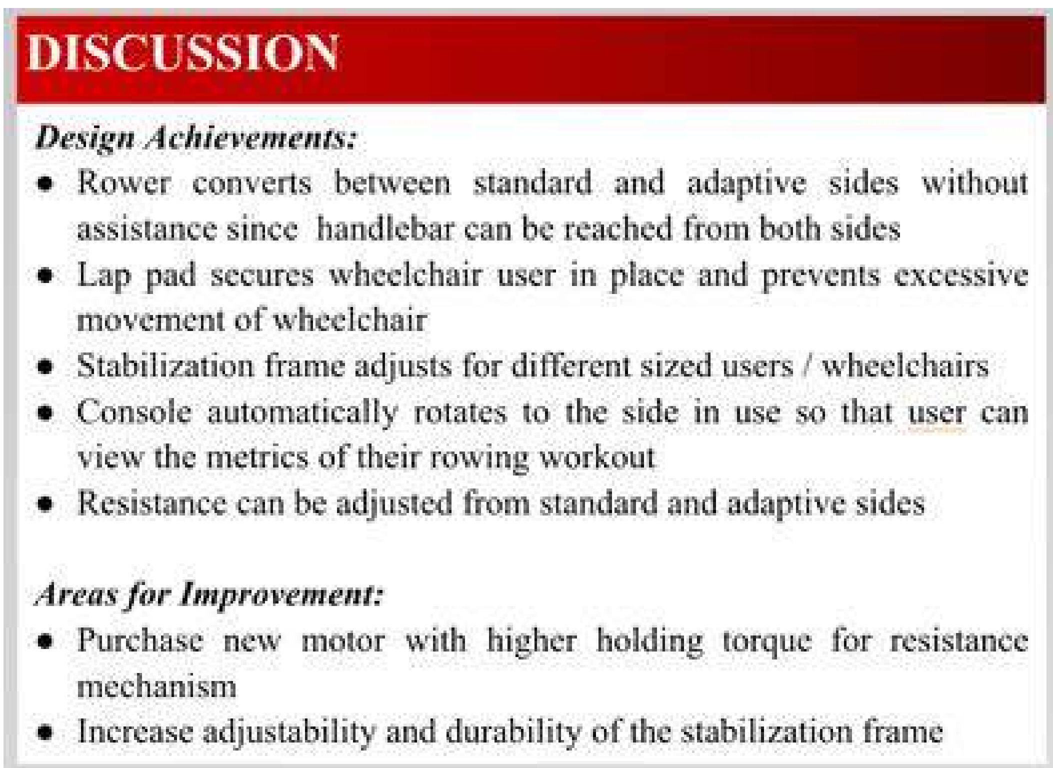
Present: —

Goals:

- Complete the discussion section of the poster
- Add in tables for survey data analysis (average scores after categorizing the questions)

Content:

- I made some edits to the discussion section of the poster:



- Below are the tables I created for analysis of the survey results from testing which will be used on the poster (see next page)
    - Please see attached Excel sheet for breakdown of which questions were used in the calculations of average scores

Standard and Adaptive Side Survey Results (Testing Participants without Physical Disabilities)	
Standard Side	Average Score (Out of 5)

Overall Ease of Use	4.22
Overall Safety	4.8
Comfort	4.6
Adaptive Side	Average Score (Out of 5)
Overall Ease of Use	4.7
Overall Safety	4.75
Comfort	4.5
Standard and Adaptive Comparison	Average Score (Out of 5)
Workout Comparability	4.38
Console Use and Transition	4.89
Likelihood of Future Use	4.9
Ease of Resistance Adjustment	4.5

Adaptive Side Only Survey Results (Testing Participants with Physical Disabilities)	
Adaptive Side	Average Score (Out of 5)
Overall Ease of Use	4.8
Overall Safety	4.83
Comfort	4.33
Likelihood of Future Use	4.67

Conclusions/action items:

In this work session, I worked on my assigned portions of the poster. In the coming days, I will review the poster individually and with the team, as well as practice presenting for the final presentation.

Roxi Reuter - Apr 23, 2023, 8:43 PM CDT


Overview

Sheet 1: Sheet1

Download

Survey_Analysis_and_Results.xlsx (11.9 kB)

Preliminary Presentation Slides

ANNABEL FRAKE - Feb 10, 2023, 3:16 PM CST

Title: Preliminary Presentation Slides

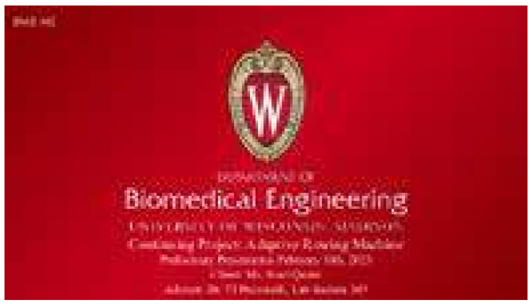
Date: 02/10/2023

Content:

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

References: none

ANNABEL FRAKE - Feb 10, 2023, 3:16 PM CST



Download

Spring_2023_Preliminary_Presentation.pdf (2.02 MB)

2/28/2023 - Updated PDS

Josh ANDREATTA - Feb 28, 2023, 3:25 PM CST

Title: 2/28/2023 - Updated PDS

Date: 2/28/2023

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

Present: Josh, Roxi, Sam, Annabel, Tim

Goals: Show updated PDS

Content:

The only change made was to remove the source and explanation of a 1050 N load for simulations of the pulley plates. Instead, the BME 301 trial tension data will be used. The pulley plates will be run with simulations of 300 N applied towards the adaptive side of the rower for a safety factor of 2, 150 N applied towards the adaptive side for a safety factor of 1, 400 N applied towards the standard side of the rower for a safety factor of 2, and 200 N applied towards the standard side for a safety factor of 1. This data was pulled from the BME 301 notebook.

Johnson Health Tech: Adaptive Indoor Rower for Wheelchair Users

Product Design Specifications

Feb 28th, 2023

Client: Mrs. Staci Quam (staci.quam@johnsonfit.com)
Advisor: Dr. Tracy Jane Puccinelli (tracy.puccinelli@wisc.edu)
Team Leader: Annabel Frake (frake@wisc.edu)
Communicator: Josh Andreatta (jandreatta@wisc.edu)
BSAC: Sam Skirpan (skirpan@wisc.edu)
BWIG: Tim Tran (ttran28@wisc.edu)
BPAG: Roxi Reuter (rmreuter@wisc.edu))
Lab: 307

Function:

Individuals with injuries or disabilities have trouble utilizing typical workout machines due to a lack of exercise equipment that is accessible to them. One of these affected groups 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 will be adapted to accommodate individuals who require the use of a wheelchair [1], but will retain the ability for someone not in a wheelchair to easily use the machine. 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 a rowing machine by individuals in wheelchairs while allowing the user to maintain proper rowing form, and will help to improve their overall well-being through exercise.

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.

Design Requirements:

1. **Physical and Operational Characteristics**
   a. *Performance Requirements:*
      i. 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.
      ii. The modifications made, to allow for attachment of the user/wheelchair, should remain intact and not break with repeated use of the rowing machine.
         1. The modifications used for the attachment should be able to resist and endure stresses caused by a pulling force within the range of 0 N to 400 N. This range was determined based on the preliminary data collected in BME 301.
         2. The modifications made to the machine should be able to endure the fatigue due to the repetitive rowing cycle.
      iii. The user will grip the handlebars to complete rowing movements. The wheelchair and the adaptive rower machine will remain stationary during rowing.
      iv. The device will be used daily.
      v. The transition of the handle and rope from the original configuration to the adapted side should be easily carried out by all users, including those in wheelchairs.
   b. *Safety:*
      i. The modifications made to the rowing machine will not pose any biological hazards to the user.
      ii. Any modifications made to the rower will be filed and made smooth in order to prevent sharp points that could harm the user. Additionally, all modifications will be reviewed to make sure that no pinching/excess pressure is felt by the user during exercise.
      iii. The modifications made to the rower will ensure that the user is securely stabilized to the rower and will not be ejected from their wheelchair during use of the rower.
      iv. Electrical components incorporated into the design will be covered to prevent harm to the circuit and/or user (i.e. water damage or electrocution).
   c. *Accuracy and Reliability:*

i. The adapted rowing machine should accurately simulate the feeling of a traditional rowing machine for the user's upper body by producing a force per pull between 100-400 N. This range accommodates for the different resistance settings.
ii. The loading and recoil motions should accommodate pulling the handle bars back to approximately one arm's length and should be smooth and absent of excessive friction.
iii. In order to prevent backwards tipping, a mechanism should be included that provides a downward reaction force to counteract the maximum backward force of 400 N with a safety factor of two. The reaction force output by this mechanism should not cause forward tipping. The force output necessary to prevent tipping should be repeatable given a certain force input from the rower.
iv. Once the adapted fixtures are designed, proper tolerances will be assigned to each of the components to ensure proper assembly and functionality of the adapted rowing machine.

d. Life in Service:

i. The modifications and attachments added to the rowing machine should last for the same duration the rowing machine typically lasts. The lifetime of a rowing machine is categorized a few different ways. The modifications made should last:
   1. At least 10 years [2]
   2. At least 8 million meters [2]
ii. The product will be able to be used for at least 10 years and withstand normal wear and tear from the user.
   1. Weight placed onto the product from the user
   2. Friction applied by the user
iii. All modifications will provide the user with a stable and safe rowing experience for the 10-year period.
   1. This includes preventing the user from tipping over while using the machine.
   2. A safe locking system that ensures the wheelchair does not move during use.
   3. Support the user's body to ensure security.

e. *Shelf Life:*

i. The product will be stored in an environment that minimizes external loads placed onto the rower. This includes when it is being manufactured overseas, while shipping, and during storage in various facilities. Maximum external loads applied will be limited to 158.76 kg [1].
ii. The temperature range for the manufacturing, shipping, and storage process should be maintained within -20°- 45°C (-4°-104°F).
iii. When stored at a facility, the product will remain functional for a minimum of 30 years.

f. Operating Environment:

i. Ideal temperature range for the machine is 5°-35°C (41°-95°F). Temperatures exceeding 95°F/35°C might lead to the device warming up, causing discomfort for the user.
ii. No large water sources should be used near this device. The LCD display relies on a power generator and water could destroy internal components of the rower.
iii. The device will allow a wheelchair user to attach the chair to the device.
   1. All forces applied by the wheelchair onto the rower will not hinder the machine's ability to perform at its optimal level.
   2. Forces will be minimized by the use of harnesses and supports.

g. *Ergonomics:*

i. The user will secure themselves to the adaptive rower. This action will utilize only hands and arms and will be possible in an upright sitting position.
ii. A locking support system will ensure the user will not move during rowing.
iii. External additions to the rower will not inhibit comfort to the user. Stability measures will not inhibit the rowing experience for wheelchair users.

iv. After the user is secured into the machine, only the upper body will be used to complete the rowing motion. In addition, the user will be in an upright position.
   1. No leg movements will be required during the use of the machine.

v. Users will not need to reach more than 70 cm (1.8 ft) from the front of the wheelchair to grab the handlebar [3].

h. Size

i. Additions will extend from the device by a maximum amount of 1.6067 m (3.5 feet). This will be measured by taking the distance perpendicular from the points of addition. The current dimension of the device is 223 cm x 55 cm x 97 cm [1].

i. Weight

i. The current weight of the design is 158.76 kg/350 lbs [1].

ii. A maximum of 40 kg (approximately a fourth of the rower's weight) of mass will be added to the existing rower. This is to ensure the rower can still easily be moved via its transportation wheels if necessary.

j. Materials:

i. When possible, adaptations will be fabricated out of clean, polished, or painted metal for support and durability.
   1. Common materials used for exercise equipment include steel and aluminum due to high durability and strength [4].
      a. The Pulley Plate and Antler will be made out of Plain Carbon Steel.

ii. Materials that have a high degree of flexibility should not be used for the stabilization structure. However, cushioning materials may be used where this structure contacts the user for added comfort.

iii. Plastics used will have a high degree of strength and durability.
   1. 3D Printed Components will be printed out of 100% Infill Tough PLA.

iv. After application of 400 N (safety factor of 2) onto the plates supporting the additional pulley is applied, a maximum deformation of 2.0 mm will be allowed. The pulley plate material will be able to withstand these typical operating conditions.

k. Aesthetics, Appearance, and Finish:

i. Adaptations made to the machine will have a smooth finish to prevent abrasions or lacerations to the user.

ii. Welds will be smooth.

iii. If time permits, adaptations will be painted black to match the rower.

2. Production Characteristics

a. Quantity:

i. One rowing machine will be constructed and modified to accommodate the inclusion of a wheelchair during use.

b. Target Product Cost:

i. A budget of $500 will be used for development of the fixtures to the rowing machine structure for both the Fall and Spring semesters.

3. Miscellaneous

a. Standards and Specifications:

i. The International Organization for Standardization (ISO) entry 20957-7:2020 stipulates the safety requirements for rowing machines, specifically rowing machines within classes H, S, and I and classes A, B, and C for accuracy. Entry 20957-1 describes the general safety requirements for stationary workout equipment. Entry 20957-1 covers the safety requirements for any additionally provided accessories to be used in conjunction with the rowing machine [5].

ii. This product does not require FDA approval as it does not fall under any of the FDA regulated products such as pharmaceuticals, medical devices, medical biologics, food, products that contain tobacco, supplements, cosmetics or electronic products that emit radiation [6].

b. Customer:

i. The adapted rowing machine should be functional for individuals in wheelchairs, but ideally should be able to function as a standard rowing machine as well.

ii. The client prefers to have the rowing machine fully built into one assembly rather than broken up into several components that need to be attached each time the rowing machine is used.

c. Patient Related Concerns:

i. The rowing machine will need to be sterilized between uses to remove debris and sweat from previous users.

ii. The added adaptations to the rowing machine should be able to accommodate a range of wheel thicknesses and wheelchair widths up to 3 inches wide.

iii. The added adaptations to the rowing machine should not cause overuse injury to other parts of the users body, such as hands and arms.

1. The user should be thoroughly taught how to properly use the machine to reduce risk of misuse or injury.

iv. If the use of patient data is deemed necessary to construct specific adaptations to the rowing machine, it should be kept secure and confidential.

d. Competition:

i. There are currently a plethora of adapted rowing options for wheelchair users available on the market. One of these options is an adapted rowing machine seat that is easily switched with a standard seat and is more accessible to get in and out of for paralyzed users [7].

ii. Adapted rowing machines such as the AROW (Adapted Rowing Machine) by BCIT REDLab [8] utilize an adapter and a stabilizer to isolate the rowing motion to the upper body of the user while keeping their chair in place.

1. These adaptations were designed specifically for the Concept 2 rowing machine.

iii. There are also existing patents for adapted rowing machines, including patents specific to wheelchair users. One such patent describes a machine that includes a unit for fixing the upper half of a user’s body to the machine, straps to keep the user's legs stabilized, and a pulley system to create the rowing motion for the upper body [9]. Many of these patents appear to require an additional person to assist the user onto the machine or the user to move themself from their chair to the machine - both scenarios that have been deemed undesirable for this project by the client.

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

References for PDS

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

[2] "How Long Will A Concept 2 Rowing Machine Last? - Rowing Machine 101." http://rowingmachine101.com/concept-2-rowing-machine-lifespan/ (accessed Feb. 09, 2022).
[3] J. Looker, "Reaching for Holograms: Assessing the Ergonomics of the Microsoft™ Hololens™ 3D Gesture Known as the 'Air Tap," Oct. 2015.
[4] "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].
[5] "ISO 20957-7:2020 | Techstreet Enterprise." https://subscriptions-techstreet-com.ezproxy.library.wisc.edu/products/878217# (accessed Sep. 20, 2022). https://www.iso.org/standard/39908.html (accessed Feb. 09, 2022).
[6] "Does my product require FDA approval? FDA Pre-Approval Requirements," Aug. 06, 2019. https://www.onlinegmptraining.com/does-my-product-require-fda-approval/ (accessed Feb. 09, 2022).
[7] "Wheelchair Rowing Equipment," *The Accessible Planet*. https://www.theaccessibleplanet.com/fitness/wheelchair-rowing-equipment/ (accessed Feb. 09, 2022).
[8] "Rowing Solutions – Adapted Rowing Machine (AROW)." https://adaptederg.commons.bcit.ca/rowing-solutions/ (accessed Feb. 09, 2022).
[9] 박대성, 김민, 정다운, and 이범석, "Rowing machine for paraplegic patient," WO2012008664A1, Jan. 19, 2012 Accessed: Feb. 09, 2022. [Online]. Available: https://patents.google.com/patent/WO2012008664A1/en

References: n/a

Conclusions:

See PDS above.

Action items:

-submit prelim deliverables

Preliminary Journal Article

ANNABEL FRAKE - Feb 28, 2023, 9:49 PM CST

Title: Preliminary Journal Article

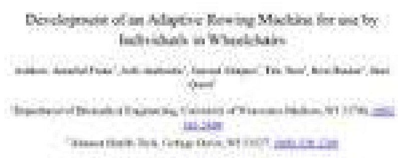
Date: 02/28/2023

Content:

-Please see the attached documents for the pdf version of the preliminary journal article.

References: none

Josh ANDREATTA - Feb 28, 2023, 9:55 PM CST


Development of an Adaptive Rowing Machine for use by Individuals in Wheelchairs

Download

Adaptive_Rowing_Machine-Preliminary_Journal_Article.pdf (30.3 MB)

Outreach Activity Guide

ANNABEL FRAKE - Mar 05, 2023, 10:01 PM CST

Title: Outreach Activity Guide

Date: 03/05/2023

Content:

-Please see the attached documents for the pdf version of the Outreach Activity Guide.

References: none

ANNABEL FRAKE - Mar 05, 2023, 10:02 PM CST


DEPARTMENT OF
Biomedical Engineering

Learning about Electricity and Energy

General Description

Program Objectives

Download

Andreatta_Frake_Reuter_Skirpan_Tran_OutreachActivityGuide.docx.pdf (159 kB)

IRB Application Files

ANNABEL FRAKE - Mar 05, 2023, 10:05 PM CST

Title: IRB Application Files

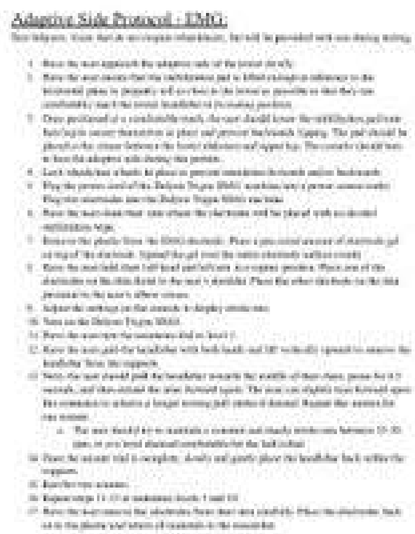
Date: 03/05/2023

Content:

-Please see the attached documents for the pdf versions of the IRB application files.

References: none

ANNABEL FRAKE - Mar 05, 2023, 10:04 PM CST


Adaptive Side Protocol - EMG:

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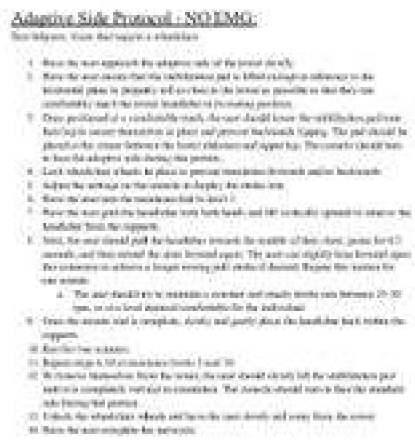
Adaptive_Side_Protocol_-_EMG.pdf (39.5 kB)

ANNABEL FRAKE - Mar 05, 2023, 10:07 PM CST



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Adaptive_SIde_Protocol_-_NO_EMG.pdf (73.5 kB)

ANNABEL FRAKE - Mar 05, 2023, 10:07 PM CST

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Adaptive_Side_Survey.pdf (45 kB)

ANNABEL FRAKE - Mar 05, 2023, 10:07 PM CST

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Comparison_Survey.pdf (71.3 kB)

ANNABEL FRAKE - Mar 05, 2023, 10:07 PM CST

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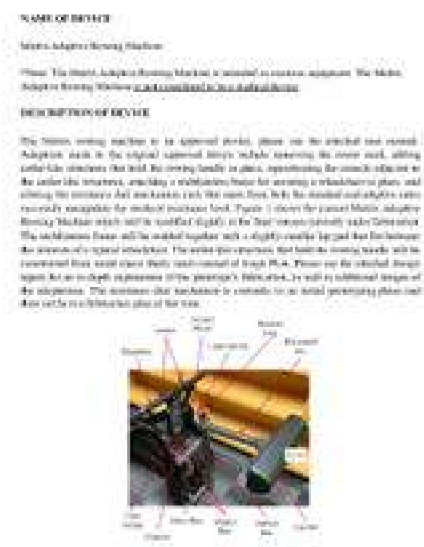
Consent_Form.pdf (57.9 kB)

ANNABEL FRAKE - Mar 05, 2023, 10:08 PM CST



NAME OF DEVICE

DESCRIPTION OF DEVICE

[Download](#)

Device_Documentation_.pdf (1.29 MB)

ANNABEL FRAKE - Mar 05, 2023, 10:08 PM CST

Standard Side Protocol- EMG:

[Download](#)

Standard_Side_Protocol_-_EMG.pdf (38.3 kB)

ANNABEL FRAKE - Mar 05, 2023, 10:08 PM CST

Standard Side Protocol - NO EMG:

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Standard_Side_Protocol_-_No_EMG_.pdf (35.7 kB)

Executive Summary

ANNABEL FRAKE - Apr 03, 2023, 10:35 PM CDT

Title: Executive Summary

Date: 04/03/2023

Content:

-Please see the attached documents for the pdf version of the executive summary.

References: none

ANNABEL FRAKE - Apr 03, 2023, 10:37 PM CDT

Download

402_Design_Excellence_Executive_Summary_Draft.pdf (80 kB) This is the first draft of the executive summary and will be revised.

ANNABEL FRAKE - Apr 21, 2023, 11:32 AM CDT

Download

402_-_Excellence_-_5_-_Adaptive_Rower_-_Executive_Summary.pdf (65.8 kB) This is the final version of the executive summary.

IRB Approval

ANNABEL FRAKE - Apr 11, 2023, 7:16 PM CDT

Title: IRB Approval

Date: 04/11/2023

Content:

-Please see the IRB approval.

References: none

ANNABEL FRAKE - Apr 11, 2023, 7:16 PM CDT

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Minimal_Risk_Research_IRB_Approval.pdf (78.9 kB)

Final Outreach Documents

ANNABEL FRAKE - Apr 15, 2023, 11:33 AM CDT

Title: Final Outreach Documents

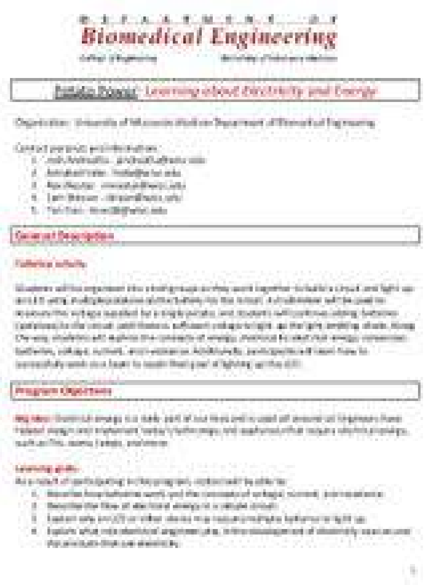
Date: 04/15/2023

Content:

-Please see the attached documents for the final pdf versions of the Outreach Activity Guide, Outreach Presentation Slides, and Outreach Event Summary.

References: none

ANNABEL FRAKE - Apr 15, 2023, 11:31 AM CDT


Biomedical Engineering

Portable Power: Learning about Electricity and Energy

General Description

Program Objectives

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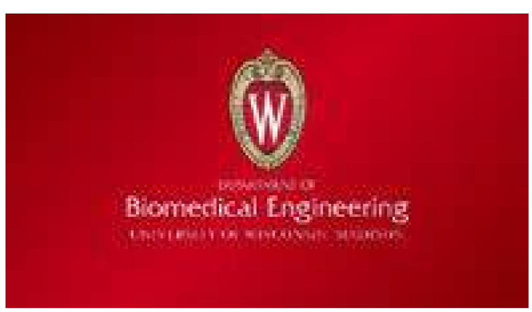
ANNABEL FRAKE - Apr 15, 2023, 11:33 AM CDT



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Outreach_Presentation.pdf (1.53 MB)

ANNABEL FRAKE - Apr 15, 2023, 11:33 AM CDT

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Outreach_Recap.pdf (41 kB)

Final Poster

ANNABEL FRAKE - Apr 26, 2023, 10:57 PM CDT

Title: Final Poster

Date: 04/26/2023

Content:

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

References: none

ANNABEL FRAKE - Apr 26, 2023, 10:56 PM CDT

Download

Final_Poster_-_Adaptive_Rower_Spring_2023.pdf (2.85 MB)

IRB Testing Consent Form

Roxi Reuter - May 01, 2023, 9:28 PM CDT

Title: IRB Testing Consent Form

Date: 05/01/2023

Content:

-Please see the attached documents for the finalized version of the consent form submitted to IRB for testing approval.

References: none

Roxi Reuter - May 01, 2023, 9:28 PM CDT

Download

Consent_Form_04042023.docx (24.3 kB)

Journal Article and Appendices

ANNABEL FRAKE - May 01, 2023, 9:22 PM CDT

Title: Journal Article and Appendices

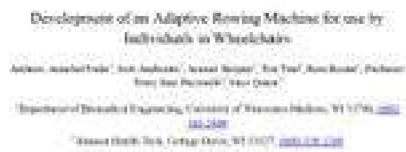
Date: 05/1/2023

Content:

-Please see the attached documents for the pdf version of the final journal article and appendices.

References: none

ANNABEL FRAKE - May 01, 2023, 9:30 PM CDT


Development of an Adaptive Rowing Machine for use by Individuals in Wheelchairs

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Adaptive_Rowing_Machine-Journal_Article.pdf (34.7 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

01/27/23 Team Meeting

ANNABEL FRAKE - Jan 27, 2023, 3:19 PM CST

Title: 01/27/23 Team Meeting

Date: 01/27/23

Content by: Annabel Frake

Present: Annabel, Roxi, Josh, Sam, Tim

Goals: plan semester with the team

Content:

- Sam and Tim swapping roles because Sam has a class conflict with BSAC
  - Tim = BSAC
  - Sam = BWIG
- comments from last semester
  - we need to be better about distributing note taking responsibilities
  - write the date as 01/27/23 and not 27JAN2023
  - Staci said she wanted weekly meetings this semester (Josh will send a follow-up email)
- IRB
  - participants:
    - team members: EMG data (don't fill out surveys because biased)
    - wheelchair users: just the survey
    - standard and adaptive users: surveys (recruit roommates and people from BME so surveys aren't biased)
  - reviewed protocols, consent form, and surveys as a team
    - originally had 3 separate surveys: standard side, adaptive side, comparison
    - we combined all 3 for people we recruit to use both sides
    - kept a separate one for only wheelchair users
    - so we have a total of 2 surveys
    - we discussed the intended audience of the protocol (researcher, participant, or IRB) and will ask advisor to clarify
  - Device documentation (NEED TO DO)
    - name of device - all
    - intended use - in gym for non-wheelchair and wheelchair users (Roxi)
    - description of device - user manual, describe adaptations (Annabel)
    - prior uses of device - all
      - Matrix rower has previous clinical and industry use
      - adaptions have no previous use
    - features that minimize risks (Tim)

- moving forward
  - send documents to advisor for review
  - review whole submission with group
  - submit (hopefully before prelim presentation)
- make surveys online through google docs so can't identify hand-writing? - ask advisor
- We will meet Feb 5th to review
  - have device documentation done by Feb 4th so we can review beforehand

- Outreach
  - reflection afterwards
  - evaluated by teacher?
  - wait to figure out activity and presentation until closer to event
  - now - figure out funding and materials
    - Tim - looked up demographics (41%), so should be able to get funding
  - go during flex time 2:07 - 2:49pm
  - March 24th or April 7th
  - Tim - respond to contact
- Prelim presentation
  - assign sections at Feb 5th meeting
  - complete slides by Mon/Tues
  - send to advisor by Wed for feedback
  - present on Friday

References: none

Conclusions:

We made a lot of good progress today in terms of planning out the semester. We are working on setting up a time for our outreach project and gaining funding for the materials. Closer to the visit, we will create a presentation and do a dry run of the activity. The IRB application is almost done. We sent the current materials to our advisor for review and will finish up the device documentation in the upcoming week. We will also brainstorm designs for the new resistance mechanism. We will continue to improve upon the designs from last semester.

Action items:

- Josh
  - updates to antlers in SolidWorks (send to Staci)
  - emails - thanks for sending all of those out!
- Sam
  - updates to stabilization frame in SolidWorks (send to Staci)
- Tim
  - IRB device documentation - features that minimize risk (have done by Feb 4th)
  - Respond to outreach teacher suggesting March 24th or April 7th (2:07 - 2:49pm) for our visit
  - Email Tracy asking about funding for outreach materials
- Roxi

  - IRB device documentation - intended use (have done by Feb 4th)
- Annabel
  - IRB device documentation - device description (have done by Feb 4th)
- All
  - first day activities
  - brainstorm resistance dial
  - research journal articles we could publish in (Feb 3rd)
  - contemplate if we should/want to ask Staci about IP
  - keep the outreach project preparation and prelim presentation in the back of your head

Upcoming Meetings:

- Friday, Feb 3rd
  - team/advisor meeting
- Sunday, Feb 5th (TBD)
  - review IRB application materials
  - brainstorming session for resistance dial
  - assign prelim presentation sections

02/04/2023 Review of Meeting Notes for 02/03/2023

ANNABEL FRAKE - Feb 04, 2023, 7:36 PM CST

Title: 02/04/2023 Review of Meeting Notes for 02/03/2023

Date: 02/04/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: review the notes for the team/advisor meeting I missed yesterday

Content: none

References: "02/03/2023 Pre-Advisor Meeting" and "02/03/2023 Advisor Meeting"

Conclusions:

I missed the 02/03/2023 meetings because I was visiting Purdue for PhD candidate interviews. I read the notes from the team and advisor meetings, and I will discuss the action items listed in those meetings with the rest of the team tomorrow.

Action items:

- confirm action items with team

02/05/2023 Team Meeting

ANNABEL FRAKE - Feb 05, 2023, 4:36 PM CST

Title: 02/05/2023 Team Meeting

Date: 02/05/2023

Content by: Annabel Frake

Present: Annabel, Sam, Josh, Tim, Roxi

Goals:

- review IRB application materials
- brainstorming session for resistance dial
- assign prelim presentation sections

Content:

- IRB feedback from Tracy
    - surveys
        - on scale of 1 to 5, 1 was always lower/less desirable option
        - also put labels (neutral, somewhat, etc.)
        - add who participant is after title
        - use person-first language
    - consent form might be a bit lengthy?
    - protocol looked fine to her, but send it off and see what they say
    - send everything to IRB contact to make sure it looks good before submission
- edited device documentation as a team
- Brainstorming for resistance dial
    - interface
        - use LCD to display resistance level and have up and down arrow buttons
        - would need to have 2 systems on both sides
        - try to use same Arduino - need to get MEGA instead? (remember that Arduino broke last semester - won't upload code)
    - reuse circular shaft stepper motor for this? Or purchase a smaller one to keep it cheaper
    - Cable
        - pros: can put stepper motor anywhere, keeps most things the same
        - cons: figure out puck size to figure out magnet calibration
    - no-cable, direct to shaft
        - pros: not changing much, not too bad to calibrate (figure out rotation per increment), limiting changes
        - cons: space constraint, how to interface between different diameter sizes

    - rack and pinion
        - pros:
        - cons: adds complexity
    - replace the old resistance dial with the LCD display, etc.
        - limits confusion about how to change resistance
        - eliminates an eye sore
    - mechanical solution I came up with
        - pros: solely mechanical
        - cons: lots of redesign, would have to remove plastic, might take longer than we have this semester
    - design decision
        - stepper motor at pivot point, remove cable, interface (LCD and up/down arrows)
        - modeling & stepper motor placement and interface to fixture - Sam, Josh
        - coding/circuit - Annabel, Roxi
        - Tim will go between the 2
        - discuss specifics of
- SolidWorks progress
    - Josh and Sam - need another week to finish and get feedback from Staci
- Outreach
    - Roxi will make list of supplies and give to Tracy
- Prelim presentation
    - Tim: intro - motivation
    - Annabel: competing designs - 400 accomplishments
    - Josh: 400 testing - 402 fabrication plan and timeline
    - Sam: 402 testing and timeline
    - Roxi: device documentation - references
- reimbursement from last semester: waiting for check in mail
- Pick a journal
    - make sure to look at impact factor (shoot for 2-3)
    - each individually review and then decide during practice meeting for prelim
- we made the updates to the IRB documents that Tracy suggested

References: none

Conclusions:

The rest of the team caught me up on the decisions made last Friday. We reviewed the IRB device documentation as a team and also made edits to the surveys based on feedback from Tracy. Josh will ask the IRB employees if they can scan our documents before submission to ensure we have everything that we will need. We also split up work for the preliminary presentation. We will create assigned slides individually and send them to Tracy for review. We will then meet on Thursday to practice presenting. We also shared brainstorming ideas for the resistance dial and ultimately decided to pursue the cable-less option with direct connection of the stepper motor to the existing pivot point (may change if there isn't enough space). We split into subgroups for this work: code/circuit (Annabel and Roxi) and stepper motor placement/connection to pivot point and modeling (Sam and Josh); Tim will help both groups. Overall, this was a very productive meeting!

Action items:

1. Josh - email IRB materials to IRB contact for review
2. Josh and Sam - continue making progress on the SolidWorks models (send to Staci by end of week)
3. Roxi - create a materials list for the outreach project
4. All - create prelim slides (done before Tracy reviews)
5. All - review journal options by practice prelim meeting (Thurs)
6. All - start work on resistance dial

Upcoming meetings:

- Thursday, February 9th (5 pm on teams) - practice prelim presentation

02/25/2023 Review of Meeting Notes for 02/24/2023

ANNABEL FRAKE - Feb 25, 2023, 3:39 PM CST

Title: 02/25/2023 Review of Meeting Notes for 02/24/2023

Date: 02/25/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: review the notes for the team/advisor meeting I missed yesterday

Content: none

References: "2/24/2023 - Manufacturing Meeting" and "02/24/2023 - Advisor Meeting"

Conclusions:

I missed the 02/024/2023 meetings because I was visiting Columbia for PhD candidate interviews. I read the notes from the team and advisor meetings, and I will discuss the action items listed in those meetings with the rest of the team at our next meeting.

Action items:

- confirm action items with team

04/07/2023 Team Meeting

ANNABEL FRAKE - Apr 07, 2023, 11:12 PM CDT

Title: 04/07/2023 Team Meeting

Date: 04/07/2023

Content by: Annabel Frake

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

Goals: fabrication, group check-in

Content:

- Outreach deliverables
  - Tim - got eval from teacher, need to send to Tracy
  - Sam - still working on summary
- IRB
  - Wille is with being on IRB application
  - Roxi will submit over weekend so we can be reviewed next week
- Integration
  - Put fabrication entries in for solidWorks and stabilization frame (Josh and Sam)
- Testing
  - I added electronics testing protocols
  - We need to add IRB protocols to team folder
- IP (talk to Staci next week)
- Final deliverables (bring up at next week's meeting)
- Advisor meeting
  - call IRB directly
  - otherwise, submit today no matter what
  - may need to drop EMG testing to get approval in time
- Integration
  - secured resistance motor
  - placed resistance motor limit switch
  - conducted initial testing
    - coding logic works
    - when rowing with a great enough overlap of the magnet with the flywheel, the eddy currents cause the fixture to move
      - I suggested we use a spring that will help keep the fixture in place but is not stiff enough that the motor won't be able to move it
      - we will need to think about this further
  - condensed all wires except for the buttons
    - cut wires to length
    - soldered motor wire connections
    - used zip ties to run wires across rowing machine
    - conducted initial testing
      - console motor stalled
      - seems like two wires are shorted on solder board, but I can't see how
      - I tried to check a soldering iron out from the MakerSpace since the one in ECG isn't clean enough for the job but they could not help me and said I needed to contact a manager
    - Roxi, Sam, and Tim attached the displays while I was working on this

References: none

Conclusions:

We met for five hours today to work on integration. We placed the resistance motor, resistance limit switch, and displays. After initial testing, we realized that the eddy currents are too strong for the motor's hold torque. We are brainstorming ways to fix this issue, such as a spring or stronger motors. After cleaning up the wiring, the console motor started to stall. Based on a connectivity test, there may be a short. This is something I will need to investigate further.

Action items:

Josh:

- Final modeling entry in team notebook folder

Annabel:

- Cut button wires to length
- try to figure out why console motor is stalling

Roxi:

- IRB

Tim:

- send Tracy teacher eval for outreach

Sam:

- outreach summary (done by Sunday and then have group review it)
- Final stabilization frame fabrication entry in team notebook folder

All:

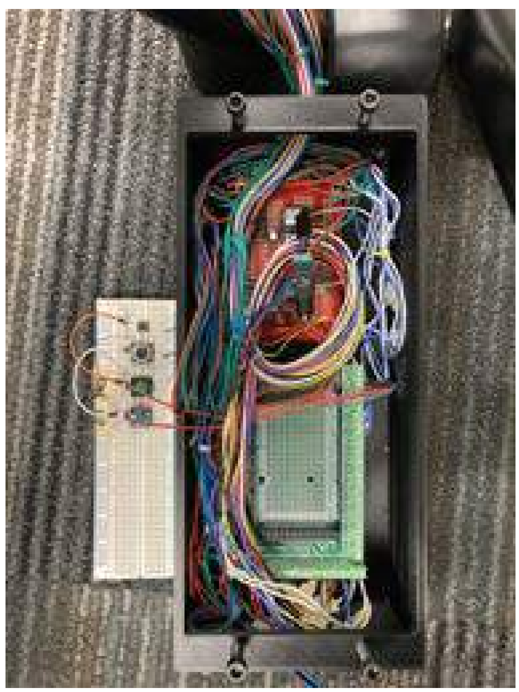
- Human subject training (Sam, Roxi)
- brainstorm fixes for the eddy currents issue
- meet to finish integration (buttons)

ANNABEL FRAKE - Apr 07, 2023, 11:13 PM CDT

Download

IMG_4013.mov (30.1 MB) Video of resistance mechanism working while rower flywheel not in motion.

ANNABEL FRAKE - Apr 07, 2023, 11:14 PM CDT



Download

IMG_7194.jpeg (4.59 MB) Image of condensed electronics box + button breadboard (will be replaced with final buttons once those have been placed and the wires can be cut to length).

ANNABEL FRAKE - Apr 07, 2023, 11:14 PM CDT

Download

IMG_7195.jpeg (4.09 MB) Front view of rower showing wires paths.

ANNABEL FRAKE - Apr 07, 2023, 11:14 PM CDT

Download

IMG_7196.jpeg (3.43 MB) Underside of antlers showing wires paths.

01/20/23 IRB Survey Draft

ANNABEL FRAKE - Jan 20, 2023, 4:27 PM CST

Title: 20JAN2023 IRB Survey Draft

Date: 20JAN2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: write a rough draft of the IRB surveys

Content: Please see the attached drafts of the survey

References:

"Tips for Low-Risk Online Surveys," *Montlair State University*. https://www.montclair.edu/institutional-review-board/faqs/internet-based-surveys/tips-for-low-risk-online-surveys/ (accessed Jan. 20, 2023).

"Institutional Review Board (IRB): Online Surveys & Questionnaires," *Institutional Review Board*. https://resources.nu.edu/irb/online-surveys (accessed Jan. 20, 2023).

Conclusions:

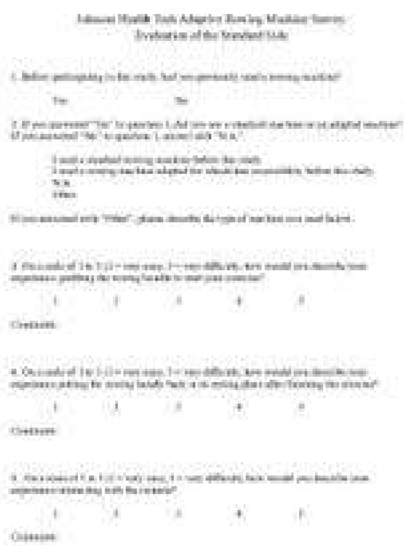
My individual assignment for the IRB application is working on the survey(s). I researched examples and tips for IRB applications, and then created rough drafts of 3 surveys (standard side use, adaptive side use, and a comparison of the 2 sides).

Action items:

1. continue to edit the drafts

2. ask the team what they think (including if personal data such as name should be collected or anonymous)

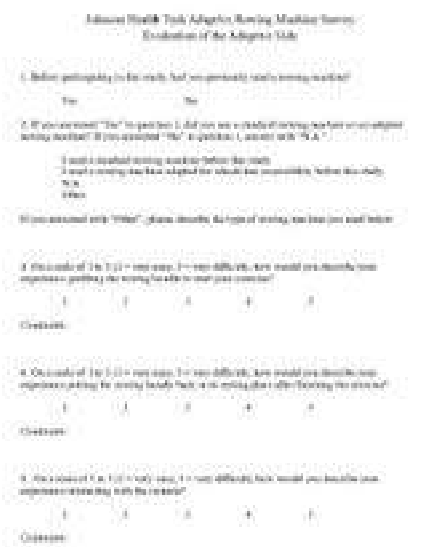
ANNABEL FRAKE - Jan 20, 2023, 4:31 PM CST



Download

Standard_Side_Survey.pdf (38.4 kB)

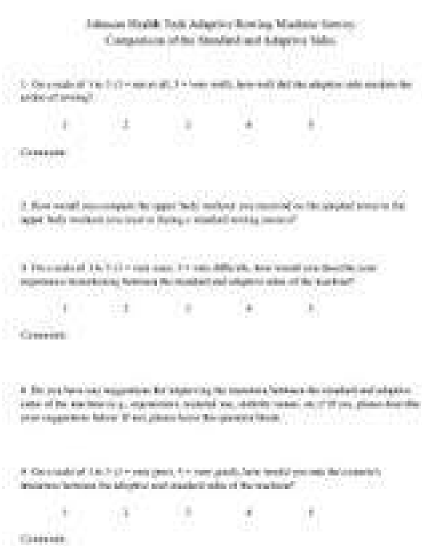
ANNABEL FRAKE - Jan 20, 2023, 4:31 PM CST



Download

Adaptive_Side_Survey.pdf (39.3 kB)

ANNABEL FRAKE - Jan 20, 2023, 4:31 PM CST



Download

Comparison_Survey.pdf (38.1 kB)

01/22/23 IRB Survey Drafts

ANNABEL FRAKE - Jan 22, 2023, 9:28 PM CST

Title: 22JAN2023 IRB Survey Drafts

Date: 22JAN2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: edit the rough drafts of the surveys

Content:

- I noticed that that pdf versions of the drafts I uploaded previously didn't show the check boxes I made, so I switched to uploading the word versions
- I made some updates to the questions and formatting
- Please see the attached drafts of the survey

References: none

Conclusions:

I made some improvements to the IRB survey questions, as well as some general formatting changes. The questions that include scales do not necessarily follow the same pattern. For example, one question might go 1 = very easy to 5 = very difficult, while another question might go from 1 = very poor to 5 = very good. This is the standard way I have seen scaling done, however, it may be confusing if the participant doesn't read the question carefully considering the desired outcome changes between these two examples. To help combat this, I added the descriptions on either end of the scale for easier viewing. I will also ask the team if they can think of a clearer way to present the question.

Action items:

1. continue to edit the drafts

2. ask the team what they think (including if personal data such as name should be collected or anonymous)

ANNABEL FRAKE - Jan 22, 2023, 9:22 PM CST

Download

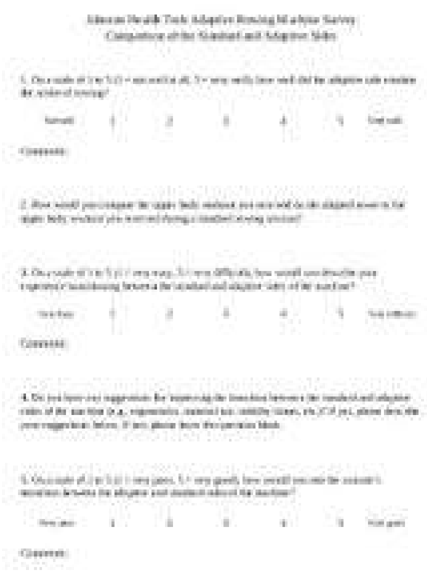
Standard_Side_Survey-2.docx (21.9 kB)

ANNABEL FRAKE - Jan 22, 2023, 9:22 PM CST

Download

Adaptive_Side_Survey-2.docx (22.6 kB)

ANNABEL FRAKE - Jan 22, 2023, 9:22 PM CST



Download

Comparison_Survey-2.docx (18.6 kB)

01/26/23 IRB Editing

ANNABEL FRAKE - Jan 26, 2023, 9:12 PM CST

Title: 26JAN2023 IRB Editing

Date: 26JAN2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: review the consent form (Roxi's assignment) and the protocols (Sam and Josh's assignment) before we discuss them tomorrow

Content:

- I made small grammar edits to the documents
- I made comments for content type questions on each document

References: none

Conclusions:

I reviewed the IRB consent form and protocols for our meeting tomorrow. I made small grammatical corrections directly (as suggested by my teammates in my peer evals last semester), and I left comments only on the content type questions.

Action items:

1. discuss all IRB application documents with team tomorrow

02/04/2023 Device Description & General Editing

ANNABEL FRAKE - Feb 04, 2023, 2:46 PM CST

Title: 02/04/2023 Device Description & General Editing

Date: 02/04/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: write the device description within the device documentation in the IRB application; general editing of device documentation

Content:

DESCRIPTION OF DEVICE

The Matrix rowing machine is an approved device; please see the attached user manual. Adaptions made to the original approved device include removing the rower neck, adding antler-like structures that hold the rowing handle in place, repositioning the console adjacent the antler-like structures, attaching a stabilization frame for securing a wheelchair in place, and altering the resistance dial mechanism such that users from both the standard and adaptive sides can easily manipulate the resistance level of the flywheel. Figure 1 is an image of the prototyped adaptation which will be modified slightly in the final version currently under fabrication. The stabilization frame will be welded together with a slightly smaller lap pad that fits between the handles of a wheelchair. The antler-like structures that hold the rowing handle will be constructed from metal instead of tough PLA. Please see the attached design report for an in-depth explanation of the prototype's fabrication, as well as additional images of the adaptations. The resistance dial mechanism is currently in an initial prototyping phase and does not have a fabrication plan at this time.

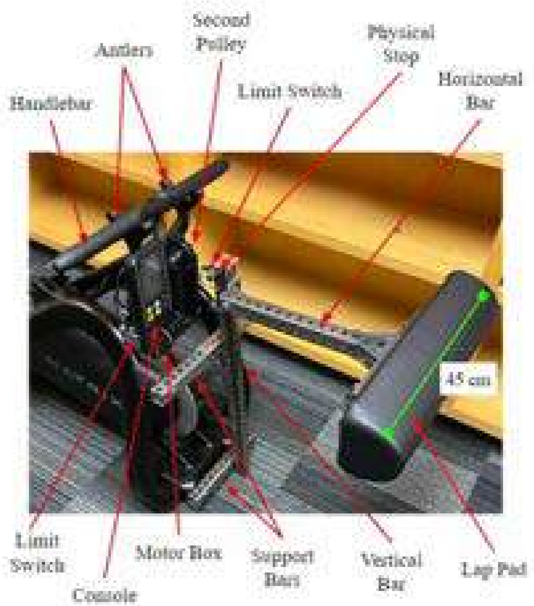


Figure 38. Prototype Assembly. The prototype assembly includes the pulley support plates with antlers, the console rotation mechanism and electronics box, and the metal adjustable stabilization frame. Please note that in the final product (will be fabricated in the coming weeks), the stabilization frame will be welded instead of secured using bolts, the antler-like structures will be constructed from metal, and the resistance dial mechanism will be modified such that users from both sides of the machine may interact with it (no prototype yet, not shown in image).

References: Roxi

Conclusions:

I wrote the device description within the device documentation of the IRB application. I asked Roxi for feedback and made some edits to the original version. I also reviewed the rest of the device documentation for our meeting tomorrow. I left a couple of content comments/questions, but everything looked really good in general.

Action items:

- Edit the device documentation with the team

02/18/23 IRB Application Review

ANNABEL FRAKE - Feb 18, 2023, 11:37 PM CST

Title: 02/18/23 IRB Application Review

Date: 02/18/23

Content by: Annabel Frake

Present: Annabel Frake

Goals: review IRB application

Content:

- I can't confirm that the information about the PI stuff is correct, but I'm assuming that we checked with Tracy on that.

- For the exemption category, it says "no physiological data collection", but we will be collecting EMG data from ourselves. Would we still qualify for exemption?

- For sharing data outside of UW Madison, won't we be sharing data from their survey responses in our research paper or does that not count?

References: IRB application

Conclusions:

Roxi submitted our initial application, and the IRB told us to submit a non-protocol based application instead. Roxi created the new application for the rest of the team to review. I looked over it tonight and found three areas where I wasn't sure if the information was correct (listed above in content). I will share these concerns with the team, and we can go from there. Other than that, the application looked good.

Action items:

1. share thoughts with group

02/06/2023 Prelim Presentation

ANNABEL FRAKE - Feb 06, 2023, 11:15 PM CST

Title: 02/06/2023 Prelim Presentation

Date: 02/06/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: create assigned prelim slides and corresponding script

Content:

Thank you, Tim.

The most prominent competing design is the Adaptive Rowing Machine, also known as AROW. It was designed by researchers at the British Columbia Institute of Technology specifically for the Concept 2 rowing machine. The design involves replacing the slider seat and bar with lap and chest pads. The user may also attach a safety strap to the wheelchair that prevents backward motion. While this design successfully adapts a rowing machine for use by individuals in wheelchairs, the design modifications void the machine's warranty and prohibit standard use of the device. The advantage of our design is its ability to retain standard functionality.

Our three main goals for last semester included improving the transition of the rowing handle between the standard and adaptive sides of the machine, increasing the durability and sturdiness of the stabilization frame, and automating the rotation of the console. To implement the first goal, we removed the original Matrix rower neck and replaced it with two antler-like structures that hold the rowing handle in a central position between the two sides. To accomplish the second goal, we redesigned the stabilization frame out of metal and used a lab pad design similar to those seen on roller coasters. Lastly, we automated the rotation of the console using a stepper motor and strategically placed limit switches that provide feedback about the console's orientation relative to the user.

To operate the device, an individual in a wheelchair rolls up to the machine, locks their wheels, lowers the lap pad, adjusts the parameters on the console, grabs the rowing handle, and then pulls the handle towards their chest to start the rowing motion. When their workout is finished, the user simply places the rowing handle back within the antlers and raises the lap pad.

I will now hand things over to Josh, who will talk about the testing we conducted last semester.

References: none

Conclusions:

Tonight, I edited the existing competing designs slide from last semester. I also made the BME 402 design accomplishments slide. Lastly, I wrote my script for the preliminary presentation.

Action items:

1.
2. edit/practice with team
3. memorize script for Friday

01/31/23 Journal Search

ANNABEL FRAKE - Jan 31, 2023, 6:56 PM CST

Title: 01/31/23 Journal Search

Date: 01/31/23

Content by: Annabel Frake

Present: Annabel Frake

Goals: find options for a suitable journal to publish our final article in at the end of the semester

Content:

- Option 1: *ACSM's Health and Fitness Journal*
    - "ACSM's Health & Fitness Journal®, an official publication from the American College of Sports Medicine (ACSM), is written to fulfill the information needs of fitness instructors, personal trainers, exercise leaders, program managers, and other front-line health and fitness professionals. Its mission is to promote and distribute accurate, unbiased, and authoritative information on health and fitness. The journal includes peer-reviewed features along with various topical columns to cover all aspects of exercise science and nutrition research, with components of ACSM certification workshops, current topics of interest to the fitness industry, and continuing education credit opportunities."
    - see attached pdf for submission information / instructions
- Option 2: *ScienceDirect*
    - **Physical Sciences & Engineering** publications cover a range of disciplines, from the theoretical to the applied.
      Life Sciences journal articles and book chapters feature original research, insightful analysis, current theory and more.
      Social Sciences & Humanities journals and books highlight historical context, current developments, theories, applications, trends and more.
      Health Sciences collections — covering education, reference information and decision support — keep you up-to-date on medical developments to stimulate research and improve patient care.
    - may be harder to publish in since it's a well-known journal
- Option 3: *Disability and Rehabilitation*
    - **Aims and scope**

      Disability and Rehabilitation is an international multidisciplinary journal publishing on all aspects of disability and rehabilitation.

      Disability and Rehabilitation aims to encourage a better understanding of disability and to promote rehabilitation science, practice and policy aspects of the rehabilitation process. The journal provides an important forum for the dissemination and exchange of ideas amongst global health practitioners and researchers.

      Disability and Rehabilitation covers a range of topics such as:

      - Rehabilitation in practice
      - Rehabilitation Policy
      - Assessment procedures
      - Education and training

      Disability and Rehabilitation accepts quantitative and qualitative research papers, reviews, case studies, multidisciplinary perspectives, and letters.
    - Authors can choose to publish gold open access in this journal.
    - see attached pdf for submission information / instructions
- Option 4: *Journal of Science in Sport and Medicine*

- *Journal of Science in Sport and Exercise* (SSEJ) is an international double-blind peer-reviewed journal covering all aspects of sport and physical activities. The journal publishes articles focusing on molecular, cellular, tissue, system and the whole-body response to a broad definition of physical activities. Submissions related to elite athletes, traditional cultural physical activities and exercise for health promotion are also welcome.

  The Journal publishes original research article, review, commentary, and letter to the editor. The topics include but not limited to:

  - Physiological characteristics and training monitoring for elite athlete
  - Talent identification and selection for sport
  - Training program for competitive capacity
  - Sports equipment and performance and health
  - Adaptations to sport participation at all levels and all ages
  - Diets promoting increased sport performance and health
  - Dietary supplementation promoting increased sport performance and health
  - Exercise prescription promoting health benefits
  - Acute response to exercise training
  - Adaptations to the long-term performance of exercise training
  - Adaptations to cultural traditional exercise
  - Adaptations to physical activity in various disease states
  - Adaptations to physical activity of children and adolescents
  - Motor learning & control
  - Sports injury prevention & rehabilitation

- *Journal of Science in Sport and Exercise* operates a double-blind peer-review system, where the reviewers do not know the names or affiliations of the authors and the reviewer reports provided to the authors are anonymous. The benefit of double-blind peer review is that it allows reviewers to judge the manuscript based on content alone, and they are not unconsciously biased by knowledge of who the authors are.

  Submitted manuscripts will generally be reviewed by two or more experts who will be asked to evaluate whether the manuscript is scientifically sound and coherent, whether it duplicates already published work, and whether or not the manuscript is sufficiently clear for publication. The Editors will reach a decision based on these reports and, where necessary, they will consult with members of the Editorial Board.
- see attached pdf for submission information / instructions

References:

American College of Sports Medicne, *ACSM's Health & Fitness Journal*, 2023. https://journals.lww.com/acsm-healthfitness/pages/aboutthejournal.aspx (accessed Jan. 31, 2023).

Elsevier B.V., *ScienceDirect*, 2023. https://www.sciencedirect.com/ (accessed Jan. 31, 2023).

Taylor & Francis, "Disability and Rehabilitation," *Taylor & Francis*, 2023. https://www.tandfonline.com/action/journalInformation?show=editorialBoard&journalCode=idre20 (accessed Jan. 31, 2023).

Springer Nature, "Journal of Science in Sport and Exercise," *Springer*, 2023. https://www.springer.com/journal/42978 (accessed Jan. 31, 2023).

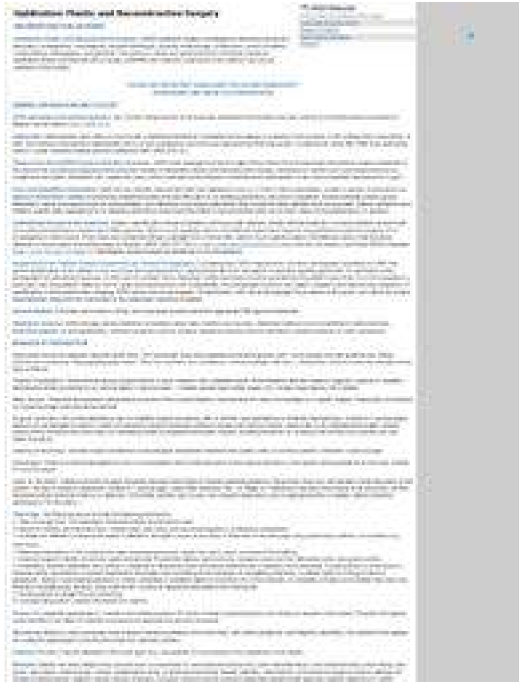
Conclusions:

I searched the internet for potential journals that we could publish our research in at the end of the semester. I found four options total, however, the ScienceDirect is less applicable to our specific topic than the other three. The *Health & Fitness Journal* and *Journal of Science in Sports and Exercise* journal are more general (i.e., cover exercise and fitness) while the *Disability and Rehabilitation* journal may include more articles with wheelchair-accessible equipment and research.

Action items:

1. share these options with the team

ANNABEL FRAKE - Jan 31, 2023, 6:02 PM CST



Download

H_FJ_information_for_authors.pdf (114 kB)

ANNABEL FRAKE - Jan 31, 2023, 6:32 PM CST

Download

Disability_and_Rehabilitation_-_information_for_authors.pdf (570 kB)

ANNABEL FRAKE - Jan 31, 2023, 6:45 PM CST

Download

Journal_of_Science_in_Sport_and_Exercise_-_information_for_authors.pdf (429 kB)

02/08/2023 Journal Search

ANNABEL FRAKE - Feb 08, 2023, 10:51 PM CST

Title: 02/08/2023 Journal Search

Date: 02/08/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: pick a favorite journal option

Content:

- *ACSM's Health & Fitness Journal*
    - impact factor: 1.130 (https://journals.lww.com/acsm-healthfitness/pages/default.aspx)
- *Disability and Rehabilitation*
    - impact factor: 2.439 (2021) (https://www.tandfonline.com/action/journalInformation?show=journalMetrics&journalCode=idre20)
- *Journal of Science in Sport and Exercise*
    - impact factor: 3.337 (https://academic-accelerator.com/Impact-of-Journal/Journal-of-Sports-Sciences)
- *Frontiers in Rehabilitation Sciences*
    - *impact factor: not a specific one, but the frontier journals have a range of 3-7 (https://www.frontiersin.org/about/impact)*
    - *Roxi found this article*
    - *Frontiers in Rehabilitation Sciences* promises to be a leading journal in its field, publishing rigorously peer-reviewed research in rehabilitation from biological, clinical, and socio-humanistic perspectives.

      Field Chief Editor Gerold Stucki, from the University of Lucerne and the Swiss Paraplegic Research, is supported by an outstanding Editorial Board of international experts. This multidisciplinary open-access journal is at the forefront of disseminating and communicating scientific knowledge and impactful discoveries to researchers, academics, clinicians, and the public worldwide.

      Frontiers in Rehabilitation Sciences is founded on the assumption that rehabilitation is the health strategy of the 21st century that aims at optimizing people's functioning, given demographic and epidemiological trends that point to a future where people live longer, but with more disabilities. This journal combines theoretical approaches and clinical practice with policy implementation to close the gap between research and practice.

      Frontiers in Rehabilitation Sciences covers a wide range of topics grouped into several sections:

- Human Functioning

- Strengthening Rehabilitation in Health Systems

- Disability, Rehabilitation, and Inclusion

- Rehabilitation for Musculoskeletal Conditions

- Pulmonary Rehabilitation

- Medical and Surgical Rehabilitation

- Interventions for Rehabilitation

- Translational Research in Rehabilitation

- Rehabilitation in Neurological Conditions

References:

American College of Sports Medicne, *ACSM's Health & Fitness Journal*, 2023. https://journals.lww.com/acsm-healthfitness/pages/aboutthejournal.aspx (accessed Jan. 31, 2023).

Taylor & Francis, "Disability and Rehabilitation," *Taylor & Francis*, 2023. https://www.tandfonline.com/action/journalInformation?show=editorialBoard&journalCode=idre20 (accessed Jan. 31, 2023).

Springer Nature, "Journal of Science in Sport and Exercise," *Springer*, 2023. https://www.springer.com/journal/42978 (accessed Jan. 31, 2023).

J. of S. Sciences, "Journal of Sports Sciences Latest Journal's Impact IF 2022-2023 | Trend, Prediction, Ranking & Key Factor Analysis," *Academic Accelerator*, Feb. 04, 2023. https://academic-accelerator.com/Impact-of-Journal/Journal-of-Sports-Sciences (accessed Feb. 08, 2023).

frontiers, "Frontiers in Rehabilitation Sciences," 2023. https://www.frontiersin.org/journals/rehabilitation-sciences/about (accessed Feb. 08, 2023).

Conclusions:

In terms of impact factor, the *Journal of Science in Sport and Exercise* would be the best option (assuming that's still reasonably attainable). The impact factor for *ACSM's Health & Fitness Journal* is a tad bit on the low side. The *ACSM's Health & Fitness Journal* and *Journal of Science in Sport and Exercise* encompass a broader range of topics related to general fitness. In contrast, the *Disability and Rehabilitation* journal would have more content similar to our research. Although, the adaptive rower isn't only for rehabilitation. I also looked at the journal Roxi found, but it seems like *Frontiers in Rehabilitation Sciences* has too high of an impact factor that we would be unlikely to publish an article in it (at least in a semester). Overall, I'm leaning towards *ACSM's Health & Fitness Journal* and *Journal of Science in Sport and Exercise.*

Action items:

1. share thoughts with the team

02/21/2023 Journal Requirements

ANNABEL FRAKE - Feb 21, 2023, 7:25 PM CST

Title: 02/21/2023 Journal Requirements

Date: 02/21/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: prepare for meeting to divide up journal sections

Content:

Questions:

1. Do we need to do the Clinical Trials Registry?
2. “Authors who do not have formal ethics review committees should include a statement that their study follows the principles of the Declaration of Helsinki.”
    a. Does this count if not in-vivo?

General structure: (no word limit, no publication fee)
Please also see Disability_and_Rehabilitation_-_information_for_authors.pdf for a checklist of what to include.

- title page
    - The title page should include the full names and affiliations of all authors involved in the preparation of the manuscript. The corresponding author should be clearly designated, with full contact information provided for this person.
- Abstract
- Keywords
- Introduction
    - "In the main text, an introductory section should state the purpose of the paper and give a brief account of previous work."
- materials and methods
    - "New techniques and modifications should be described concisely but in sufficient detail to permit their evaluation. Standard methods should simply be referenced."
    - "All original research papers involving humans, animals, plants, biological material, protected or non-public datasets, collections or sites, must include a written statement in the Methods section, confirming ethical approval has been obtained from the appropriate local ethics committee or Institutional Review Board and that where relevant, informed consent has been obtained. For animal studies, approval must have been obtained from the local or institutional animal use and care committee. All research studies on humans (individuals, samples, or data) must have been performed in accordance with the principles stated in the Declaration of Helsinki. In settings where ethics approval for non-interventional studies (e.g. surveys) is not required, authors must include a statement to explain this. In settings where there are no ethics committees in place to provide ethical approval, authors are advised to contact the Editor to discuss further."
- Results
    - "Experimental results should be presented in the most appropriate form, with sufficient explanation to assist their interpretation; their discussion should form a distinct section."
- Discussion
    - "Experimental results should be presented in the most appropriate form, with sufficient explanation to assist their interpretation; their discussion should form a distinct section."
- acknowledgments
- declaration of interest statement
    - "The authors report no conflicts of interest."
- References
- appendices (as appropriate)

- table(s) with caption(s)
- Figures
- figure captions (as a list)
    - "Tables and figures should be referred to in text as follows: figure 1, table 1, i.e. lower case. The place at which a table or figure is to be inserted in the printed text should be indicated clearly on a manuscript. Each table and/or figure must have a title that explains its purpose without reference to the text."
- Other (not sure where it goes)
    - Need statement to confirm consent somewhere
    - Health and safety

References:

Taylor & Francis, "Disability and Rehabilitation," *Taylor & Francis*, 2023. https://www.tandfonline.com/action/journalInformation?show=editorialBoard&journalCode=idre20 (accessed Jan. 31, 2023).

"Taylor & Francis manuscript layout guide," *Author Services*. https://authorservices.taylorandfrancis.com/publishing-your-research/writing-your-paper/journal-manuscript-layout-guide/ (accessed Feb. 21, 2023).

International Committee of Medical Journal Editors, "Recommendations," *ICMJE*. https://www.icmje.org/recommendations/ (accessed Feb. 21, 2023).

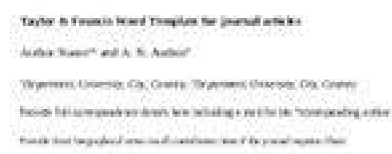
Conclusions:

To prepare for our meeting to divide up sections of the journal article, I reviewed the journal requirements and added the files to the google drive for the rest of the team.

Action items:

1. meet with team to divide up sections of the prelim journal article

ANNABEL FRAKE - Feb 21, 2023, 7:16 PM CST


Taylor & Francis Word Template for journal articles

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ANNABEL FRAKE - Feb 21, 2023, 7:16 PM CST


Disability and Rehabilitation

Instructions for authors

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ANNABEL FRAKE - Feb 21, 2023, 7:17 PM CST


Taylor & Francis manuscript layout guide

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Manuscript_layout_guide.pdf (142 kB)

ANNABEL FRAKE - Feb 21, 2023, 7:17 PM CST


Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals

Updated May 2022

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Uniform_Requirements_for_Manuscripts_Submitted_to_Biomedical_Journals.pdf (636 kB)

02/26/2023 Adaptive Resistance Mechanism Appendix (Code and Circuit)

Title: 02/26/2023 Adaptive Resistance Mechanism Appendix (Code and Circuit)

Date: 02/26/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: write my assigned section of the journal article/appendix

Content:

Appendix K: BME 402 Adaptive Resistance Mechanism

Circuit and Code

Because individuals who require the use of wheelchairs operate the adaptive rowing machine from the side opposite the machine's original intended use, these indivi accessibility and workout disruption. To improve the ergonomics of the rowing machine for individuals who require the use of wheelchairs, an adaptive resistance mechani

To increment/decrement the resistance level from either the standard or adaptive sides of the machine, the current cable mechanism will be replaced with an electrical driver, and +12 Volt power supply will control the stepper motor's position according to feedback from several switches within the circuit. Each side of the machine will program will complete is to rotate the stepper motor in the counterclockwise direction until the limit switch is depressed. The position of the limit switch will be such that intended resistance level. This setup logic is illustrated in **Figure 1**.

Figure 1. Resistance Dial Setup Coding Flowchart. At the beginning of the program (i.e., when the device is first powered on), check the state of the resistance dial limit switch. If it is not depressed, rotat

Once the resistance level is calibrated to a known starting point, a user from either side of the machine can adjust the resistance level by using the up/down arrow butt button is pressed and the current resistance level is more than the minimum value of 1, the stepper motor will rotate counterclockwise by a set number of degrees that cor digit seven segment LED display will be present on both sides of the machine to display the current resistance level to the user. After each press of a button, the display wil

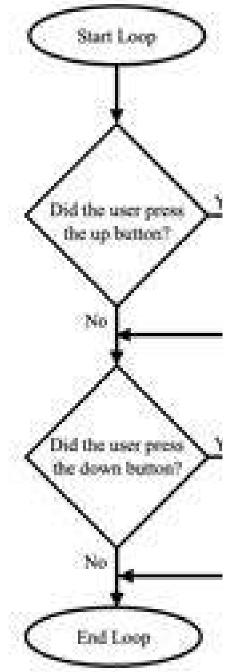


Figure 2. Resistance Dial Void Loop Coding Flowchart. Each loop iteration, the code checks the state of the up and down resistance level buttons. If the up button is pressed and the current resistance lev magnet and the flywheel such that the resistance level is decremented by one. After rotation, update the display to accurately portray the current resistance level. The loop continuously repeats to ensure that

The circuit will be constructed according to the schematic shown in **Figure 3**. An Arduino Mega is necessary because the Arduino Uno does not have enough digit design and improve durability [1]. The NEMA 17 stepper motor will be purchased from the same vendor that sold the one used in the console rotation mechanism [2]. Th will be taken from materials supplied by JHT. Two sets of up/down arrow buttons [3] and 2 two digit seven LED [4] displays will be purchased from online vendors. The p circuit design.

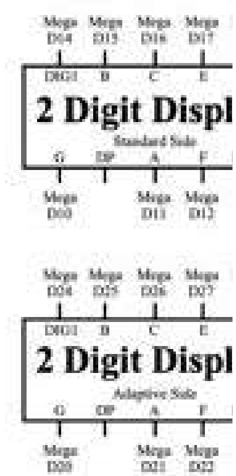


Figure 3. Resistance Dial Circuit Schematic. The resistance dial circuit consists of an Arduino Mega, DRV8825, NEMA17 stepper motor, +12V power supply, two 100 μF capacitors, two 2 digit 7 segme

References:

[1] Electronics-Salon, “Electronics-Salon Prototype Screw/Terminal Block Shield Board Kit for Arduino MEGA-2560 R3.: Amazon.com: Industrial & Scientific,” *Amazo*

[2] “Amazon.com: STEPPERONLINE Stepper Motor Nema 17 Bipolar 40mm 64oz.in(45Ncm) 2A 4 Lead 3D Printer Hobby CNC : Industrial & Scientific.” https://www.

[3] Billet Automotive Buttons, “19mm Pair ‘ARROW SYMBOLS 2’ Billet Push Buttons Switches Power Windows Turn Signals etc,” *Billet Automotive Buttons*. https://bi

[4] uxcell, “Amazon.com: uxcell Common Anode 10 Pin 2 Bit 7 Segment Display 0.59 x 0.55 x 0.28 Inch 0.35" Red LED Display Digital Tube 5pcs : Industrial & Scientif
59e3022bebe1&pf_rd_r=0S8PXF0FCBZJE3V01DQD&pd_rd_wg=OqsPS&pd_rd_r=8849b393-ec01-45e2-a4e6-
e975705c6e4a&s=industrial&sp_csd=d2lkZ2V0TmFtZT1zcF9kZXRhaWw&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzQzRKVDJBRUdXVlYwJmVuY3J5cHRlZEl

Feb. 26, 2023).

- I also added Arduino code appendices for the final code from BME 400 and the preliminary code from BME 402

Appendix G: BME 400 Final Arduino Code

```
// 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 switches.
byte const transitionSwitchPin = 12; // This limit switch is placed near the stabilization frame. When its state changes, the rower is transitioned between adaptive and stand
byte const standardSwitchPin = 10; // This limit switch is placed near the console on the standard side. When it is pressed, the console 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 console 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, th
  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 adaptive 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 fac
  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 is 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 tc
  else if (transitionSwitch.getState() && digitalRead(adaptiveSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Call the function that rotates the console to face the adaptive 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");
}
```

Appendix L: BME 402 Preliminary Arduino Code

```
// Written by:  Annabel Frake

// Class:       BME 402

// Purpose:     Code for changing the display output (between 1 and 10 resistance levels) using up and down buttons.


// Include necessary libraries.

#include "SevSeg.h"

#include <ezButton.h>;


// Declare pins for the buttons.

byte const upButtonPin = 10;

byte const downButtonPin = 11;


// Create ezButton objects for the up and down buttons.

ezButton upButton(upButtonPin);

ezButton downButton(downButtonPin);


// Create a SevSeg object for the display.

SevSeg sevseg;


// Define digital pins for the DIR and STEP features of the stepper motor.

byte const dirPin = 8; // need to update once have Mega

byte const stepPin = 9; // need to update once have Mega


// Define the time delay that defines the rotation degree for one increment of the resistance dial.

int incrementDelay = 1000; // microseconds


// Declare variable for resistance level
```

```
int resistanceLevel = 1; // Will need to discern what this is based on the location of the stepper motor in later code. Maybe set the resistance level manually to 1 every time

void setup()
{
 // Initialize the serial port.
 Serial.begin(9600);

 // Set the stepper pinmodes to OUTPUT.
 pinMode(stepPin, OUTPUT);
 pinMode(dirPin, OUTPUT);

 byte numDigits = 2;
 byte digitPins[] = {12, 13}; // {D3, D4}
 byte segmentPins[] = {9, 2, 3, 5, 6, 8, 7, 4}; // {A, B, C, D, E, F, G, DP}

 bool resistorsOnSegments = true;
 bool updateWithDelaysIn = true;
 byte hardwareConfig = COMMON_ANODE;
 sevseg.begin(hardwareConfig, numDigits, digitPins, segmentPins, resistorsOnSegments);
 sevseg.setBrightness(90);

 // Assign the up and down buttons with a debounce time of 50 milliseconds
 upButton.setDebounceTime(50);
 downButton.setDebounceTime(50);
}

void loop()
{
 // Call the loop() function for the up and down buttons.
 upButton.loop();
 downButton.loop();

 if (upButton.isPressed() && resistanceLevel < 10)
 {
  // If the up button is pressed, increment the resistance level.
  resistanceLevel += 1;

  // Increment the position of the magnet over the flywheel using a stepper motor.
  increment();

  Serial.print("Resistance level incremented to: ");
  Serial.println(resistanceLevel);
 }
```

```
  if (downButton.isPressed() && resistanceLevel > 1)
  {
    // If the down button is pressed, decrement the resistance level.
    resistanceLevel -= 1;

    // Decrement the position of the magnet over the flywheel using a stepper motor.
    decrement();

    Serial.print("Resistance level decremented to: ");
    Serial.println(resistanceLevel);
  }

  sevseg.setNumber(resistanceLevel);
  sevseg.refreshDisplay();
}

// A function to rotate the magnet such that the resistance level is incremented once.
void increment()
{
  // Specify the direction the motor will rotate: clockwise.
  digitalWrite(dirPin, HIGH);

  digitalWrite(stepPin, HIGH);
  delayMicroseconds(incrementDelay); // rotate X degrees
  digitalWrite(stepPin, LOW);
}

// A function to rotate the magnet such that the resistance level is decremented once.
void decrement()
{
  // Specify the direction the motor will rotate: counterclockwise.
  digitalWrite(dirPin, LOW);

  digitalWrite(stepPin, HIGH);
  delayMicroseconds(incrementDelay); // rotate X degrees
  digitalWrite(stepPin, LOW);
}
```

References: none

Conclusions:

I wrote my assigned sections of the journal article/appendix. I also added the Arduino code appendices to the document.

Action items:

1. edit the journal article/appendices with the rest of the team

02/27/2023 Preliminary Journal Article Editing

ANNABEL FRAKE - Feb 28, 2023, 1:32 AM CST

Title: 02/27/2023 Preliminary Journal Article Editing

Date: 02/27/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: edit the rough draft of our journal article

Content:

- none

References: none

Conclusions:

In anticipation of our group editing meeting (2/28 at 8 pm on Teams), I read through the rough draft of the journal article and associated new appendices. I made grammatical corrections and left comments on content questions and general grammar that needs to be fixed throughout.

Action items:

1. meet with the team tomorrow night to discuss comments and finish editing before submission

03/05/2023 Outreach Meeting Prep

ANNABEL FRAKE - Mar 05, 2023, 10:16 PM CST

Title: 03/05/2023 Outreach Meeting Prep

Date: 03/05/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: review the outreach project in anticipation of our meeting tomorrow

Content:

- I reviewed the outreach activity guide
- question for the group meeting: do we have a worksheet to handout?

References: outreach activity guide

Conclusions:

I reviewed the outreach activity guide for our meeting tomorrow to make sure that I'm prepared to go through the activity with the rest of the team.

Action items:

1. meet with the team tomorrow to test out the activity and make sure we are ready for the in-person visit

03/22/2023 Outreach Prep

ANNABEL FRAKE - Mar 22, 2023, 3:52 PM CDT

Title: 03/22/2023 Outreach Prep

Date: 03/22/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: prepare for outreach activity on Friday

Content:

What do **you** think biomedical engineering is?

[field answers]

Biomedical engineering is the application of engineering principles to the solve problems related to healthcare.

For example, biomedical engineers design smart watches that monitor your health.

Or they might design a pacemaker that can correct irregular heartbeats and by helping your heart beat at a rhythm that is sustainable.

Biomedical engineers may also design prosthetics for people who've lost limbs such as their arm or leg. Some researchers are even connecting these devices to the patient's brain so that they can move the prosthetic just by thinking.

Biomedical engineers can also use their knowledge of biology to determine how your body reacts to certain materials, which can help them improve methods for wound closure or other things.

Another example of biomedical engineering is imaging, which helps doctors see inside your body to diagnose diseases and injuries such as broken bones.

As a final example, biomedical engineers help develop tests that can diagnose illnesses, such as the Covid-19 test.

References: none

Conclusions:

My assigned part of the presentation for Friday is the "What is BME?" slide. Today, I prepared what I plan to say during the presentation. This may change slightly as I go through it and I may need to make it shorter if we are running long for the activity, but this is a relatively good outline of what I would like to say.

Action items:

1. attend outreach activity on Friday

03/24/2023 Outreach Visit

ANNABEL FRAKE - Mar 28, 2023, 1:49 AM CDT

NOTE: I went to the ER on 03/24/2023 and was unable to make an entry for the outreach activity until now (03/28/2023).

ANNABEL FRAKE - Mar 28, 2023, 1:48 AM CDT

Title: 03/24/2023 Outreach Visit

Date: 03/24/2023

Content by: Annabel Frake

Present: Annabel, Roxi, Tim, Josh, Sam, Mr. Ropa and class

Goals: conduct the outreach activity

Content:

- went early to the school to setup
- gave the mini presentation on biomedical engineering at the beginning (I did the "What is BME?" slide)
    - the kids came up with some good examples, but most of their responses were focused on environmental engineering (focus of Mr. Ropa's class)
- went through the activity
    - completed steps, allowed time, and then went to next step
    - once we went through the basics of a circuit with one potato, we set them loose to figure out how to light the LED
    - most groups automatically went with the series approach but I did have one group start with parallel
    - they all picked it up really quickly
    - we often needed more potatoes to light the LED than their calculation
    - the LEDs weren't very bright, but they did light up
    - we didn't have time to go through the reflective questions at the end of the slideshow, but we talked through the logic of the problem with a lot of the groups
- we cleaned up and left

References: none

Conclusions:

We completed our outreach activity at Spring Harbor Middle School with Mr. Ropa's seventh grade flex class. Each group of student's successfully lit the LED using the potatoes. Overall, it was a fun experience.

Action items:

1. complete the post-outreach activities

04/10/2023 Outreach Summary Review

ANNABEL FRAKE - Apr 10, 2023, 8:21 PM CDT

Title: 04/10/2023 Outreach Summary Review

Date: 04/10/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: review the outreach summary Sam volunteered to write

Content:

- I made grammatical changes to the outreach summery

References: none

Conclusions:

Sam kindly offered to write the outreach summary because he thought that it would be easier for one person to get all their thoughts on paper than multiple considering the relatively short length of the document. I edited his rough draft of the summary by making grammatical changes, as well as content updates where applicable.

Action items:

1. let the team know that I made edits

04/17/2023 Executive Summary Restructuring and Editing

ANNABEL FRAKE - Apr 18, 2023, 12:14 AM CDT

Title: 04/17/2023 Executive Summary Restructuring and Editing

Date: 04/17/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: restructure the executive summary to make it more concise, implement the comments Dr. TJP made

Content:

- see attached pdf

References: none

Conclusions:

Today, I edited the executive summary to make it more concise and changed some of the grammar. I also asked my mom to read through it to get the perspective of someone who hasn't been actively working with the project. I'm a little worried that I made it sound more like a Tong Executive Summary than a Design Excellence Executive Summary, so I will ask the team what they think and reword things if necessary.

Action items:

1. share with team
2. write testing position of executive summary

ANNABEL FRAKE - Apr 18, 2023, 12:29 AM CDT

Download

402_Design_Excellence_Executive_Summary_Draft.pdf (79 kB)

04/18/2023 Executive Summary Editing

ANNABEL FRAKE - Apr 18, 2023, 6:30 PM CDT

Title: 04/18/2023 Executive Summary Editing

Date: 04/18/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: look over Roxi's edits

Content:

- I asked Roxi to look over my edits to see if they made the document better or if we should revert it back to its draft version
- she liked the edits and made some of her own
- I also made a few more edits reading through it again

References: none

Conclusions:

Roxi reviewed my edits for the executive summary and made some edits/comments of her own. I did some more editing of the document when reviewing her changes/suggestions.

Action items:

1. share edits with Josh, Sam, and Tim
2. add testing section

ANNABEL FRAKE - Apr 18, 2023, 6:30 PM CDT

Download

402_Design_Excellence_Executive_Summary.pdf (79.8 kB)

04/20/2023 Executive Summary Review

ANNABEL FRAKE - Apr 20, 2023, 10:48 PM CDT

Title: 04/20/2023 Executive Summary Review

Date: 04/20/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: review the executive summary

Content:

- I read through the executive summary one last time
- I made some minor grammar changes
- I left a comment asking the team if we should rephrase the final paragraph to highlight that we met the design criteria
    - although, based on how we worded things, the workout on the adaptive vs standard sides is not matched, so we may not have met all design criteria

References: none

Conclusions:

I reviewed the executive summary a final time.

Action items:

1. submit final executive summary

04/22/2023 Poster

ANNABEL FRAKE - Apr 22, 2023, 4:17 PM CDT

Title: 04/22/2023 Poster

Date: 04/22/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: edit the final design section of the poster (my assigned section

Content:

References: none

Conclusions:

I added some of the photos Sam and I took yesterday to the final design section of the poster and added labels.

Action items:

1. edit poster with rest of group
2. measure how long the lap pad is now and update on the poster

04/24/2023 Presentation Script

ANNABEL FRAKE - Apr 25, 2023, 1:00 AM CDT

Title: 04/24/2023 Presentation Script

Date: 04/24/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: write scripts for the poster presentation and design excellence presentation

Content:

Poster: (~2 min 16 sec)

Thank you, Tim.

In terms of design criteria, the rowing machine must be accessible to wheelchair users and require zero external assistance to operate. The design must be compatible with average wheelchair dimensions and prevent wheelchair tipping and translation during the rowing motion. Additionally, the pulley mechanism must withstand a maximum force of 400 Newtons. Other design criteria include safety, ease of fabrication, ease of use, durability, and cost.

After three semesters of design iterations, the final design consists of an antler-like structure and associated pulley, a stabilization frame, a console rotation mechanism, and a resistance adjustment mechanism. We replaced the original Matrix rower neck with two antler-like structures fabricated from steel that hold the rowing handle in a central position relative to the standard and adaptive sides of the rower. The addition of a second pulley allows the user to easily transition the rowing handle from one side of the machine to the other.

To secure a user on the adaptive side of the machine, we created a metal stabilization frame with a lap pad design similar to those seen on roller coasters. An individual in a wheelchair can roll up to the standard side, lock their wheelchair in place, lower the lap pad using a pin adjustment mechanism, and begin their workout. The lap pad supplies a downward force that prevents translation and tipping during the rowing motion.

With the elimination of the original Matrix rower neck, we decided to reposition the console to a point adjacent one of the antlers. We used a stepper motor and several strategically placed limit switches to automate the rotation of the console between the adaptive and standard sides of the machine. Based on the orientation of the lap pad, the console automatically rotates to face the side of the machine currently in use.

Lastly, we replaced the original mechanical resistance mechanism with an electronic version that allows the user to alter the resistance level from either side of the machine. We 3D-printed a press-fit shaft that connects a stepper motor to the magnet housing near the flywheel of the rower. By interacting with a user-friendly interface, the consumer can view and alter the resistance level by rotating the motor to change the overlap between the magnet and flywheel. The greater the overlap, the greater the resistance.

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

Design Excellence: (~1 min 25 sec)

Thank you, Josh.

In order to view the console display from either side of the machine, the team originally created a 3D pin fixture that allowed the user to mechanically rotate the console between sides. With the elimination of the original Matrix rower neck, we decided to reposition the console to a point adjacent 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 pad near its pivot point. Two more limit switches placed near the base of the console provide feedback about the orientation of the display. Based on the position of the lap pad, the console automatically rotates to face the side of the machine currently in use.

This semester, we tackled a previously unmet design criteria by replacing the original mechanical resistance mechanism with an electronic version that allows the user to alter the resistance level from either side of the machine. We 3D-printed a press-fit shaft that connects a stepper motor to the magnet housing near the flywheel of the rower. Rotating the stepper motor changes the overlap between the magnet and the flywheel; the greater the overlap, the greater the resistance. We designed a user-friendly interface that displays the current resistance value and allows the consumer to alter the resistance level using up and down push buttons.

Sam will now talk about testing and future work.

References: none

Conclusions:

I wrote rough drafts of my scripts for the poster presentation and the design excellence presentation.

Action items:

1. continue to refine speeches and practice
2. I asked Sam and Josh if there is anything else I need to include about the antlers and/or stabilization frame and will implement their feedback when I get a response

04/25/2023 Presentation Script

ANNABEL FRAKE - Apr 25, 2023, 9:48 PM CDT

Title: 04/25/2023 Presentation Script

Date: 04/25/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: revise scripts and memorize

Content:

Poster: (~2 min 30 sec)

Thank you, Tim.

In terms of design criteria, the adaptive rowing machine must be accessible to users in wheelchairs and require zero external assistance to operate. The design must be compatible with average wheelchair dimensions and prevent wheelchair tipping and translation during the rowing motion. Additionally, the pulley mechanism must withstand a maximum load of 400 Newtons. Other design criteria include safety, ease of fabrication, ease of use, durability, and cost.

After three semesters of design iterations, the final design consists of an antler-like structure and associated pulley, a stabilization frame, a console rotation mechanism, and a resistance adjustment mechanism. We replaced the original Matrix rower neck with two antler-like structures fabricated from steel that hold the rowing handle in a central position relative to the standard and adaptive sides of the rower. The addition of the second pulley allows the user to easily transition the rowing handle between sides.

To secure a user on the adaptive side, we created a metal stabilization frame with a lap pad design similar to those seen on roller coasters. An individual in a wheelchair need only roll up to the standard side, lock their wheelchair in place, and lower the lap pad using a pin adjustment mechanism before beginning their workout. The lap pad supplies a downward force that prevents translation and tipping during the rowing motion.

With the elimination of the original Matrix rower neck, we decided to reposition the console to a point adjacent one of the antlers. We used a stepper motor and several strategically placed limit switches to rotate the console between the adaptive and standard sides of the machine. Based on the orientation of the lap pad, the console automatically rotates to face the side of the machine currently in use.

Lastly, we replaced the original mechanical resistance mechanism with an electronic version that allows the user to alter the resistance level from either side of the machine. We 3D-printed a press-fit shaft that connects a stepper motor to the pre-existing magnet housing near the flywheel of the rower. Rotating the stepper motor changes the overlap between the magnet and the flywheel; the greater the overlap, the greater the resistance. A user-friendly interface displays the current resistance value and allows the consumer to alter the resistance level via push buttons.

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

Design Excellence: (~1 min 25 sec)

Thank you, Josh.

In order to view the console display from either side of the machine, the team originally created a 3D pin fixture that allowed the user to mechanically rotate the console between sides. With the elimination of the original Matrix rower neck, we decided to reposition the console to a point adjacent 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 pad near its pivot point. Two more limit switches placed near the base of the console provide feedback about the orientation of the display. Based on the position of the lap pad, the console automatically rotates to face the side of the machine currently in use.

This semester, we tackled a previously unmet design criteria by replacing the original mechanical resistance mechanism with an electronic version that allows the user to alter the resistance level from either side of the machine. We 3D-printed a press-fit shaft that connects a stepper motor to the magnet housing near the flywheel of the rower. Rotating the stepper motor changes the overlap between the magnet and the flywheel; the greater the overlap, the greater the resistance. We designed a user-friendly interface that displays the current resistance value and allows the consumer to alter the resistance level using up and down push buttons.

Sam will now talk about testing and future work.

References: none

Conclusions:

I revised my scripts based on feedback from Josh and Sam. I memorized the poster presentation script.

Action items:

1. continue to practice poster presentation

2. memorize design excellence

04/26/2023 Presentation Script

ANNABEL FRAKE - Apr 26, 2023, 11:32 PM CDT

Title: 04/26/2023 Presentation Script

Date: 04/26/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: revise scripts based on feedback from Roxi and memorize

Content:

Poster: (~2 min)

Thank you, Tim.

In terms of design criteria, the adaptive rowing machine must be accessible to users in wheelchairs and require zero external assistance to operate. The design must be compatible with average wheelchair dimensions and prevent wheelchair tipping and translation during the rowing motion. Additionally, the pulley mechanism must withstand a maximum load of 400 Newtons. Other design criteria include safety, ease of fabrication, ease of use, durability, and cost.

After three semesters of design iterations, the final design consists of an antler-like structure and associated pulley, a stabilization frame, a console rotation mechanism, and a resistance adjustment mechanism. The labels in Figures 6 through 8 on the poster call out design components that we either created entirely from scratch or modified from the original. Each mechanical component was modeled in SolidWorks prior to fabrication, as seen in Figures 2 through 5.

We replaced the original Matrix rower neck with two antler-like structures fabricated from steel that position the rowing handle in an accessible location for users on either side of the machine.

To secure a user on the adaptive side, we created a metal stabilization frame with a lap pad design similar to those seen on roller coasters. The lap pad secures the user by applying a downward force and may be adjusted using a pin mechanism.

With the elimination of the original Matrix rower neck, we repositioned the console and integrated several electrical components so that the console automatically rotates to face the side of the machine currently in use.

Lastly, we replaced the original mechanical resistance mechanism with a 3D-printed press-fit shaft that connects a stepper motor to the pre-existing magnet housing near the flywheel of the rower. Rotating the stepper motor changes the overlap between the magnet and the flywheel; the greater the overlap, the greater the resistance. A user-friendly interface displays the current resistance value and allows the consumer to alter the resistance level via push buttons.

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

Design Excellence: (~1 min 25 sec)

Thank you, Josh.

In order to view the console display from either side of the machine, the team originally 3D-printed a pin fixture that allowed the user to mechanically rotate the console between sides. With the elimination of the original Matrix rower neck, we decided to reposition the console to a point adjacent 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 pad near its pivot point. Two more limit switches placed near the base of the console provide feedback about the orientation of the display. Based on the position of the lap pad, the console automatically rotates to face the side of the machine currently in use.

This semester, we tackled a previously unmet design criteria by replacing the original mechanical resistance mechanism with an electronic version that allows the user to alter the resistance level from either side of the machine. We 3D-printed a press-fit shaft that connects a stepper motor to the magnet housing near the flywheel of the rower. Rotating the stepper motor changes the overlap between the magnet and the flywheel; the greater the overlap, the greater the resistance. We designed a user-friendly interface that displays the current resistance value and allows the consumer to alter the resistance level using up and down push buttons.

Sam will now talk about testing and future work.

References: none

Conclusions:

I revised my scripts based on feedback from Roxi. I memorized both scripts.

Action items:

1. practice with team

ANNABEL FRAKE - Apr 26, 2023, 10:58 PM CDT

[Download]

Poster_script_edits.pdf (270 kB) Feedback from Roxi

04/27/2023 Presentation Script

ANNABEL FRAKE - Apr 28, 2023, 1:18 AM CDT

Title: 04/27/2023 Presentation Script

Date: 04/27/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: practice scripts

Content:

Poster: (~2 min 10 sec)

Thank you, Tim.

In terms of design criteria, the adaptive rowing machine must be accessible to users in wheelchairs and require zero external assistance to operate. The design must be compatible with average wheelchair dimensions and prevent wheelchair tipping and translation during the rowing motion. Additionally, the pulley mechanism must withstand a maximum load of 400 Newtons. Other design criteria include safety, ease of fabrication, ease of use, durability, and cost.

After three semesters of design iterations, the final design consists of an antler-like structure and associated pulley, a stabilization frame, a console rotation mechanism, and a resistance adjustment mechanism. The labels in Figures 6 and 8 call out design components that we either created entirely from scratch or modified from the original. Each mechanical component was modeled in SolidWorks prior to fabrication, as seen in Figures 2 through 5.

We replaced the original Matrix rower neck with two antler-like structures fabricated from steel that position the rowing handle in an accessible location for users on either side of the machine.

To secure a user on the adaptive side, we created a metal stabilization frame with a lap pad design similar to those seen on roller coasters. The lap pad may be adjusted using a pin mechanism and secures the user by applying a downward force.

With the elimination of the original Matrix rower neck, we repositioned the console and integrated several electrical components so that the console automatically rotates to face the side of the machine currently in use.

Lastly, we replaced the original mechanical resistance mechanism with a 3D-printed press-fit shaft that connects a stepper motor to the pre-existing magnet housing near the flywheel of the rower. Rotating the stepper motor changes the overlap between the magnet and the flywheel; the greater the overlap, the greater the resistance. A user-friendly interface displays the current resistance value and allows the consumer to alter the resistance level via push buttons.

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

Design Excellence: (~1 min 06 sec)

Thank you, Josh.

The team originally 3D-printed a pin fixture that allowed the user to manually rotate the console to face either the standard or adaptive side. With the elimination of the Matrix rower neck, we repositioned the console and used a stepper motor to automate its rotation based on feedback from a limit switch positioned behind the lap pad near its pivot point. Two more limit switches placed near the base of the console provide feedback about the orientation of the display. Depending on the position of the lap pad, the console automatically rotates to face the side of the machine currently in use.

This semester, we tackled a previously unmet design criteria by replacing the original mechanical resistance mechanism with a 3D-printed press-fit shaft that connects a stepper motor to the pre-existing magnet housing near the flywheel of the rower. Rotating the stepper motor changes the overlap between the magnet and the flywheel; the greater the overlap, the greater the resistance. A user-friendly interface displays the current resistance value and allows the consumer to alter the resistance level via push buttons.

Sam will now talk about testing and future work.

References: none

Conclusions:

I practiced my scripts.

Action items:

1. present

04/29/2023 Journal Appendices

ANNABEL FRAKE - Apr 29, 2023, 6:50 PM CDT

Title: 04/29/2023 Journal Appendices

Date: 04/29/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: update/create appendices for this semester

Content:

- I updated the following appendices:
    - **Appendix M: BME 402 Adaptive Resistance Mechanism**
    - **Appendix U: BME 402 Final Prototype Images**
- I created the following appendices:
    - **Appendix N: BME 402 Final Circuit Schematic**
    - **Appendix O: BME 402 Final Coding Flowcharts**
    - **Appendix P: BME 402 Final Arduino Code**
    - **Appendix Q: Electronic Testing Protocol and Results**

References: none

Conclusions:

I worked on my assigned portion of the journal / appendices by updating and creating appendices for the things I worked on this semester.

Action items:

1. edit journal and appendices individually and with group

04/30/2023 Journal/Appendices Editing

ANNABEL FRAKE - Apr 30, 2023, 11:14 PM CDT

Title: 04/30/2023 Journal/Appendices Editing

Date: 04/30/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: edit journal article and appendices

Content:

- I edited the journal article and appendices.
- I left conceptual comments (no grammatical ones to save time in the group meeting).

References: none

Conclusions:

I edited the journal article and appendices.

Action items:

1. edit with rest of team

05/01/2023 End of Semester Reflection

ANNABEL FRAKE - May 01, 2023, 9:43 PM CDT

Title: 05/01/2023 End of Semester Reflection

Date: 05/01/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: reflect on end of semester

Content: N/A

References: none

Conclusions:

Overall, I'm very happy with the progress that we made this semester. I really enjoyed showing visitors and judges at the poster presentation how much progress we've made in the past year. There are still some components of the design and testing protocols that could be improved, but the advances we made this year are quite spectacular and I'm very proud of my team for their hard work.

Action items: none

01/26/23 EMG

ANNABEL FRAKE - Jan 26, 2023, 9:31 PM CST

Title: 26JAN2023 EMG

Date: 26JAN2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: read the pages (p. 20-21, 50) Dr. Wille recommended on EMG

Content:

Muscle Map Frontal

Most of the important limb and trunk muscles can be measured by surface electrodes (right side muscles in Fig. 26a/26b). Deeper, smaller or overlaid muscles need a fine wire application to be safely or selectively detected. The muscle maps show a selection of muscles that typically have been investigated in kinesiological studies. The two yellow dots of the surface muscles indicate the orientation of the electrode pair in ratio to the muscle fiber direction (proposals compiled from 1, 4, 10 and SENIAM).

Frontal View

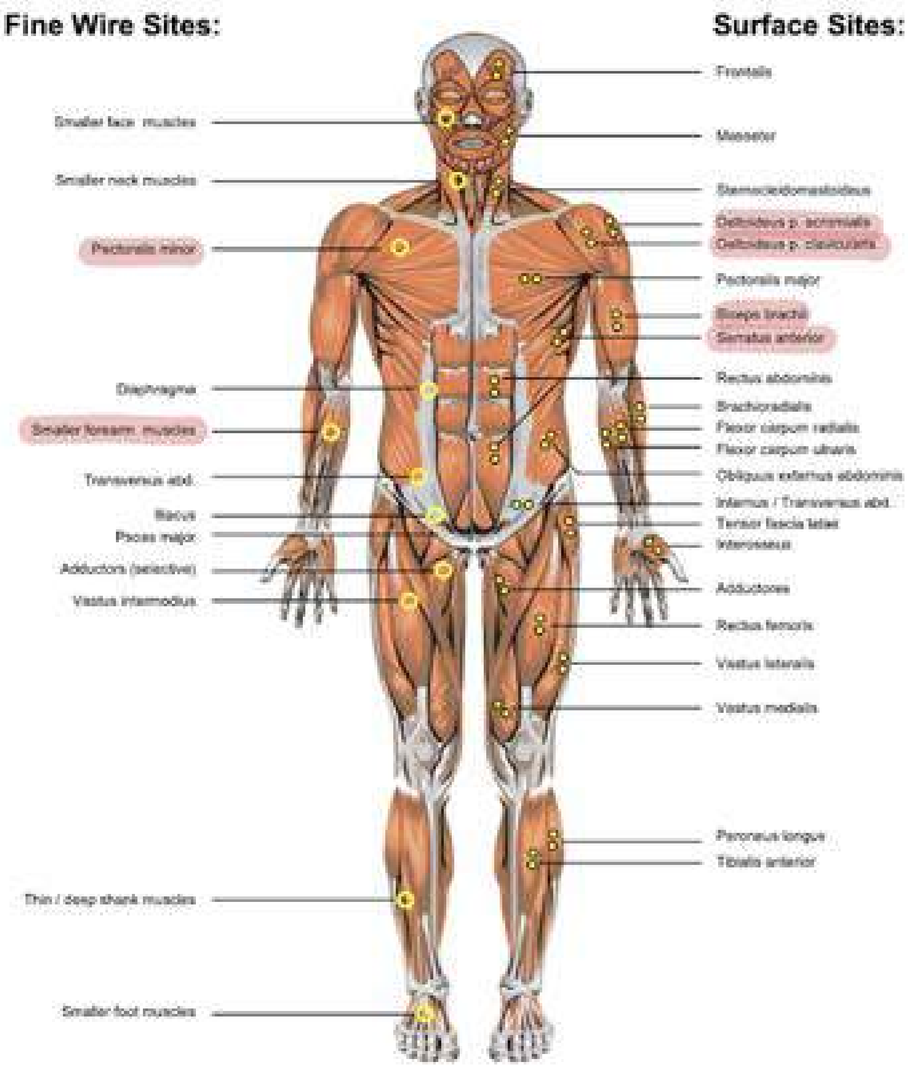


Fig. 26a: Anatomical positions of selected electrode sites, frontal view. The left side indicates ***deep*** *muscles and positions for fine wire electrodes, while the right side is for* ***surface*** *muscles and electrodes*

Muscle Map Dorsal

Dorsal View

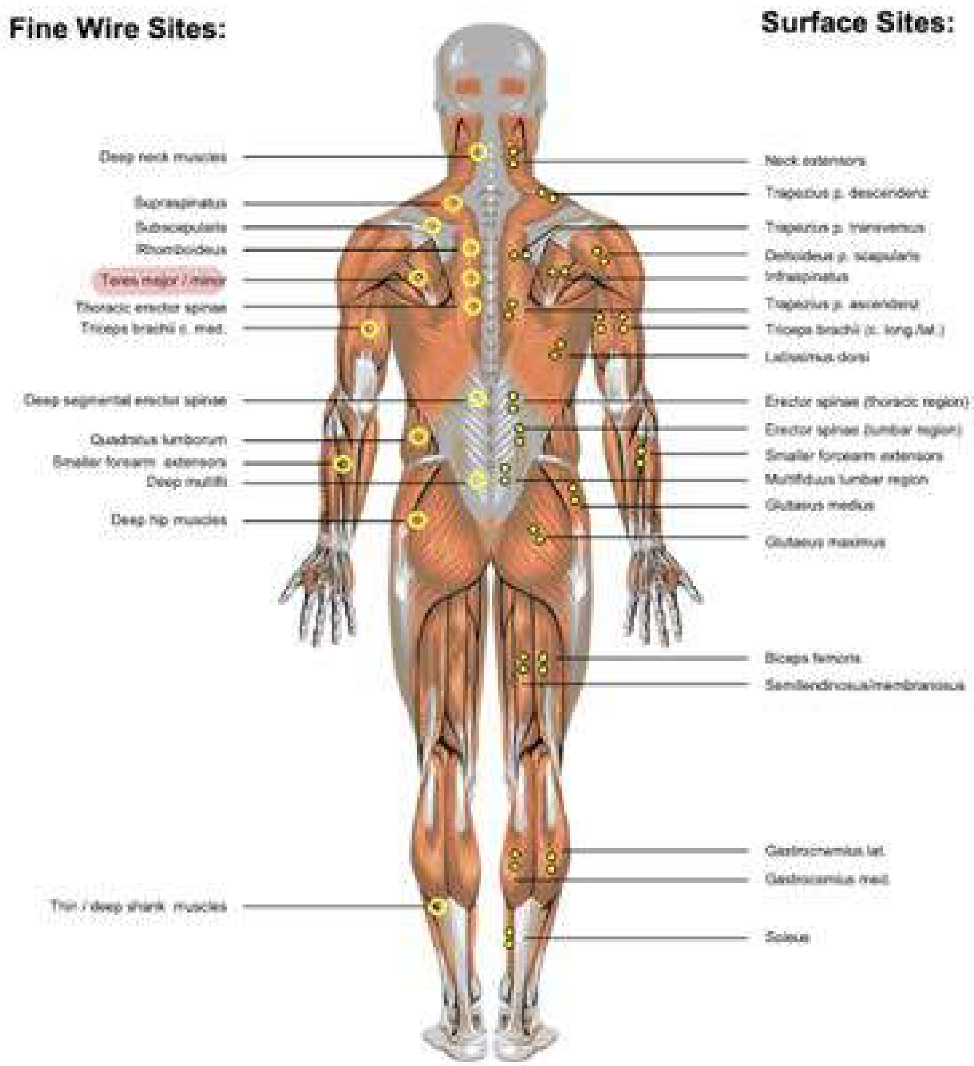


*Fig. 26b: Anatomical positions of selected electrode sites, dorsal view. The left side indicates **deep** muscles and positions for fine wire electrodes, while the right side is for **surface** muscles and electrodes*

Reference electrodes

At least one neutral reference electrode per subject needs to be positioned. Typically an electrically unaffected but nearby area is selected, such as joints, bony area, frontal head, processus spinosus, christa iliaca, tibia bone etc. Due to differential amplification against any reference, the latest amplifier technology (NORAXON active systems) needs no special area but only a location nearby the first electrode site. Remember to prepare the skin for the reference electrode also and use electrode diameters of at least 1 cm.

EMG Analysis: How Much Activity?

Question level 4: How much is the muscle active?

On this question level the EMG amplitude has to be calculated on a metric scale, giving a number to the question *"How much?"* This question cannot be answered by the original microvolt scaling, because the original electrical muscle activity is influenced by the local given detection condition which can vary greatly. To overcome this external influence, a rescaling to percent of a certain reference value is applied - preferred to the maximum EMG signal available in optimal static contraction condition (see The concept of MVC-normalization).

The question: *How much EMG* basically addresses how much work or effort a particular muscle needs to share in a certain exercise or task. This kind of evaluation is important in order to understand the effect of treatment and training exercises (Fig. 74) and reveal their character of being low, submaximal or maximal in demand: e.g. efficient strength training exercises need a innervation level of at least 40 – 60% of MVC to create a positive effect strength increase due to supercompensation (muscle hypertrophy in healthy subjects).

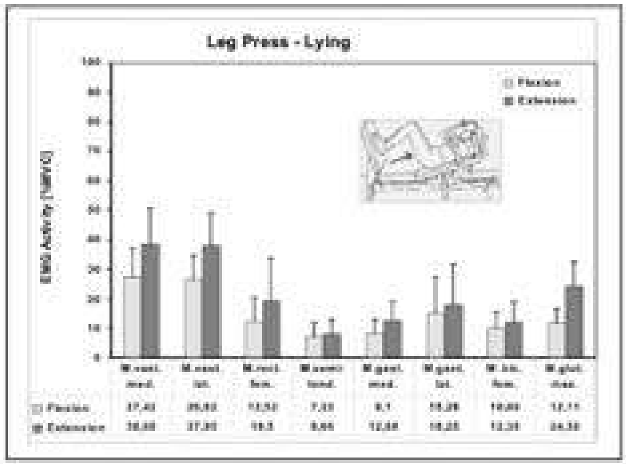


Fig. 74: Muscular innervation profile of 8 hip/leg muscles in the horizontal squat movement. Data shows the MVC normalized mean EMG of 6 extension and flexion periods measured for a group of 10 subjects at 40% of the individual for one repetition maximum.

Ergonomics may need to understand the neuromuscular demand of a given work activity to improve techniques and conditions to lower stress and strain on employees. The design of work tools, seats and other work space related conditions/devices will benefit from the analysis of the neuromuscular effort.

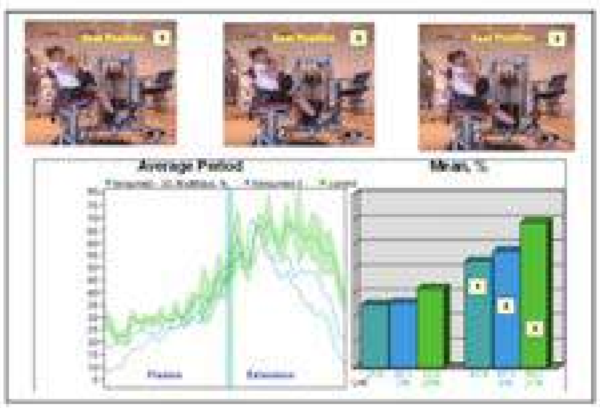


Fig. 75: EMG efficiency analysis for 3 different seat positions based on the MVC-normalized average curve of the multifidus muscle in a sequence of back flexion/extension cycles. At a given load (60% Max.), seat position 3 shows the highest EMG innervation.

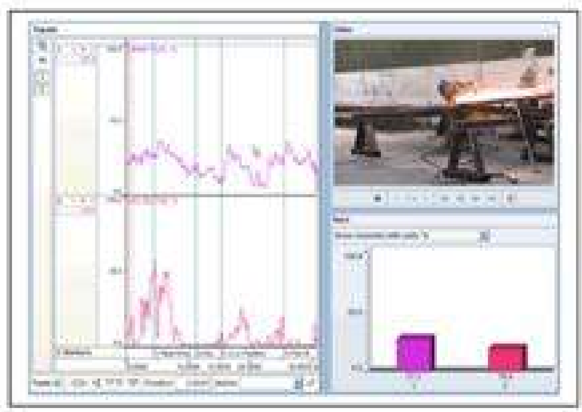


Fig. 76: Ergonomic EMG analysis of two shoulder muscles (upper trace - trapezius p. desc; lower trace - deltoideus anterior) in a work task in a steel production process. The MVC normalized signal shows the muscular demand in ratio to the given video picture

References:

P. Konrad, “The ABC of EMG: A Practical Introduction to Kinesiological Electromyography,” *Noraxon INC. USA.*, 2006, [Online]. Available: https://www.noraxon.com/wp-content/uploads/2014/12/ABC-EMG-ISBN.pdf

Conclusions:

Dr. Wille recommended that we look at these 3 pages in the pdf she provided us with, so I wanted to review them before my team's IRB meeting tomorrow. Pages 20 and 21 provide electrode positions for target muscle groups. We have not decided which muscles we will record from yet, but this will be a good reference for electrode placement once we have decided. On page 50, it mentions that we will need to scale the original microvolt reading by a reference value to quantify the muscle activity present. This resource will help guide our discussion of our IRB testing protocols tomorrow, and gives us a better idea of how we will analyze the data we collect. I'll plan to look more closely at this as the semester progresses.

Action items:

1. talk with the team about the EMG aspect of the IRB testing protocols

ANNABEL FRAKE - Jan 26, 2023, 8:15 PM CST

Download

The_ABC_of_EMG.pdf (3.78 MB)

01/26/23 Matrix Resistance Dial Removal

ANNABEL FRAKE - Jan 26, 2023, 9:15 PM CST

Title: 26JAN2023 Matrix Resistance Dial Removal

Date: 26JAN2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: look at the instructions for removing the resistance dial provided to us by the client

Content:

- 
  1) Refer to 9.3.1 and 9.3.2 to remove the covers.
  2) Remove the spring (Figure A).
  3) Turn the cover to left and it will be removed (Figure B).

  FIGURE A

  FIGURE B

- 
  4) Remove the 2 screws holding tension knob to the frame (Figure C).
  5) Remove the tension knob (Figure D).

  FIGURE C

  FIGURE D

References: JHT

Conclusions:

We are visiting JHT tomorrow morning to learn how to remove the resistance dial from the Matrix rower. We will also hopefully gain a better understanding of how this mechanism works; this will aid our brainstorming for how to manipulate the resistance dial on the opposite side of the machine. In anticipation of this visit, I reviewed the service manual our client provided us with last semester that includes some images of the removal of the resistance dial.

Action items:

1. visit JHT

ANNABEL FRAKE - Jan 26, 2023, 8:22 PM CST


MATRIX

ROWER-02 (AR11)
SERVICE MANUAL

Download

Rower_Service_Manual.pdf (13.1 MB)

02/04/2023 Stepper Motor Shaft Adaptions

ANNABEL FRAKE - Feb 04, 2023, 3:18 PM CST

Title: 02/04/2023 Stepper Motor Shaft Adaptions

Date: 02/04/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: learn about securement methods to motor shafts

Content:

- common failure point is the coupling point between motor shaft and mechanics
  - more common if bi-directional, start/stop, changes in torque
- most failures are because of an improper choice in connection
- most common methods for attaching mechanics to stepper/servo motors:
  - clamps or split clamps
    - clamps = split clamps
    - main goal = prevent axial movement
    - one piece or 2 piece design (see image in attached pdf)
    - increased strength due to distribution of force
    - easy to use
    - low cost
    - high holding torque
    - recommended for servo applications
    - 2 piece clamps have higher holding power because some of it is not used to close the clamp around the shaft
    - recommended to use loctite on screw
    - won't damage shaft
    - cost-effective (although more expensive than some options)
    - should clean mating surfaces with isopropyl
  - adhesives
    - Loctite
      - 10 different types (rated on temp, cure time, holding strength)
    - one of most cost-effective options
    - doesn't take up a lot of space
    - longer setup and removal time
    - recommended, 2nd only to clamps
    - could use clamp in combination with this
  - keyless bushings

        - less common than clamps
        - good if plan to attach and remove mechanics a lot
        - good if need a really good connection between motor shaft and mechanics
        - Trantorque design most common (see attached pdf for image)
        - as nut tightened, clamps down on shaft, outer sleeve expands (opposing tapers)
        - one of most expensive options
        - bigger size, so often can't use with smaller designs
        - large rotational moment of inertia (could add extra load when load itself is small diameter with small moment of inertia)
        - generally, ratio of OD to ID has to be large (1.5x to 2.5x)
        - evenly distributed forces
    - keys and keyways
        - fast way to transmit torque to load
        - relatively inexpensive
        - not good for bi-directional applications that start/stop often
        - will wear with vibration and mechanical rubbing
        - need a bit of clearance between the shaft and key
        - if key is damaged, can be hard to disassemble
    - set screws or grub screws
        - affordable
        - easy to install
        - unreliable for motion control applications
        - can damage motor shaft
        - may work in low power applications
        - widely available
        - unreliable attachment
        - recommend thread locking agent so screw doesn't loosen
        - set screws lead to small radial offset of load -> non-concentric motion
    - pinning
        - unreliable method
        - expensive for motor control
            - pins inexpensive, but tooling process is expensive
        - ok for non-aggressive, uni-directional applications
        - hard to do accurately and consistently
        - sometimes machining errors or weak points

  - have to machine the motor shaft
  - should ideally drill load and shaft simultaneously
  - recommend coiled pin

References:

“Securing Mechanics to Motor Shafts,” *Teknic, Inc.*, Sep. 18, 2020. https://teknic.com/securing-mechanics-motor-shafts/ (accessed Feb. 04, 2023).

Conclusions:

One of my design ideas for the resistance dial mechanism involves connecting the stepper motor directly to the rotation point of the magnet fixture (without a belt and pulley mechanism). I researched different ways to secure items to the end of a motor shaft and figure out the plausibility of this design idea. Overall, I think the best option for our project would be to use a split clamp. However, this may not work if the diameter of the motor shaft is different from the diameter of the hole in the magnet fixture.

Action items:

- apply this knowledge to the resistance dial / share with the team

---

ANNABEL FRAKE - Feb 04, 2023, 3:19 PM CST


Securing Mechanics to Motor Shafts

Download

Securing_Mechanics_to_Motor_Shafts_Teknic_Inc..pdf (965 kB)

02/12/2023 4 Digit 7 Segment Display

ANNABEL FRAKE - Feb 12, 2023, 6:25 PM CST

Title: 02/12/2023 4 Digit 7 Segment Display

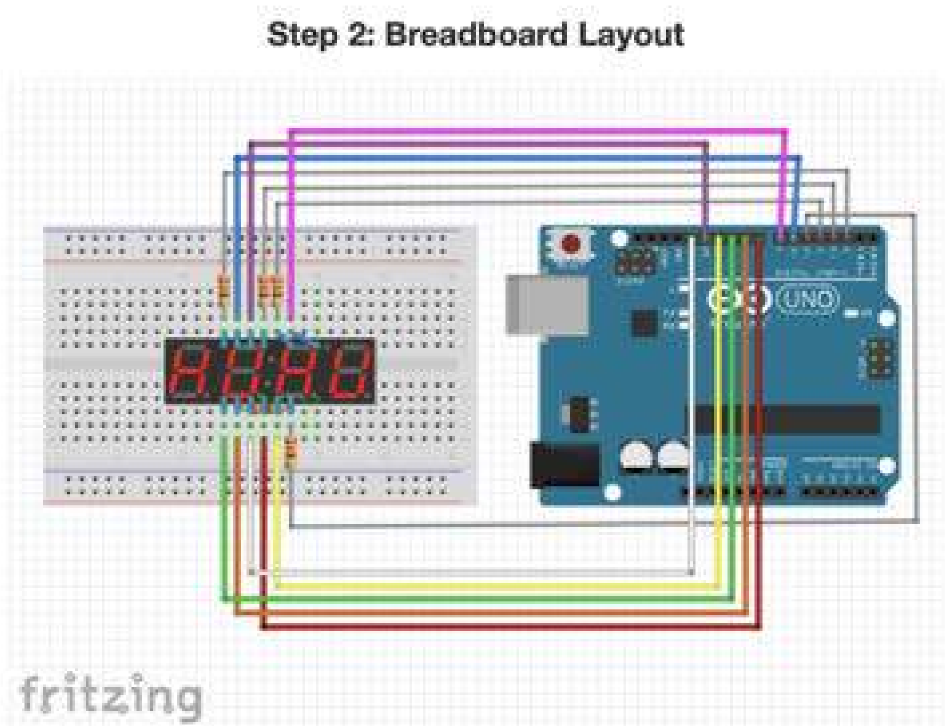
Date: 02/12/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: learn about 4 digit 7-segment displays

Content:

- https://www.instructables.com/Using-a-4-digit-7-segment-display-with-arduino/
  - takes up almost all of digital pins on Arduino Uno
  - most displays have 12 pins (directly connect to Arduino or have resistor in between)
  - displays don't require GND or power pin
  - materials
    - 4 330ohm resistors
    - 12 males jumper wires
    - Arduino Uno
    - breadboard
  - Block diagram
    - 

    - 8 of the 12 pins are used for the 8 segments

- 7 segments for the digit and one for the decimal point
- 4 of the 12 pins control the individual digits
  - these pins require the resistors
  - if don't connect resistor to right pin, digit won't work or segment won't work (potentially fatal damage)
- "When setting up the circuit switch the yellow and the purple wires (I messed up my circuit diagram)."
  - not really sure what this means...
- use SevSeg library (download: https://www.arduinolibraries.info/libraries/sev-seg)
- Code:

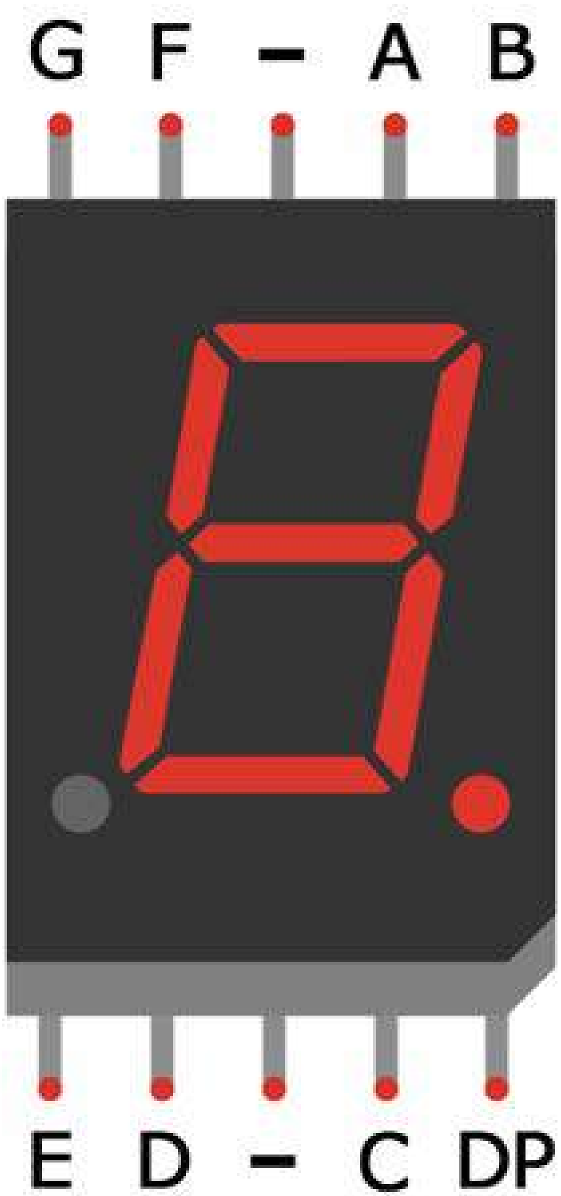
```
#include "SevSeg.h"
SevSeg sevseg; //Initiate a seven segment controller object


void setup() {
    byte numDigits = 4;
    byte digitPins[] = {2, 3, 4, 5};
    byte segmentPins[] = {6, 7, 8, 9, 10, 11, 12, 13};
    bool resistorsOnSegments = 0;
    // variable above indicates that 4 resistors were placed on the
digit pins.
    // set variable to 1 if you want to use 8 resistors on the
segment pins.
    sevseg.begin(COMMON_CATHODE, numDigits, digitPins, segmentPins,
resistorsOnSegments);
    sevseg.setBrightness(90);
}
void loop() {
    sevseg.setNumber(3141, 3);
    sevseg.refreshDisplay(); // Must run repeatedly
```

- Troubleshooting
  - if displays 8888
    - change "COMMON CATHOD" to "COMMON ANODE"

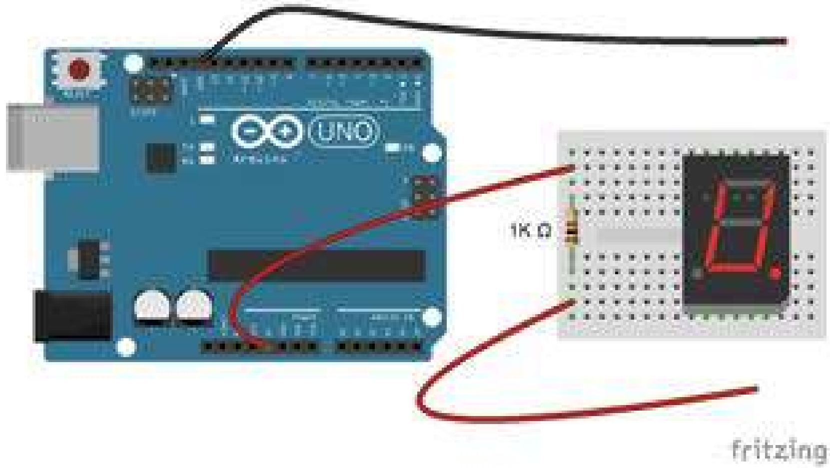
- https://www.circuitbasics.com/arduino-7-segment-display-tutorial/
  - displays come can come in red, blue, green, etc.
  - can range from 0.56 in to 4 in, or even 6.5 in
  - LEDs
    - cathode (-) connected to ground
    - anode (+) connected to digital pin through resistor (start at 1k ohm)
  - 7 segment display consists of 7 LEDS called segments
  - actually 8 segments, one for decimal
  - segments named A-G and DP
  - 2 types of 7-segment displays

- common cathode
    - all cathodes connected to ground
    - LEDS turned on and off by switching power to anode
- common anode
    - all anodes connected to Vcc
    - LEDS turned on and off by switching power to cathode

- 1 digit
    - 10 pins, 2 of which are connected to ground

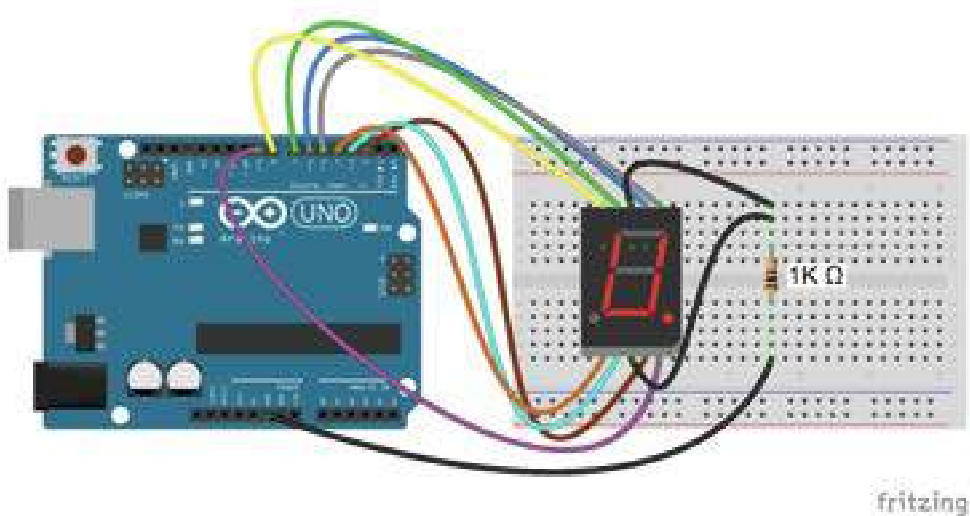


    -
    - find info about common anode/cathode on data sheet
        - can also run a test



Connect the ground (black) wire to any pin of the display. Then insert the positive (red) wire into each one of the other pins. If no segments light up, move the ground wire over to another pin and repeat the process. Do this until at least one segment lights up.

    - When the first segment lights up, leave the ground wire where it is, and connect the positive wire to each one of the other pins again. If a different segment lights up with each different pin, you have a common cathode display. The pin that's connected to the ground wire is one of the common pins. There should be two of these.
    - If two different pins light up the same segment, you have a common anode display. The pin that's connected to the positive wire is one of the common pins. Now if you connect the ground wire to each one of the other pins, you should see that a different segment lights up with each different pin.

- common pin connected to ground (common cathode) or power (common anode)
    - probe each pin with other wire, when segment lights up, write down segment name and create a pin diagram
- 

Segment Pin	Arduino Pin
A	6
B	5
C	2
D	3
E	4
F	7
G	8
DP	9

- download SevSeg library
- Code
  - #include "SevSeg.h" SevSeg sevseg; void setup(){ byte numDigits = 1; byte digitPins[] = {}; byte segmentPins[] = {6, 5, 2, 3, 4, 7, 8, 9}; bool resistorsOnSegments = true; byte hardwareConfig = COMMON_CATHODE; sevseg.begin(hardwareConfig, numDigits, digitPins, segmentPins, resistorsOnSegments); sevseg.setBrightness(90); } void loop(){ sevseg.setNumber(4); sevseg.refreshDisplay(); }
  - `hardwareConfig = COMMON_CATHODE` – This sets the type of display. I'm using a common cathode, but if you're using a common anode then use `COMMON_ANODE` instead.
  - `byte numDigits = 1` – This sets the number of digits on your display. I'm using a single digit display, so I set it to 1. If you're using a 4 digit display, set this to 4.

    `byte digitPins[] = {}` – Creates an array that defines the ground pins when using a 4 digit or multi-digit display. Leave it empty if you have a single digit display. For example, if you have a 4 digit display and want to use Arduino pins 10, 11, 12, and 13 as the digit ground pins, you would use this: `byte digitPins[] = {10, 11, 12, 13}`. See the 4 digit display example below for more info.

- `byte segmentPins[] = {6, 5, 2, 3, 4, 7, 8, 9}` – This declares an array that defines which Arduino pins are connected to each segment of the display. The order is alphabetical (A, B, C, D, E, F, G, DP where DP is the decimal point). So in this case, Arduino pin 6 connects to segment A, pin 5 connects to segment B, pin 2 connects to segment C, and so on.

  `resistorsOnSegments = true` – This needs to be set to true if your current limiting resistors are in series with the segment pins. If the resistors are in series with the digit pins, set this to false. Set this to true when using multi-digit displays.

- `sevseg.setBrightness(90)` – This function sets the brightness of the display. It can be adjusted from 0 to 100.

  `sevseg.setNumber()` – This function prints the number to the display. For example, `sevseg.setNumber(4)` will print the number "4" to the display. You can also print numbers with decimal points. For example, to print the number "4.999", you would use `sevseg.setNumber(4999, 3)`. The second parameter (the 3) defines where the decimal point is located. In this case it's 3 digits from the right most digit. On a single digit display, setting the second parameter to "0" turns on the decimal point, while setting it to "1" turns it off.

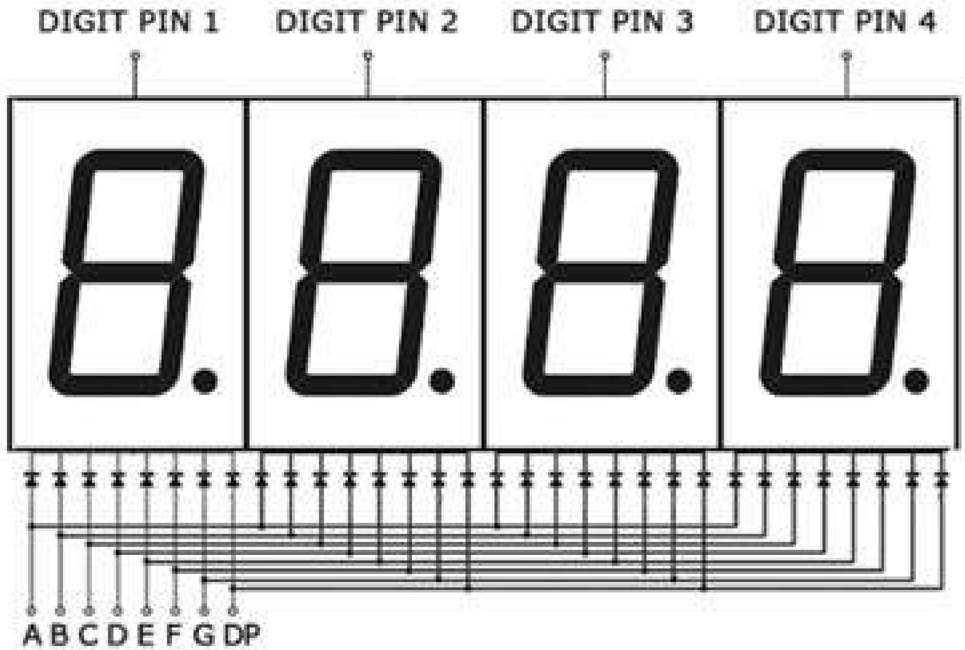
  `sevseg.refreshDisplay()` – This function is required at the end of the loop section to continue displaying the number.

- Count Up Timer Example

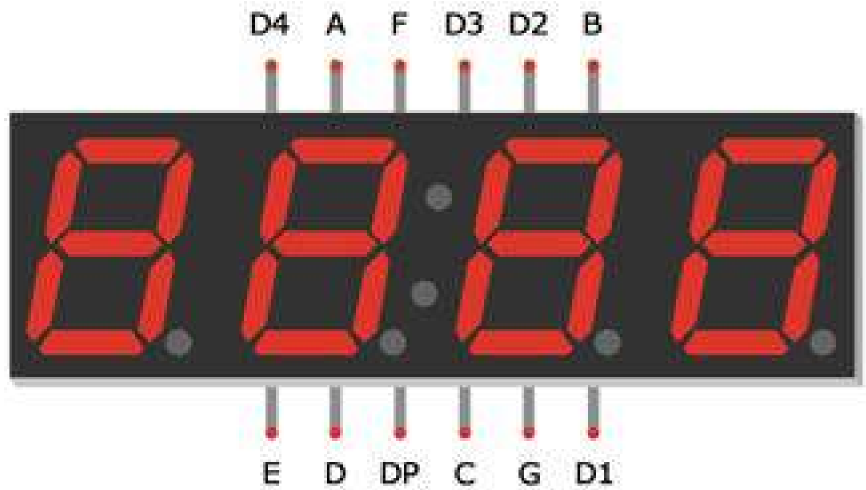
  - #include "SevSeg.h" SevSeg sevseg; void setup(){ byte numDigits = 1; byte digitPins[] = {}; byte segmentPins[] = {6, 5, 2, 3, 4, 7, 8, 9}; bool resistorsOnSegments = true; byte hardwareConfig = COMMON_CATHODE; sevseg.begin(hardwareConfig, numDigits, digitPins, segmentPins, resistorsOnSegments); sevseg.setBrightness(90); } void loop(){ for(int i = 0; i < 10; i++){ sevseg.setNumber(i, i%2); delay(1000); sevseg.refreshDisplay(); } }

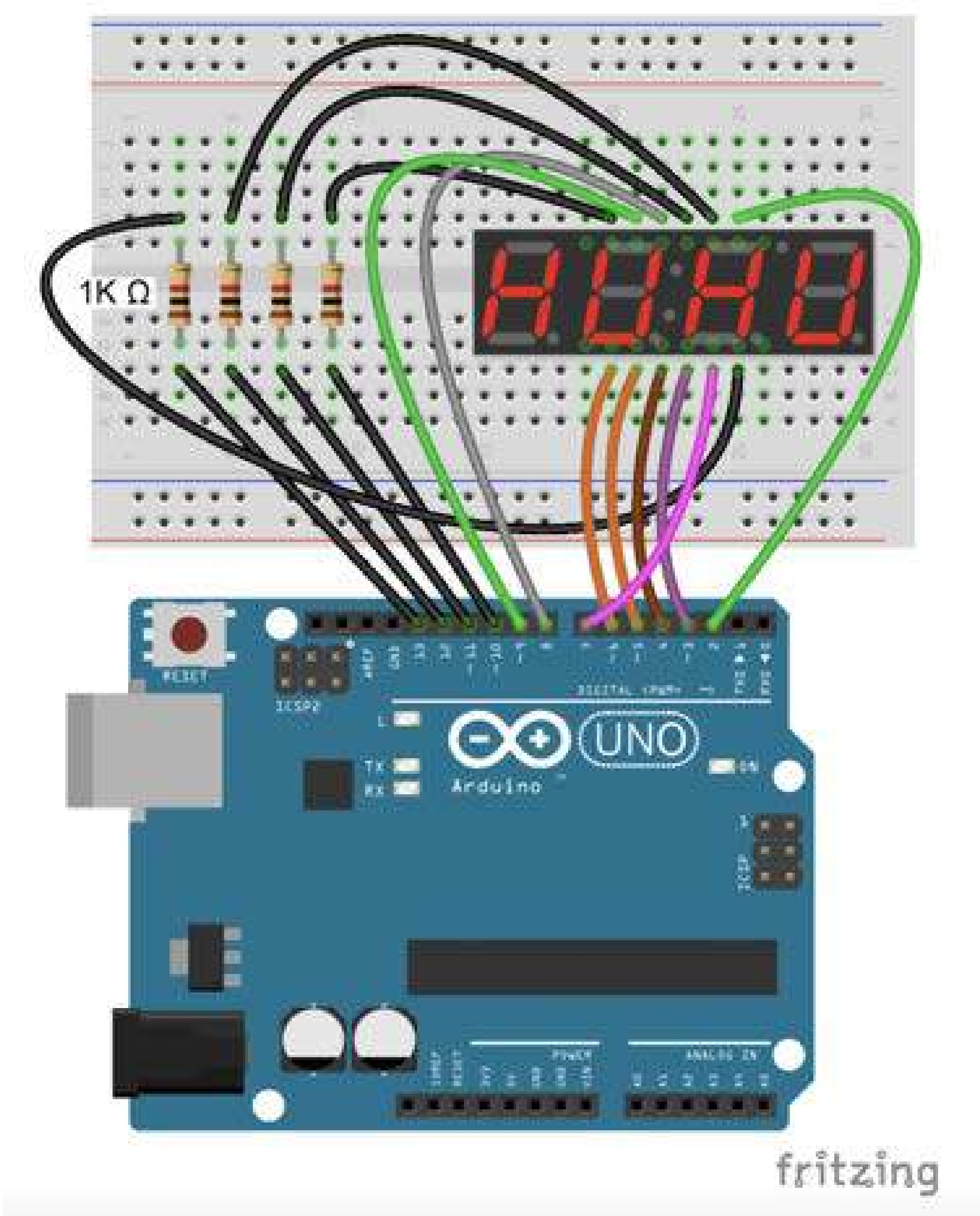
  - The `sevseg.setNumber(i, i%2)` function prints the value of i. The i%2 argument divides i by 2 and returns the remainder, which causes the decimal point to turn on every other number.

- 4 digits
  - 1 segment pin controls same segment on all digits
  - turn digit on or off by switching digit pin
  - digit pins MUST be connected to current limiting resistors



Here is a diagram showing the pinout of these displays:



- 

- Code:
  - #include "SevSeg.h" SevSeg sevseg; void setup(){ byte numDigits = 4; byte digitPins[] = {10, 11, 12, 13}; byte segmentPins[] = {9, 2, 3, 5, 6, 8, 7, 4}; bool resistorsOnSegments = true; bool updateWithDelaysIn = true; byte hardwareConfig = COMMON_CATHODE; sevseg.begin(hardwareConfig, numDigits, digitPins, segmentPins, resistorsOnSegments); sevseg.setBrightness(90); } void loop(){   sevseg.setNumber(4999, 3);   sevseg.refreshDisplay(); }

References:

chickeneater, “Using a 4 Digit & 7 Segment Display, With Arduino,” *Instructables*. https://www.instructables.com/Using-a-4-digit-7-segment-display-with-arduino/ (accessed Feb. 12, 2023).

Arduino, “SevSeg,” *Arduino Library List*, 2023. https://www.arduinolibraries.info/libraries/sev-seg (accessed Feb. 12, 2023).

K. Pattabiraman, “How to Set up Seven Segment Displays on the Arduino,” *Circuit Basics*, May 23, 2017. https://www.circuitbasics.com/arduino-7-segment-display-tutorial/ (accessed Feb. 12, 2023).

Conclusions:

To display the resistance level, we plan to use a display that reads values between 1 and 10. I have a personal 4 digit 7 segment display that I want to use to prototype the code. After I get the logic working, we can purchase two 2 digit 7 segment displays to use in the actual design (we only need 2 digits to display values 1 to 10). This tutorials provide example code and circuit diagrams that I will use to prototype the coding logic. The second tutorial I found seems more reputable, so I will implement that example.

Action items:

1. try this using my personal 4 digit 7-segment display

02/04/2023 Initial Brainstorming

ANNABEL FRAKE - Feb 04, 2023, 6:34 PM CST

Title: 02/04/2023 Initial Brainstorming

Date: 02/04/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: brainstorm ways to adapt the resistance dial mechanism

Content:

- see attached pdf

References: none

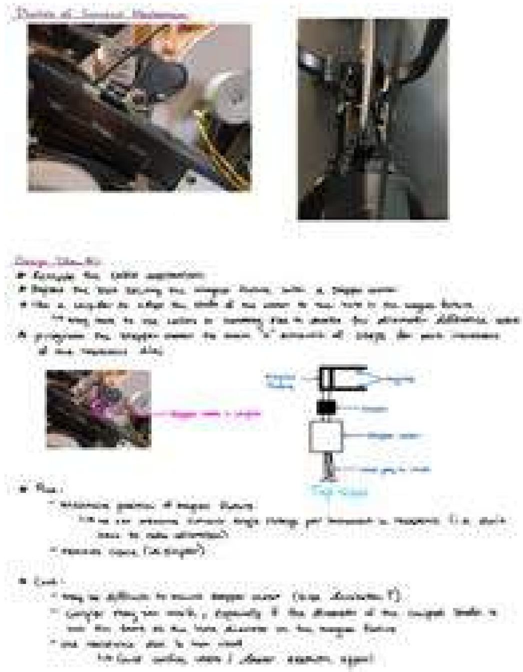
Conclusions:

I came up with 4 design ideas for the adaptive resistance dial mechanism. The first option replaces the bolt at the pivot point of the magnet fixture with a stepper motor to directly rotate the magnet. The second option also directly rotates that pivot point, but the stepper motor is placed below the pivot point and attached it via pulleys and a belt. The first option may not work because of limited space at the pivot point and/or a lack of a good coupling. The second option would allow us to move the stepper motor to a location with more room (most likely directly below the pivot point). Both the first and second options remove the cable system while the third option keeps that intact. A stepper motor/linear actuator is placed anywhere that it fist within the plastic encasement and is used to change the length of the cable. It may be harder to relate the linear translation of the cable to steps motor and/or time the linear actuator is moving. The fourth option is mechanical in nature. The magnets would be attached to a sliding door mechanism that changes the overlap of the magnets with the flywheel in intervals (pin mechanism?). Handles accessible from either side of the machine would allow users to directly pull/push the magnet "x" number of clicks to the desired resistance level. This method could be simpler than electrical solutions, but it may be more involved in terms of maneuvering around physical obstacles and interfacing with the plastic encasement to expose the handles that push/pull the sliding bars manipulating the magnets.

Action items:

- share ideas with team

ANNABEL FRAKE - Feb 04, 2023, 7:26 PM CST



Download

Resistance_Dial_Brainstorming_4FEB23.pdf (15.6 MB)

02/13/2023 4 Digit 7 Segment Display

ANNABEL FRAKE - Feb 14, 2023, 12:52 AM CST

Title: 02/13/2023 4 Digit 7 Segment Display

Date: 02/13/2023

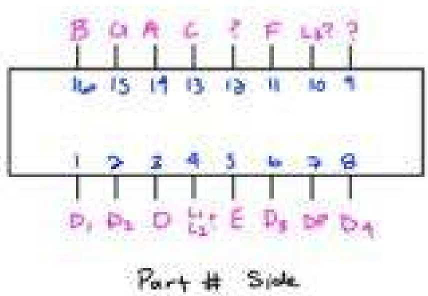
Content by: Annabel Frake

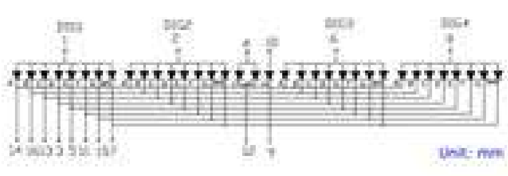
Present: Annabel Frake

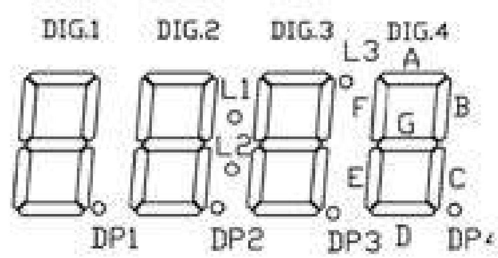
Goals: implement the 7 segment display example program

Content:

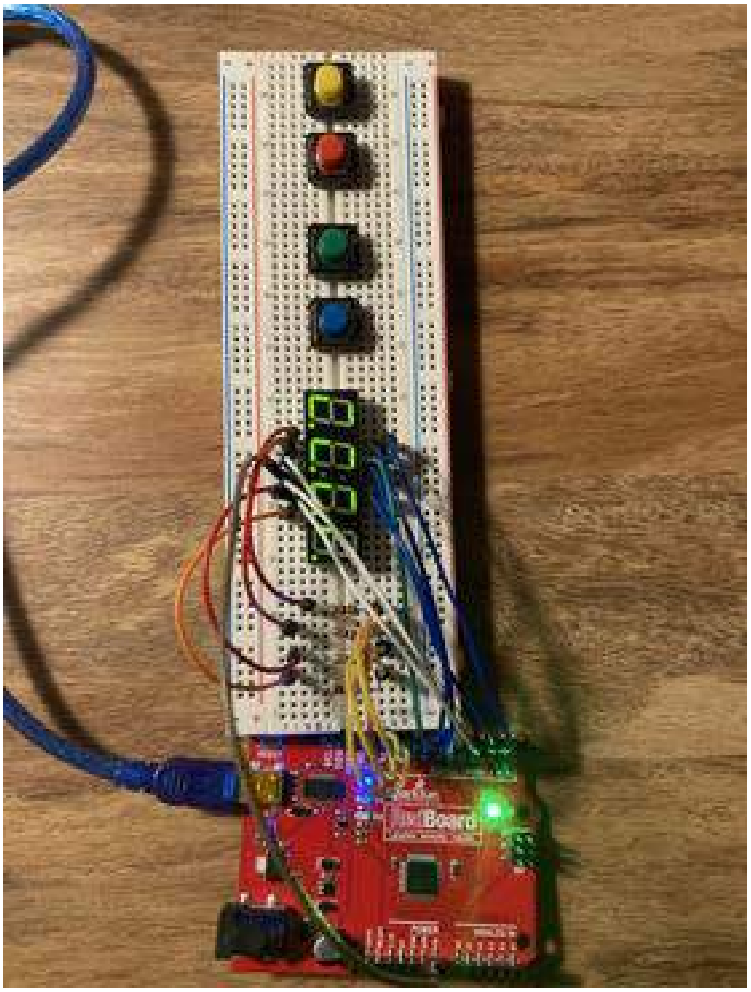
- Determine if display is common cathode or common anode
    - I followed the procedure from the tutorial, and I'm pretty sure my display is COMMON CATHODE
    - using this probing method and the data sheet, I mapped the 7 segments and DP
    - I found pins that light up L1 and L2&L3 (simultaneously)
    - haven't found the common pin
    - I tried researching pinouts online, but didn't have any luck







- I hooked up the wires I do have figured out, and the display lights up, but does not display the intended output

- 

- I will continue to research the common pin / display pinout this week
- I enlisted the help of Tim and Roxi

References:

K. Pattabiraman, "How to Set up Seven Segment Displays on the Arduino," *Circuit Basics*, May 23, 2017. https://www.circuitbasics.com/arduino-7-segment-display-tutorial/(accessed Feb. 12, 2023).

Conclusions:

I started to implement the tutorial code I found for the 4 digit 7 segment display. I started by mapping the pins on the device. I corroborated the segment and DP pins with the data sheet, but I'm still trying to figure out what pins 4, 9, 10, and 12 connect to. Pin 4 seems to match to L1 and L2 while pin 10 seems to connect to L3, but I'm not positive on that one. I searched extensively for the pinout online, but only found the data sheet. I told Roxi and Tim what I've been working on and asked them to help research it if they would like. I will continue to work on this and hopefully get the example code running by the end of the week.

Action items:

1. continue to research the pinout and work on implementing the example code

ANNABEL FRAKE - Feb 14, 2023, 12:45 AM CST


CHINA YOUNG SUN LED TECHNOLOGY CO., LTD.

Model No : YSD-439AK2B-35

LED Chip Absolute Maximum Ratings (Ta=25 ℃)

LED Chip Typical Electrical & Optical Chara Cteristics (Ta=25 ℃)

Download

YSD-439AK2B-35.pdf (63.4 kB) Data Sheet

ANNABEL FRAKE - Feb 14, 2023, 12:45 AM CST

Download

Example_4Digit_7Segment.ino (517 B) Example Arduino Code

02/14/2023 4 Digit 7 Segment Display

ANNABEL FRAKE - Feb 14, 2023, 11:39 PM CST

Title: 02/14/2023 4 Digit 7 Segment Display

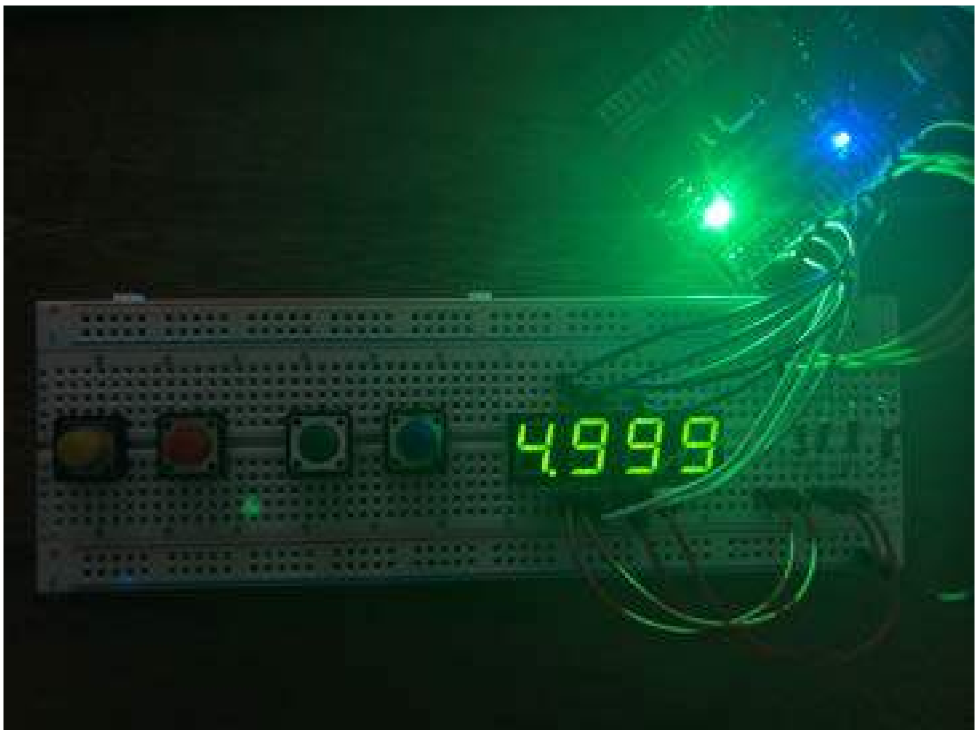
Date: 02/14/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: implement the 7 segment display example program

Content:

- after further analysis, I realized that (despite the tutorial's instructions), I have a COMMON ANODE display
- once I switched that in the code, it outputted the correct number (4.999)
- 

- I added a push button and altered the code so that it should only print to the display when the button is pressed
- when I tried to upload the code, I kept getting an error message
- I've seen this error before last semester, it occurred when the connection between the computer and Arduino was spotty
- I will need to try uploading it using a different cable or computer if it continues not to work

References:

K. Pattabiraman, “How to Set up Seven Segment Displays on the Arduino,” *Circuit Basics*, May 23, 2017. https://www.circuitbasics.com/arduino-7-segment-display-tutorial/(accessed Feb. 12, 2023).

Conclusions:

After considerable troubleshooting, I figured out that the display is a COMMON ANODE and not COMMON CATHODE. I changed the code and successfully printed numbers to the display. I altered the code so that the display should only light up when the button is pressed, but the code wouldn't upload to the board. I will try uploading another day but may need to use a different computer and/or USB cable.

Action items:

1. continue to work on code with buttons and display

ANNABEL FRAKE - Feb 14, 2023, 11:32 PM CST


CHINA YOUNG SUN LED TECHNOLOGY CO., LTD.
Model No.: YSD-439AK2B-35
LED Chip Absolute Maximum Ratings (Ta=25 ℃)
LED Chip Typical Electrical & Optical Characteristics (Ta=25 ℃)

Download

YSD-439AK2B-35.pdf (63.4 kB) Data Sheet

ANNABEL FRAKE - Feb 14, 2023, 11:32 PM CST

Download

Example_4Digit_7Segment.ino (517 B) Example Arduino Code

ANNABEL FRAKE - Feb 14, 2023, 11:34 PM CST

Download

4_Digit_1_Button.ino (1.48 kB) Code to light up display when a button is pressed.

02/15/2023 4 Digit 7 Segment Display

ANNABEL FRAKE - Feb 16, 2023, 12:14 AM CST

Title: 02/15/2023 4 Digit 7 Segment Display

Date: 02/15/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: develop the counting logic for resistance levels

Content:

- Last time, I had issues uploading to the Arduino board and came back it to this time
- after some internet searching, I found a website (https://www.programmingelectronics.com/avrdude-stk500_recv/) that suggested removing any pins connected to D0 or D1 (RX and TX) pins
- I had connected the button to those pins because they were the only open ones, but after removing them, the code uploaded to the Arduino board, so I will need to avoid them in the future
- I didn't have any other open digital pins, so I removed the pins for digits 1 and 2 since we only need a 2 digit display in the final design
    - this gives be enough pins for one 2 buttons
- I successfully implemented a code to display "4.9" only when a button is pressed
    - I learned that the display must be constantly refreshed (hopefully we don't need any delays)
    - sevseg.blank() clears the display
- Next, I created a code that changes the resistance level with "up" and "down" buttons
    - I constrained the range between 1 and 10

References:

K. Pattabiraman, “How to Set up Seven Segment Displays on the Arduino,” *Circuit Basics*, May 23, 2017. https://www.circuitbasics.com/arduino-7-segment-display-tutorial/(accessed Feb. 12, 2023).

M. James, “Fix avrdude: stk500_recv(): programmer is not responding | SOLVED,” *Programming Electronics Academy*, Apr. 26, 2021. https://www.programmingelectronics.com/avrdude-stk500_recv/ (accessed Feb. 15, 2023).

D. Reading, “SevSeg.” Feb. 06, 2023. Accessed: Feb. 15, 2023. [Online]. Available: https://github.com/DeanIsMe/SevSeg

“Arduino Reference - Arduino Reference.” https://www.arduino.cc/reference/en/ (accessed Oct. 16, 2022).

Conclusions:

After some searching, I figured out why the code wouldn't upload to the Arduino Uno yesterday; the connections to Rx and Tx were interfering with the upload. I unconnected digits 1 and 2 and used those digital pins to implement up and down buttons (out of digital pins otherwise). After some troubleshooting, I successfully wrote and debugged a code that increments/decrements the display when the up and down buttons are pressed. I constrained the if loops so that the display can never go above 10 or below 1. I had to set the resistance level to a known value at the beginning of the program, but once I add the servo/stepper motor, I will need to figure out a way to discern the resistance level based on the position of the motor. This will ensure that, if the device is unplugged and plugged back in (or the power goes out, etc.), that the resistance display accurately represents the resistance level at the flywheel.

Action items:

1. update code so that it knows what resistance level the flywheel is at when program starts

ANNABEL FRAKE - Feb 15, 2023, 11:30 PM CST

Download

4_Digit_1_Button.ino (1.25 kB) Code for lighting a 4 digit 7 segment display when a button is pressed.

ANNABEL FRAKE - Feb 15, 2023, 11:57 PM CST

Download

ResistanceDisplay1.0.ino (2.03 kB) First iteration of the code for changing the display output (between 1 and 10 resistance levels) using up and down buttons.

ANNABEL FRAKE - Feb 15, 2023, 11:58 PM CST

Download

ResistanceDisplay2.0.ino.ino (1.95 kB) Second iteration of the code for changing the display output (between 1 and 10 resistance levels) using up and down buttons.

ANNABEL FRAKE - Feb 16, 2023, 12:07 AM CST

Download

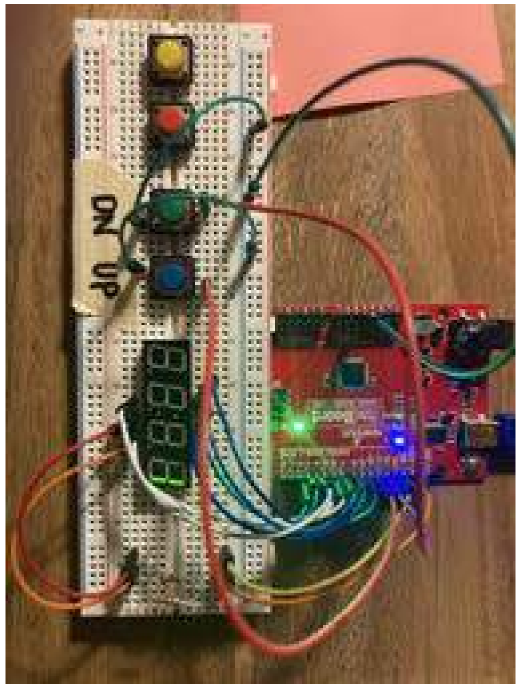
IMG_6804.MOV (10.4 MB) Video of the 4_Digit_1_Button.ino code implementation.

ANNABEL FRAKE - Feb 16, 2023, 12:08 AM CST

Download

IMG_6805.MOV (26.2 MB) Video of the ResistanceDisplay2.0.ino.ino code implementation.

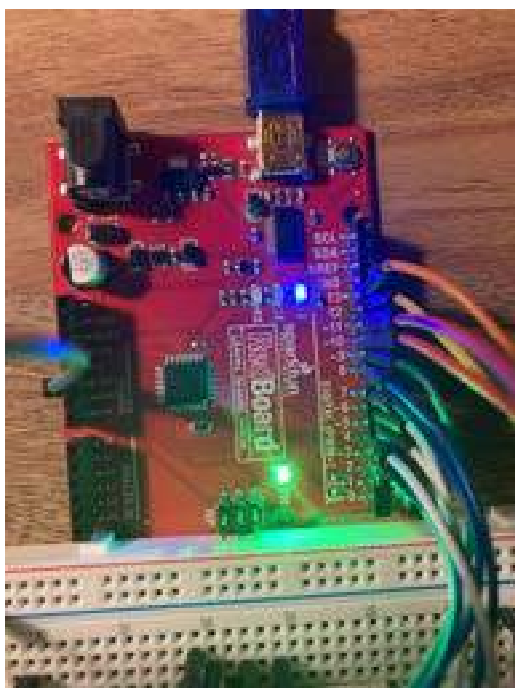
ANNABEL FRAKE - Feb 16, 2023, 12:06 AM CST



Download

IMG_6806.jpeg (3.79 MB) Image of breadboard and Arduino connections. Only 2 digits and 2 buttons are in use.

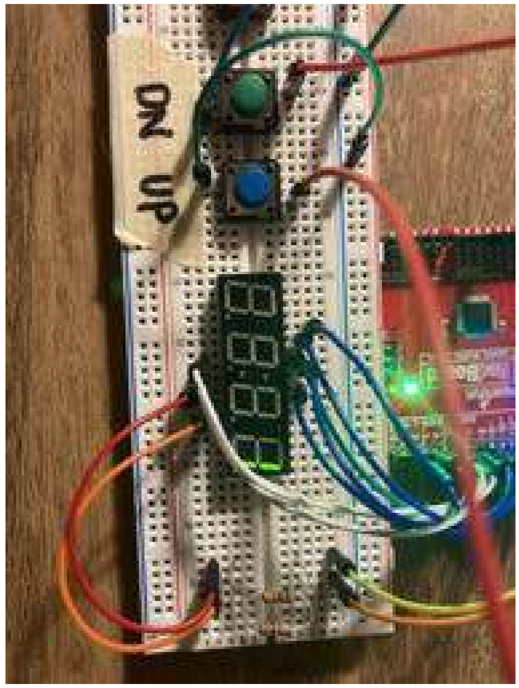
ANNABEL FRAKE - Feb 16, 2023, 12:07 AM CST



Download

IMG_6807.jpeg (3.33 MB) Closeup of Arduino connections

ANNABEL FRAKE - Feb 16, 2023, 12:07 AM CST



Download

IMG_6808.jpeg (4.19 MB) Closeup of breadboard connections.

02/21/2023 Display + Motor

ANNABEL FRAKE - Feb 21, 2023, 9:51 PM CST

Title: 02/21/2023 Display + Motor

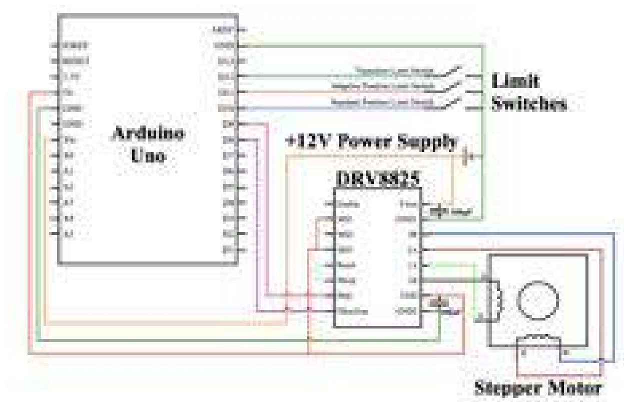
Date: 02/21/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: add a stepper motor to the display code and circuit

Content:

- I updated the display code to include logic for a stepper motor that rotates X degrees in each direction depending on the up/down button presses
- won't know the X degree until calibration
- using my design schematic from last semester, I added my personal D shaft motor to the circuit
- 

- I couldn't connect the DIR and STEP pins because I ran out of digital pins on the Arduino Uno
- At this point, I need the Mega
- I also realized that I left the power supply with the rower, so I'll need to grab that from the storage closet
- Tim also suggested that we add a limit switch so that we can reset the resistance level to 1 every time the power comes on
    - this way, we know where the stepper motor is at and what resistance level it corresponds to
    - I will implement this after I get the motor to incrementally rotate with button presses of the up/down buttons

References: previous design work (BME 400)

Conclusions:

I created a draft code that includes a stepper motor rotation by X degrees every time the resistance level is incremented (clockwise rotation) or decremented (counterclockwise rotation). I started to build the circuit, but ran out of digital pins and didn't have the power supply, so I will need to test this code at a later point. Once I confirm that this code works (after troubleshooting), I will add a limit switch that provides clarity on the orientation of the magnet over the flywheel when the power is turned on. In other words, when the device is turned on, the stepper motor associated with the flywheel will rotate until a stop hits the limit switch. At that position, the resistance level is 1. After that point, the code will behave normally.

Action items:

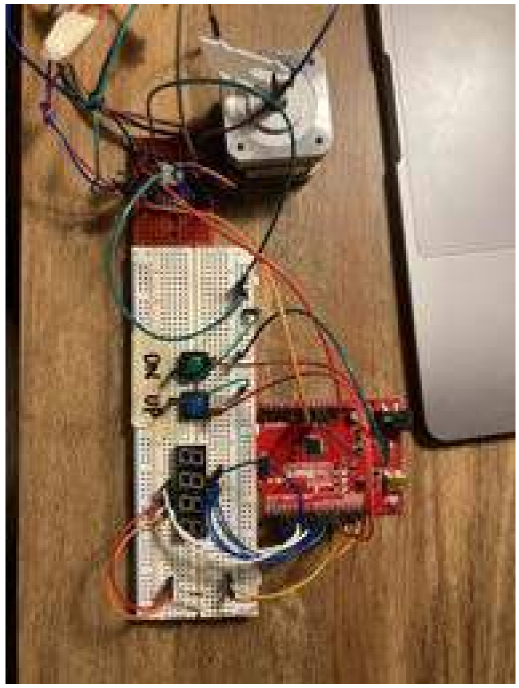
1. implement with Mega and test
2. add limit switch as way to start resistance level at one every time power turns on

ANNABEL FRAKE - Feb 21, 2023, 9:42 PM CST

Download

ResistanceDisplay3.0.ino (3.3 kB) Third iteration of the code for changing the display output (between 1 and 10 resistance levels) using up and down buttons with the addition of the stepper motor to change overlap of magnet with flywheel.

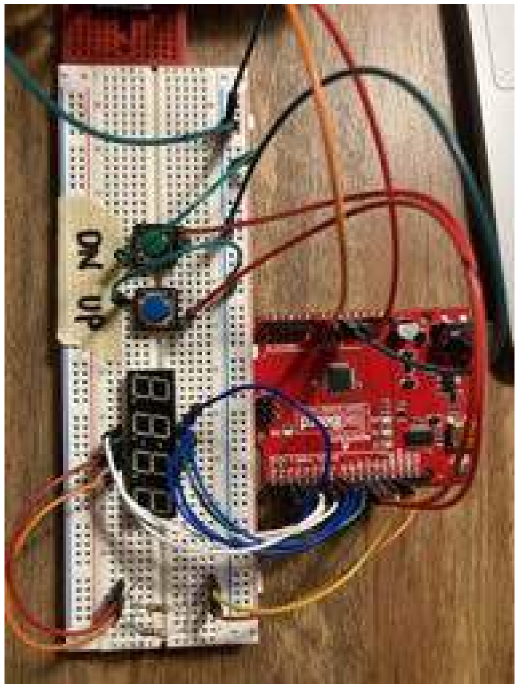
ANNABEL FRAKE - Feb 21, 2023, 9:55 PM CST



Download

IMG_6826.jpeg (4.29 MB) Circuit including Arduino Uno, 2 breadboards, and stepper motor.

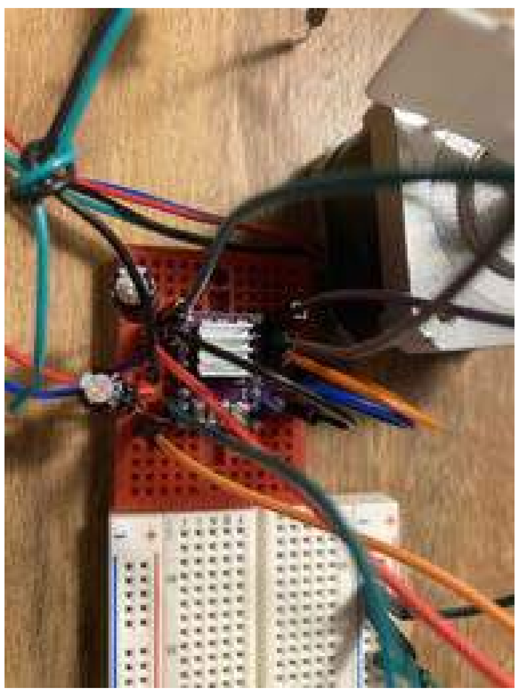
ANNABEL FRAKE - Feb 21, 2023, 9:55 PM CST



Download

IMG_6828.jpeg (4.48 MB) Closeup of breadboard and Arduino Uno connections.

ANNABEL FRAKE - Feb 21, 2023, 9:56 PM CST



Download

IMG_6827.jpeg (3.26 MB) Closeup of smaller breadboard with DRV8225.

02/25/2023 Coding Flowchart

ANNABEL FRAKE - Feb 25, 2023, 5:03 PM CST

Title: 02/25/2023 Coding Flowchart

Date: 02/25/2023

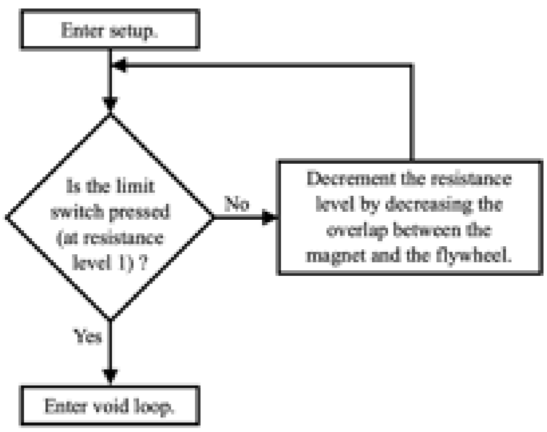
Content by: Annabel Frake

Present: Annabel Frake

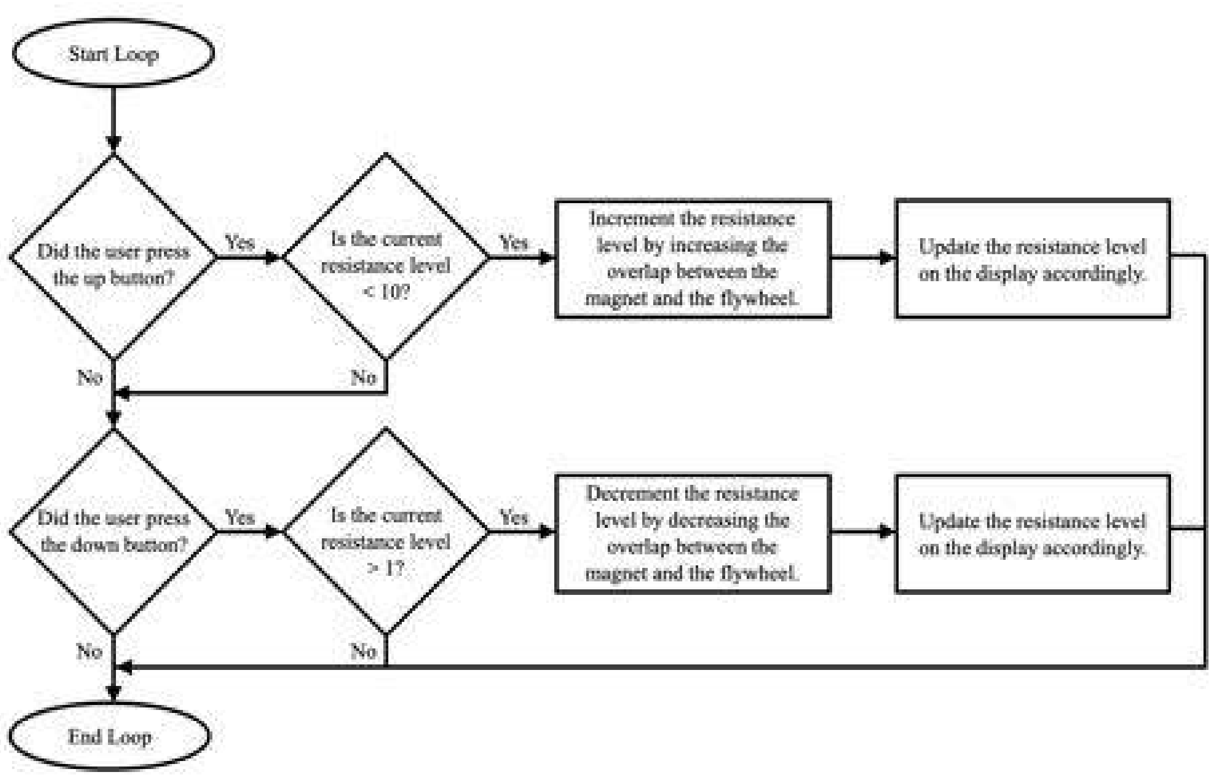
Goals: create a coding flowchart for the resistance dial

Content:

Setup:



Void loop:



References: none

Conclusions:

I created two coding flowcharts for the resistance dial. The first one describes the setup in which a while loop ensures the the resistance level is at 1. To ensure that the device knows where the magnet is located relative to the flywheel when power is first applied to the system, the stepper motor will rotate such that the overlap between the magnet and the flywheel decreases until a limit switch is pressed, indicating that the resistance level is 1. The second coding flowchart describes the void loop in which the resistance level can be incremented/decremented with the use of an up/down button, respectively. The resistance display is updated accordingly.

Action items:

1. create the schematic

02/25/2023 Materials Search

Title: 02/25/2023 Materials Search

Date: 02/25/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: find links for materials necessary for adaptive resistance mechanism

Content:

- 2 digit 7 segment display
    - link: https://www.amazon.com/dp/B07GTQTD8S/ref=sspa_dk_detail_2?psc=1&pd_rd_i=B07GTQTD8S&pd_rd_w=UxLvU&content-id=amzn1.sym.af9528d2-09ba-47ee-b909-59e3022bebe1&p e975705c6e4a&s=industrial&sp_csd=d2lkZ2V0TmFtZT1zcF9kZXRhaWw&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzQzRKVDJBRUdXVlYwJmVuY3J5cHRlZElkPUEwODkxMzc1MVp
    - see attached data sheet
    - Tim found this one
- Arduino Mega screw terminal attachment
    - link: https://www.amazon.com/Electronics-Salon-Prototype-Terminal-Arduino-MEGA-2560/dp/B00UT13YXA
    - this one is a little cheaper than the one Tim found, but we would need to assemble it ourselves (doable, but an extra thing to do)
- Arduino Mega
    - sold at MakerSpace for $22.00
- stepper motor
    - link: https://www.amazon.com/gp/product/B00PNEQI7W/ref=ppx_yo_dt_b_asin_title_o00_s00?ie=UTF8&psc=1
    - same stepper motor as one used for console
- up/down arrow buttons
    - link: https://billetautomotivebuttons.com/products/19mm-pair-arrows-symbols-v2-billet-push-buttons-switches-power-windows-turn-signals-etc
    - I don't necessarily like this one and it's expensive, so we should keep looking
    - worst case, we use a regular push button and place a label on it with arrow directions
- Limit switch:
    - sourced from JHT from Staci
    - same one as used in the console design

References:

See above links for materials

data sheets:

Xlitx, "CL3621BH." [Online]. Available: http://www.xlitx.com/datasheet/CL3621BH.pdf

Conclusions:

I compiled purchase option links for our adaptive resistance dial mechanism materials list. I will use the pinouts found here for the schematic (although the schematic may need to change if the act

Action items:

1. use this information to create the circuit schematic

ANNABEL FRAKE - Feb 25, 2023, 5:16 PM CST

Download

CL3621BH.pdf (245 kB)

02/25/2023 Schematic

ANNABEL FRAKE - Feb 25, 2023, 5:59 PM CST

Title: 02/25/2023 Schematic

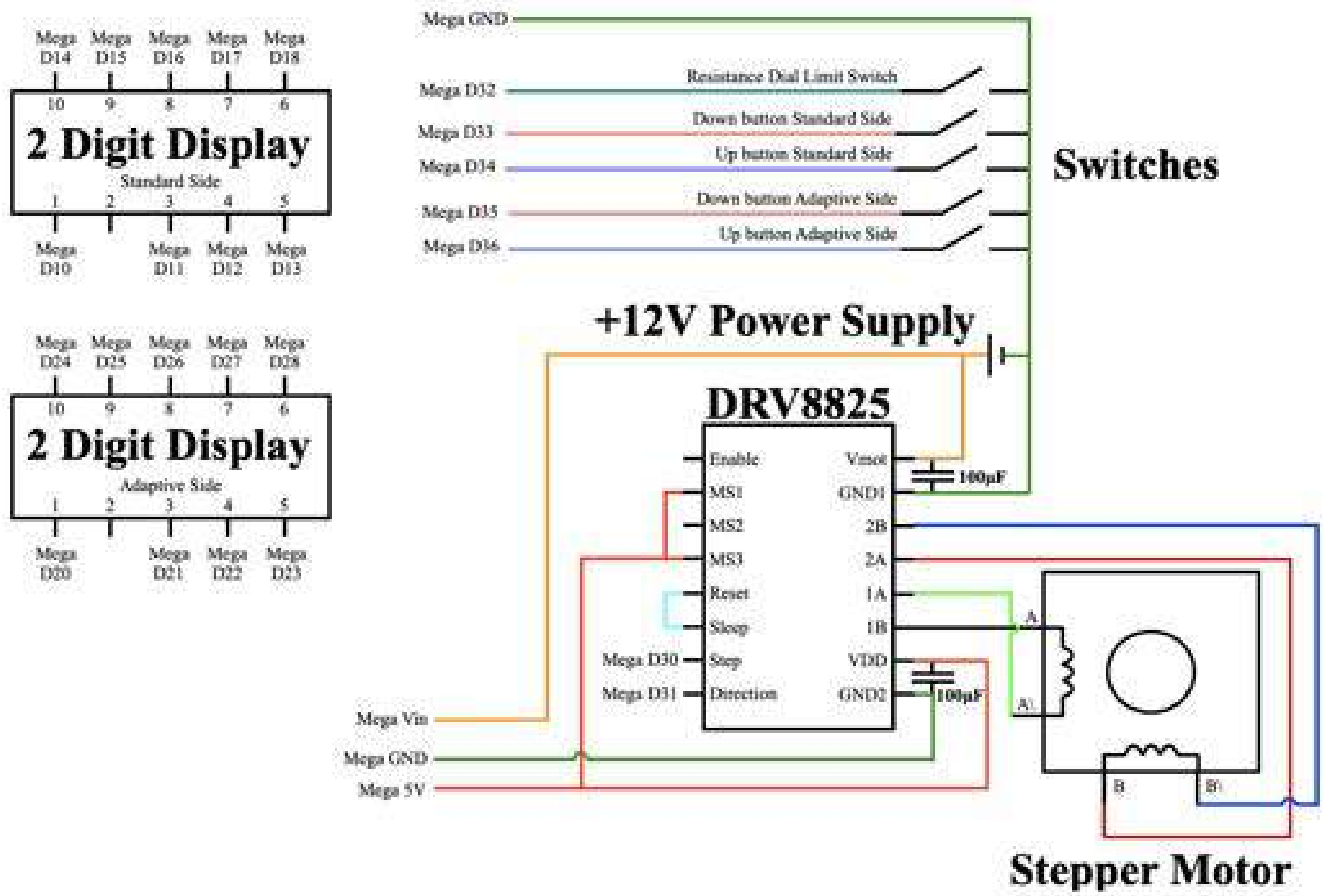
Date: 02/25/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: create a circuit schematic for the resistance dial

Content:



References:

Xlitx, “CL3621BH.” [Online]. Available: http://www.xlitx.com/datasheet/CL3621BH.pdf

Conclusions:

I created a circuit schematic for the adaptive resistance mechanism. Because the Arduino Mega has so many pins, I didn't directly include it in the schematic. To make things more readable, I added labels indicating which pin on the Arduino Mega that a specific wire connects to via implicit wires.

Action items:

1. write my sections of the journal article appendices using the coding flowchart and schematic for the adaptive resistance mechanism

ANNABEL FRAKE - Feb 25, 2023, 5:16 PM CST

Download

CL3621BH.pdf (245 kB)

ANNABEL FRAKE - Feb 26, 2023, 11:54 AM CST

Title: 02/26/2023 Schematic

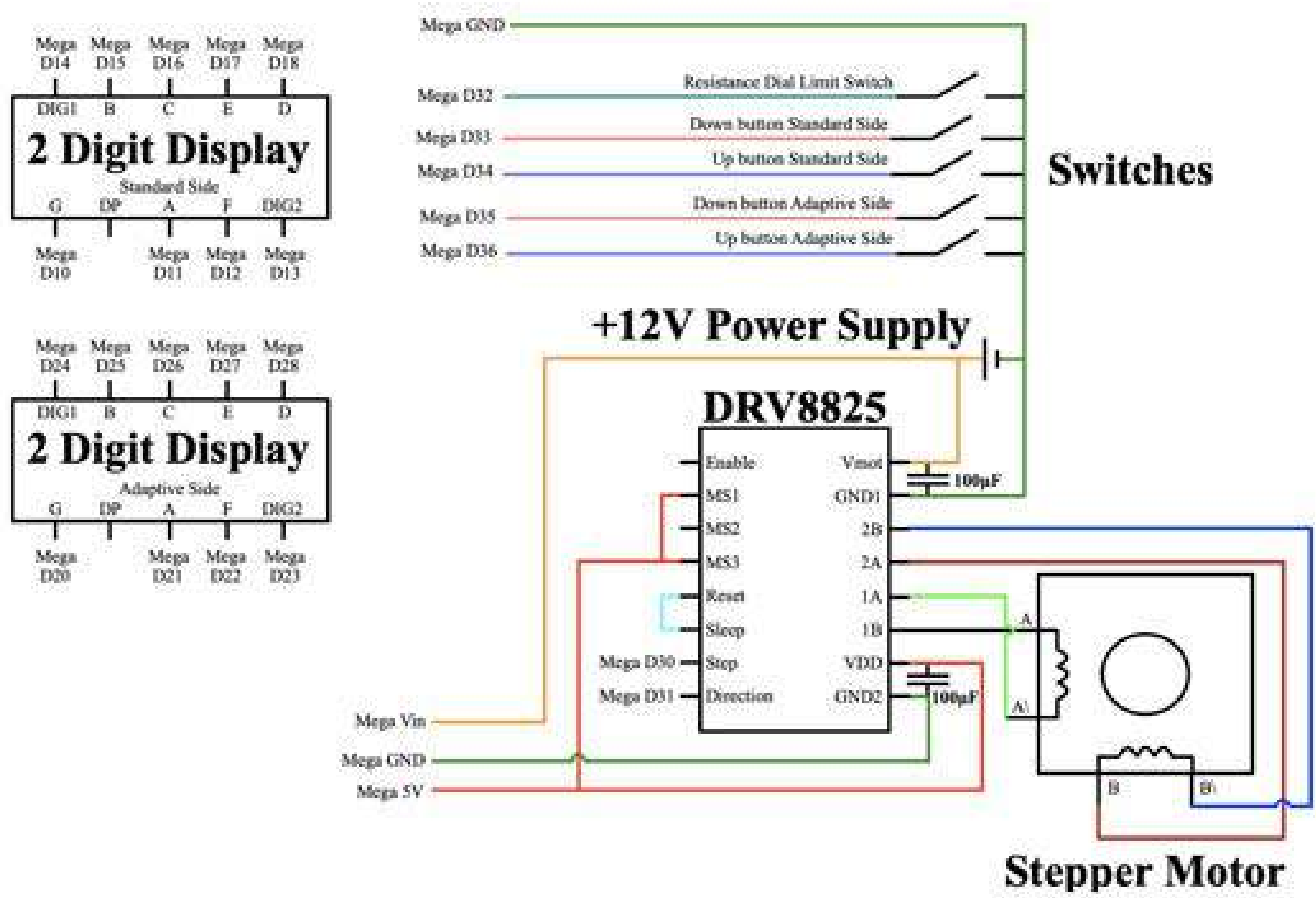
Date: 02/26/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: update schematic

Content:



References:

Xlitx, "CL3621BH." [Online]. Available: http://www.xlitx.com/datasheet/CL3621BH.pdf

Conclusions:

I updated the schematic so that the 2 digit displays show the segments/digit connections instead of just the pin numbers.

Action items:

1. **update journal article appendix**

03/03/2023 Troubleshooting

ANNABEL FRAKE - Mar 03, 2023, 3:52 PM CST

Title: 03/03/2023 Troubleshooting

Date: 03/03/2023

Content by: Annabel Frake

Present: Annabel; Roxi, Tim (later on)

Goals: troubleshoot the motor + display code

Content:

- I finished building the circuit that includes the stepper motor and the 4 digit 7 segment display
- I tried it using the Arduino Uno, but had issues with the motor stalling
- I remembered that I had the same issues last semester and determined that the coils on my personal stepper motor must have been run down
- Roxi and I went to the MakerSpace to purchase an Arduino Mega for the project and also got a D shaft stepper motor there to test
- Roxi, Tim, and I were unable to get the circuit to work
- the DRV8825 heated up to the point of smoking
- Roxi and I went to the MakerSpace to ask, and Yash said to try another motor driver in case it was fried
- I didn't have an extras on me, so I will have to try that later this weekend
- Roxi, Tim, and I purchased most of the electronic components during the meeting
    - we are waiting to get the buttons until we can ask Josh about the sizing
    - we need to order the stepper motor (because the current rating on the one from the MakerSpace is different from the one we have been using, we just decided it would be better to stay consistent
    - I will keep the stepper motor we purchased today as a personal motor

References: Yash and the MakerSpace

Conclusions:

Roxi, Tim, and I purchased most of the electrical components for the design. We also spent time troubleshooting the circuit that contains the stepper motor and display, but were unable to get it operational. Based on feedback from Yash at the MakerSpace, I will try replacing the DRV8825 later this weekend.

Action items:

1. continue to debug

03/04/2023 Code Development

ANNABEL FRAKE - Mar 04, 2023, 9:32 PM CST

Title: 03/04/2023 Code Development

Date: 03/04/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: add the limit switch logic to the code; transition from the Arduino Uno to the Mega

Content:

- I was going to test the circuit again but realized that I forgot the power supply at the MakerSpace when I plugged it into an outlet to show Yash
- I will go first thing Monday morning to retrieve it (MakerSpace is closed on the weekends)
- in the meantime, I transitioned the connections from my personal Arduino Uno to the Mega Roxi and I purchased at the MakerSpace
- I also added the limit switch logic to the code and added the physical switch to the circuit
- I also realized that the way I implemented the stepper motor code had issues
- I need to do PWM and the increment time separately
- I used millis() for this
- I got the limit switch logic to work
- the timer also works for the motor, but the code is implemented twice
- in other words, when a button is pressed, the resistance increments twice instead of once
- I still haven't figured this out and will need to come back to it

References:

https://forum.arduino.cc/t/millis-running-twice/621188/21

https://reference.arduino.cc/reference/en/language/functions/time/millis/

Conclusions:

I added the limit switch logic to the code such that the resistance level is set to 1 at the start of the program. I updated the coding logic for the increment up/down in terms of the motor rotation, but when a button is pressed, the code is implemented twice (i.e. resistance incremented/decremented twice with one click). I will need to come back to this later is see if I can figure out why this happens. Other than that, the setup is ready to test once I get the power supply back from the MakerSpace.

Action items:

1. retrieve the power supply from the MakerSpace
2. test

ANNABEL FRAKE - Mar 04, 2023, 9:38 PM CST

Download

ResistanceDisplay3.0.ino (3.35 kB)

ANNABEL FRAKE - Mar 04, 2023, 9:38 PM CST

Download

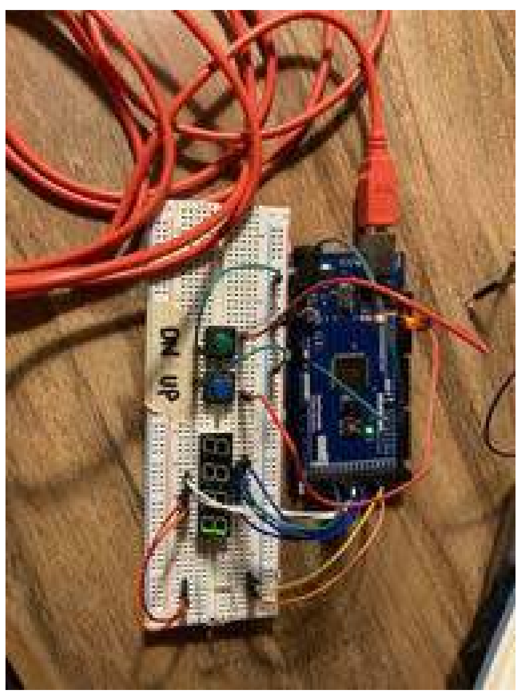
ResistanceDisplay4.0.ino (5.27 kB)

ANNABEL FRAKE - Mar 04, 2023, 9:38 PM CST

Download

timing_development.ino (1.4 kB) Code to test the millis() function.

ANNABEL FRAKE - Mar 04, 2023, 9:39 PM CST



Download

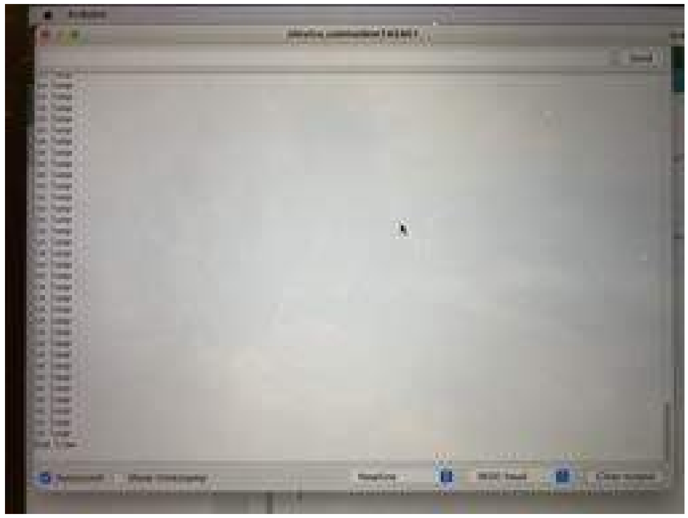
IMG_6959.jpeg (4.39 MB) Image of display setup with Arduino mega.

ANNABEL FRAKE - Mar 04, 2023, 9:40 PM CST

Download

IMG_6960.MOV (12.4 MB) Proof the display code functions properly with the Arduino Mega.

ANNABEL FRAKE - Mar 04, 2023, 9:40 PM CST



Download

IMG_6961.jpeg (3.88 MB) Sample Serial output of timing loop such that stepper motor rotates for x amount of time.

ANNABEL FRAKE - Mar 04, 2023, 9:41 PM CST

Download

IMG_6962.MOV (8.48 MB) Video of timing code. I press the button. The code enters the increment function and prints "in loop" while the stepper motor should be rotating. Then program prints "end loop."

03/05/2023 Troubleshooting

ANNABEL FRAKE - Mar 05, 2023, 4:44 PM CST

Title: 03/05/2023 Troubleshooting

Date: 03/05/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: debug the error where the code repeats twice with every button click

Content:

- I used print statements and found that the code does exit all of the logic and then go immediately back into the if statement to do it a second time
- I tried using lastButtonState logic, but the same thing happens
- I tried increasing the debounce time, but the same thing happens

References:

"Arduino Reference - Arduino Reference." https://www.arduino.cc/reference/en/ (accessed Oct. 16, 2022).

Conclusions:

I continued to debug the error from last night, but with not luck. I'll keep thinking about my logic and come back to it later.

Action items:

1. keep debugging

ANNABEL FRAKE - Mar 05, 2023, 4:42 PM CST

Download

ResistanceDisplay6.0.ino (5.43 kB) Troubleshooting with lastButtonState logic.

ANNABEL FRAKE - Mar 05, 2023, 4:43 PM CST

Download

ResistanceDisplay5.0.ino (5.13 kB) Current version of code since lastButtonState logic did not resolve the issue.

03/05/2023 Troubleshooting Take 2

ANNABEL FRAKE - Mar 05, 2023, 9:52 PM CST

Title: 03/05/2023 Troubleshooting Take 2

Date: 03/05/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: debug the error where the code repeats twice with every button click

Content:

- I continued to troubleshoot
- figured out that the state changed twice (press and release)
- I changed the code to use .isReleased() instead of .isPressed() so that the code is only triggered if when the click is finished, and that fixed the problem

References: none

Conclusions:

I fixed the error! Next step is to test with the motor once I have the power supply back.

Action items:

1. test with motor

ANNABEL FRAKE - Mar 05, 2023, 9:51 PM CST

Download

ResistanceDisplay7.0.ino (5.06 kB) Newest version using .isReleased() instead of .isPressed().

ANNABEL FRAKE - Mar 05, 2023, 10:23 PM CST

Download

IMG_6964.MOV (49.8 MB) Video of the code working with the limit switch logic.

ANNABEL FRAKE - Mar 05, 2023, 10:23 PM CST

Download

Screen_Shot_2023-03-05_at_10.19.01_PM.png (158 kB) Serial monitor output from the actions taken in the video.

03/10/2023 Troubleshooting + MakerSpace Visit

ANNABEL FRAKE - Mar 11, 2023, 12:38 PM CST

*Note: This entry was created a day after the meeting because I had another meeting right after this one and could not make the entry until today.

Title: 03/10/2023 Troubleshooting + MakerSpace Visit

Date: 03/10/2023

Content by: Annabel Frake

Present: Annabel, Tim, Roxi, MakerSpace staff

Goals: troubleshoot the circuit and get the motor to spin successfully

Content:

- John Lombardo at the MakerSpace kindly helped us troubleshoot our circuit
- we confirmed that the 12V power supply did indeed supply around 12 Volts
- whenever we connected the 12V power supply, the voltage would drop to around 9V
- when we only hooked up one coil on the motor at a time, the circuit didn't heat up at all
- the issue arose when we hooked up both coils
- we unhooked everything from the board going to the Arduino mega and not heating occurred
- we plugged in the DIR and STEP pins
    - no heating occurred but the motor didn't move
- we tied MS1 and MS3 to 5 volts, but nothing happened
- we found a schematic online in which the reset and sleep pins were tied to 5 volts, so we tried that and the motor shaft became rigid (couldn't turn it because power was holding it in place)
- eventually, we ended up with sleep and reset tied to 5V, MS1 and MS3 floating, and the board hooked up to ground on the Arduino
    - this caused the motor to spin without heating
- based on schematics we found online and using the data sheet, the pin I had been connecting +5 V to from the Arduino connects to a Fault line on the chip that's on the board
    - John said that this would cause heating because fault is an output that lets the circuit know if something is wrong
- I will go back and double check the sources I used for the console circuit to see if I misinterpreted the wiring diagrams
    - the way I had it set up is the current circuit for the console design, so I am not sure why it worked for that and not this
    - I will probably go back and prefabricate the console circuit using these new connections to make sure everything is as it should be
- after the troubleshooting to get the motor to work, Tim and I tried the code I wrote for incremented x amount of steps per resistance level increment
    - after some adjustment of the increment values and PWM delays, we got it working
    - then, we tried to figure out how many steps we needed to take to rotate approximately 3 degrees (the average measurement Sam found when he calibrated the resistance level)
    - using a protractor, we determined that 1 step of the motor is equivalent to roughly 3 degrees
- Tim brought up a good point - we should be careful of rebound on the limit switch because this system has to be highly accurate (a change of 3 degrees causes a resistance level increment)

References: John Lombardo

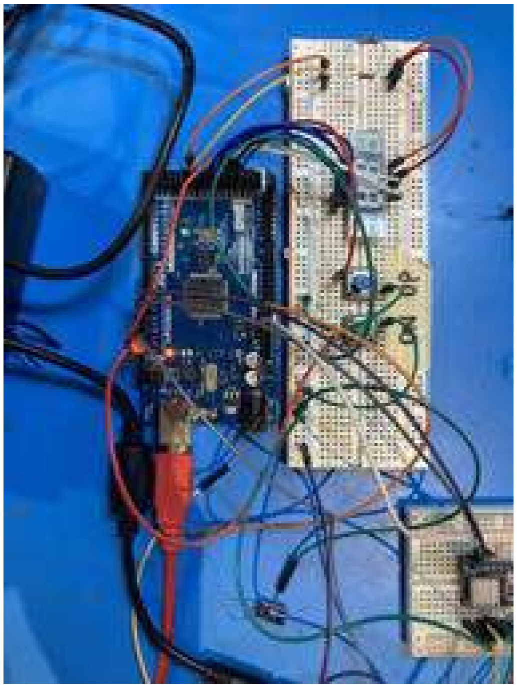
Conclusions:

Overall, our visit to the MakerSpace was extremely helpful. We got the motor to spin and found some potential issues that we need to address within the console circuit (since there is overlap between the two circuit schematics). I will investigate this in more depth over spring break. We also found that 1 step of the motor (all MS pins floating) equates to 3 degrees of rotation, which is exactly where we want to be for this project.

Action items:

1. fabricate the circuit
2. integrate the console and resistance mechanism circuits and code
3. test

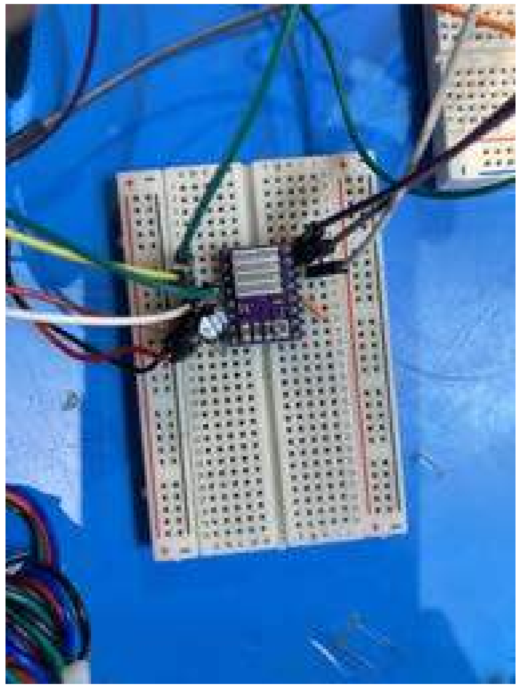
ANNABEL FRAKE - Mar 11, 2023, 12:41 PM CST



Download

IMG_6986.jpeg (3.25 MB) An image of the Arduino Mega and button/display connections.

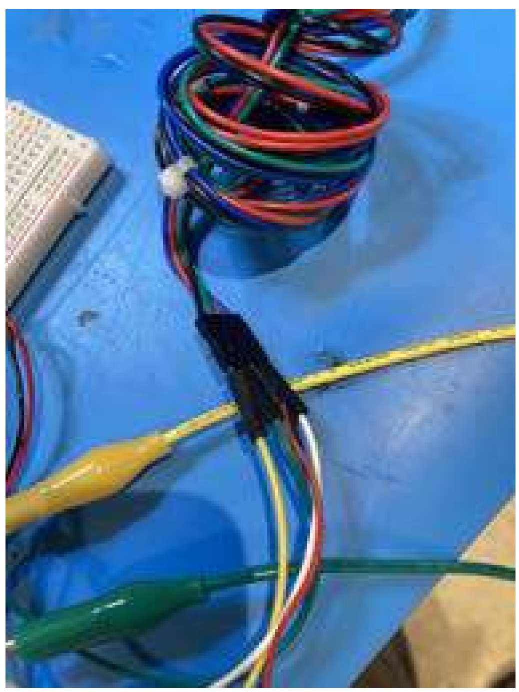
ANNABEL FRAKE - Mar 11, 2023, 12:41 PM CST



Download

IMG_6987.jpeg (2.89 MB) An image of the DRV8825 connections.

ANNABEL FRAKE - Mar 11, 2023, 12:41 PM CST



Download

IMG_6988.jpeg (1.88 MB) Image showing motor connections. Blue and green are one coil and red and blue are the other coil.

ANNABEL FRAKE - Mar 11, 2023, 12:43 PM CST

Download

IMG_6992.MOV (22.1 MB) Video of the circuit operating as designed. Side view.

ANNABEL FRAKE - Mar 11, 2023, 12:44 PM CST

Download

IMG_6994.MOV (31.7 MB) Video of the circuit operating as designed. Top view.

ANNABEL FRAKE - Mar 11, 2023, 1:36 PM CST

Download

Stepper_Motor_Example.ino (804 B)

ANNABEL FRAKE - Mar 11, 2023, 1:37 PM CST

Download

ResistanceDisplay7.0.ino (5.1 kB)

03/11/2023 Circuit Schematic Investigation

ANNABEL

Title: 03/11/2023 Circuit Schematic Investigation

Date: 03/11/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: finalize the circuit schematic that uses the stepper motor and DRV8825 and investigate whether I incorrectly wired the console circuit

Content:

- Datasheet of actual chip on board: https://www.ti.com/lit/ds/symlink/drv8825.pdf?ts=1678442630282&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FDRV8825%253Futm_source%253Dgoogle%2526utm_medium%253Dcpc%2526utm_campaign%GPN_EN-cpc-pf-google-eu%2526utm_content%253DDRV8825%2526ds_k%253DDRV8825%2526DCM%253Dyes%2526gclid%253DEAIaIQobChMIwPWt9o3R_QIVmdwYCh2FZQe9EAAYAiAAEgIPz_D_E
    - MS pin connections to do microstepping (we could use this if 1 full step is too large and we need less rotation than 3 degrees)

Table 1. Stepping Format

MODE2	MODE1	MODE0	STEP MODE
0	0	0	Full step (2-phase excitation) with 71% current
0	0	1	1/2 step (1-2 phase excitation)
0	1	0	1/4 step (W1-2 phase excitation)
0	1	1	8 microsteps/step
1	0	0	16 microsteps/step
1	0	1	32 microsteps/step
1	1	0	32 microsteps/step
1	1	1	32 microsteps/step

    -
    - I looked more closely at the fault pin

STATUS				
nFAULT	18	OD	Fault	Logic low when in fault condition (overtemp, overcurrent)

(1) Directions: I = input, O = output, OD = open-drain output, IO = input/output

8.3.7.1 Overcurrent Protection (OCP)

An analog current limit circuit on each FET limits the current through the FET by removing the gate drive. analog current limit persists for longer than the OCP time, all FETs in the H-bridge will be disabled a nFAULT pin will be driven low. The device remains disabled until either nRESET pin is applied, or removed and reapplied.

Overcurrent conditions on both high-side and low-side devices; that is, a short to ground, supply, or acro motor winding all result in an overcurrent shutdown. Note that overcurrent protection does not use the sense circuitry used for PWM current control, and is independent of the I_{SENSE} resistor value or xVREF volt

8.3.7.2 Thermal Shutdown (TSD)

If the die temperature exceeds safe limits, all FETs in the H-bridge will be disabled and the nFAULT pin driven low. After the die temperature has fallen to a safe level, operation automatically resumes.

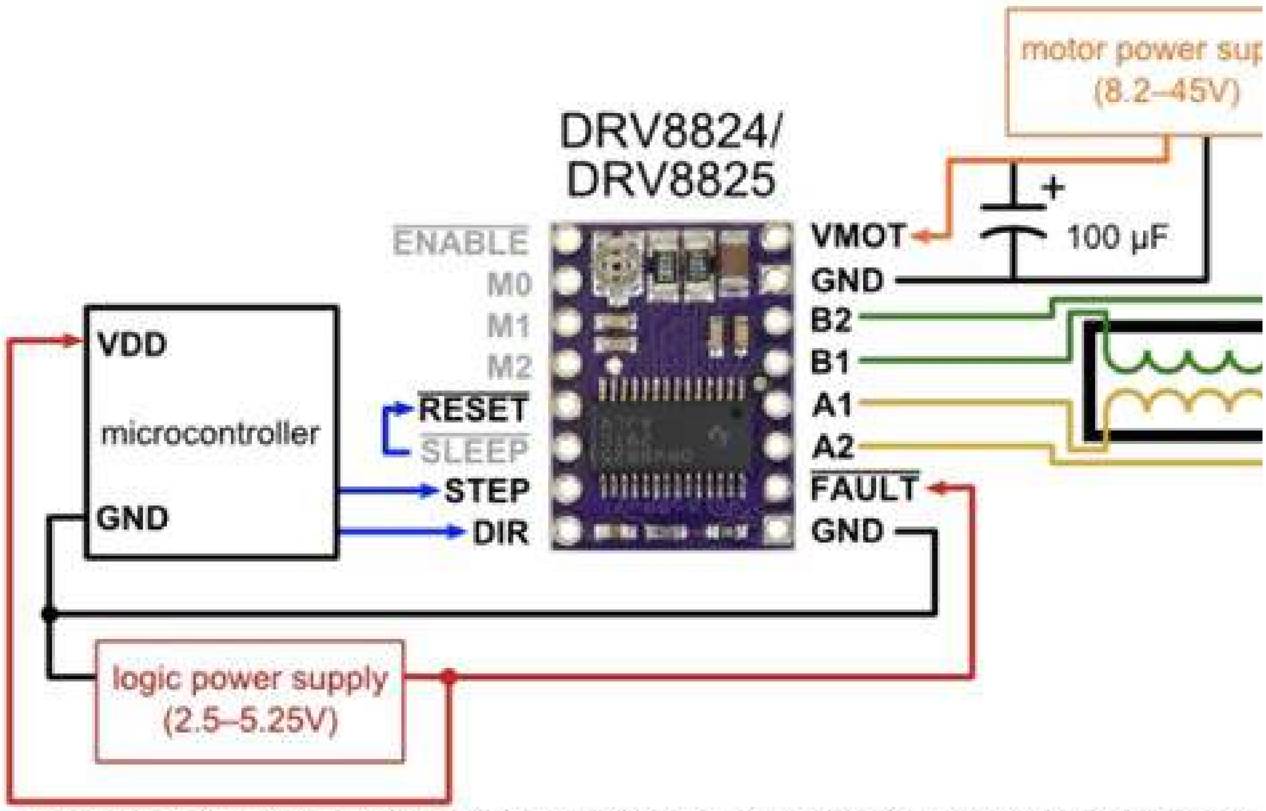
        - These descriptions explain why nothing shut down when the circuit heated up so much it started to smoke. With fault tied to 5V, it could not be driven low
- Datasheet of board: https://www.tme.eu/Document/1dd18faf1196df48619105e397146fdf/POLOLU-2133.pdf
    - step settings:

MODE0	MODE1	MODE2	Microstep Resolut
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

-

The DRV8825 also features a **FAULT** output that drives low whenever the H-bridge FETs a disabled as the result of over-current protection or thermal shutdown. The carrier board co this pin to the **SLEEP** pin through a 10k resistor that acts as a**FAULT** pull-up whenever **SL** externally held high, so no external pull-up is necessary on the **FAULT** pin. Note that the c includes a 1.5k protection resistor in series with the **FAULT** pin that makes it is safe to con pin directly to a logic voltage supply, as might happen if you use this board in a system des the pin-compatible A4988 carrier. In such a system, the 10k resistor between **SLEEP** and I would then act as a pull-up for **SLEEP**, making the DRV8825 carrier more of a direct repla for the A4988 in such systems (the A4988 has an internal pull-up on its **SLEEP** pin). To ke from pulling down the **SLEEP** pin, any external pull-up resistor you add to the**SLEEP** pin ir should not exceed 4.7k.

-

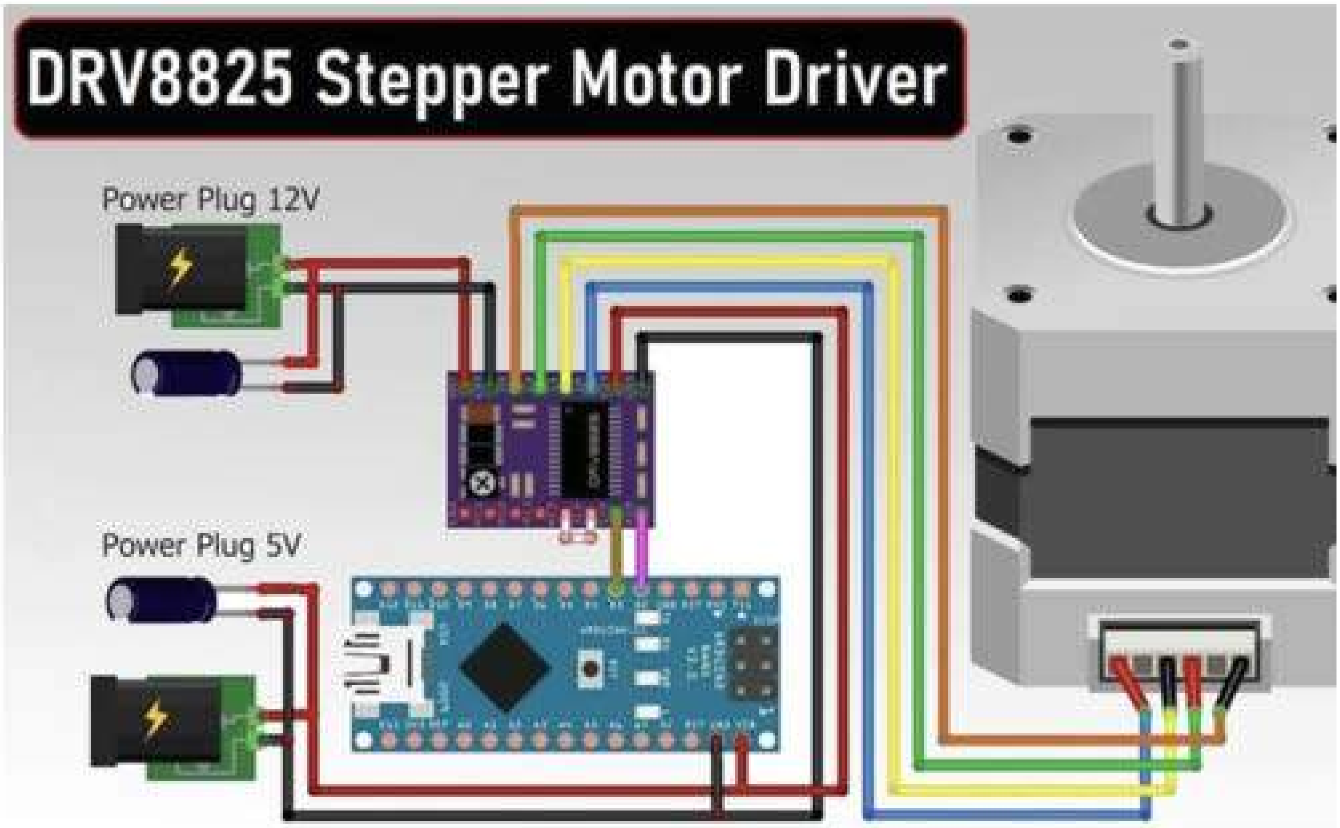


Alternative minimal wiring diagram for connecting a microcontroller to a DRV8824/DRV8825 step
motor driver carrier (full-step mode).

  - This data sheet indicates that Fault can be tied to a logic power supply (and then reset and sleep are not), which is what I had done for the console circuitry and implement here as well
  - perhaps the Arduino Mega provides a little bit more than 5V as compared to the Uno, so the logic power supply might have exceeded its limit on the fault line?
- Tutorial: https://how2electronics.com/control-stepper-motor-with-drv8825-driver-arduino/
  - This is the tutorial I used last semester
  - they do connect 5V to fault and only tie Sleep and reset together without connecting those to 5V

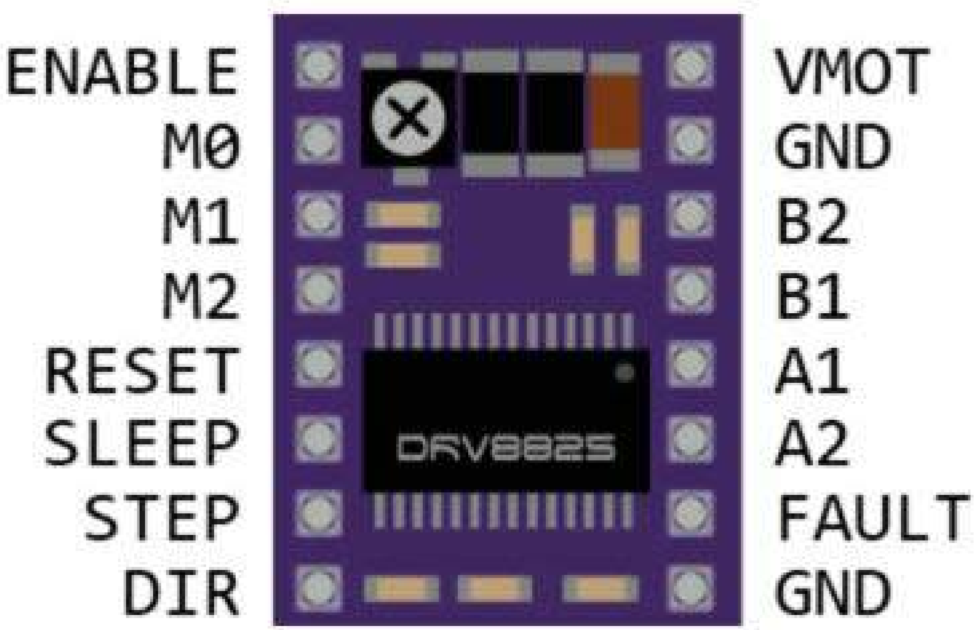
6. Fault Detection Pin: The DRV8825 features a FAULT output that drives LOW whenever the bridge FETs are disabled due to over-current protection or thermal shutdown. The Fault pin is to the SLEEP pin & when it is driven LOW, the whole chip is disabled.

4. Power States Control Pin: The DRV8825 has three different inputs for controlling its powe i.e EN, RST, and SLP. The EN pin is always active low input by default which enables the drive is active low input. Pulling this pin LOW puts the driver in sleep mode, minimizing the facility consumption. The RST is a lively low input which when pulled LOW, all STEP inputs are ignore resets the driver by setting the internal translator to a motor initial stage.

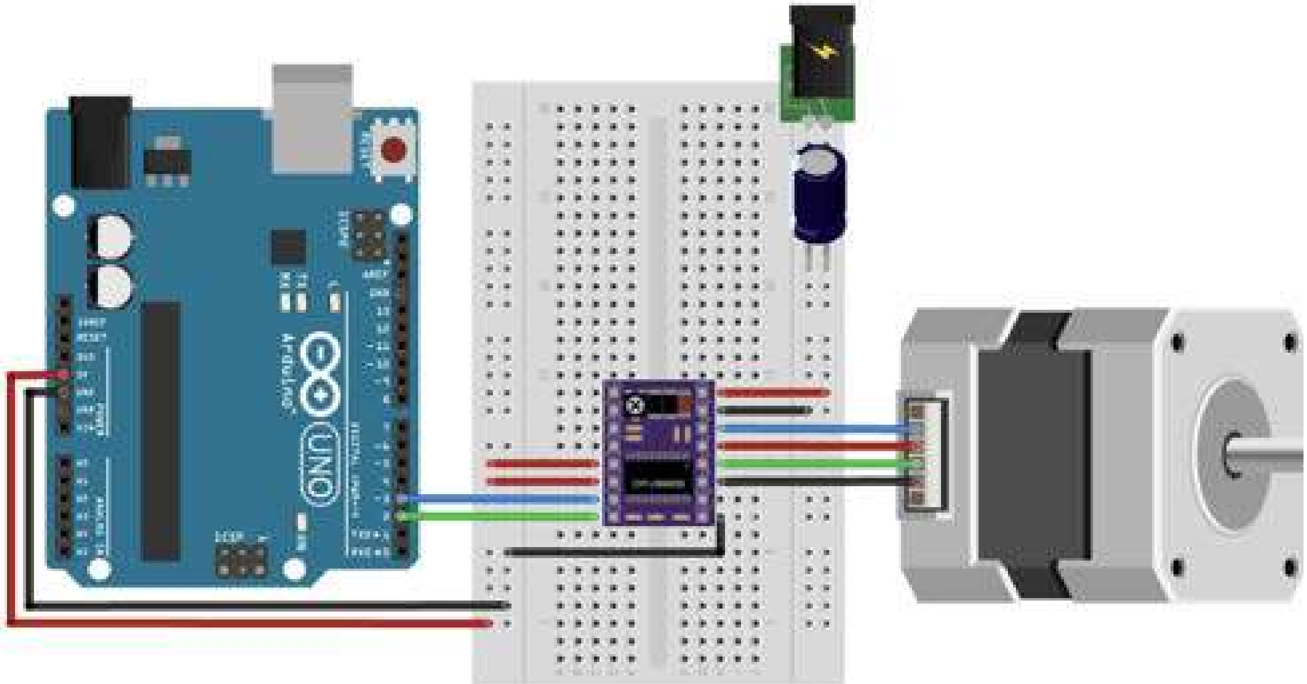


- So I did wire things correctly according to this tutorial

- Tutorial: https://lastminuteengineers.com/drv8825-stepper-motor-driver-arduino-tutorial/
  - this tutorial, which I had referenced last semester for tuning the current, does not connect anything to the fault line



DRV8825 Pinout

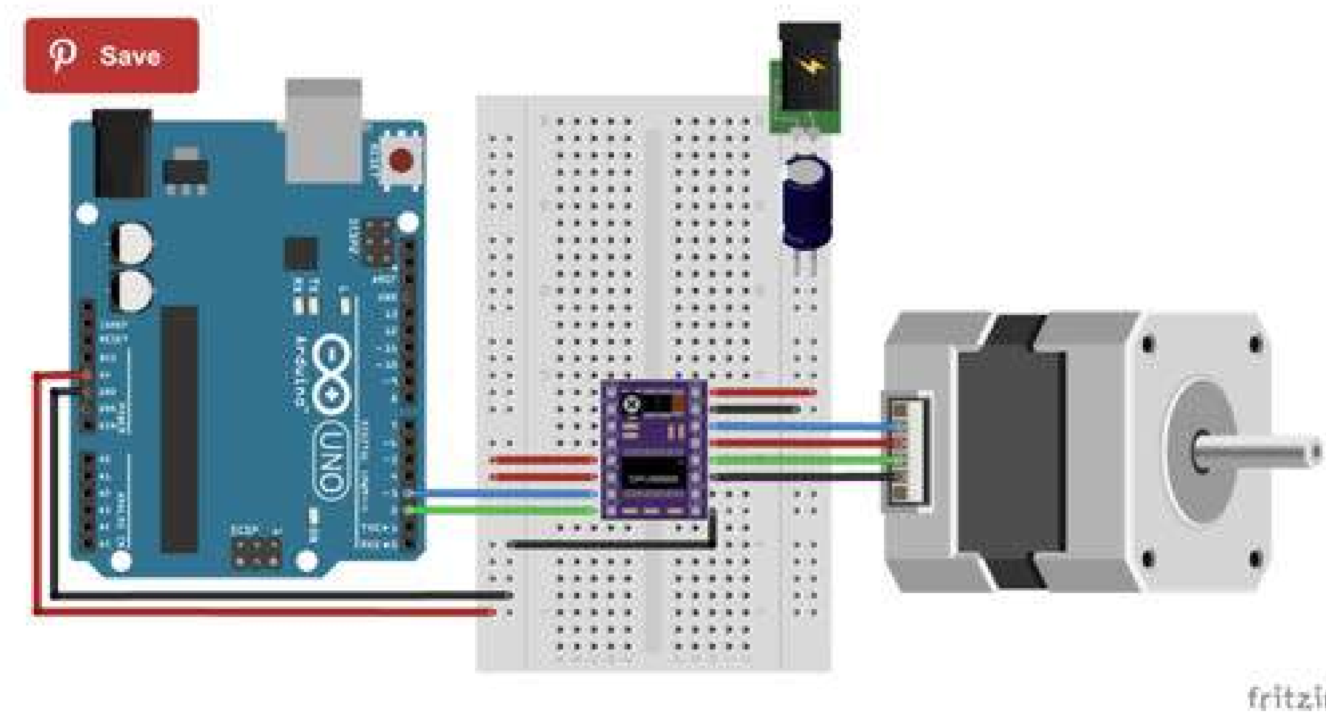


- Tutorial: https://www.makerguides.com/drv8825-stepper-motor-driver-arduino-tutorial/
  - This one also does not connect anything to the fault line

You need to connect RST (reset) and SLP (sleep) to 5 V otherwise, the d won't turn on.

The EN (enable) pin can be left disconnected, it is pulled low by default. this pin is set high the driver is disabled.

The DRV8825 also features a FAULT output that drives low whenever th bridge FETs are disabled as the result of over-current protection or ther shutdown. This pin is left disconnected for this tutorial.



◦

References:

Texas Instruments, “DRV8825 Stepper Motor Controller IC.” [Online]. Available: https://www.ti.com/lit/ds/symlink/drv8825.pdf?ts=1678442630282&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FDRV8825%253Futm_source%253Dgoogle%2526utm_medium%253Dcpc%2526utm_campaign%253Da google-eu%2526utm_content%253DDRV8825%2526ds_k%253DDRV8825%2526DCM%253Dyes%2526gclid%253DEAIaIQobChMIwPWt9o3R_QIVmdwYCh2FZQe9EAAYAiAAEgIPz_D_I

Pololu, “DRV8825 Stepper Motor Driver Carrier, High Current.” [Online]. Available: https://www.tme.eu/Document/1dd18faf1196df48619105e397146fdf/POLOLU-2133.pdf

“In-Depth: Interface DRV8825 Stepper Motor Driver Module with Arduino,” *Last Minute Engineers*, Dec. 23, 2018. https://lastminuteengineers.com/drv8825-stepper-motor-driver-arduino-tutoria

“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 tutorial I used last semester did indeed connect 5V to the fault line, and based on the data sheet for the board, you can connect fault to a logic power supply. With that said, the rest of the sourc 5V and instead connect sleep and reset to 5V. Although, the fault pin is shorted to the sleep pin, so that would make me think that either schematic would work. I'm wondering if perhaps since I us that it supplied more than 5V and exceeded the limit range of 5.25V for the board. To be on the safe side, I will most likely rewire the console circuit to match the connections we are using the the floating). If I have time after spring break, I may go back to the MakerSpace and ask John what he thinks about the discrepancy in wiring diagrams I found online.

Action items:

- Rewire the console circuit to be on the safe side

ANNABEL FRAKE - Mar 11, 2023, 12:45 PM CST

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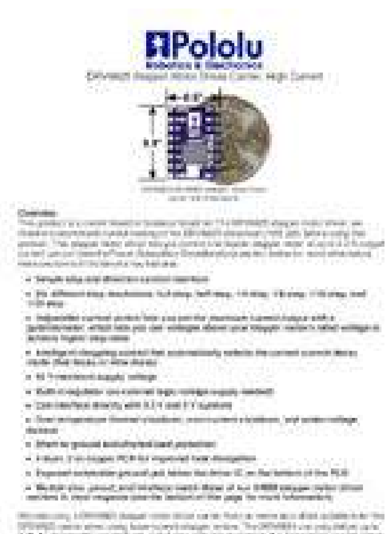
drv8825.pdf (1.82 MB) Datasheet. https://www.ti.com/lit/ds/symlink/drv8825.pdf?ts=1678442630282&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FDRV8825%253Futm_source%253Dgoogle%2526utm_medium%253Dcpc%2526utm_campaign%253Dasc-null-null-GPN_EN-cpc-pf-google-eu%2526utm_content%253DDRV8825%2526ds_k%253DDRV8825%2526DCM%253Dyes%2526gclid%253DEAIaIQobChMIwPWt9o3R_QIVmdwYCh2FZQe9EAAYAiAAEgIPz_D_BwE%2526gclsrc%253Daw.ds

ANNABEL FRAKE - Mar 11, 2023, 1:01 PM CST


Pololu

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POLOLU-2133.pdf (324 kB) Datasheet: https://www.tme.eu/Document/1dd18faf1196df48619105e397146fdf/POLOLU-2133.pdf

03/12/2023 Circuit Fabrication

ANNABEL FRAKE - Mar 13, 2023, 1:07 AM CDT

Title: 03/12/2023 Circuit Fabrication

Date: 03/12/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: fabricate circuit

Content:

- I soldered the screw terminal attachment for the Arduino Mega
- I then remade the resistance mechanism using the 2 digit 7 segment LED displays
  - because the displays output the same number, I tied the individual segments (i.e., segment A) to the same digital output pin
- after troubleshooting, I confirmed that everything still worked as intended
- then, I added the console mechanism circuit
- I also added the console code to the resistance mechanism code
- at first, things weren't working
- I did some extensive troubleshooting and determined that the DRV8825 I was using for the console was burned out
- once I replaced it with a new component, the circuit worked
- the circuit functions as intended
- the resistance cannot be changed while the console is rotating, but that likely wouldn't happen when someone is actually using the device
  - worst case scenario, the resistance wouldn't change and they would have to adjust it again once the console is done moving
  - I can't think of a way to make this better since I can only do one thing at a time
  - maybe if the console rotation takes too long, I can introduce an interrupt for the resistance mechanism, but I don't think it would be worth it considering that the console rotation doesn't take that long at all

References: none

Conclusions:

I completed extensive fabrication and testing tonight. I soldered the mega attachment since it came disassembled. Then, I recreated and troubleshooted the resistance mechanism circuit and until it worked. Next, I added the console logic to the code and implemented those components in the circuit. I used the same DRV8825 connections as those used for the resistance mechanism (recommended by John). Initially, things weren't working, so I had to make some adjustments to the code global variables and swap out one of the DRV8825 components. In the end, I got things to function as intended. There is minimal heating of the DRV8825 boards. The next step would be integrate/update the console and resistance mechanism schematics and coding flowcharts. I will also solder the DRV8825's and 7 segment displays to solder boards, etc. to make the circuit more permanent. Overall, I'm super excited that things are working!

Action items:

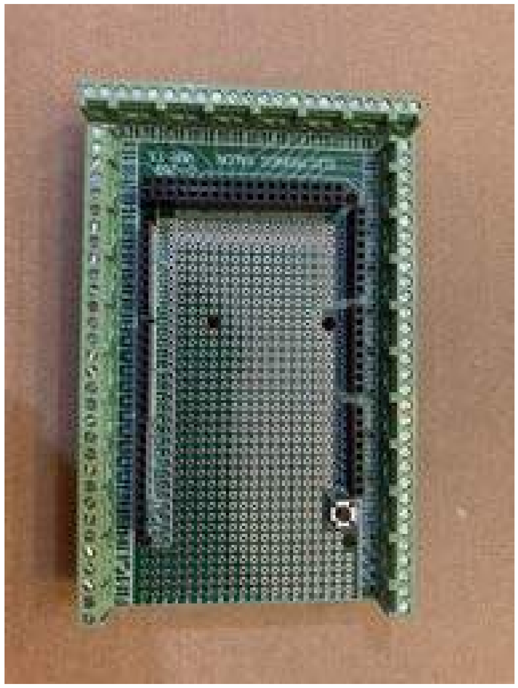
1. continue to fabricate the circuit
2. update the schematics and coding flow charts

ANNABEL FRAKE - Mar 13, 2023, 1:08 AM CDT

Download

integratedCircuit_1.0.ino (9.9 kB) Code that includes logic for the console and resistance mechanism circuits.

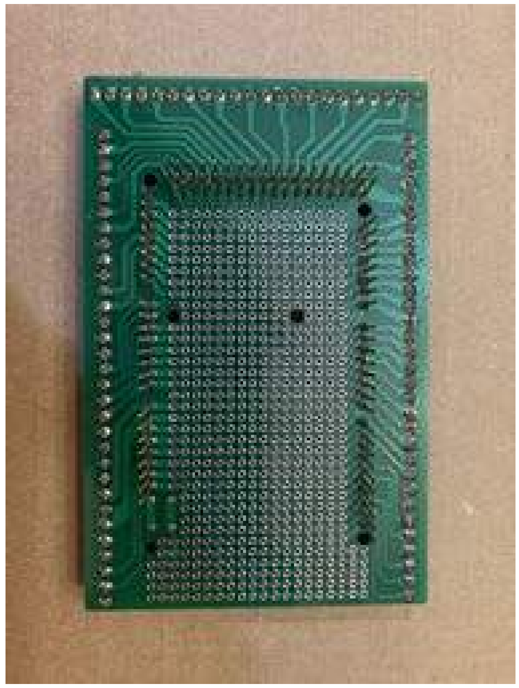
ANNABEL FRAKE - Mar 13, 2023, 1:13 AM CDT



Download

IMG_7009.jpeg (4.36 MB) Top view of soldered Mega connector.

ANNABEL FRAKE - Mar 13, 2023, 1:13 AM CDT



Download

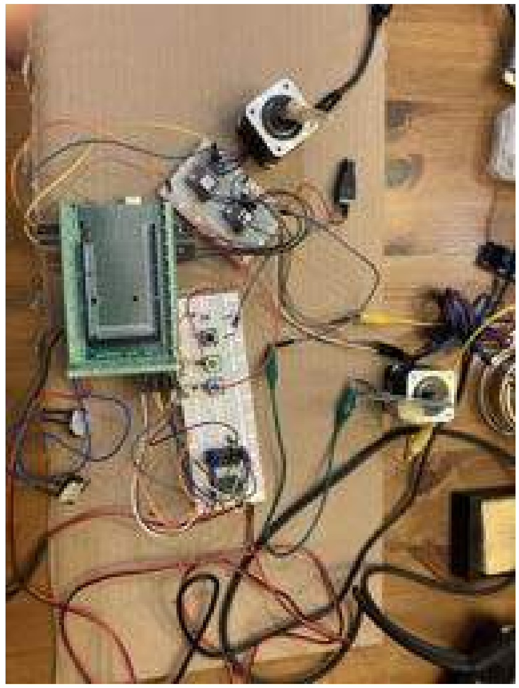
IMG_7010.jpeg (4.11 MB) Bottom view of soldered Mega connector.

ANNABEL FRAKE - Mar 13, 2023, 1:18 AM CDT

Download

IMG_7029.MOV (48.4 MB) Video of integrated circuit operating as intended. When the program starts, the resistance mechanism sets the resistance level to 1. Subsequent button presses from the up/down buttons (2 of each) change the position of the stepper motor and the output to the 7-segment displays. Depending on the feedback from the console limit switches, the console stepper motor will rotate to change the orientation of the console according to the user's needs.

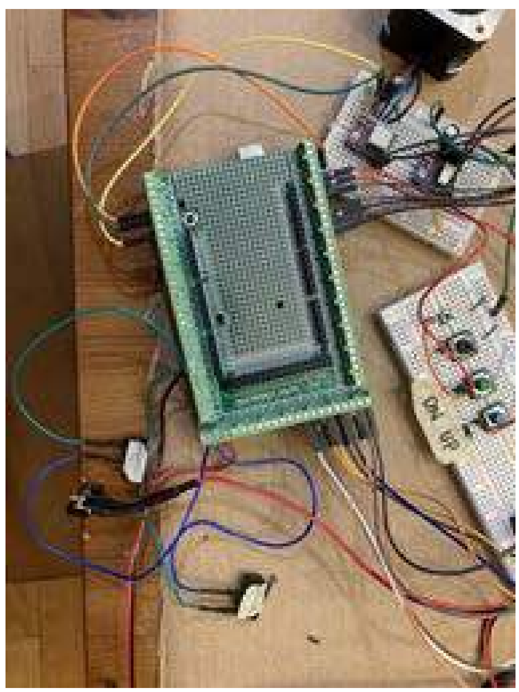
ANNABEL FRAKE - Mar 13, 2023, 1:28 AM CDT



Download

IMG_7030.jpeg (4.07 MB) Image of overall circuit. Includes two breadboards, one arduino mega, two stepper motors, 4 limit switches, 4 push buttons, two displays, and one 12V power supply.

ANNABEL FRAKE - Mar 13, 2023, 1:26 AM CDT



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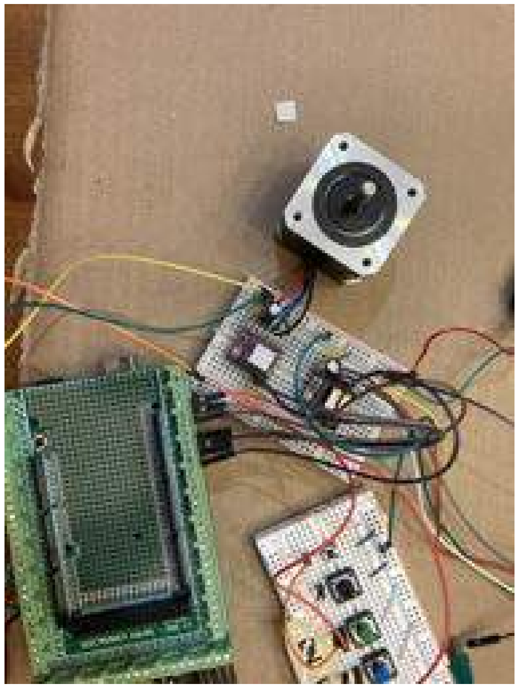
IMG_7018.jpeg (4.49 MB) Closeup of Mega connections and console limit switches (adaptive and standard).

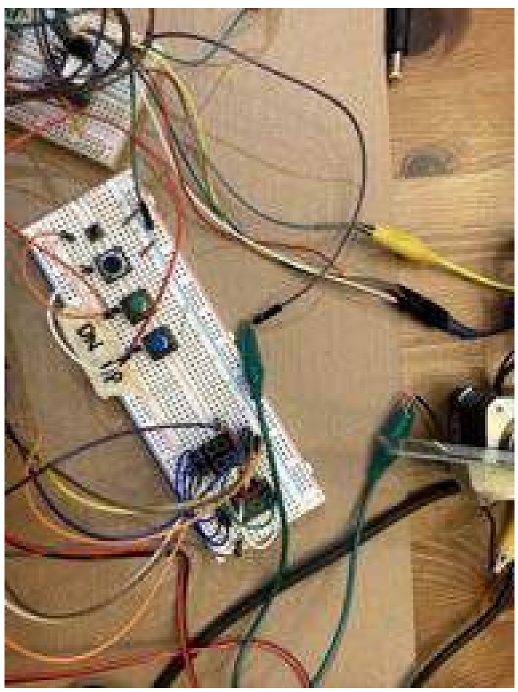
ANNABEL FRAKE - Mar 13, 2023, 1:27 AM CDT



Download

IMG_7019.jpeg (4.31 MB) View of the DRV8825 breadboard, console stepper motor, and some of the mega connections.

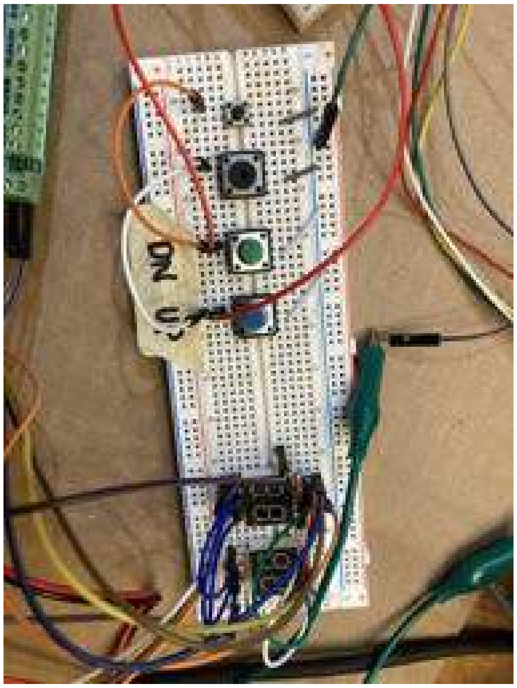
ANNABEL FRAKE - Mar 13, 2023, 1:27 AM CDT



Download

IMG_7020.jpeg (4.58 MB) Connections shown for the display and button breadboard, as well as the resistance stepper motor and limit switch.

ANNABEL FRAKE - Mar 13, 2023, 1:26 AM CDT



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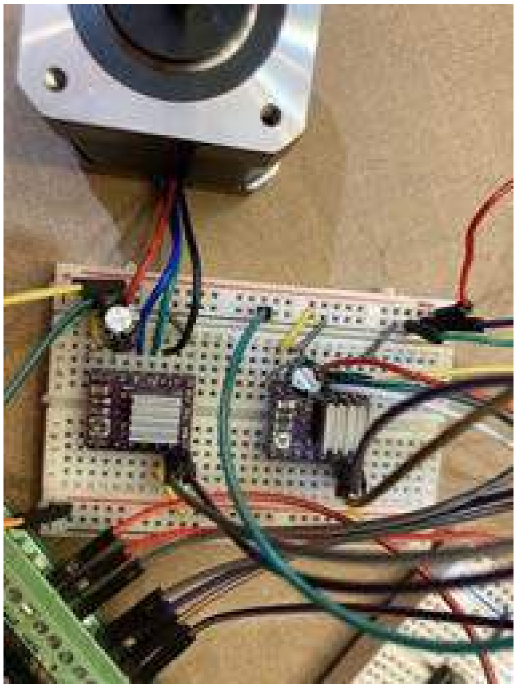
IMG_7021.jpeg (4.17 MB) Closeup of display and button breadboard.

ANNABEL FRAKE - Mar 13, 2023, 1:25 AM CDT



Download

IMG_7022.jpeg (3.66 MB) Closeup of DRV8825 connections for the console circuit (left) and resistance mechanism (right).

03/14/2023 Integrated Code

ANNABEL FRAKE - Mar 14, 2023, 7:52 PM CDT

Title: 03/14/2023 Integrated Code

Date: 03/14/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: go through the code to check for errors, clean things up, and add comments if necessary for clarification

Content:

```
// Written by:  Annabel Frake
// Class:       BME 402
// Purpose:     Rotate the console of a Matrix rowing machine between the standard and adaptive sides. Change the rowing resistance level (between 1 and 10) using up and down buttons. This change modifies the position of the magnet over the flywheel to change the rowing resistance level and updates identical 2 digit 7 segment displays that output the current resistance level.


// Include the necessary libraries.
#include "SevSeg.h"
#include <ezButton.h>;


// Create a SevSeg object for the display.
SevSeg sevseg;


// Declare digital pins for the up/down buttons. Note: there are two buttons for each, but they are tied to the same pin because their functionality is identical.
byte const upButtonPin = 12;
byte const downButtonPin = 13;


// Declare digital pins for the limit switches.
byte const resistanceLimitSwitchPin = 11; // This limit switch is placed near the magnet fixture such that, when it is depressed, the resistance level is 1.
byte const transitionSwitchPin = 45; // This limit switch is placed near the stabilization lap pad bar. When its state changes, the rower transitioned between adaptive and standard use or vice versa. When this limit switch is depressed, the console should be on the standard side and when it is not depressed, the console should be on the adaptive side.
byte const standardSwitchPin = 46; // This limit switch is placed near the console on the standard side. When it is pressed, the console is facing the standard user.
byte const adaptiveSwitchPin = 47; // This limit switch is placed near the console on the adaptive side. When it is pressed, the console is facing the wheelchair user.


// Define digital pins for the DIR and STEP features of the resistance mechanism stepper motor and console stepper motor.
byte const resistanceDirPin = 6;
byte const resistanceStepPin = 7;
byte const consoleDirPin = 8;
byte const consoleStepPin = 9;
```

```
// Create ezButton objects for the up and down buttons and the transition limit switch.
ezButton transitionSwitch(transitionSwitchPin);
ezButton upButton(upButtonPin);
ezButton downButton(downButtonPin);
```

```
// Define the number of steps for one increment of the stepper motor. Note: one rotation is achieved with 200 steps.
int stepsPerIncrement = 1; // Step - corresponds to roughly 3 degrees.


// Define the time delay for the manual PWM of the stepper motors.
int resistanceSpeedDelay = 5000; // microseconds
int consoleSpeedDelay = 30000; // microseconds


// Declare a variable for the resistance level. The resistance level is set to 1 at the beginning of the program.
int resistanceLevel = 1;


void setup()
{
  // Initialize the serial port.
  Serial.begin(9600);


  // Set the stepper motor pinmodes to OUTPUT.
  pinMode(resistanceDirPin, OUTPUT);
  pinMode(resistanceStepPin, OUTPUT);
  pinMode(consoleDirPin, OUTPUT);
  pinMode(consoleStepPin, OUTPUT);


  // Set the limit switch pins to INPUT_PULLUP. Note: An internal pull-up 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(resistanceLimitSwitchPin, INPUT_PULLUP);
  pinMode(standardSwitchPin, INPUT_PULLUP);
  pinMode(adaptiveSwitchPin, INPUT_PULLUP);


  // Assign the up and down buttons and the transition limit switch with a debounce time of 50 milliseconds
  transitionSwitch.setDebounceTime(50);
  upButton.setDebounceTime(50);
  downButton.setDebounceTime(50);


  // Define pins for the two 2 digit 7 segment displays. Because they display the same output, they are connected to the same digital out pins.
  byte numDigits = 2;
  byte digitPins[] = {26, 27}; // {D2, D1}
  byte segmentPins[] = {28, 29, 30, 31, 32, 33, 34}; // {A, B, C, D, E, F, G}


  // Define characteristics for the two 2 digit 7 segment displays.
  bool resistorsOnSegments = true;
  bool updateWithDelaysIn = true;
  byte hardwareConfig = COMMON_ANODE;
  sevseg.begin(hardwareConfig, numDigits, digitPins, segmentPins, resistorsOnSegments);
  sevseg.setBrightness(90);
```

```
  // Set the resistance level to 1.
  setResistance();
}


void loop()
{
  // Call the loop() function for the up and down buttons and the transition limit switch.
  upButton.loop();
  downButton.loop();
  transitionSwitch.loop();


  // If the up button is pressed and the resistance level is less than 10, increment the resistance level. Note: .isReleased() must be used instead of .isPressed() or the code will implement twice.
  if (upButton.isReleased() && resistanceLevel < 10)
  {
    // Call the function that increments the position of the magnet over the flywheel.
    resistanceLevel = increment();


    Serial.print("Resistance level incremented to: ");
    Serial.println(resistanceLevel);
  }


  // If the down button is pressed and the resistance level is greater than 1, decrement the resistance level. Note: .isReleased() must be used instead of .isPressed() or the code will implement twice.
  if (downButton.isReleased() && resistanceLevel > 1)
  {
    // Call the function that decrements the position of the magnet over the flywheel.
    resistanceLevel = decrement();


    Serial.print("Resistance level decremented to: ");
    Serial.println(resistanceLevel);
  }


  // 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 adaptive side.
    rotateToAdaptive(adaptiveSwitchPin);
  }


  // If the transition limit switch state does not change, check the position of the console and ensure it is in the correct orientation.
  else
  {
    checkConsolePosition();
  }


  // Update the output of the display to accurately portray the current resistance level.
  sevseg.setNumber(resistanceLevel);
  sevseg.refreshDisplay(); // Refresh the display so that the change is registered.
}


// A function to rotate the magnet such that the resistance level is incremented once.
int increment()
{
  // Specify the direction the motor will rotate: clockwise.
  digitalWrite(resistanceDirPin, HIGH);


  // Rotate the motor by stepsPerIncrement.
  for (int i = 0; i < stepsPerIncrement; i++)
  {
    // Manually perform PWM.
    digitalWrite(resistanceStepPin, HIGH);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
    digitalWrite(resistanceStepPin, LOW);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
  }


  // Increment the resistance level by one.
  return resistanceLevel += 1;
}


// A function to rotate the magnet such that the resistance level is decremented once.
int decrement()
{
  // Specify the direction the motor will rotate: counterclockwise.
  digitalWrite(resistanceDirPin, LOW);


  // Rotate the motor by stepsPerIncrement.
  for (int i = 0; i < stepsPerIncrement; i++)
  {
    // Manually perform PWM.
    digitalWrite(resistanceStepPin, HIGH);
```

```
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
    digitalWrite(resistanceStepPin, LOW);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
  }


  // Decrement the resistance level by one.
  return resistanceLevel -= 1;
}


// A function to set the resistance level to 1. Note: This code only implements once in void setup to ensure that the resistance level is known when the program starts.
void setResistance()
{
  // Specify the direction the motor will rotate: counterclockwise.
  digitalWrite(resistanceDirPin, LOW);


  // Rotate the motor in the specified direction until the limit switch is depressed, indicating a resistance level of 1.
  while (digitalRead(resistanceLimitSwitchPin)) // Note: logic is flipped because of INPUT_PULLUP.
  {
    // Manually perform PWM.
    digitalWrite(resistanceStepPin, HIGH);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
    digitalWrite(resistanceStepPin, LOW);
    delayMicroseconds(resistanceSpeedDelay); // Determines speed of stepper motor.
  }


  Serial.println("Resistance Level Set to 1");
}


// 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(consoleDirPin, 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(consoleStepPin, HIGH);
    delayMicroseconds(consoleSpeedDelay); // Determines speed of stepper motor.
    digitalWrite(consoleStepPin, LOW);
    delayMicroseconds(consoleSpeedDelay); // Determines speed of stepper motor.
  }


  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(consoleDirPin, 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(consoleStepPin, HIGH);
    delayMicroseconds(consoleSpeedDelay); // Determines speed of stepper motor.
    digitalWrite(consoleStepPin, LOW);
    delayMicroseconds(consoleSpeedDelay); // Determines speed of stepper motor.
  }


  Serial.println("Console position: adaptive");
}


// A function that checks the current position of the console and corrects its orientation if a discrepancy is detected.
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 is 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 adaptive side.
    rotateToAdaptive(adaptiveSwitchPin);
  }
}
```

References: none

Conclusions:

Today, I went through the integrated code to clean things up and make sure I had descriptive comments for each step of the code.

Action items:

1. update pins and/or rotation directions once final circuit implemented and functionality checked

ANNABEL FRAKE - Mar 14, 2023, 7:52 PM CDT

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integratedCircuit_1.0.ino (11 kB)

03/14/2023 Integrated Circuit Fabrication

ANNABEL FRAKE - Mar 15, 2023, 12:34 AM CDT

Title: 03/14/2023 Integrated Circuit Fabrication

Date: 03/14/2023

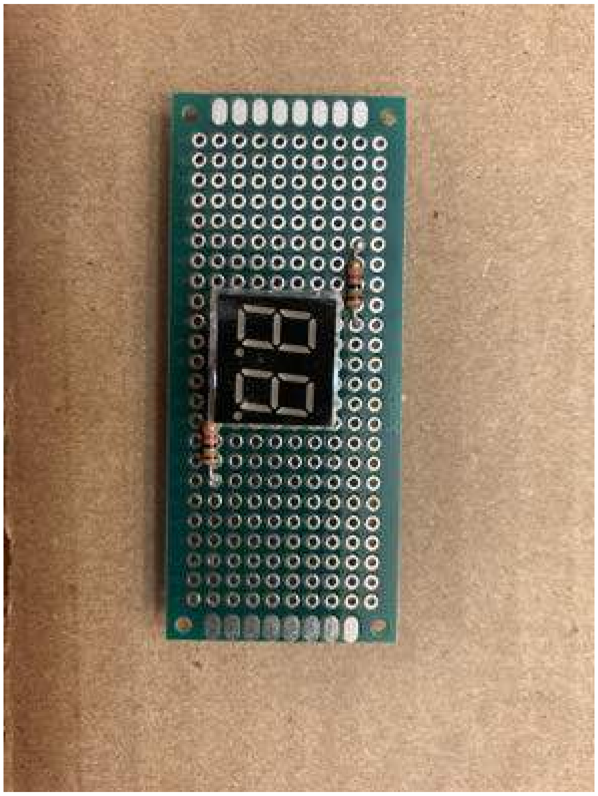
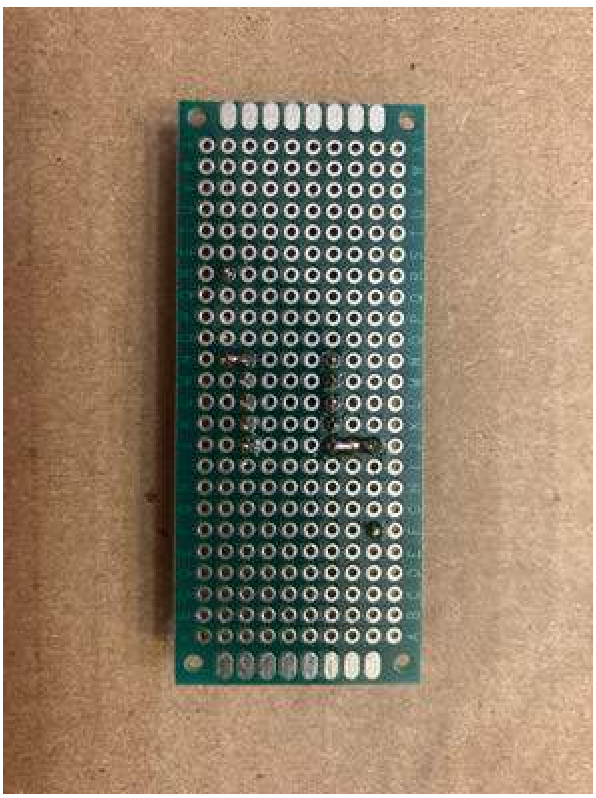
Content by: Annabel Frake

Present: Annabel Frake

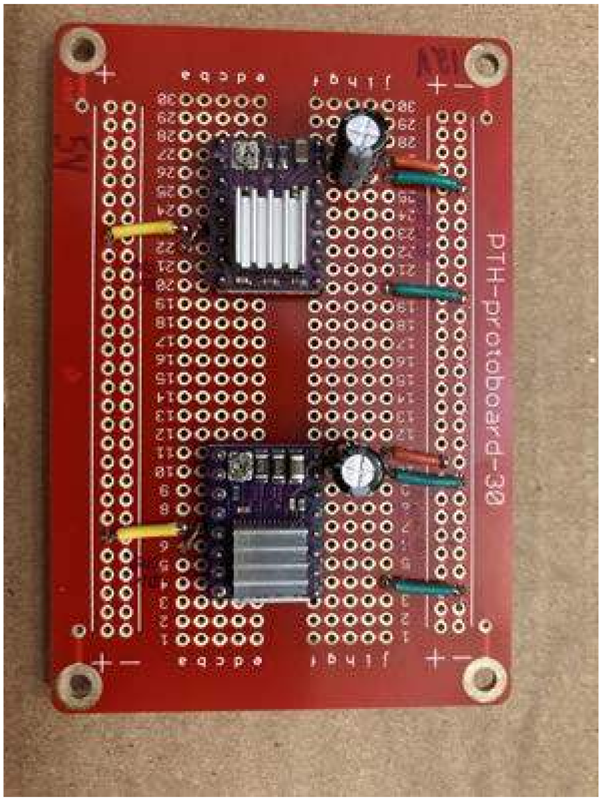
Goals: place the DRV8825s and displays on solder boards

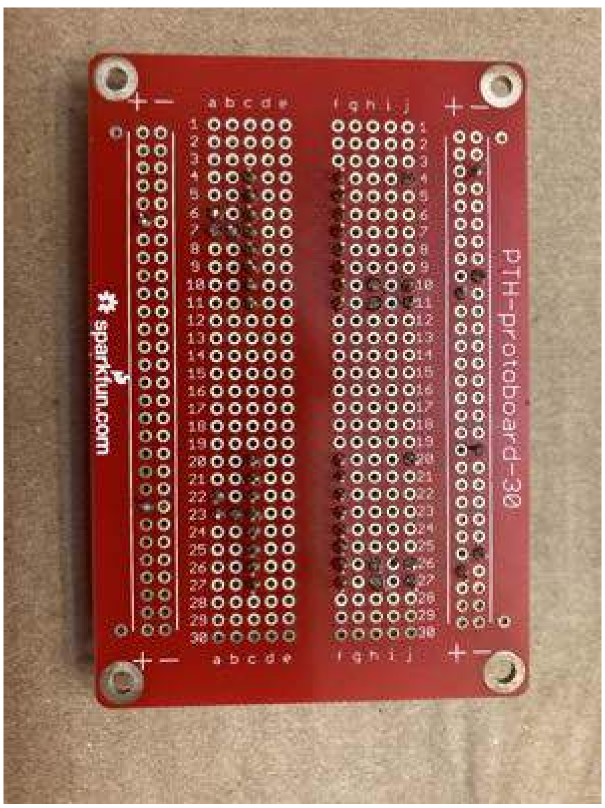
Content:

- I thought through where each component would be placed so that I can plan which components can go together on the same solder board
    - 
- I constructed solder boards for the displays

- 
- 

- I constructed a solder board for the DRV8825 motor drivers

- 

- 

References: none

Conclusions:

I started the final fabrication of the circuit. I soldered the components onto solder boards and the other components (resistors and capacitors) and on-board connections. I still need to solder wires onto the board that connect to the Mega, however, I'm toying with the idea of waiting to do that until I can measure the exact length of the wire needed to get from the position of the solder board to the mega. I don't want to accidentally make the wires too short, but at the same time, I won't be able to test the circuit until the additional wires are soldered on. I'll continue to think on this. One other thing I know for sure that I would like to get done over break is to re-solder the limit switches. Or, at the very least, unsolder them so that I can solder new wires on once we determine the appropriate lengths of the wires.

Action items:

1. re-solder limit switches
2. add wires going to mega

03/17-18/2023 Integrated Circuit Fabrication

ANNABEL FRAKE - Mar 18, 2023, 4:00 PM CDT

Title: 03/17-18/2023 Integrated Circuit Fabrication

Date: 03/17-18/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: finish fabricating the final circuit (minus the buttons)

Content:

- between yesterday and today, I probably spent roughly 10+ hours finishing up the circuit (minus the buttons)
- I finished soldering the wires for the limit switches, 7 segment displays, and motor circuits
- I estimated the wire lengths, and in most cases made them way longer than they need to be to be on the safe side
- I asked Sam what he would estimate the length of the transition limit switch would need to be, and he said roughly 1.2 m with 0.1-0.2m extra
- I ended up making it roughly 1.5 m
- after finishing the soldering, I hooked everything back up but it didn't work right away
- I was having issues with the console motor
- the resistance motor operated as intended, and plugging the console motor into that circuit worked as well
- when I tried both motors with the console circuit, however, neither worked - the motor would only spin in one direction
- I initially thought it was an issue with the DRV8825, but it turned out that the STEP and DIR pins had shorted
- after correcting that, the circuit functioned as intended
- However, I noticed that the display flickered/grew dimmer/turned off when the console motor rotated
- I remember reading that delay functions mess with the output to the display
- to correct for this, I blanked the display in the code at the bringing of the loops/functions where the console motor is instructed to spin (note, the resistance motor only moves 3 degrees and is so fast that the display is not effected, so I did not blank during those loops/functions)
- this also serves to let the user know that they cannot change the resistance level while the console is rotating (although I do not think they would try to since the console only rotates when the lap bar changes position and the user would be getting themselves into or out of the stabilization frame)
- it was a long, arduous process of soldering and troubleshooting, but I'm glad that it all finally works

References: none

Conclusions:

Over the past two days, I have fabricated most of the final circuit (at least as much as I can at the moment). It took a lot of work and troubleshooting, but I finally got things operational. Moving forward, I need to add the up/down arrow buttons, cut the wires to length, and finish soldering the wires that are currently temporarily connected until the wires are cut to their final length.

Action items:

1. add buttons once they are purchased

2. cut wires to length

3. solder the console stepper motor to the wire extensions after wire lengths are finalized

4. place components in their final destinations after working with the rest of the team

---

ANNABEL FRAKE - Mar 18, 2023, 4:01 PM CDT

Download

Stepper_Motor_Example.ino (891 B) Example code used to troubleshoot the stepper motor issues.

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final_code_spring_2023_bme_402.ino.ino (12.1 kB)

ANNABEL FRAKE - Mar 18, 2023, 4:08 PM CDT

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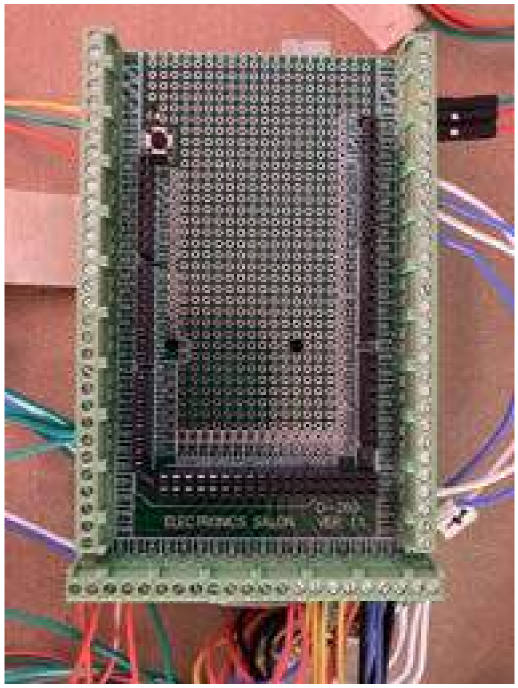
IMG_7055.jpeg (3.78 MB) Image of fabrication/troubleshooting setup.

ANNABEL FRAKE - Mar 18, 2023, 4:09 PM CDT



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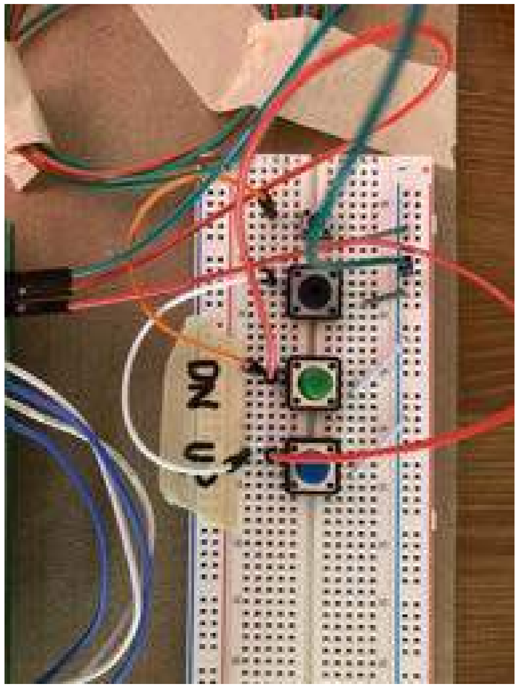
IMG_7057.jpeg (4.2 MB) Close-up of mega connections (see final integrated schematic).

ANNABEL FRAKE - Mar 18, 2023, 4:09 PM CDT

Download

IMG_7056.jpeg (4.32 MB) Image of final fabricated circuit (minus buttons). I taped everything down to a piece of cardboard for easy transport.

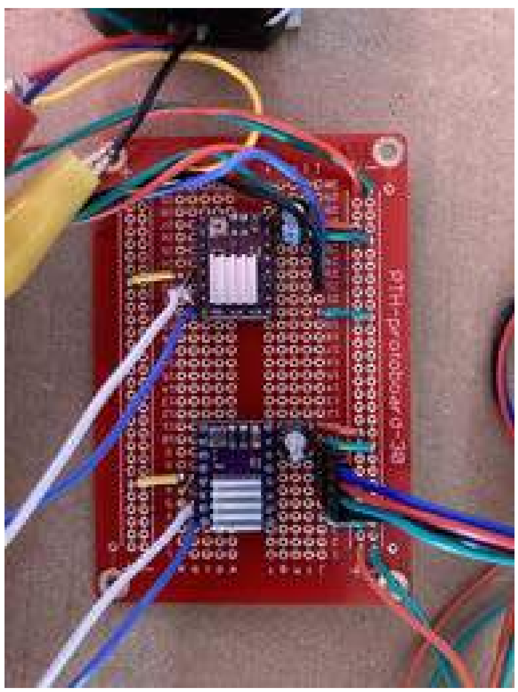
ANNABEL FRAKE - Mar 18, 2023, 4:10 PM CDT



Download

IMG_7058.jpeg (3.71 MB) Close-up of up/down button connections (see final integrated schematic).

ANNABEL FRAKE - Mar 18, 2023, 4:10 PM CDT



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IMG_7059.jpeg (4.03 MB) Close-up of DRV8825 connections (see final integrated schematic).

ANNABEL FRAKE - Mar 18, 2023, 4:10 PM CDT

Download

IMG_7060.jpeg (3.59 MB) Front view of 2 digit 7 segment displays (see final integrated schematic).

ANNABEL FRAKE - Mar 18, 2023, 4:10 PM CDT

Download

IMG_7065.MOV (53 MB) Video of circuit functioning as intended.

03/28/2023 Button Wiring Check

ANNABEL FRAKE - Mar 28, 2023, 2:20 AM CDT

Title: 03/28/2023 Button Wiring Check

Date: 03/28/2023

Content by: Annabel Frake

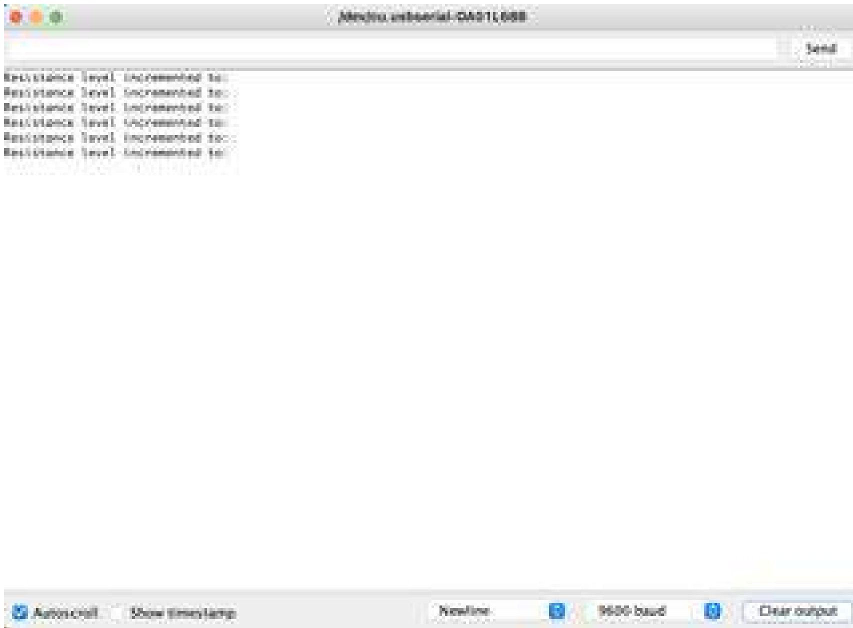
Present: Annabel Frake

Goals: check the wiring for the buttons Staci bought for us to use with the resistance mechanism

Content:

- I tested the buttons Staci bought in preparation of our integration meeting tomorrow
- I wrote a quick program to turn on the on board LED when the button is pressed using digitalRead()
    - I used INPUT_PULLUP
    - everything operates as intended
    - Example output:
    - 

- I then wrote a program to test the buttons with the ezButton library (the way they are used in the final code)
    - I only used one button
    - I used print statements to make sure that something happened every time the button was released
    - Example output:

- 

References: none

Conclusions:

I confirmed that the switches are NO and that I know how to hook them up correctly within the circuit once we get the wires (which I will most likely do in the morning).

Action items:

1. integrate the buttons with the rest of the circuit

ANNABEL FRAKE - Mar 28, 2023, 2:18 AM CDT

Download

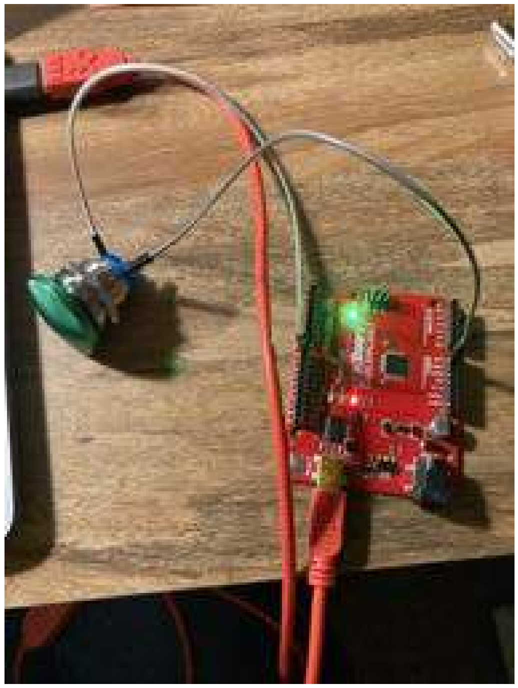
test_Button.ino (551 B) Code to test the buttons using digitalRead().

ANNABEL FRAKE - Mar 28, 2023, 2:17 AM CDT

Download

button_Test_with_ezButton.ino (1.01 kB) Code to test button using ezButton library (what is used in final code for project)

ANNABEL FRAKE - Mar 28, 2023, 2:21 AM CDT



Download

IMG_7104.jpeg (3.79 MB) Image of button connections. One pin goes to GND and the other to D8.

ANNABEL FRAKE - Mar 28, 2023, 2:21 AM CDT

Download

IMG_7105.MOV (6.53 MB) Video of LED_BUILTIN blinking when button pressed (test_Button.ino).

04/01/2023 Circuit Integration with Rower

ANNABEL FRAKE - Apr 01, 2023, 7:17 PM CDT

Title: 04/01/2023 Circuit Integration with Rower

Date: 04/01/2023

Content by: Annabel Frake

Present: Annabel Frake

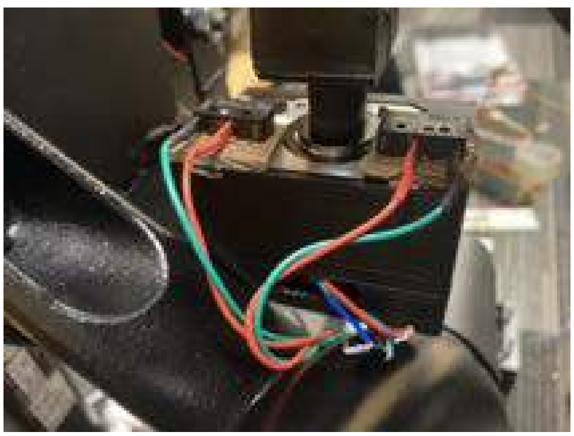
Goals: integrate the electronics with the rowing machine

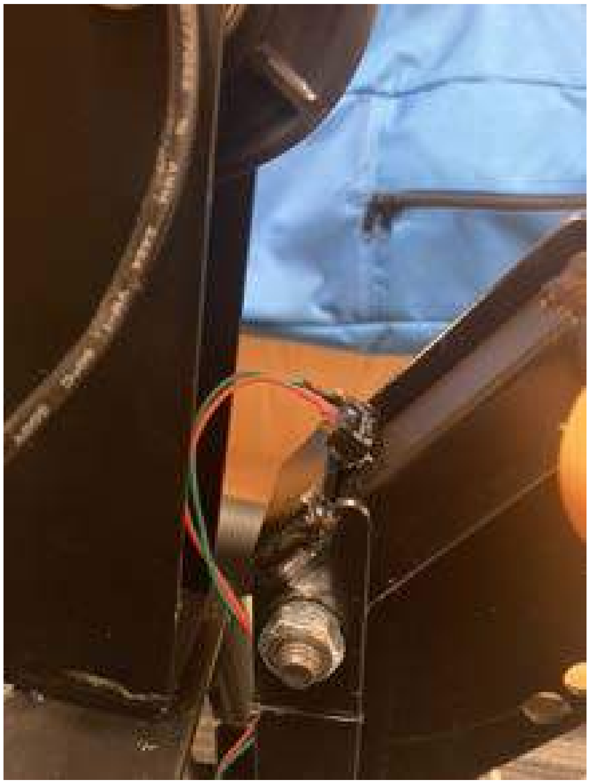
Content:

- I attached the Mega and DRV8825's breadboard to the electronics box
    - 
    - He only drilled 2 holes on the same side of the board, so things are a bit loose
    - in hindsight, we should have also spaced the two components a little farther apart so there was more room for the USB cable to plug in (it works, but not the best)
    - the hole for the 12V power supply plug is too large, so we will have to figure something out for that
- I attached Josh's 3D prints for the 7 segment displays

- 
- I got 3 bolts on one of the display cases
- the holes on the other display case didn't match up well
  - 

    - 

- I attached the standard and adaptive limit switches
  - 
  - Because there is no longer a lid on what was converted from the old electronics box, the limit switches were not high enough for the flag to hit them
  - I hot glued some particle board to increase the height and then hot glued the limit switches
- I placed the transition limit switch

- 

- I tested the console portion of the code
    - when I plugged the 12V power supply in, the power flickered on and off if I touched the associated wires going to the DRV8825's breadboard
        - to fix this, I reheated the solder connections
        - after that, things behaved as expected
    - The console rotated as expected based on feedback from the transition limit switch (see attached video)

References: none

Conclusions:

I worked on integrating the electronics with the rowing machine. I attached the Mega and DRV8825's breadboard to the electronics box. I placed the standard, adaptive, and transition limit switches. I undid the wire connections for the 7 segment displays going to the Mega so that I could put on Josh's 3D covers for them (I labeled the wires with the corresponding digital pin number). I did not reconnect them to the Mega because one of the casings did not fit the best, so I want to see if we can jerry-rig something as a team to make it look nicer. Also, I would like to wait until we position the displays in their final location so that I may cut the wires shorter before reconnecting them to the Mega. I tested the console portion of the code and everything behaved as expected. When I had briefly tried it during Friday's meeting, it wasn't working, so I am not sure if the temporary tape job I had used made things too loose, but regardless, things work now.

Action items:

1. meet with the team to determined the placement of the resistance motor & limit switch, displays, and buttons
2. cut wires to length
3. solder remaining connections

ANNABEL FRAKE - Apr 01, 2023, 7:18 PM CDT

Download

IMG_7155.MOV (30.1 MB) Video of the console rotating as designed.

04/04/2023 Code Update

ANNABEL FRAKE - Apr 04, 2023, 11:04 PM CDT

Title: 04/04/2023 Code Update

Date: 04/04/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: update code

Content: see attached code

References: none

Conclusions:

At our group meeting tonight, we tested the functionality of the code. Because we moved the magnet fixture from below back to its original position, I needed to change the direction that the motor rotates at startup. Attached to this entry is the updated code.

Action items:

1. continue to fabricate and test

ANNABEL FRAKE - Apr 04, 2023, 11:05 PM CDT

Download

final_code_spring_2023_bme_402.ino.ino (12.1 kB)

04/10/2023 Troubleshooting

ANNABEL FRAKE - Apr 10, 2023, 7:53 PM CDT

Title: 04/10/2023 Troubleshooting

Date: 04/10/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: find a soldering iron; troubleshoot the motor stalling

Content:

- I went to the MakerSpace to see if they would let me check out a Soldering iron
  - the one in the green room is broken and doesn't work very well
  - The Makersapce won't let me check one out that leaves the building, but they said the TeamLab has some you can check out
  - Josh said he could check one out for me tomorrow
- I cleaned up the soldering board with rubbing alcohol in case that was causing issues
- I realized that the two wires I thought were shorting last time were connected because they correspond to the same coil in the motor
- I tried powering on the circuit and everything worked beautifully... but that didn't last
- I added electrical tape to cover the exposed connections on the solder board and re-secured the board to the electronics box
- I plugged the resistance motor back in
- ...things stopped working
- I'm thinking that maybe the connections on the solder board are weak, so that sometimes (when things are touching just right), the circuit operates normally and then other times (when the connections are bad), the circuit operates abnormally
- I tried commenting out sections of the code to remove the motor entirely or just the commands to move it
- I determined that both motors displayed the stuttering behavior (indicative that maybe the issue is with the power connection since it affects both motors?)
- If I got rid of the DIR and STEP pinmode declarations but left the motor hooked up to the circuit (has power), the motor is fine
  - the shaft is held in place by the power, but doesn't stutter
- If the DIR and STEP pinModes are defined (even if the motor is not instructed to move), the motors stutter
- I know that the code works because it worked before and hasn't changed since it last worked
- I know that the circuit connections are accurate because the circuit was operational before
- Therefore, my current hypothesis is that a connection somewhere is faulty
- I will fortify the connections once I get access to a soldering iron and see if that fixes things

References: none

Conclusions:

I made inquires about checking out a good soldering iron and should have access to one once Josh checks one out from the TeamLab. I also did some troubleshooting with the circuit, and I think that some of the connections may have gone bad (as a result of moving wires around and bending them at their connection point?). I will test this theory by fortifying the connections.

Action items:

1. fortify soldering connections
2. continue to troubleshoot

ANNABEL FRAKE - Apr 10, 2023, 7:55 PM CDT

Download

IMG_7216.MOV (8.9 MB) Video of console motor stuttering.

ANNABEL FRAKE - Apr 10, 2023, 7:55 PM CDT

Download

IMG_7217.MOV (3.14 MB) Video of resistance motor stuttering.

04/11/2023 Troubleshooting

ANNABEL FRAKE - Apr 11, 2023, 7:13 PM CDT

Title: 04/11/2023 Troubleshooting

Date: 04/11/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: troubleshoot circuit

Content:

- I tried to fortify soldering connections
- I also tried more troubleshooting
- I got it to work for a while, but didn't trust and it and eventually it stopped working again
- I'm not sure what's wrong
- I'll have to continue to work on it or maybe see if someone from the MakerSpace is willing to come to ECB to help me

References: none

Conclusions:

The circuit is still not working. I'm not sure what's wrong, so I will need to continue to troubleshoot.

Action items:

1. continue to troubleshoot

ANNABEL FRAKE - Apr 11, 2023, 7:14 PM CDT

Download

IMG_7223.MOV (48.3 MB) Video of circuit working as it should. This did not last.

04/12/2023 PCB Gerber File Creation Consultation with Dr. Coventry

ANNABEL FRAKE - Apr 12, 2023, 2:30 PM CDT

Title: 04/12/2023 PCB Gerber File Creation Consultation with Dr. Coventry

Date: 04/12/2023

Content by: Annabel Frake

Present: Annabel Frake, Dr. Brandon Coventry

Goals: create a PCB board for the DRV8825s

Content:

- I asked Dr. Brandon Coventry in the WITNe lab that I work in if he had any suggestions about what might be wrong with my circuit
- he suggested that a PCB board would have better connections and be more stable than a solder board
- he offered to help me design a board and spin it
- he used Eagle Fusion 360 to create the board for me
    - I explained how I needed things to be connected, and he walked me through the process of creating the schematic, board layout, and Gerber files
    - Below are some notes I took during the process
        - Make new project
            - Has schematic and actual board
        - Make new part
            - Library
            - SnapEDA to download part, save into project
        - Schematic
            - Drag part in
            - Caps
            - Ground
            - Add test pad for motor connections
            - Design rules check
        - Board
            - Ground layer (help reduce noise)
            - Add standoffs to board
        - Gerber files
            - CAM processor
            - Need Top and bottom Copper
            - Auto drill where holes should be
    - it was a teaching moment, but I would like to acknowledge the fact that he was at the computer physically creating the design we were discussing
    - we created the Gerber files
    - he said that the Hai lab on campus might be able to mill the board for us before the weekend, otherwise, we could contact the Physical Sciences lab (http://www.psl.wisc.edu/services/electronics-shop)

References: Dr. Brandon Coventry

Conclusions:

Dr. Brandon Coventry within the WITNe lab on campus helped me to quickly design a PCB board so that we could have fast turnaround for testing next week. We created the schematic, board, and Gerber files using Eagle Fusion 360. He is going to see if the Hai lab on campus would be willing to mill the board for us. Otherwise, we will need to try the Physical Sciences lab.

Action items:

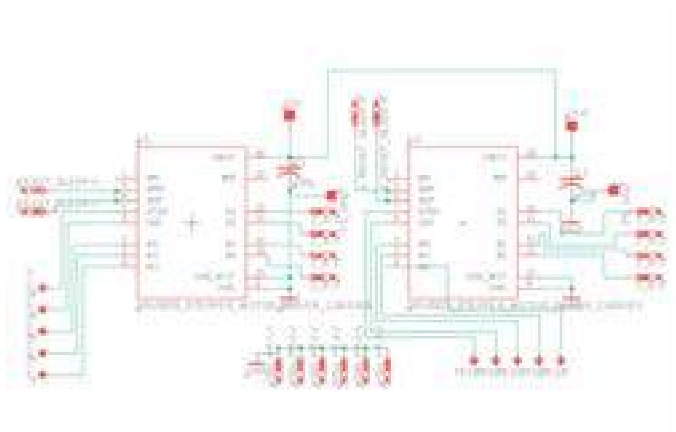
1. get the board spun, implement, and test

ANNABEL FRAKE - Apr 12, 2023, 2:31 PM CDT

Download

BME402.zip (720 kB) These are the zip files for everything we completed today in Eagle. It includes the Gerber files (CAM outputs).

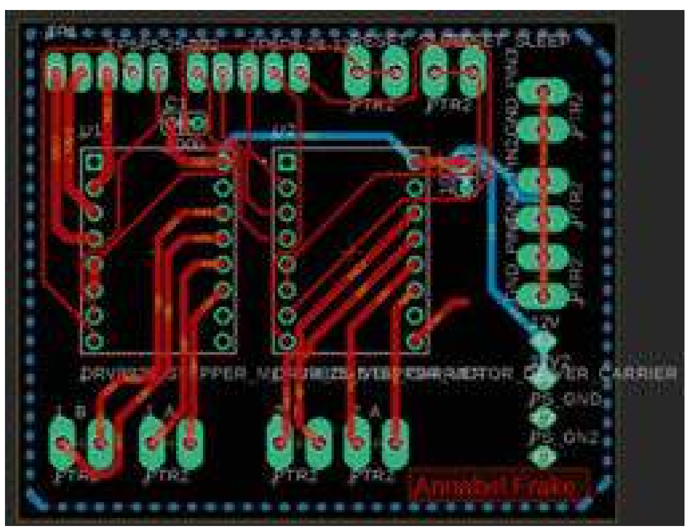
ANNABEL FRAKE - Apr 12, 2023, 2:44 PM CDT



Download

Screen_Shot_2023-04-12_at_2.43.31_PM.png (93 kB) Snapshot of schematic.

ANNABEL FRAKE - Apr 12, 2023, 2:44 PM CDT



Download

Screen_Shot_2023-04-12_at_2.43.49_PM.png (236 kB) Snapshot of board layout.

04/12/2023 Troubleshooting

ANNABEL FRAKE - Apr 12, 2023, 10:03 PM CDT

Title: 04/12/2023 Troubleshooting

Date: 04/12/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: troubleshoot circuit

Content:

- after speaking with Brandon, I went back to ECB to continue to troubleshoot
- I have breakout solder boards for DRV8825s from a previous design project that I used to replace the solder board
- I only implemented it for one motor to see if I could get one to work
- The motors did not turn on or hold their position with the application of power
- I checked the voltage on the power supply, and it was +12 V
- I checked the voltage at Vin on the Mega, but it was only 6V
    - according to a forum post I found, that behavior is indicative of blowing the 12V regulator on the board (https://forum.arduino.cc/t/arduino-uno-not-working-with-external-power-supply/313721)
    - I ran to the MakerSpace and bought a new board
- the motors still did not respond to power application, but the display and buttons worked if the Mega was plugged into my computer
    - if the circuit was powered solely by the power supply, then the buttons / display exhibited weird behavior and sometimes turned unresponsive
    - I'm not sure if that is an issue with the power supply?

References: https://forum.arduino.cc/t/arduino-uno-not-working-with-external-power-supply/313721

Conclusions:

I went to ECB and tried troubleshooting the circuit for another couple of hours. I figured out that I most likely fried the 12V power regulator on the Mega, so I bought a new one at the MakerSpace. The displays/buttons work when powered by my computer but not when powered by the power supply. I'm considering whether that means there is an issue with the power supply. The motors did not turn on at all. I will need to continue to work on this. I'm trying my best to find a solution as quickly as possible.

Action items:

1. continue to troubleshoot

04/13/2023 Troubleshooting - (FIXED!)

ANNABEL FRAKE - Apr 15, 2023, 11:20 AM CDT

NOTE: This entry was created after the actual troubleshooting session because, by the time we finished, it was midnight and I needed to complete homework for other classes. This is the first opportunity I have had to create the entry.

ANNABEL FRAKE - Apr 15, 2023, 11:16 AM CDT

Title: 04/13/2023 Troubleshooting - (FIXED!)

Date: 04/13/2023

Content by: Annabel Frake

Present: Annabel Frake, Dr. Brandon Coventry

Goals: fix the circuitry

Content:

- I called the PSL but they said that they don't mill PCB boards, so abandoned that idea
- I brought the circuit back down to breadboard level to see if I could get it working that way
  - starting only with 1 motor hooked up at a time
- my mentor from the WITNe lab, Dr. Brandon Coventry, helped me troubleshoot the circuit
- we confirmed that the signals from the program were showing up on the Mega board itself (in terms of seeing a high vs low on a direction pin and a pulsed signal on the step pin)
  - this ruled out the Mega as the potential problem
- we looked at the signals on the DRV8825s
  - we determined that one of the wires for the STEP and DIR pins going to the Mega broke
  - when replaced with wires from my prototyping kit, we got the signals at the DRV8825 that we expected
- we tried the resistance motor, console motor, and my personal motor and ruled out the possibility that the motor was the main issue
- we moved on to the DRV8825 board and noticed that the voltage dropped from 12V to around 7V
  - after some additional troubleshooting, we figured out that the jack converter that I had used for the 12V power supply must have been damaged somehow
  - once I plugged the 12V power supply directly into the Mega, we got 12V at the DRV8825
- at this point, the motor moved, but it was jerking like it had been at the start of this whole endeavor
  - we concluded that it was not getting enough current
  - after replacing the DRV8825, we got my personal motor to move
  - we tried the resistance motor, and it moved as intended
  - we tried the console motor, and it sounded like a jack hammer
    - we therefore concluded that that motor must have been damaged somehow and replaced it in the circuit with my personal motor
- I temporarily jerry rigged some stuff so that I could try both motors at once and make sure the circuit was operating as intended
  - IT WORKED!
  - please see attached video

References: none

Conclusions:

After a long, arduous troubleshooting session that lasted at least 4 hours, my mentor and I were able to fix the circuit. I believe that the power supply jack was the original failure, and then the wire failure, DRV8825 failure, and motor failure occurred somehow during the troubleshooting I've been doing all week to fix things. The circuit is currently functional, but I will need to solder breakout board to replace the personal ones I used in testing, as well as replace the breadboard circuit with a breakout board circuit. Overall, I'm glad that the circuit is functional again for testing next week!

Action items:

1. make the circuit permanent again (ie solder)

ANNABEL FRAKE - Apr 15, 2023, 11:18 AM CDT

Download

IMG_7248.MOV (50.7 MB) Video of the circuit operating as intended. Because the limit switches by the console motor are taped in place, the motor stutters a bit when the limit switch is not fully depressed, but that will be fixed once the limit switches are secured once more.

04/14/2023 Soldering at the MakerSpace

ANNABEL FRAKE - Apr 15, 2023, 11:28 AM CDT

NOTE: This entry was created after the actual soldering session because I finished just in time to make it to my work meeting and then I had a club commitment right after that. This is the first opportunity I have had to create the entry.

ANNABEL FRAKE - Apr 15, 2023, 11:26 AM CDT

Title: 04/14/2023 Soldering at the MakerSpace

Date: 04/14/2023

Content by: Annabel Frake

Present: Annabel Frake

Goals: solder breakout boards for the DRV8825s

Content:

- the breakout boards I had been using in troubleshooting are from my personal prototyping kit, so I remade them for this project
- I used solder boards from the ECB design materials stash
- I used headers from my personal stash because I could not find any similar ones at the MakerSpace or in ECB and I didn't have time to order any since the circuit needs to be done for testing next week
- Photos of the boards:
  - 
  - 

- 

References: none

Conclusions:

I soldered new breakout boards for the project that essentially allow you to connect to the necessary pins on the DRV8825s using screw terminals. This makes it easier to swap out a DRV8825 if it breaks rather than needing to unsolder it from a solder board. I made two, one for the console motor and another for the resistance motor.

Action items:

1. implement this in the circuit

04/15/2023 Final Circuit Fabrication

ANNABEL FRAKE - Apr 15, 2023, 4:09 PM CDT

Title: 04/15/2023 Final Circuit Fabrication

Date: 04/15/2023

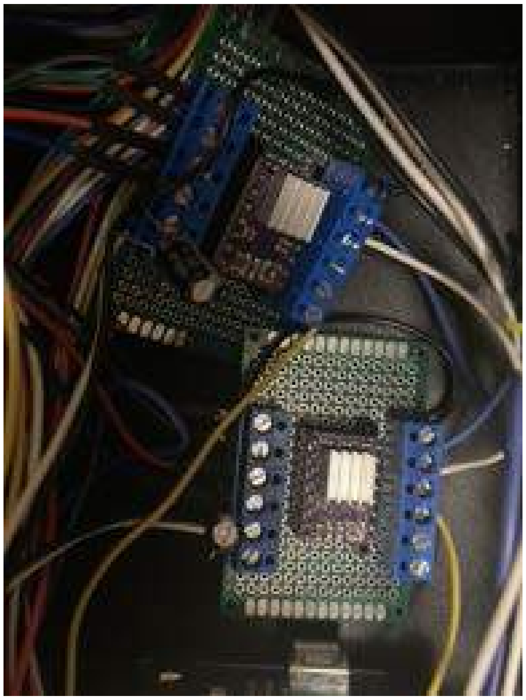
Content by: Annabel Frake

Present: Annabel Frake

Goals: implement the breakout boards

Content:

- I replaced the breadboard circuit from testing, as well as my personal breakout board with the breakout boards I fabricated yesterday
- I also reran the console motor wires to the electronics box
- the circuit is now all put together
- 

- 
- 
- 

References: none

Conclusions:

Today, I went into ECB to replace the testing circuit I created this week with the breakout boards I fabricated at the MakerSpace yesterday. The circuit is now finished.

Action items:

1. Test the circuit using the protocol I wrote once the console motor is secure

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

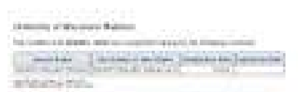
Goals: provide documentation of biosafety training

Content:

-see attached pdf

References: UW Madison Biosafety Training Canvas Module

ANNABEL FRAKE - Mar 09, 2021, 10:32 PM CST



Download

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

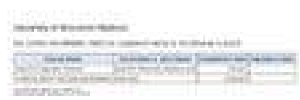
Goals: provide documentation of chemical safety training

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

Download

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.

ANNABEL FRAKE - Jan 26, 2023, 9:47 PM CST

Download

Training_Record_Research_Animal_Resources_and_Compliance_University_of_Wisconsin_Madison.pdf (166 kB) I completed the Mouse training on 23JAN2022.

Preferred Template

ANNABEL FRAKE - Sep 09, 2022, 2:00 PM CDT

Title:

Date:

Content by:

Present:

Goals:

Content:

References:

Conclusions:

Action items:

2/5/2023 - Thoughts on Resistance Dial Mechanism

Josh ANDREATTA - Feb 05, 2023, 2:14 PM CST

Title: 2/5/2023 - Thoughts on Resistance Dial Mechanism

Date: 2/5/2023

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Jot down thoughts on best course of action for the resistance dial

Content:

After discussing with Staci, I think that the best plan for the resistance dial would be to physically mount the magnet to a stepper motor and place it somewhere within the casing of the interior shell of the rower. This gives us the advantage of being able to put the motor anywhere we want within this casing and we won't have to worry about the extra tension from the spring connected to the cable on the current mechanism. To best place the motor, it should close to where the hinge point is now for the magnet so as not to disrupt any other portions of the interior of the rower flywheel. I reviewed sams design and agree with his general concept of mounting the motor close to the current magnet hinge point. Also, this will make modeling easier for the structure that holds the motor. All it will need is a mount to the current frame through the bolt hole and an attachment of the magnet to the stepper motor. We will need to take apart the rower and calibrate how much rotation occurs between each resistance level. Once we have this calibration, we can translate this to the motor by figuring out how many steps of the motor shaft twisting is required for each level change.

References: n/a

Conclusions:

I will explain these core concepts to the team and we can then agree on the best location to put the motor next to the flywheel. After this, we will have to dimension the interior rower space to properly model the attachment mechanism of the motor to the rower.

Action items:

-Meet with team today to edit and submit IRB application documents

-Assign testing slides

-Agree on plan for resistance dial mechanism

2/21/2023 - Plan for Resistance Dial CAD Development

Josh ANDREATTA - Feb 21, 2023, 3:41 PM CST

Title: 2/21/2023 - Plan for Resistance Dial CAD Development

Date: 2/21/2023

Content by: Josh Andreatta

Present: Josh Andreatta, Sam Skirpan

Goals: Write down plan for resistance dial CAD development

Content:

The above image shows the magnet housing and how it screws in to the two supports on the internal rower.

The above image shows the place where we would like to move the magnets and place the stepper motor for the resistance dial mechanism.

Today I worked with sam to brainstorm details about what we would like to make for the resistance dial mechanism and develop a plan of next steps for achieving those steps. Shown above is the housing structure that holds the magnets that rotate about the fly wheel. In this picture, it can be seen how the bar is screwed into the two angled supports. Since we know that this juncture works and fits, I think it would be best to simply unscrew it and move it down to the bottom of the rower frame (shown above). Since we will be disconnecting the spring and cable wire that currently rotates the magnets, we will need a new mechanism to cause magnet rotation. To do this, we plan on using a stepper motor. I would like to make a mating piece that can fit over the shaft of the stepper motor that fits into where the bolt goes through the magnet housing. This would ensure that when the stepper motor rotates, the magnets would rotate in a circle about the flywheel. As a team, we have discussed moving the electronics down to this position to declutter the area by the antlers. I have emailed staci requesting CAD models of the rower frame base and the housing of the magnets. Once I receive this, I will start to make models of the adaption to the stepper motor, and making a new electronics box that is capable of holding all of our electronics.

References: n/a

Conclusions:

I will wait for Staci to send me the CAD needed to make this model. Once I get this, I will begin working on the SolidWorks for the housing of the stepper motor and associated electronics.

Action items:

-Email Staci requesting for CAD parts of images above

-Begin work on CAD development once Staci responds

-Continue work on Antler finalization/simulations

-Prelim report

3/14/2023 - Initial Connection for Resistance Dial Mechanism

Josh ANDREATTA - Mar 14, 2023, 11:38 AM CDT

Title: 3/14/2023 - Initial Connection for Resistance Dial Mechanism

Date: 3/14/2023

Content by: Josh Andreatta

Present: Josh Andreatta

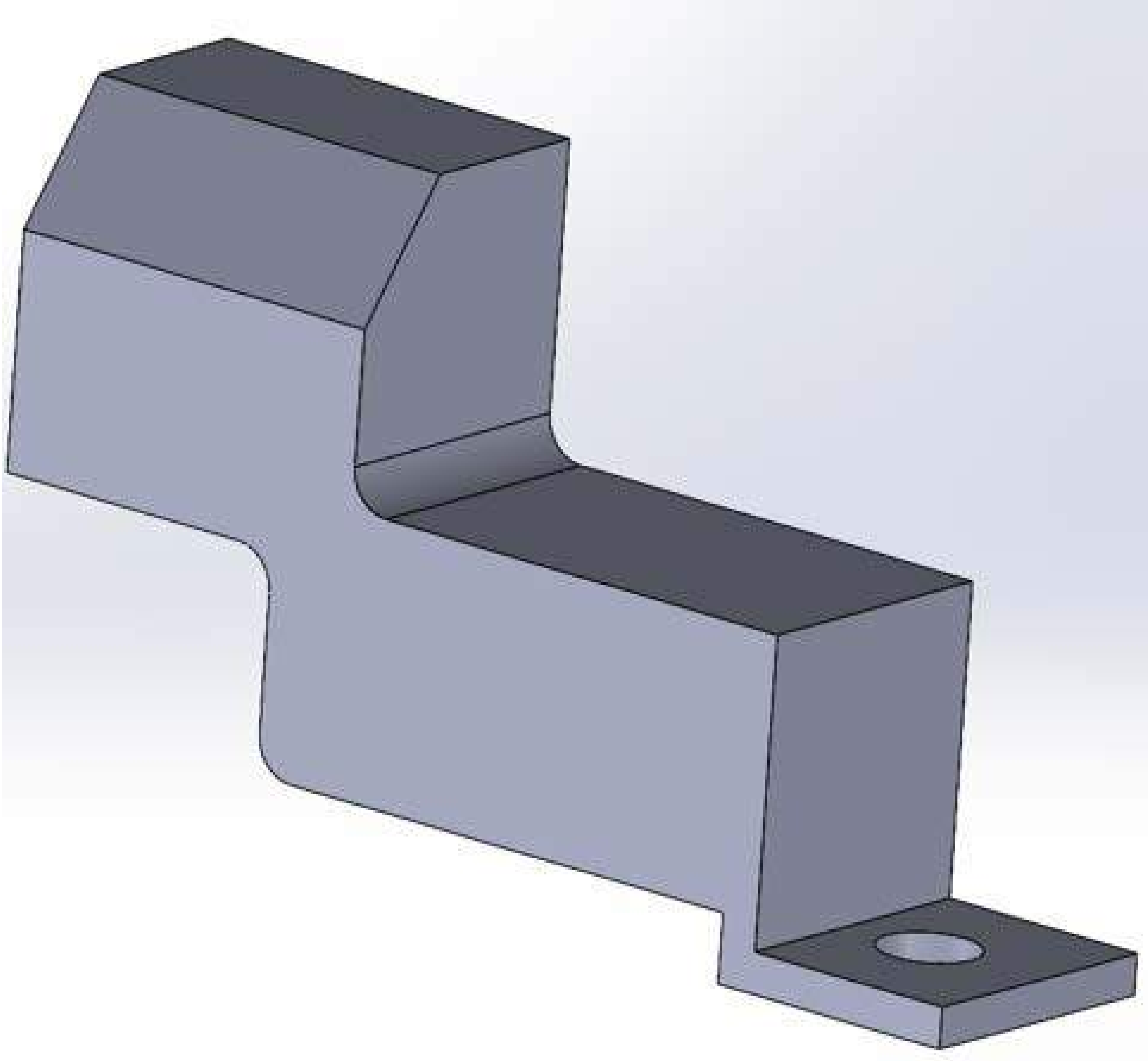
Goals: Show the first iteration of the connection between the magnet housing and the stepper motor.

Content:

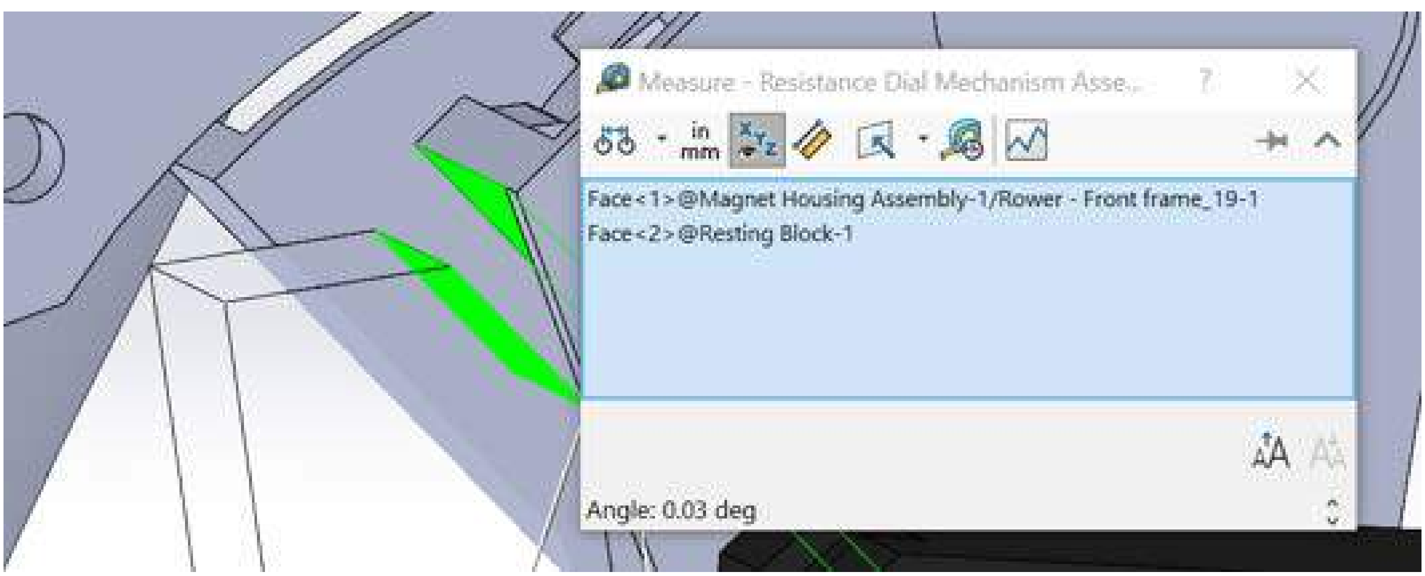
Today I modeled the initial connection between the D-shaft of the stepper motor and the magnet housing. To make a simple but likely effective design, I just recreated the mechanism that the magnet housing already uses to rotate. Currently, a screw is inserted into the shaft of the magnet housing nad held in place with a nut. The housing rotates about this screw point. To modify this, I made my connection to be the screw. As shown below, I created a stepped shaft that press-fits onto the D-shaft of the stepper motor and has a step down to press fit within shaft of the magnet housing. The ending of this is threaded so that the washer and nut can be screwed onto this end and tightened against the housing, just like the screw is tightened currently. The press fit will make sure that when the motor shaft turns, the 3D printed shaft will turn with it. Then, since the nut holds the shaft tight against the magnet housing, and due to the press-fit of the 3D printed shaft within the magnet housing itself, when the motor turns, the magnet housing will rotate as well. When I get back to school, I just need to double check the proper thread size of the screw that we have, and make sure it is modeled as so.

Next, I made a block that will prevent the magnet housing from falling backward due to gravity. Although the housing itself will be screwed into the rower as described in a previous entry, when the motor is turned off, the rotating portion of the magnet housing is free to fall in the direction of gravity. To prevent this, I made a block that can seamlessly screw in with the housing that will catch the magnet housing IF it does fall and rotate due to gravity. On this slanted face, we intend to place a limit switch which will tell the circuit that it has fallen back to the state of resistance level 1. Once we know this position, I will modify the distance that the slanted face of the stop is from the slanted face of the magnet housing to have enough room for the limit switch while ensuring that when the switch is depressed, it is at the location the magnets should be at for rowing at resistance level 1.

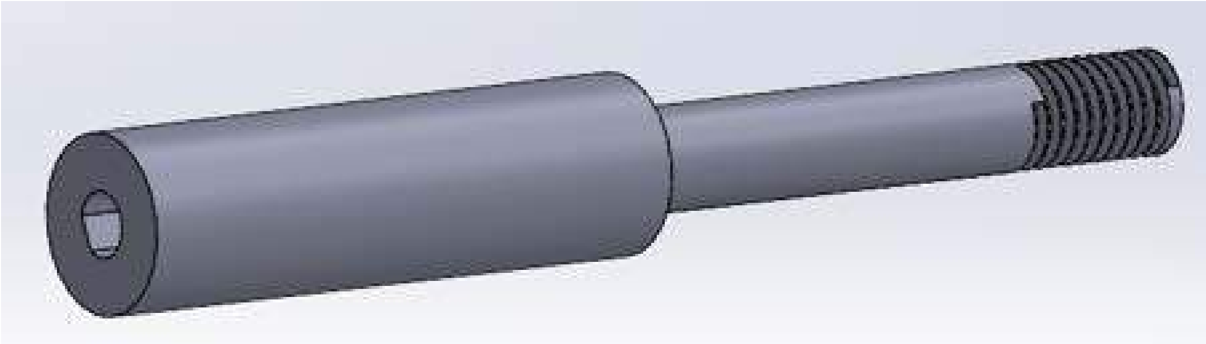
Once back at school, I will confirm the thread size of the screw in the housing and 3D print the shaft connection. Then, we will conduct initial testing to see how this connection functions in rotating the magnet housing with the stepper motor. Once this works, we will measure and confirm the position of the magnet housing on the two bars of the rower near the base of the machine. Once we determine this distance, I can make the electronics box that will hold this second stepper motor and the associated electronics. I will also then be able to adjust the distance of the slanted face of ther esting block as described above. Please see below for images.



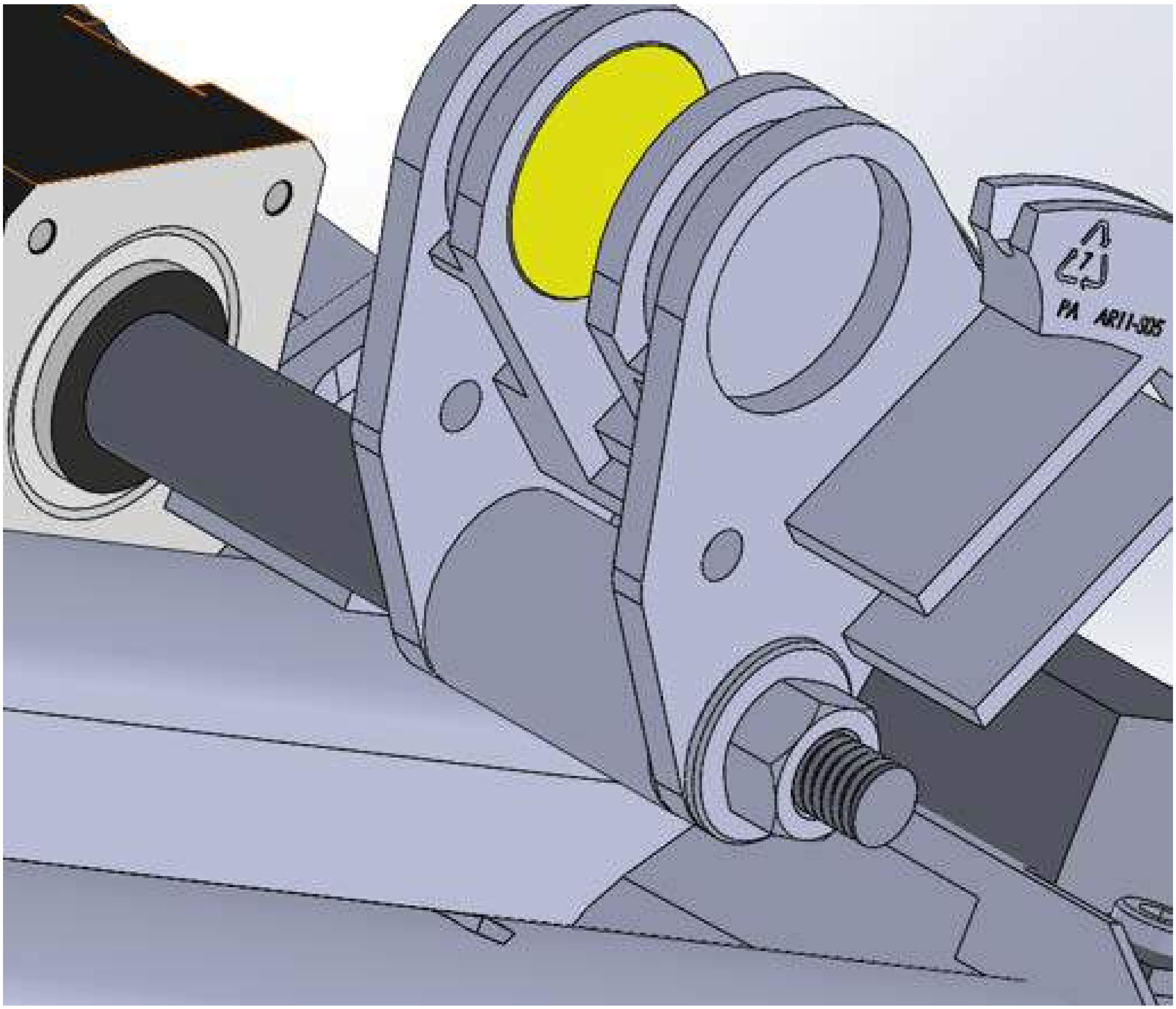
The above image shows the resting block with a slanted face.



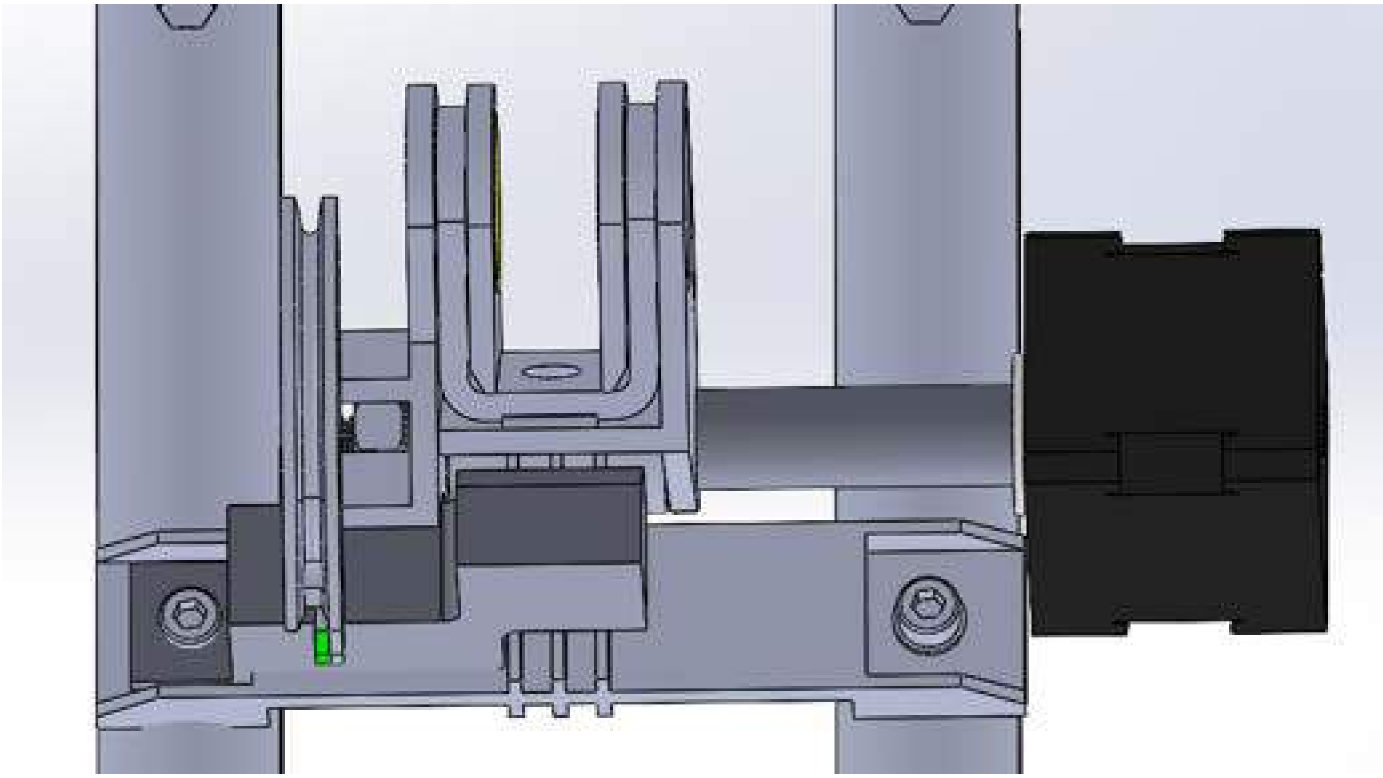
The above image shows how the slanted face of the resting block and the magnet housing are essentially parallel, allowing it to catch it upon any fall.



The above image shows the stepped shaft connection between the magnet housing and the stepper motor.



The above image shows how the nut screws the connection in just as it screwed in the bolt before.



The above image shows the top view of the assembly. The motor is off to the side because in order to have the motor shaft remain concentric with the insertion into the magnet housing, it must sit as so. Due to the two metal support bars that hold the flywheel, this is as close to the housing that the motor can sit while maintaining the concentricity.

References: n/a

Conclusions:

I have confirmed this design with Annabel and will print this once I get back to school. After the initial print, I will meet with Annabel to combine the print with the electronics to see how it works and what initial adjustments need to be made.

Action items:

-Print design at Wendt (anything special to have Staci pay through her account?)

-Test and iterate connection design with electronics

-Once all parts confirmed and connection finalized, make new electronics box for the rower base and modify the existing electronics box for the console rotation. Then print and iterate until finalized.

-Wait to here back from Dr. Wille about EMG - if not, use equipment at JHT with Staci

-Reach out to people to get 3 wheelchair participants for testing in early April

-Outreach on Friday afternoon

-Drive to JHT and pick up pulley plates and antlers and stabilization frame. Then integrate with rower and see how it works

-Run rope let go test with metal antlers and pulley plates

Josh ANDREATTA - Mar 14, 2023, 11:39 AM CDT

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Magnet_Housing_Assembly.SLDASM (555 kB)

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Resistance_Dial_Mechanism_Assembly.SLDASM (3.73 MB)

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Rower_-_Front_frame.SLDASM (3.04 MB)

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Stepper_Motor_Magnet_Connection.SLDPRT (163 kB)

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Field_Goal_for_Console_Display_Left_Part.STL (111 kB)

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Field_Goal_for_Console_Display_Right_Part.STL (104 kB)

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Resting_Block.STL (15.3 kB)

3/24/23 - Resistance Dial and Console Rotation Electronics Boxes Models

Josh ANDREATTA - Mar 24, 2023, 9:59 AM CDT

Title: 3/24/23 - Resistance Dial and Console Rotation Electronics Boxes Models

Date: 3/24/23

Content by: Josh Andreatta

Present: Josh Andreatta, Annabel Frake

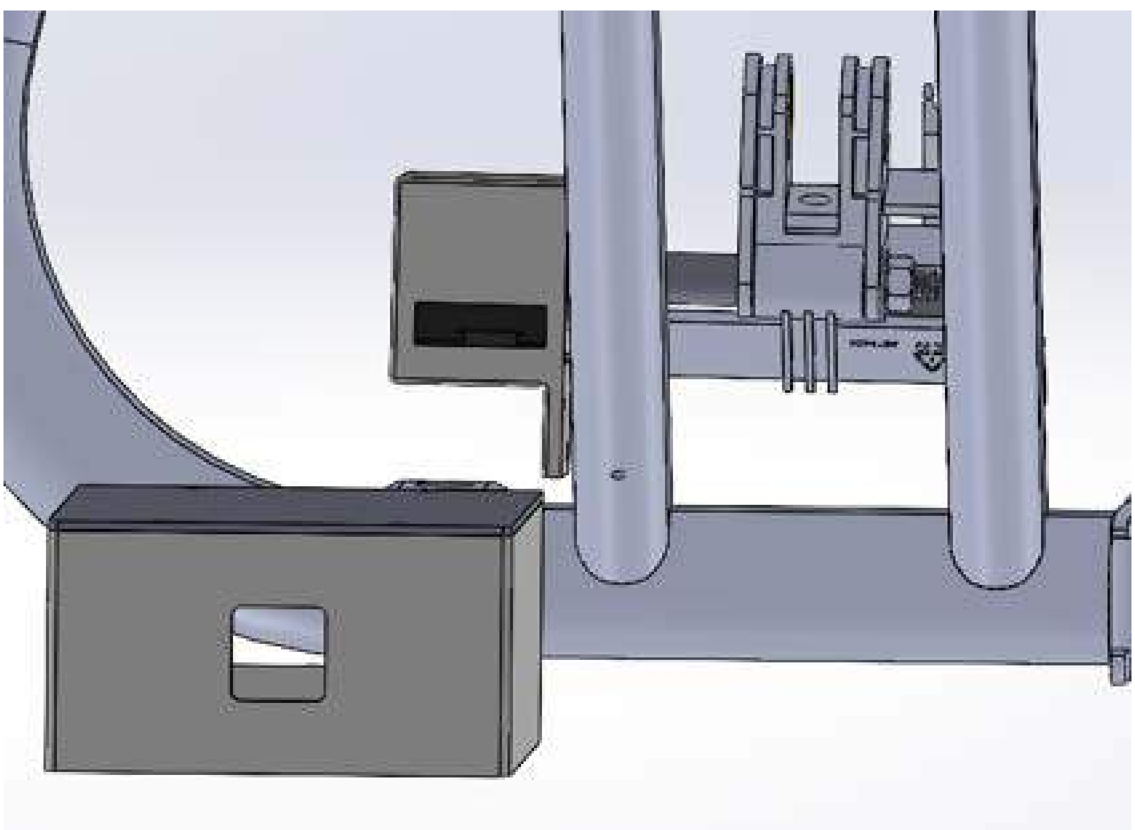
Goals: Show my models of these boxes

Content:

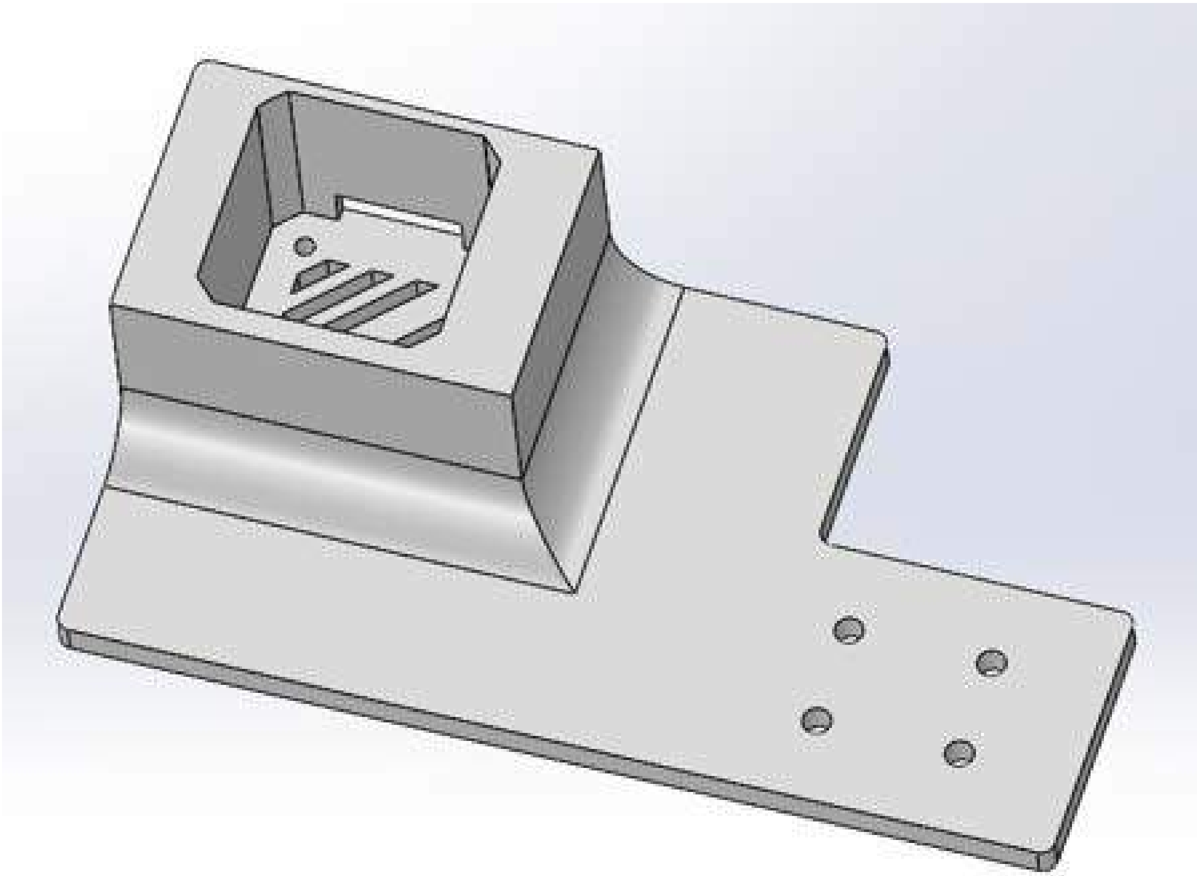
The first component I adjusted was the component between the stepper motor and the magnet housing. This piece needed a slightly smaller diameter as compared to its previous print. I also lowered the diameter on the console field goal posts where they enter the console to improve their fit. Next, I adjusted the box for console rotation so that it only holds the stepper motor. This is because the electronics are now all being localized to one box at the base of the rower as described below. Therefore, the box for the console rotation only needs to include the stepper motor. This box will not need a lid anymore because there are no open electronics in it. There is still room to glue the limit switches in place. The holes were altered to align with the new holes on the pulley plate assembly. Please see below for pictures of these slight adjustments.

Next, I made a small holder for our LCD displays. This is simply a base board that the display can sit on, and a cover that will go on top and screw together with the solder board and base board. There is a hole in the center to allow visibility for the LCD display itself.

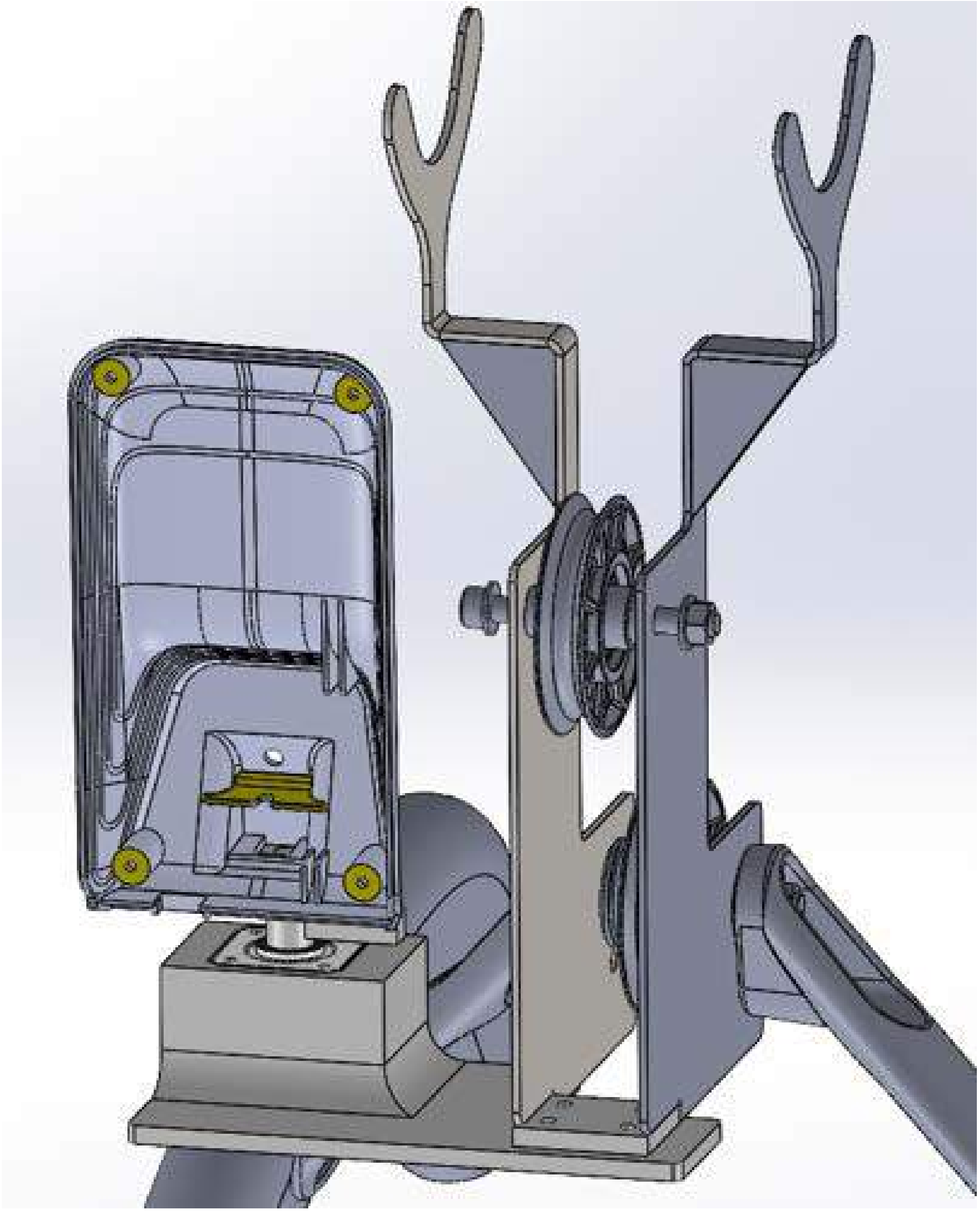
Next, I modeled the box to hold the arduino mega and the motor controller board. We came to the consensus that this can just be a box that sits on the ground and can be tucked away from the user. There are holes on the front and back to thread wires in and out of, as well as a small hole in the side for easy access to the power cord. The box has an accompanying lid to enclose the open electronics and wires from the external environment. Next, I made a small housing chamber for the stepper motor itself. To ensure that the motor and housing will not rotate as the shaft of the motor rotates, I added 2 screw holes that we can use to screw the housing into the side of the rower as shown below. This allows us to set the magnets at the height necessary for proper magnet overlap, and then once that is set, we can screw the stepper motor housing chamber into place. Ideally, since I added lots of extra clearance in the box, and I know that the motor will fit in the cavity of its housing chamber, all of these components will only need to be printed once. We will either glue the electronics within the box, or tap out screw holes for them and screw them into place to make rigid connections. Please see below for images.



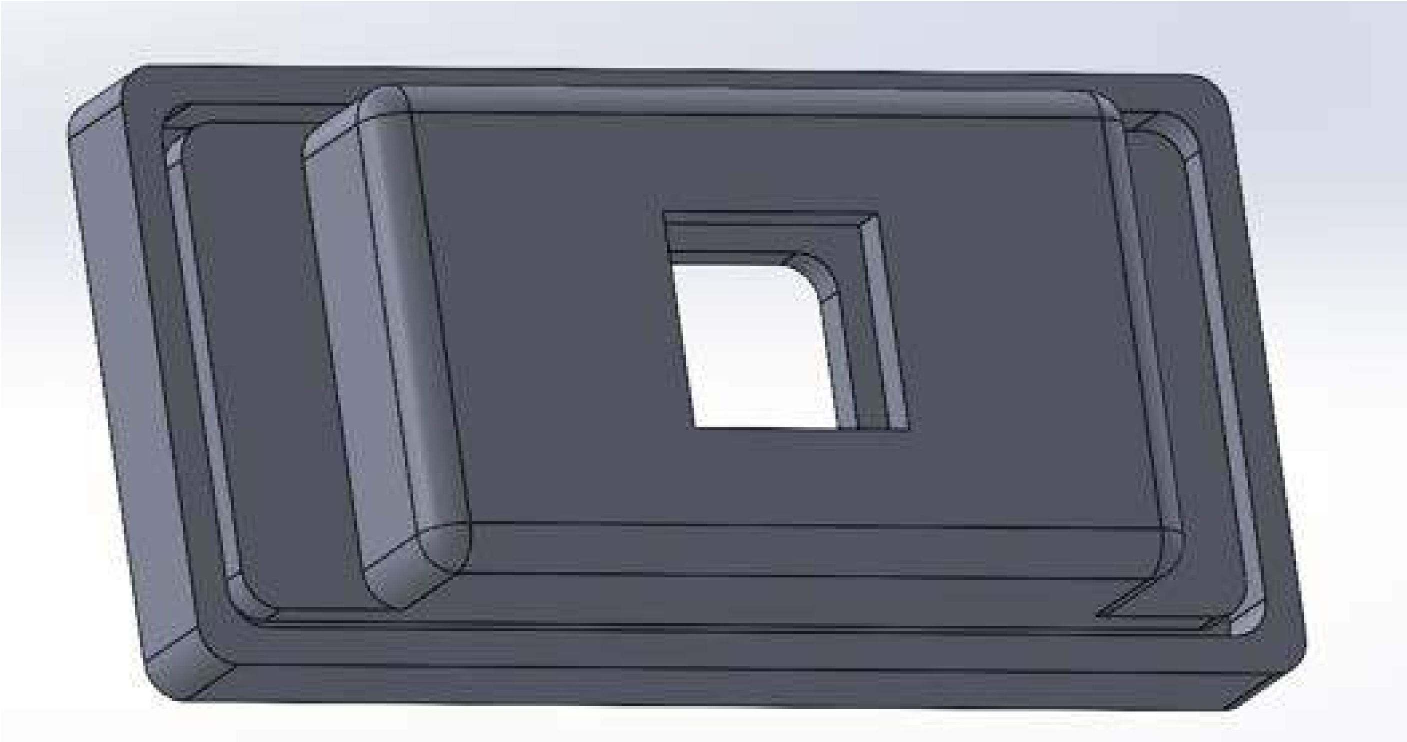
The above image shows the backview of the motor housing screwed into the rower, and the electronics box on the ground.



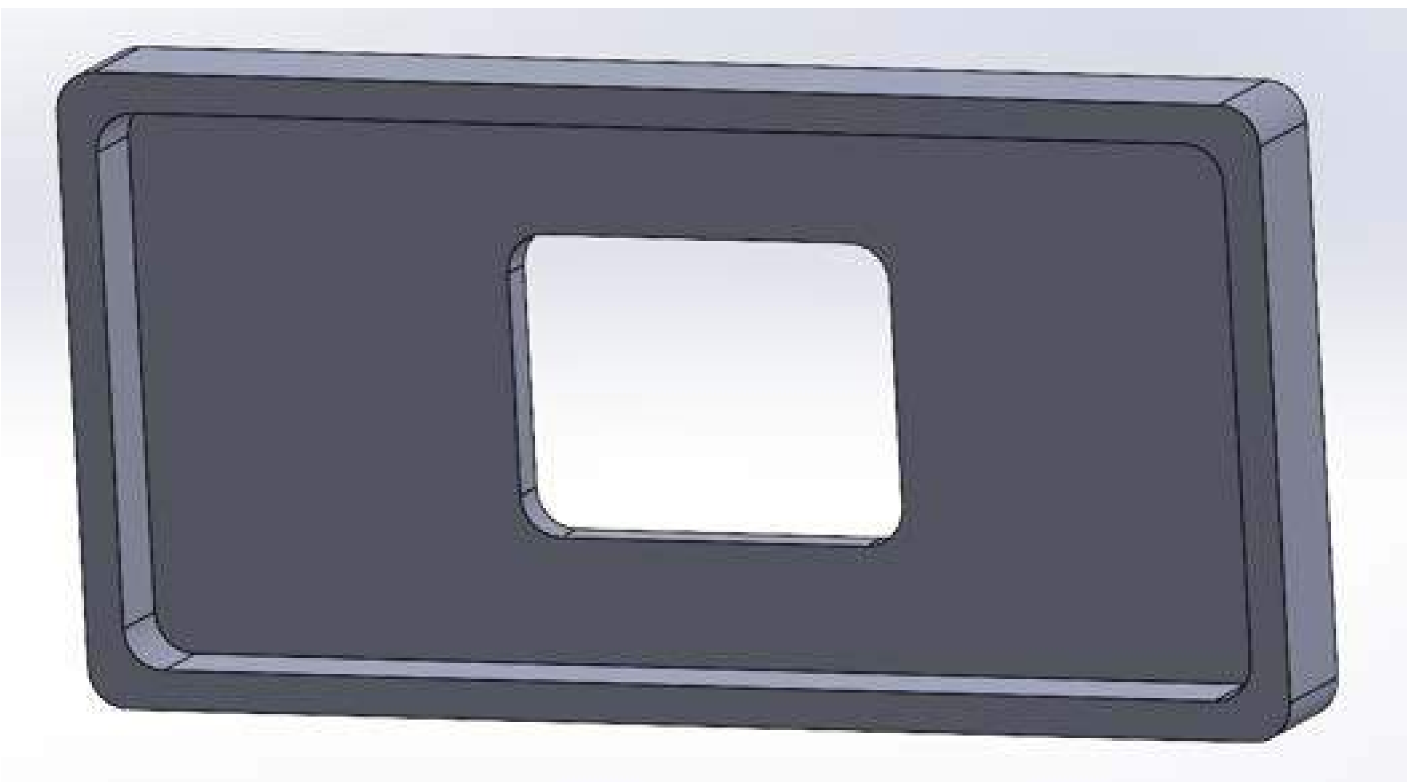
The above image shows the updated console rotation box holding only the motor.



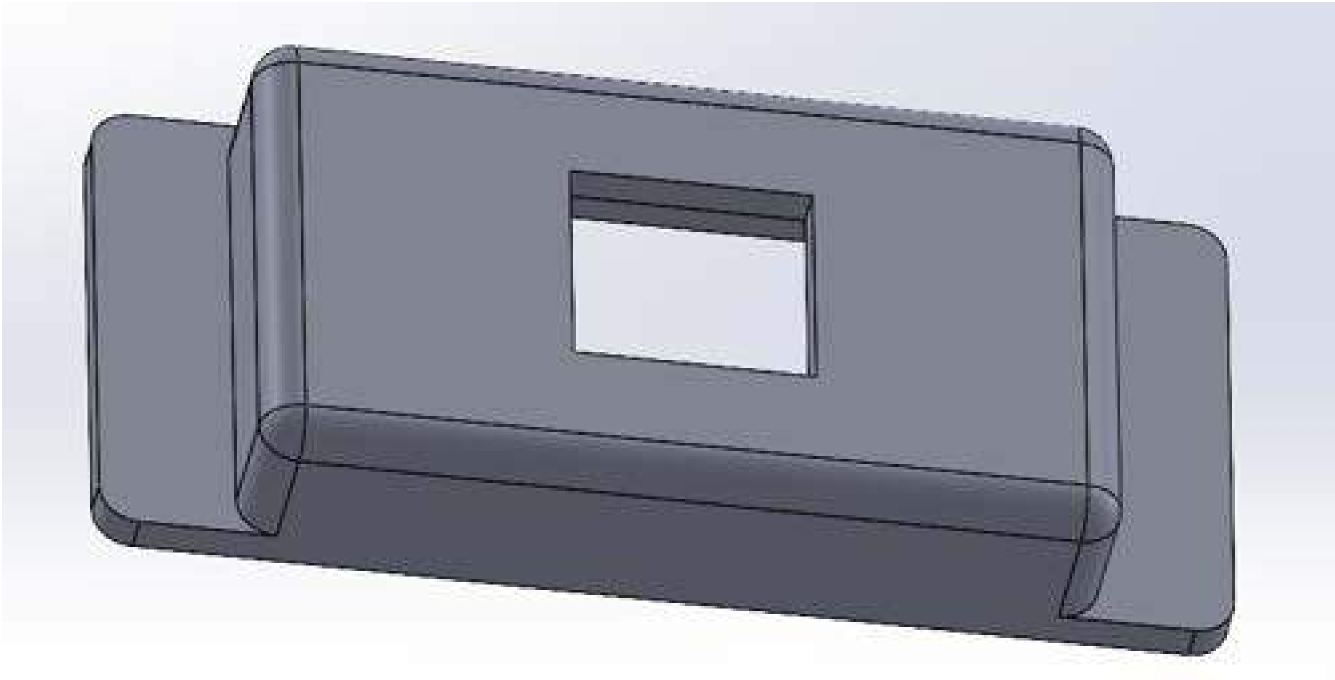
The above image shows the new console rotation box incorporated with the pulley plate assembly.



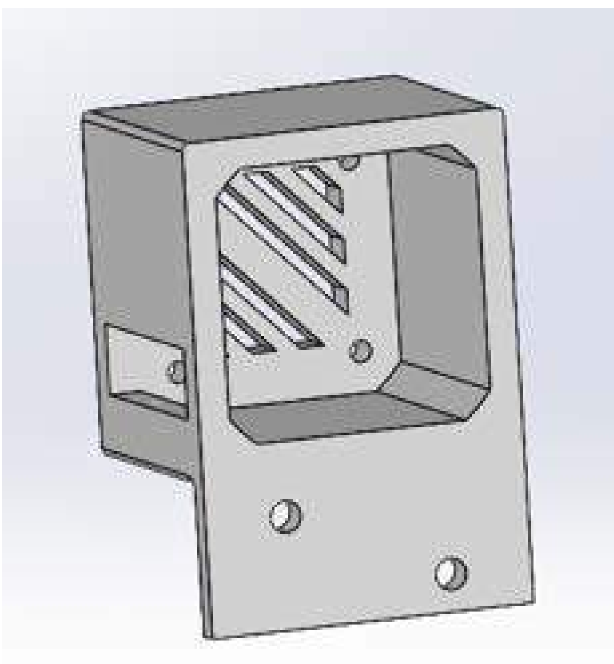
The above image shows the LCD display assembly.



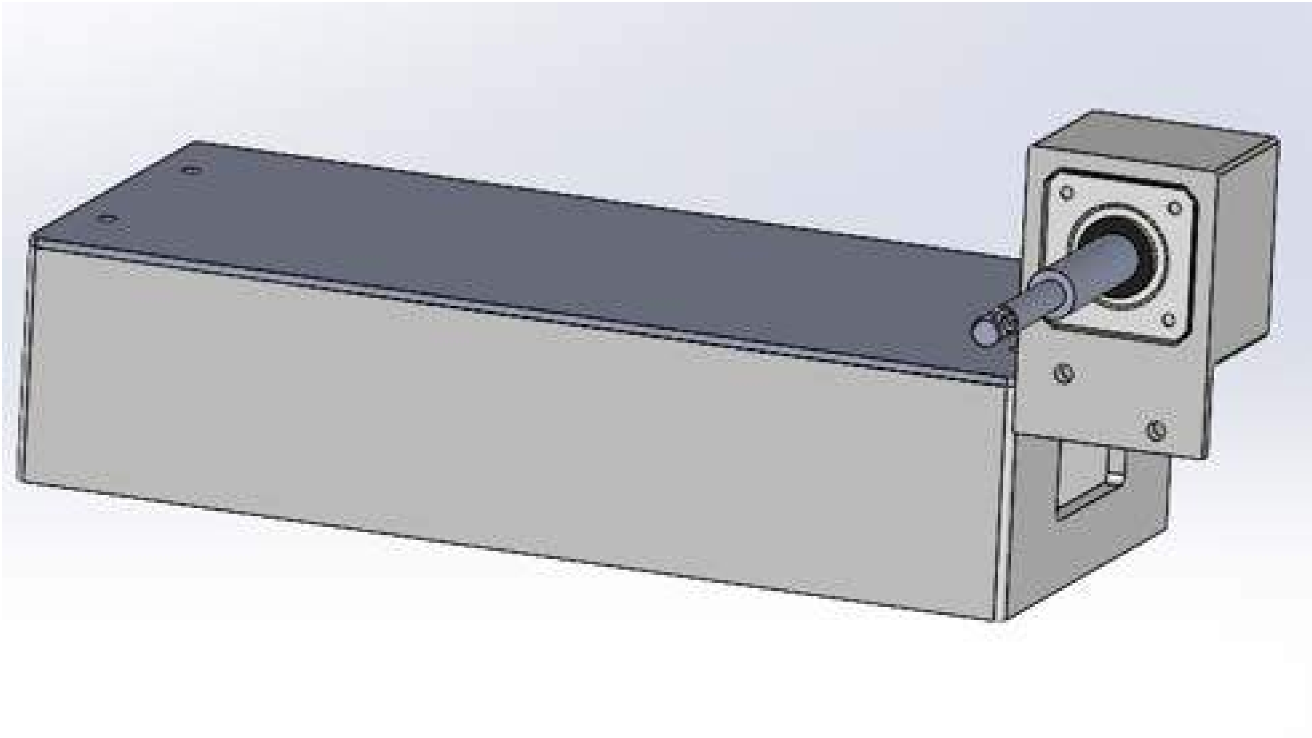
The above image shows the base board of the LCD display.



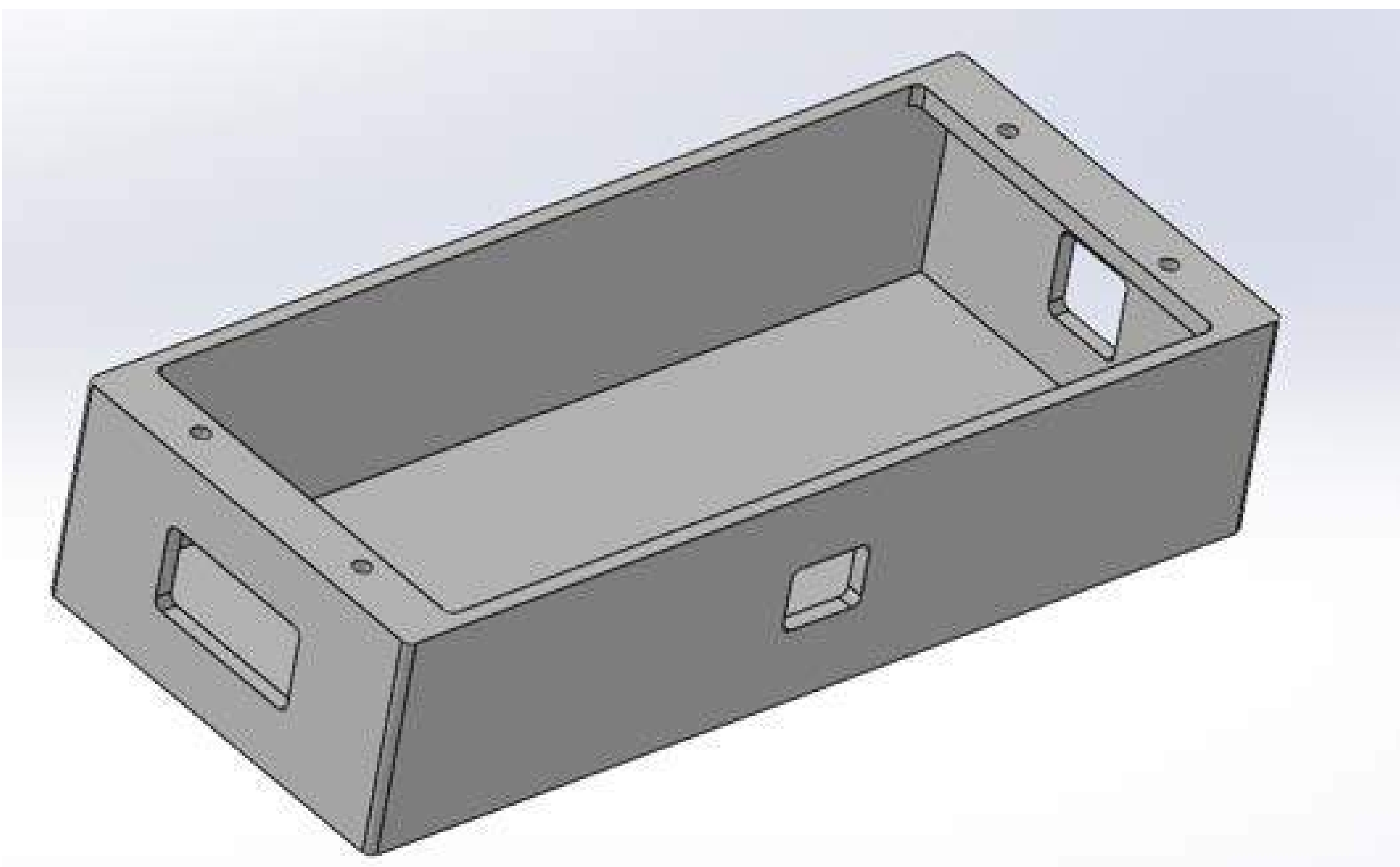
The above image shows the cover for the LCD display assembly.



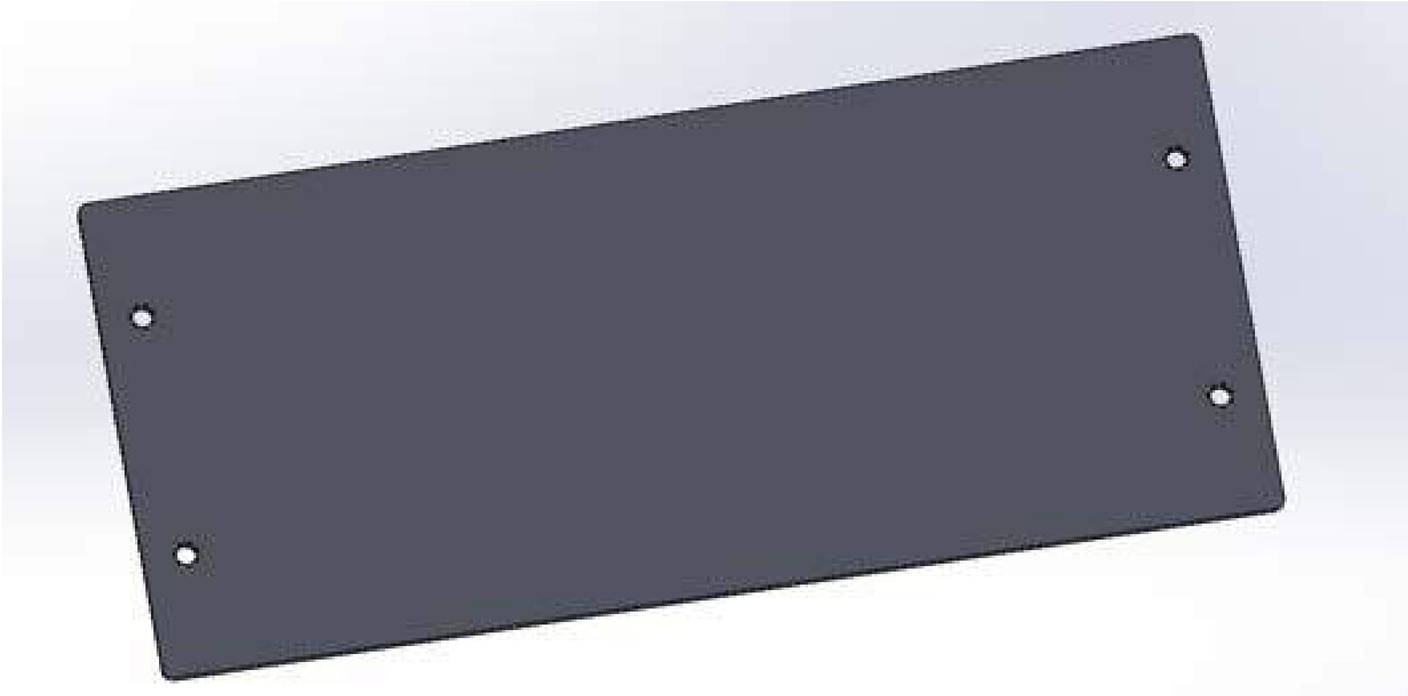
The above image shows the housing for the resistance dial stepper motor.



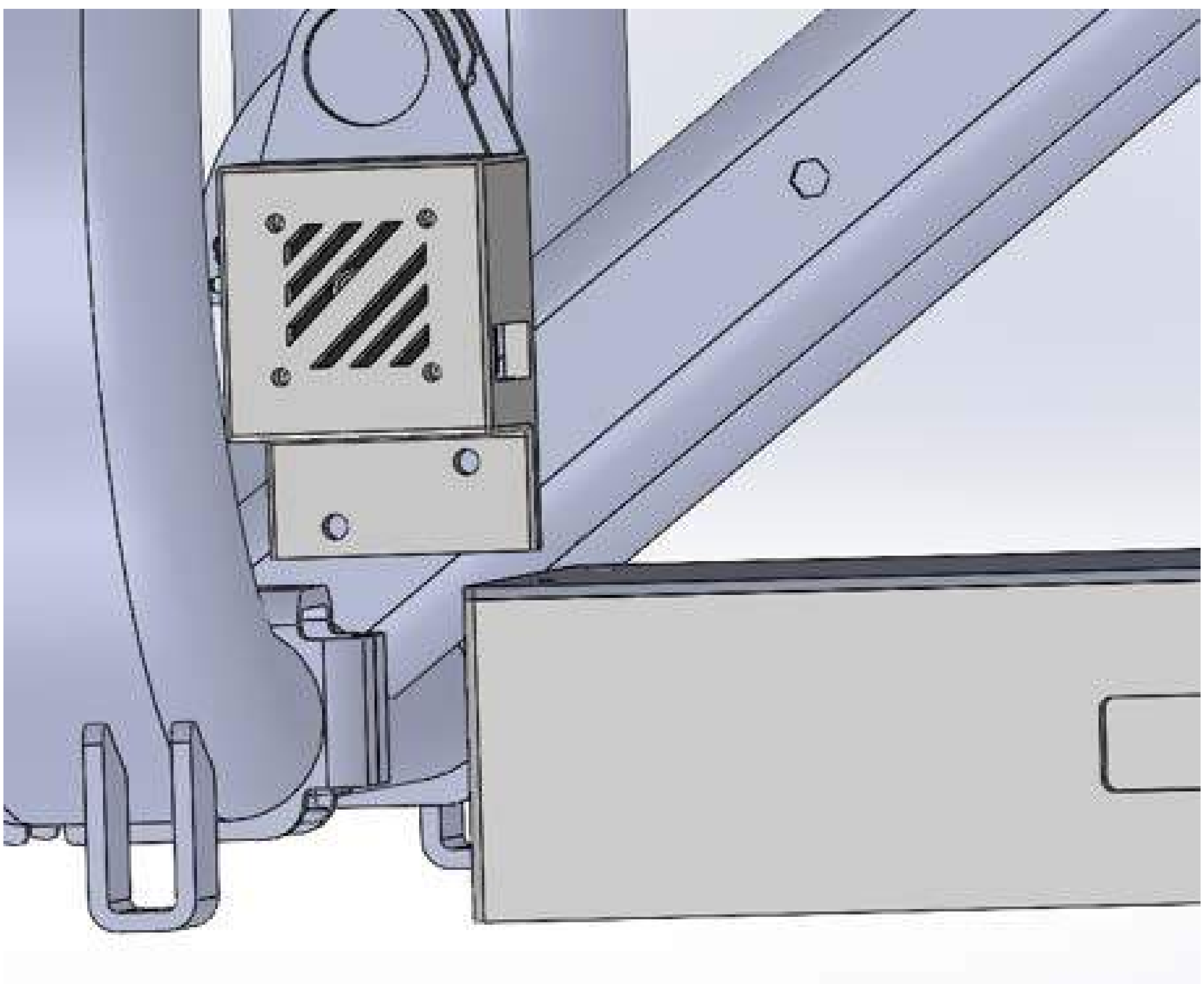
The above image shows the full assembly of the resistance dial box with stepper motor housing.



The above image shows the electronics box at the base of the rower.



The above image shows the lid for the electronics box.



The above image shows how the stepper motor housing will be screwed into the side of the rower at the base.

References: Annabel for input on spacing for the electronics

Conclusions:

These parts were confirmed with Annabel and the rest of the team, and then printed at the makerspace. They ideally should only need to be printed this one time. Once printed, we will use a drill press to tap out the holes for screwing together the lid with the box, the electronics into the box, and the motor housing into the rower. Then we will collect the screws and assemble everything and integrate with the full rower. Our goal is by the end of next week (March 31), we will have all of the 3D prints finished and incorporated into the rower with the pulley plates and stabilization frame. This will give us all of april to conduct our testing.

Action items:

-I printed everything at the MakerSpace (except the lid for the big electronics box) and it should all be done by monday. Hopefully, since I added plenty of clearance, this will be the only print for these pieces. I will print the lid on Monday also.

-I printed another set of iterations of the connection between the stepper motor and magnet housing, and another iteration of the console field goal posts to continue to improve their fit. I will continue to adjust and print these small components until we are satisfied with the fits.

-Dr. Wille ordered our at home EMG testing kit, so hopefully we will not need to go to JHT for that testing.

-We will respond to the wheelchair basketball team today to let them know that we will be ready for testing anytime in the first 3 weeks of april.

-We will drive to JHT today or monday to pick up our metal parts and then integrate them in with the rower.

Josh ANDREATTA - Mar 24, 2023, 10:01 AM CDT

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LCD_Display_Assembly.SLDASM (71.7 kB)

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LCD_Display_Base.SLDPRT (91 kB)

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Magnet_Housing_Assembly.SLDASM (555 kB)

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Rower_Base_Electronics_Box_Lid.SLDPRT (66 kB)

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Stepper_Motor_Housing.SLDPRT (10.3 MB)

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Stepper_Motor_Magnet_Connection.SLDPRT (227 kB)

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Motor_Arm_Box.SLDPRT (10.5 MB)

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Console_Motor_Box.STL (102 kB)

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Field_Goal_for_Console_Display_Left_Part.STL (112 kB)

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LCD_Display_Base.STL (24.3 kB)

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LCD_Display_Cover.STL (57.3 kB)

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Resistance_Dial_Stepper_Motor_Housing.STL (525 kB)

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Rower_Base_Electronics_Box_Lid.STL (37.7 kB)

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Rower_Base_Electronics_Box.STL (71.6 kB)

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Stepper_Motor_Magnet_Connection.STL (384 kB)

2/3/2022 - Red/Green Pass Permits

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

Title: Red/Green Pass Permits

Date: 2/3/2022

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show documentation for my red and green pass permits

Content:

You have the following permits and upgrades:

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

References: n/a

Conclusions:

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

Action items:

Meet with client and start PDS.

9/15/2021 - Chemical and Biosafety Trainings

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

Title: Chemical and Biosafety Trainings

Date: 9/15/2021

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Complete Chemical and Biosafety Trainings

Content:

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

Conclusions/action items:

I completed the Chemical and Biosafety Trainings.

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

Download

Trainings.pdf (139 kB)

2/5/2023 - Work on Prelim Presentation Testing Slides

Josh ANDREATTA - Feb 05, 2023, 5:34 PM CST

Title: 2/5/2023 - Work on Prelim Presentation Testing Slides

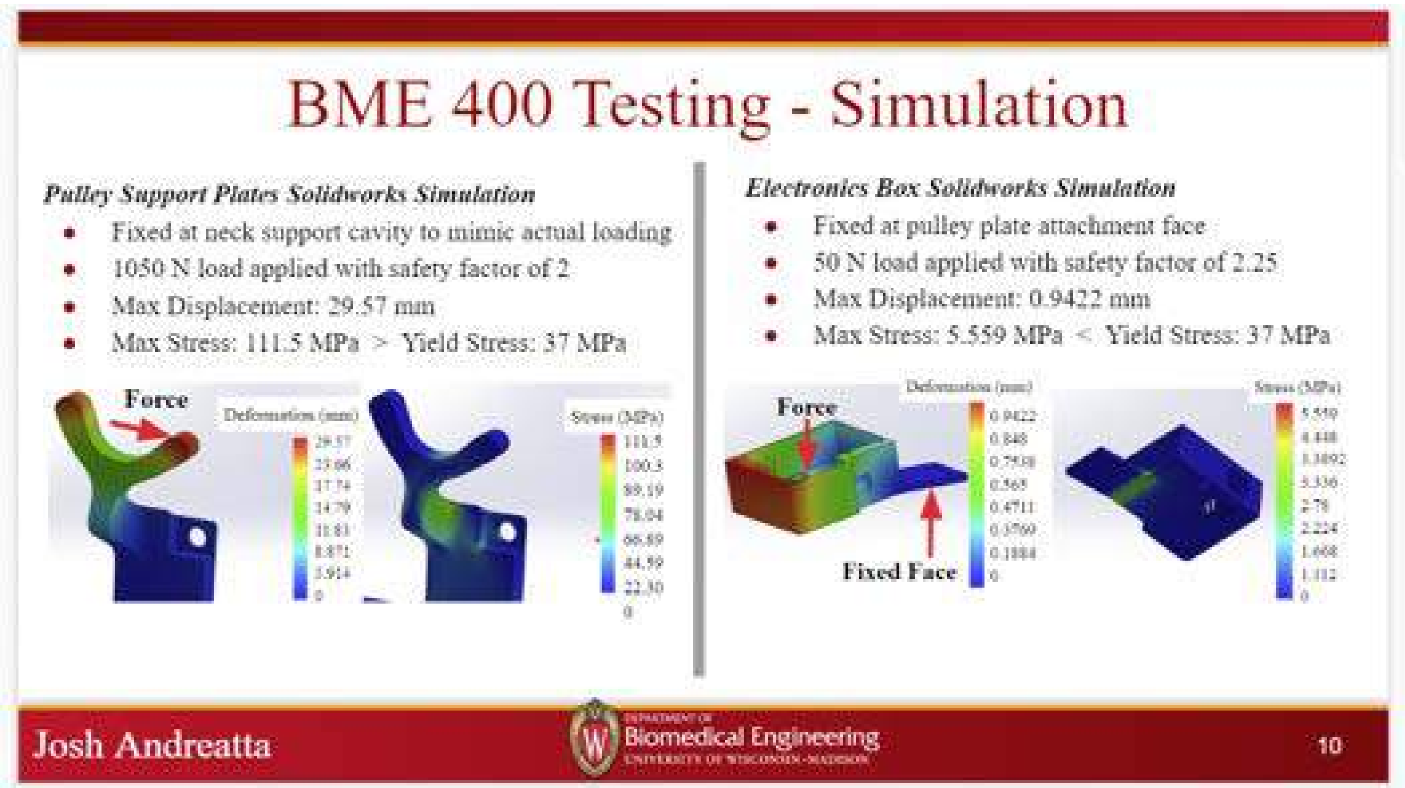
Date: 2/5/2023

Content by: Josh Andreatta

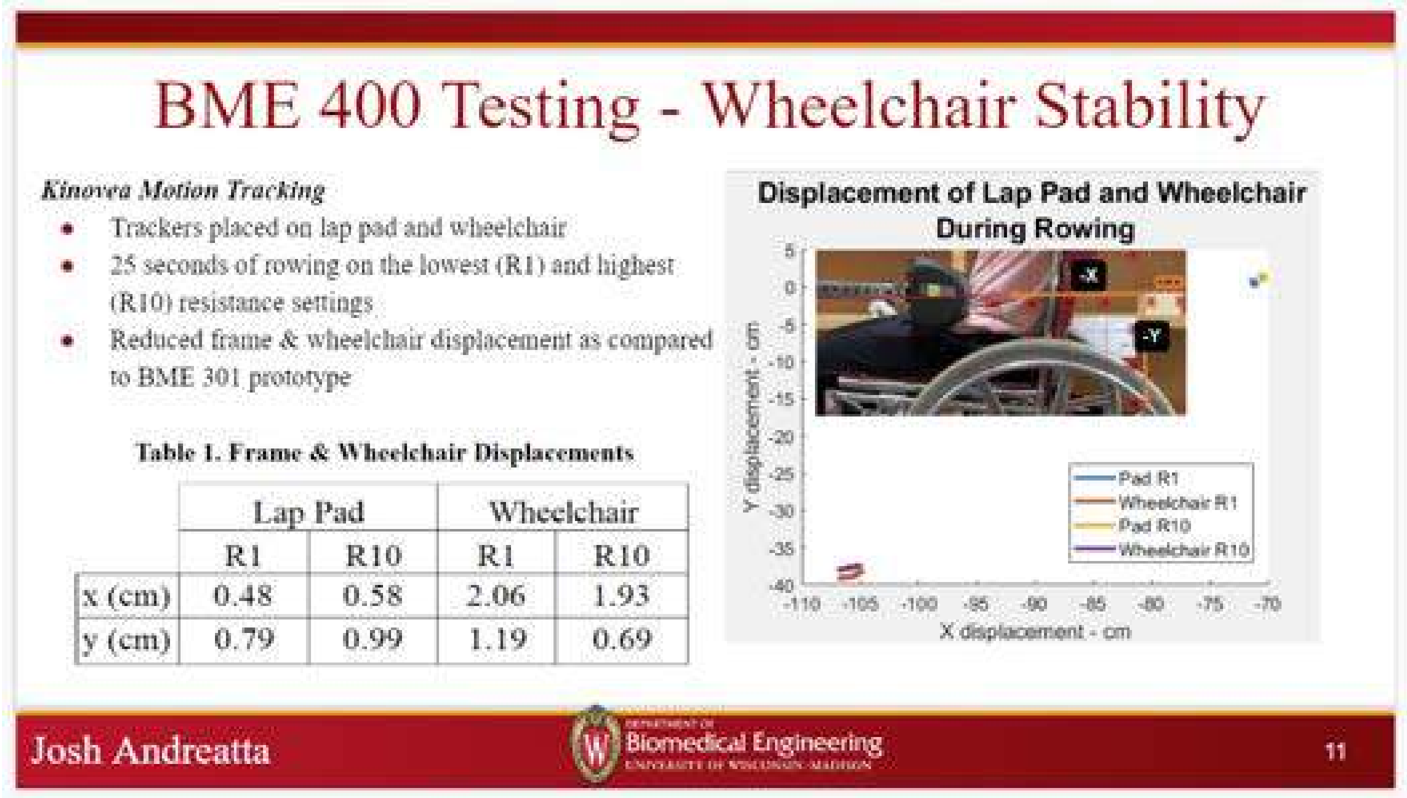
Present: Josh Andreatta

Goals: Show work for the prelim presentation slides

Content:



The above image shows the simulation testing slide.



The above image shows the wheelchair stabilization testing slide.

The above image shows the fabrication plan for Spring 2023 slide.

Script: "Thanks Annabel. Last semester, we assessed 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 proved that the antler is predicted to fail under this extreme of a load when modeled as Tough PLA.

Next, a similar test was run for the motor box. The box was held fixed on its lower 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 motor box was predicted to perform well under the expected conditions.

Lastly, we analyzed 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 graph, the frame & pad itself essentially did not move during the rowing motion at either resistance level, but the wheelchair did move slightly back and forth. Overall, this proved the success of the pad to keep the user and wheelchair grounded while rowing.

For this semester, we plan on upgrading a few of our existing components. First, we are going to split each pulley plate & antler into two separate pieces that will screw together. This will make it easier to fabricate out of metal at JHT, and improve the strength of this critical component. Next, we will confirm the screw hole placements for the components within the electronics box and then fabricate this out of metal at JHT as well. For the stabilization frame, we are going to switch out the current lap pad for a lesser width pad to fit within the arms of the wheelchair. We will replace the current bars with non-perforated hollow bars and then weld the assembly at JHT. Lastly, we plan on developing an initial prototype to change the resistance level from both the standard and adaptive sides of the rower. Currently, we are developing designs that will place a stepper motor within the plastic housing of the flywheel. We will then attach the rotating magnets to the stepper motor and develop a user interface via an arduino to control how much the stepper motor rotates, and thus, how much the magnets rotate to change the resistance. We also would like to incorporate an LCD on each side of the rower to show the current resistance level. Next, sam will discuss our plan for testing."

References: n/a

Conclusions:

See above slides and script.

Action items:

-Email Staci to ask about journal suggestions/does she want to be an author

-Send out IRB documents to the IRB contact

-Meet with team to edit presentation on ? Wait for response from Tracy. Meet Thursday at 5-5:30 ish to practice presentation on zoom

-Work on SolidWorks updates to Pulley Plates and Antlers

-Practice prelim presentation script

2/26/2023 - Prelim Journal Article Draft Work

Josh ANDREATTA - Feb 26, 2023, 9:35 AM CST

Title: 2/26/2023 - Prelim Journal Article Draft Work

Date: 2/26/2023

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show my work for the prelim journal article draft

Content:

My sections for the Prelim Journal Article Draft were to create and organize the appendices for BME 301 and BME 400 content that is not directly mentioned in the article. I also was responsible for making an Appendix detailing the changes that I have made to the pulley plates and antlers. This appendix walks through the initial change of creating a two-piece design, talks about its drawbacks, and then discusses the most recent design where the part is one piece again, but thinned to be a uniform thickness. I also was responsible for writing the portion of the resistance dial mechanism appendix that details how the stepper motor will interface with the magnet housing and how everything will be rigidly attached to the rower itself. I have detailed my thoughts on this in my Design Ideas folder, and I just summarized my design thoughts in this appendix. No CAD models have been made yet, because Staci only sent us the required part files on Friday afternoon and I have been working to finish the updates the pulley plate and antler design as a higher priority. Below is the order of the appendices that I created, organized, and wrote. Within each appendix, I re-numbered the figures and added any references that were required.

The above image shows the list of appendices I developed.

References: n/a

Conclusions:

I will edit the report with the team on Monday evening and make sure it is ready for submission.

Action items:

-Edit report with team on Monday evening (time TBD)

-SolidWorks continue (plates/antlers & resistance dial mechanism)

2/27/2023 - Thoughts on First Half of Semester Progress

Josh ANDREATTA - Feb 27, 2023, 7:45 PM CST

Title: 2/27/2023 - Thoughts on First Half of Semester Progress

Date: 2/27/2023

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Write down my thoughts about our first half of semester progress

Content:

I think that this has been a really productive first half of the semester for us so far. Our team has worked very well together again and did so in teams like we did last semester. This has allowed us to accomplish more tasks and do so quicker. Tim, Annabel, and Roxi have come up with code and a list of materials needed for the resistance dial mechanism. Sam and I have brainstormed an initial design idea for the resistance dial mechanism and how it will work. However, we have not begun to model it, but this is my next direct focus. My main priority up to this point was improving and updating the CAD for the Pulley Plates and Antlers so that JHT can begin to make them out of metal. This was the most important change and so I wanted to make sure it got done first. I think we are almost ready for JHT to begin fabrication and so I can start on the modeling of the resistance dial mechanism. Additionally, sam has made CAD models for updates to the stabilization frame and has been working with Tim to develop a plan to implement those changes and weld together the assembly. Along with our design improvements, we have come up with a date and activity for outreach. Prior to spring break, we are going to confirm our shopping list and date, and make our slides and do the activity ourselves. Then, after spring break, we can focus on prototyping the resistance dial mechanism, completing outreach, and recruiting wheelchair users for our in person testing (we are still waiting to hear back from the IRB). We already have our testing protocols and testing plan ready so we are ahead of the game when it comes time to test. JHT may make our electronics housing out of metal, but it seems like we will most likely stick with a 3D printed version for this semester (the main thing to make out of metal was the pulley plates and antlers.

By breaking ourselves up into teams that focus on different aspects of the project, we have been able to tackle and accomplish improvements for the project across almost every single aspect of the project. I think that we have continued to work well together as a team during our team meetings. We are very productive, efficient, and open-minded. We are working at a good pace to get everything done in time for presentations at the end of the semester and our quality of work continues to be very good. I am proud of the way our team has been functioning and the work we have done so far this semester. Below are my goals for before and after spring break:

Before Spring Break, I would like to:

- Have a rough model of the resistance dial mechanism modeled in SolidWorks (maybe print if I have time?)
- Have team confirm our outreach date, materials list, make slides, and practice activity
- Confirm that the pulley plates have started to be made at JHT
- Reach out to Dr. Wille about EMG testing and wheelchair users

After Spring Break, I would like to (do and help out with):

- Finalize resistance mechanism model and integrate with electronics on rower
- Finalize electronics box(es) and integrate with rower
- Complete outreach activity
- Conduct EMG and survey testing
- Conduct letting handlebar go testing
- Final Deliverables

Other members of the team will (I will of course help if needed, but my sub-team tasks are specifically the ones above):

- Make improvements to stabilization frame (trim down lap pad, implement pin mechanism, weld at JHT)
- Work on electronics for resistance dial mechanism
- Also help out with final testing and deliverables and outreach

References: n/a

Conclusions:

Overall this has been a great start to the semester. We have made tremendous progress across all aspects of our project and we have put ourselves in a good position to have a great product by the end of the semester. We are excited to keep going!

Action items:

-Continue work on CAD (resistance dial mechanism & pulley plate/antler design and simulation, and eventually updating the electronics housing)

-Create slides and practice activity for outreach before spring break

-Make sure we have details for outreach(required items, approval of when we are going) before spring break

3/24/23 - Update to Resistance Dial Appendix

Josh ANDREATTA - Mar 24, 2023, 11:32 AM CDT

Title: 3/24/23 - Update to Resistance Dial Appendix

Date: 3/24/23

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show updated resistance dial appendix.

Content:

Assembly Integration with Matrix Rower

The stepper motor and associated housing will be placed within the plastic housing that contains all the internal components of the rower (flywheel, rope, supports, etc.). The resistance level changes by rotating a pair of magnets around the internal flywheel of the rower. When the magnets have increased overlap with the flywheel, it produces more Eddy currents which increases the resulting resistance felt by the user while rowing. As long as the magnets can rotate about the flywheel to the same degree that they rotate in their current position within the rower, the same resistance levels can be achieved. Given this fact, the proposed design includes moving the magnets to a location within the plastic housing of the rower that has room to fit the stepper motor. Currently, the proposed design aims to move the magnets to the base of the rower and screw in the stepper motor to the rigid base. This will be done by simply unscrewing the current housing of the magnets from the two angled support bars (**Figure 4**), flipping it 180°, and re-screwing it into the same two angle support bars, but near the base of the rower (**Figure 5**). Prior to unscrewing the magnet housing, a calibration will be done to determine how much the magnets rotate between each change in resistance level. Given this degree of rotation, the stepper motor can be calibrated to produce the same amount of rotation once connected with the magnet housing.

Figure 4. Current location of magnet housing. The magnet housing is currently screwed into the support portion of the two angled support bars that are within the plastic housing of the rower. The housing is one large piece of plastic that rotates about the central bolt shown above. The proposed resistance dial mechanism will keep this entire structure intact, but move it to another location within the inside of the rower.

Figure 5. Proposed location of magnet housing. The proposed resistance dial design will aim to move the location of the magnet housing to a location where there is enough space to add a stepper motor. In the above figure, the magnet housing would be flipped 180° and screwed into the two angled support bars where the line is drawn connecting them. The stepper motor will be screwed into the side of the angled bar and the associated electronics box will be placed flat on the ground.

To physically attach the magnet housing to the stepper motor, a mechanism was developed that fits between the shaft of the stepper motor and the bolt through hole in the magnet housing (**Figure 6**). The bolt through hole is the magnet housing's rotation point. To keep this same rotation point, the mechanism connects this region to the stepper motor. To simplify the design, this connector piece mimics that bolt that was already in place. On one end, the component has a press-fit cavity that fits on the D-shaft of the stepper motor. On the other end, threads were 3D printed on the component to allow us to still tighten the connector to the magnet housing using the washer and nut that were previously used with the bolt. Next, a housing chamber was developed to hold the stepper motor in place (**Figure 7**). This small piece has a cavity that the stepper motor can sit in and holes to allow it to be screwed in place. There are two holes on the bottom extension that will be used to rigidly screw this piece into the side of the angled bar. This will make sure that the magnet housing stays rigidly connected to the stepper motor and that the stepper motor housing is rigidly connected to the rower frame itself. Then, whenever the stepper motor rotates, it will rotate the magnet housing, thus rotating the magnets about the flywheel and changing the resistance. The last component of the design is a structure to hold all the electronics, similar to the motor box that was designed for console rotation. This box was designed to simply sit flat on the floor (**Figure 8**). This new electronics box will hold both the electronics for the resistance dial mechanism and those for console rotation. Due to spatial limitations near the base of the rower, it was easier to have this box be freely-floating on the ground, rather than screwed into some random connection point on the rower base. This box has a hole in the front and back walls to allow for threading of wires to the stepper motor for the resistance dial mechanism and to the stepper motor for console rotation. Because this new box holds all electrical components (except the stepper motors), the console rotation electronics box will only contain the stepper motor and console. Therefore, this box was updated to only have the cavity for the stepper motor (**Figure 9**). The final component designed was a small encasement to hold the two LCD displays that show which resistance level the machine is currently set at. This component includes a base tray that the display can rest in, and a cover that sits on top to enclose the electronics included on the solder board (**Figure 10**). To attach together, the screw holes on the solder board will be tapped out on both the base and cover and all 3 pieces will be sandwiched and screwed together. ***Input pictures of final PRINTED versions next*.**

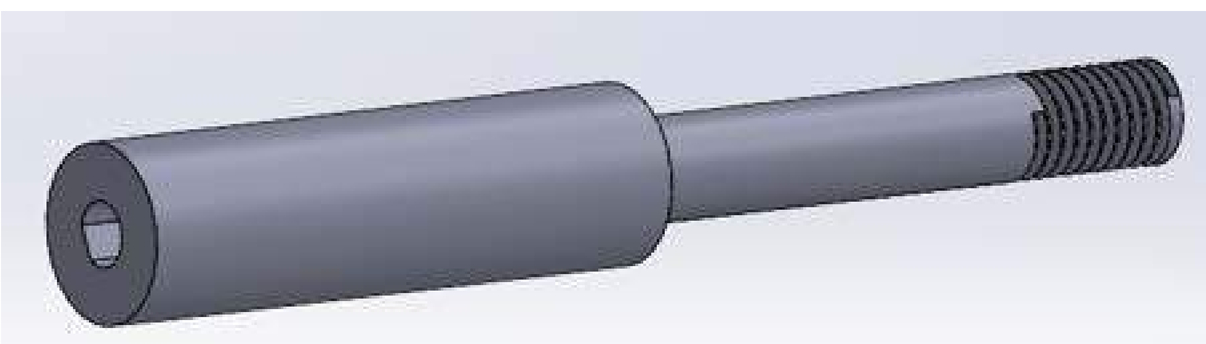


Figure 6. Stepper Motor - Magnet Housing Connection. The connector includes a press-fit cavity to fit on the D-shaft of the stepper motor, and 3D printed threads that allow for attachment to the magnet housing. This connector will allow the stepper motor to rotate the magnet housing to change the resistance level.

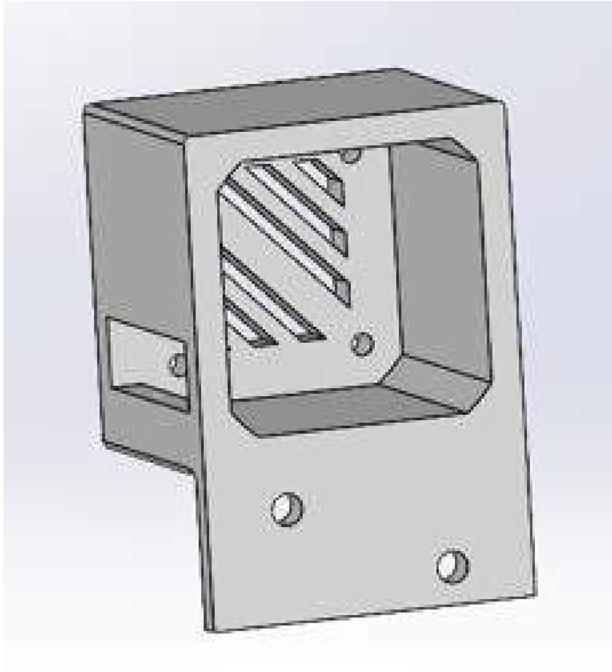


Figure 7. Stepper Motor Housing. The stepper motor housing will allow for the stepper motor to be screwed into the housing. Additionally, two holes on the lower extension will be used to screw this piece into the side of the angled bar in the rower frame to hold the entire structure rigidly in place. Thus, whenever the shaft rotates, the motor will not rotate with the shaft.

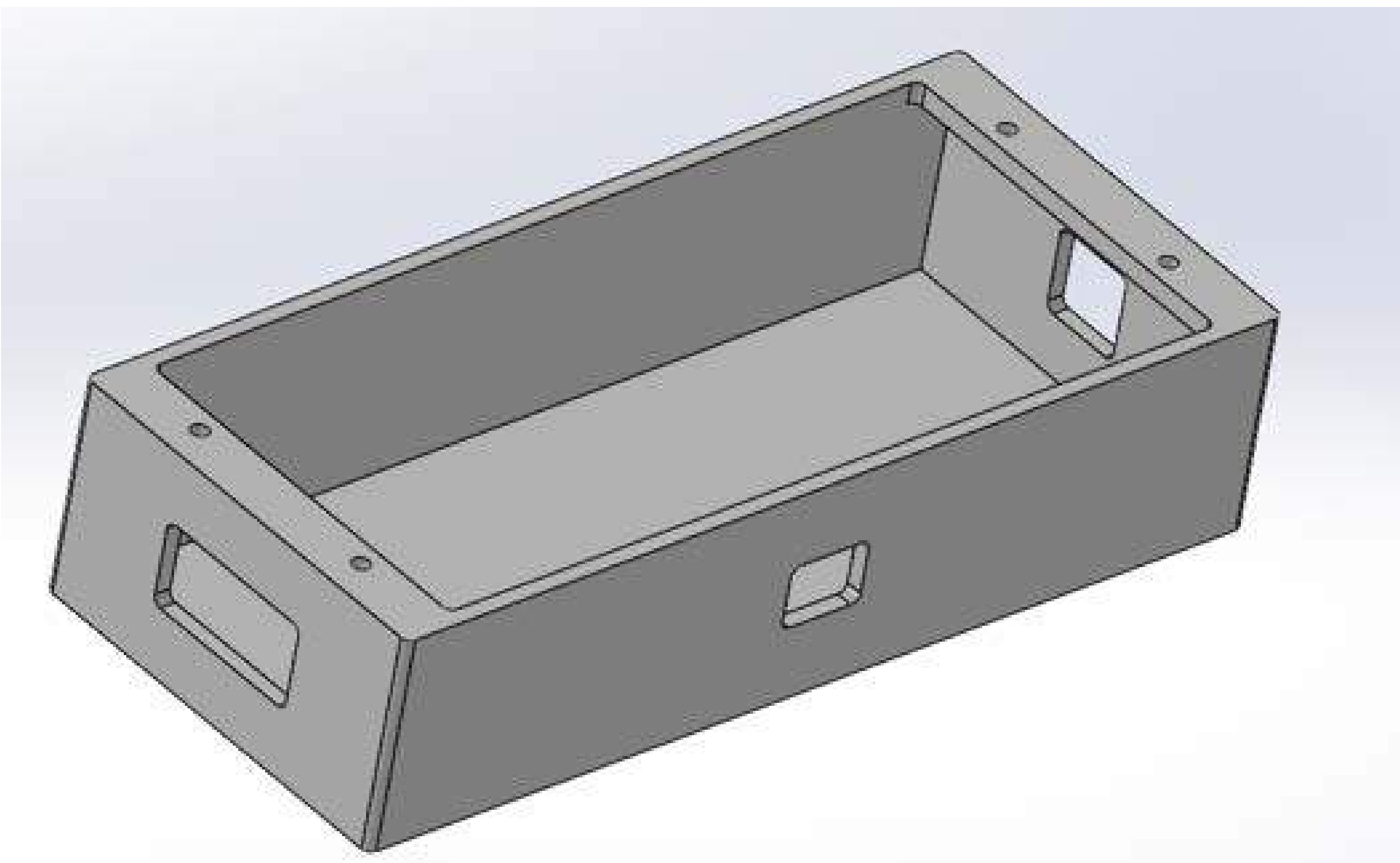


Figure 8. Electronics Box. The electronics box will include the Arduino Mega and the motor controller. It has holes on the front and back walls for wires to be thread in and out of. There is also a side hole to allow for easy access to the power supply cord. This box will sit flat on the ground near the rower base.

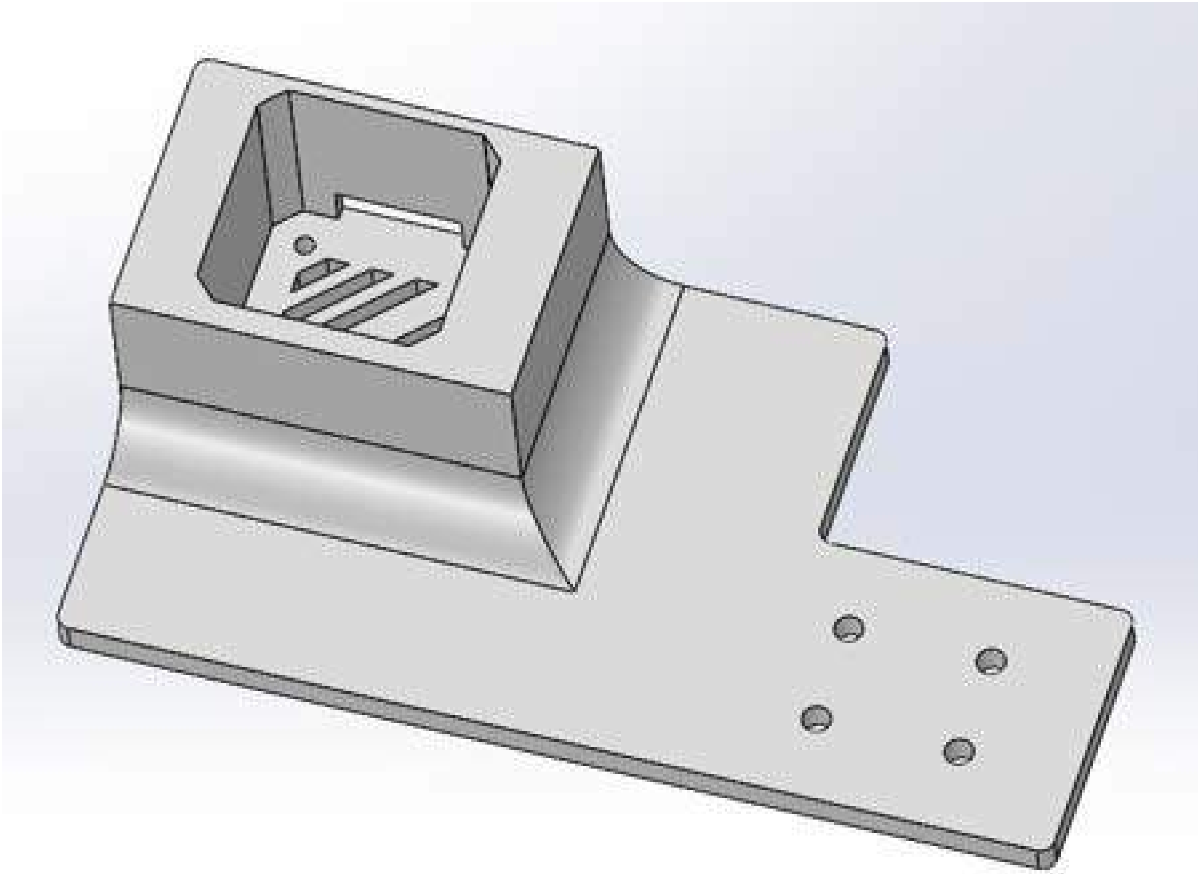


Figure 9. Updated Console Rotation Box. The updated console rotation box only includes a cavity for the stepper motor to sit in and be screwed in place. Since the arduino and motor controller were moved to the electronics box at the rower base, their cavities were removed from this box.

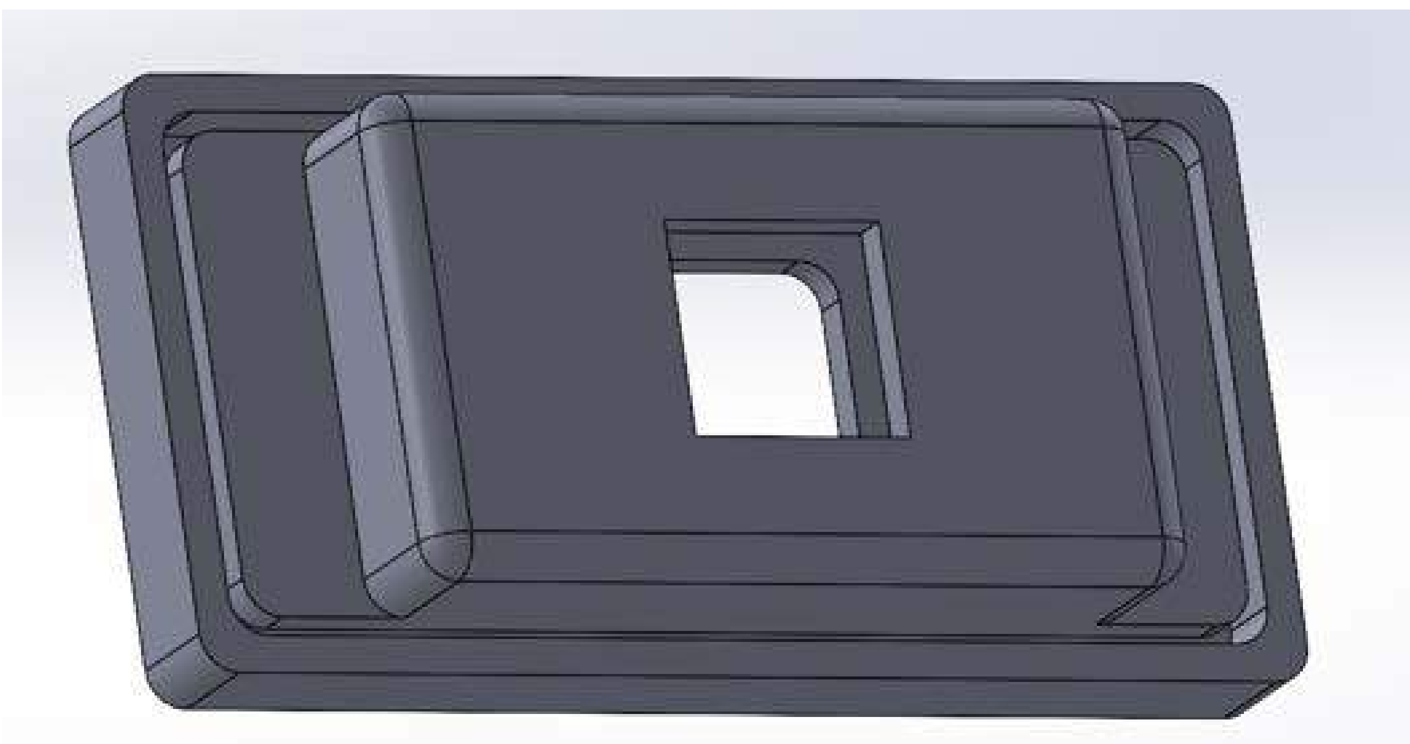


Figure 10. LCD Display Assembly. The LCD display assembly includes a base plate for the solder board to sit on, and a cover to enclose the open resistors. There is a hole on the top to allow visibility of the LCD display itself.

References: n/a

Conclusions:

I updated the resistance dial appendix with the CAD images of the components of the mechanism and the electronics boxes. Once these are printed, I will add a section that shows their physical components integrated with the rest of the rower.

Action items:

-Test!

4/22/23 - Rough Draft of Design Excellence Script

Josh ANDREATTA - Apr 22, 2023, 9:18 PM CDT

Title: 4/22/23 - Rough Draft of Design Excellence Script

Date: 4/22/23

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Develop a rough draft of my design excellence script

Content:

Thanks Roxi! As you can see here, over the course of our 3 semesters on this project, we have iterated the mechanical components of our design several times. One of the main components is the pulley plate and antlers. This structure allows users to be able to row from both the standard and adaptive sides of the machine. In the very beginning, the design included the rower neck with a cut made in the side that would allow for users to manually move the rope to row from the adaptive side via a second pulley that was held in place by these 2 3D printed plates. Next, that design was transformed into what we call the antlers, which centrally locates the handlebar to a convenient place for users to access from both sides of the rower. After lots of iteration on the geometry and strength of this part through several 3D prints and simulation analysis, we worked with JHT to make a final version out of stainless steel. The next main component of the design is our stabilization frame. In order to prohibit any movement of users on the adaptive side, we needed to make a structure that could hold them securely and safely in place. In BME 301, we developed this wooden structure that users would strap themselves into. Last semester, we greatly improved this design by incorporating this prototype of a lap pad that could be lowered onto a users lap to secure them. After lots of design improvements, we again worked with JHT to fabricate our final stabilization frame out of stainless steel. This adjustable frame can safely prohibit movement of a wide variety of sizes of both users and wheelchairs. In addition to these core structures, we also made several advancements to the rower that automate several previously manually controlled parts of the rowing experience. Next, annabel will touch on the automation of our rower.

References: n/a

Conclusions:

Practice this with the team and memorize

Action items:

-Practice with the team and memorize

-Make and edit testing section of the poster and associated script

-Edit poster with team on monday

4/23/23 - Poster Sections & Script

Josh ANDREATTA - Apr 23, 2023, 8:55 PM CDT

Title: 4/23/23 - Poster Sections & Script

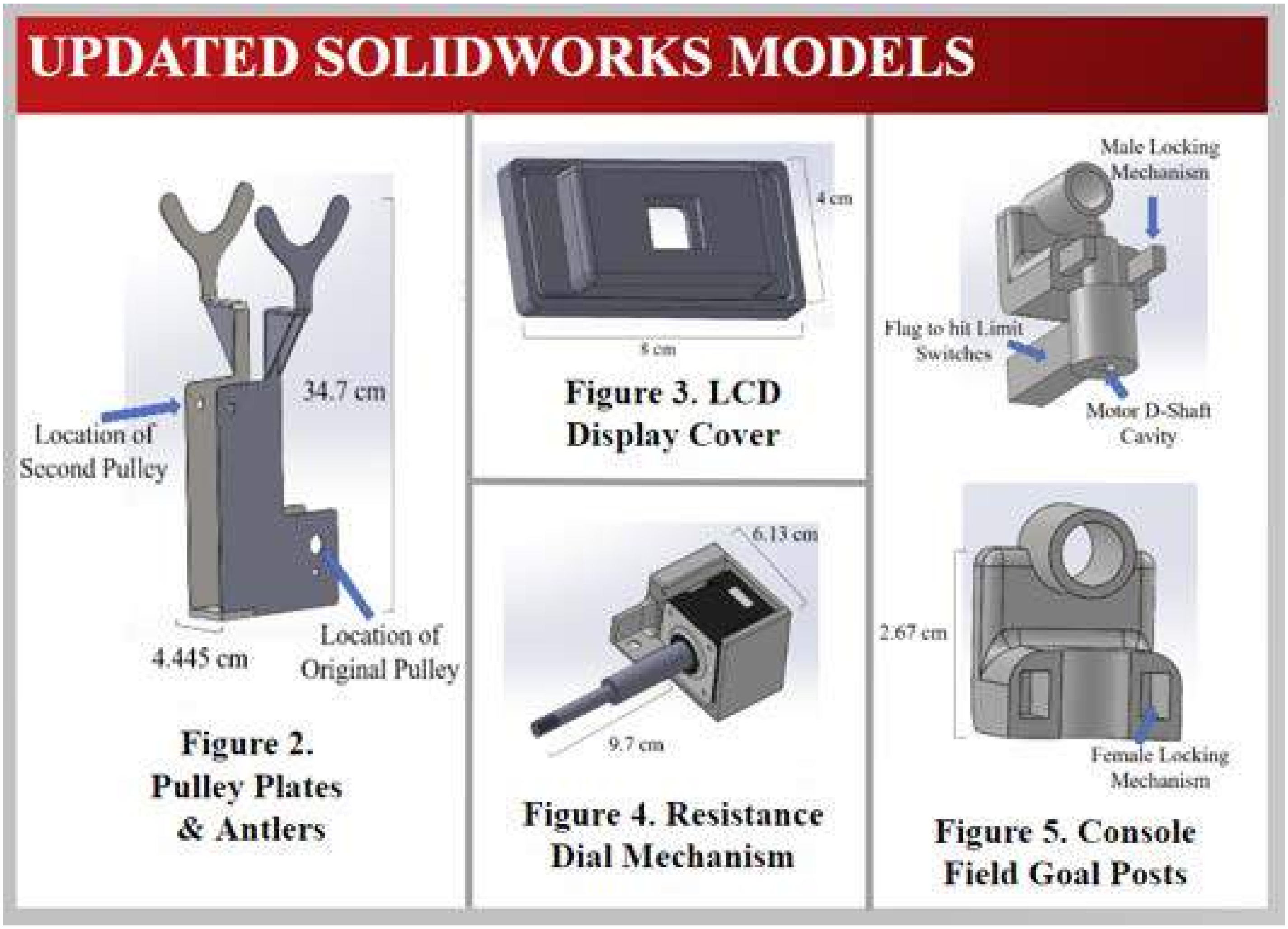
Date: 4/23/23

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show poster sections I made and my script for the presentation

Content:



The above image shows the CAD portion of the poster with updated/new models.

TESTING & RESULTS

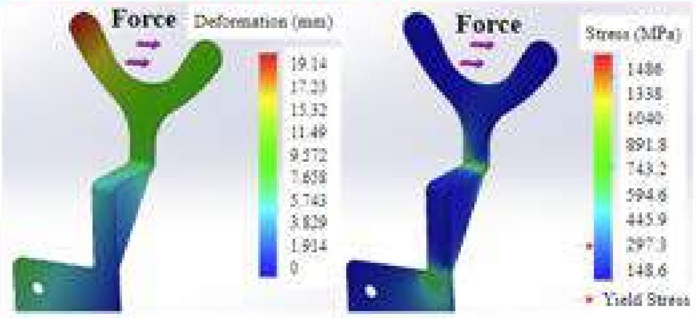


Figure 8. Antler Simulation Testing

- Fixed at neck support cavity to mimic actual loading
- 400 N load applied with safety factor of 2
- Max Displacement: 19.14 mm
- Max Stress: 891.8 MPa > Yield Stress: 220.6 MPa

Standard and Adaptive Side Survey Results (Testing Participants without Physical Disabilities)	
Standard Side	**Average Score (Out of 5)**
Overall Ease of Use	4.22
Overall Safety	4.8
Comfort	4.6
Adaptive Side	**Average Score (Out of 5)**
Overall Ease of Use	4.7
Overall Safety	4.75
Comfort	4.5
Standard and Adaptive Comparison	**Average Score (Out of 5)**
Workout Comparability	4.38
Console Use and Transition	4.89
Likelihood of Future Use	4.9
Ease of Resistance Adjustment	4.5

Adaptive Side Only Survey Results (Testing Participants with Physical Disabilities)	
Adaptive Side	**Average Score (Out of 5)**
Overall Ease of Use	4.8
Overall Safety	4.83
Comfort	4.33
Likelihood of Future Use	4.67

- Suggestions
  - Move console & buttons closer
  - Add more lap pad adjustment levels

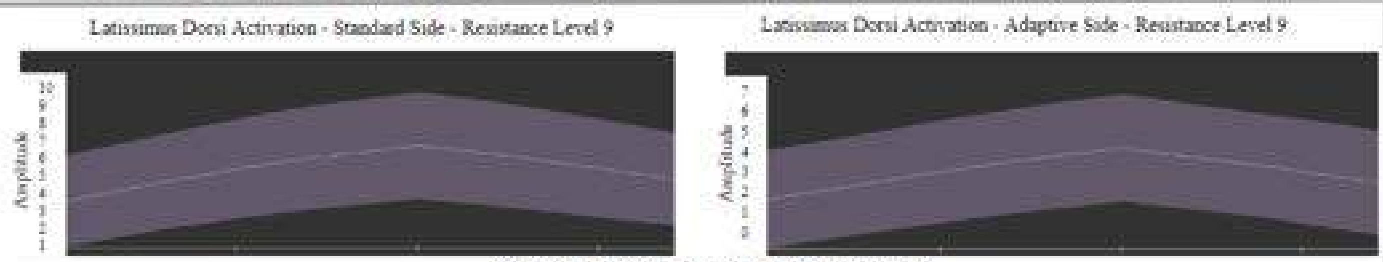


Figure 9. EMG Testing & Comparison

- EMG data was recorded on the biceps, rear deltoids, and latissimus dorsi on the standard and adaptive sides at resistance levels 1, 3, 5, 7, and 9
- No major difference in the activation profiles for the biceps or rear deltoid
- The latissimus dorsi had slightly increased activation levels on the standard side compared to the adaptive side

The above image shows the testing portion of the poster, which includes CAD simulation, EMG, and the survey.

Script: Thanks Annabel! To analyze the strength and geometry of our finalized pulley plate and antlers, we conducted a SolidWorks simulation of the final plates modeled as Plain Carbon Steel. Compared to previous semesters where a 1050 N load was used, this semester, we used loads that were more representative of a practical use-case. From our rope tension testing data done in BME 301, we found that the maximum force generated while rowing from the standard and adaptive sides never surpassed 400 and 300 N respectively. Thus, we used these loads to conduct our final simulations with a safety factor of 2. As shown in the worst case loading scenario, which is the 400 N load applied toward the standard side, the max displacement was roughly 2 cm with a max stress larger than that of the yield stress. Despite these slightly large stresses and deformations, the safety factor of 2 and reality that these extreme loads are unlikely to occur during an actual workout led us to be confident in the performance of this final design.

Next, after receiving IRB approval, we conducted EMG testing on ourselves. To do this, we used an EMG machine to record the level of muscle activation of the biceps, rear deltoids, and latissimus dorsi while rowing on both sides of the machine at resistance levels 1,3,5,7, and 9. Overall, we saw that there was comparable levels of activation between each side for respective resistance levels for the biceps and deltoid. The lats showed a slightly higher level of activation on the standard side. These findings make sense because the use of the arms is relatively the same on both sides, but the back muscles are likely used more on the standard side since users bend over when they flex and extend their legs, which results in a higher level of activation.

Finally, we conducted human subject testing in which several people used our machine and filled out a survey rating their experience. In total, we had 11 people use both sides of the machine, and 3 people only use the adaptive side. The main suggestions for improvement that we got were to move the console and resistance buttons closer to the user on each side for those with shorter arms, and to add more adjustment levels on the lap pad to account for slight differences in user heights. Overall, everybody really enjoyed their experience and had very few issues using the machine. Next, Roxi will talk about our discussion.

References: n/a

Conclusions:

See above

Action items:

-Edit poster with team monday night, then send to tracy for final edits, print wednesday, practice thursday night at 9pm in ECB

-Practice my poster and design excellence scripts

5/1/2023 - Final BME Design Thoughts

Josh ANDREATTA - May 01, 2023, 10:38 PM CDT

Title: 5/1/2023 - Final BME Design Thoughts

Date: 5/1/2023

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Write my final semester and design thoughts

Content:

Throughout my time in design, I have learned so much. I particularly enjoyed the last 3 semesters working on the adaptive rowing project. It was so great to be able to work on a project for such a long time and really see it evolve. This semester, I feel that our team accomplished every single thing that we wanted. We were able to make the pulley plates and antlers and the stabilization frame out of steel with JHT. Additionally, we were able to create the entire resistance mechanism and get it to properly function from both sides of the machine. We made several design iterations throughout the semester and greatly improved our design from where we started in January. We also conducted all the testing we wanted. This included simulations, EMG testing, and human subject testing. We worked very hard to get IRB approval that allowed us to conduct all of our human subject testing. This really helped us analyze our design. I feel that we worked very well in our subteams again. By splitting up the work between the plates and antlers, the stabilization frame, and the CAD and code of the resistance mechanism, we all had enough to work on at a steady pace. I am super proud of our final design and how it functions. The next step is to determine the next steps for us and the project. This will be one of several options including donating the machine to a local gym/user, JHT taking the machine to mass manufacture, or us working with ourselves and/or JHT to patent the device. We will figure out what exactly we want to achieve this week in our final semester meetings. Overall, this was a great learning experience and I can't wait to see where the project moves forward from here!

References: n/a

Conclusions:

Please see above.

Action items:

-Submit all final deliverables

-Determine team next steps for the project

1/27/2023 - Josh's Early Semester Plans

Josh ANDREATTA - Feb 08, 2023, 4:38 PM CST

Title: 1/27/2023 - Josh's Early Semester Plans

Date: 1/27/2023

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Describe my goals for the beginning of the semester

Content:

At the start of the semester the team is focusing on completing all of the necessary documents for our testing plans. I helped by drafting the protocol for wheelchair users using the adaptive side of the rower (this will be added later to the notebook once edited and finalized). Next, we are meeting as a team to see what other documents need to be created for the IRB application. We will then edit the documents and submit the application hopefully by the end of next week. Today when we meet with Dr. Puccinelli, I want to go over the following things:

- Update on plans for outreach activity (have available days already!)
- Question regarding necessity for EMG testing or just have wheelchair user complete the tension testing again (or motion capture)
- Update on fabrication plans
    - I will update pulley plates and antlers to be more manufacturable (less material and split into two parts). Then, JHT will fabricate out of metal
    - JHT will fabricate motor box out of metal
        - We still need to finalize hole placements and wait to see if the box changes based on the resistance dial mechanism
    - Staci said the only testing she wants us to do is the letting go of the handlebar and running simulations of final parts modeled as metal. There is no need for MTS testing!
- Sam and Tim update on frame welding plans (no pin mechanism, JHT will weld, Sam to update SolidWorks model)
- Update on thoughts on resistance dial mechanism
    - Either place directly at magnets locations or interact with pull wire

I will work with the team to finish completing our testing documents. Once this is done, I will edit the pulley plates and antlers to become more manufacturable. I will talk with staci to see what she thinks of the changes and ensure they are what we discussed today. Once this is done, I will send the final parts and drawings to JHT for them to fabricate out of metal. After this, I will turn my attention to helping design anything required for the chosen resistance dial mechanism. Sam and Tim will work on the updates to the stabilization frame, and roxi and annabel will help work on the resistance dial mechanism. Tim will also keep facilitating our outreach (which will most likely be done at mid-march).

References: n/a

Conclusions:

I will help the team finish our testing documents, and then work to finalize the antlers and pulley plates so they can be made out of metal.

Action items:

- **Meet with Dr. Puccinelli to go over above action items**
- **Meet with team afterwards to debrief and discuss next steps for testing application**
- **Complete assigned sections for testing plans/application**
- **Next week, begin work on SolidWorks updates**
- **Eventually, finalize resistance dial mechanism**

- **Eventually, reach out to places to find wheelchair users for human subjects testing**

2/8/2023 - Initial Change to Pulley Plates & Antlers Into Two Pieces

Josh ANDREATTA - Feb 08, 2023, 4:56 PM CST

Title: 2/8/2023 - Initial Change to Pulley Plates & Antlers Into Two Pieces

Date: 2/8/2023

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show my first changes to Pulley Plates & Antlers into separate pieces

Content:

Today I made the initial changes to the pulley plates and antlers to separate them into individual components that will be screwed together. First, I removed the upper back corner of the pulley plate to remove excess material. I also thinned the entire pulley plate by removing 0.22in material from the inner surface. I had to leave the original thickness at the top where the second pulley sits because we have a set number/thickness of washers that go between the second pulley and this inside surface of the plate. Next, I made the back separation block permanent in the plate so that it can just swing into and lock into the other plate (the other plate would have the front separation block permanent to swing into this plate). Next, I split the assembly into two parts: the plate and the antler. I made the antler such that it can fit flush into the plate as shown in the images below. This offers space to have 4 screws put in, 2 in the back face of the antler, and 2 in the side face of the antler/pulley plate. This ensures that we have 2 sets of orthogonal screws to prevent rotation in any direction. I also made the antler such that it is 1 inch taller as compared to the previous antler design (see image below). This was necessary because with the old antler design, you could not sit the console completely straight up (it had to lean slightly forward). With this extra inch of space, the console should be able to sit upright under the new antler. I have a list of questions I want to go over with Staci before I finalize the design. I did not insert any screw holes yet because I want to make the other large changes first, and only insert screw holes at the end once it is finished. Once me and Staci agree on a final manufacturable design, I will 3D print it at a very low infill just to confirm that the parts fit together well and fit on the rower well. Then, I will model them in SolidWorks as the metal staci wants to fabricate them out of. Then I will complete the simulation tests, and send her the parts for fabrication. Once complete, we will complete the physical test where we pull the handlebar and let it go and see what happens. Below are my questions to go over with Staci on Friday:

1. Do you know of any journals that this project would be a good entry for? Do you want to be included as an author?

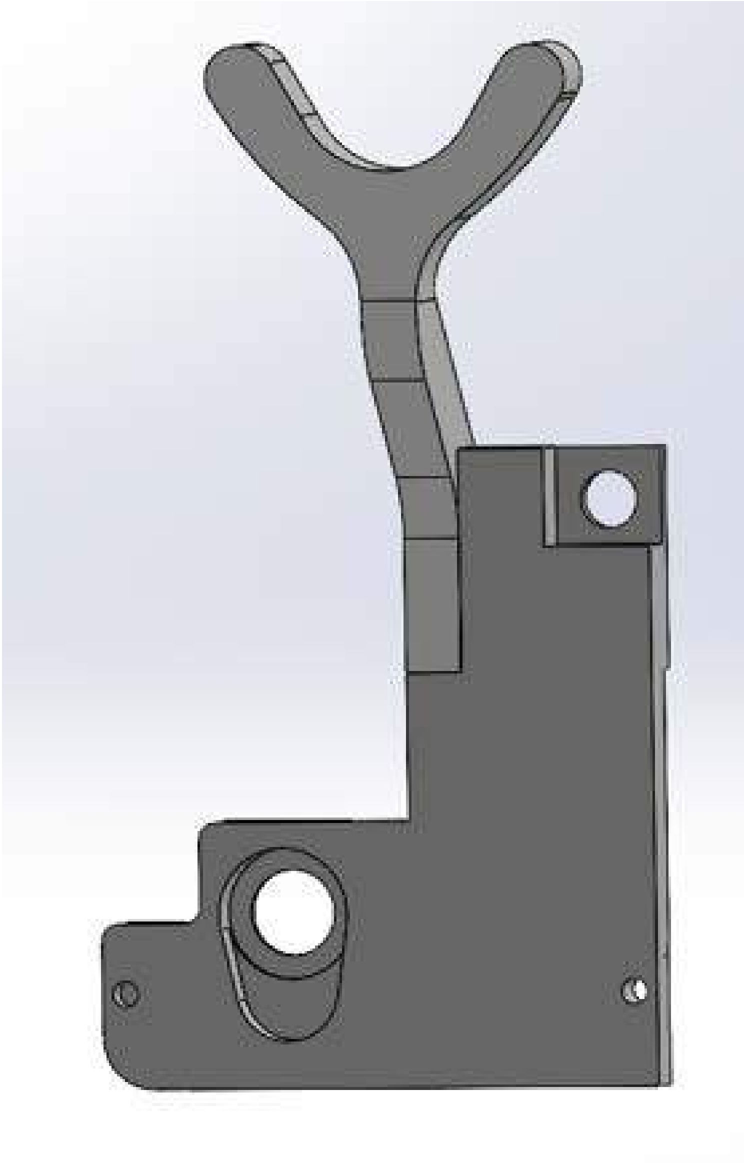
2. Thoughts on where I removed material/thickness? Should I do it in other places? There are limitations (i.e., screw holes under pulley plates).

3. Do you like the way the antler sits in the pulley plate? Slot idea? Which is easier to fabricate?

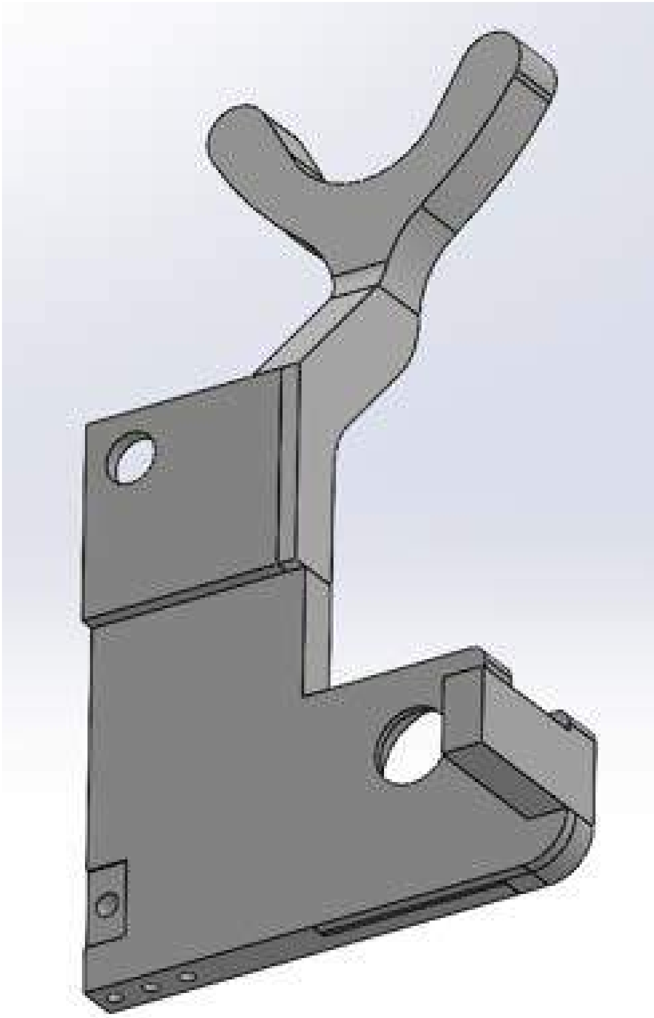
4. Are you okay with the step in thickness where the second pulley plate sits?

5. What metal will be used for fabrication?

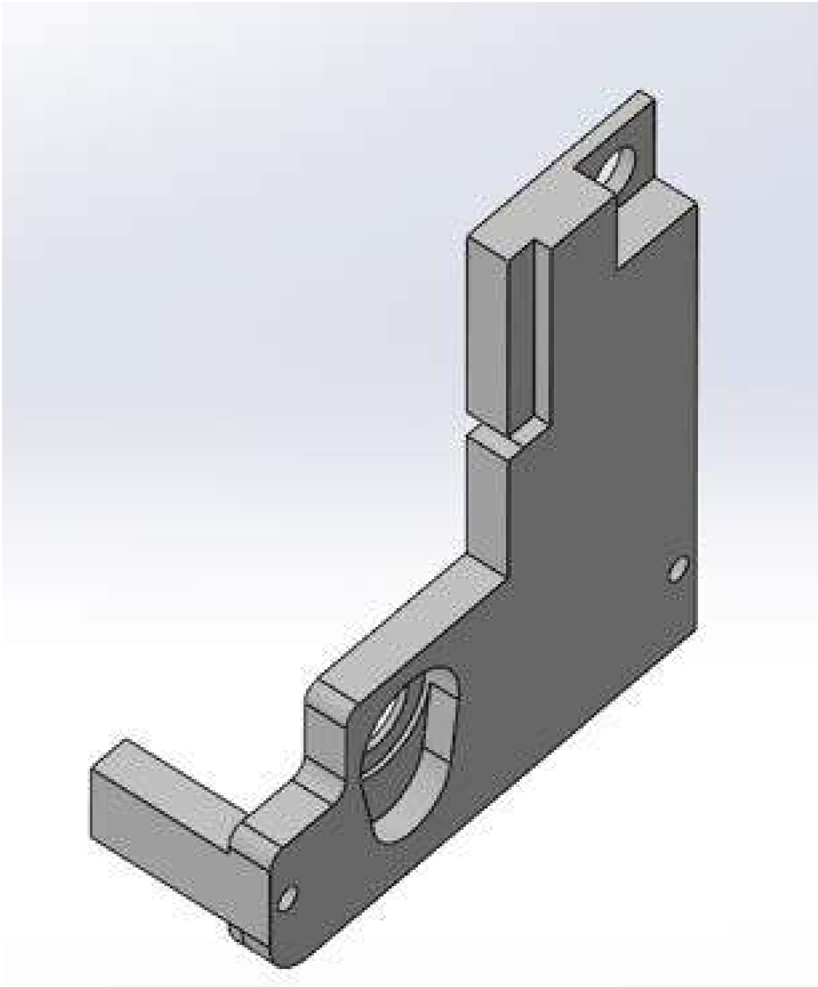
6. Do you agree with the 4 screw insertion plan?



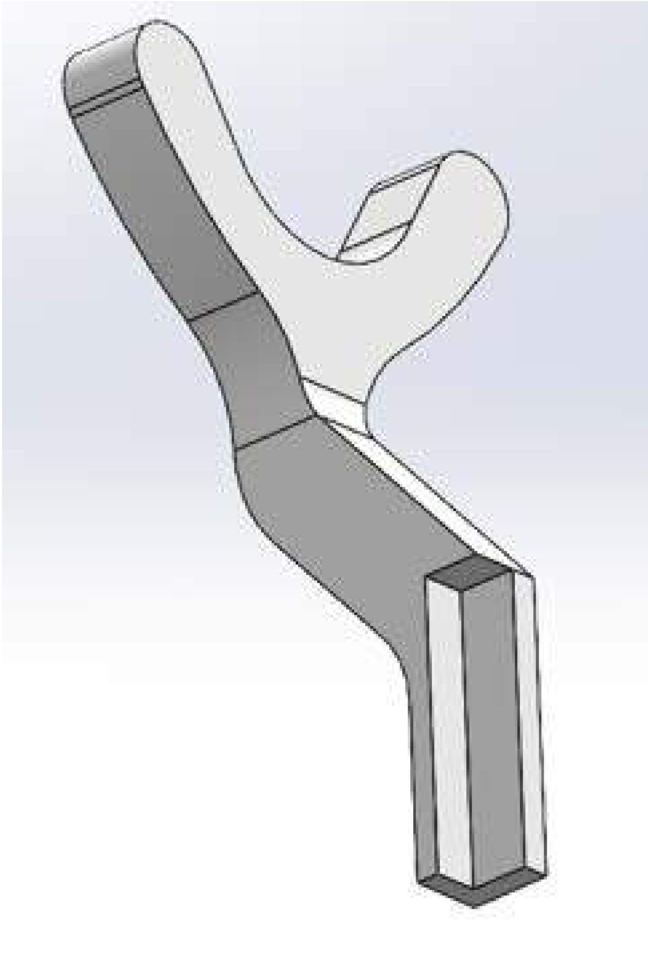
The above image shows the separated pulley plate and antler assembly front view.



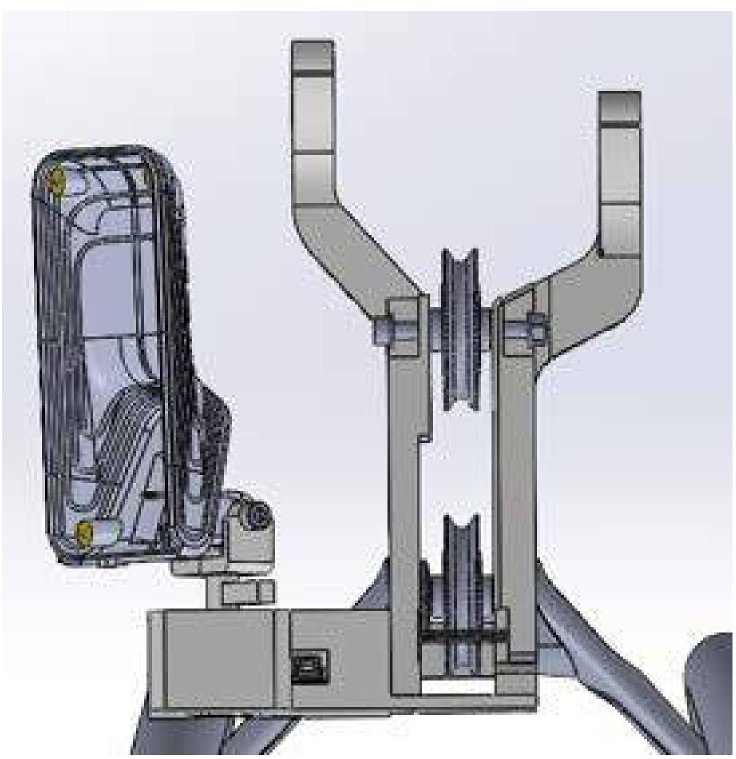
The above image shows the separated pulley plate and antler assembly back view.



The above image shows the separated pulley plate.



The above image shows the separated antler.



The above image shows the comparison between new (left) and old (right) pulley plate and antler assemblies.

References: n/a

Conclusions:

In our meeting with Staci on Friday, I will show her these and gather her feedback to the above questions. Based on her responses, I will make those changes. Once those are complete, I will check the models with her again. Once she agrees on a final design, I will make her drawings and send them to her for fabrication.

Action items:

-Practice prelim presentation script

-Meet with team Thursday at 5:35 to practice/edit prelim presentation

-Meet with Staci Friday at 1:35 for bi-weekly meeting

-Interview for story Friday at 2-3

-Make sure IRB stuff is submitted

-Continue work on Pulley Plate & Antler Adjustments

-Start work on Resistance Dial Mechanism

-Make sure we know who is in charge of organizing outreach next steps

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Josh ANDREATTA - Feb 08, 2023, 4:44 PM CST

Download

Left_Antler.SLDPRT (236 kB)

Josh ANDREATTA - Feb 08, 2023, 4:45 PM CST

Download

Left_Assembly.SLDASM (91.5 kB)

Josh ANDREATTA - Feb 08, 2023, 4:45 PM CST

Download

Left_Pulley_Plate.SLDPRT (625 kB)

2/12/2023 - Final Version of Separated Pulley Plates & Antlers for Metal Fabrication at JHT

Josh ANDREATTA - Feb 12, 2023, 11:36 AM CST

Title: 2/12/2023 - Final Version of Separated Pulley Plates & Antlers for Metal Fabrication at JHT

Date: 2/12/2023

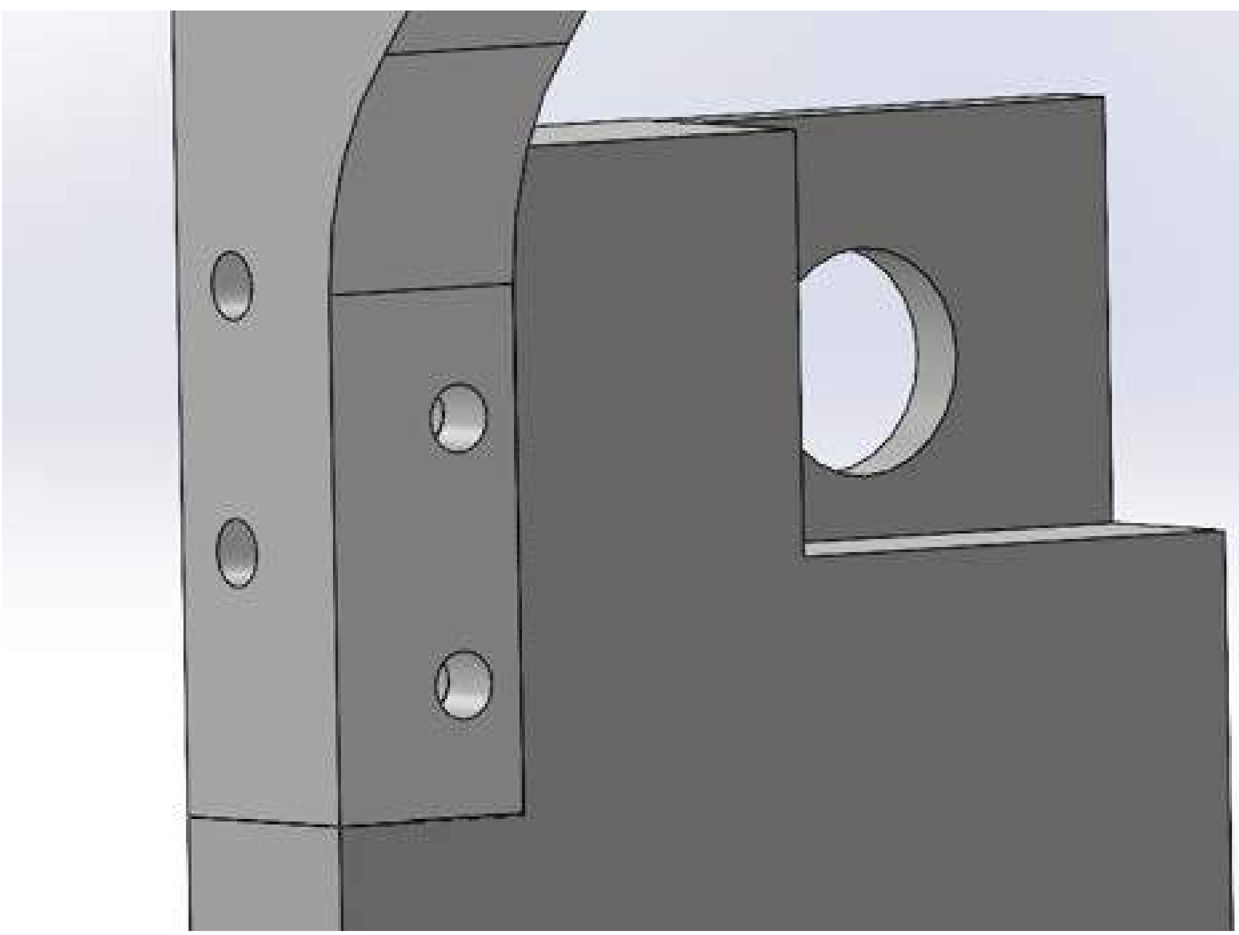
Content by: Josh Andreatta

Present: Josh Andreatta

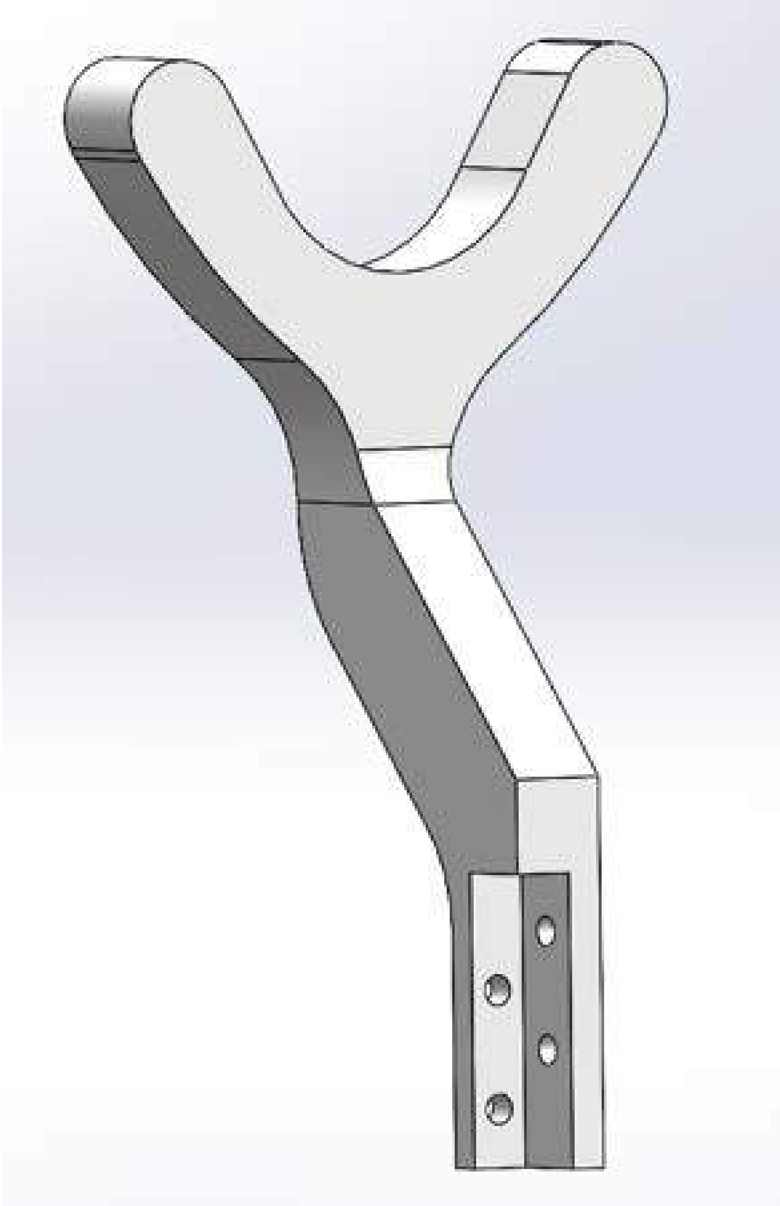
Goals: Add screw holes and triple check changes to parts before sending to Staci

Content:

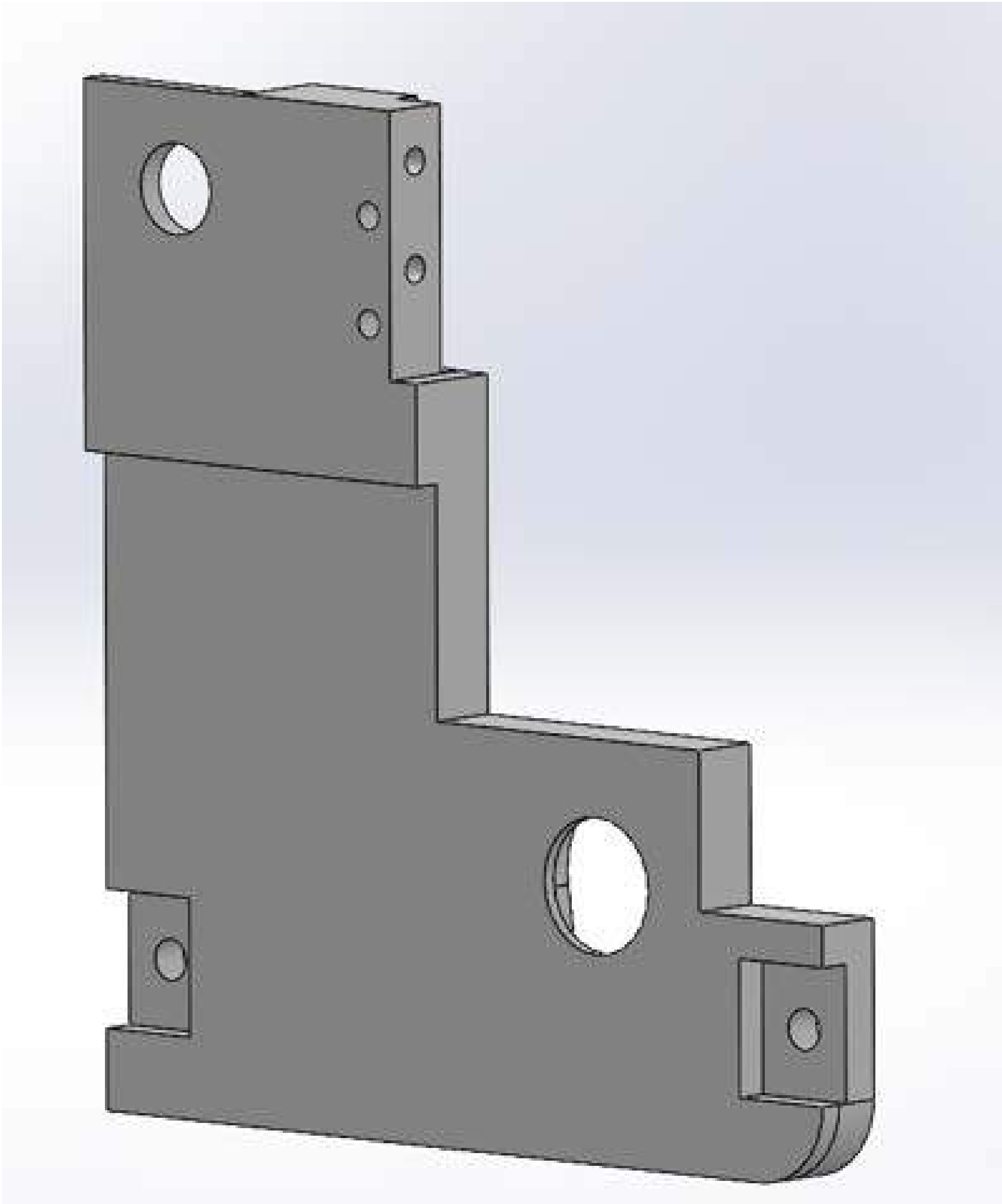
Today I finished making the changes to the pulley plates and antlers to make the separate pieces that can be screwed together and made out of metal. In our Friday meeting with Staci, she said she liked all the changes I made and didn't want me to change anything I did. Today, I double checked that all of the dimensions were correct, changes were made properly, and then lastly I added in the threaded screw holes for attaching the separated antler to the separated pulley plate. Once this was complete, I made a mirrored and linked version of the left side to easily construct the right side set of pieces. Finally, I adjusted the dimensions of the front and back separation blocks to ensure they would fit within the two pulley plates, and I made slight adjustments to the motor box to make sure that the holes for the front separation block and the holes for screwing the box into the bottom of the two pulley plates aligned. I sent Staci and email with all parts so she can begin fabrication out of metal on the right and left pulley plate and antlers, as well as the front and back separation blocks. As we continue to design a mechanism for the resistance dial (which will end up including some amount of electronics), I will need to discuss with the team if we want to merge the electronics for the console with those of the resistance dial. This will alter the overall electronics box, so I am waiting to finish that design until we know exactly what we plan on doing for the resistance mechanism. However, I did make the slight changes today to make sure the box is compatible with the final version of the pulley plates. Finally, after talking with the team on Friday, we decided it wouldn't hurt for me to make the antlers slightly taller than I did before. So today, I added another .75inches to make the total height between the second pulley and the top of the antler cavity around 6.25 inches, compared to the 4.5 inches from the BME 400 design. Below are pictures of the final design.



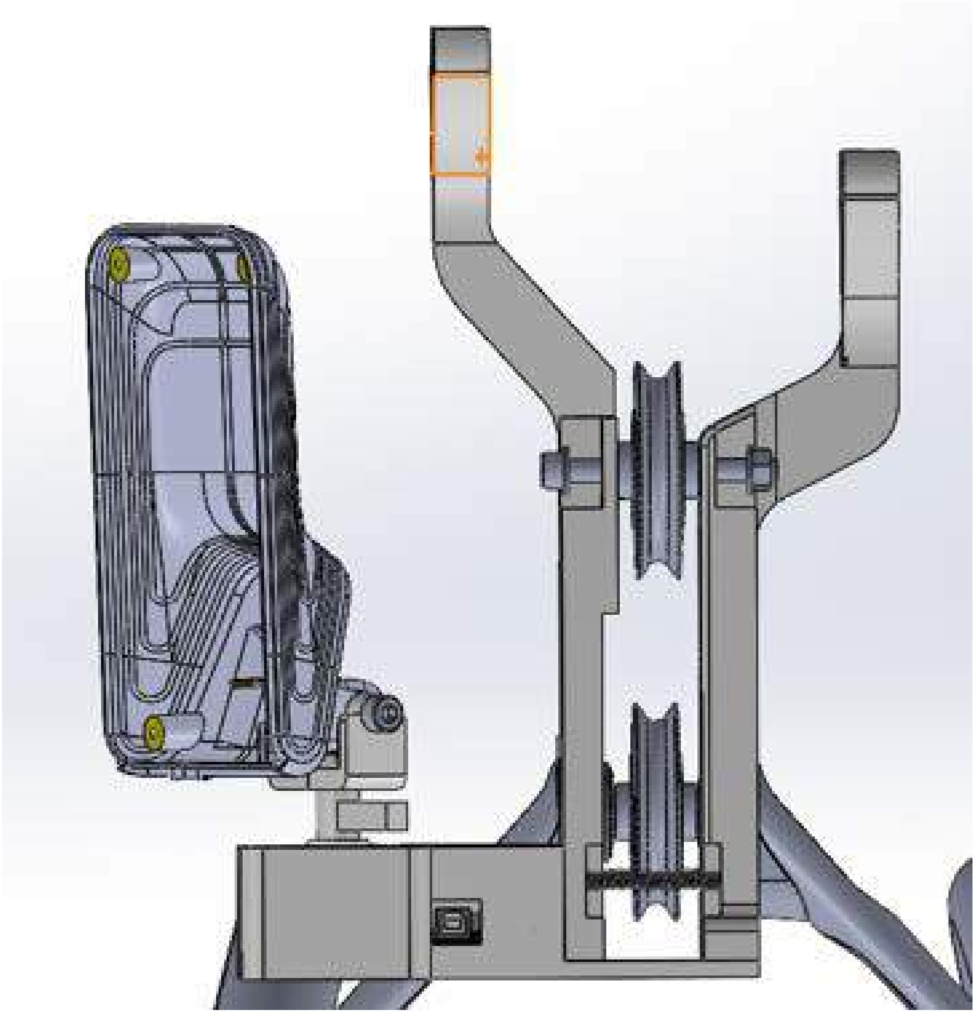
The above image shows the interlocking screw connections that connect the separated pulley plates and antlers.



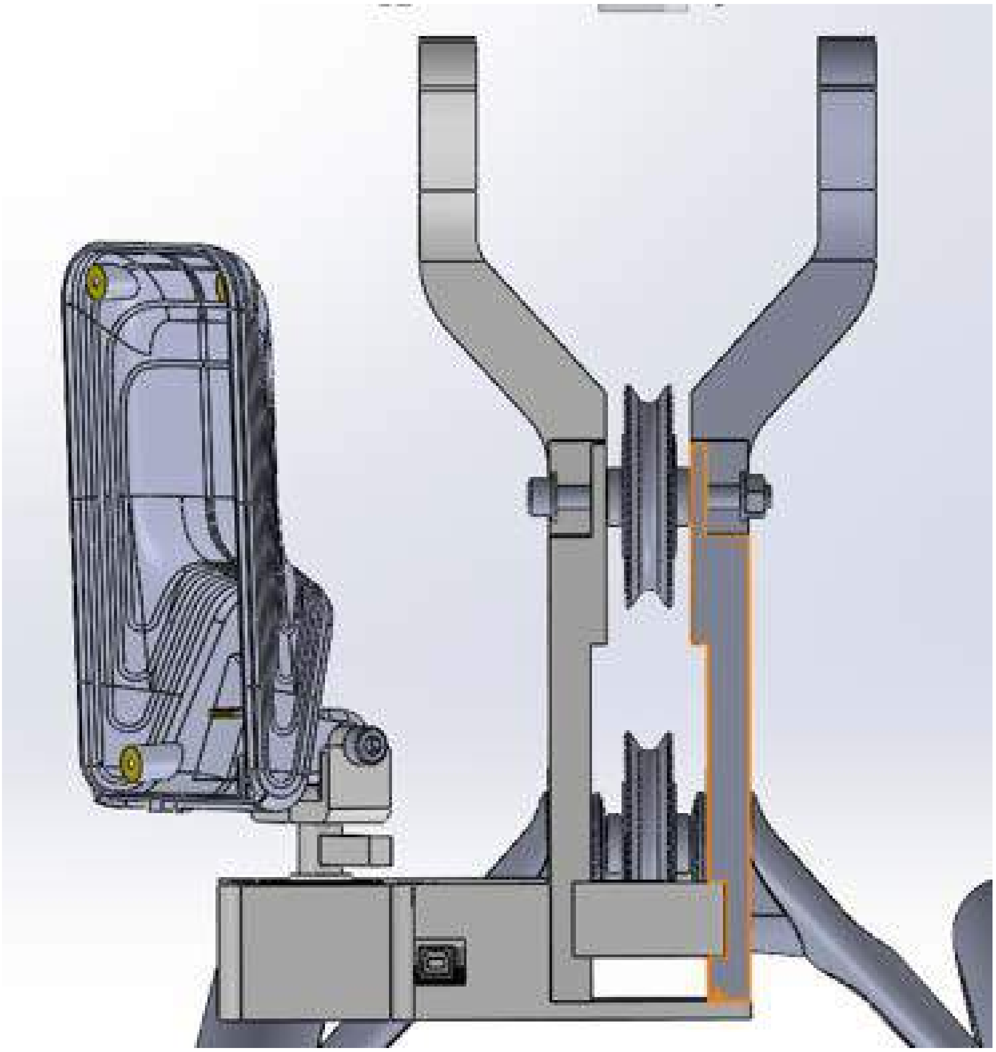
The above image shows the final version of the separated antler.



The above image shows the final version of the separated pulley plate.



The above image shows the final version of the antler for metal fabrication with the version at the end of BME 400.



The above image shows the front view of the rower with both right and left final version of the separated pulley plates and antlers.

References: n/a

Conclusions:

Staci was happy with the changes I made to make these pieces separate pieces that screw together and easy to fabricate out of metal. I have sent Staci an email with all of the parts so she can begin working with her model shop team on fabrication.

Action items:

-Wait to here back from Staci and see if she needs any additional info from me

-Once Staci tells us the metal she will be using, I will run the SolidWorks simulations on the Pulley Plate and Antler using the 1050 N load again

-Set up MakerSpace account for Staci with Tracy

-Continue to help brainstorm/design ideas for the resistance mechanism (eventually model, simulate, and print)

-Once electronics are all determined, make necessary changes to motor box

Josh ANDREATTA - Feb 12, 2023, 11:36 AM CST

Download

Back_Separation_Block.SLDPRT (61.6 kB)

Josh ANDREATTA - Feb 12, 2023, 11:36 AM CST

Download

console.log (13.6 kB)

Josh ANDREATTA - Feb 12, 2023, 11:36 AM CST

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Front_Separation_Block.SLDPRT (60.8 kB)

Josh ANDREATTA - Feb 12, 2023, 11:36 AM CST

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Left_Antler.SLDPRT (279 kB)

Josh ANDREATTA - Feb 12, 2023, 11:36 AM CST

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Left_Assembly.SLDASM (98.6 kB)

Josh ANDREATTA - Feb 12, 2023, 11:36 AM CST

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Left_Pulley_Plate.SLDPRT (670 kB)

Josh ANDREATTA - Feb 12, 2023, 11:36 AM CST

Download

Right_Antler.SLDPRT (134 kB)

Josh ANDREATTA - Feb 12, 2023, 11:36 AM CST

Download

Right_Assembly.SLDASM (101 kB)

Josh ANDREATTA - Feb 12, 2023, 11:36 AM CST

Download

Right_Pulley_Plate.SLDPRT (192 kB)

Josh ANDREATTA - Feb 12, 2023, 11:36 AM CST

Download

Motor_Arm_Assembly.SLDASM (7.86 MB)

2/17/2023 - JHT Final Pulley Plate and Antler Designs

Josh ANDREATTA - Feb 17, 2023, 12:54 PM CST

Title: 2/17/2023 - JHT Final Pulley Plate and Antler Designs

Date: 2/17/2023

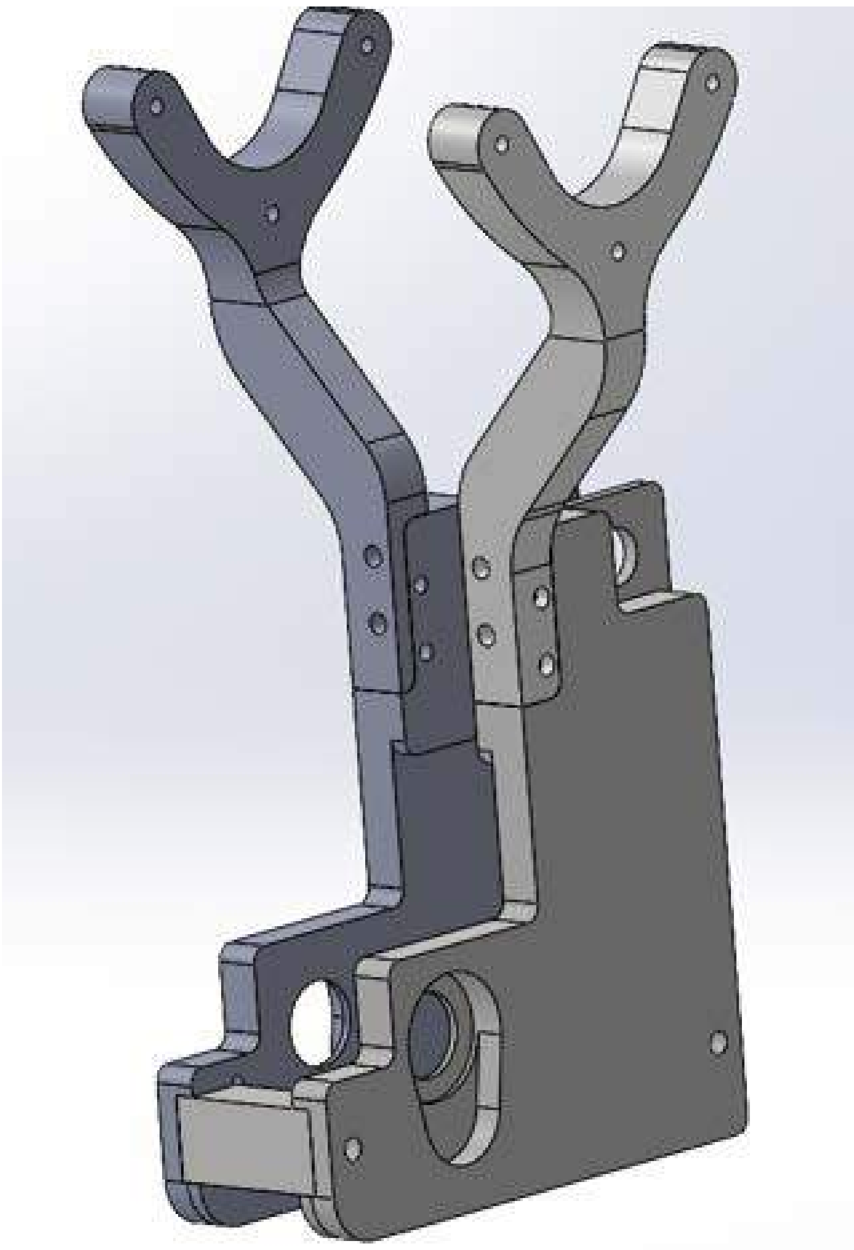
Content by: Josh Andreatta

Present: Josh Andreatta

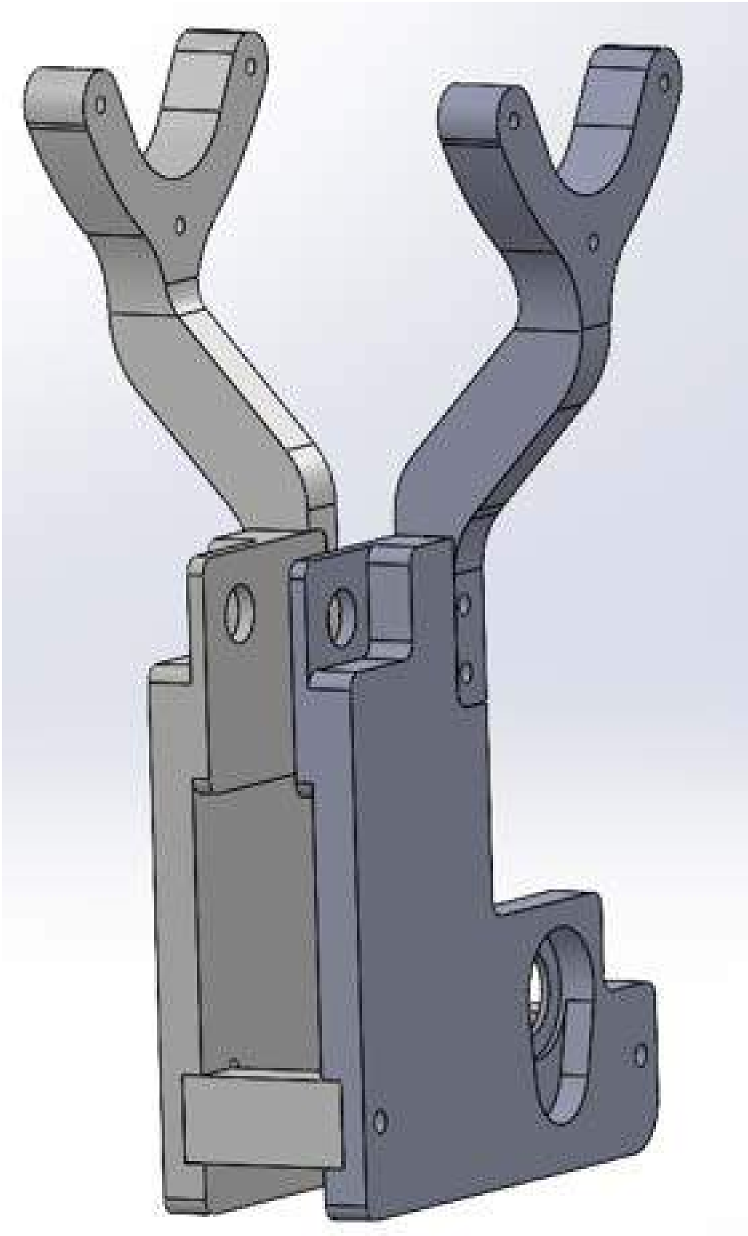
Goals: Show final CAD models for manufacturing

Content:

Staci responded to my models with the small changes she made that were necessary for her team to fabricate. Below are pictures of the final models and the email of her changes for manufacturability.



The above image shows the back view of the final CAD assembly.



The above image shows the front view of the final CAD assembly.

We are going to use Aluminum 6061 for the material.

I also wanted to let you know that I am making the following changes for manufacturability here.

Changes:

Separation blocks:

- changing from .8in x 1in to be 0.75in x 1in due to standard material sizes
- Reduced to 1 model so that the dimensions only need to be controlled in one place
- Made the through hole threaded

Pulley Plates:

- Adding a 3/16" radii to the outside corners. We are going to use a 3/16" bit to cut the part
- Drilled out the corners of the separation block pockets. Drilling out corners prevents us from having to add radii to the separation block corners.
- Adjusted the separation block pockets to be the same depth. They were off by 0.005in. I think this is due to the move face feature.
- Decreased the overall width by 0.02in to use a standard material thickness.

Antlers:

- Adding 3 – M6 tapped holes in the cup area to allow us to fixture the part in the CNC
- Added mating fillets
- Changed the ¼ threaded holes to be through holes

The above image shows Staci's changes to the CAD for manufacturability.

References: Staci Quam

Conclusions:

The models are complete and ready to be fabricated. I asked Staci when she expects them to be complete and ready for pick up but she has not answered yet.

Action items:

-Begin resistance dial brainstorm/modeling

-Get ready for starting prelim report

-Eventually re-do SolidWorks simulations with parts modeled as Aluminum 6061

2/20/2023 - Thin Antlers for Manufacturing

Josh ANDREATTA - Feb 20, 2023, 6:55 PM CST

Title: 2/20/2023 - Thin Antlers for Manufacturing

Date: 2/20/2023

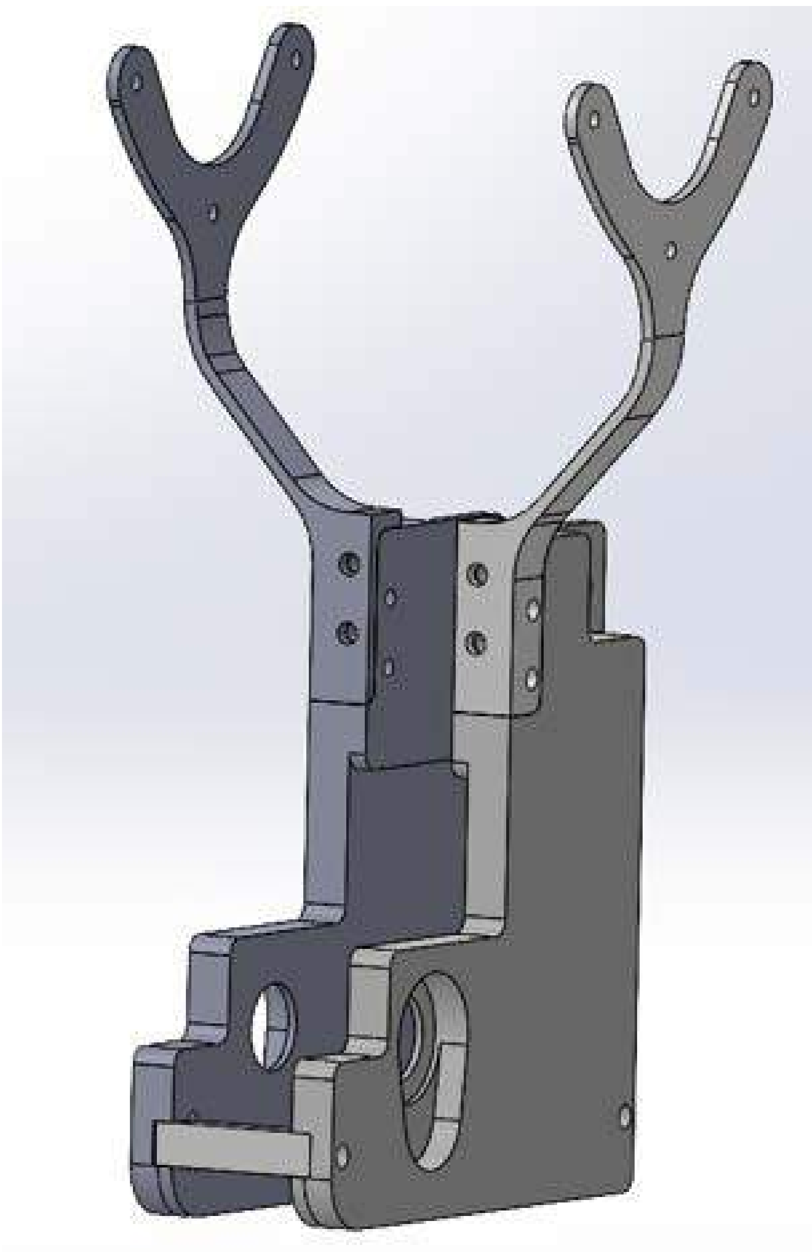
Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Thin Antlers for Manufacturing

Content:

Staci emailed me today with two suggestions. She said that with the current thickness of the antlers, the manufacturing costs would get expensive. She suggested I thin the parts down to around .14in. So, I thinned all the walls of the antlers from 0.77in to 0.15in. I also made the separation blocks smaller in width and height as per her suggestion. My main concern with thinning the antlers is that now there is less surface area for the handlebar to contact as it rests in the cavity of the antler. I brought this to staci's attention. Based on her feedback, we will agree upon further changes that accommodate both the design and manufacturing requirements.



The above image shows the smaller separation block and thinned antler walls.

We are going to have to simplify the design a little further. The pure material cost of making the parts as they are, is $431.60.

I have a few asks,

1. Can you pack and go your full assembly into a zip file and send it to me. This will let me look through and provide suggestions.
2. The antlers are currently 0.77in thick. With metal, this is going to be overkill. Can you reduce the thickness and run your FEA again. You should be able to get away with going as thin as 0.1406in or possibly less.
3. Since the separation blocks do not support any weight, go ahead and really reduce their sizes. They can be much smaller than 0.75"x0.5".

Ill have more suggestions once I see the full CAD.

The above image shows staci's questions for me today.

References: Staci Quam

Conclusions:

I have sent the full model with updated parts to Staci for further review. Based on her feedback, we will make and agree on changes that satisfy the design and ease of manufacturing.

Action items:

-Brainstorm resistance dial with Sam Tuesday afternoon

-Meet with team to assign sections of prelim journal article draft tuesday evening

-Eventually, rerun simulations on final antlers and pulley plates once geometry is agreed upon

---

Josh ANDREATTA - Feb 20, 2023, 6:55 PM CST

DATA

Download

Full_Pulley_Plate_Assembly_JHT.SLDASM (219 kB)

Josh ANDREATTA - Feb 20, 2023, 6:55 PM CST

DATA

Download

Left_Antler_JHT.SLDPRT (385 kB)

Josh ANDREATTA - Feb 20, 2023, 6:55 PM CST

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Left_Assembly_JHT.SLDASM (124 kB)

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Left_Pulley_Plate_JHT.SLDPRT (754 kB)

Josh ANDREATTA - Feb 20, 2023, 6:55 PM CST

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Right_Antler_JHT.SLDPRT (159 kB)

Josh ANDREATTA - Feb 20, 2023, 6:55 PM CST

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Right_Assembly_JHT.SLDASM (128 kB)

Josh ANDREATTA - Feb 20, 2023, 6:55 PM CST

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Right_Pulley_Plate_JHT.SLDPRT (230 kB)

Josh ANDREATTA - Feb 20, 2023, 6:55 PM CST

Download

Separation_Block_JHT.SLDPRT (67 kB)

2/25/2023 - One Part Antler and Plate Thinning & Other Changes

Josh ANDREATTA - Feb 25, 2023, 12:27 PM CST

Title: 2/25/2023 - One Part Antler and Plate Thinning & Other Changes

Date: 2/25/2023

Content by: Josh Andreatta

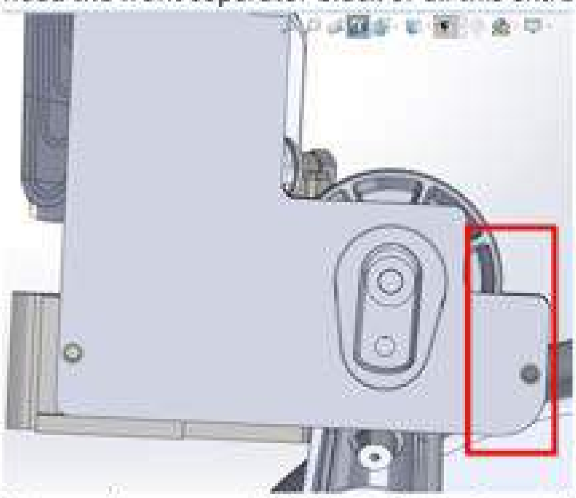
Present: Josh Andreatta

Goals: Make the changes suggested by Staci to the pulley plates and antlers

Content:

After our meeting with Staci on Friday, she sent me a summary email with the changes she wanted to me to make to the parts to improve their manufacturability. Below is an image with those requests.

1. Make the Antlers and Pulley plates a single piece and thin out to be 12gage sheet metal
2. Remove the tapped holes I added to the antlers. Since we will not be using the CNC mill we do not need these to secure the parts anymore
3. Turn antler bend to two 90deg
4. Your choice, but with the metal and having the whole pulley plate being in the same plane, you no longer need the front separator block or all this extra material

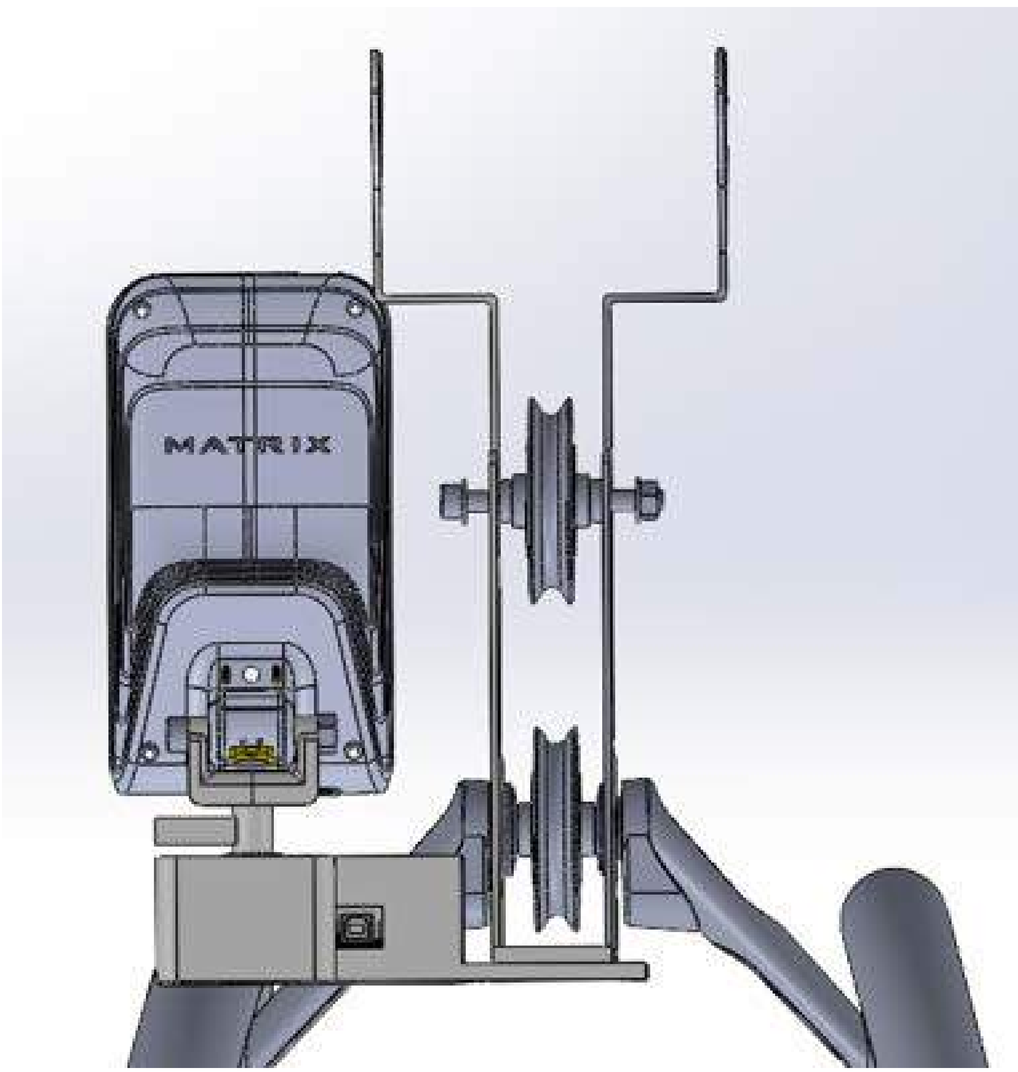


5. Flatten the separation block to be ¼ plate with threaded holes. Tom recommends M6 so that you have more thread engagement
6. Make cut out of the separation block in the pulley plates. Tom recommends welding the separation block to the pulley plates. Because there will be no recessed features, this shouldn't cause any issues with assembling. Otherwise, I believe you would need to put another bend in the pulley plates that would give you a location to bolt on the separation block

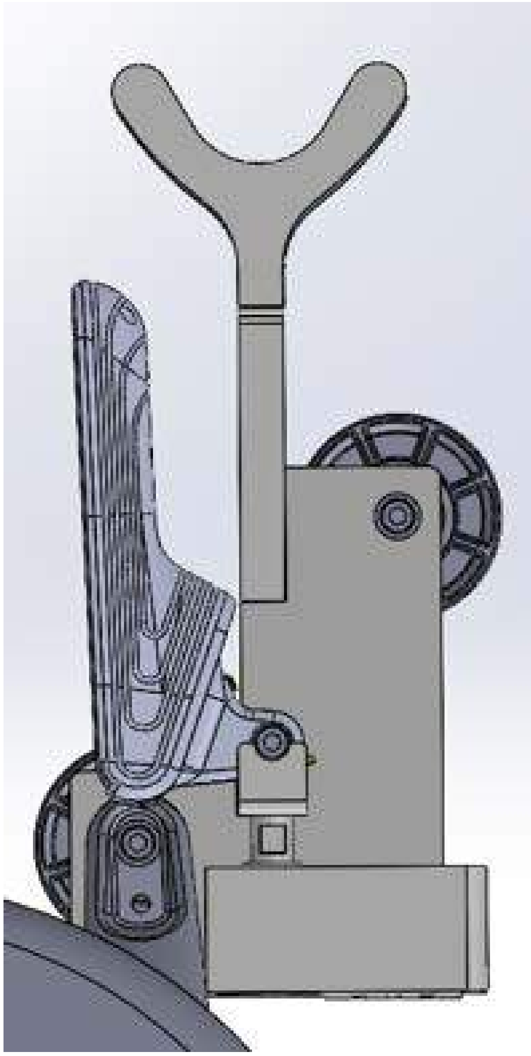
The above image shows the changes Staci wanted me to make on the pulley plate and antlers.

She wanted me to make these changes because the prior version I sent her would have cost more than $430 to fabricate out of Aluminum 6061. After talking with a machinist at JHT, staci decided that we could actually go back to the original design where the pulley plate and antler are one component and not two separated pieces. She suggested that since we will be making the parts out of metal, it is unnecessary to have the parts be super thick since we will have increased durability and strength. They have a machine at JHT that can bend 12 gage metal, so she asked me to make the entire plate and antler this thickness (0.104inches). Additionally, since the plates would now be one flat piece, we can't wrap them around the rower neck support arms like we used to. To prevent rotation, she suggested we take advantage of the lower hole on the rower neck support arms that don't do anything currently. If we drill a hole in the plate where this hole is, we would have to points of attachment to the rower (one from this hole, and one directly above it where the pulley is screwed into the rower). This would essentially prohibit any translation or rotation. To fill any gaps, she said we can use washers or spot weld metal to fill in the empty space.

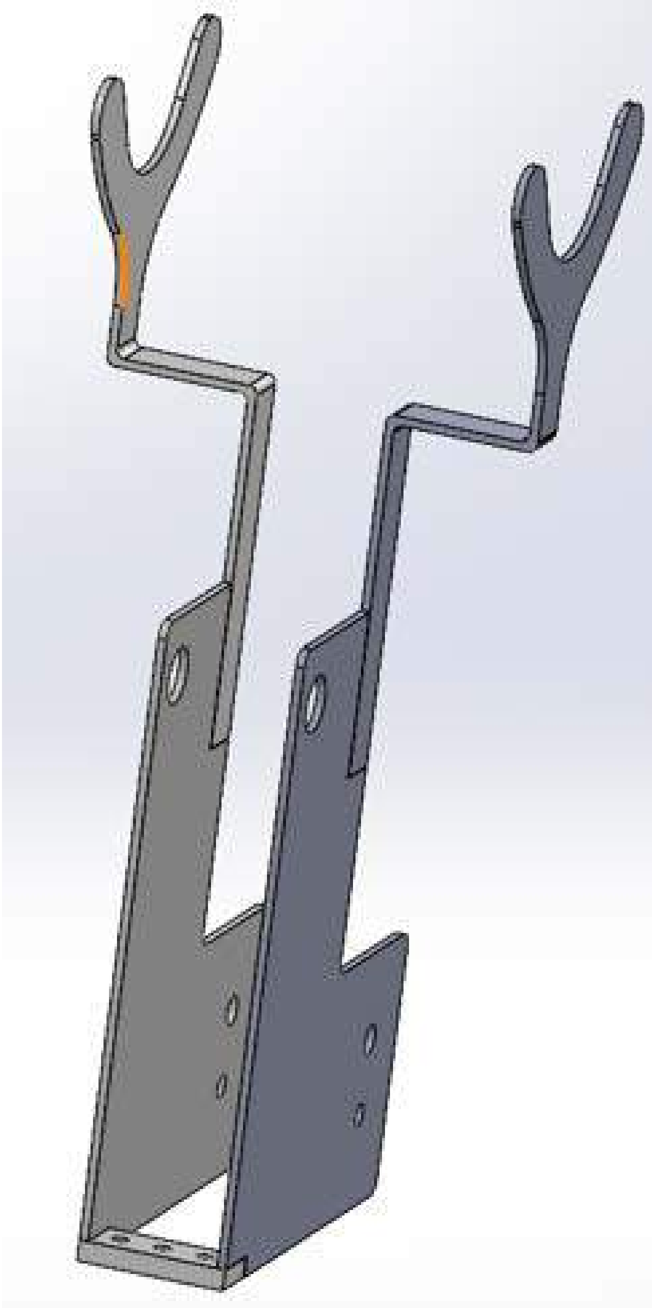
Another change that she wanted me to make was to have the antlers bend at 90 degrees again, rather than on an incline. This is because it will be easier to control the bend with their machine that bends sheet metal. The last change was for how we would attach the motor box to the plates. Since the plates are very thin now, we can't screw into them from the bottom. Instead, we decided to make a cut at the bottom front edge of the plates for a separation block that will be welded to the two plates. This separation block will have three screw holes in the center between the plates. This is where we will now attach the motor box to the rest of the assembly. The machinist told us to make these screws M6 rather than 1/4-20 because we will get more threads per inch and have more contact resulting in a stronger and more stable connection. These changes can all be seen below. I made these changes and sent the files to staci and will wait for her feedback. Once we finish, we will alter the motor box as necessary (this also depends on the electronics we use for the resistance dial mechanism).



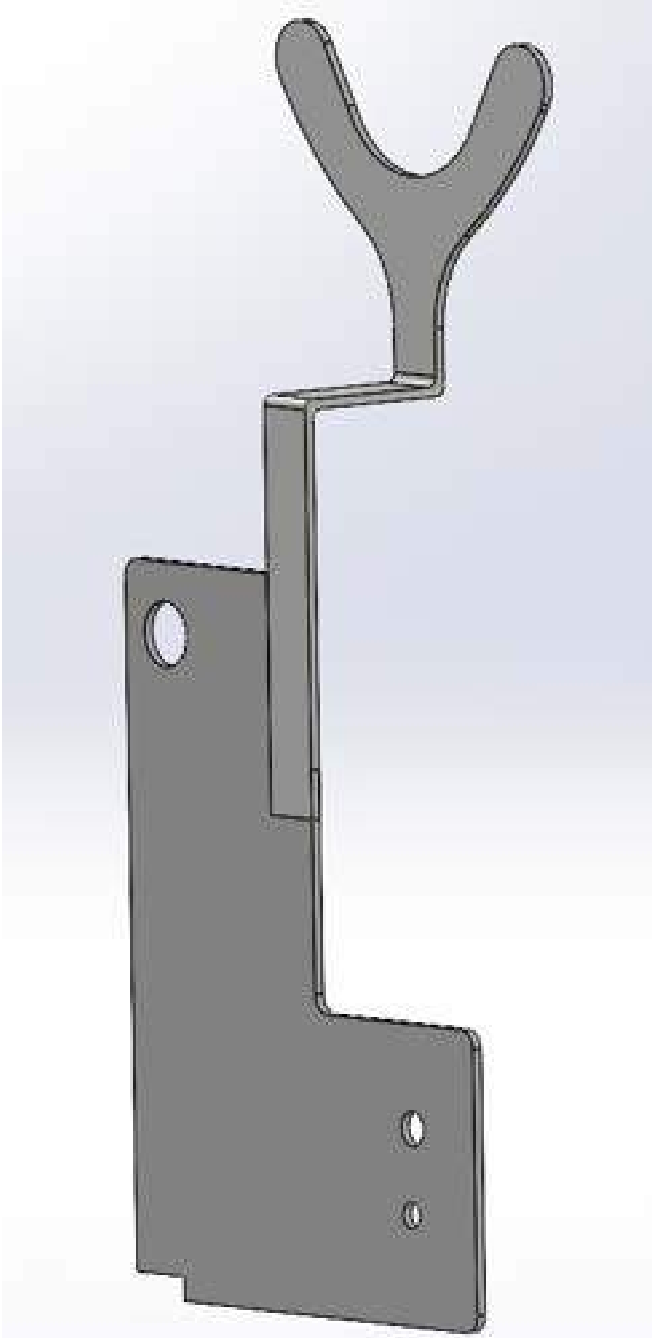
The above image shows the front view of the entire rower assembly with the thinned antlers and plates as one piece each.



The above image shows the side view of the entire rower assembly with the thinned plate and antlers as one piece each.

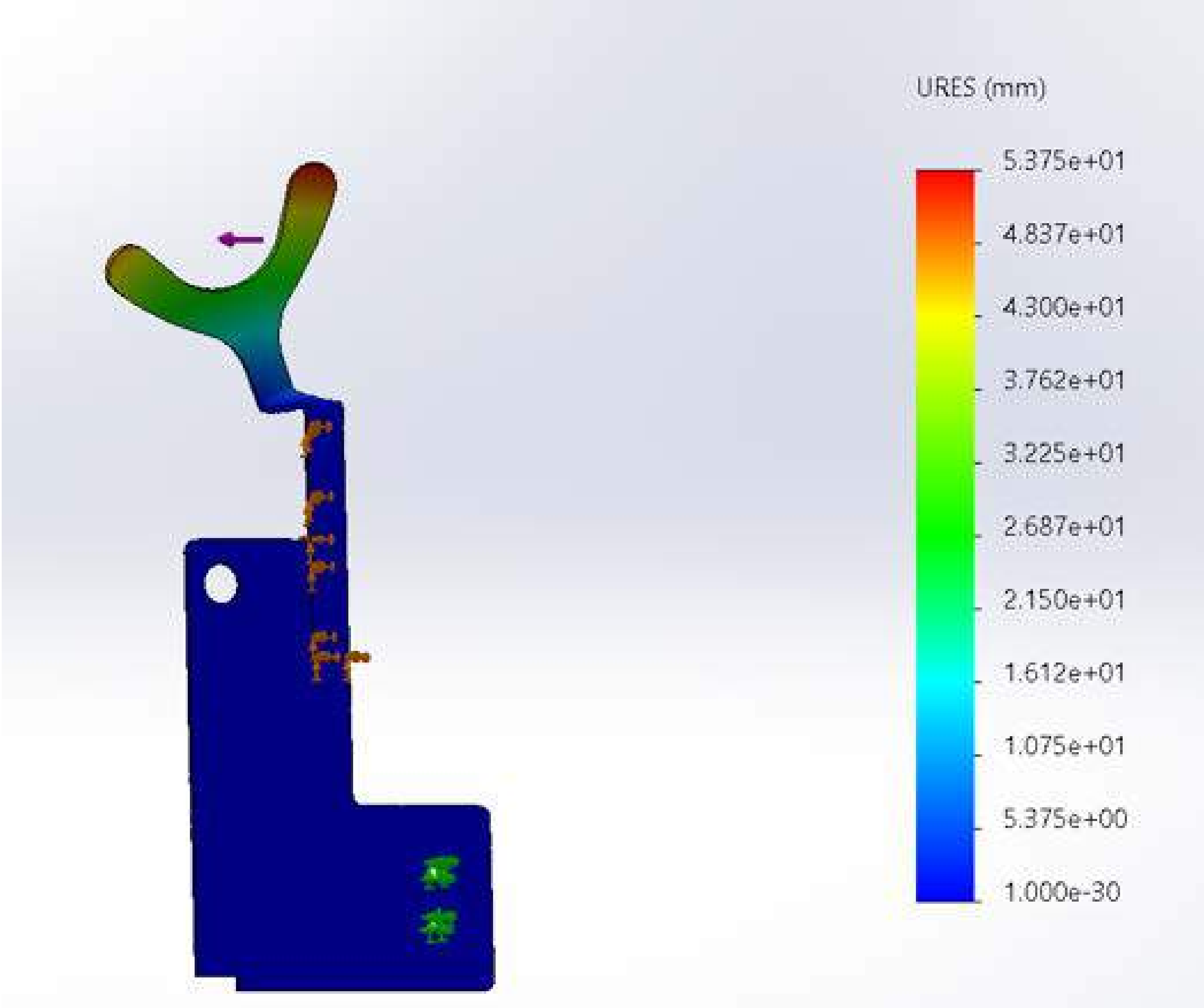


The above image shows the assembly of the right and left side plate and antlers after thinning.



The above image shows the part of the combined antler and plate after all changes were made.

I also ran a quick simulation for the pulley plate and antler as one piece. I held the part fixed at the two locations where it will be fixed to the rower neck support arms via screws (green arrows below), and at the edges that connect the antler and plate (to make it think it is one part instead of two separated pieces). I then applied a 1050N load at the antler cavity like usual, and got that we would see yielding and failure in the antler with a mx displacement of 5.375cm. I sent this to Staci and asked for her feedback. It's possible I chose the wrong alloy of Aluminum 6061 for this simulation, or that we need to make changes to the geometry or material. I will wait for her feedback on both the FEA and the parts themselves and continue working on them until we reach a final design that satisfies everything.



The above image shows the results of a simulation done with 1050N load on the antler cavity modeled as Aluminum 6061.

References: Staci

Conclusions:

I made these changes and sent Staci links to access the parts and assemblies. I will wait for her to get back to me and then based off her feedback, I will continue to work with her to make changes until we both agree on a final design.

Action items:

-Wait for staci to respond, then continue to finish pulley plate and antler part modeling and simulation

-Begin work on resistance dial attachment mechanism modeling (Staci sent me the parts Friday 2/24)

-Write/Edit prelim journal article draft sections (Appendices)

Josh ANDREATTA - Feb 25, 2023, 12:28 PM CST

Download

Full_Pulley_Plate_Assembly_JHT.SLDASM (107 kB)

Josh ANDREATTA - Feb 25, 2023, 12:28 PM CST

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Left_Antler_JHT.SLDPRT (468 kB)

Josh ANDREATTA - Feb 25, 2023, 12:28 PM CST

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Left_Assembly_JHT.SLDASM (69.1 kB)

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Left_Assembly_JHT.SLDPRT (107 kB)

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Left_Pulley_Plate_JHT.SLDPRT (836 kB)

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Right_Antler_JHT.SLDPRT (134 kB)

Josh ANDREATTA - Feb 25, 2023, 12:28 PM CST

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Right_Assembly_JHT.SLDASM (70 kB)

Josh ANDREATTA - Feb 25, 2023, 12:28 PM CST

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Right_Pulley_Plate_JHT.SLDPRT (132 kB)

Josh ANDREATTA - Feb 25, 2023, 12:28 PM CST

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Separation_Block_JHT.SLDPRT (82.1 kB)

2/27/2023 - Final Updates to Pulley Plates and Antlers

Josh ANDREATTA - Feb 27, 2023, 7:29 PM CST

Title: 2/27/2023 - Final Updates to Pulley Plates and Antlers

Date: 2/27/2023

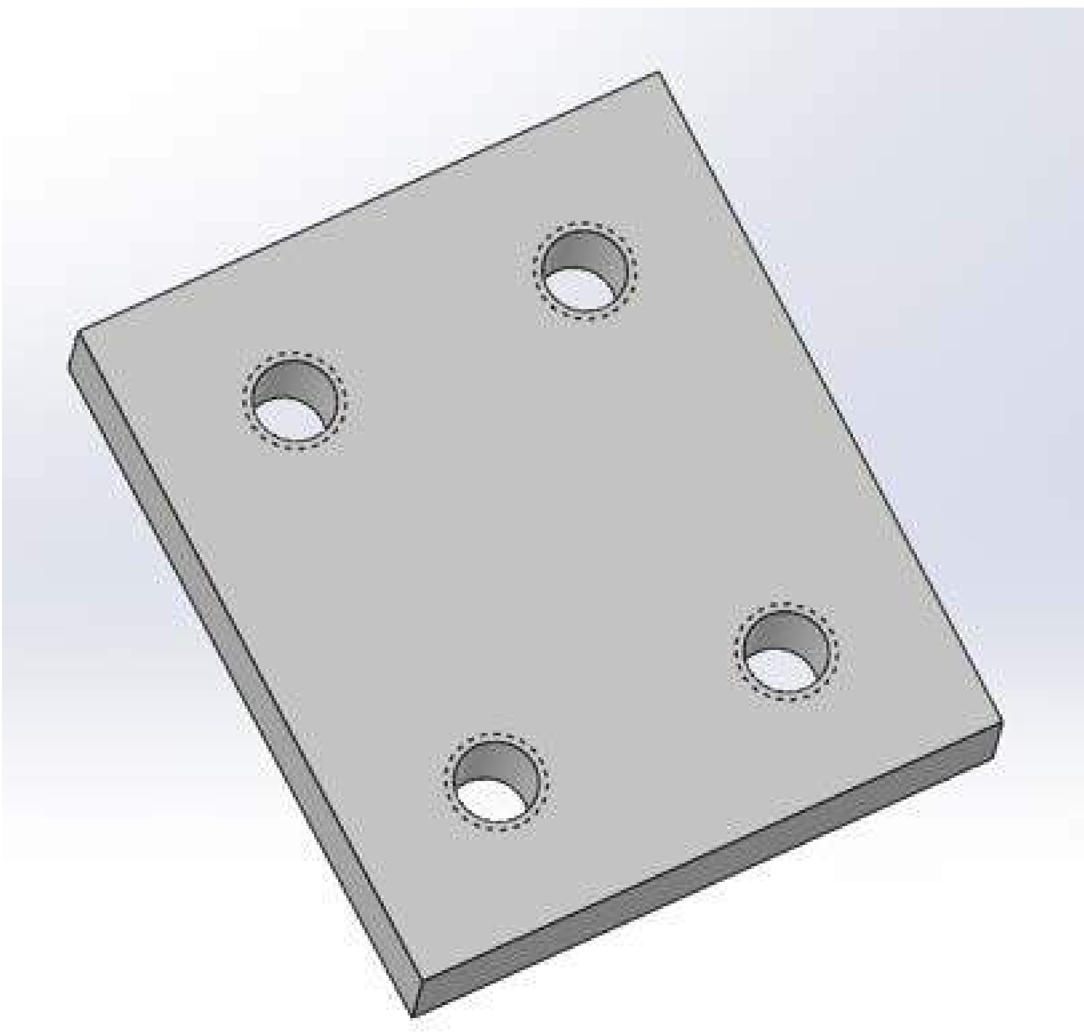
Content by: Josh Andreatta

Present: Josh Andreatta

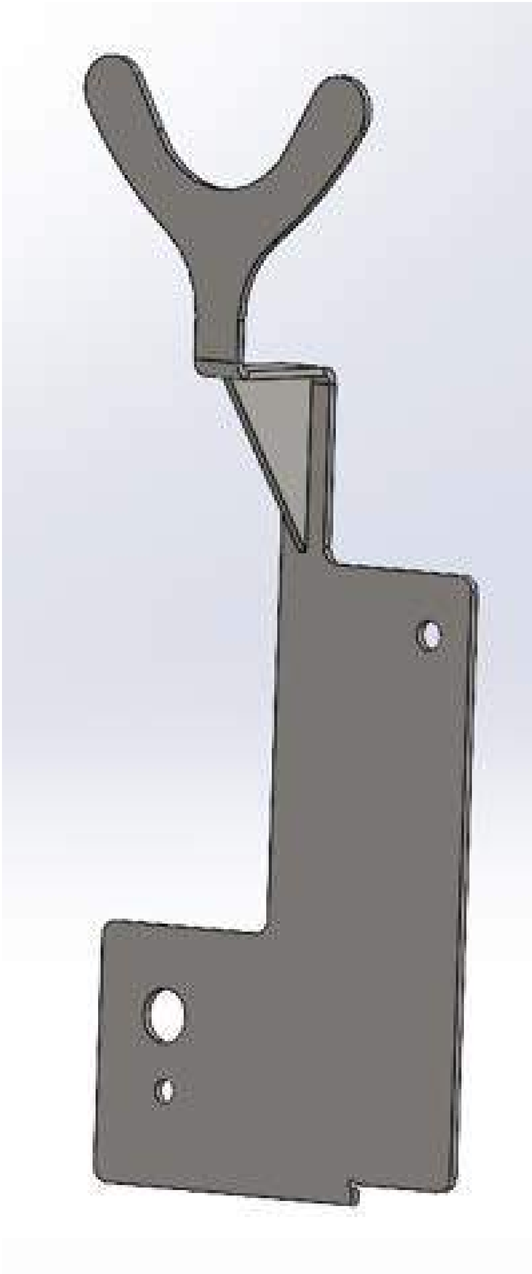
Goals: Explain and show the final Pulley Plates and Antlers

Content:

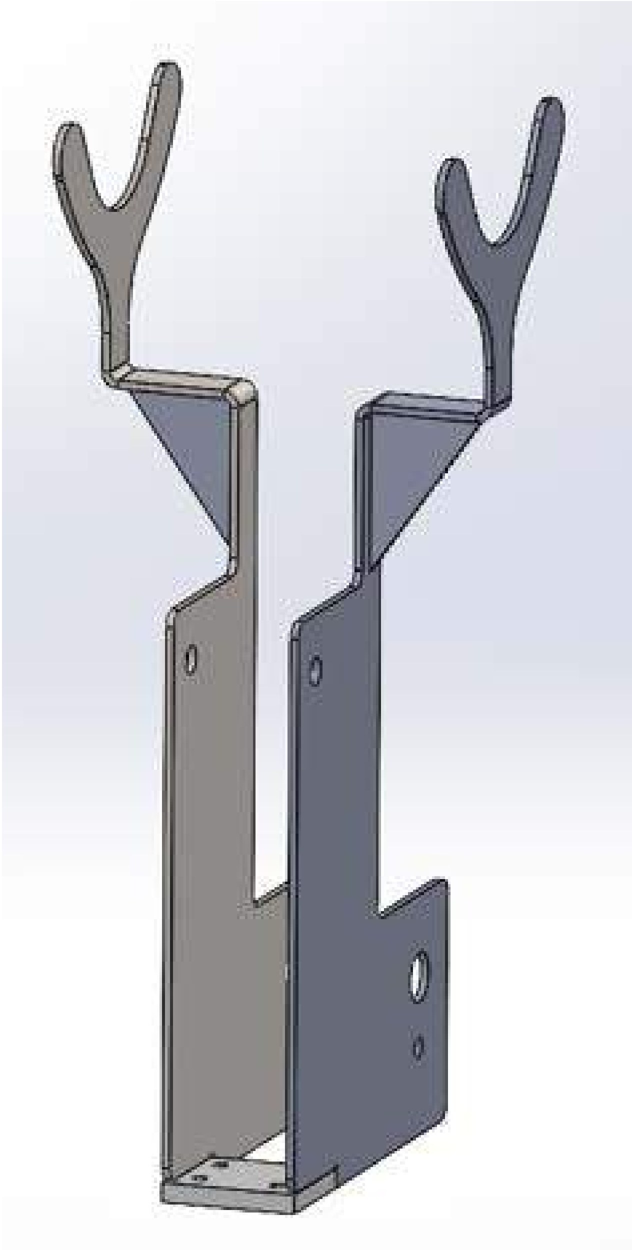
Today I met with Staci for 1 hour on teams to go over the final changes that needed to be made to the pulley plates and antlers. I thought that this would streamline the process rather than waiting for email responses. I only had to make a few minor changes. First, I set the material as "Plain Carbon Steel" because that is the sheet metal that they will make it out of. Next, I modified the antler portion to be described as sheet metal and Staci helped me put two 0.1 inch radii fillets at the 90 degree bends that are still the 0.105 inch thickness (which is the constant thickness of the plate). Next, we made the separation block 1.5 inches wide instead of 0.75 inches. Then, rather than having 3 screw holes in a row, we made a set up of 4 corner screw holes to improve the grip strength between them and the block. We also added a "gullet" to go under the 90 degree bend of the antler. This will act as a truss support to reduce any bending stresses and deformations that occur under loading (see the testing simulation entry for more detail on this). Lastly, we double checked and made sure that all of the holes in the plate for screws were the correct sizes. Staci thinks that these should be ready to go. She will look them over one last time with her machining team and then start the fabrication process. See below for images.



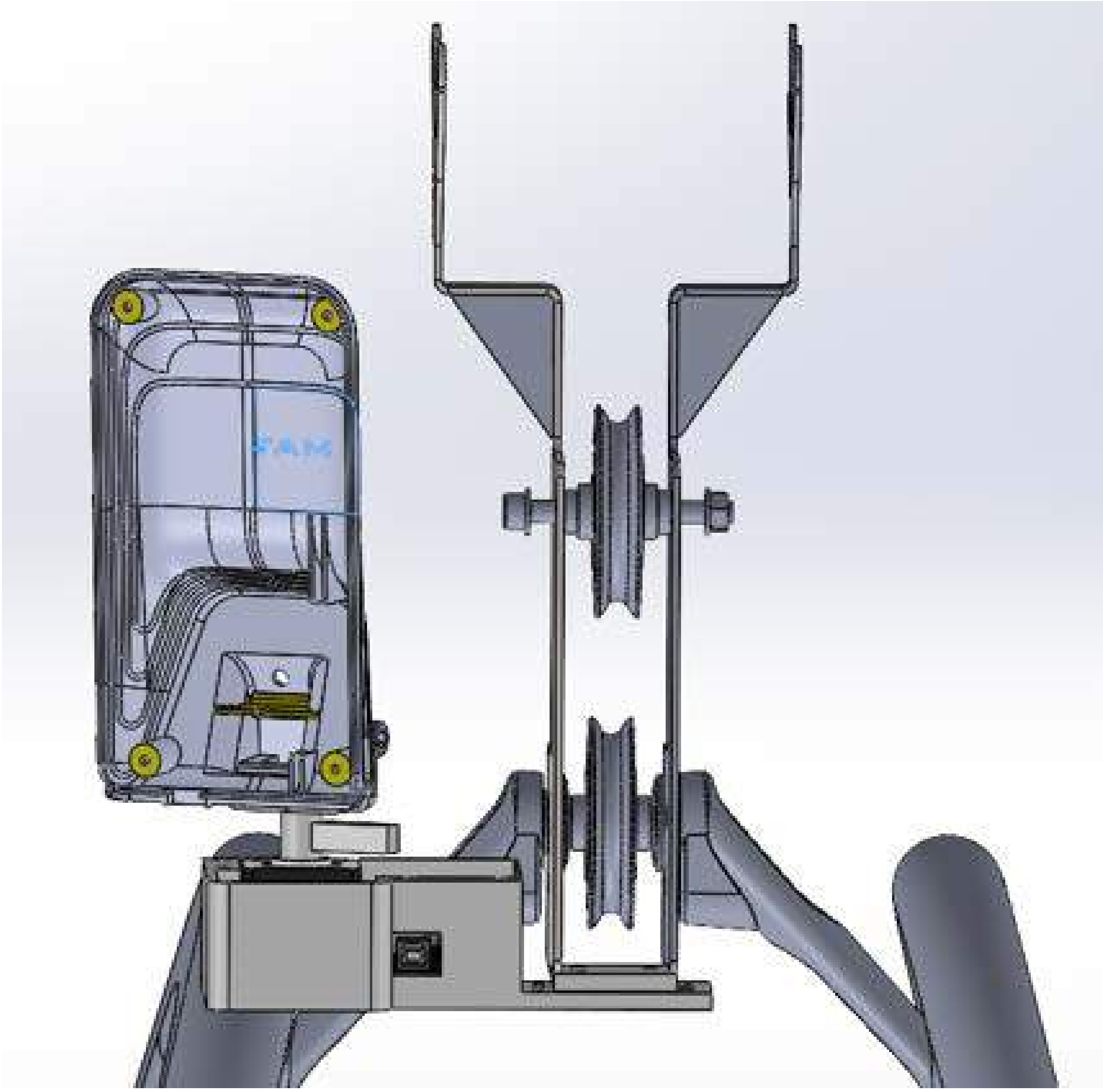
The above image shows the new separation block with 4 corner screw holes.



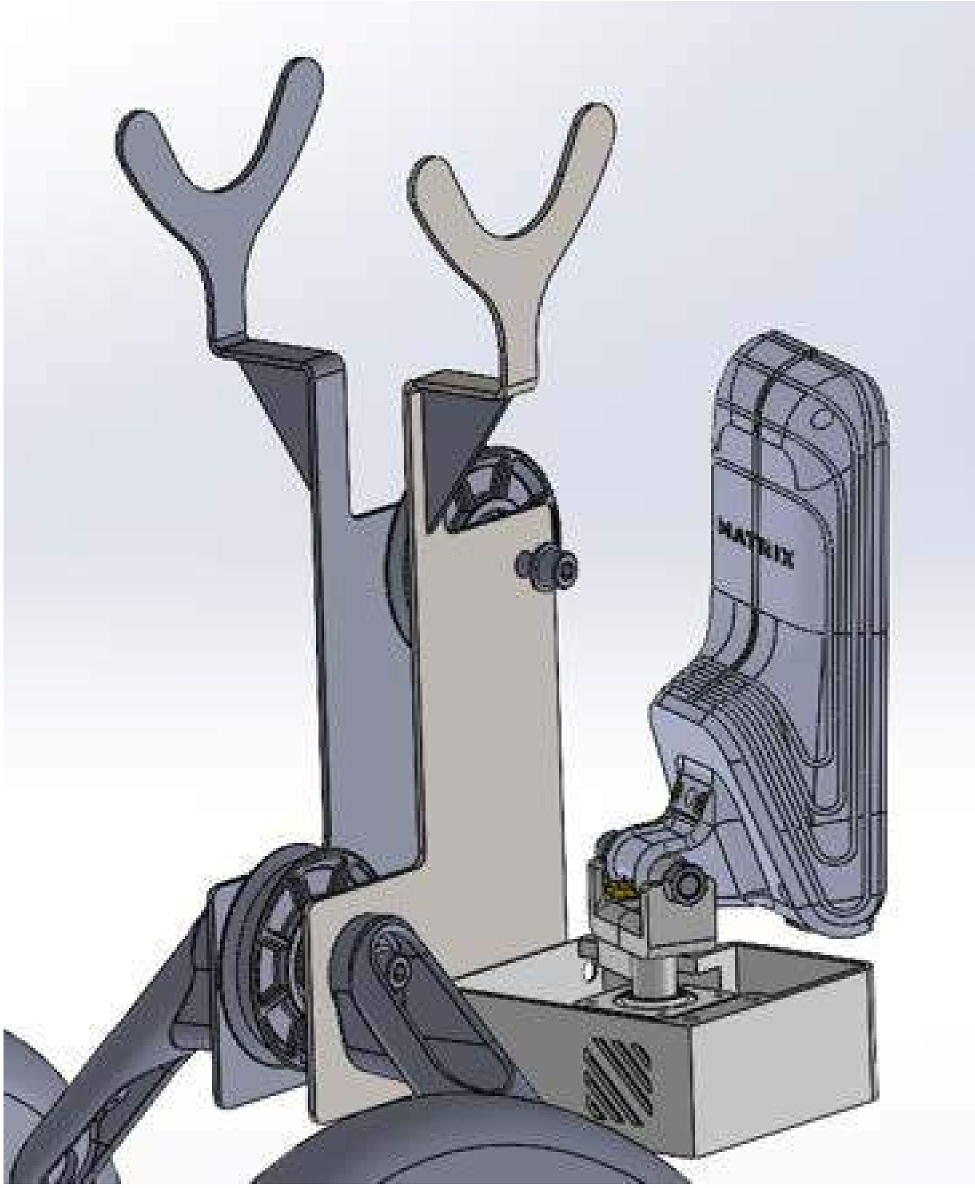
The above image shows the final version of the pulley plate and antler.



The above image shows what the final welded assembly of the two plates and separation block will look like.



The above image shows a front view of the entire rower assembly.



The above image shows the back angled view of the entire rower assembly.

References: Staci Quam

Conclusions:

These changes were confirmed live with Staci and the final part and assembly files have been sent to Staci for a final double check. She will let us know when they begin to start fabrication.

Action items:

-Turn in prelim report and notebook to canvas/website/email

-Start modeling attachment mechanism for resistance dial

-Outreach!

Josh ANDREATTA - Feb 27, 2023, 5:05 PM CST

Download

Final_Left_Pulley_Plate_Antler.SLDPRT (224 kB)

Josh ANDREATTA - Feb 27, 2023, 5:05 PM CST

Download

Final_Pulley_Plate_Antler_Assembly.SLDASM (113 kB)

Josh ANDREATTA - Feb 27, 2023, 5:05 PM CST

Download

Final_Right_Pulley_Plate_Antler.SLDPRT (151 kB)

Josh ANDREATTA - Feb 27, 2023, 5:05 PM CST

Download

Gullet.SLDPRT (43.1 kB)

Josh ANDREATTA - Feb 27, 2023, 5:05 PM CST

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Rower_Assembly_with_Final_Pulley_Plates_Antlers.zip (49.8 MB)

Josh ANDREATTA - Feb 27, 2023, 5:05 PM CST

Download

Separation_Block.SLDPRT (84.9 kB)

3/22/2023 - Prints for Resistance Dial Mechanism

Josh ANDREATTA - Mar 22, 2023, 2:28 PM CDT

Title: 3/22/2023 - Prints for Resistance Dial Mechanism

Date: 3/22/2023

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show initial resistance dial prints and make adjustments

Content:

I printed the parts I modeled for the resistance dial mechanism. The nut was able to fit on the 3D printed threads which was great. However, the part itself was too loose in the magnet housing so I will print this again to iterate it to make it a press fit. We met as a group yesterday to integrate the prints with the electronics, and we had to tape the 3D printed part to the housing, but once we did, it rotated with the motor and worked properly! This told us that once we get the fit right from printing, our prototype should work. Then we discussed how we want to collect all of the electronics. We decided that I will just make a box of the parts general dimensions and then tap out the holes ourselves to screw everything into place. I will begin to model these this week so we can get an initial print ready. The goal we set for ourselves was to have all of our 3D printed components finalized and incorporated on the rower by the end of March. Below are two pictures of the initial prints of the resistance dial pieces.

The above image shows the 3D printed threads that fit within the magnet housing and attach to the stepper motor for rotation.

The above image shows the resting block that will catch the magnets if they fall due to gravity in their new location on the rower frame.

References: n/a

Conclusions:

These adjustments will continue to be made and iterated upon until the parts fit how we would like on the rower.

Action items:

-Continue to make adjustments and print until correct fit for resistance dial stuff

-Model and print prototyped boxes for the electronics for the resistance dial and console rotation stuff (make lid also)

-Adjust original electronics box for console rotation to only include the stepper motor for the console, and change how it attaches to the pulley plates with the new screw holes (adjust lid also)

-Meet with Tracy Thursday 2:30, then team at 3 to practice outreach activity a final time

-Interview Friday at 12:30 on zoom, then outreach

-Finalize plans for EMG testing (Wille vs Staci) and start reaching out to participants for testing

-Finalize plan with Staci for part pick up and when they can screw in the magnet housing to the rower for us

3/27/2023 - Prints of Electronics Boxes and Smaller Components

Josh ANDREATTA - Mar 27, 2023, 8:34 PM CDT

Title: 3/27/2023 - Prints of Electronics Boxes and Smaller Components

Date: 3/27/2023

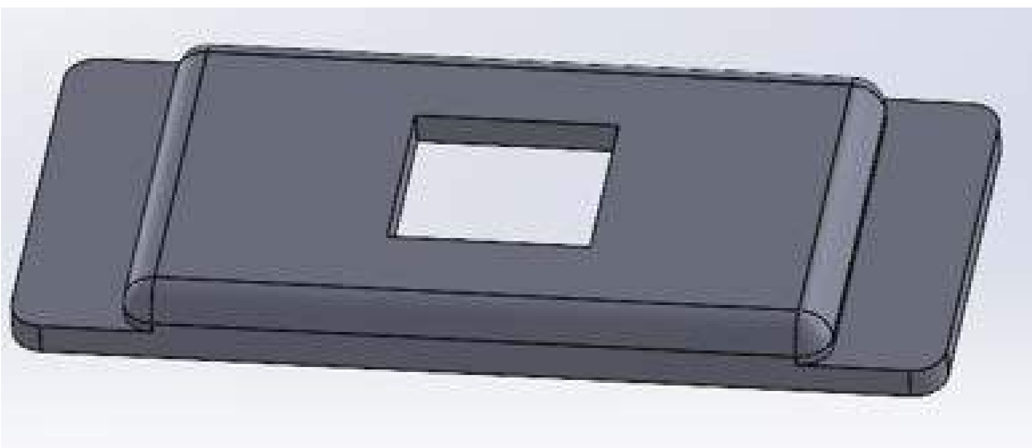
Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show pictures of the initial prints.

Content:

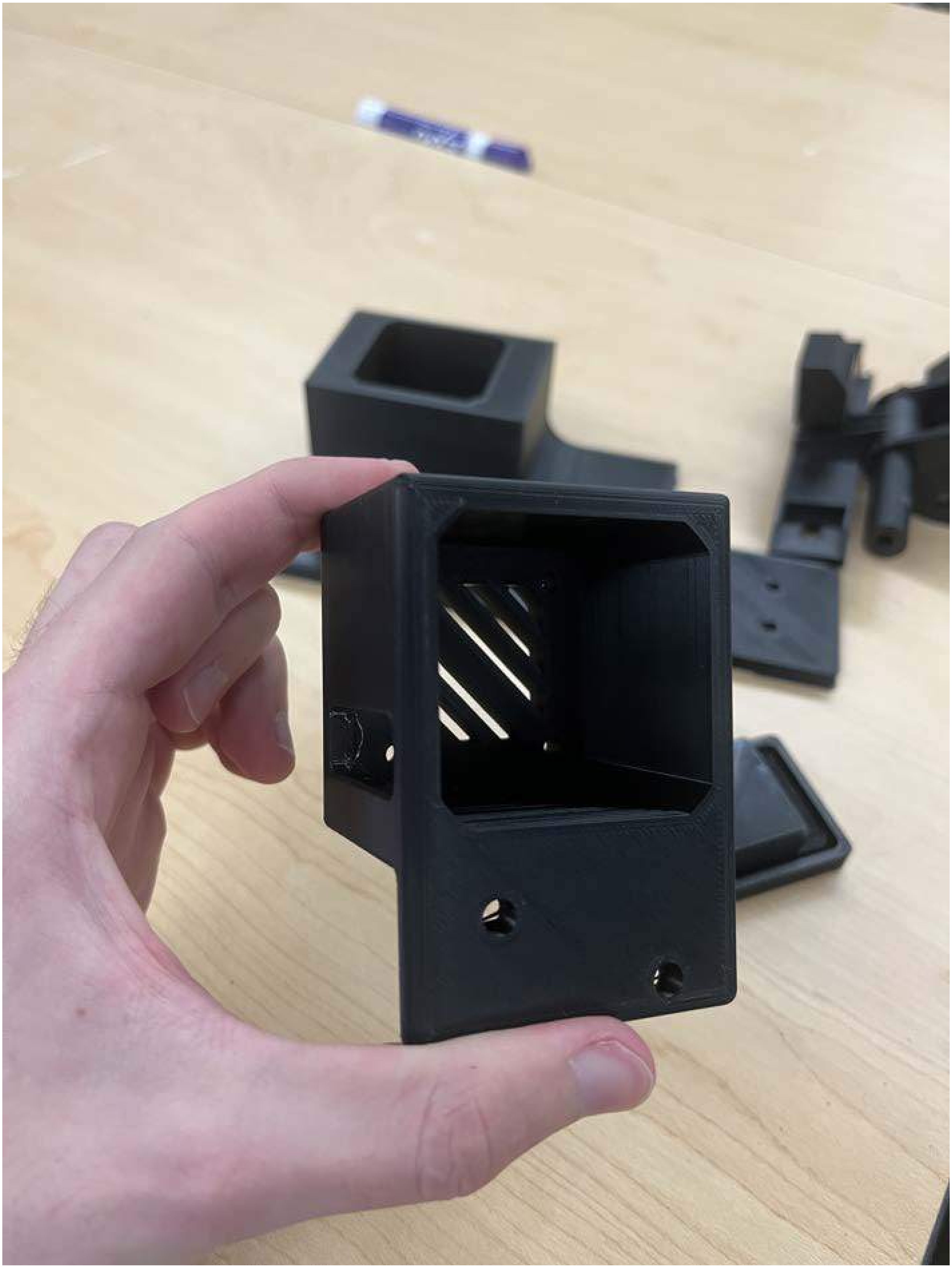
Today I picked up the parts that I printed over the weekend and assessed how well they fit with the rest of the rower assembly. The electronics box will be able to properly fit all of the electronics that we have and is very durable. The console rotation box fits with the metal pulley plates and the motor fits well within it. The resistance dial motor housing fits on the side of the rower and the motor fits will within it as well. None of these 3 components will need to be adjusted and reprinted again. The console field goal posts were still too small, so I increased the diameter of where they go into the console and will reprint for a tighter fit. The LCD display was too tall and the display was too far down within the cover. Therefore, I decreased the height of the cover so that the display screen will actually stick up a little out of the cover to be more visible, while still keeping room to protect the electronics on the solder board. Lastly, the connector between the motor and the magnet housing had a snug fit, and was able to be press fit in with a hammer. However, I realized that I had designed the connector to be press fit along the incorrect diameter. Therefore, I adjusted this piece to have a smaller diameter where it fits in the through of the bolt, and a slightly larger than necessary diameter where the piece connects to the rotating magnet component. This will then be the location of the press fit and once the part is clamped on the end with the washer and nut, the magnets should rotate with the shaft of the motor. (Previously, the press fit was attempting to rotate the part of the housing that was already screwed rigidly into place). Please see pictures below.



The above image shows the LCD display with the smaller height.

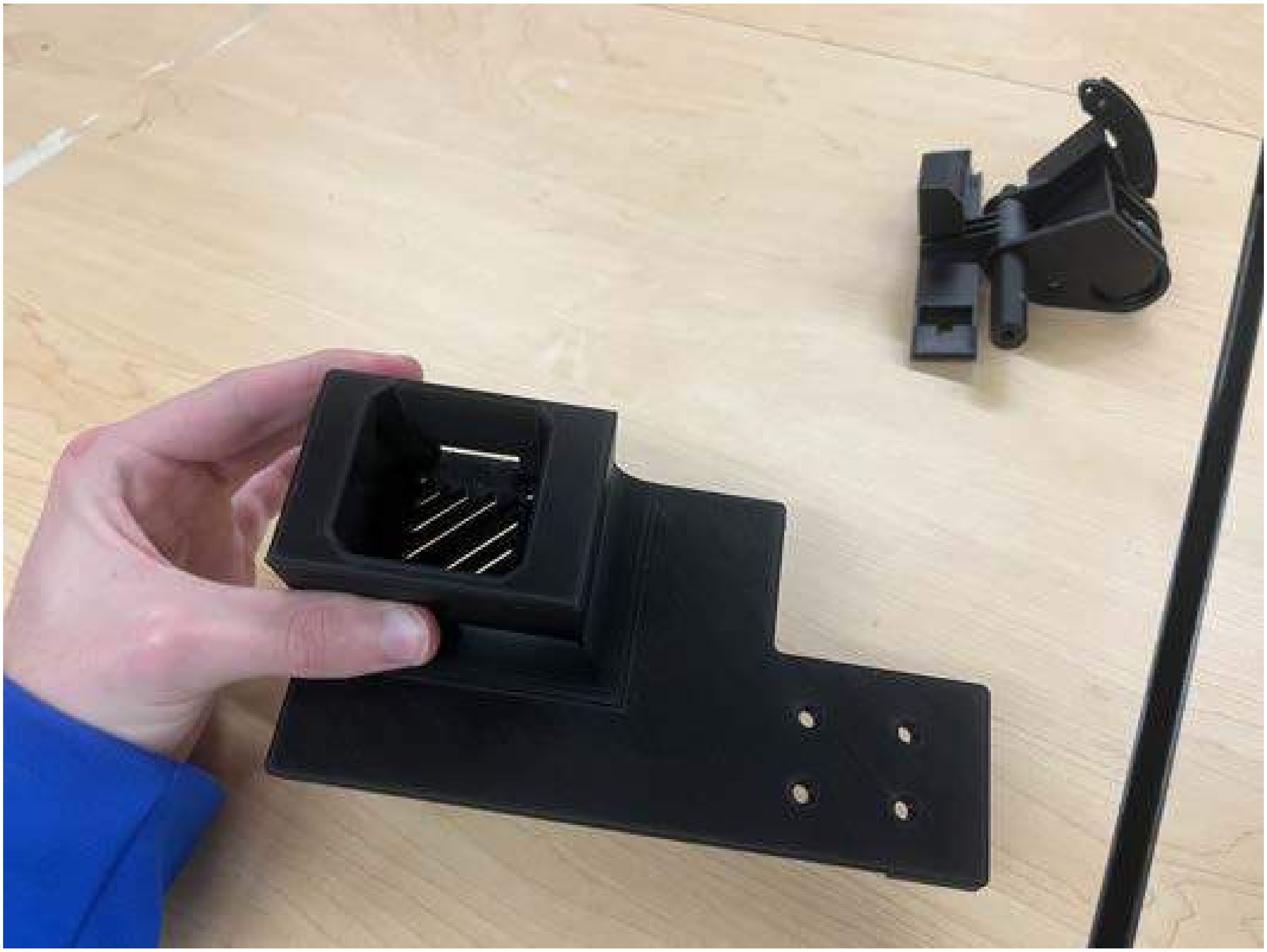
The above image shows the electronics box that will sit on the floor next to the rower base.

The above image shows the LCD display base and cover.



The above image shows the motor housing that will be screwed into the side of the rower.

The above image shows the connector within the magnet housing.



The above image shows the updated console motor box.

Below is a list and description of parts that may require further work with drilling/tapping out screw holes:

- Electronics box (unless we get small enough screws that can thread with the layers of the print)
    - The lid will be printed with slightly larger holes to act as through holes and will not need further work.
    - 4 screws needed
- Console Motor Box
    - May need to tap out where the screws fit in to the pulley plates
    - 4 M6 screws needed
- Motor Housing
    - 2 1/4-20 screws needed
- Electronics Box
    - Will either tap out holes to screw in electronics or will set in and glue in place
- All stepper motor already have screws
    - may need to get same but longer screws to fit within the two cavities (test and see)
- LCD display
    - need to tap out holes for solder board
    - 4 screws X 2 = 8 total screws

- Need to screw in to rower: Motor Housing and Magnet housing (need longer screws for this)

Below are the steps to follow for integration on Tuesday:

- Remove current stabilization frame
- Remove current pulley plates and antlers
- Attach new pulley plate and antlers
- Attach new stabilization frame
- Try to attach new Console Motor Box
- Assemble electronics into electronics box
- Create plan for finishing final prototype fabrication during this week (finish 3D prints, using TEAM lab to screw things in)
- Create plan for finishing outreach requirements and turning in
- Create plan for testing in April

References: n/a

Conclusions:

The electronics box, console rotation box, and motor housing all work well! I will reprint the smaller components that still need tweaking to improve their fit. Once integration occurs, we will have to gather all the necessary screws and possibly tap/drill out holes for the screws (we will discuss what we plan to do Tuesday evening when we meet for integration).

Action items:

-Make adjustments to motor and magnet housing connection, LCD display, and console field goal posts and print again

-Print above (with electronics box lid) on Tuesday morning

-Integrate with all rower assembly components and make an entry about integration on Tuesday evening at 7:30

-Come up with plan for finding wheelchair participants

-Send outreach form to Mr. Ropa and write our 3 paragraph recap of experience to turn in

-Once all 3D prints are finalized, update appendix with proper photos of CAD and integrated parts

Josh ANDREATTA - Mar 27, 2023, 8:34 PM CDT

Download

LCD_Display_Cover.SLDPRT (131 kB)

Josh ANDREATTA - Mar 27, 2023, 8:34 PM CDT

Download

Rower_Base_Electronics_Box_Lid.SLDPRT (63.9 kB)

Josh ANDREATTA - Mar 27, 2023, 8:34 PM CDT

Download

Stepper_Motor_Magnet_Connection.SLDPRT (223 kB)

Josh ANDREATTA - Mar 27, 2023, 8:34 PM CDT

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Field_Goal_for_Console_Display_LEFTLEFT_Part.SLDPRT (208 kB)

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Field_Goal_for_Console_Display_Right_Part.SLDPRT (178 kB)

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Field_Goal_for_Console_Display_Left_Part.STL (112 kB)

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Field_Goal_for_Console_Display_Right_Part.STL (104 kB)

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LCD_Display_Cover.STL (57.3 kB)

Josh ANDREATTA - Mar 27, 2023, 8:34 PM CDT

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Rower_Base_Electronics_Box_Lid.STL (37.7 kB)

Josh ANDREATTA - Mar 27, 2023, 8:34 PM CDT

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Stepper_Motor_Magnet_Connection.STL (377 kB)

3/28/2023 - List of Required Screws and Plan for TEAMLab Fabrication

Josh ANDREATTA - Mar 30, 2023, 1:35 PM CDT

Title: 3/28/2023 - List of Required Screws and Plan for TEAMLab Fabrication

Date: 3/28/2023

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: List the screws needed and steps for fabrication at TEAM Lab

Content:

1. Stabilization Frame
    1. Get 2 M5 x 1 inch
2. Talk to Team lab about best method for creating two-three new level holes in the pin plate (possibly reserve a mill for this and ask for help to ensure its done correctly)
3. Talk to Team lab about how best to use drill to screw in magnet housing and motor housing. Then find time to check out drill and assemble
    1. Motor Housing - **MODEL FOR NEW PLACEMENT???**
        1. Need 2 1/4-20 x 1.5 inch screws and nuts - have!
        2. Print with wider through holes after make new model!
    2. Magnet Housing
        1. Need 2 5M X0.8 x 1.25 inch screws and nuts
4. Electronics Box
    1. Determine necessary screw size by bringing parts down stairs and trying different screws out
    2. Tap holes accordingly
    3. Get proper screws and nuts accordingly - need 2 longer of longer screws - dont have - glue or try to fit nut on anyway?
5. Electronics Box Lid
    1. need 4 1/4-20 X 0.5 inch screws
    2. Widen all holes
6. Console Box
    1. Need 4 M6x0.75 inch and nuts - have
    2. Tap (see if screws fit first to avoid unnecessary tapping) and assemble
7. LCD Display
    1. Use extra solder board to see what screws are needed
    2. Tap holes
    3. Get 8 screws and nuts and assemble
8. Need 2 longer screw for motor - dont have!
9. Get M8 nut for magnet motor connection
10. Print new motor housing for resistance dial mechanism? and print new motor magnet connection?

I am also going to print a final round of the motor magnet housing connector with slightly varying D shaft cavity sizes as we need it a little smaller. I will print 3 versions in the hopes that one of them works well as a press fit. I will pick this up with the lid hopefully before 4 pm.

References: n/a

Conclusions:

Tomorrow at 4pm I will go to the TEAM Lab to collect these screws and drill and tap out all the holes and make sure all the screws fit. The LCD displays, electronics box, and console rotation box will be screwed in by Annabel over the weekend after she is able to cut all the wires to length. I will make sure that everything aligns and fits tomorrow so that Annabel just has to assemble. Once Sam and I talk with the TEAM Lab about the best way to drill into the pin plate and the rower, we will reserve a mill and check out a hand drill and finish the attachment of the stabilization frame and the magnet housing to the rower.

Action items:

-Go to TEAM Lab at 4pm tomorrow to gather all necessary screws, washers, and nuts for all parts and tap/drill out all necessary holes. Organize based on part component in baggies.

-Ensure the fit is correct for all parts.

-Leave console box, electronics box/lid, and LCD display for Annabel to assemble over weekend once electronics are integrated.

-Have developed plan/time for making extra holes in pin plate and screwed in motor and magnet housing to rower. (Sam to complete ImageJ analysis first).

Josh ANDREATTA - Mar 28, 2023, 11:08 PM CDT

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0.9_Scale_Connector.STL (377 kB)

Josh ANDREATTA - Mar 28, 2023, 11:08 PM CDT

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0.95_Scale_Connector.STL (377 kB)

Josh ANDREATTA - Mar 28, 2023, 11:08 PM CDT

Download

0.925_Scale_Connector.STL (377 kB)

3/30/2023 - Fabrication of Rower and (Final) Prints

Josh ANDREATTA - Mar 30, 2023, 6:39 PM CDT

Title: 3/30/2023 - Fabrication of Rowe and (Final) Prints

Date: 3/30/2023

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Describe the past two days of fabrication and the final prints I made

Content:

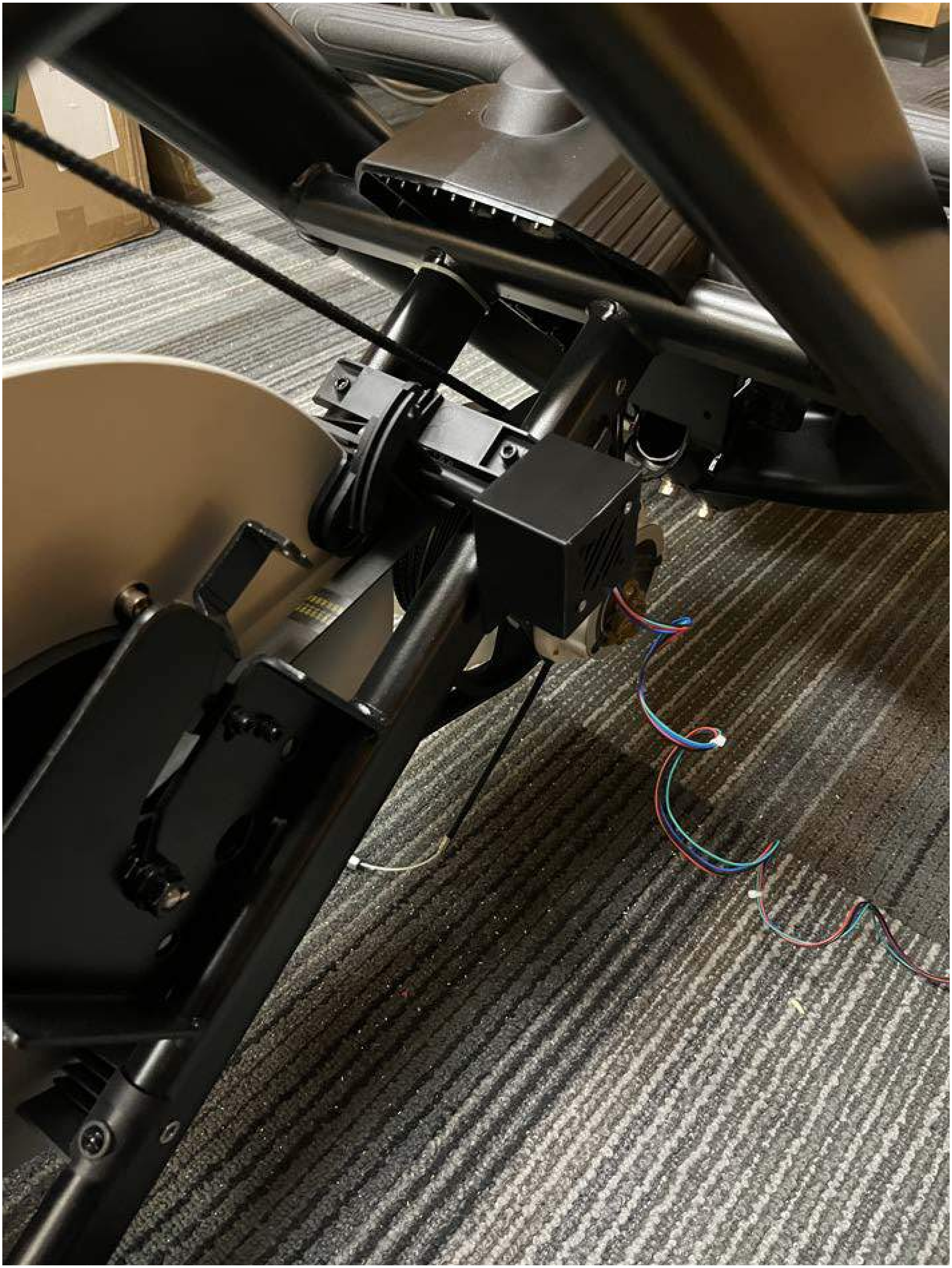
Yesterday, Sam and I met in the TEAM Lab and collected all the screws that we needed based on the previous entry for the entire assembly. I used a drill press to make the screw through holes in the LCD display covers and the electronics box. Today, I checked to see if the components all fit. The LCDs fit in the cover with the screws, but on one of them, the cover is slightly off kilter - but it still covers the electronics and allows for the LCD display to be seen. Its not perfect, but it is close and it works. The motor controller and arduino mega both fit in the box. Each of those components only has 2 holes because the other holes couldn't be drilled because the press couldn't reach them. However, this is okay because only 2 holes are needed to prevent translation and rotation. Today, I used the drill press to widen the through holes in the console box housing. After completing this, I tried to thread the screws to connect the console box with the metal pulley plates. After further investigation, it appears that one of the machinist at JHT did not do a great job when making the threads in the metal base of the pulley plates. I could only actually get screws in the front two holes. I had to really twist the wrench to get them in because it seems like the threads aren't straight and are ever so slightly diagonal. However, after messing around with it, I was able to secure the console box with the pulley plates using those front two holes. Next, I tried to find screws to screw the motor for the magnet housing into its holder, but the TEAM Lab doesn't carry them, so we will likely have to glue or tape that motor in place.

Next, I realized something in our resistance dial mechanism that could change which would make our fabrication process easier. Originally, we planned on putting the stepper motor in with the electronics box at the base of the rower. However, since the box is a separate component now, I realized that we could actually keep the magnets in their original placement on the rower. This makes fabrication easier because we don't need to screw the magnet housing into the rower because we can just use the holes that are already made for it. Keeping the magnets here also makes it easier to screw the motor housing into. As shown below, we can utilize the flat edge surface my finger is pointing into to mount the motor housing. I modified the model and 3D printed a new version of the motor housing that can reach down to that edge. Any space in between will be filled with washers for ease of fabrication. With the motor up near the original magnet position, we are unable to put back on that half of the plastic cover. However, we decided this is okay because JHT can always make a new plastic cover, and we really just wanted to prove the proof of concept of our resistance dial mechanism. Once this part is printed and I confirm that it fits, we will use a drill and attach it to the frame with 2 1/4-20 screws and nuts and washers (as needed).

Finally, we realized that the pin plate did not have enough holes to accommodate taller users, or wheelchairs that have taller sitting heights. I worked with someone in the TEAM Lab staff today and drilled two additional holes along the proper arc in the steel pin plate. I got to learn how to set up the drill press for drilling out of flat steel plates, which was something I have never done before, so that was a good learning experience. I organized all the components and their screws in the rower room. Please see below for pictures!

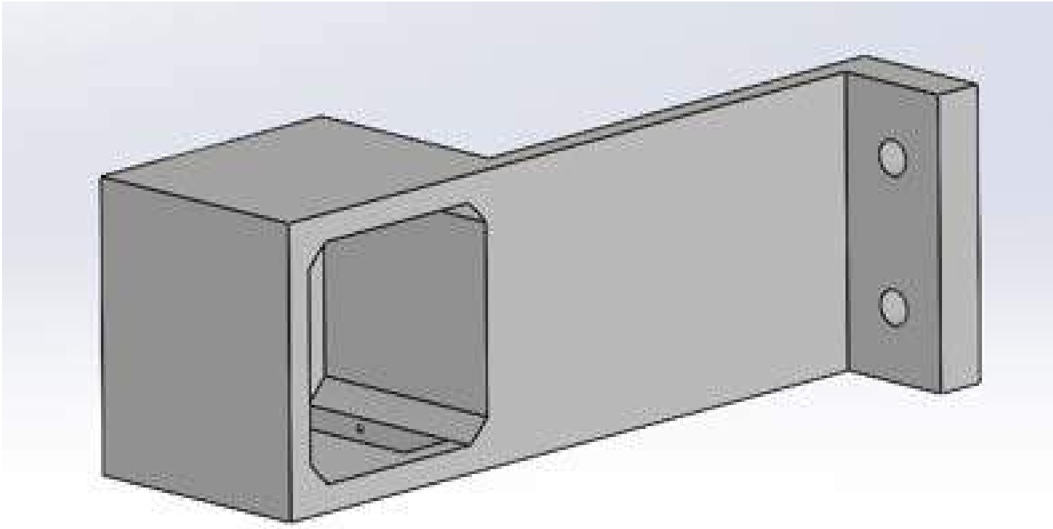
The above image shows the pin plate before drilling new holes. The arc where holes will be centered can be seen.

The above image shows the pin plate after drilling two additional holes. The pin fits properly within them.



The above image shows the top view of the newly proposed motor location when the magents stay in their original location.

The above image shows the flat edge we will screw the motor housing into.



The above image shows the new motor housing. I expect there to be some slight changes we will need to make to this. I will see how it looks tomorrow, update, and reprint a final version.

References: n/a

Conclusions:

I would like to have the rower completely fabricated by next week (preferably towards the beginning of the week). To accomplish this, below is what needs to occur:

- Josh to get new motor housing and make sure it fits (adjust if needbe - hopefully not)
  - Josh and Sam to use drill to screw into rower flat edge
- Josh to put on fresh motor connection on magnet housing and stepper motor
- Josh and Sam to screw stabilization frame into rower
- Annabel to solder and assemble LCD displays and electronics box
- Annabel and Tim to attach LCD displays, limit switches, and buttons somewhere on rower

Action items:

-Pick up motor-magnet-connector and new motor housing. Go to ECB and see if they fit (and if not, adjust and reprint)

-BME Tong Lec, Meeting with Tracy/Staci, Write & Submit Executive Summary Draft

-Annabel to assemble LCD Displays and electronics box stuff over the weekend

-Next week, finish fabrication, including placement and attachment of limit switches and buttons. After this, organize rower room.

-Make/complete testing plans!!!!!

Josh ANDREATTA - Mar 30, 2023, 6:40 PM CDT

Download

Stepper_Motor_Housing.SLDPRT (10.1 MB)

Josh ANDREATTA - Mar 30, 2023, 6:40 PM CDT

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0.95_Scale_Connector.STL (377 kB)

Josh ANDREATTA - Mar 30, 2023, 6:40 PM CDT

Download

Stepper_Motor_Housing.STL (378 kB)

3/31/2023 - Updated Motor Housing Print and Console Rotation Box

Josh ANDREATTA - Mar 31, 2023, 12:11 PM CDT

Title: 3/31/2023 - Updated Motor Housing Print and Console Rotation Box

Date: 3/31/2023

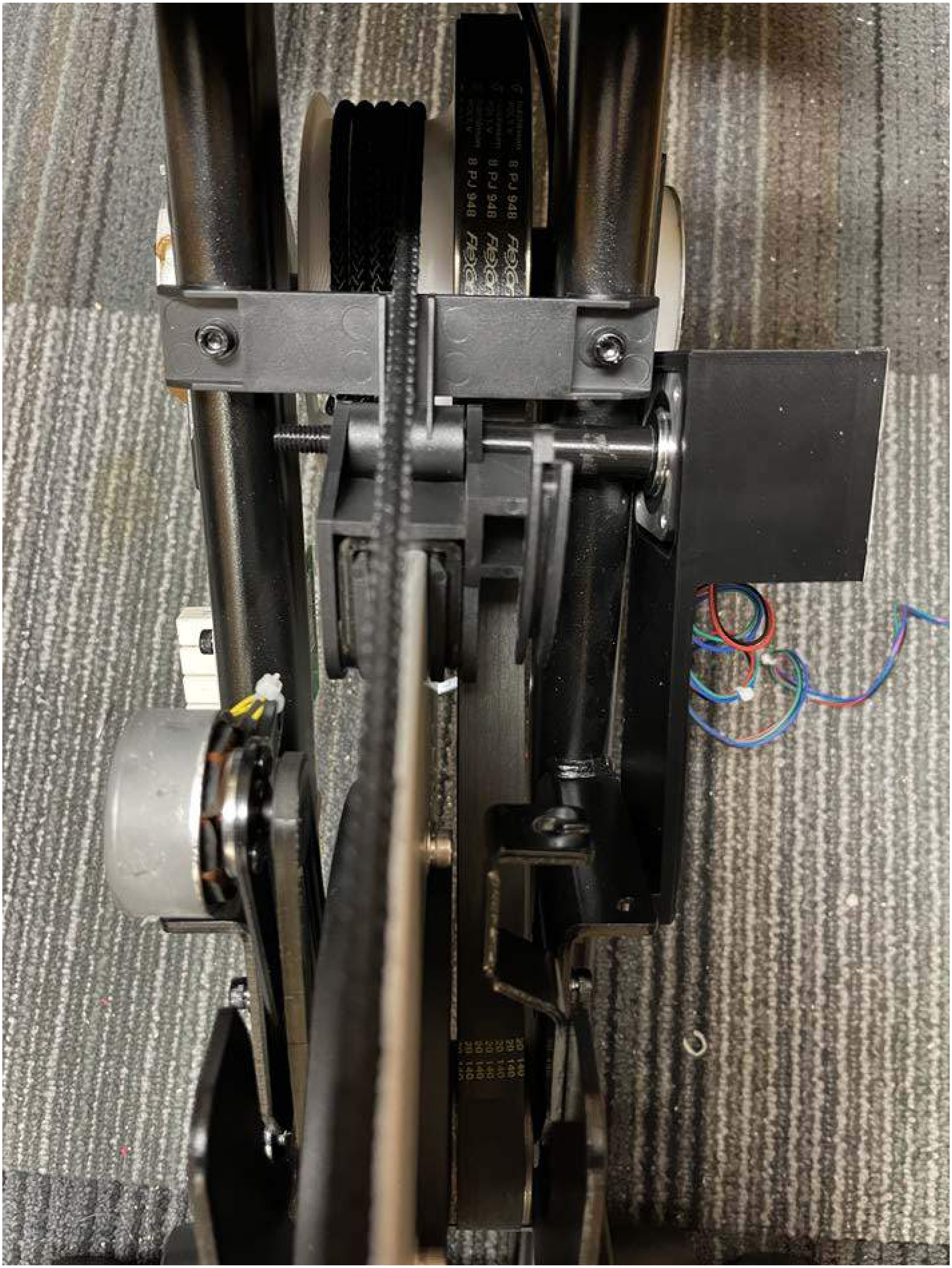
Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show new print of motor housing and the console rotation box mounted to the pulley plates

Content:

Today I picked up the new motor housing print and put it on the rower. Turns out, it fits very well! There is a slight discrepancy in the angle of the housing with the flat edge, but not great enough to need a second print and adjustment. After tweaking with the component, I think we will be able to position it properly and screw it into place. I also printed two extra connectors for the motor-magnet connection so we have fresh ones to tap into place. Below are pictures:



The above image shows the top view of the magnet and motor assembly.

The above image shows how the new motor housing will screw into the rower flat edge.

The above image shows the front view of the console box secured to the metal pulley plates.

The above image shows the back view of the console box secured to the metal pulley plates.

Next week, Sam and I need to screw the motor housing into the rower. Sam needs to screw the stabilization frame into the rower. Annabel needs to assemble all the electronics. Then, we will just need to double check and make sure everything is properly attached. We also need to figure out a way to secure the motor in the housing because the TEAM Lab does not have proper screws.

References: n/a

Conclusions:

The prints should all be completed. I will meet with the team this afternoon to show them everything and then we will finish fabrication over the weekend and next week. We will also formulate our testing plan.

Action items:

-Annabel to solder electronics and assemble in electronics box

-Next week, Josh and Sam to screw motor housing into flat edge on rower frame and mount motor connection on motor and magnet housing

-All brainstorm way to secure motor for resistance dial mechanism

-All to brainstorm way to attach limit switches and buttons

-Send emails to coordinate wheelchair participant recruitment

4/5/2023 - New Idea for Motor Housing to Ease Fabrication

Josh ANDREATTA - Apr 05, 2023, 12:10 AM CDT

Title: 4/5/2023 - New Idea for Motor Housing to Ease Fabrication

Date: 4/5/2023

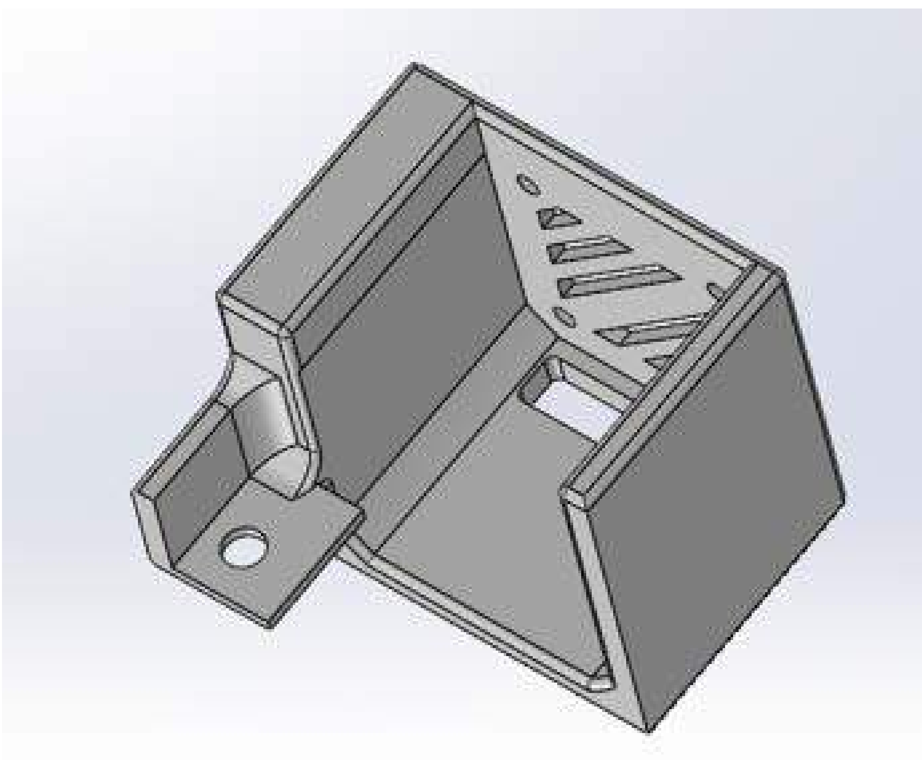
Content by: Josh Andreatta

Present: Josh Andreatta

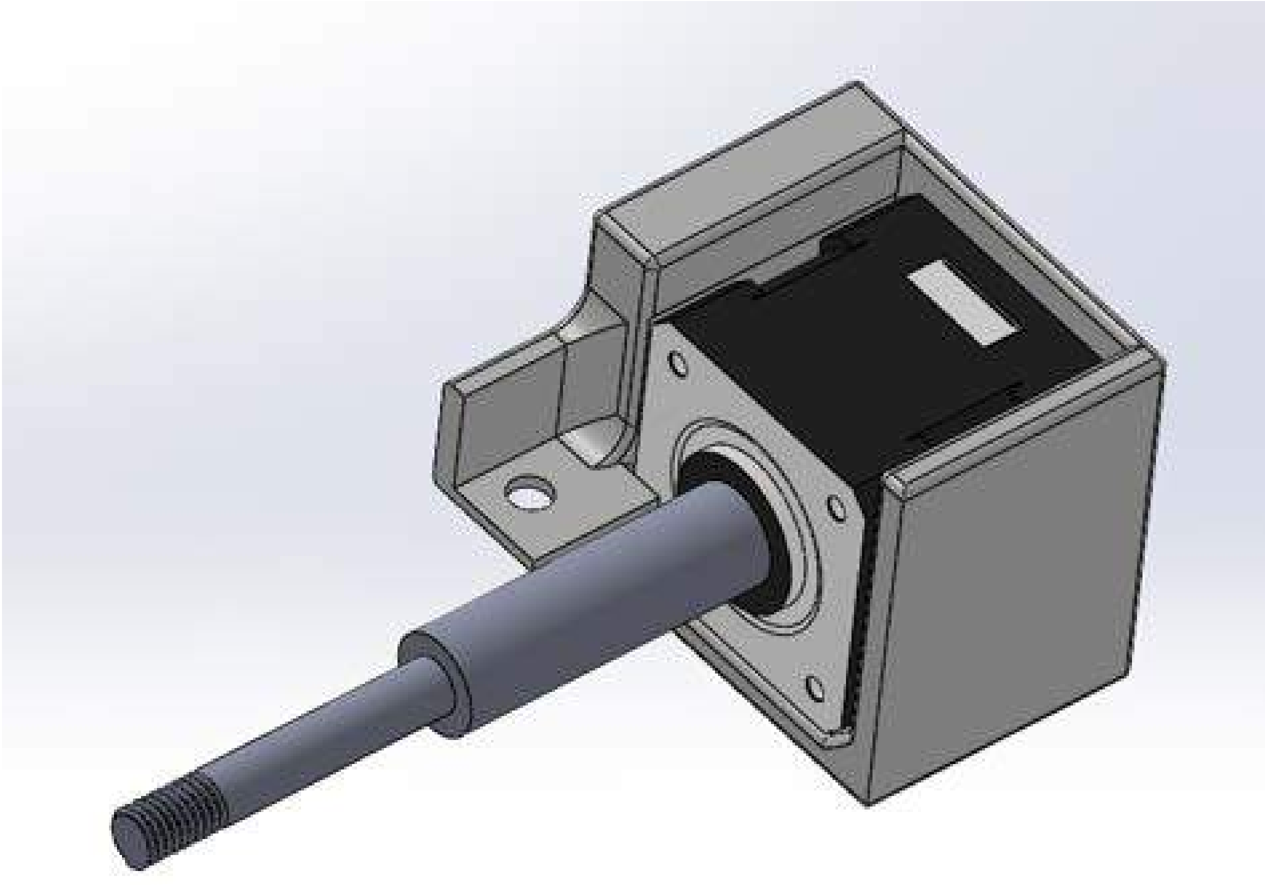
Goals: Show the CAD of my new idea for attaching the motor to the rower for the resistance dial mechanism

Content:

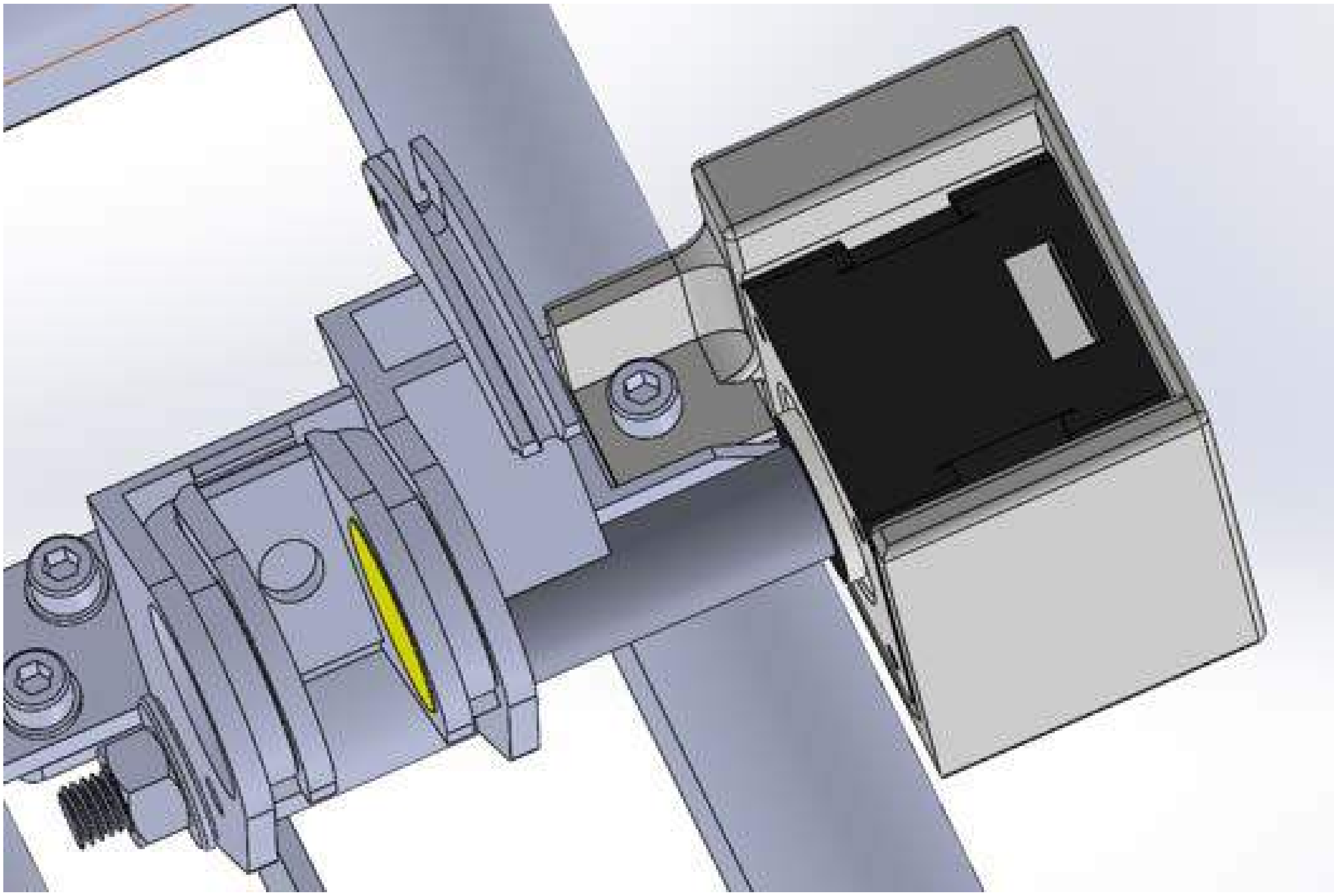
Today, me, Sam, Tim, and Annabel (roxi wasn't feeling well) met to work on the assembly of the rower. When we tried to put the motor housing for the resistance mechanism that I printed on, we realized that it wasn't perfectly parallel to the flat surface that we intended to drill into. We could technically get it to fit, but only if we slightly bent the structure. By doing this, the shaft of the motor became slightly misaligned with the magnets, so we did not want to do this. Instead, we came up with the idea of screwing the housing into the screw hole that is already present on the magnet housing as shown below. We can do this because we can take the motor and spin it while its turned off, insert the housing, and then spin to place the hole over where the screw hole is on the magnet housing. We may need to get a slightly longer screw from TEAMLab but possibly not. Also, since the TEAMLab did not have the correct length of the M3 screws for attaching the stepper motor itself to the motor housing, I ordered some off of McMaster-Carr that should arrive on Thursday. Lastly, we came to the conclusion that I need to print a fresh LCD display cover, because the holes do not exactly line up with the solder board on one set. I will reprint the fresh LCD display cover and new motor housing tomorrow morning. When it is finished, I will go see how the housing fits on the rower and make any adjustments necessary. At this time, I will also drill out fresh holes in the LCD display cover and make sure it fits properly on the solder board. When the screws arrive, I will make sure they are the correct pitch (the motor did not specify the pitch of the screw threading) and finish this assembly. See below for pictures.



The above image shows the new motor housing with a flat portion to screw into the magnet housing.



The above image shows how the motor sits in the housing.



The above image shows how the housing is attached to the rower frame. The housing will be slide onto the motor, the motor will be screwed in to the housing, and then the motor will be rotated so that the flat jut lies flat on the magnet housing and it will be screwed in to that piece.

References: n/a

Conclusions:

I will stop by the MakerSpace tomorrow to print this, in addition to the extra motor-magnet-connector and the fresh LCD display cover. The screws I ordered should arrive Thursday. When the print is done, I will take it to ECB and see if it fits like I want or if anything needs to be changed. Once the screws come in, I will attach everything together.

Action items:

-Print new motor housing, connector, and LCD display cover

-Assemble by drilling holes in new LCD display cover and putting housing on motor and magnet assembly (and make adjustments as necessary)

-Meet on Friday to tape/hot glue the rest of the buttons and limit switches

-On friday, make sure all fabrication is done so annabel can finish soldering the wires. The rest of us can clean up and organize the rower room.

-Continue to wait to hear back from people about testing participant recruitment

Josh ANDREATTA - Apr 05, 2023, 12:11 AM CDT

Download

Stepper_Motor_Housing.SLDPRT (10.3 MB)

Josh ANDREATTA - Apr 05, 2023, 12:11 AM CDT

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Stepper_Motor_Magnet_Connection.SLDPRT (220 kB)

Josh ANDREATTA - Apr 05, 2023, 12:11 AM CDT

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Stepper_Motor_Magnet_Housing_Connection_Assembly.SLDASM (560 kB)

Josh ANDREATTA - Apr 05, 2023, 12:11 AM CDT

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LCD_Display_Cover.STL (57.3 kB)

Josh ANDREATTA - Apr 05, 2023, 12:11 AM CDT

Download

Stepper_Motor_Housing.STL (524 kB)

4/22/23 - Final Fabrication of Rower

Josh ANDREATTA - Apr 22, 2023, 8:54 PM CDT

Title: 4/22/23 - Final Fabrication of Rower

Date: 4/22/23

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Discuss where to find final fabrication entry

Content:

Throughout the semester, I helped design, model, 3D print, and install all of the 3D printed components, in addition to the metal pulley plates and antlers which were made by JHT. I used the TEAMLab to collect screws, nuts, and drill holes in several of the parts. Please find my final fabrication entry in the team fabrication folder for a few pictures of the final rower all assembled together.

References: n/a

Conclusions:

See above.

Action items:

-**Make and edit final poster sections and scripts**

2/1/2023 - Wheelchair user Protocol EMG & No EMG

Josh ANDREATTA - Feb 01, 2023, 3:51 PM CST

Title: 2/1/2023 - Wheelchair user Protocol EMG & No EMG

Date: 2/1/2023

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Develop protocols for wheelchair users using the rowing machine with and without EMG

Content:

I developed a protocol for wheelchair users who will use our rowing machine and then fill out a survey based on their experience. I made a second protocol for non-wheelchair users using a wheelchair on the adaptive side for EMG testing to compare muscle activation between the standard and adaptive side of the rower. The blanks regarding EMG equipment details will be filled in once we have confirmation on the specific equipment we will be using.

Wheelchair User Protocol - NO EMG:
Note: For non-wheelchair users testing on the adaptive side of the rower, a standard wheelchair will be provided for use during testing.

1. Have the user approach the adaptive side of the rower slowly.
2. Have the user ensure that the stabilization pad is lifted enough in reference to the horizontal plane to properly roll as close to the rower as possible so that they can comfortably reach the rower handlebar in its resting position.
3. Once positioned at a comfortable reach, the user should lower the stabilization pad onto their lap to secure themselves in place and prevent backwards tipping. The pad should be placed at the crease between the lower abdomen and upper lap. The console should turn to face the adaptive side during this portion.
4. Lock wheelchair wheels in place to prevent translation forwards and/or backwards.
5. Adjust the settings on the console to display the desired information (stroke rate, distance traveled, speed, etc.).
6. Have the user turn the resistance dial to level 1.
7. Have the user grab the handlebar with both hands and lift vertically upward to remove the handlebar from the supports.
8. Next, the user should pull the handlebar towards the middle of their chest, pause for 0.5 seconds, and then extend the arms forward again. The user can slightly lean forward upon this extension to achieve a longer rowing pull stroke if desired. Repeat this motion for one minute.
    a. The user should try to maintain a constant and steady stroke rate between 25-30 rpm, or at a level deemed comfortable for the individual.
9. Once the minute trial is complete, slowly and gently place the handlebar back within the supports.
10. Rest for two minutes.
11. Repeat steps 6-10 at resistance levels 5 and 10.
12. To remove themselves from the rower, the user should slowly lift the stabilization pad until it is completely vertical in orientation. The console should turn to face the standard side during this portion.
13. Unlock the wheelchair wheels and have the user slowly roll away from the rower.
14. Have the user complete the survey(s).

Wheelchair User Protocol - EMG:

1. Have the user approach the adaptive side of the rower slowly.

2. Have the user ensure that the stabilization pad is lifted enough in reference to the horizontal plane to properly roll as close to the rower as possible so that they can comfortably reach the rower handlebar in its resting position.
3. Once positioned at a comfortable reach, the user should lower the stabilization pad onto their lap to secure themselves in place and prevent backwards tipping. The pad should be placed at the crease between the lower abdomen and upper lap. The console should turn to face the adaptive side during this portion.
4. Lock wheelchair wheels in place to prevent translation forwards and/or backwards.
5. Plug the power cord of the ____ machine into a power source/outlet. Plug ___ (number of electrodes) electrodes into the ___ machine (name of machine). Make sure they are connected to the correct polarization nodes.
6. Have the user clean their _____ (part of the body where the electrode is) with an alcohol sterilization wipe.
7. Remove the plastic from the EMG electrode. Place a pea-sized amount of electrode gel on top of the electrode. Spread the gel over the entire electrode surface evenly.
8. Place the electrode on the skin over the top of the user's _____ (muscle group name) group.
9. Adjust the settings on the console to display the desired information (stroke rate, distance traveled, speed, etc.).
10. Turn on the ____ (machine name). MORE INFO ABOUT SPECIFICS OF EMG MACHINE AND INTERFACE
11. Have the user turn the resistance dial to level 1.
12. Have the user grab the handlebar with both hands and lift vertically upward to remove the handlebar from the supports.
13. Next, the user should pull the handlebar towards the middle of their chest, pause for 0.5 seconds, and then extend the arms forward again. The user can slightly lean forward upon this extension to achieve a longer rowing pull stroke if desired. Repeat this motion for one minute.
    a. The user should try to maintain a constant and steady stroke rate between 25-30 rpm, or at a level deemed comfortable for the individual.
14. Once the minute trial is complete, slowly and gently place the handlebar back within the supports.
15. Rest for two minutes.
16. Repeat steps 6-10 at resistance levels 5 and 10.
17. Have the user remove the electrodes from their skin carefully. Place the electrodes back on to the plastic and return all materials to the researcher.
18. Turn off the EMG machine and unplug from the power supply.
19. To remove themselves from the rower, the user should slowly lift the stabilization pad until it is completely vertical in orientation. The console should turn to face the standard side during this portion.
20. Unlock the wheelchair wheels and have the user slowly roll away from the rower.
21. Have the user complete the survey(s).

References: n/a

Conclusions:

This will be edited by Dr. Puccinelli before we submit to the IRB.

Action items:

-Meet with Tracy Friday to discuss IRB documents and testing presentation plan

-Update Tracy about outreach date (3/24 Friday)

2/12/2023 - Final Version of Wheelchair EMG & NO EMG Protocols

Josh ANDREATTA - Feb 12, 2023, 11:40 AM CST

Title: 2/12/2023 - Final Version of Wheelchair EMG & NO EMG Protocols

Date: 2/12/2023

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Show final version of both protocols

Content:

Adaptive Side Protocol - EMG:

Test Subjects: Users that do not require wheelchairs, but will be provided with one during testing

1. Have the user approach the adaptive side of the rower slowly.
2. Have the user ensure that the stabilization pad is lifted enough in reference to the horizontal plane to properly roll as close to the rower as possible so that they can comfortably reach the rower handlebar in its resting position.
3. Once positioned at a comfortable reach, the user should lower the stabilization pad onto their lap to secure themselves in place and prevent backwards tipping. The pad should be placed at the crease between the lower abdomen and upper lap. The console should turn to face the adaptive side during this portion.
4. Lock wheelchair wheels in place to prevent translation forwards and/or backwards.
5. Plug the power cord of the Delysis Trigno EMG machine into a power source/outlet. Plug two electrodes into the Delysis Trigno EMG machine.
6. Have the user clean their skin where the electrodes will be placed with an alcohol sterilization wipe.
7. Remove the plastic from the EMG electrode. Place a pea-sized amount of electrode gel on top of the electrode. Spread the gel over the entire electrode surface evenly.
8. Have the user hold their left hand and left arm in a supine position. Place one of the electrodes on the skin distal to the user's shoulder. Place the other electrode on the skin proximal to the user's elbow crease.
9. Adjust the settings on the console to display stroke rate.
10. Turn on the Delysis Trigno EMG.
11. Have the user turn the resistance dial to level 1.
12. Have the user grab the handlebar with both hands and lift vertically upward to remove the handlebar from the supports.
13. Next, the user should pull the handlebar towards the middle of their chest, pause for 0.5 seconds, and then extend the arms forward again. The user can slightly lean forward upon this extension to achieve a longer rowing pull stroke if desired. Repeat this motion for one minute.
    a. The user should try to maintain a constant and steady stroke rate between 25-30 rpm, or at a level deemed comfortable for the individual.
14. Once the minute trial is complete, slowly and gently place the handlebar back within the supports.
15. Rest for two minutes.
16. Repeat steps 11-15 at resistance levels 5 and 10.
17. Have the user remove the electrodes from their skin carefully. Place the electrodes back on to the plastic and return all materials to the researcher.
18. Repeat steps 6-17. For step 8, instead of placing the electrodes on the users left bicep, place one electrode on the user's left middle deltoid and the other electrode on the center of the user's left latissimus dorsi muscle.
19. Turn off the EMG machine and unplug from the power supply.

20. To remove themselves from the rower, the user should slowly lift the stabilization pad until it is completely vertical in orientation. The console should turn to face the standard side during this portion.
21. Unlock the wheelchair wheels and have the user slowly roll away from the rower.
22. Have the user complete the survey(s).

Adaptive Side Protocol - NO EMG:

Test Subjects: Users that require a wheelchair

1. Have the user approach the adaptive side of the rower slowly.
2. Have the user ensure that the stabilization pad is lifted enough in reference to the horizontal plane to properly roll as close to the rower as possible so that they can comfortably reach the rower handlebar in its resting position.
3. Once positioned at a comfortable reach, the user should lower the stabilization pad onto their lap to secure themselves in place and prevent backwards tipping. The pad should be placed at the crease between the lower abdomen and upper lap. The console should turn to face the adaptive side during this portion.
4. Lock wheelchair wheels in place to prevent translation forwards and/or backwards.
5. Adjust the settings on the console to display the stroke rate.
6. Have the user turn the resistance dial to level 1.
7. Have the user grab the handlebar with both hands and lift vertically upward to remove the handlebar from the supports.
8. Next, the user should pull the handlebar towards the middle of their chest, pause for 0.5 seconds, and then extend the arms forward again. The user can slightly lean forward upon this extension to achieve a longer rowing pull stroke if desired. Repeat this motion for one minute.
    a. The user should try to maintain a constant and steady stroke rate between 25-30 rpm, or at a level deemed comfortable for the individual.
9. Once the minute trial is complete, slowly and gently place the handlebar back within the supports.
10. Rest for two minutes.
11. Repeat steps 6-10 at resistance levels 5 and 10.
12. To remove themselves from the rower, the user should slowly lift the stabilization pad until it is completely vertical in orientation. The console should turn to face the standard side during this portion.
13. Unlock the wheelchair wheels and have the user slowly roll away from the rower.
14. Have the user complete the survey(s).

References: n/a

Conclusions:

These were submitted to the IRB for official review.

Action items:

-Wait to here back from IRB to see if we need to make any changes to the documents

-Reach back out to contacts about potential wheelchair users for testing

-Make sure we are getting ready for outreach activity

2/27/2023 - Simulation Testing for Final Pulley Plates and Antlers

Josh ANDREATTA - Feb 27, 2023, 5:10 PM CST

Title: 2/27/2023 - Simulation Testing for Final Pulley Plates and Antlers

Date: 2/27/2023

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Discuss results of simulations on final pulley plates and antlers

Content:

After completing the SolidWorks models of the final versions of the Pulley Plate and Antlers with the client's advice, SolidWorks simulations were run on the single component plate/antler under 4 loading conditions. The component was modeled as one piece of Plain Carbon Steel Sheet metal, as this is what they will physically be fabricated from. In BME 301 and BME 400 simulations, loads of 1050 N were used for all simulations. This was because this was determined to be the maximum force a human could apply to a rowing machine. However, after discussion with the client, it was determined that this load is really describing the maximum load that would be applied to the rower itself, and not to the handlebar-antler interface. Therefore, it was determined that this load value was an inappropriate choice for running simulations on the manufactured plate/antler. This was confirmed when running simulations with the 1050 N load. Stresses would be several orders of magnitudes larger than the yield strength of Plain Carbon Steel and deformations would be close to 30 cm. So, as a proxy, the tension data collected in BME 301 was used instead. From this data, the maximum tension developed on the adaptive side while rowing never exceeded 300 N. Therefore, a simulation was run with a 300 N load placed at the distal tip of the antler facing the adaptive side to assess the deformation (**Figure 1**) and stress (**Figure 2**). Similarly, the BME 301 tension data showed that the maximum tension that developed on the standard side while rowing never exceeded 400 N. Therefore, a simulation was run with a 400 N load placed at the distal tip of the antler facing the standard side to assess the deformation (**Figure 3**) and stress (**Figure 4**). Both of these pairs of simulations have a safety factor of 2, since ideally this load would be distributed equally between both the right and left pulley plate and antlers. Next, a simulation was run in which each of these loads were cut in half. This was done to simulate the expected stresses and deformations that each plate/antler would endure under a maximum load. Therefore, a simulation was run with a 150 N load placed at the distal tip of the antler facing the adaptive side to assess the deformation (**Figure 5**) and stress (**Figure 6**). Similarly, a simulation was run with a 200 N load placed at the distal tip of the antler facing the standard side to assess the deformation (**Figure 7**) and stress (**Figure 8**).

As can be seen in the figures below, the maximum displacement of 2.643 cm occurs when a 400 N load is applied towards the standard side of the rower. However, this describes a safety factor of two. When looking at the 150 N and 200 N loading scenarios (which describe how much force one pulley plate and antler would truly be expected to endure), the max displacement of 1.167 cm occurs when a 200 N load is applied towards the standard side of the rower. After discussing these results with the client, the client is confident that the physical steel sheet metal part will not deform. Additionally, it is very unlikely that the plates themselves will actually ever experience loading of this magnitude. These forces are the forces that develop while rowing at the highest resistance level. It is very unlikely for someone to pull on the handlebar while it is still in the antler cavities. Therefore, although these loading conditions predict a little bit of displacement and slight yielding to occur, it is likely that loads much less than these will actually be applied to the component and thus no displacement or yielding will occur. A person who is using the rower will understand that they must first lift the handlebar out of the cavity prior to rowing. Any slight loads felt by the pulley plate and antlers would be from the user lifting the handlebar out of the cavity at a slight angle, which would apply slight pressure to the inner surface of the antler cavity. These slight loads are not predicted to cause yielding or failure. Once the parts are fabricated and attached to the rower, a physical test will be performed in which the handlebar will be pulled back and let go to fly towards the pulley plate and antlers to determine if it causes them to break.

When running these simulations, Staci helped me do a few things that would improve the accuracy of the results. First, she showed me how to make the part solid and create a fine mesh, which produces more accurate results than a coarse mesh. Lastly, she helped me design the gullet which is there to reduce the stresses and deformations experienced by the part. As mentioned previously, upon trial simulations without the gullet, the deformations and stresses were quite large which is why we added the gullet. It will just be welded on to the antler structure during fabrication.

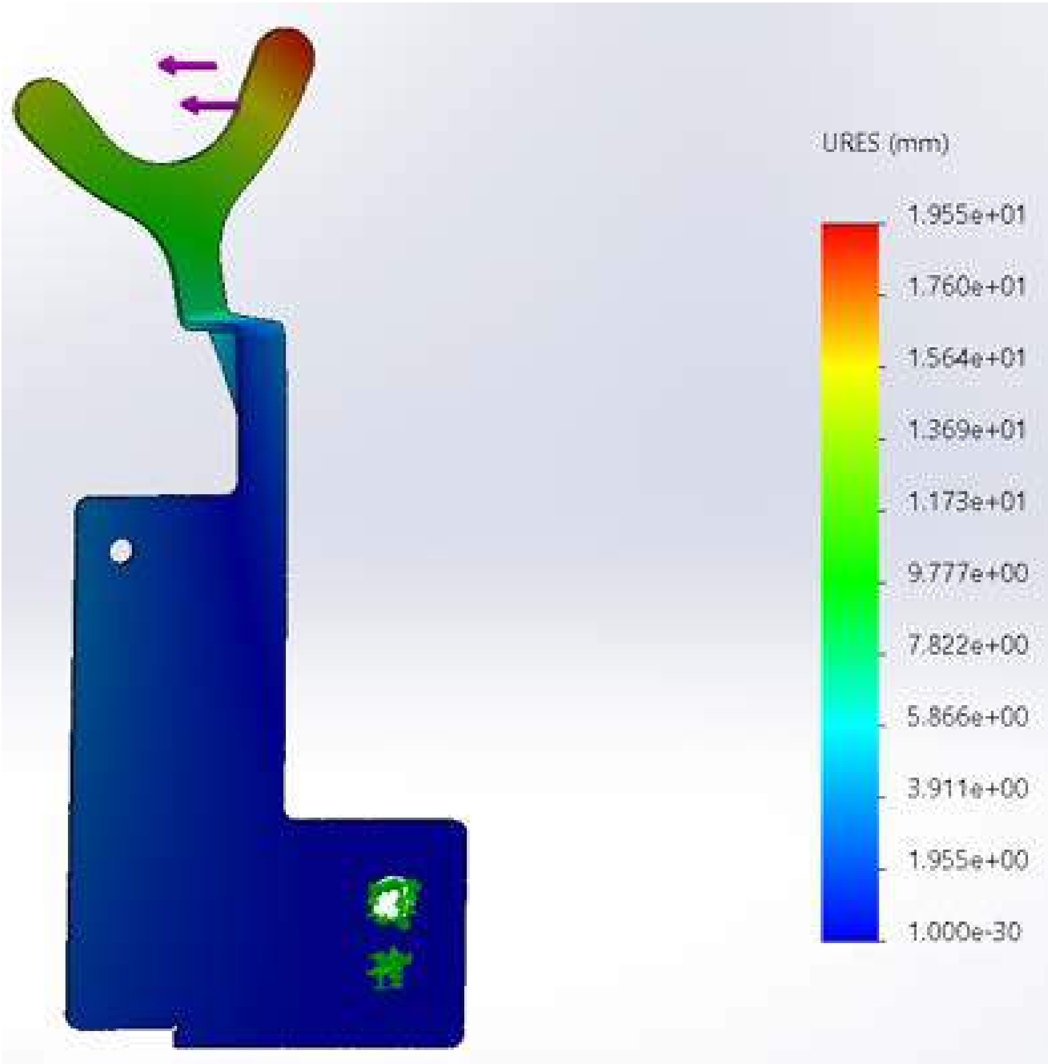


Figure 1. 300 N Load Adaptive Side Deformation. Under a 300 N load applied towards the adaptive side of the rower, the Pulley Plate and Antler experience a max displacement of 1.955 cm at the distal tip of the Antler.

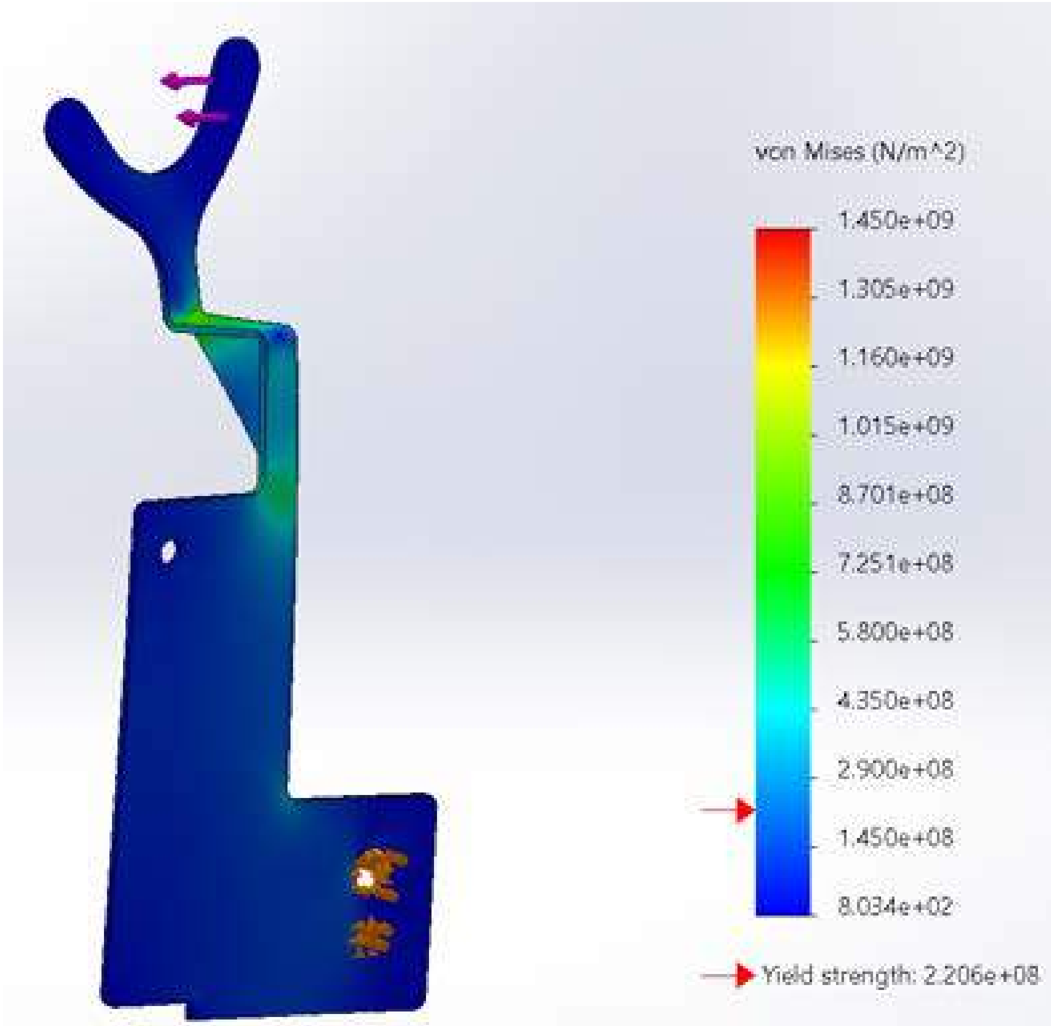


Figure 2. 300 N Load Adaptive Side Stress. Under a 300 N load applied towards the adaptive side of the rower, the Pulley Plate and Antler experience a max stress of 1450 MPa at the corner between the gullet and the vertical portion of the Antler.

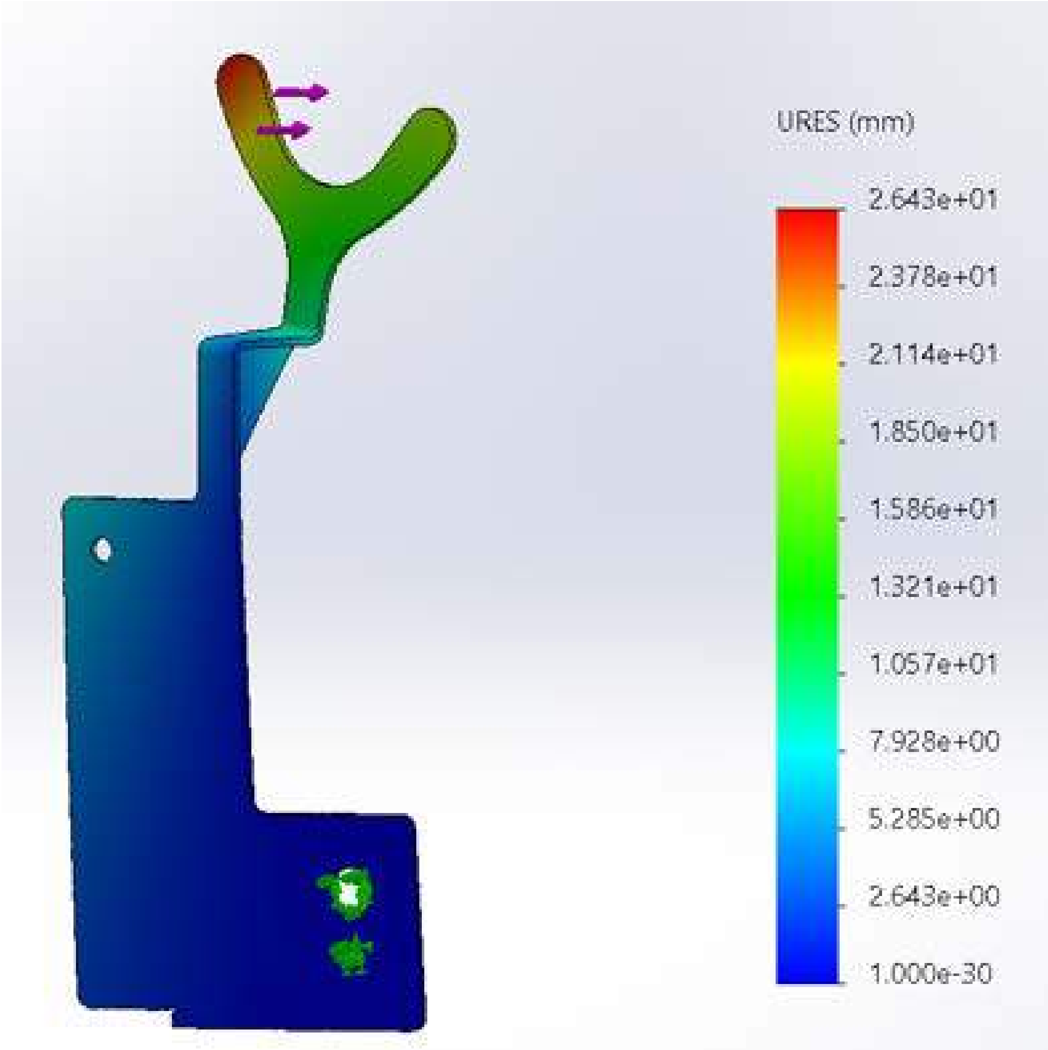


Figure 3. 400 N Load Standard Side Deformation. Under a 400 N load applied towards the standard side of the rower, the Pulley Plate and Antler experience a max displacement of 2.643 cm at the distal tip of the Antler.

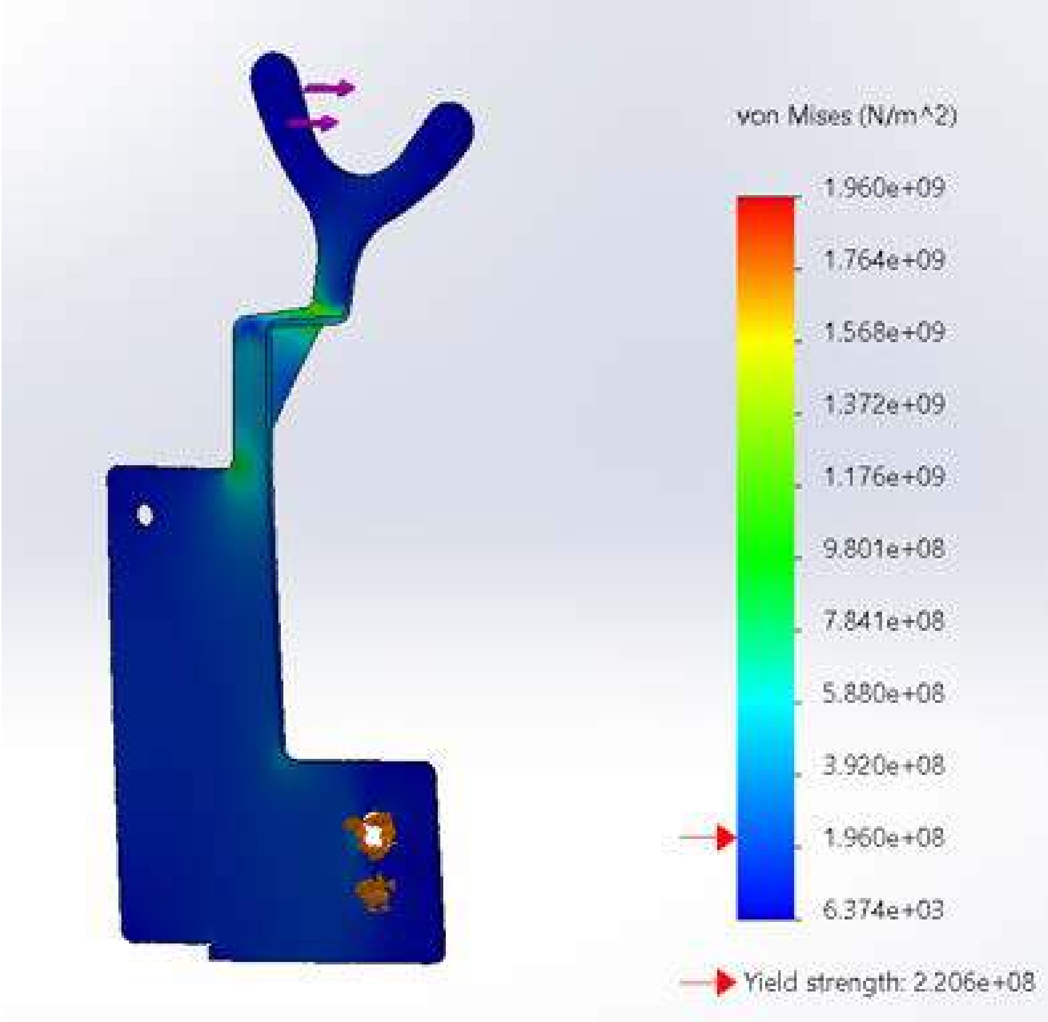


Figure 4. 400 N Load Standard Side Stress. Under a 400 N load applied towards the standard side of the rower, the Pulley Plate and Antler experience a max stress of 1960 MPa at the corner between the gullet and the vertical portion of the Antler.

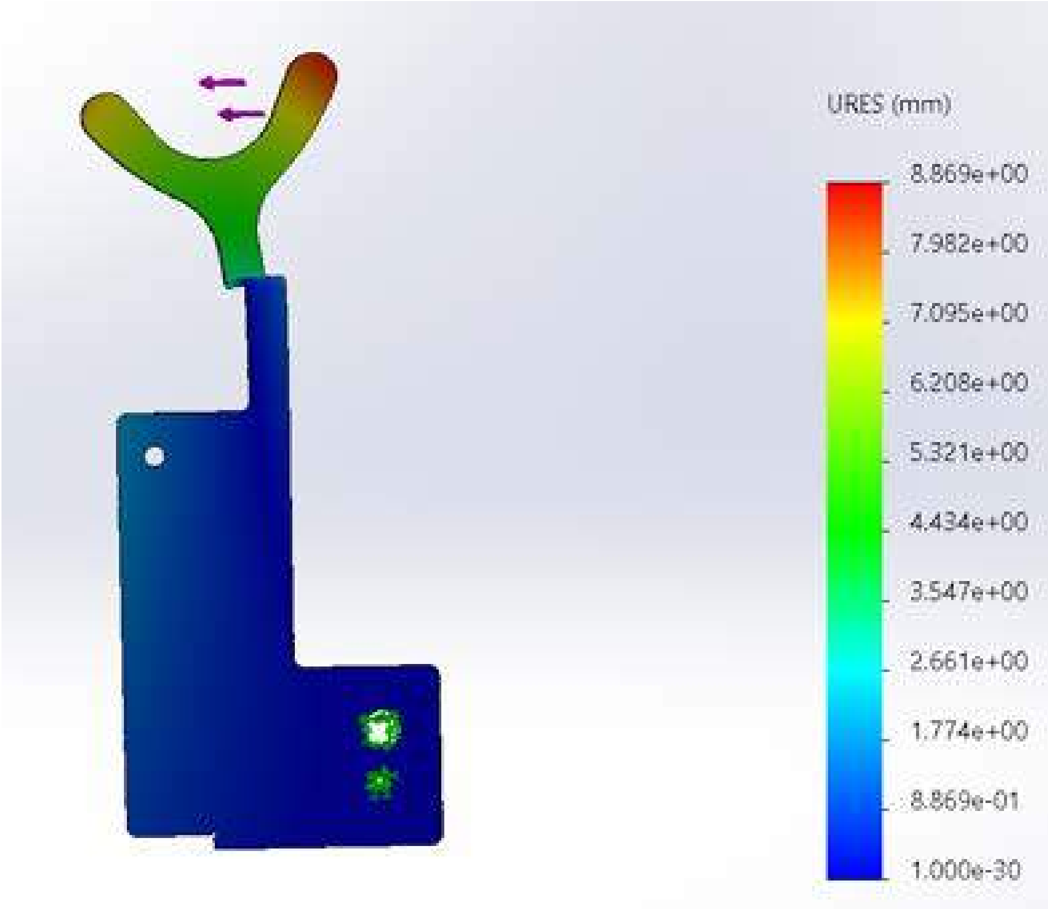


Figure 5. 150 N Load Adaptive Side Deformation. Under a 150 N load applied towards the adaptive side of the rower, the Pulley Plate and Antler experience a max displacement of 0.8869 cm at the distal tip of the Antler.

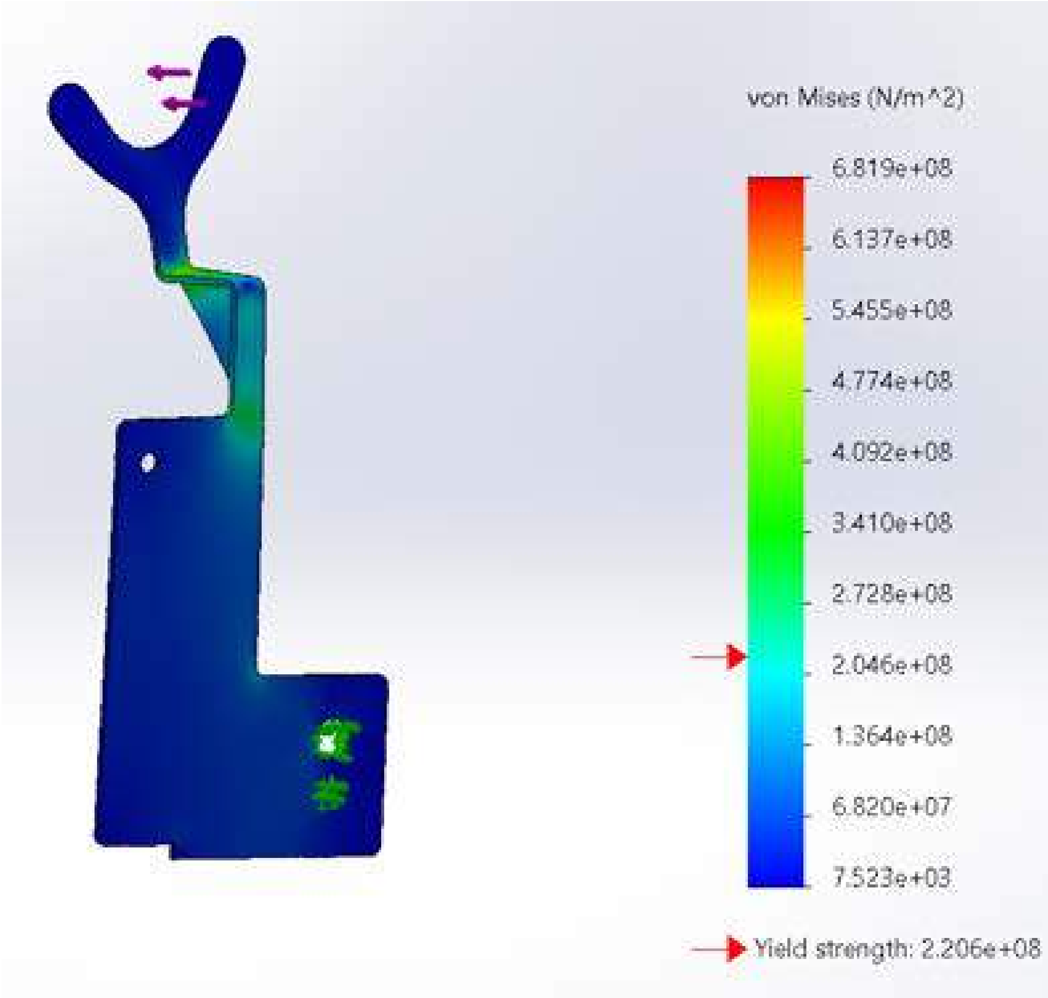


Figure 6. 150 N Load Adaptive Side Stress. Under a 150 N load applied towards the adaptive side of the rower, the Pulley Plate and Antler experience a max stress of 681.9 MPa at the corner between the gullet and the vertical portion of the Antler.

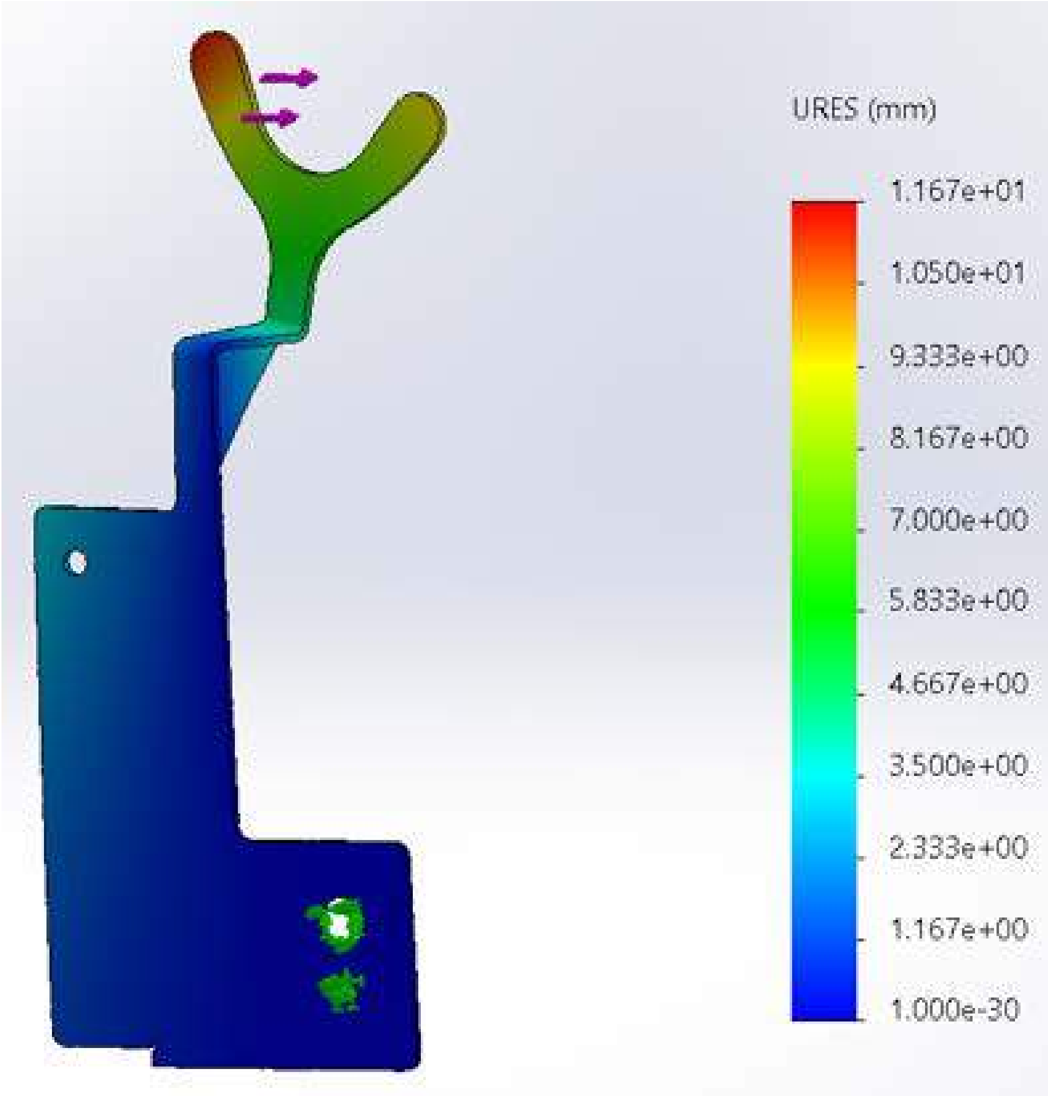


Figure 7. 200 N Load Standard Side Deformation. Under a 200 N load applied towards the standard side of the rower, the Pulley Plate and Antler experience a max displacement of 1.167 cm at the distal tip of the Antler.

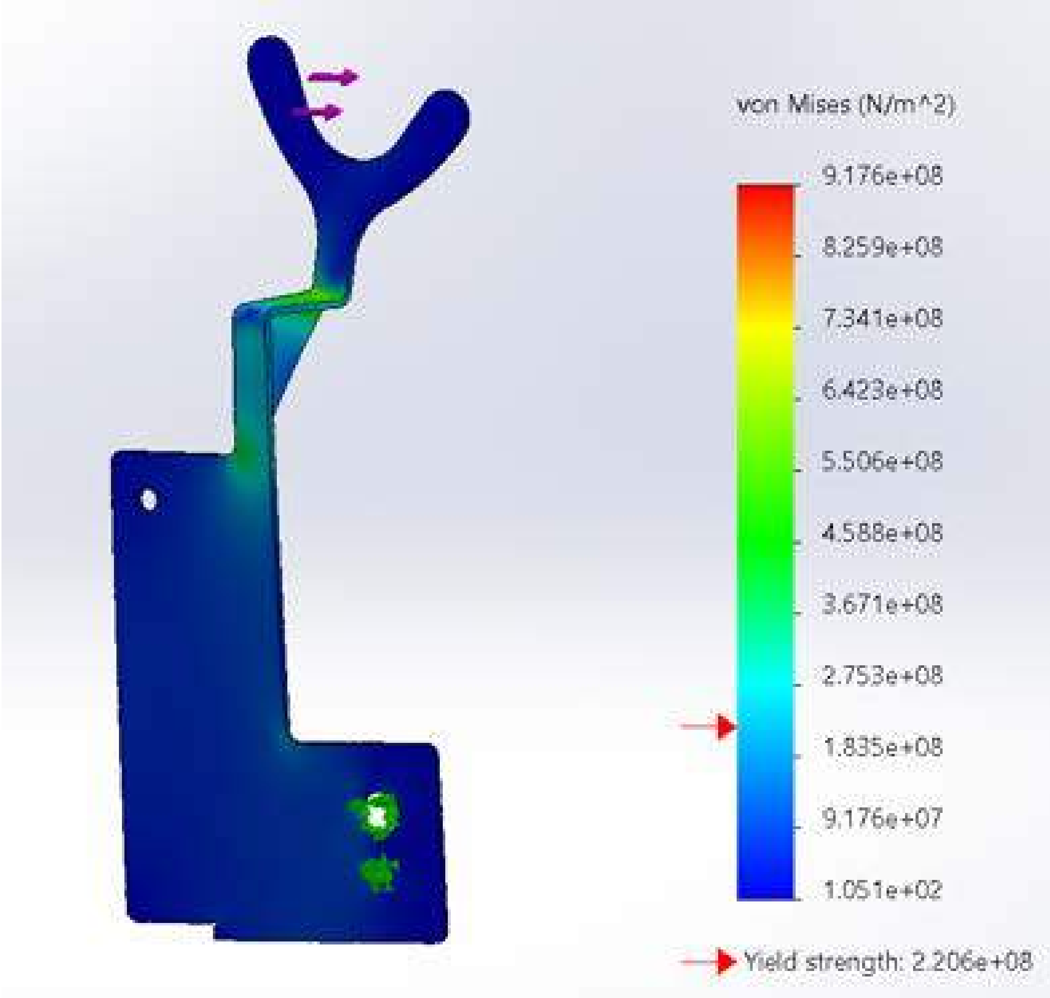


Figure 8. 200 N Load Standard Side Stress. Under a 200 N load applied towards the standard side of the rower, the Pulley Plate and Antler experience a max stress of 917.6 MPa at the corner between the gullet and the vertical portion of the Antler.

References: Staci Quam

Conclusions:

These results have been added to the journal article appendix for documentation. The team does not predict any failure of the plates will occur under typical loads experienced by these parts.

Action items:

-Outreach!

-Submit prelim report and notebook on canvas/website/email

-Model resistance dial mechanism attachment

3/14/2023 - Simulation Testing for Final Pulley Plates and Antlers with 2 Gullets

Josh ANDREATTA - Mar 14, 2023, 12:12 PM CDT

Title: 3/14/2023 - Simulation Testing for Final Pulley Plates and Antlers with 2 Gullets

Date: 3/14/2023

Content by: Josh Andreatta

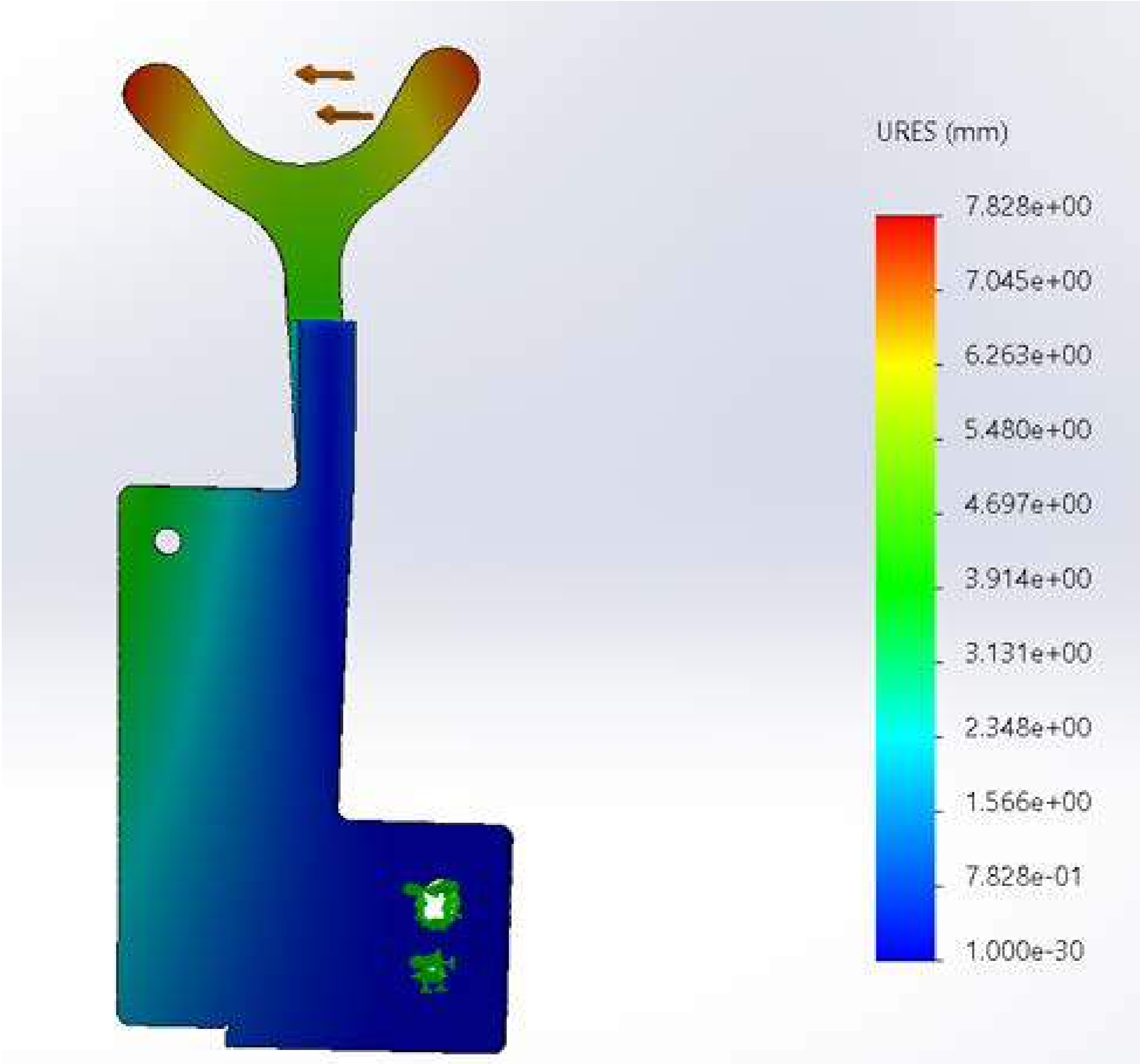
Present: Josh Andreatta

Goals: Discuss results of simulations on final pulley plates and antlers after Staci added 2 gullets instead of just 1

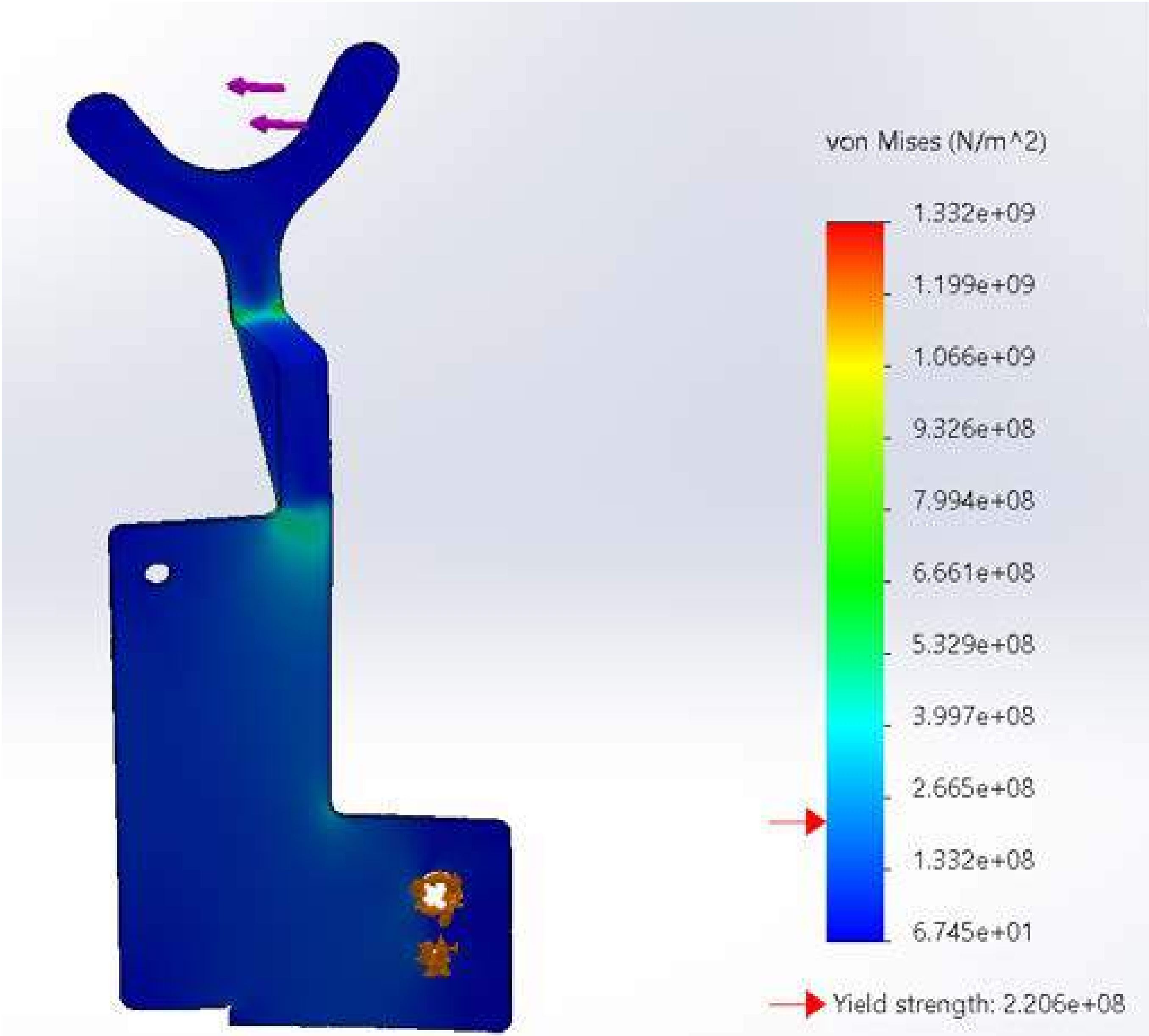
Content:

After completing the SolidWorks models of the final versions of the Pulley Plate and Antlers with the client's advice, SolidWorks simulations were run. The component was modeled as one piece of Plain Carbon Steel Sheet metal, as this is what they will physically be fabricated from. In the previous entry, only one gullet was used to limit bending stresses and deformations. However, JHT actually put two on each antler so the below simulations reflect that change. Only loads of 300 N (adaptive) and 400 N (standard) were used in the simulation as they give a safety factor of 2 (as explained in the previous entry). Safety factor's of 1 are not of interest to us.

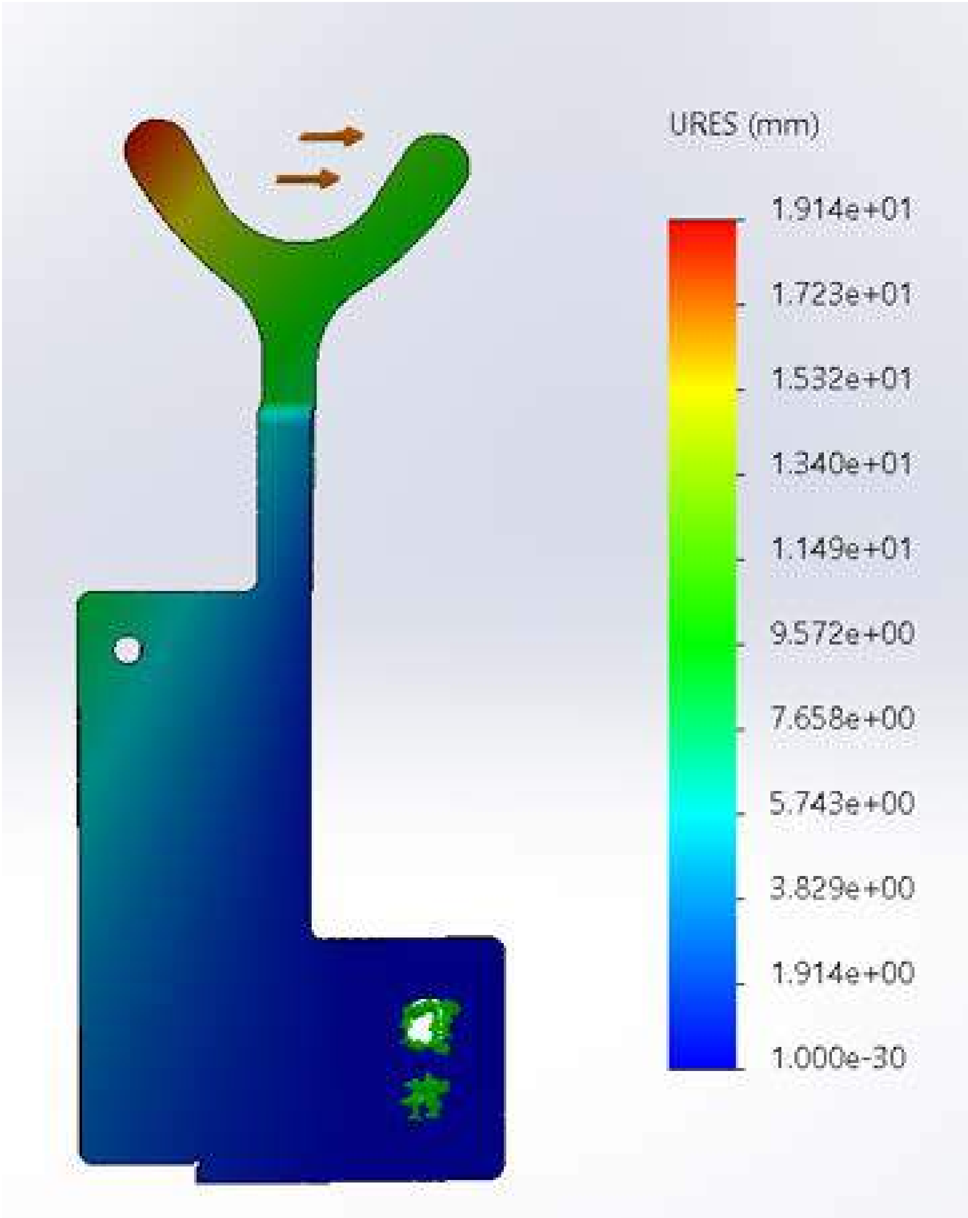
As shown below, the max deformation that develops for the 300 N load directed towards the adaptive side is 7.828 mm with a max stress of 8x10^8 Pa which is just slightly larger than the yield strength. The max deformation that develops for the 400 N load directed towards the standard side is 19.14 mm with a max stress of 8x10^8 Pa which is just slightly larger than the yield strength. After discussing these results with the client, the client is confident that the physical steel sheet metal part will not deform. Additionally, it is very unlikely that the plates themselves will actually ever experience loading of this magnitude. These forces are the forces that develop while rowing at the highest resistance level. It is very unlikely for someone to pull on the handlebar while it is still in the antler cavities. Therefore, although these loading conditions predict a little bit of displacement and slight yielding to occur, it is likely that loads much less than these will actually be applied to the component and thus no displacement or yielding will occur. A person who is using the rower will understand that they must first lift the handlebar out of the cavity prior to rowing. Any slight loads felt by the pulley plate and antlers would be from the user lifting the handlebar out of the cavity at a slight angle, which would apply slight pressure to the inner surface of the antler cavity. These slight loads are not predicted to cause yielding or failure. Once the parts are fabricated and attached to the rower, a physical test will be performed in which the handlebar will be pulled back and let go to fly towards the pulley plate and antlers to determine if it causes them to break. As can be seen by comparing this entry with the previous entry, the deformations and stresses developed are lower using 2 gullets as compared to 1. Still, the typical forces we expect the parts to endure in real-life are not expected to cause yielding or failure as explained above.



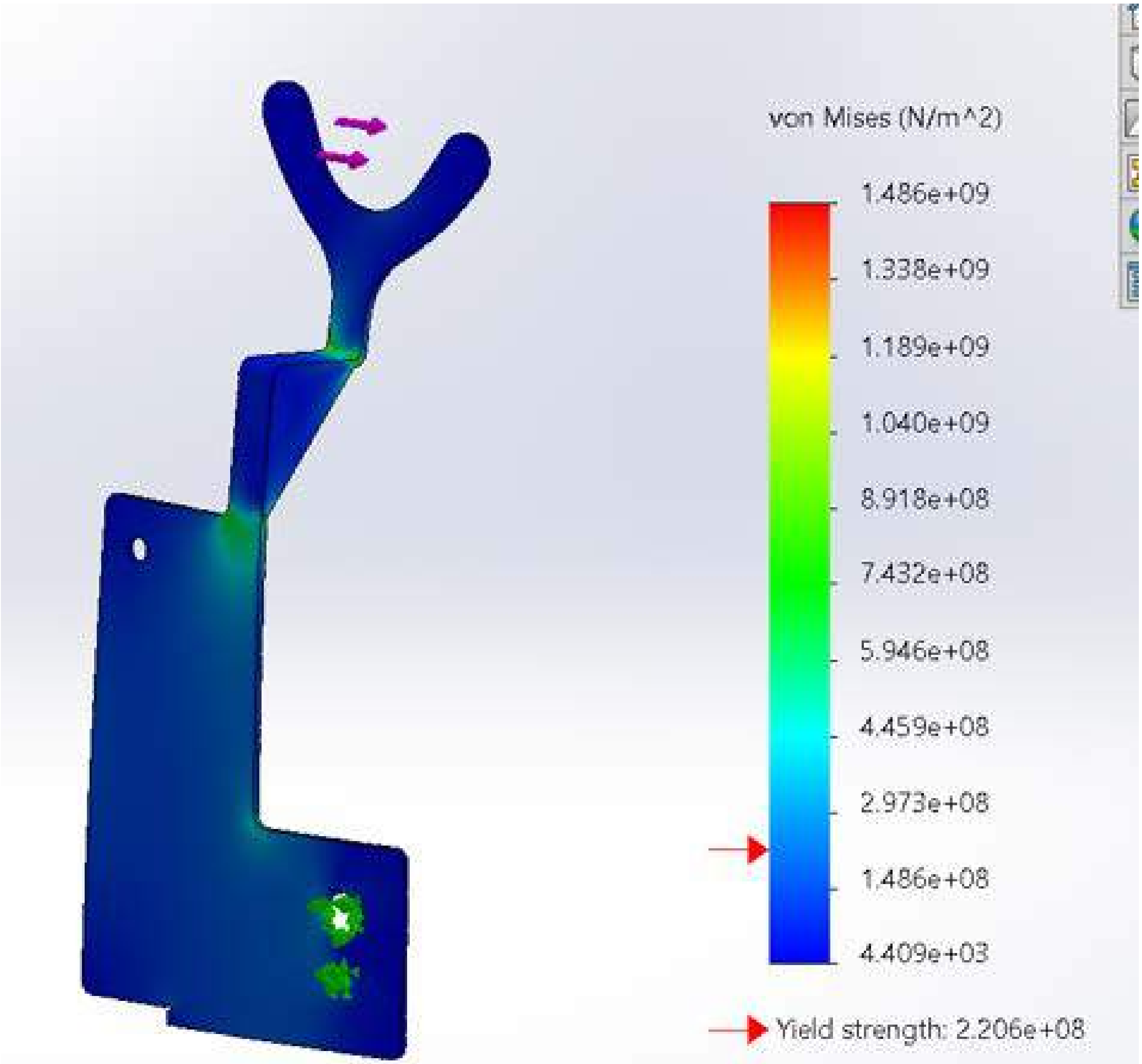
The above shows the deformation of 300 N applied towards the adaptive side.



The above image shows the stress of 300 N applied towards the adaptive side.



The above image shows the deformation of 400 N applied towards the standard side.



The above image shows the stress of 400 N applied towards the standard side.

References: Staci Quam

Conclusions:

The team does not predict any failure of the plates will occur under typical loads experienced by these parts.

Action items:

-Pick up parts from JHT!

Josh ANDREATTA - Mar 14, 2023, 12:12 PM CDT

Download

Left_Antler_with_2_Gullets.SLDPRT (176 kB)

4/22/23 - Comparison Survey Analysis

Josh ANDREATTA - Apr 22, 2023, 8:52 PM CDT

Title: 4/22/23 - Comparison Survey Analysis

Date: 4/22/23

Content by: Josh Andreatta

Present: Josh Andreatta

Goals: Discuss where to find comparison survey analysis

Content:

Please see the team testing folder for my entry on the comparison survey analysis. I helped collect trial data on 1 individual who used both sides of the rower and on 3 people who only used the adaptive side of the rower. I then took responsibility for analyzing all of the comparison survey results, and Roxi did the adaptive side only surveys.

References: n/a

Conclusions:

See above.

Action items:

-Make and edit final poster testing section & script

-Make and edit design excellence script

Preferred Template

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

Title:

Date:

Content by:

Present:

Goals:

Content:

References:

Conclusions:

Action items:

04/04/2023 EMG Research

Roxi Reuter - Apr 04, 2023, 6:20 PM CDT

Title: Human SpikerBox Research (EMG)

Date: 04/04/2023

Content by: Roxi Reuter

Present: —

Goals:

- Become more familiar with the EMG equipment which we will be using to test our adaptive rower design and ensure the correct muscle activation is happening on the adaptive side

Content:

- Here is a link to the SpikerBox which we will be using from the company Backyard Brains
- This equipment will be used by us for EMG purposes, but it can also be used on other parts of the body for EKG, EEG, and EOG signals
- We will need to connect this device to either a smartphone or PC to view and analyze data
- In order to get signals from muscles, here are the steps we'll follow:
    - 1. Place the electrodes on your body
    - 2. Connect the alligator clips to the electrode and the opposite end of the cord to the SpikerBox
    - 3. Connect the USB between the smartphone/computer and the SpikerBox
    - 4. Launch the software and analyze the signal

Conclusions/action items:

The Human SpikerBox seems fairly simple to use, according to the website tutorial and videos. Directions will also be provided in the box for EMG use, but basically we will just hook up the electrodes and analyze muscle activation on our smartphones or computers with the company's software. I am looking forward to trying this out when testing plans are approved by IRB!

02/03/2023 Journal Research

Roxi Reuter - Feb 03, 2023, 11:11 AM CST

Title: Journal Article Research

Date: 02/02/2023

Content by: Roxi Reuter

Present: —

Goals:

- Research journals for possible publication of this semester's journal article at the end of the semester

Content:

- Possible journals:
  - Frontiers in Rehabilitation Sciences - seems to be a journal which focuses on improving the wellbeing of individuals with disabilities
  - ASCM's Health and Fitness Journal - fitness trends, injuries, and all things health and wellness, including inclusive practices
  - Disability and Rehabilitation Journal - (Taylor Francis Online) "Disability and Rehabilitation aims to encourage a better understanding of disability and to promote rehabilitation science, practice and policy aspects of the rehabilitation process."
  - Journal of Science and Medicine in Sport (JSAMS) - "The Journal considers for publication Original research and Review papers in the sub-disciplines relating generally to the broad sports medicine and sports science fields: sports medicine, sports injury (including injury epidemiology and injury prevention), physiotherapy, podiatry, physical activity and health, sports science, biomechanics, exercise physiology, motor control and learning, sport and exercise psychology, sports nutrition, public health (as relevant to sport and exercise), and rehabilitation and injury management."

Conclusions/action items:

In addition to finding some of my own journals for possible publication, I also researched a few of the journals that Annabel had suggested so I have a better understanding of the contents of each. Overall, I believe all seem like plausible options; however, "Frontiers in Rehabilitation Sciences" and "Disability and Rehabilitation Journal" might be the most fitting journals for our BME 402 project. This is something that we will be discussing as a team and with our advisor in upcoming meetings

02/09/2023 Journal Selection

Roxi Reuter - Feb 09, 2023, 1:35 PM CST

Title: Journal Selection

Date: 02/09/2023

Content by: Roxi Reuter

Present: —

Goals:

- Narrow down journal articles taking into consideration the impact factor (2-3 is the range we're looking at)

Content:

- How to find impact factor: (source)
  - "The Impact Factor is calculated by dividing the number of citations in the JCR year by the total number of articles published in the two previous years. An Impact Factor of 1.0 means that, on average, the articles published one or two year ago have been cited one time."
    - Look at past two years (number of citations/number of publications)
- Frontiers in Rehabilitation Sciences - seems to be a journal which focuses on improving the wellbeing of individuals with disabilities
  - **Impact factor**: 5.5 per website (https://www.frontiersin.org/about/impact)
- ASCM's Health and Fitness Journal - fitness trends, injuries, and all things health and wellness, including inclusive practices
  - **Impact factor**: unable to find information
- Disability and Rehabilitation Journal - (Taylor Francis Online) "Disability and Rehabilitation aims to encourage a better understanding of disability and to promote rehabilitation science, practice and policy aspects of the rehabilitation process."
  - **Impact factor**: 2.439 impact factor in 2021 (https://www.tandfonline.com/action/journalInformation?show=journalMetrics&journalCode=idre20)
- Journal of Science and Medicine in Sport (JSAMS) - "The Journal considers for publication Original research and Review papers in the sub-disciplines relating generally to the broad sports medicine and sports science fields: sports medicine, sports injury (including injury epidemiology and injury prevention), physiotherapy, podiatry, physical activity and health, sports science, biomechanics, exercise physiology, motor control and learning, sport and exercise psychology, sports nutrition, public health (as relevant to sport and exercise), and rehabilitation and injury management."
  - **Impact factor**: unable to find information

Conclusions/action items:

In this research session, I looked into how the impact factor (IF) of a journal is calculated, and I explored the IFs of the journals we had previously researched. I was unable to find/calculate the IF for two of our journal options ("JSAMS" and "ASCM's Health and Fitness Journal"), but I did find the IF for "Frontiers in Rehabilitation Science" (5.5) and "Disability and Rehabilitation Journal" (2.439 in 2021). Since we are aiming for an impact factor of 2-3, it seems that "Disability and Rehabilitation Journal" is our best fit.

02/01/2023 Resistance Ideas Elaboration

Roxi Reuter - Feb 01, 2023, 4:12 PM CST

Title: Resistance Adjustments Brainstorming

Date: 02/01/2023

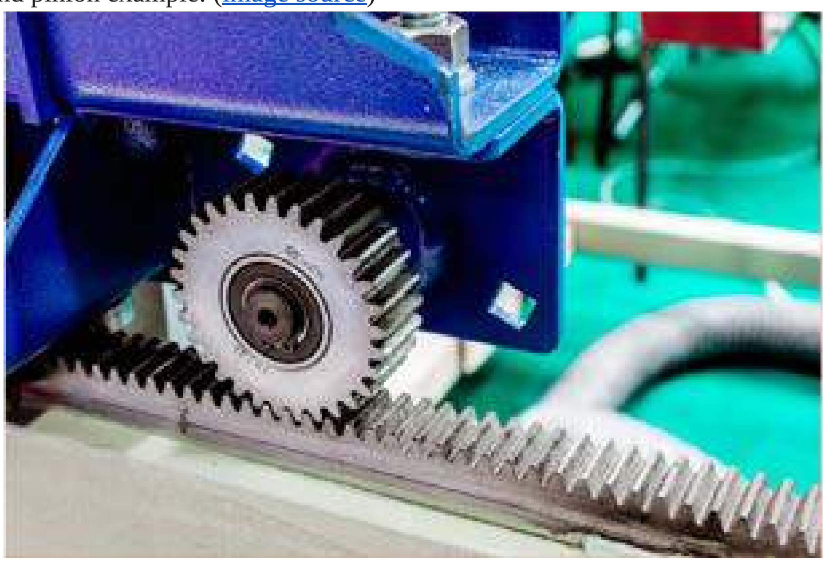
Content by: Roxi Reuter

Present: —

Goals:

- Brainstorm or elaborate on resistance dial adjustment ideas such that the resistance of the rower can be adapted from both the standard and adaptive sides

Content:

- Please see attachments for elaborations of ideas, sketches, and pros/cons of each idea
- Ideas:
    - 1. Replace magnet hinge with stepper motor for rotation of magnet set across flywheel
    - 2. Rack and pinion (similar to Athena bike at JHT)
    - 3. Plastic puck and motor housing combo (in standard ellipticals(
- Rack and pinion example: (image source)
    - 
- Puck and motor housing example (in this case with motor inside already - available for purchase, not sure if sizing is correct); source

- 

Conclusions/action items:

Again, please see attachments for elaborations on some of the ideas the team brainstormed during our meeting at JHT. I also included a list of pros and cons of each. As of now, I think either the stepper motor replacing the magnet hinge or the puck and motor housing option seems like the easiest just because there are fewer changes to the original resistance system. I will do more research in these methods and look at how we could interface these with the current Arduino (or possibly a new one) and how we can have two user interfaces (i.e., arrows or buttons) that serve both the standard and adaptive sides for resistance adjustments.

Roxi Reuter - Feb 01, 2023, 4:13 PM CST

Download

Resistance_Dial_Brainstorming.pdf (1.39 MB)

Roxi Reuter - Feb 05, 2023, 2:22 PM CST

Other thoughts:

- Calculation for idea #1 may not be as difficult as I originally thought…
  - Use a protractor to measure the amount the magnet set moves (degrees) and just make sure the stepper motor rotates that amount in the code
- LCD screens will be used to display resistance level on the standard and adaptive sides
- LCD and buttons will go...
  - Where the resistance dial currently is on the standard side
  - On/be part of the lap pad on the adaptive side

02/23/2023 Resistance Code Edge Cases Brainstorming

Roxi Reuter - Feb 23, 2023, 3:11 PM CST

Title: Edge Cases Brainstorming

Date: 02/23/2023

Content by: Roxi Reuter

Present: —

Goals:

- Brainstorm edge cases for resistance dial code. In other words, what happens if an out of ordinary situation is encountered?

Content:

- What happens if the power is cut to the machine? Does the resistance level reset to the base level (level 1)? Does the resistance level stay the same as before power was cut to the machine?
- What happens if the button is held down? Does the resistance keep increasing?
- What happens if the button is pressed multiple times in a row?
- Since we are planning on having an up and a down arrow button, what happens if they are pressed simultaneously?
- How does the code respond to presses out of range? (i.e., pressing the down button when the resistance is already at the lowest level or pressing the up arrow button when the resistance level is at its highest)
- Will the magnet movement be affected if, for example, a button is pressed while the flywheel is moving?
- How does the code respond to pressing buttons on opposite sides of the machine simultaneously?

Conclusions/action items:

In this meeting session, I brainstormed different cases that should be addressed in the resistance dial adjustment code. I will meet up with Annabel and Tim in the next week to discuss these cases and make necessary changes to the code to take these into consideration.

02/28/2023 Resistance Dial Electronics Items

Ro›

Title: Resistance Dial Materials Research

Date: 02/28/2023

Content by: Roxi Reuter

Present: —

Goals:

- Review materials for purchase needed for electronics of the resistance dial mechanism
- Try to find new buttons with a wiring schematic since the current ones do not include a wiring schematic needed to interface them with the Arduino and stepper mo

Content:

- Materials Table:

Item	Source	Price	Comments
Common anode 2 digit 7-segment display	Link	$6.49 for 3 displays or $6.99 for 5 displays	Either need this display or the cathode one (both will work)
Common cathode 2 digit 7-segment display	Link	$7.99 for 2 displays	Either need this display or the anode one (both will work)
Up and Down Arrows	Link	$37 for a pair of two buttons	This seems a little expensive, so I will research alternatives. Plus, we will need one pair for each side of the rowing machine.
Arduino Mega	MakerSpace	$22	Off-brand but cheaper alternative offered at the UW-Madison MakerSpace.
Screw Terminal Block	Link	$32	Sits on top of Arduino Mega
Stepper Motor	–	–	We will be using an extra we have from the previous semester's design.

Alternative button ideas:

- We could just purchase circular buttons and 3D print an arrow that fits over them.
  - Something like this may work - check with Annabel
    - https://www.amazon.com/DIYhz-AC250V-AC125V-Momentary-Button/dp/B079D3ZZ1L/ref=sr_1_9?crid=1QKT8NE659EAU&keywords=large+round+buttons+electronics&qid=1677615088&sprefix=large+round+buttons+electronic%2Caps%2C24
    - https://www.amazon.com/BACAUTOPARTS-Arrows-Momentary-Trailer-Motorcycle/dp/B09L6T3P6L/ref=sr_1_15?crid=20ZE1H06BW9A5&keywords=up%2Bdown%2Barrow%2Bbuttons&qid=1677615198&sprefix=up%2Bdown%2Barrow%2Bbutton%2Caps%
15&th=1
    - https://www.amazon.com/Electrical-Buddy-Monmentary-Button-Pushbutton/dp/B07Q7TN5KF/ref=sr_1_42?crid=20ZE1H06BW9A5&keywords=up+down+arrow+buttons&qid=1677615291&sprefix=up+down+arrow+button%2Caps%2C166&sr=8-42

Conclusions/action items:

I looked into the materials that Annabel, Tim, and I are planning on purchasing for the electronics aspect of the resistance dial mechanism. We will be purchasing these iter on Friday. I also looked into a few more options for buttons since the current option seems very expensive. I will consult with the team on Friday about these items, and we

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

HSP CITI Training (IRB Requirement)

Roxi Reuter - Apr 08, 2023, 10:16 AM CDT

Download

CITI_Training.pdf (79 kB)

01/18/2023 IRB Team Meeting

Roxi Reuter - Jan 26, 2023, 5:17 PM CST

Title: IRB Meeting

Date: 01/18/2023

Content by: Roxi Reuter

Present: Josh, Sam, Annabel, Tim, Roxi

Goals:

- Ask our advisor, Tracy, questions about the IRB application which needs to be completed and approved prior to testing this semester

Content:

Below I have listed a number of questions that the team came up with while discussing what remains for the IRB application:

1. Are you (Tracy) in charge of filling out the "Request for PI Status" document?
    1. Yes
2. How detailed should the protocol documentation be? Should we include EMG testing in this? Do you have access to EMG equipment that we can use?
    1. Very detailed
    2. As a side note, do you think we should do EMG testing on the people we recruit? We were worried about this deterring some of the individuals, and we aren't sure if we'll be able to find many wheelchair users for testing. Our other option was to do the EMG testing on ourselves to see where there is muscle activation during adaptive rowing.
        i. Already answered
3. How do you recommend recruiting these wheelchair and non-wheelchair users?
    1. Reach out to local physical therapists in Madison (be clear that we are seeking IRB approval) - looking for wheelchair users
    2. Christa Willy has connections??? Ask her about EMG as well
    3. Reach out to Willy first - if no response at first, focus on UW health system and mention IRB process
4. Do we need any consent or assent documents for this testing? If so, what should this consist of?
    1. Yes - paragraph at beginning (by participating in this survey, I consent to my data being used to analyze…)
    2. May need to get us a CAE drive to store this data in
5. For device documentation in the IRB application, would the rower be considered an approved or unapproved device? The rower itself should be an approved device, but we were unsure if our device is still considered approved since there are modifications to it.
    1. Talk to someone in IRB (gut - unapproved)
6. Do you have any other testing recommendations or survey suggestions?
    1. Have this done before submitting IRB
    2. Can share a draft of survey with Tracy

Other notes:

- Ideally we should recruit three wheelchair users
    - Questions to ask them: User-friendly? Safe?
    - No EMG
- Type out exactly what protocol using for each of the tests, even tests on ourselves

- Five of us + Anna on standard and adaptive sides (direct comparison)
    - Muscle activation
- Amit Nimunkar - ask about EMG leads, don't collect data or use them on yourselves until there is IRB approval
    - Direct all EMG questions to him
        - Choose the largest muscle groups involved in rowing and test them one at a time
- Each person will have a set of data, so we will have to compare individual data to individual data
    - Can develop a protocol for consistency (one person try just adaptive side multiple times and make sure data is consistent)
        - If data is inconsistent, may need to do averages
- Need all the specifics (exact details, etc.) for machines and other devices used
- No analysis details needed, they just need to know how we are interacting with people
- Two protocols:
    - One for us (EMG)
    - One for wheelchair users on adaptive side
- Details: title, description, numbered list of steps in testing
- Be as detailed as you can and minimize risk, present it in a way that shows there is minimal risk
- Have this done by the first week of class so that if IRB comes back with questions
- Journal article - be more concise and more technical

Conclusions/action items:

This meeting, the whole team met with Tracy to discuss questions on our IRB application which is needed for carrying out testing this semester. Tracy was very helpful in answering questions and pointing us in the right direction for our testing plans and testing equipment. Josh, our communicator, will reach out to a variety of individuals to continue our IRB application and testing plan. We will continue working on the application and get it submitted within the first few weeks of the semester.

01/26/2023 IRB Forms Review

Roxi Reuter - Jan 28, 2023, 10:40 AM CST

Title: IRB Forms Review

Date: 01/26/2023

Content by: Roxi Reuter

Present: —

Goals:

- Review the consent form, surveys, and protocols for the IRB application before the first general team meeting

Content:

- Consent form:
  - Overall, looks pretty solid
  - A few comments from Annabel (withdrawal after data collection and if researcher signature is needed), but other than that it looks like everything else should be good to go
- Surveys:
  - In general, the surveys look like they don't need much adjustment before handing them in for the IRB application
  - The only other question I would add (either for just wheelchair users or for all users) is "How likely are you to use a similar adaptive rowing machine in the future?"
- Protocols:
  - There are a few more details which need to be filled in for these documents, especially on the EMG portions when we know more information about the exact equipment we will be using
  - There also are a few spots where it must be clarified if the researcher or the participant is carrying out the tasks

Conclusions/action items:

Overall, we have made substantial progress on the IRB documents. Tomorrow (01/27/2023), the team will be meeting to go over these documents and make necessary adjustments such that the IRB application can be submitted as soon as possible. We are also making a trip to JHT and having our first class meeting of BME 402. We are excited to tackle another semester on this project!

Final copies of all the documents referenced in these notes will be available in the team LabArchives notebook.

01/27/2023 JHT Resistance Meeting

Roxi Reuter - Jan 28, 2023, 10:46 AM CST

Title: JHT Meeting Recap

Date: 01/27/2023

Content by: Roxi Reuter

Present: Entire team, Staci, Alan

Goals:

- Take apart the Matrix rower with Staci and Alan to check out the resistance dial and brainstorm methods to allow adjustment from both the standard and adaptive sides

Content:

- We met at JHT from about 8-10AM
- Alan and Staci assisted us in taking apart a similar Matrix rower to the one we've made modifications on
  - Mainly, Alan took apart the resistance dial and took off the cover of the rowing machine so that we could see how the resistance adjustment works
  - In short, turning the resistance dial winds or unwinds a cable which moves a set of magnets. The higher the amount of overlap between the magnets and the flywheel, the higher the resistance.
- We threw around a bunch of ideas on how we could allow adjustment of the resistance from both the standard and adaptive sides:
  - Likely, mechanical mechanisms will be difficult to configure since they must move in sync with each other (we would need a linear system). An electronic approach will probably be easier.
  - We can either keep the wire or get rid of it. We are still debating on the best solution
  - One option is to replace the bolt at the hinge of the magnet system with a stepper motor which would rotate the magnets in the same path in which they already rotate. We would have to ensure that the math is correct so that the stepper motor rotates the magnets the equivalent amount as they are currently rotated with the dial. We would not need to keep the wire in this case.
  - Alan also showed us two alternative methods:
    - 1. A standard elliptical uses a cheap plastic puck and motor housing case which could be placed anywhere inside the casing of our rower. We would need to figure out what puck size we need to coil the wire so that the wire is coiled the same amount as it is currently upon moving the resistance dial.
    - 2. On the Matrix Athena bike, a rack and pinion is used in combination with a stepper motor which could serve the purpose of coiling and uncoiling the resistance wire in the rower. This option seemed a bit more complicated.

Conclusions/action items:

Overall, this was a very productive and fun meeting at JHT! We learned a lot about the rower and came out of the meeting with not only tons of ideas on how we can implement resistance adjustment on the adaptive side but also expectations and goals for the semester. In the coming days, each member will do individual brainstorming of resistance adjustments so we can tackle this challenge over the course of the semester. We are extremely excited to be working with JHT on the adaptive rower project again this semester!

Roxi Reuter - Jan 28, 2023, 11:49 AM CST

Download

IMG_3505.HEIC (1.55 MB) Picture of the resistance components inside the Matrix rowing machine: flywheel and magnets

01/27/2023 Team and Advisor Meetings

Roxi Reuter - Jan 28, 2023, 4:37 PM CST

Title: Advisor and Team Meetings

Date: 01/27/2023

Content by: Roxi Reuter

Present: Entire team, Tracy

Goals:

- Talk about semester goals and testing plans
- Make an action plan to complete IRB application and appropriate documentation

Content:

- We will continue to meet with Tracy from 1:05-1:35PM each Friday for check-in meetings
- To-do:
    - Swap enrollment into Tracy's section
    - Decide on team roles. We do not need to keep the same roles as last semester.
    - First progress report is due next Thursday at 5PM
- Focus this semester is on a journal article.
    - Identify a suitable journal for our project; focus on something attainable. Follow submission guidelines for outline. Impact factor 1-3. Still need an appendix for this.
        - Failed experiments, raw data would be additions to appendix (most of the appendix is from last semester's report).
    - Read articles by journal of choice to get an idea of writing style and content. We will need a high level of detail in the notebook because we will need to reference this in the journal article.
- All deliverables are due Friday, April 21.
- Keep track of important dates on BME schedule
    - First important date: 02/10/2023 (Friday) we will be presenting a plan for the semester on Zoom just to Tracy
        - More information on design website (402 preliminary design presentations) - problem statement should be modified to cover what we are doing this semester
        - Try to be very specific with dates and tasks for a plan - in presentation, this should take up a few slides (possibly one slide per month)
- Team meeting
    - We switched a few team roles (BSAC conflicts)
    - Tasks for upcoming week
        - Sam - Solid
        - Roxi - intended use
        - Annabel - description of device
        - Tim - features that minimize risk
- Outreach - in contact with school, need to pick time and date to actually do the activity at Spring Harbor Middle School
- JHT update - Josh will be updating SolidWorks files to make the pulley plates and antlers into a few separate pieces so that they can be made out of metal and welded by the shop team at JHT
- Testing - no MTS, do the "let go" test of handlebar after the handlebars are made of metal
- Stabilization frame update - same setup as current design and will be screwed into the rower, but all other connection points will be welded together by JHT shop team, no perforated bars

- Resistance dial - main focus of the semester (allowing resistance adjustments from standard AND adaptive sides)
    - Possible ideas:
        - Puck and stepper motor casing (cheaper)?
        - Wire? No wire?
        - Athena bike model - rack and pinion?
        - Replace hinge point of magnets with stepper motor?
            - In whichever case, we will need to do math to get equivalent movement to resistance adjustments
- We will still do EMG testing (compare own data to own data) - see muscle activation on both sides of rower
- Start talking to Staci about protecting own intellectual property and WARF moving forward
- The team spent the remaining time editing IRB documents and dividing up work for the first week

Conclusions/action items:

The team had a very productive meeting today. We went to JHT and set project goals, as well as started brainstorming for resistance dial adjustments from the adaptive sides. In the coming week, we have the following tasks:

- Sam - stabilization frame SolidWorks
- Josh - pulley plates and antler modifications in SolidWorks, sending out emails to appropriate people on IRB application and client/advisor for weekly meetings
- Tim - IRB device documentation (features that minimize risks), ask about outreach school demographic for funding, respond to availability (March 24 or April 7), ask Tracy about funding for outreach activity (demographic)
- Roxi - IRB device documentation (intended use)
- Annabel - IRB device documentation (device description)
- All - brainstorm for resistance dial mechanism and first day activities
- Complete device documentation by February 4 for review at meeting on February 5.

We will be meeting as a team to catch up with each other next Friday (February 3) before or after our advisor and client meetings. In the meantime, we will be completing individual activities.

02/03/2023 Team Meeting

Roxi Reuter - Feb 04, 2023, 3:38 PM CST

Title: Team Meeting

Date: 02/03/2023

Content by: Roxi Reuter

Present: Sam, Tim, Josh, Roxi

Goals:

- Discuss things we want to go over during advisor meeting
- Prepare for Sunday meeting at 2PM

Content:

- Things we want to ask Tracy/ to do during today's meeting:
    - IRB documents review (consent form, protocol, etc.)
    - About presentation (how long it will take, formality, etc.)
    - Go over notebook
    - Discuss outreach activity (20-25 kids) → Roxi get a list of materials, quantities, links, etc. for groups of 2-3 students
- Meeting Sunday to edit IRB documents, assign stuff for testing presentation, etc.
- Sam's idea of how to split up work for resistance dials:
    - physical/modeling team
    - Electronics team

Conclusions/action items:

This was a short team meeting which we just used to catch up with each other on tasks and research progress that we have been working on. Next, we will meet with our advisor and discuss our notebooks, as well as talk about semester goals and how we plan to accomplish them.

02/03/2023 Advisor Meeting

Roxi Reuter - Feb 04, 2023, 3:38 PM CST

Title: Advisor Meeting

Date: 02/03/2023

Content by: Roxi Reuter

Present: Sam, Josh, Tim, Tracy, Roxi

Goals:

- Talk about semester goals, testing plans, outreach, journal

Content:

- No weekly notebook checks, just mid-semester evaluation
    - Can share stuff that's in our notebooks if it's helpful to weekly meetings
- We shared what we accomplished this week
- Journal article - pick one and also look at the impact factor (2 or 3 but can try for higher)
    - Tell Staci that we are writing a journal article and ask her if she wants to be on as an author (reach out to her before next week's client meeting)
- Outreach activity - get list of supplies to Tracy, do not buy anything ourselves
    - Tracy puts stuff in bin in BME copy room
    - Thinking of doing outreach Friday, Mar 24, 2023 - Tracy will not be meeting with us that day
- Presentation next week:
    - Shoot for 10 minutes, but time limit is flexible (do not go over 15 minutes, 10–15 minutes is what we should aim for)
    - Will be done around 1:35PM for client meeting to follow
    - Can run slides by Tracy
- Survey: Put the person first in all of our language ("person who uses a wheelchair" instead of "wheelchair user")
    - Make sure scale is all the same (positive side is same and negative side is same - just be consistent)
    - More intuitive for higher number to be a better outcome
    - Would be better to identify something in the middle (label all number, can use "somewhat", "a little bit", etc.)
    - Grammar for 1: sounds better to say "Have you previously used another rowing machine?"
    - If we want more feedback - open response is a good idea
    - Be sure we have ratings for things we want ratings for!
    - After title add participant ("participants who do not use wheelchairs"
- Testing protocols: separate them when turning it in
    - Test the protocol on someone. Tell them what to do and see if they are doing it right.
    - Have someone go through steps and just ensure we aren't missing anything
- Consent form - have IRB take a look at that
    - Pretty long consent form
    - Condense just to make sure they actually read it
    - Send this off to IRB contact
    - Add "aggregate data with no identifying information may be published"
    - Just reach back out to same contact as before

Conclusions/action items:

Action items:

- Pick a journal
- Reach out to Staci about being an author
- List of supplies for outreach and confirming date
- Scheduling time to run prelim presentations
- Update IRB materials
- Sending IRB consent form
- Have someone try out testing protocol

For Sunday:

- Resistance dial brainstorming
- If time, look at articles
- Complete IRB device documentation

02/05/2023 Team Meeting

Roxi Reuter - Feb 05, 2023, 4:26 PM CST

Title: Team Meeting

Date: 02/05/2023

Content by: Roxi Reuter

Present: Sam, Josh, Tim, Annabel, Roxi

Goals:

- Review IRB device documentation
- Divide up work for preliminary testing presentation
- Brainstorming session for resistance dial

Content:

- We reviewed the IRB device documentation and make group edits after individually reading it
- Then, we moved into brainstorming for the resistance dial
    - We all shared our ideas, and the general consensus was a cableless design (stepper motor rotating the magnets)
        - Ideally, we will put stepper motor shaft directly through the
    - Planning on LCD displays (one on standard side and one on adaptive side) with up and down arrows for each LCD to adjust the resistance
- Subteams:
    - Modeling and stepper motor placement - Sam and Josh
    - Circuit and coding - Roxi and Annabel
    - Tim will float between subteams
- We will be discussing timelines and goals
- Preliminary slides:
    - Roxi - Device documentation, budget, acknowledgements
    - Aim for two minutes of talking

Conclusions/action items:

This week will be a big week for the team! Along with completing and practicing the preliminary presentation, we will also be working on final touches for the IRB application and its associated documents. The team plans on meeting a few times this week to review presentation slides, practice presenting, and talk about goals and deadlines for tackling the resistance dial adjustment. Our next planned meeting is Thursday (02/09/2023) at 5PM on Zoom to practice the presentation which will be given the following day during the advisor meeting.

02/10/2023 Team, Advisor, Client Meeting

Roxi Reuter - Feb 10, 2023, 5:52 PM CST

Title: Team and Advisor Meeting

Date: 02/10/2023

Content by: Roxi Reuter

Present: Josh, Sam, Annabel, Tim, Roxi

Goals:

- Present preliminary presentation
- Discuss semester plans and plan of action

Content:

- The whole team presented the preliminary presentation to Dr. TJ Puccinelli via Zoom
- We then discussed:
    - Meeting agenda with Staci (asking her if she wants to be an author on our journal article, intellectual property questions, SolidWorks designs, semester plan)
    - Josh and Sam finished their SolidWorks
    - IRB application submission
- During the Client meeting:
    - Josh explained the modifications to the current pulley plate and antler design which is to be fabricated out of metal by JHT (including thinning the plates, adding permanent separation blocks, and increasing the height of the antlers to accommodate the height of the console)
        - Feedback from Staci: thickness looks good, but do not make block permanently attached to the plates (increased thickness too much), the fabrication will not have 90º angles (instead, there will be fillets),
        - Fabrication will be out of steel (exact details will come later from JHT on alloy so that can be accurately represented for simulation testing
    - Sam also shared his SolidWorks stabilization frame design. The only issue he ran into was the vertical and horizontal bar alignment (did not perfectly align, but the shop will account for this and make sure it works with our rower)
        - Feedback from Staci: think more about how we will implement pivot point adjustment of bar (we will need the user to be able to reach and adjust this from their wheelchair), add holes for lap pad before sending it to her
- Finally, we met with a COE writer (Tom Ziemer) so that he can write a story on our project

Conclusions/action items:

Today, we met as a team with Tracy, our advisor, to present our preliminary BME 402 presentation via Zoom. We also updated our client, Staci, on our current progress in the project and met with a COE write, Tom Ziemer to be featured in COE writing. This weekend, I will submit the IRB application and put together a list of outreach items and links. We will all continue working on the resistance dial mechanism throughout the week and reconvene next Friday (02/17/2023).

02/17/2023 Team, Advisor, Electronics Meetings

Roxi Reuter - Feb 18, 2023, 8:08 PM CST

Title: Team and Advisor Meeting

Date: 02/17/2023

Content by: Roxi Reuter

Present: Tim, Annabel, Roxi, Sam, Josh

Goals:

- Discuss team design updates

Content:

Team Meeting

- I updated the team on the IRB application
- I also showed them the outreach
- Josh sent over the SolidWorks design file of the pulley plate and antler design to Staci
    - She made some slight adjustments to the design for ease of manufacturing
    - Unknown if we are still using the motor box
    - Having added screw holes gives us the opportunity to use the electronics box if needed but also allows other options, as well
- Sam showed his SolidWorks designs on the pin mechanism for the stabilization frame
    - Pin mechanism will not be spring-loaded

Advisor Meeting:

- Each team member shared their individual progress for this week
- Journal article updates:
    - No preliminary work in journal article but put in appendix
    - Do not put simulation testing in journal article (just one sentence in end of intro)
    - Journal article style should be same as other in journals
        - Intro
        - Materials and methods
        - No results but put subtitles (keep subtitles same as use for materials and methods)
        - Be specific with type of tests, etc.
        - Smaller details should be kept in the appendix but not in the actual journal article
        - Journal article: final design (no design updates)
    - Length should be 4000-5000 (concise is best)
    - Write in format you would a regular report (no double column, figures at end, etc.)

Electronics Meeting

- Annabel showed us the code for the resistance dial which she has so far
- We have a list of materials to purchase, but we need to weigh out pros and cons of using off-brand materials (cheaper) vs. name brand (like Arduino, but the downside is that these products are more expensive) for our project purposed

    - Last semester, we bought an off-brand Arduino to use for the electronics (console rotation), but the off-brand board ended up breaking, so we have to buy a new one
- In the coming weeks, we will schedule a time for Annabel, Tim, and me to meet to go over code, troubleshooting, and learn more about the electronics in general
    - Until then, we should compile a solid list of materials with purchasing links and figure out how we can make purchases through JHT

Conclusions/action items:

Today we had very productive discussions in our meetings. It was great to catch up with everyone on their progress this week especially in terms of SolidWorks models to actually visualize design concepts. The resistance dial is still a work in progress, but the team has split into subgroups (motor placement and electronics) to tackle this design challenge. In the coming week, we will continue working on individual assignments, review the IRB application and outreach materials, and start working on the journal article. We will reconvene next week for our team, advisor, and client meetings.

02/21/2023 Team Meeting

Roxi Reuter - Feb 21, 2023, 8:58 PM CST

Title: Team Meeting

Date: 02/21/2023

Content by: Roxi Reuter

Present: Sam, Tim, Josh, Annabel, Roxi

Goals:

- Divide up journal article
- Update team on progress of subteams (motor placement and electronics for resistance dial)

Content:

- Josh mentioned his updates to the pulley plate and antler SolidWorks model
  - He is in contact with Staci over modifications to the thickness of the design since the fabrication costs are expensive
- Sam is still working on his pin adjustment SolidWorks model
- Sam and Tim also did work on the motor placement for the resistance dial mechanism today (move the entire housing and screws to the opposite side of the wheel where there is more room)
- Tim, Annabel, and I cannot purchase our electronics materials for the resistance dial yet because we need JHT to purchase items for us this semester since the reimbursement process is a little different now
- The team also discussed the journal article. Annabel was kind enough to go ahead and make a section in our shared Google Drive with template information from our selected journal
  - After going through the journal sections, we have a number of clarification questions for the expectations for some sections
  - We will ask Tracy about these during our next advisor meeting on Friday (02/24).
  - Appendices will be super simplified (for example, one paragraph talking about work from BME 301)
- We divided up the journal article and have a plan to meet next Monday (02/27) after 7:30PM

Conclusions/action items:

The team met briefly to split up the journal article work. The preliminary article is due next Wednesday (03/01) at 11:59PM. Our next team meeting will be in person in ECB on Friday, February 24 at 12:45PM with advisor and client meetings to follow. In the meantime, each member should continue working on their assigned project tasks and start working on the journal article.

02/23/2023 BPAG Meeting

Roxi Reuter - Feb 23, 2023, 3:04 PM CST

Title: BPAG Meeting

Date: 02/23/2023

Content by: Roxi Reuter

Present: —

Goals:

- Document important notes for BPAG role

Content:

- I missed the in-person BPAG meeting due to illness, but Dr. P sent me the recording, and I have also been BPAG twice before this
- Dr. P told me, in short, that most of the BPAG meeting content is the same as in the past, but there is more emphasis on having the client purchase project materials since the reimbursement process through the BME department has become more strict and complicated
- Presentation notes:
    - It is best to have client purchase for you
    - Make sure all expenses are approved by client prior to purchasing
    - Anything is fair game for purchasing because JHT is not affiliated with UW-Madison BME
    - At the MakerSpace, clients can set up an account with a fund number
    - MakerSpace shopfee is $50/person
    - If reimbursement is needed, only the BPAG will be reimbursed. Start this process before the poster session. Original receipts are needed.
    - LabArchives, makerspace fee, and poster printing are not reimbursable
    - Document all purchases in spreadsheet template on BME design website.

Conclusions/action items:

This was a good refresher on financial responsibilities for BME projects. The team has been wondering how Staci, our client, can make purchases for us through the MakerSpace, so knowing that she can set an account up through them for purchases helps us out a lot. Another option would be if she gives us a prepaid card or debit card which we can use to make purchases. That will simplify the process, since we will not have to go through the BME department for reimbursement.

Roxi Reuter - Feb 23, 2023, 3:04 PM CST

Download

BPAG__Purchasing_Guidelines_for_BME_Design_Teams.pdf (736 kB)

02/24/2023 Team, Advisor, Client Meetings

Roxi Reuter - Feb 25, 2023, 2:45 PM CST

Title: Team, Advisor, Client Meeting

Date: 02/24/2023

Content by: Roxi Reuter

Present: Tim, Josh, Sam, Roxi

Goals:

- Discuss journal article
- Update team members on subteam progress
- Talk to Staci about SolidWorks and manufacturing plan

Content:

Team Meeting

- We shared our individual progress for the week
- Josh is still back and forth with Staci on SolidWorks adjustments on the antlers and pulley plates
- Sam finished his SolidWorks pin mechanism model on the stabilization frame
- I submitted the IRB application and worked on brainstorming edge cases
- Tim also worked on brainstorming edge cases for the resistance dial coding

Advisor Meeting

- Each member shared with Tracy what they accomplished this week (see team meeting above)
- We also asked questions on the journal article and got clarifications on the content and layout
- Note: no need to select another journal article (clinical trial registration is not required but should be done if applicable to the project, but this is not the case for us)
- We also got to see a nice magic trick from ATP to end the meeting :)

Client Meeting

- Staci and a coworker (machinist who will be discussing manufacturing with us) met with us today for 30 minutes
- Staci mentioned that they do not have a lap pad of a length that will work, so she is suggesting that we cut the one we have
    - There should be seams on one side (use scissors or an exacto knife to cut off the seam), and see if the fabric can slide off. Then, we can cut the board and figure out how to stitch what is remaining of the outer piece back on.
    - Do not cut it directly because the ends will be exposed (this is a last resort option)
- Manufacturing:
    - Don't need the same amount of material for actual manufacturing design vs. 3D designs (we will need a lot less material for the pulley plates if we use metal)
    - This is a $400 vs. $10 option
    - Suggestion from Staci - keep the pulley plate and antlers all one piece, and they will use a machine to bend the metal which they have available. Thinner material is cheaper and weighs less, but it is still very durable (cannot bend by hand but can with a machine). However, everything would need to be the same thickness.

    - Suggestion to move spacer to bottom of pulley plate design and place screw holes in the middle of the spacer
    - Revert to the original two 90º turns
- In terms of purchasing, Staci will write us a personal check so that we don't have to go through the BME department reimbursement process due to strictness

Conclusions/action items:

Today's meetings were very productive and packed with information both in terms of design aspects and the preliminary journal article! In the next week, the team will work on the individual assigned journal article sections, continue subgroup work, and reconvene on Monday (02/27) to review the journal article as a team before submitting it.

02/28/2023 Team Journal Article Meeting

Roxi Reuter - Feb 28, 2023, 10:08 PM CST

Title: Journal Article Editing Session

Date: 02/28/2023

Content by: Roxi Reuter

Present: Entire team

Goals:

- Edit the journal article
- Plan outreach prep meeting

Content:

- The team met to edit the journal article together after individually reviewing and editing the sections
- Josh was mainly in charge of the appendix section, and he updated the PDS as part of that. This was added to the LabArchives notebook, as well.
- Besides editing content, we also formatted the journal article to be consistent throughout the main portion, as well as the appendix section
- We also discussed planning outreach meeting times to confirm

Conclusions/action items:

We had a long meeting today, but it was very productive, and we completed our journal article rough draft. We will be meeting this Friday (03/03) at 12:30PM in ECB before our advisor meeting to finalize outreach plans and work on setting up a time to test out the activity. In the meantime, we should individually complete the peer and self evaluations and continue work on subgroup tasks.

03/03/2023 Team, Advisor, Electronics Meetings

Roxi Reuter - Mar 04, 2023, 4:47 PM CST

Title: Team, Advisor, Electronics Meeting

Date: 03/03/2023

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss outreach information
- Talk about IRB updates
- Plan next week's meeting for testing the outreach activity

Content:

Team Meeting:

- We discussed IRB application updates
- Sam sent his pin mechanism for the stabilization frame to Staci
- Next week, we will try to get as much measuring done as possible / electronics assembled before spring break
- Next Friday we will be meeting to do the outreach slides together
- Monday meeting materials to test outreach activity (5PM Green room):
    - Multimeter - Josh
    - Bag of potatoes - Sam
    - Alligator clips - Sam
    - Pennies and nails - Roxi
    - LED - Annabel/Josh

Advisor Meeting

- Next week's advisor meeting will be on Zoom
- The pulley plates are finalized, and Staci has sent them to the JHT shop team to fabricate. We can pick those up after spring break.
    - Safety factor should be more than one
- Tracy confirmed our outreach presentation outline, so we will go ahead and use that to draft our presentation and confirm material quantities.

Electronics Meeting:

- We went over materials we need to purchase for the electronics circuit
    - Find new (cheaper) buttons for changing the resistance
    - Possibly purchase wire
    - Other materials listed in LabArchives, but the above points are the changes to the current list
- We ran into some issues getting our new stepper motor to start spinning, so we spent a large portion of the meeting troubleshooting that.

- After checking over the circuit connections to ensure they were correct and doing some research online to double-check the wiring, Annabel and I ended up going to the MakerSpace for help. They suggested that we try a new motor driver since we have extras and ours was fairly hot.
    - Annabel had the spare motor drivers in her apartment, so we ended the meeting after ordering materials.

Conclusions/action items:

Today's meetings, in total, were long but productive. In the team meeting, we updated each other on project progress for each subteam of the resistance dial mechanism design and spent time planning out times to meet to prepare for our outreach activity. In our advisor meeting, we mainly talked about our SolidWorks model updates and JHT fabrication progress. We also asked for clarification on a few points about outreach requirements. Finally, in the electronics subteam meeting (Annabel, Tim, and me), we worked on troubleshooting the circuit and getting the new motor we purchased to spin. We had difficulties with this, so we asked for help at the MakerSpace. Additionally, we purchased materials from Amazon for the finalized circuit, including 7-segment displays, a terminal block shield board kit, and wire. We will meet early next week (Monday at 5PM) to work on outreach plans. In the meantime, I will individually be working on updating the IRB application and complete the preliminary self and peer review reflection.

03/06/2023 Outreach Practice

Roxi Reuter - Mar 06, 2023, 9:24 PM CST

Title: Outreach Activity Meeting

Date: 03/06/2023

Content by: Roxi Reuter

Present: Sam, Josh, Annabel, Tim, Roxi

Goals:

- Go through outreach activity and confirm material quantities

Content:

- We went over the outreach activity, and that did not take very much time
    - We ran into a slight issue since we only had about 1.5V of power from 3 potatoes, and the LED required 3V
- Conclusion:
    - Order 1.5V LEDs
    - Increase potatoes to 5/group
        - This also affects quantities of alligator clips, pennies, and nails

Conclusions/action items:

Today's meeting was very brief to get a feel for the outreach activity. We did not get the LED we had to light up because it was a 3V LED, but we found 1.5V LEDs online. We will be changing material quantities and sending the list to Dr. TJ Puccinelli today or tomorrow.

03/10/2023 Team, Advisor, Client, Electronics Meetings

Roxi Reuter - Mar 10, 2023, 6:15 PM CST

Title: Team, Advisor, Client, Electronics Meetings

Date: 03/10/2023

Content by: Roxi Reuter

Present: Entire team

Goals:

- Discuss goals over spring break and work on outreach slides

Content:

Team Meeting

- Sam drove the lap pad from the rower over to Staci at JHT for their fabrication items
- Staci might make some minor edits to the stabilization frame
- I updated the team on the IRB application and I will be sending Dr. Nimunkar an email asking if we can borrow some (approximately 10-11) for our outreach activity
- As for placement of the buttons on the adaptive side, we will be playing around with the exact locations
- We finished outreach slides, and Josh reached out to Professor Puccinelli to ask if sources need to be cited
- Over Spring break, I will work on the handout for the outreach activity

Advisor Meeting:

- Professor Puccinelli wanted updates from each of the team members on the project progress
- We discussed details on materials for the outreach activity
- Then, we looked at the journal article together and received feedback from Professor Puccinelli
  - Refer to updates on the rower in Figure 3 with letters
  - Add supplemental information (for example, surveys)
  - Put “Professor” instead of “Dr.” when referring to Dr. P and Dr. TJ Puccinelli in the acknowledgements section
- Be sure to follow journal article guidelines
  - Specifically, see if there are any reference guidelines (IEEE, MLA, APA, etc.)

Client Meeting:

- Sam and Staci discussed the stabilization frame SolidWorks model
- Staci updated the pad, so it is shorter now and should fit within the wheelchair armrests
- The pulley plate assembly is completed. Now, JHT will be working on the stabilization frame.
  - The pulley plate assembly is painted black, and Staci was kind enough to show us a picture of it. It looks great!
- JHT has EMG testing equipment which we can use if the campus
  - Staci is not as familiar with the EMG system, so we should allow extra time to relearn the system if this is the route we go.
  - Can split rower into two (take it apart), and it will fit into a standard car
- Staci will be setting up an account at the MakerSpace for 3D printing and purchasing materials.

- Staci will be looking for buttons which we can use for the resistance dial that they currently have at JHT.
- We will be shifting our next meeting with Staci to Mar 31, 2023 since we will be doing our outreach

Electronics Meeting:

- Annabel, Tim, and I went to the MakerSpace to work on the electronics portion of the resistance dial
- I checked over Annabel's wiring to make sure everything was correct before asking for help in the MakerSpace since the motor is still refusing to spin. The issue we're having is that the motor makes noise with the current connections we have, but it does not spin, and the motor driver heats up to the point of smoking. We tried a new motor driver, per the suggestion of the MakerSpace staff last week, but the same issue is persisting.
- We got help from an electrical engineer instructor who happened to be in at the MakerSpace.
- I had to leave before the troubleshooting was finished, but Annabel and Tim let me know that they got the motor to work, and one step on the stepper motor is about 3º.

Conclusions/action items:

We had a long day of meetings today, but we accomplished a lot during that time. I emailed Dr. Nimunkar to touch base on borrowing multimeters for the outreach activity, and he confirmed that we can. We also finalized outreach activity materials, slides, and general plans for that day. During our meeting with Staci, we got to see an image of the fabricated pulley plate and antler design. They look great! Next week we will be on Spring break, but we have divided up tasks to work on during that time. I will be working on the handout for outreach activity, and I will attempt to try the activity with some of my family members to get a feel for mistakes/questions to expect since none of my family members have a strong background in electronics or circuits. Additionally, I will try to collect pennies for the outreach activity and arrange a time to pick up the multimeters from the BME 310 TAs. I will also help out with the journal article edits over Spring break and look at the reference format from journal article

Roxi Reuter - Mar 10, 2023, 6:14 PM CST

Download

image003_1_.png (1.52 MB) Pulley plate and antler fabrication from JHT (picture from Staci)

03/21/2023 Team Meeting (Outreach, design updates)

Roxi Reuter - Mar 31, 2023, 12:42 PM CDT

Title: Team Meeting

Date: 03/21/2023

Content by: Roxi Reuter

Present: Sam, Tim, Josh, Annabel, Roxi

Goals:

- Talk about outreach, integrate 3D prints, plan for picking up stabilization frame, discuss future tasks due for the course

Content:

- Expenses to add to the expense sheet from 3D prints $5.84 and $0.88
- Staci said that the stabilization frame got delayed due to a higher priority project, but it should be done within the next week or two
    - We are waiting to hear when that is done so that we can coordinate a time to pick everything up
- In terms of testing, we heard back from the wheelchair basketball team in Madison, and we may have some prospective candidates (waiting to hear back on possible dates that some individuals would be able to test the adaptive side of the wheelchairs)
- Executive summary is due April 7, so that should be on our agenda in coming weeks
- We should send a follow-up email to Tracy about a time we will pick up materials for outreach on Friday and practice outreach before that
- We will plan on getting to the school at around 1:30PM, so we will leave at 1:20PM
    - We will do our advisor meeting at Josh and Sam's apartment right before leaving for the outreach activity
- In terms of the presentation, here are the assignments:
    - Sam - activity steps
    - Josh - objectives and materials
    - Roxi - Activity overview
    - Tim - key terms
    - Annabel - what is BME
- Looking at electronics, we received a suggestion from Staci on buttons to order for the resistance dial mechanism
    - Annabel will be emailing her to check and see if they are normally open or normally closed since there was no schematic in the Amazon item description
- We have another interview which we will be doing for the Badger Herald on our project, which we will try to schedule for this Friday from 12:30-1PM right before our advisor meeting and outreach
    - Instead of handing out the worksheet, we will write the outreach questions on the board and have volunteers answer the questions
- We are waiting until after outreach activity is complete to start worrying about the executive summary draft which is due April 7

Conclusions/action items:

This meeting was mainly used to catch up on project updates and finalize outreach. We will complete the outreach activity on 03/24 at Spring Harbor Middle School and continue project progress after that point. One thing we must keep in mind is the executive summary due April 7, 2023, which is coming up soon. We will work on that at our team meeting on Friday, March 31.

03/23/2023 Advisor and Outreach Meeting

Roxi Reuter - Mar 23, 2023, 4:22 PM CDT

Title: Advisor and Outreach Meeting

Date: 03/23/2023

Content by: Roxi Reuter

Present: Josh, Annabel, Tim, Sam, Roxi

Goals:

- Discuss final outreach plans
- Talk about this week's progress on the rower

Content:

- We discussed outreach plans with Dr. TJ Puccinelli. We have all materials and will be testing after our advisor meeting today
- Josh completed some SolidWorks updates which he will be printing soon
- Tim contacted the wheelchair basketball team, but participants are anywhere from 7-18 years old. For our study they must be 18 or older. Because of this, we may have to look to other options.
- Josh emailed Staci back about picking up the stabilization frame (if it is ready).
- Tomorrow, we are meeting at Josh and Sam's apartment just before 12:30PM so that we can do an interview on our project, then go to outreach at Spring Harbor Middle School.
- Tim emailed Mr. Ropa to see if any of the photo release forms have been handed out and signed. Mr. Ropa responded that he handed out the forms and will send an email reminder to return those.
- We ran through the outreach presentation and made sure we had all the necessary outreach materials, including pennies.
- We also performed the activity ourselves with the materials to ensure it worked properly, and it did.
- Sam and Tim took the materials back to Sam and Josh's apartment so that it will all be there when we meet tomorrow and leave for the activity.

Conclusions/action items:

Today's one hour meeting was spent going over project updates with our advisor and ensuring we had all materials for the activity. We also completed the outreach as a team to make sure everything went smoothly and we had all materials before doing the activity tomorrow (03/24) in person at Spring Harbor Middle School.

03/31/2023 Tong Lecture

Roxi Reuter - Mar 31, 2023, 12:53 PM CDT

Title: Tong Lecture - Jinger

Date: 03/31/2023

Content by: Roxi Reuter

Present: BME students

Goals:

- Learn more about Jinger's career path and accomplishments

Content:

- Jinger has an entrepreneurial journey and travels the world
- Jinger works from home, but since she travels, her home is anywhere in the world
- She attended UNLV as an ME undergrad student
- Jinger has worked on a variety of projects throughout undergraduate school and beyond
- One of the projects Jinger presented to us was a sustainable house that was built in Las Vegas, which now serves a sustainability and energy/solar learning classroom
    - The architecture students simulated trees (which obviously are not found in the middle of the desert) on a sort of metal screen
- After the solar house project and graduating, she saw the opportunity to begin a startup with her friend that specialized in drones
- She admitted one of her companies failed, and she went back to China to recover from this loss. In China, she continued her work with drones to create a new, emerging market.
- Current things she is doing:
    - Distributive innovation and open-source hardware (some of her passions)

Conclusions/action items:

I thought the Tong lecture was very interesting, and it inspires me to fulfill my passions of engineering, Spanish, and travel. I also have interest in starting my own business someday, so this lecture was a great stepping stone in that direction. I think listening to others' experiences and lessons from their career is always helpful, no matter what specific profession they are in.

03/31/2023 Team, Advisor, Client Meeting

Roxi Reuter - Apr 02, 2023, 11:08 AM CDT

Title: Team, Advisor, Client Meetings

Date: 03/31/2023

Content by: Roxi Reuter

Present: Tim, Sam, Josh, Annabel, Roxi

Goals:

- Discuss project updates and outreach, work on executive summary

Content:

Advisor Meeting:

- We discussed project updates and showed Dr. Puccinelli our rowing machine updates
- Then, we talked about IRB application updates
    - Add Dr. Wille to the application for EMG stuff (talk to her about this first, ideally today)

Client Meeting:

- We showed our integration results to Staci and talked about improvements that could be made in the future
- This meeting was very short and just focused on project updates and keep Staci in the loop on that aspect of the project
    - We will meet with her again in two weeks

Team Meeting:

- During our team meeting, we drafted our executive summary for the "Design Excellence" award.

Conclusions/action items:

All of our meetings today were pretty short, just to touch base on project updates and discuss the future direction of our project. We will be working on updating the IRB application, as well as thinking of other testing plans which we can do if our current testing plans are not approved.

04/07/2023 Team, Advisor Meetings

Roxi Reuter - Apr 07, 2023, 4:03 PM CDT

Title: Team and Advisor Meeting

Date: 04/07/2023

Content by: Roxi Reuter

Present: Josh, Sam Tim, Annabel, Roxi

Goals:

- Discuss how we are handling the IRB application (one last shot to get approval before testing needs to be done)
- Finish up outreach
- Discuss testing plans
- Finish integration

Content:

Team Meeting:

- We briefly touched on outreach. We have everything done except the summary.
- I updated the team on the IRB application. We have one shot left to get approval, so we are debating on taking out the EMG part for testing since that seems to be the biggest hold up with approval. We will talk to Tracy during our advisor meeting to see what she thinks about leaving in or taking out the EMG testing.
    - Dr. Wille is fine with us putting her name on the application and adding comments about her helping us with the EMG because she offered to do so.
- As for testing, Sam, Josh, and I still need to complete the HSP testing
- We brainstormed ideas for button and screen placement
- We ended up attaching the displays to the rower with hot glue and will meet again next week to attach buttons

Advisor Meeting:

- We discussed IRB application updates and updates to the rower which took place this week (displays, buttons, electronics, button placement ideas, etc.)
- Add to IRB application
    - Christa Wille is a physical therapist (PT, DPT) and has an undergraduate degree, and is pursuing a degree in, biomechanics at UW-Madison.
        - Pursuing PhD in Biomedical Engineering with an emphasis in biomechanics
        - Doctor of Physical Therapy
        - She has purchased the Human SpikerBox for her lab and will be the one helping us collect and analyze data
- Contact number for Kate Knudson IRB: (608) 265-9792
    - Main questions:
        - 1. Do you think having Dr. Christa Wille as someone helping the team use EMG (DPT and PhD. in biomechanics)?
        - 2. Timeline? Would it be better to remove EMG and just focused on the user testing? Not much time left to get this done
        - If she doesn't answer, leave a detailed message and state that it is time-sensitive

Conclusions/action items:

Our meeting today was very long, but we got a lot accomplished. During our advisor meeting, we discussed the IRB application and possible testing plans. After some back-and-forth in emails with Dr. Puccinelli, I updated the EMG sections of the application and submitted it to the IRB. I also called Kate Knudson to inquire about the timeline and possibly taking out EMG testing as part of the protocol if that means the application will be approved in this round of reviews. She did not answer, but I left a message. After IRB submission, we attached the displays to the rower with hot glue, and Annabel worked on cutting wires to the appropriate length and soldering.

04/11/2023 Final Fabrication Meeting

Roxi Reuter - Apr 14, 2023, 1:04 PM CDT

Title: Final Fabrication Meeting

Date: 04/11/2023

Content by: Roxi Reuter

Present: Sam, Annabel, Roxi

Goals:

- Work on button placement and attempt to finish fabrication
- Troubleshoot the motor issue that we're running into

Content:

- Annabel has been working on checking connections and soldering wires. We have run into a slight issue with the motors, as sometimes we are having trouble with a faulty connection or something similar which causes the motors to improperly function.
- Sam brought out the drill that was checked out from the TEAM Lab to begin drilling holes for the buttons.
- We could not figure out the issue with the electronics and now an element is sparking, so Annabel might be redoing the whole board or working on a printed circuit board which will allow for more stable connections and (hopefully) fix the issue that we're running into
- Sam drilled holes for the buttons on the standard side buttons, and we attached those. The drilling process was a bit tedious since we should have used a medium-sized bit instead of going straight from a smaller bit to a larger one, and we had to file a little bit.
- When we drilled the holes on the adaptive side, the 3D-printed part by the antlers which has the motor box and connects to the console, the component cracked a little bit. We got the buttons attached, however, and we are going to add an extra support block so that no bending of the plastic component to which the adaptive buttons are connected occurs.
- Button wires were also attached (which connect back to the circuitry).

Conclusions/action items:

During this meeting, we got quite a bit of fabrication done! We drilled the holes for buttons and placed them, then interfaced them with the electronics. We are close to being completely done with fabrication. There are still a few issues with the electronics that Annabel is working on solving, but these will be fixed shortly before testing occurs.

04/14/2023 Team, Advisor, Client Meetings

Roxi Reuter - Apr 14, 2023, 2:42 PM CDT

Title: Team, Advisor, Client Meetings

Date: 04/14/2023

Content by: Roxi Reuter

Present: Sam, Josh, Tim, Annabel, Roxi

Goals:

- Finish up fabrication
- Work on finalizing testing plans

Content:

Team Meeting:

- We now have two wheelchair participants for testing!
- Annabel has been troubleshooting the electronics for a while, and she finally figured out the issues with the help of her lab mentor who has a PhD in electrical engineering.
    - The issues mainly came down to a broken wire and a broken jack on the power supply.
- We have been brainstorming ways to decrease movement of the magnets when rowing because there has been movement when rowing on increased resistance levels. Staci said that they use a similar motor for one of their bikes, and if we supply more current to the motor, there should be enough torque to prevent this rotation.
    - We tried this, but we were still seeing movement in the magnets when the stroke rate was higher while Sam was rowing.
    - To troubleshoot this problem, we have two springs which we'll attach to the magnet housing which will (hopefully) prevent this unwanted backward magnet movement during rowing.

Advisor Meeting:

- We have now IRB approval!! We do not have to resort our
    - Mention IRB approval in the executive summary, and add a brief summary of what the test participants are going to be doing.
    - For more executive summary space:
        - Put title in header
        - Change margin size
        - No space between paragraphs
- We updated Dr. Puccinelli on our spring idea for the magnet housing to prevent backward motion
- Josh updated Dr. Puccinelli on the
- Executive summary update: overall we are on track, but there are a few things that we need to take out.

Client Meeting:

- Staci explained the current idea with the motor and holding torque again. Although we tried this, we did not have much luck, so we are trying to add springs. Staci thinks that we will be fighting ourselves if we do this.
    - She said since we designed the system to work without the spring, there are adjustments that we will need to make to account for this change. She thinks that we will have issues on the low-resistance end.

- Staci said that they ran into this same issue on their indoor resistance bike at JHT, but it came down to the frequency that the electronic system checked the position of the motor and the current supplied to the motor. There had to be sufficient current supplied to the motor so that the maximum holding torque would be available.
- Staci said if we don't find a spring that works, don't worry about it. We are designing for the 80%, not the 20%.
- She suggested that we try rowing on the adaptive side to see if there is a similar movement issue.
  - There is not very much movement on the adaptive side because not enough force is generated without the use of legs.
  - The spring idea did not work.

Conclusions/action items:

Today's meeting was very productive! We finalized plans for testing now that we have IRB approval, and we will try to meet to do testing next week (both EMG with Dr. Wille and adaptive side testing). Final outreach activity materials are submitted, and we will be moving forward to executive summary changes, as well as final deliverables. We are excited to see what the remainder of the semester brings and for the future of this project.

04/23/2023 Individual Poster Work and Survey Results

Roxi Reuter - Apr 23, 2023, 8:42 PM CDT

Title: Individual Poster Work

Date: 04/23/2023

Content by: Roxi Reuter

Present: —

Goals:

- Complete the discussion section of the poster
- Add in tables for survey data analysis (average scores after categorizing the questions)

Content:

- I made some edits to the discussion section of the poster:

DISCUSSION

Design Achievements:

- Rower converts between standard and adaptive sides without assistance since handlebar can be reached from both sides
- Lap pad secures wheelchair user in place and prevents excessive movement of wheelchair
- Stabilization frame adjusts for different sized users / wheelchairs
- Console automatically rotates to the side in use so that user can view the metrics of their rowing workout
- Resistance can be adjusted from standard and adaptive sides

Areas for Improvement:

- Purchase new motor with higher holding torque for resistance mechanism
- Increase adjustability and durability of the stabilization frame

- Below are the tables I created for analysis of the survey results from testing which will be used on the poster (see next page)
  - Please see attached Excel sheet for breakdown of which questions were used in the calculations of average scores

Standard and Adaptive Side Survey Results (Testing Participants without Physical Disabilities)	
Standard Side	Average Score (Out of 5)

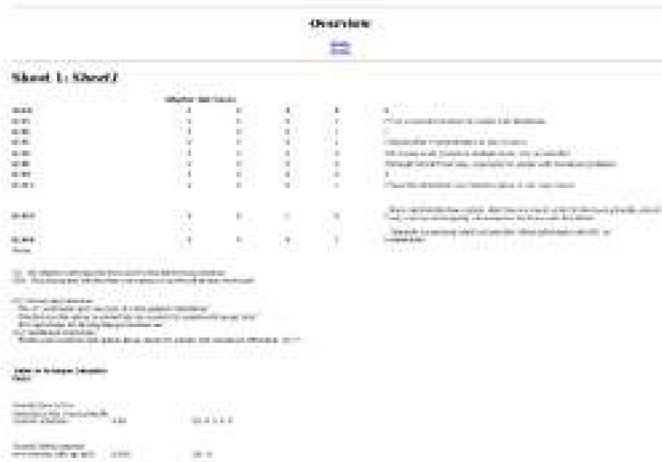
Overall Ease of Use	4.22
Overall Safety	4.8
Comfort	4.6
Adaptive Side	Average Score (Out of 5)
Overall Ease of Use	4.7
Overall Safety	4.75
Comfort	4.5
Standard and Adaptive Comparison	Average Score (Out of 5)
Workout Comparability	4.38
Console Use and Transition	4.89
Likelihood of Future Use	4.9
Ease of Resistance Adjustment	4.5

Adaptive Side Only Survey Results (Testing Participants with Physical Disabilities)	
Adaptive Side	Average Score (Out of 5)
Overall Ease of Use	4.8
Overall Safety	4.83
Comfort	4.33
Likelihood of Future Use	4.67

Conclusions/action items:

In this work session, I worked on my assigned portions of the poster. In the coming days, I will review the poster individually and with the team, as well as practice presenting for the final presentation.

Roxi Reuter - Apr 23, 2023, 8:43 PM CDT

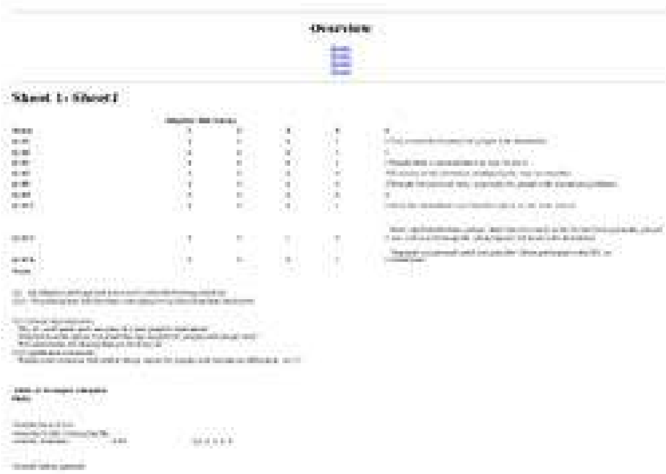

Overview

Sheet 1: Sheet1

Download

Survey_Analysis_and_Results.xlsx (11.9 kB)

Roxi Reuter - Apr 26, 2023, 3:33 PM CDT


Overview

Sheet 1: Sheet1

Download

Survey_Analysis_and_Results.xlsx (16.3 kB) Updated Spreadsheets with Calculations for Tables

Roxi Reuter - Apr 26, 2023, 3:34 PM CDT

Usability Survey Testing:

Standard and Adaptive Side Survey Results (10 Testing Participants without Physical Disabilities)		
Standard Side	Average Score (Out of 5)	Standard Deviation
Overall Ease of Use	4.22	1.02
Overall Safety	4.80	0.42
Comfort	4.60	0.52
Adaptive Side	Average Score (Out of 5)	Standard Deviation
Overall Ease of Use	4.72	1.38
Overall Safety	4.75	0.44
Comfort	4.50	0.52
Standard and Adaptive Comparison	Average Score (Out of 5)	Standard Deviation
Workout Comparability	4.38	0.50
Console Use and Transition	4.89	0.33
Likelihood of Future Use	4.50	0.53
Ease of Resistance Adjustment	4.90	0.32

Adaptive Side Only Survey Results (3 Testing Participants with Physical Disabilities)		
Adaptive Side	Average Score (Out of 5)	Standard Deviation
Overall Ease of Use	4.80	0.41
Overall Safety	4.83	0.41
Comfort	4.33	1.15
Likelihood of Future Use	4.67	0.58

Download

Screen_Shot_2023-04-26_at_15.34.32.png (226 kB) Updated Tables on Poster

04/24/2023 Team Poster Editing

Roxi Reuter - Apr 25, 2023, 6:40 PM CDT

Title: Final Poster Editing Meeting

Date: 04/24/2023

Content by: Roxi Reuter

Present: Josh, Sam, Tim, Annabel, Roxi

Goals:

- Edit the poster
- Discuss other final deliverables
- Schedule a time to review the poster with Tracy

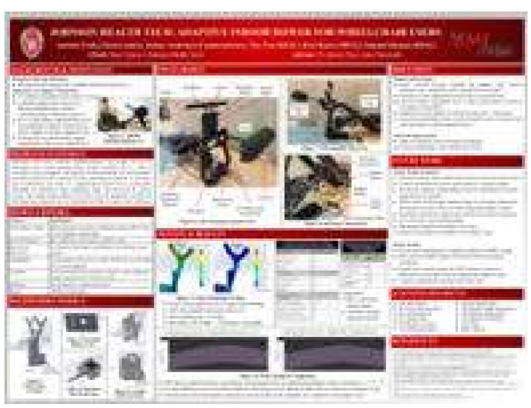
Content:

- Since everyone has had a chance to read through the poster and make individual edits/comments, we are
- I updated the survey table results with the number of testing participants
    - We had a bit of a discrepancy on number of testing participants because not everyone filled out the survey correctly or did the correct survey
- In my portion of the poster (discussion), I should emphasize safety feedback on lap pad/device in general, mention accuracy of motor for areas of improvement (degree differences) and the general issue of the resistance dial mechanism

Conclusions/action items:

The team poster editing session was long but necessary so that our presentation goes as smoothly as possible. We will meet with Dr. TJ Puccinelli on Wednesday via Zoom to edit our poster, and we will practice the advisor and judges presentation together as a team on Thursday night. We are looking forward to our poster presentation! Please see attached file for poster after team edits during this meeting.

Roxi Reuter - Apr 25, 2023, 6:40 PM CDT



Download

Final_Poster_-_Adaptive_Rower_Spring_2023.pdf (2.86 MB)

05/01/2023 Journal Article Editing

Roxi Reuter - May 02, 2023, 7:46 PM CDT

Title: Final Journal Article Editing

Date: 05/01/2023

Content by: Roxi Reuter

Present: Josh, Tim, Sam, Annabel, Roxi

Goals:

- Make final edits to the journal article and submit it
- Contact Dr. TJ Puccinelli about setting up a time for our final advisor meeting

Content:

- We each edited the journal article individually, and we began addressing comments that we each made individually
    - This helped speed up the review process
- Things to-do:
    - Final peer and self reviews (Friday)
    - Look through feedback on poster presentation (Wednesday)
    - Update notebook (due Wednesday but update by tomorrow night)
        - Roxi **-** add updated consent form
        - Roxi **-** update with meeting notes and poster presentation work
    - Roxi **-** make invoice for JHT/Staci
- Josh will be emailing Staci to have a final meeting with her. We will talk about next steps for the project.
- We will also talk to Tracy about next steps for the journal article during our final advisor meeting, which we will work on setting up a time for with Dr. TJ Puccinelli.
    - We are aiming for Thursday evening (May 4, 2023).

Conclusions/action items:

We finished up our journal article during today's team meeting, and we turned it in. In terms of future work, we are waiting to discuss project continuation with Staci and Dr. TJ Puccinelli. We are working on scheduling final meetings with our client and advisor to have these discussions. In the meantime, we will finish reading poster reviews, finalize our team notebook, and complete peer and self evaluations. Additionally, I will be working on the invoice for JHT for reimbursement.

01/19/2023 Consent Form

Roxi Reuter - Jan 28, 2023, 12:23 PM CST

Title: IRB Consent Form

Date:

Content by: Roxi Reuter

Present: —

Goals:

- Create the IRB consent form needed for testing, as well as the IRB exemption application

Content:

- Please see attachment for the finalized IRB consent form
- This was reviewed by team members and will be sent to Dr. Tracy Jane Puccinelli, our advisor, for review before turning it in with the application

Conclusions/action items:

Now that the consent form is complete, the final document we have left to begin for the IRB application is the device documentation which will be divided up amongst group members in the first team meeting.

Roxi Reuter - Jan 28, 2023, 12:24 PM CST

Download

Consent_Form.pdf (57.7 kB)

02/01/2023 Device Documentation

Roxi Reuter - Feb 01, 2023, 11:20 AM CST

Title: Device Documentation

Date: 02/01/2023

Content by: Roxi Reuter

Present: —

Goals:

- Complete my assigned portion of the device documentation (intended use)
- Meet with team to edit device documentation and review IRB application for submission

Content:

- Intended use:
    - The Matrix Adaptive Rowing Machine has been modified from the standard Matrix Rowing Machine to accommodate individuals in wheelchairs through the aforementioned adaptions. It is a more inclusive device which can be easily converted between the standard and adaptive sides such that the both wheelchair- and non-wheelchair- individuals are able to utilize the device. This device is adjustable, and therefore can accommodate users and wheelchairs of various sizes while still maintaining the safety standards of the original device. The Matrix Adaptive Rowing Machine is intended for gym or home use to maintain and/or build an individual's strength and physical fitness. The standard side provides the traditional full-body rowing workout, while the adaptive side offers an upper body strength training for individuals requiring wheelchairs.
- Previous use:
    - Previously, the Matrix Adaptive Rowing Machine was used for individual use in homes and fitness centers and has also been used in clinical settings. The adaptations which allow wheelchair access have not previously been utilized.

Conclusions/action items:

I completed my portion of the device documentation for the IRB application (intended use) and also started another section for the team (previous use). Additionally, I formatted the document for the team so we do not need to do that during the team meeting. I will continue ensuring that all materials are prepared for the IRB application and work on editing these documents with the team on Sunday (02/05).

02/06/2023 IRB Application Review and Updates

Roxi Reuter - Feb 06, 2023, 10:07 PM CST

Title: IRB Application Review and Updates

Date: 02/06/2023

Content by: Roxi Reuter

Present: —

Goals:

- Update and review IRB application
- Ensure all required and supplemental materials are attached to the application
- Submit application

Content:

- I reviewed the IRB application
- One remaining question to discuss with Tracy and/or the team:
  - Will data be shared outside UW-Madison? (journal?)
- I added all documents to the IRB application (minus the original user manual which I will dig up/ask for since we have it from a previous semester I believe)
- Dr. TJ Puccinelli still needs to fill out the PI form for the application

Conclusions/action items:

The IRB application is almost complete! There is one remaining question to verify with the team regarding release/publication of data outside of the UW-Madison realm. This may be tricky to answer since we are unsure if we will actually publish in a journal this semester, but that is the goal. Part of the team has a meeting with Dr. TJ Puccinelli on Wednesday to review slides (those available during her office hours), so she will be kindly reminded of the PI form during that time, if not before then via email. The overall goal is to submit the IRB application by the end of this week for review.

02/21/2023 IRB Application Submission

Roxi Reuter - Feb 21, 2023, 10:47 PM CST

Title: IRB Submission

Date: 02/21/2023

Content by: Roxi Reuter

Present: –

Goals:

- Review IRB application for a final time
- Make necessary revisions
- Submit application

Content:

- We received feedback from our first IRB application (a protocol-based one), but the reviewer on the IRB team told us to submit a non protocol-based application
- I reviewed the entire IRB application and made some grammatical corrections
- I also changed the application in terms of data sharing in case we end up publishing our journal article at the end of the semester with information from this semester's testing

Conclusions/action items:

During our team meeting tonight, I confirmed with the other members that everyone has had a chance to read the IRB application for content to ensure all questions are answered in a manner which all team members agree upon. Everyone did have a chance to look over the application, so I made the changes we discussed and submitted the application tonight after reviewing it for one last time.

03/10/2023 IRB Application Updates

Roxi Reuter - Mar 10, 2023, 11:49 AM CST

Title: IRB Application Updates

Date: 03/10/2023

Content by: Roxi Reuter

Present: —

Goals:

- Make changes to the IRB application per suggestions from the IRB reviewer

Content:

- We received feedback from an IRB reviewer on our application. She made about nine comments on the application, which required me to change answers to a few questions.
- The biggest change to the application is the consent form, which needs to follow IRB format. The reviewer was kind enough to edit the consent form document and make direct edits to it. I will be updating the consent form per her comments.
- I finished making edits to the IRB application and submitted it again.
- Please see updated consent form attached to this entry.

Conclusions/action items:

I took a few hours to address all the IRB comments, review the application, and update the consent form. I resubmitted the application today, and I will be monitoring the application and my email for more responses/comments. I will update the team about the progress of the application at our meeting today (03/10/2023).

Roxi Reuter - Mar 10, 2023, 11:49 AM CST

Download

Consent_Form_IRB_Updated.docx (23.4 kB)

03/20/2023 IRB Application Resubmission

Roxi Reuter - Mar 20, 2023, 10:01 AM CDT

Title: IRB Application Updates

Date: 03/20/2023

Content by: Roxi Reuter

Present: —

Goals:

- Update IRB application per suggestions by pre-reviewer so that it can be addressed at the next IRB meeting this week

Content:

- This time, there were only three comments to address
- Mainly, I fixed the consent form, and added additional information to some of the short response questions when it was requested.
    - Please see updated consent form attached to this entry
- I submitted the application again before the deadline, so it should be addressed this week

Conclusions/action items:

We received feedback from the IRB on our resubmitted application. Fortunately, I was able to get all of the updates made to the application before 5PM today (03/20), which means that our application will likely be reviewed by the board this week. Please see attached updated consent form.

Roxi Reuter - Mar 20, 2023, 10:01 AM CDT

Download

Consent_Form_IRB_Updated_r2.docx (27.2 kB) Updated Consent Form

04/04/2023 IRB Updates

Roxi Reuter - Apr 04, 2023, 3:47 PM CDT

Title: IRB application updates

Date: 04/04/2023

Content by: Roxi Reuter

Present: —

Goals:

- Update IRB applications per suggestions from the IRB committee

Content:

- Last week, we finally got feedback from the IRB team on our testing application. We had two pre-submission reviews before this. The board is simply looking for a few more details before approval, which I completed today.
- These changes included:
    - Specifying where data will be stored
    - Giving more details about when, where, and how the post-study survey will be conducted.
    - Updating the consent form to address injuries and contact information/procedures if they occur.

Conclusions/action items:

Today I updated the IRB application to address the review board's comments which mainly included adding more details that the board requested before they are able to approve our application. Please see the attached updated consent form. We are running low on time before testing needs to begin, so I will let the team know that I updated this application, and we will review it in depth before submitting again. We are also waiting to hear back from Dr. Wille to see if she will be a part of our application since the IRB is requesting that we provide information on who will be using the EMG and what certification/training they have. Dr. Wille offered to help with figuring out the EMG kit and analyzing the data.

Roxi Reuter - Apr 04, 2023, 3:48 PM CDT

University of Wisconsin-Madison
Consent to Participate in Research

TITLE OF STUDY:

PRINCIPAL INVESTIGATOR

PURPOSE OF STUDY

What will I need to do in this study?

Download

Consent_Form_04042023.docx (24.3 kB)

02/09/2023 Outreach Materials

Roxi Reuter - Feb 09, 2023, 1:03 PM CST

Title: Outreach Activity Supplies List

Date: 02/09/2023

Content by: Roxi Reuter

Present: —

Goals:

- Start compiling a list of items for the outreach activity: potato power!

Content:

- See attached outreach notes for list of items needed, time, date, and location of outreach activity

Conclusions/action items:

In the coming week, I will need to hand this list over (with links) to Tracy in order to purchase our outreach materials. First, I will have to ask her and/or the team about a couple of things:

1. How much extra material should we order? I have it estimated at 10 groups, although we may only have 7-9.
2. Is it better to order the Amazon kits + potatoes for the students (downfall **-** some of the reviews said that more components, such as wires, were necessary than what was included) or purchase all the components separately?

I will ask the team and Tracy these questions during our upcoming meetings and finish up the list of necessary outreach items.

Roxi Reuter - Feb 09, 2023, 1:04 PM CST

Download

Outreach_Materials_Notes.pdf (473 kB)

Roxi Reuter - Feb 10, 2023, 1:59 PM CST

Update:

After consulting with the team, we will be purchasing supplies separately for 30 students (about 10 groups). I will complete that for the next advisor meeting.

02/16/2023 Outreach Material Sources and Pricing

Roxi Reuter - Feb 17, 2023, 12:05 AM CST

Title: Outreach Materials List

Date: 02/16/2023

Content by: Roxi Reuter

Present: –

Goals:

- Compile a list of outreach materials and sources

Content:

- See table below for details on outreach material items, quantities, sources, and prices

Item	Source	Quantity	Total Price
Pennies	(Roxi)	30	—
Galvanized Zinc Nails (Set of 75)	Amazon	1	$3.19
Alligator Clips (Set of 50)	Amazon	1	$15.99
LEDs (Set of 100)	Amazon	1	$4.99
Digital Multimeter	Amazon (or borrow from ECB)	3-10 (quantity can vary because groups can share)	$11.99/multimeter
Potatoes	Grocery Pick Up	30	?

Conclusions/action items:

Above is the table of materials needed for our team outreach activity on potato power. We will teach kids at Spring Harbor Middle School about the basics of electricity and circuits, part of the bioinstrumentation track in BME.

Although I have completed the sourcing and pricing of the activity materials, I will need to run this by the team and also test the activity out to verify the necessary quantities of each item to eliminate discrepancies about item quantities that I have read online.

03/06/2023 Individual Outreach Trial

Roxi Reuter - Mar 09, 2023, 6:06 PM CST

Title: Outreach Trial

Date: 03/09/2023

Content by: Roxi Reuter

Present: —

Goals:

- Try outreach activity again with personal supplies and update materials list with quantities and links

Content:

- I set up the outreach activity again with my personal supplies because when we tried the outreach activity as a group, we did not have enough potatoes to power our LED
    - The LED that we used was a 3V LED, and we only had approximately 1.5V from the three potatoes that were brought
- I got the activity to work using my red LED in my BME 201 electronics kit, which required 2.0-2.4V to light up. I also used about five potatoes, so I had just over 2V of power from the potatoes.
- The LED did not light up very bright, but when I shut the lights off, it was noticeable.
- Takeaways:
    - Order 1.5V LEDs
    - Use five potatoes per group to ensure enough volts are supplied to the LED and lights it up. Adjust alligator clip, penny, and nail quantities accordingly.
    - If worse comes to worst and the lights do not light up very bright or at all, we can combine groups and make a larger potato circle. We can also use this as a teaching moment to ask students what they think would help power the LED (more power and therefore more potatoes).
    - We can also shut the lights off to have a "reveal moment" so that the students can see more clearly that their LED is lit.
- See attached pictures from my personal trial of the outreach activity. This shouldn't take too long, so we should have plenty of time to present slides at the beginning and have the students complete the associated worksheet.

Conclusions/action items:

Since the outreach activity did not quite work when we tried it as a team due to lack of materials, I decided to try it on my own using things I had lying around my apartment. I got the activity to work, but I confirmed that we should order lower voltage LEDs (1.5V) and increase the number of potatoes. This was discussed with the rest of the team, and I found all supplies on Amazon. I sent the list to Dr. TJ Puccinelli for purchase. We will be completing the activity on March 24, 2023, at Spring Harbor Middle School near the UW campus.

Roxi Reuter - Mar 09, 2023, 6:10 PM CST

Download

IMG_3832.HEIC (1.91 MB) Outreach Activity Pictures

Roxi Reuter - Mar 09, 2023, 6:10 PM CST

Download

IMG_3831.HEIC (897 kB) Outreach Activity Pictures

Roxi Reuter - Mar 09, 2023, 6:10 PM CST

Download

IMG_3830.HEIC (1.37 MB) Outreach Activity Pictures

03/07/2023 Updated Materials List

Roxi Reuter - Mar 07, 2023, 10:19 AM CST

Title: Updated Outreach Materials List

Date: 03/07/2023

Content by: Roxi Reuter

Present: –

Goals:

- Compile a list of outreach materials and sources for outreach after testing the activity

Content:

- See table below for details on updated outreach material items, quantities, sources, and prices

Item	Source	Quantity	Total Price
Pennies	—	50	$0.50
Nails	Amazon	1	$5.99
Alligator Clips (Set of 60)	Amazon	1	$18.99
1.2-1.5V LEDs (Set of 100)	Amazon	1	$7.99
Digital Multimeter	Amazon (or borrow from ECB)	3-10 (quantity can vary because groups can share)	$11.99/multimeter
Potatoes	Grocery Pick Up	50	?

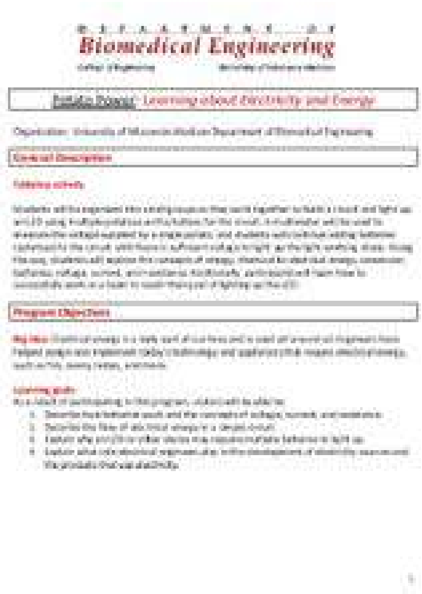
Conclusions/action items:

Above is the table of materials needed for our team outreach activity on potato power. We will teach kids at Spring Harbor Middle School about the basics of electricity and circuits, part of the bioinstrumentation track in BME.

Since the team has tried the outreach activity already, we know how much time we expect the activity to take and the amount of supplies needed. I will double check this with the rest of the team and send the list to Dr. TJ Puccinelli for purchasing.

03/22/2023 Outreach Handout

Roxi Reuter - Mar 22, 2023, 8:29 PM CDT



DEPARTMENT OF
Biomedical Engineering

Learning about Electricity and Energy

General Description

Program Objectives

[Download](#)

Handout.docx.pdf (69.3 kB)

Roxi Reuter - Mar 22, 2023, 8:29 PM CDT

Title: BME 402 Outreach Handout

Date: 03/22/2023

Content by: Roxi Reuter

Present: —

Goals:

- Create a handout with steps for each group which will be utilized during the outreach activity

Content:

- Right now, my group has a general set of instructions and objectives for the kids when doing our outreach activity.
- I will be making a summarized version of this for each group to follow along with during the activity.
- Please see the attached handout.

Conclusions/action items:

I created a summary of the activity steps which will be used as a handout for the groups during our outreach activity this Friday (03/24) at Spring Harbor Middle School. All of the material in the original document will be presented before beginning the activity, but the handout will just be used for activity steps and won't be as overwhelming for the students. I will present this to the team when we try the outreach activity, and then I will print them to bring them to bring to the outreach activity.

02/28/2023 Journal Article Work and Editing

Roxi Reuter - Feb 28, 2023, 1:40 PM CST

Title: Preliminary Journal Article Work

Date: 02/28/203

Content by: Roxi Reuter

Present: –

Goals:

- Work on assigned individual sections of journal article
- Edit article individually

Content:

- I was assigned the abstract section for the journal article, as well as the results and discussion sections. Since we have not yet carried out testing, I will be outlining the results and discussion section.
- Results and discussion sections:

Results

Testing is not yet complete; no results are currently available.

Adaptive Side

Several individuals were recruited to participate in testing of the adaptive side of the rowing machine, as mentioned in the “Methods and Materials” section. Following completion of the study, a survey was given to each user, both individuals in wheelchairs and participants that did not require wheelchair use, to analyze the safety and effectiveness of rowing on the wheelchair accessible portion of the machine. The two surveys (adaptive side survey and comparison survey) were administered to the appropriate groups of participants. Several questions about the safety, ease of use, comfort, and overall design feedback were included on each survey. Participants were asked to provide a rating on a scale from 1 to 5 (1 being the most negative feedback option, and 5 being the most positive). Space for additional comments and short answer questions pertaining to user experience were also included.

Outline of things to touch on in this section:

- Number of participants which had previously used a rowing machine (mention type of rowing machine used if applicable and relevant to data analysis)
- Rower handlebar ease of manipulation ratings and comments
- Interaction with console and comments
- Resistance level changing (ease of use and comments)
- Overall ease of use

- Safety evaluation and comments
- Comfort ratings
- Additional comments

Adaptive and Standard Side Comparison

- Number of participants with rowing experience
- Rower handlebar ease of manipulation ratings and comments
- Interaction with console and comments
- Resistance level changing ease of use and comments
- Overall ease of use
- Safety evaluation and comments
- Comfort ratings
- Additional comments

Discussion

Testing data is not yet available. The discussion will be completed upon completion of testing.

Outline of things to touch on in this section:

- Connections and main takeaways from testing data collected
- Potential sources of testing errors / influences
    - Users with little to no experience rowing and with varying fitness levels (impacts survey feedback)
    - Use of legs on the adaptive side by users not requiring wheelchairs
    - Difficulty in rating ease of use, etc. if no previous experience with rowing
    - Inconsistent rowing during trials
- Analysis of test results in terms of overall user experience and impact on society and different demographics
    - How will this benefit the general population?
    - Discuss design size (compact), fitness inclusivity, and health benefits for individuals in wheelchairs
    - Comparison between sides of the rowing machine

- Abstract:

Abstract

Exercise is essential for maintaining a healthy lifestyle. Fitness centers offer a wide variety of workout equipment to strengthen and exercise various muscle groups within the body. However, most exercise machines are not accessible to individuals in wheelchairs and require external modifications for accommodation. To address this problem, the Johnson Health Tech Adaptive Rower team modified an existing Matrix rower to allow adaptive use by individuals in wheelchairs on one side of the machine and standard use on the opposite side. Safety mechanisms, such as a stabilization frame and lap pad were integrated to ensure a safe adaptive

exercise experience. The console was relocated and implemented with automatic rotation for ease of use. After initial testing using SolidWorks simulations for excessive loading cases, the design was adjusted slightly and fabricated out of a more durable metal material. The resistance dial mechanism was modified with the help of a stepper motor to enable adjustment from either the standard or adaptive sides. EMG and recruited user testing of the hybrid device revealed ____. This unique and convertible design increases gym inclusivity and improves quality of life through exercise.

Conclusions/action items:

Although there are some blanks in the journal article, this is because testing has not yet been completed. This will serve as a template for the final journal article after testing is completed. Besides completing the abstract section and outlining the results and discussion sections as much as possible, I also read through other members' sections, made individual edits and comments, and helped format the journal article. I will be meeting with the rest of the team today (02/28) on Microsoft Teams to edit the journal article as a team and plan a few more things with the outreach activity. The journal article and other preliminary assignments, such as peer and self evaluations, are due this week.

05/02/2023 Journal Article Work (Final)

Roxi Reuter - May 02, 2023, 8:16 PM CDT

Title: Final Journal Article Work

Date: 05/02/2023

Content by: Roxi Reuter

Present: –

Goals:

- Work on assigned individual sections of journal article
- Edit article individually

Content:

- I completed the results and discussion sections for the journal article, as well as individual editing

Results

Table 1. Adaptive Only Survey Results

Adaptive Side Only Survey Results (3 Testing Participants with Physical Disabilities)		
Adaptive Side	Average Score (Out of 5)	Standard Deviation
Overall Ease of Use	4.80	0.41
Overall Safety	4.83	0.41
Comfort	4.33	1.15
Likelihood of Future Use	4.67	0.58

Table 2. Comparison Survey Results

Standard and Adaptive Side Survey Results (10 Testing Participants without Physical Disabilities)		
Standard Side	Average Score (Out of 5)	Standard Deviation
Overall Ease of Use	4.22	1.02
Overall Safety	4.80	0.42
Comfort	4.60	0.52
Adaptive Side	Average Score (Out of 5)	Standard Deviation

Overall Ease of Use	4.72	1.35
Overall Safety	4.75	0.44
Comfort	4.50	0.52
Standard and Adaptive Comparison	Average Score (Out of 5)	Standard Deviation
Workout Comparability	4.38	0.50
Console Use and Transition	4.89	0.33
Likelihood of Future Use	4.50	0.53
Ease of Resistance Adjustment	4.90	0.32

Adaptive Side

The adaptive side testing participants provided very positive feedback on the Adaptive Rower design. All three participants had previously used a standard rowing machine, so each had experience with rowing and could therefore use that prior experience as a baseline to score their interaction with the adaptive rower in the anonymous survey. Questions were grouped into four broad categories of analysis: Overall Ease of Use, Overall Safety, Comfort, and Likelihood of Future Use. Overall Ease of Use, which encompassed the ease of manipulating the rower handle, console, and resistance dial, scored a 4.80 out of 5, with a standard deviation of 0.41. Similarly, Safety averaged a score of 4.83 with a standard deviation of 0.41, addressing security of the wheelchair during rowing while the lap pad was in use. No testing participant felt as though they would tip over the wheelchair while rowing on the adaptive side. Finally, Comfort and Likelihood of Future Work score 4.33 and 4.67, respectively, with corresponding standard deviations of 1.15 and 0.58. Overall, the adaptive rowing experience scored highly in all areas, with safety being the overall highest score in all the categories.

Adaptive and Standard Side Comparison

Ten participants without physical disabilities tested the standard and adaptive sides of the rower. Almost all participants had used a standard rowing machine prior to testing; only one individual had no previous experience using a rowing machine. The comparison survey had three sections: Standard Side, Adaptive Side, and Comparison Between Sides. Similar to the adaptive only side survey, each section's results were grouped into categories for analysis. The standard and adaptive side categories included Overall Ease of Use, Overall Safety, and Comfort. Workout Comparability, Console Use and Transition, Ease of Resistance, and Likelihood of Future Use averages were reported for the comparison section. All scores and standard deviations for the standard and adaptive sides were comparable, for Overall Ease of Use, Overall Safety, and Comfort with each category scoring 4.5 or higher out of 5. Comparison section results also scored highly. Workout Comparability received a 4.38 with a standard deviation of 0.50, indicating that testing participants found the workouts from both sides of the rowing machine comparable in terms of muscle activation and intensity. The rower was overall found to be very user-friendly, as Console Use and Transition averaged a score of 4.89 and Ease of Resistance Adjustment received a 4.90, with standard deviations of 0.33 and 0.32, respectively. The majority of participants indicated that they are very likely to use a similar device in the future, as reflected in the Likelihood of Future Use category with a score of 4.50 and standard deviation of 0.53.

Altogether, the users that tested both sides of the rowing machine gave very positive feedback and scored each category highly. Despite these results, several survey responses provided suggestions for improving the adaptive rower design. The two main suggestions provided on the surveys included moving the console and buttons closer to the user on each side of the machine and increasing the adjustability of the lap pad and stabilization frame to accommodate more individuals and their wheelchairs.

Discussion

A standard Matrix rowing machine was successfully adapted to accommodate individuals in wheelchairs since the handlebar now rests in a more central location between the standard and adaptive sides, and it can be reached easily from both sides of the machine. No external assistance is required to transition the rower between the standard and adaptive sides. Additionally, the lap pad and stabilization frame were added to the adaptive side of the machine to provide comfort and security to individuals rowing in wheelchairs. This safety mechanism is adjustable to secure users and wheelchairs of varying sizes while minimizing the movement of the wheelchair during exercise to prevent tipping and decrease risk of injury. The console which provides the metrics of the rowing workout automatically rotates between the standard and adaptive sides based on which side is in use, further increasing the ease of use. This permits users to view their rowing metrics while working out. Lastly, the resistance mechanism was modified from the original mechanical system to an electronic system such that the resistance level of the rowing workout can be changed via the press of a button from either the standard and adaptive sides of the rower. Two display screens show the current resistance level to users.

As can be seen in **Table 1** and **Table 2**, positive feedback on usability was received from testing participants. This data confirmed the safety, comfort, ease of use, and exercise comparability of both the standard and adaptive sides of the Adaptive Rowing Machine. Since there were testing participants with little to no rowing experience and varying fitness levels, this may have served as a source of error. Users with no previous rowing experience may have had difficulty rating survey questions since they did not have a baseline to compare their adaptive workout experience. Additionally, use of legs on the adaptive side by users not requiring wheelchairs and an inconsistent rowing pace during trials may have skewed the survey results. Furthermore, multiple individuals oversaw usability testing independent of each other, creating the possibility of variations in test administration.

Although substantial progress has been made on this project, a couple areas of improvement were noted during the design process. Further research and exploration is needed to improve the accuracy and reliability of the resistance adjustment mechanism, as slight errors in the mechanism function occurred during testing. Furthermore, the adjustability of the stabilization frame must be increased to accommodate more individuals and wheelchairs on the adaptive side of the rower. Overall, the Adaptive Rowing Machine fills the gap in the market for exercise equipment which accommodates both individuals who do and do not require the use of a wheelchair. Accordingly, this device increases gym inclusivity and benefits the general population by providing exercise options to those who may or may not have lower extremity disabilities or injuries.

Conclusion:

We will edit the article as a team and turn it in before the deadline on 05/03/2023.

02/06/2023 Journal Review

SAMUEL SKIRPAN - Feb 06, 2023, 1:49 PM CST

Title: Journal Review

Date: 2/6/2023

Content by: Sam

Present: Sam

Goals: Review the various journals that Roxi and Annabel found to determine which one I would like to pursue.

Content:

- It appears that the ASCM Health and Fitness Journal could be a great option for us to pursue
  - The impact factor is around 1.13 according to the ASCM website
    - Source: https://www.acsm.org/education-resources/journals/health-fitness-journal#:~:text=Impact%20Factor%3A%201.130,%C2%AE%20on%20Facebook%20and%20Twitter.
  - I think our device could connect with the journal because the journal is focussed on current topics for health and fitness related ideas
    - Our big topic would be the increased accessibility of machines for individuals requiring wheelchairs
- The JSAMS journal has an impact factor around 3.6, which is a little higher but still doable
  - source: https://sma.org.au/publications-media/journals/#:~:text=The%20journal%20is%20the%20most,2018%20impact%20factor%20of%203.623.
  - The journal focuses mainly on sports medicine and sports science, which could potentially connect with our project
- Opinions:
  - I think we should try to pick a journal that has a smaller impact factor so that there is a higher possibility that we could actually get published
    - It would be very, very cool and interesting if we were able to get published into a magazine that is printed
  - I really enjoy the ASCM health and fitness journal
    - It also seems like a journal that I would typically read if I was reading a random magazine

Conclusions/action items:

I think that we should try to go forward with the ASCM Health and Fitness Journal because it looks very interesting, relates to our project, and also has a lower impact factor. This would mean there is a higher probability of our work getting published.

Action items: Share my thoughts on the journal search with the team.

02/02/23 Resistance Dial Brainstorming Thoughts

SAMUEL SKIRPAN - Feb 02, 2023, 9:34 AM CST

Title: Resistance Dial Brainstorming Thoughts

Date: 02/02/23

Content by: Sam

Present: Sam

Goals: Come up with some ideas for the resistance dial and note them in notebook.

Content:

- Initial thoughts:
    - There were initially two ways that we could approach creating the resistance dial such that it could be accessed from the adaptive side: using the cable or not using the cable
        - My gut thought is that we should not use the cable because it seems that using the cable would create a lot more work for us as a team
            - We would have to find the right tension in the cable, and have the motor torque work against that tension, which could be difficult
    - For the cable-less idea:
        - We would be able to place the stepper motor wherever we would like, which is really nice
        - The things it would require:
            - A solidworks creation of a device that could hold the stepper motor
            - Calculating where the starting and endpoints are for the magnet as it comes across the flywheel
                - This would be done to try and maintain the same relative resistances for the adaptive rowing machine as they were for the traditional rowing machine
                - This could be slightly difficult, but I don't imagine it being that bad
                - We would also potentially ask Staci if the resistances need to be the exact same or of they could be slightly different
                    - If they could be slightly different, then this will not be a problem at all
            - Finding out how many steps would be required for one resistance number adjustment
                - We would do this through trial and error testing on the machine
        - Purchase a new stepper motor
        - Find a way to hook up the stepper motor to the currently existing motor box

Conclusions/action items:

In my opinion, we should try to go with the cable-less design for the resistance dial mechanism. When we were at JHT, it seems like the cable added a lot of complexity to the process. Using a cable-less mechanism would likely make it a lot easier to hook up the stepper motor to the rowing machine.

Action items: create a sketch for the resistance dial idea. Work on stabilization frame solidworks.

02/02/23 Resistance Dial Brainstorming Sketch

SAMUEL SKIRPAN - Feb 02, 2023, 9:41 AM CST

Title: Resistance Dial Brainstorming Sketch

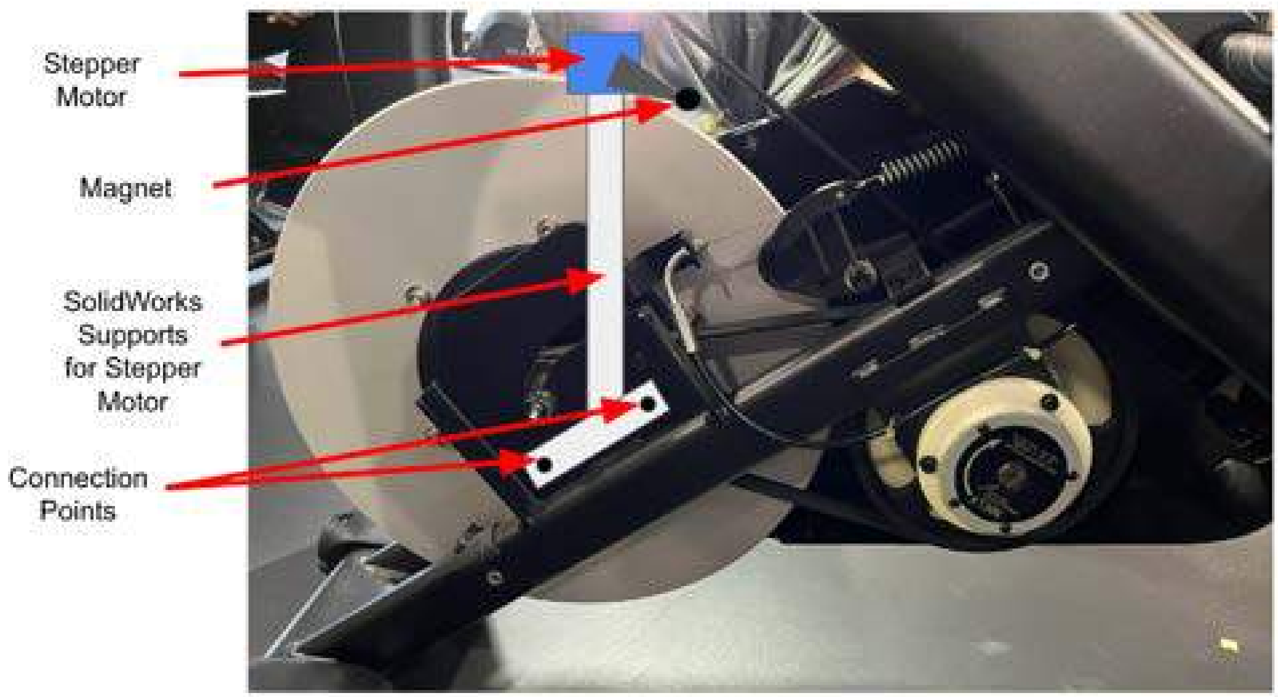
Date: 02/02/23

Content by: Sam

Present: Sam

Goals: Create sketch of brainstormed cable-less idea for resistance dial.

Content:



-
    - Above is my brainstormed sketch for the cable-less resistance changing mechanism
    - For this idea, we would have to use solidworks and eventually 3D print the support mechanism that is attached to the rower frame
    - The support mechanism would then hold the stepper motor, which would have the magnet rotate
    - The connection points at the bottom would use screws to attach the support mechanism into the rowing machine holes that already exist at those points
    - The wire for the stepper motor would be able to run along the support mechanism bars and then the exisiting bars of the rowing machine up to the electronics box
- Other ideas/thoughts to consider:
    - The interface for the user to change resistance:
        - Would be really nice if we had a dial with a digital display that told you what level of resistance you were on at any given moment
            - Whenever you turn on the machine, it the code would read what resistance you are at and print it
            - This would also use basically the same dial that we currently have, but we would need an additional one

Conclusions/action items:

In the image above, I created a sketch of what I think the resistance mechanism should look like. The whole purpose of moving the magnet from its current point is so we can put the stepper motor in place, which allows us to change the resistance from both sides.

Action items: Meet with team to discuss brainstormed resistance mechanism ideas. Work on solidworks for stabilization frame.

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

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.

04/08/2023 Human Subjects Training

SAMUEL SKIRPAN - Apr 08, 2023, 4:40 PM CDT

Title: Human Subjects Training

Date: 4/8/23

Content by: Sam

Present: Sam

Goals: Document completion

Content:

CITI PROGRAM

Completion Date 08-Apr-2023
Expiration Date 08-Apr-2026
Record ID 55306024

This is to certify that:

SAMUEL SKIRPAN

Has completed the following CITI Program course:

Not valid for renewal of certification through CME.

Basic/Refresher Course - Human Subjects Research
(Curriculum Group)
UW Human Subjects Protections Course
(Course Learner Group)
1 - Level 1
(Stage)

Under requirements set by:

University of Wisconsin - Madison

CITI
Collaborative Institutional Training Initiative

Verify at www.citiprogram.org/verify/?w16ac1b1c-59d9-4a1b-ada9-a22ddec6654c-55306024

Conclusions/action items:

01/29/23 Thoughts and Plans for Semester

SAMUEL SKIRPAN - Jan 29, 2023, 3:11 PM CST

Title: Thoughts and Plans for Semester

Date: 01/29/23

Content by: Sam

Present: Sam

Goals: Note the main thoughts and ideas that I have for my work this semester.

Content:

- After meeting at JHT, I am going to be in charge of remodeling the stabilization frame in SolidWorks within the next two weeks
  - The other group members will either be doing work in SolidWorks or they will be working on the IRB
  - After I am finished with the modeling, I will send it to Staci
    - At JHT, they will cut the bars to correct length and then weld all the pieces together for us
    - After they are done cutting and welding the frame, I will go drive out and pick up the frame
    - They also are going to get us a new pad that is a little less wide
      - This is so we can fit smaller width wheelchairs
- We will need to make teams for the resistance dial work
  - I think that using the non-cable idea will be the easiest and most efficient for us this semester
    - It seemed like using the cable would make it a lot more difficult to build out
- We will try to get our IRB application in within the next two weeks if possible
  - We are still waiting on confirmation of protocols from Dr. P and more information on the EMG machine we will be using
  - I really hope that we are able to get the exemption for the IRB process
- We will then start to try and recruit users for the testing
  - This might be slightly difficult, but I will be happy if we can get at least 3 wheelchair users
- I am excited to go do the outreach activity with a middle school
  - I really enjoy working with and teaching kids

Conclusions/action items:

The main things I will be working on this semester include modeling the stabilization frame again in SolidWorks, picking it up and attaching it to the rowing machine, helping with the design of the resistance dial, completing the outreach activity, and being a part of the testing process. I am exciting to see what our rowing machine looks like at the end of the semester!

Action items: Brainstorm ideas for the resistance dial. Model frame in SolidWorks.

02/06/2023 Work on Preliminary Presentation

SAMUEL SKIRPAN - Feb 06, 2023, 10:18 AM CST

Title: Work on Preliminary Presentation

Date: 2/6/2023

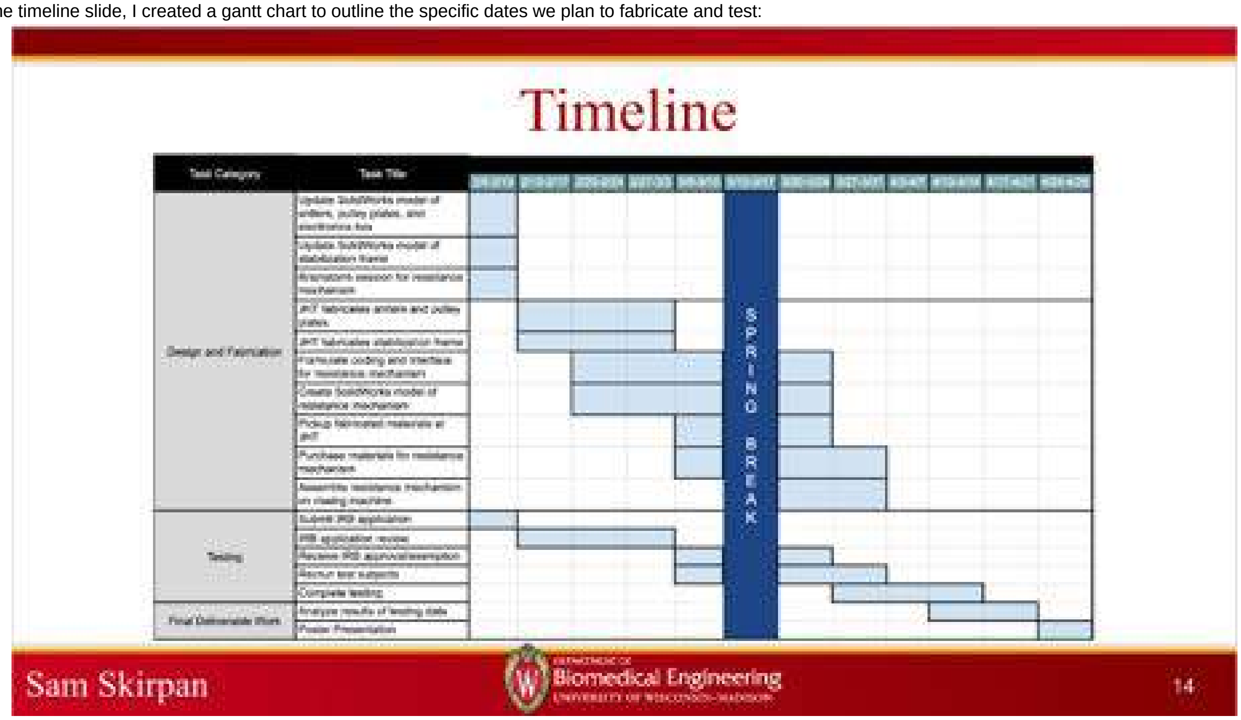
Content by: Sam

Present: Sam

Goals: Note the work that I completed for the preliminary presentation on the sections of testing and timeframe for fabrication and testing.

Content:

- For the preliminary presentation, I am responsible for the testing section and the timeline section of our testing and fabrication
- For the testing section, I created the following slide:
  - 

    - This slide outlines both tests we will be completing, as well as the subjects, data, and purpose of each test
    - Additionally, it lists our overall goal for the testing we are completing
- For the timeline slide, I created a gantt chart to outline the specific dates we plan to fabricate and test:
  - 

Conclusions/action items:

For the testing and timeline sections, I will be responsible for presenting. The two slides pictured above are the ones that I created for the preliminary presentation.

Action items: practice preliminary presentation. Deliver presentation. Work on SolidWorks of stabilization frame.

02/08/2023 Updating of Preliminary Presentation Section

SAMUEL SKIRPAN - Feb 08, 2023, 2:00 PM CST

Title: Updating of Preliminary Presentation Section

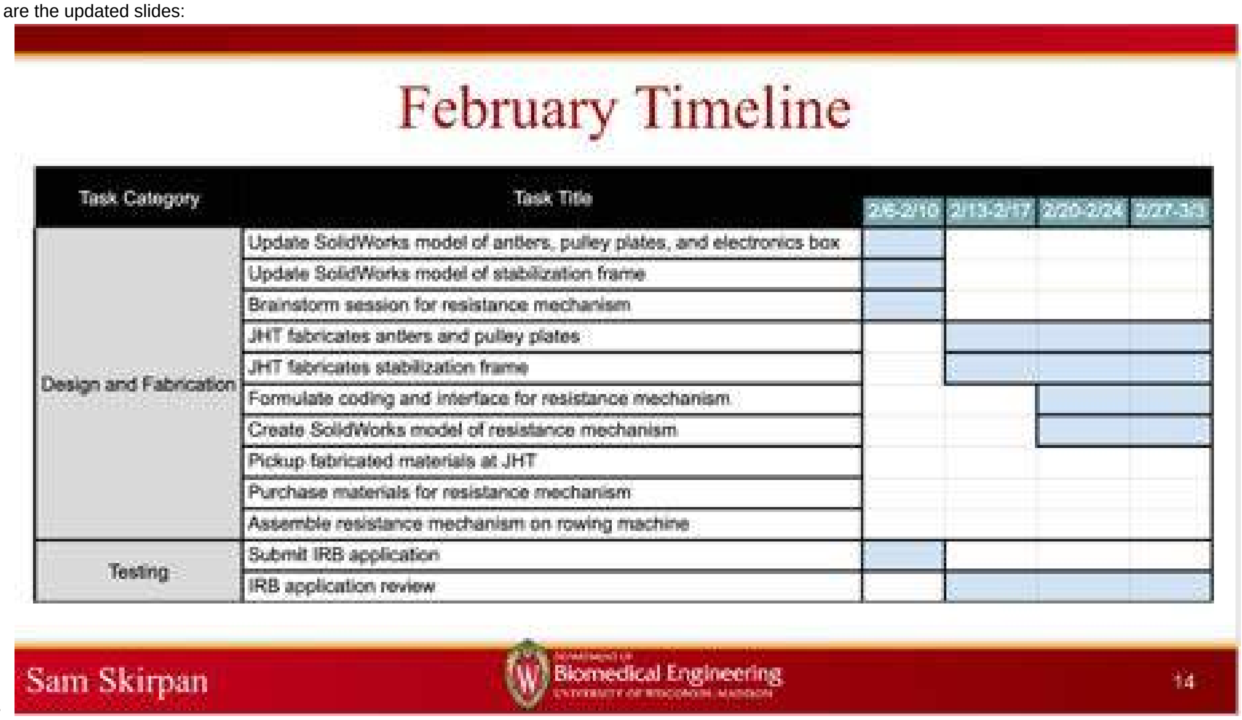
Date: 02/08/2023

Content by: Sam

Present: Sam

Goals: Update testing and timeline sections of preliminary presentation according to Dr. Puccinelli's comments.

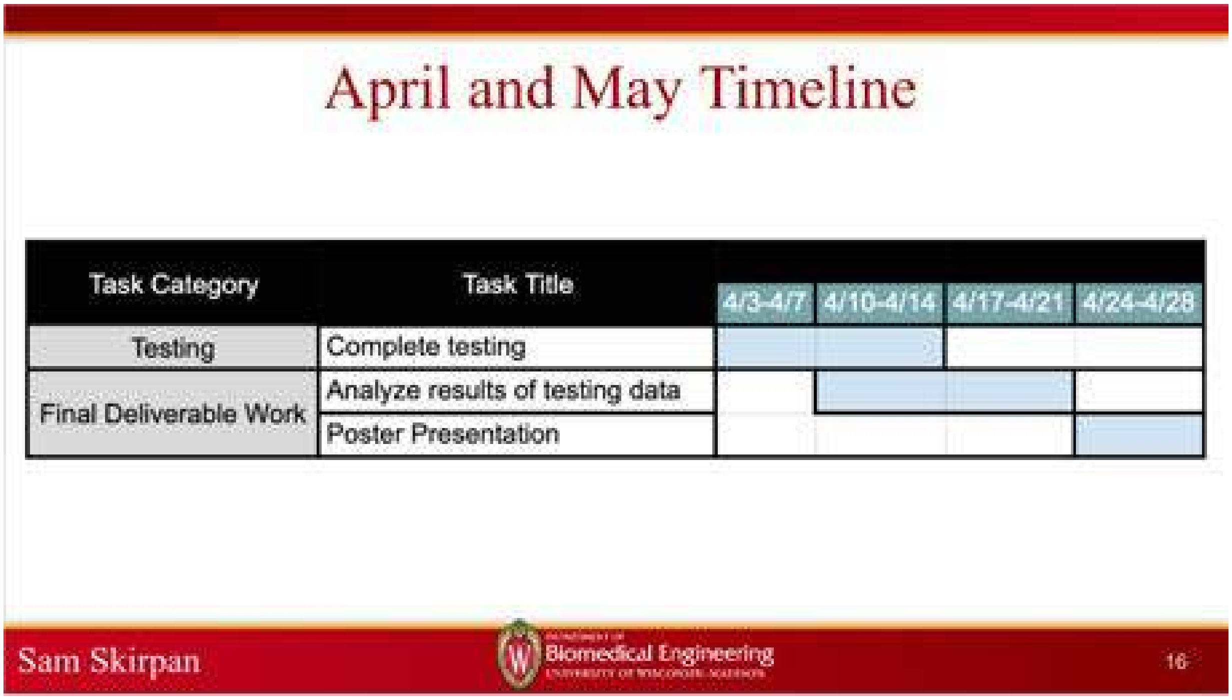
Content:

- Dr. P noted that we should separate the timeline slide into 3 separate slides, so I went back and did this
- I separated them by the months of Feb, Mar, and April and only noted the activities and tasks that were going to be completed in that month
- Here are the updated slides:
  - 

Task Category	Task Title	2/6-2/10	2/13-2/17	2/20-2/24	2/27-3/3
Design and Fabrication	Update SolidWorks model of antlers, pulley plates, and electronics box				
	Update SolidWorks model of stabilization frame				
	Brainstorm session for resistance mechanism				
	JHT fabricates antlers and pulley plates				
	JHT fabricates stabilization frame				
	Formulate coding and interface for resistance mechanism				
	Create SolidWorks model of resistance mechanism				
	Pickup fabricated materials at JHT				
	Purchase materials for resistance mechanism				
	Assemble resistance mechanism on rowing machine				
Testing	Submit IRB application				
	IRB application review				

  - 

Task Category	Task Title	2/27-3/3	3/6-3/10	3/13-3/17	3/20-3/24	3/27-3/31
Design and Fabrication	JHT fabricates antlers and pulley plates			S		
	JHT fabricates stabilization frame			P		
	Formulate coding and interface for resistance mechanism			R		
	Create SolidWorks model of resistance mechanism			I		
	Pickup fabricated materials at JHT			N		
	Purchase materials for resistance mechanism			G		
	Assemble resistance mechanism on rowing machine					
Testing	Submit IRB application			B		
	IRB application review			R		
	Receive IRB approval/exemption			E		
	Recruit test subjects			A		
	Complete testing			K		

- 

Conclusions/action items:

These updated slides will make it a little easier to walk through each individual task and deadline that we set as a group.

Action items: Meet with team to rehearse presentation.

02/09/2023 Talking Points for Preliminary Presentation

SAMUEL SKIRPAN - Feb 09, 2023, 10:12 AM CST

Title: Talking Points for Preliminary Presentation

Date: 02/09/2023

Content by: Sam

Present: Sam

Goals: Note talking points for the preliminary presentation.

Content:

- Below are the points I want to get across for the preliminary presentation:
    - Thanks Josh. So moving on to our testing plan. Our overall goal for testing is to verify the ability of the adaptive rowing machine to keep the user safe, provide a sufficient workout on both the adaptive and standard sides, and allow for the user to easily interact with all parts of the device, such as the stabilization frame, the console, and the resistance mechanism.

      This semester, we plan on conducting two main tests, both which will require the recruiting of testing participants. The first test focuses on the comparison of the standard and adaptive sides. For this test, we plan on using ourselves as the subjects as well as a few other individuals that do not require the use of a wheelchair. With this test, all the subjects will use the rower on the standard side and then get into a wheelchair that we provide for them and use the adaptive side. In terms of data, we will be hooking an EMG up to each participant to collect muscle activation measurements. Also, each participant will take the survey we created for them to rate various parts of their experience.

      For the second test, we plan on recruiting users who require the use of wheelchairs to determine their experience and interaction with the adaptive side of the rowing machine. For this test, all participants will fill out a survey rating their safety, comfort, and ease of use experience during the rowing workout.
    - Moving on to our fabrication and testing timeline, we first have the month of February. Some of the main things that we are working on currently include the updating of our solidworks models and submitting the IRB application. In the near future, we will send these models off to JHT, where they will begin fabricating them. While we are waiting for JHT, we will start creating the solidworks models and code for the resistance mechanism as well as wait for our IRB application to be reviewed.

      In March, JHT will hopefully have the antler, pulley plates, and stabilization frame all fabricated and ready to be picked up. After finalizing our designs for the resistance mechanism, we will eventually purchase the necessary components and begin assembling the mechanism on the rowing machine. As for testing, we hope to receive IRB approval by the beginning of march, and then start to recruit test subjects and begin testing.

      Then lastly, in April, we will be able to focus mainly on completing the tests I mentioned before within the first two weeks. As for final deliverable work, we will analyze the testing results during the middle of April and finally present our poster and get our journal completed and submitted. Next I will pass it off to Roxi!

Conclusions/action items:

For the prelim presentation, I am responsible for talking about our testing and timeline for this semester. Above are the talking points that I have for my slides.

Action items: Practice presentation with team!

02/21/2023 Meeting with Josh for Resistance Mechanism Placement

SAMUEL SKIRPAN - Feb 21, 2023, 3:13 PM CST

Title: Meeting with Josh for Resistance Mechanism Placement

Date: 2/21/23

Content by: Sam

Present: Sam

Goals: Discuss potential locations where we can place the stepper motor for the resistance mechanism.

Content:

- Josh and I met at ECB with the rowing machine to discuss attachment points for the stepper motor and the magnet rotation
- We talked about potentially placing it at the base of the front of the rowing machine
    - This would give us enough space to have the motor sit next to the axle and not get in the way of the housing
    - We also would be able to use the same support mechanism that the magnet piece currently uses to hold the magent
    - This would require running the stepper motor shaft through the axle of the magnet rotation
        - Would probably require a D shaft on the stepper motor and a way to elongate the shaft
- I am also going to be responsible for measuring the stepping of the magnet when it rotates to change the resistance

Conclusions/action items:

Josh and I met to discuss possible locations for the stepper motor. We decided to place it at the base of the front of the rower, where it will be easy to screw in.

Action items: Measure/determine the angle steps the magnet makes for each increment of the resistance dial.

02/27/2023 Work on Preliminary Journal

SAMUEL SKIRPAN - Feb 27, 2023, 1:54 PM CST

Title: Work on Preliminary Journal

Date: 2/27/23

Content by: Sam

Present: Sam

Goals: Complete the materials and methods section of the journal.

Content:

- I was responsible for completing the materials and methods section of the prelim journal article
- I decided to split the section into 3 main components:
    - Overview:
        - To verify the ability of the Adaptive Rowing Machine to keep users safe, comfortable, and provide a sufficient workout, subjects were recruited to use the machine. __ participants that required the use of a wheelchair were recruited to test the adaptive side. To compare the adaptive side to the standard side, __ participants who do not require the use of a wheelchair were recruited. Prior to completing testing, exemption was provided by the IRB. Additionally, all participants signed consent forms and were provided with all relevant details regarding the testing process and purpose.
    - Adaptive Side:
        - Users who required the use of a wheelchair participated in testing by only using the adaptive side of the Adaptive Rowing Machine. These participants were directed to roll up to the adaptive side of the machine, lower the lap pad onto their lap, and grab the handlebar from the antler mechanism. Once they held the handlebar, the participants were directed to complete the rowing motion by pulling the handlebar to their chest, and subsequently push it back out in front of their body. Users were asked to complete this rowing exercise for one minute. This test was completed on resistance levels of 1, 5, and 10. After completing the three trials, the participants were directed to place the handlebar back in the resting position and lift the lap pad back to its resting position. The participants were then asked to complete a survey rating their experience interacting with the Adaptive Rowing Machine. The survey included questions about the user's level of comfort, perceived safety, and ability to interact with the console, handlebar, lap pad, and resistance mechanism. SOMETHING ABOUT ANALYSIS METHODS?
    - Adaptive and Standard Side Comparison:
        - To compare the adaptive and standard sides of the Adaptive Rowing Machine, users who do not require the use of a wheelchair used both the adaptive and standard sides. On the adaptive side, the users were provided with a wheelchair, asked to wheel to the adaptive side of the rowing machine, and pull the lap pad down onto their lap. Similar to the Adaptive Side testing previously described, the participants were directed to complete one minute rowing trials on the resistance levels of 1, 5, and 10. However, the participants who did not require the use of wheelchairs were directed to use their legs as little as possible while rowing. After completing the trials on the adaptive side, the participants were asked to get out of the wheelchair, move the handlebar from the antler mechanism to the original handlebar holder, and position themselves on the sliding seat on the standard side of the rowing machine with their feet strapped in. The users were then directed to grab the handlebar and complete one minute rowing trials on the resistance levels of 1, 5, and 10. Afterward, the participants placed the handlebar back in the handlebar holder and completed a survey rating this experience. Similar to the Adaptive Side survey, participants rated their comfort, safety, and interactions with various components of the Adaptive Rowing Machine. However, the Adaptive and Standard Side Comparison survey also asked the user to rate their perceived difference in workouts between the adaptive and standard sides. SOMETHING ABOUT ANALYSIS METHODS?

Conclusions/action items:

I was assigned the section of materials and methods for the journal article. I split the section into 3 subsections and outlined the protocols and materials for each section.

Action items: meet with team to review the prelim journal. Ask team if we need to include analysis methods or if that is part of the results section

03/07/2023 Lap pad to JHT

SAMUEL SKIRPAN - Mar 10, 2023, 10:49 AM CST

Title: Lap pad to JHT

Date: 3/7/2023

Content by: Sam

Present: Sam

Goals: Drop lap pad off at JHT after discussion with Staci.

Content:

- I engaged in an email conversation with Staci
    - She wanted me to bring the lap pad and pin to JHT before spring break so that they could work on it over the break in the machine shop
- Unfortunately, we did not know where the pin mechanism was that she gave us last semester
- I went over to ECB and removed the lap pad from the rowing machine using a hex wrench
- I then drove the lap pad to JHT and left it at the front desk with a note "For Staci" on it
- Staci and I also discussed some adjustments to the stabilization frame
    - There is the potential that she will need slightly alter the pin mechanism such that the rope does not contact it while the user is rowing from the adaptive side
    - She said that she would make any small adjustments as necessary when they are fabricating it at JHT

Conclusions/action items:

I drove the lap pad to JHT for Staci so they can fabricate the stabilization frame. Also, Staci said that she would make any adjustments necessary before they fabricate it.

Action items: pick stabilization frame up from JHT after Spring break.

03/21/2023 Edits for Prelim Journal Article

SAMUEL SKIRPAN - Mar 21, 2023, 10:54 AM CDT

Title: Edits for Prelim Journal Article

Date: 3/21/23

Content by: Sam

Present: Sam

Goals: Make edits that Dr. P left for us in the prelim journal.

Content:

- Today, I spent about 30-45 minutes making some of the edits that Dr. P left for us in our prelim journal article
- I made all of the on the spot edits in real time, so those should be all set for the final deliverable
- However, some of the comments that Dr. P left are a little more time consuming and large edits
  - For these, I left comments on the side of the document where she wanted us to make those edits
    - I transferred the comments into our google document
  - In addition to leaving the comment, I also added a suggested action plan that we can take with the team
    - For example, Dr. P said that we should include the surveys in our journal article
      - I think these surveys would take up a lot of space if we put the entire thing in
      - Instead, I think that we should add some of the representative questions from the surveys into our article and state that the other questions would ask about all the other components of the device
- As a team, we should try to go through these larger edits to discuss a plan of action

Conclusions/action items:

I spent some time today going through the comments that Dr. P left us in our prelim journal article and made the necessary edits. For the larger edits, we will discuss them as a team.

Action items: Meet with team to discuss the large edits and come up with an action plan.

04/04/2023 Placement of Magnet Housing

SAMUEL SKIRPAN - Apr 04, 2023, 4:17 PM CDT

Title: Placement of Magnet Housing

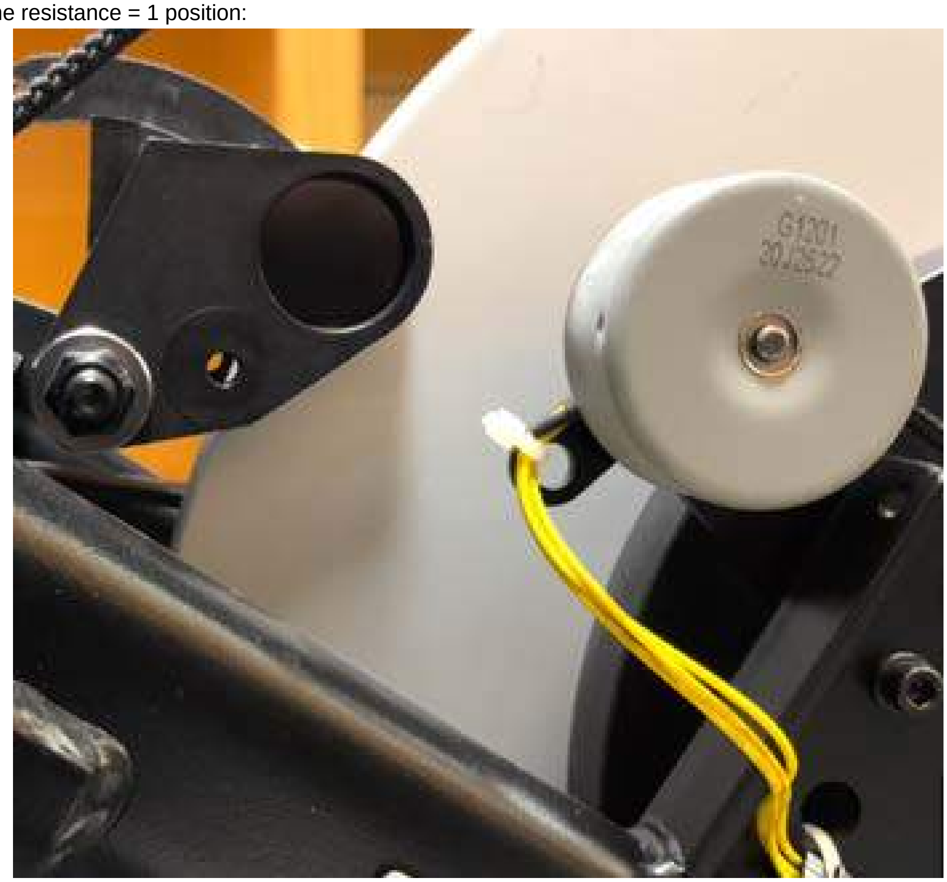
Date: 4/4/23

Content by: Sam

Present: Sam

Goals: Use pictures from initial resistance dial and magnet housing to find starting and end position for the new magnet housing

Content:

- In our meeting later today, the team and I will meet to drill holes in the rowing machine and place the magnet housing once again
    - The magnet housing was originally attached and connected to the device in it's original position
- Since we removed the magnet housing from the rower, we will need to figure out the locations of the starting and end positions of the magnet in the resistance = 1 position and in the resistance = 10 position
- I can use the resistance mech pictures that I took earlier on to find out the starting and ending positions of the resistance mechanism
- For the resistance = 1 position:
    - 

    - As shown in this picture, it appears that the magnet overlap with the flywheel is about half way
        - We can use this halfway measurement for the placement of the resting position of the magnet
        - This will be used to place the R1 limit switch, which zeros the resistance changing
- For the resistance = 10:

- 

- I may need to analyze this picture a little bit more, but it appears like the resistance = 10 position of the magnet is right when the magnet fully overlaps with the flywheel
  - Measurement to use: right when the magnet overlaps completely with the flywheel

Conclusions/action items:

I spent some time analyzing the starting and ending points of the magnet location for resistances 1 and 10. We will use the R1 location for the placement of the limit switch which resets the resistance adjustment mechanism.

Action items:

- Meet with team to work on further incorporation of the design
- Use the halfway overlap point for the placement of the limit switch for R1

04/04/2023 Consulting with Josh about Motor Holding Design

SAMUEL SKIRPAN - Apr 05, 2023, 12:09 PM CDT

Title: Consulting with Josh about Motor Holding Design

Date: 4/4/23

Content by: Sam

Present: Josh and Sam

Goals: Figure out a design for the motor holder for the resistance adjustment mechanism.

Content:

- Last night, after meeting with the team to work on the integration of the designs, we figured out that we would need to come up with a new design for the motor holder for the resistance adjustment part
- I proposed during the meeting that we utilize the one screw hole that already is on the rowing machine used to attach the magnet holder
    - This would make it such that we would not have to drill out an additional hole
    - Also, I believe it would be enough to just use one hole to immobilize the motor from turning with the shaft
- NOTE: Josh did all of the SolidWorks modeling of the motor holder; I just worked with him to come up with the design a little bit
- For the design we plan on using:
    - A similar motor box design to the current design, but without one of the sides
        - The open side will allow for the motor to slip into the holder
        - The excluded side will still be printed, but it will be placed in the holder after
            - Will likely use glue or tape to hold it in place
    - The flap that will secure with the screw will twist into place

Conclusions/action items:

Josh and I talked for a little bit yesterday after our integration meeting about the design of the motor holder for the magnet housing. We decided on an open face design that will twist into place to secure the motor. This design will use one of the screw holes from the magnetic housing holder.

Action items:

- Work with team to continue integration of the design
- Write the outreach recap paragraphs

04/10/2023 Outreach Recap Write-up

SAMUEL SKIRPAN - Apr 10, 2023, 1:40 PM CDT

Title: Outreach Recap Write-up

Date: 4/10/23

Content by: Sam

Present: Sam

Goals: Write the outreach activity recap.

Content:

Here is the outreach recap that I wrote for the team:

The Adaptive Rowing Machine team completed the Potato Electricity outreach activity on Friday, March 24 at Spring Harbor Middle School in Madison, WI. Spring Harbor Middle School has a minority enrollment of 44%. Specifically, 16% of students are Hispanic/Latino, 10% are African American, 10% are Asian or Asian/Pacific Islander, and 8% are two or more races. Our activity was conducted in a seventh grade classroom that consisted of approximately 15 students. The activity we completed consisted of a presentation on what Biomedical Engineering is, a basic overview of circuit terminology and components, and creating a circuit out of potatoes, pennies, nails, and wires to light up an LED. The classroom was split up into groups of two to three students so that they could collaborate with each other during the activity. After completing our discussion on what Biomedical Engineering was, each group was tasked with finding the voltage created by a single potato, and determining how many potatoes it would take to light up a 2.1 V LED. Additionally, students were tasked with finding out how to attach multiple potatoes together to light up the LED.

Since the students that completed the activity were slightly on the older and more mature side, we decided to make our activity involve more brainstorming and creative thinking from the students. Our presentation involved asking the students many questions about their experiences and prior knowledge of biomedical engineering. For our activity, rather than walking the students through each individual step and showing them exactly what to do, we allowed the students to creatively problem solve how they could wire multiple potatoes to create enough voltage to power an LED. We walked around and asked the students if they needed help along the way. However, rather than just completing the next step for them, we asked them questions to try and get them on the right track with their ideologies.

We did not have any irregular constraints that we had to abide by while completing our outreach activity. Overall, the audience reacted positively to our activity. There were some students that were more eager than others to participate, which was expected. However, there were not any students that were completely against completing the activity. One part of the outreach that students really enjoyed was whenever we asked them questions about their prior knowledge of what Biomedical Engineering is and to give us some examples of Biomedical Engineering that they know of. However, one part of the activity that was slightly difficult for students was when they had to decide how to connect multiple potatoes together to light up the LED. If they were not making any progress, some of the students would give up and not try as much unless given guidance. In order to improve the outreach activity, our team could have made a few changes. First, if we noticed that multiple groups were having the same problem, we could have given the whole class some help by making an announcement. Additionally, in order to promote more collaboration and problem solving between classmates, we could have had students that were doing well help out students that were running into some problems. Ultimately, our activity was completed successfully and was a fun opportunity for the students to engage with engineering principles.

Conclusions/action items:

See above for the outreach recap that we will send to Tracy.

04/11/2023 Thoughts/Action Items for Fabrication Meeting Tonight

SAMUEL SKIRPAN - Apr 11, 2023, 2:47 PM CDT

Title: Thoughts/Action Items for Fabrication Meeting Tonight

Date: 4/11/23

Content by: Sam

Present: Sam

Goals: Come up with list of things I should complete tonight to be efficient during meeting

Content:

- Things that need to be done tonight:
  - Mark the centers of all of the buttons on the plastic rower part and the 3D printed console holder
    - Use a center bit for this
  - Then use the drill to drill out the guiding hole
  - Then switch the drill to the 7/8ths bit and drill out the main holes
  - Make sure the buttons fit in the hole
    - Then secure the buttons in place using the nut on the backside
  - Create a fabrication entry for the stabilization frame
- Annabel and Roxi will be working with the electronics as I am completing this list
  - Annabel will be doing some trouble shooting to make the electronics work perfectly again

Conclusions/action items:

For our meeting tonight, I wanted to be efficient with my time, so I made a list of things I need to complete and in order. Annabel and Roxi will also be there to help out.

Action items: see above list.

04/20/2023 EMG Testing Purpose and Data

SAMUEL SKIRPAN - Apr 20, 2023, 3:0

Title: EMG Testing Purpose and Data

Date: 4/20/23

Content by: Sam

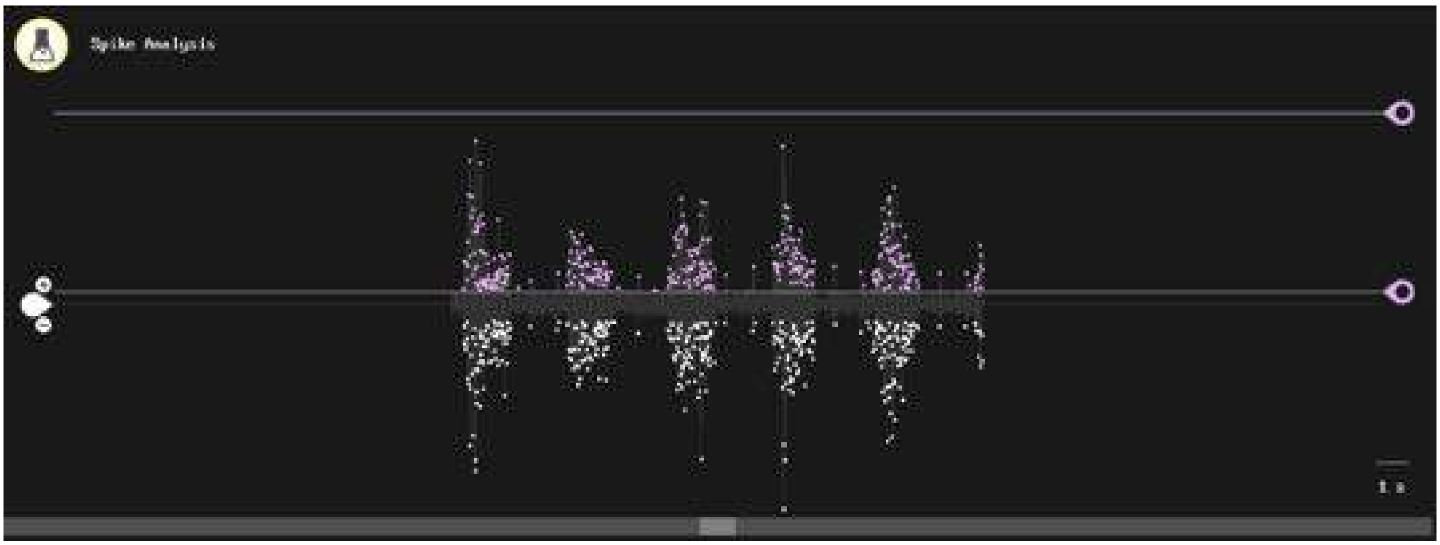
Present: Sam

Goals: Take screenshots of all of the average waveforms from the EMG data and organize it into one document. Also, measure the peak of each average waveform.

Content:

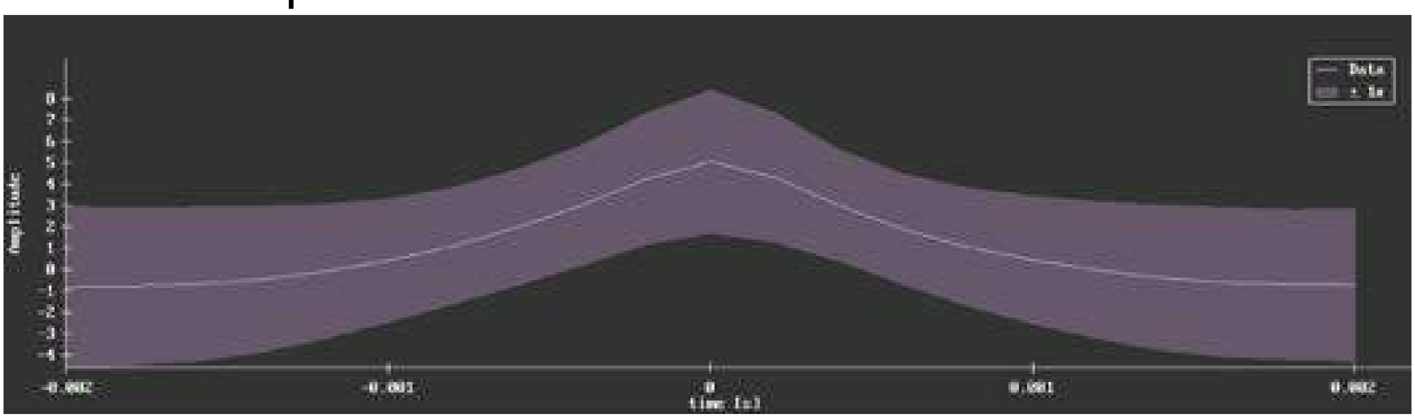
Purpose for EMG testing: For the EMG testing, 5 trials were captured for each condition. The different conditions were standard bicep, adaptive bicep, standard rear delt, adaptive rear delt, standard lat, and adaptive lat. Each of these conditions were tested on resistance levels of 1, 3, 5, 7, and 9 to determine if there would be a trend in the the respective muscle group activations for increases in resistance. After the data was collected, it was analyzed in SpikeRecorder using the analysis software.

Below is an example of one of the EMG graphs captured from the data collection. The filter was used to collect the desired signals for each muscle activation signal.

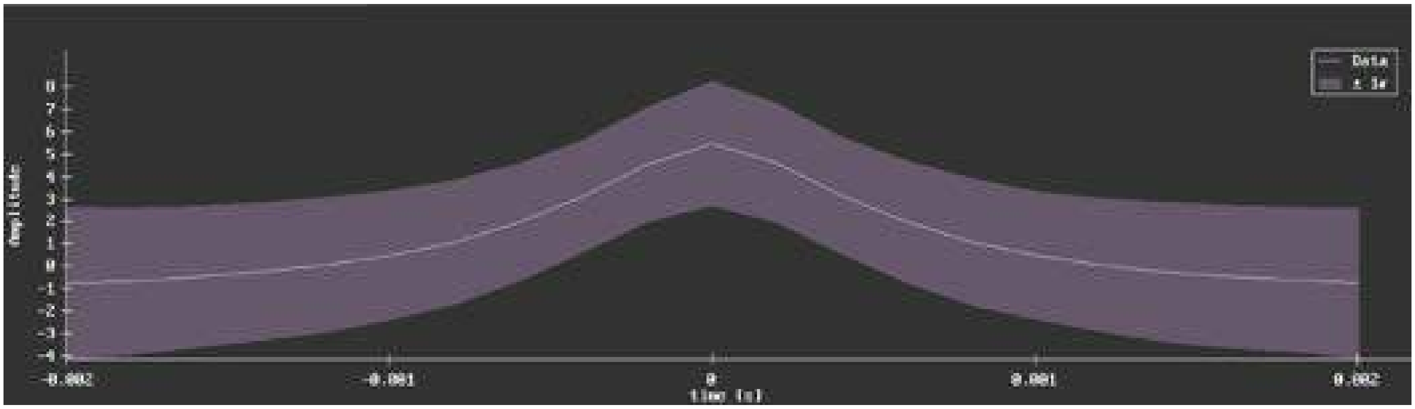


Below are the average waveforms computed for each trial.

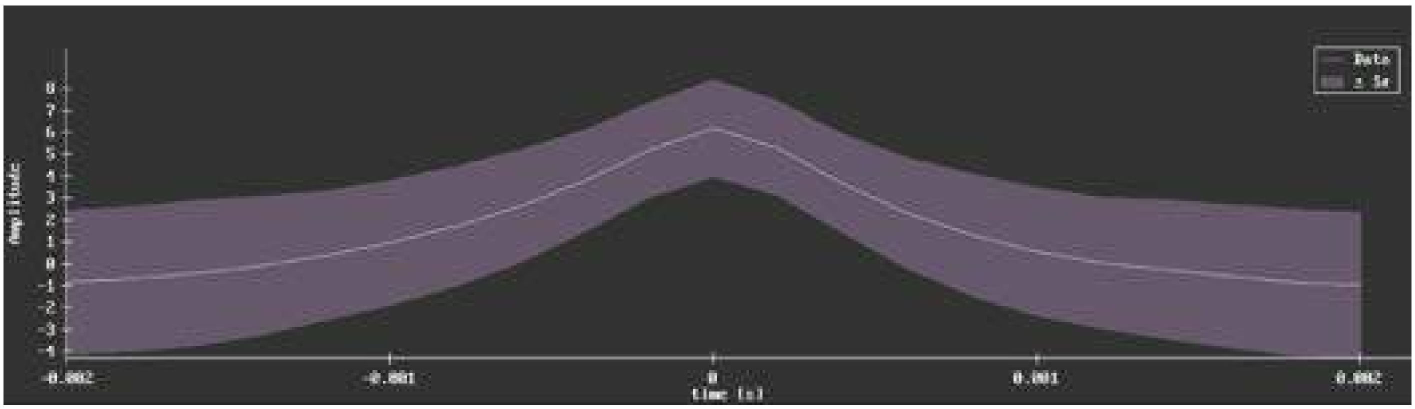
Standard Bicep

- 

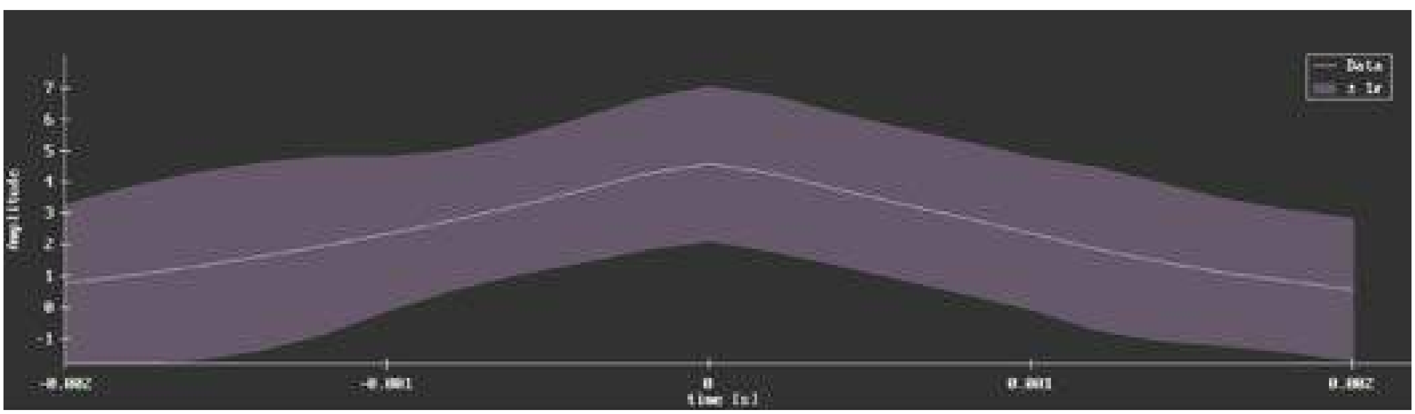
    - SSB1
        - Max around 5

- 

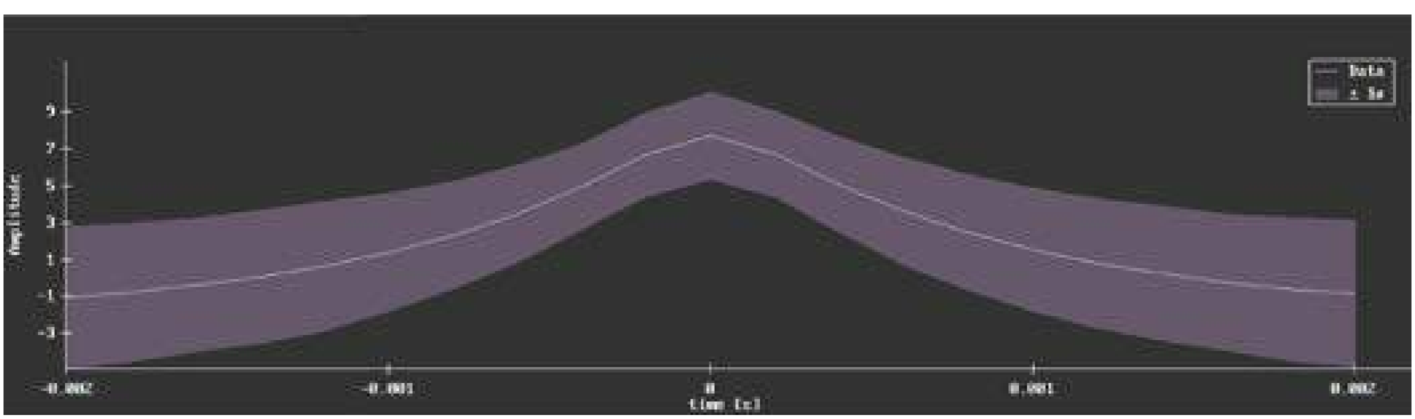
  - SSB3
    - Max around 5.5

- 

  - SSB5
    - Max around 6

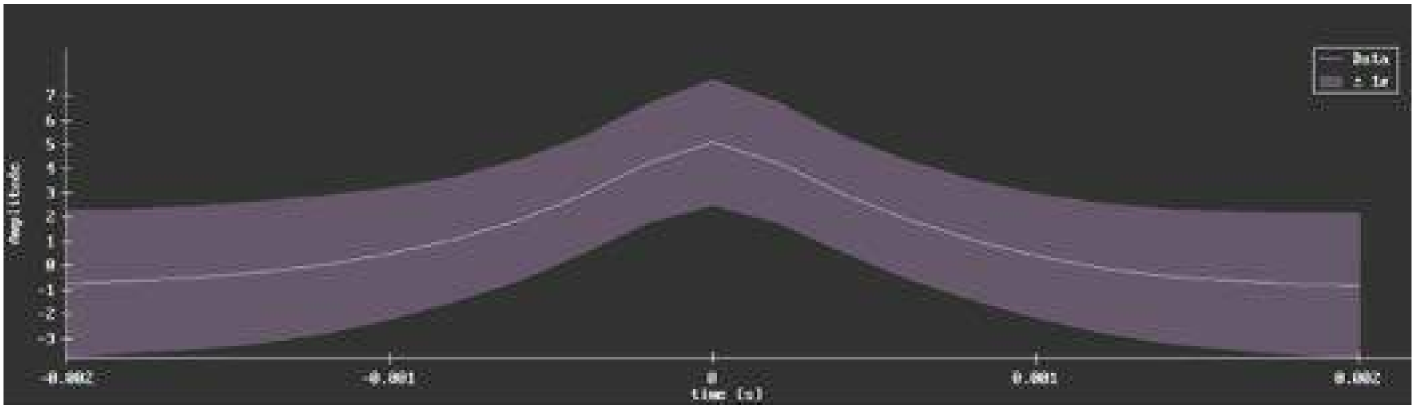
- 

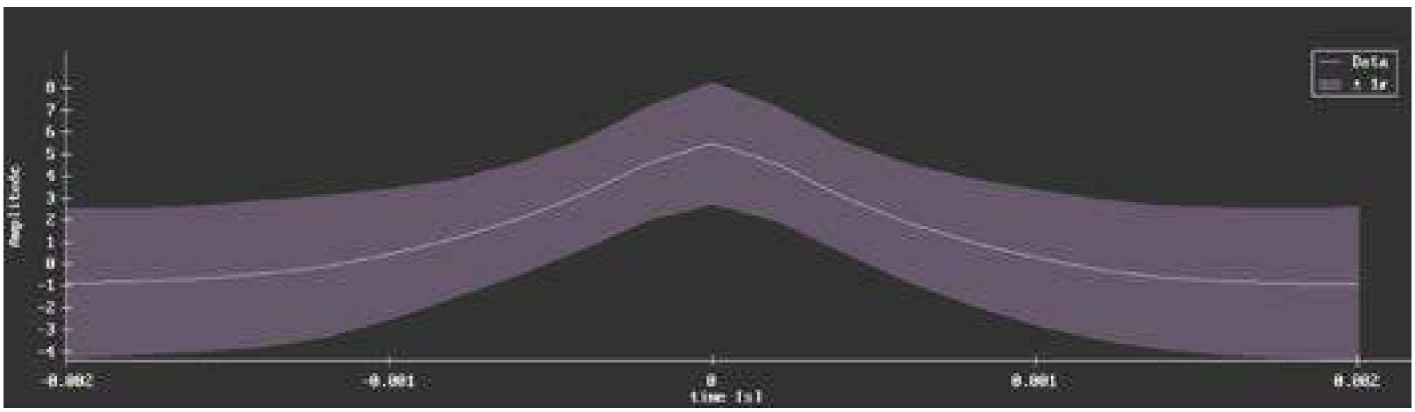
  - SSB7
    - Max around 7.5

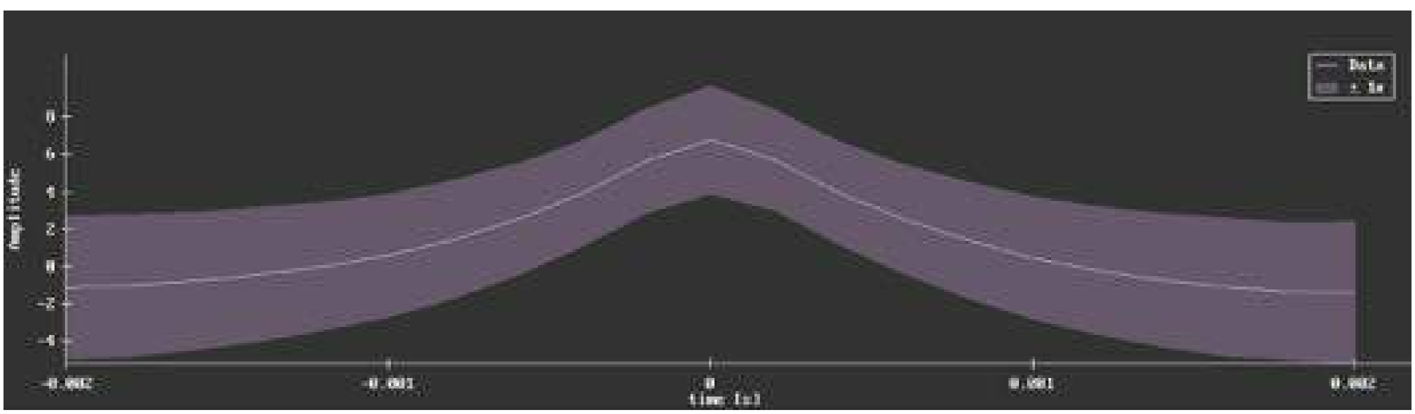
- 

- SSB9
  - Max around 8

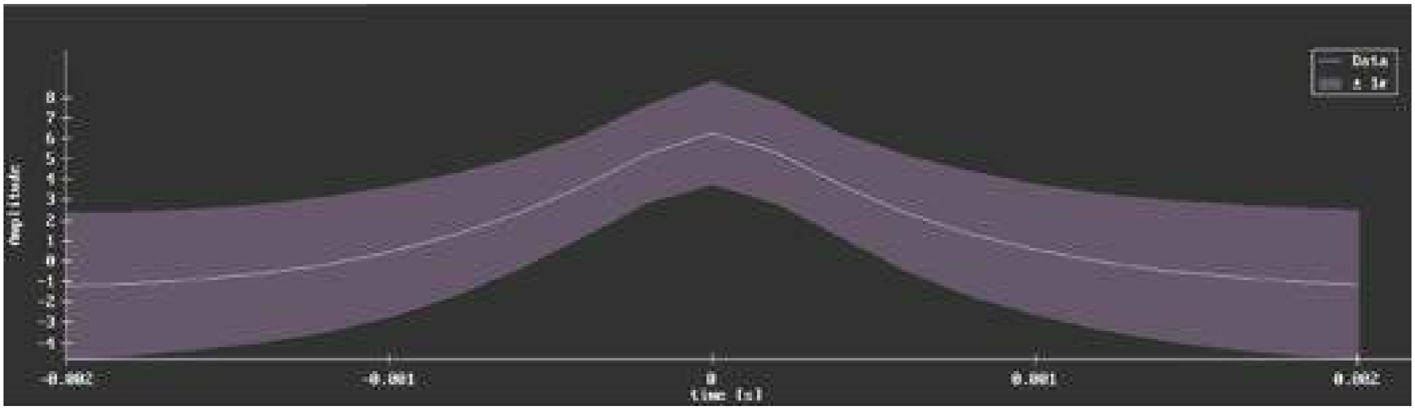
Adaptive Bicep

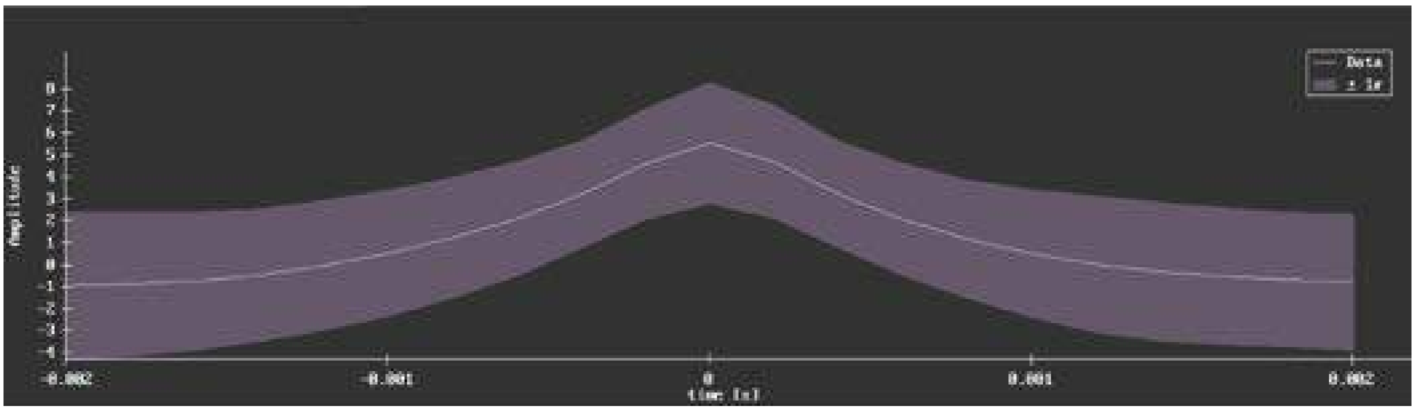
- 

  - ASB1
    - Max around 5
- 

  - ASB3
    - Max around 5.5
- 

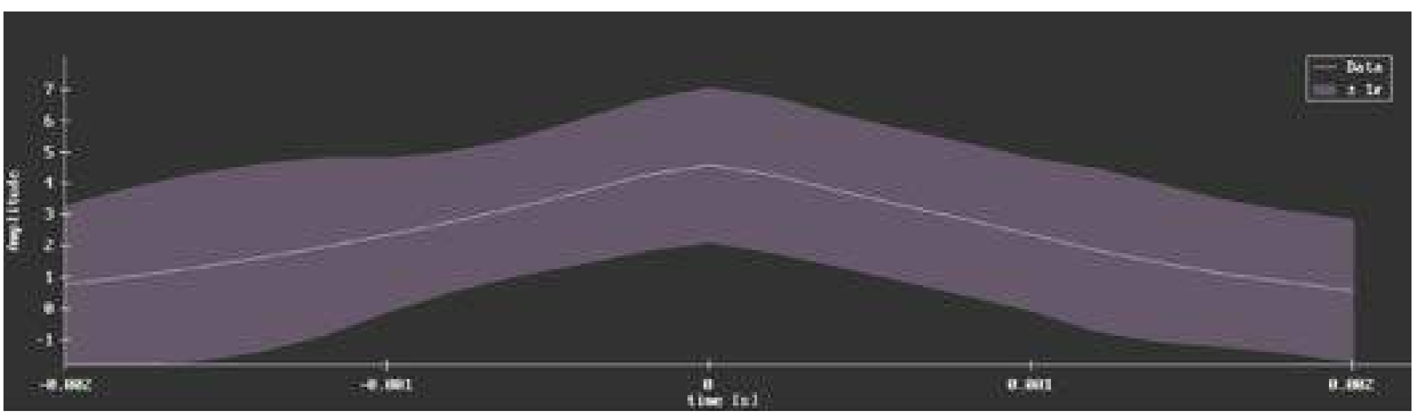
  - ASB5
    - Max around 7

- 

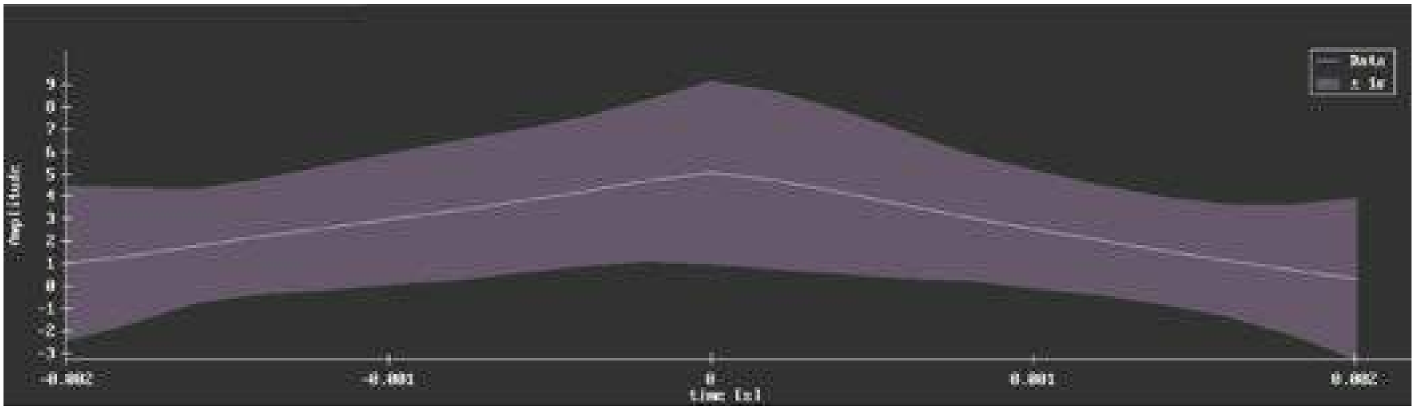
    - ASB7
        - Max around 6.5
- 

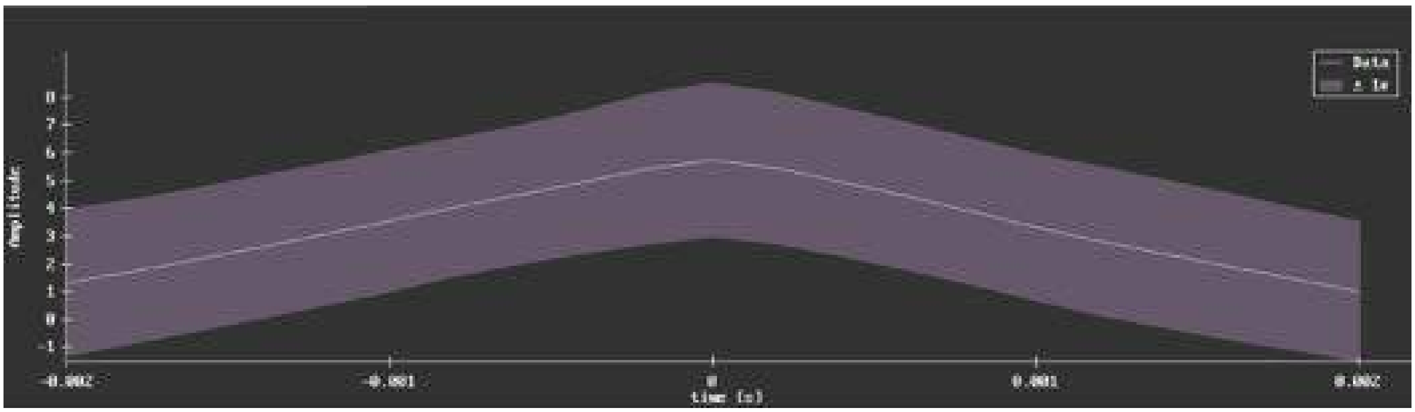
    - ASB9
        - Max around 6

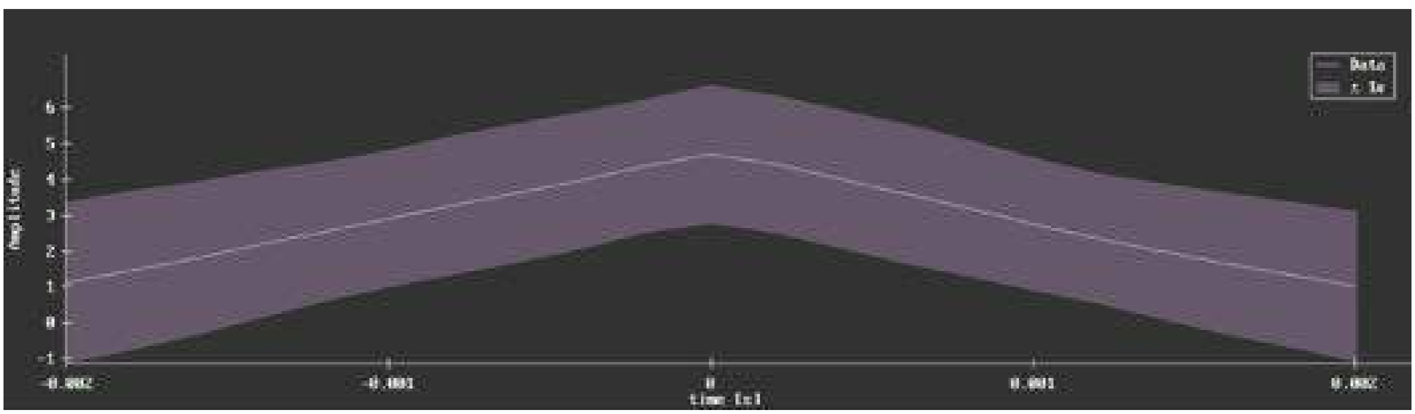
Standard Rear Deltoid

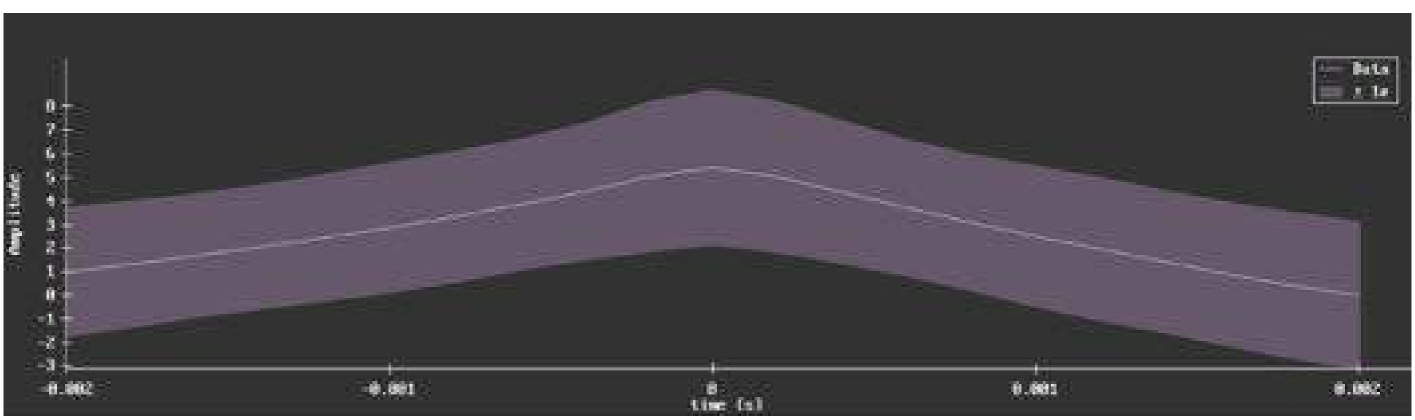
- 

    - SSD1
        - Max around 4.5

- 

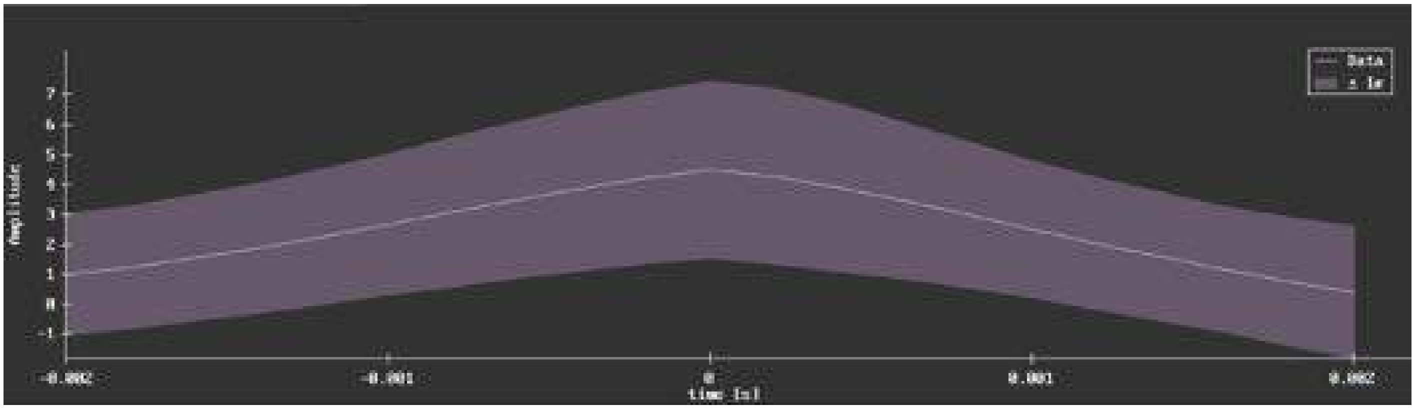
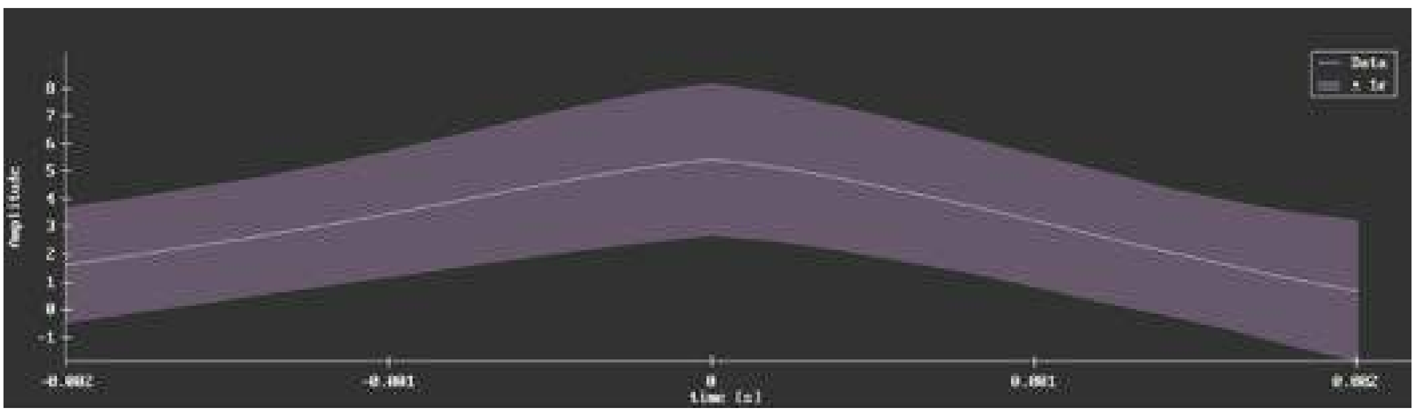
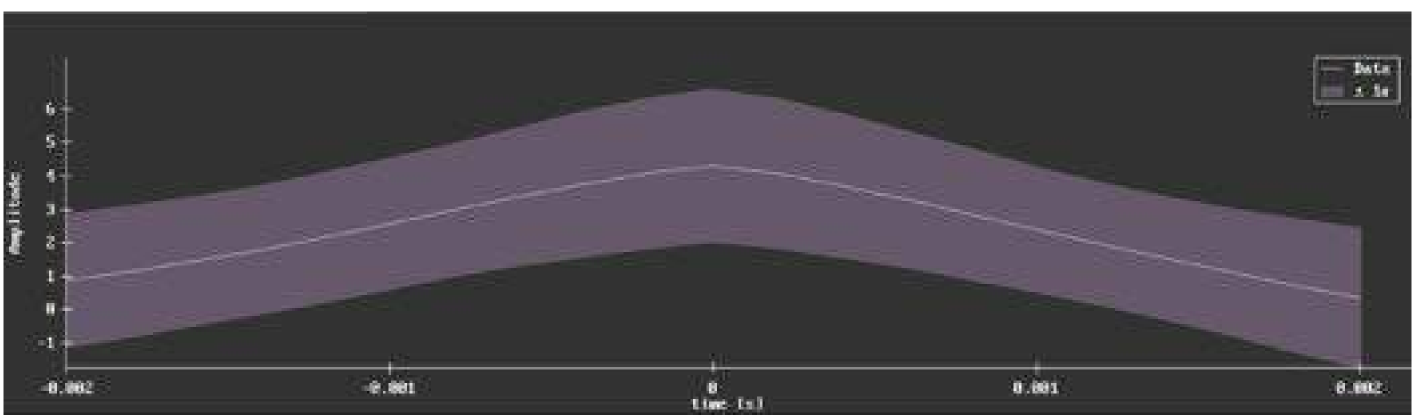
  - SSD3
    - Max around 5
- 

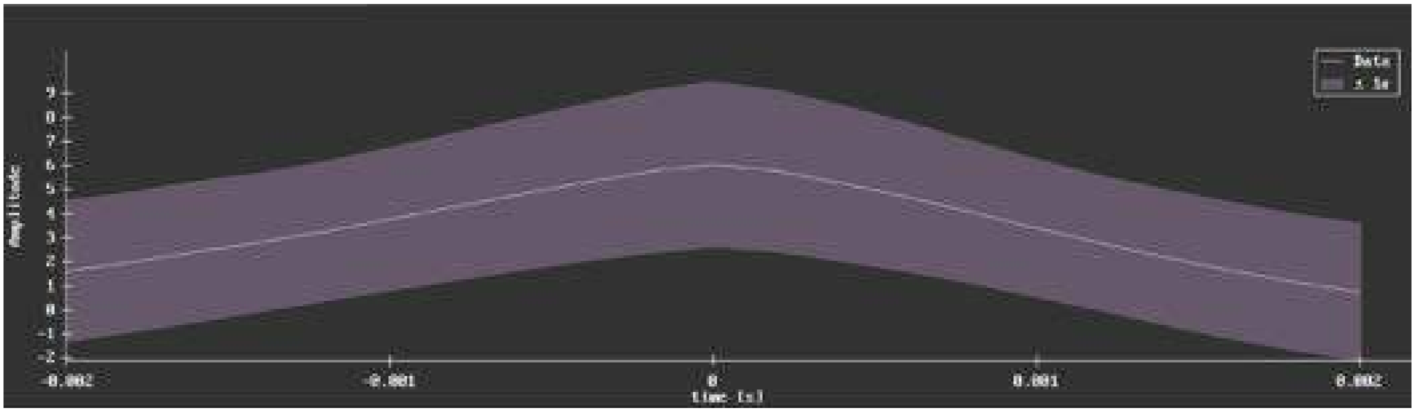
  - SSD5
    - Max around 6
- 

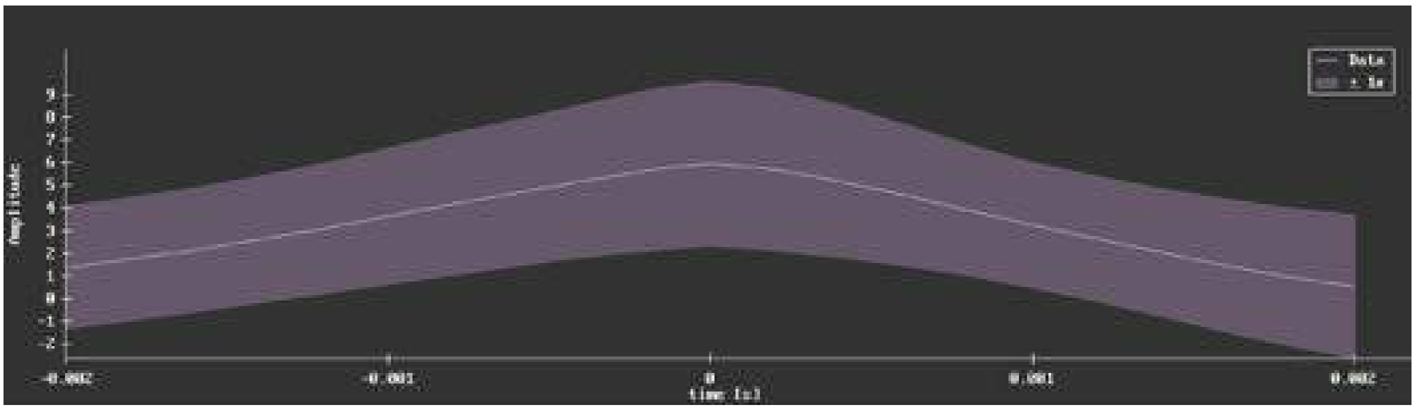
  - SSD7
    - Max around 5
- 

- SSD9
  - Max around 6

Adaptive Rear Deltoid

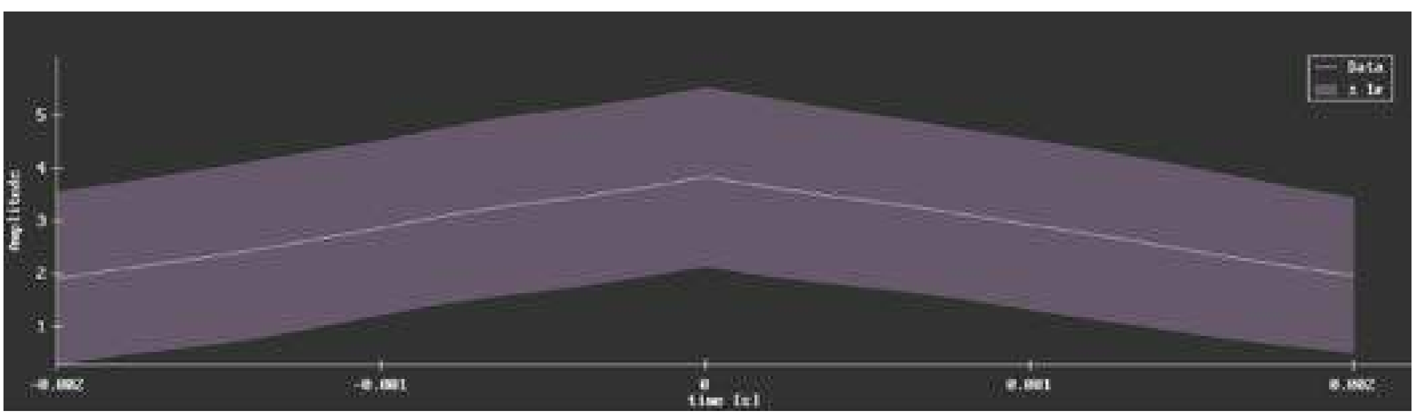
- 
  - ASD1
    - Max around 4.5
- 
  - ASD3
    - Max around 5.5
- 
  - ASD5
    - Max around 4.5

- 

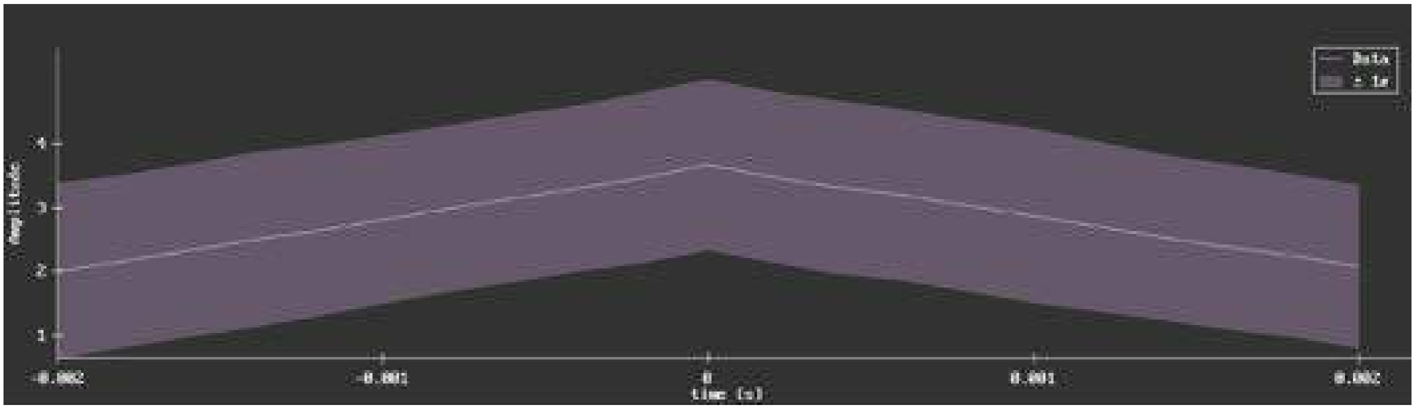
    - ASD7
        - Max around 6
- 

    - ASD9
        - Max around 6

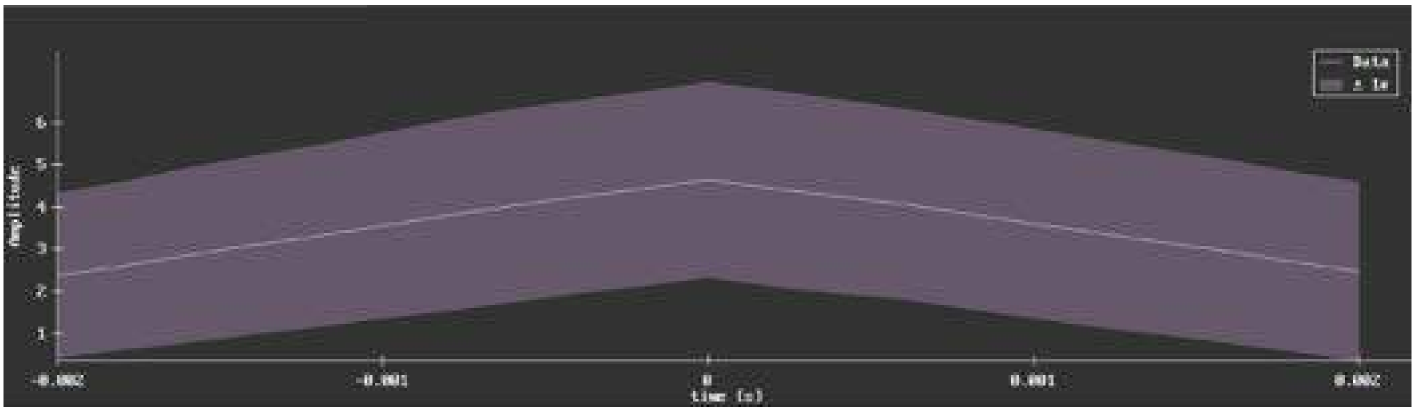
Standard Latissimus Dorsi

- 

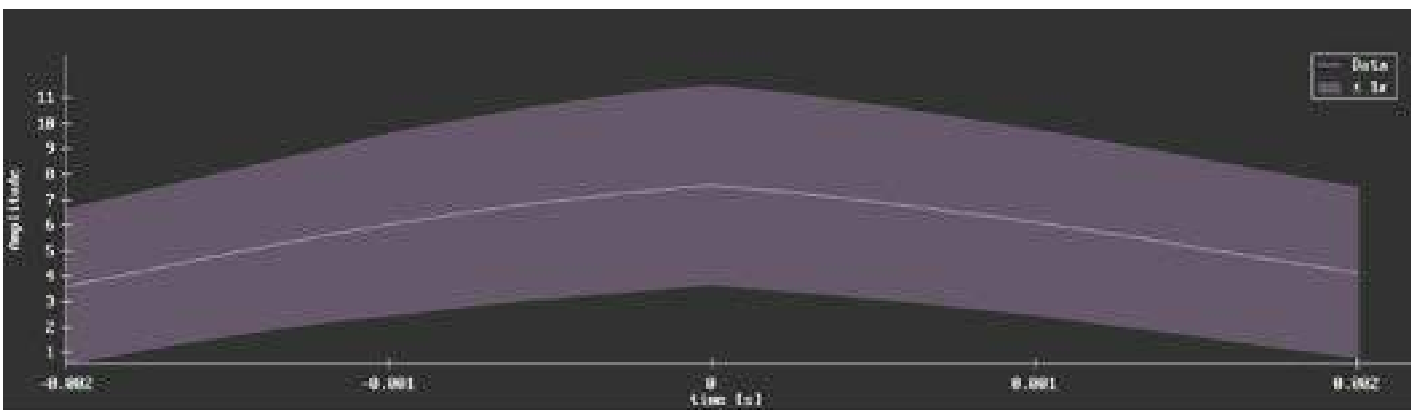
    - SSL1
        - Max around 4

- 

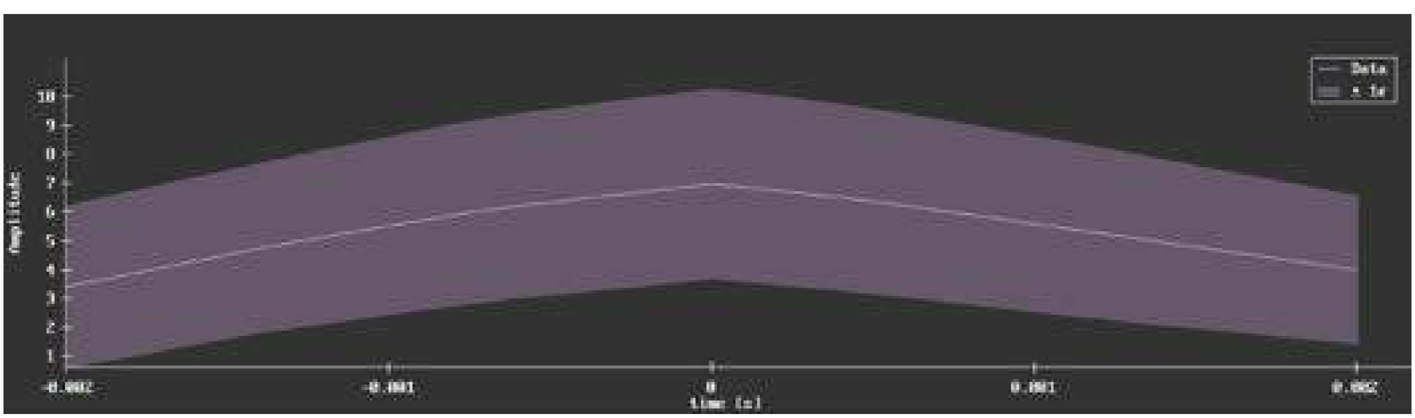
    - SSL3
        - Max around 3.5

- 

    - SSL5
        - Max around 4.5

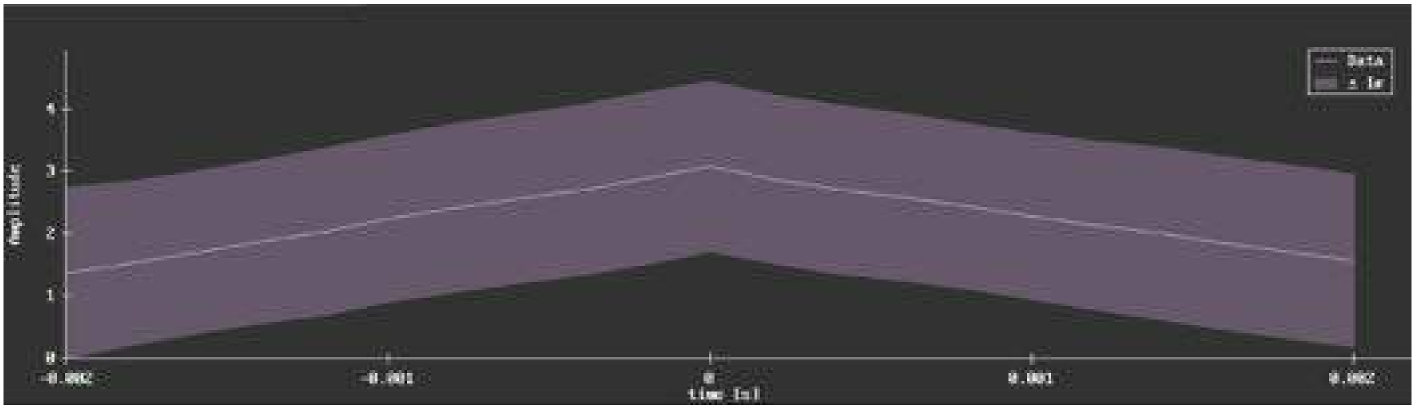
- 

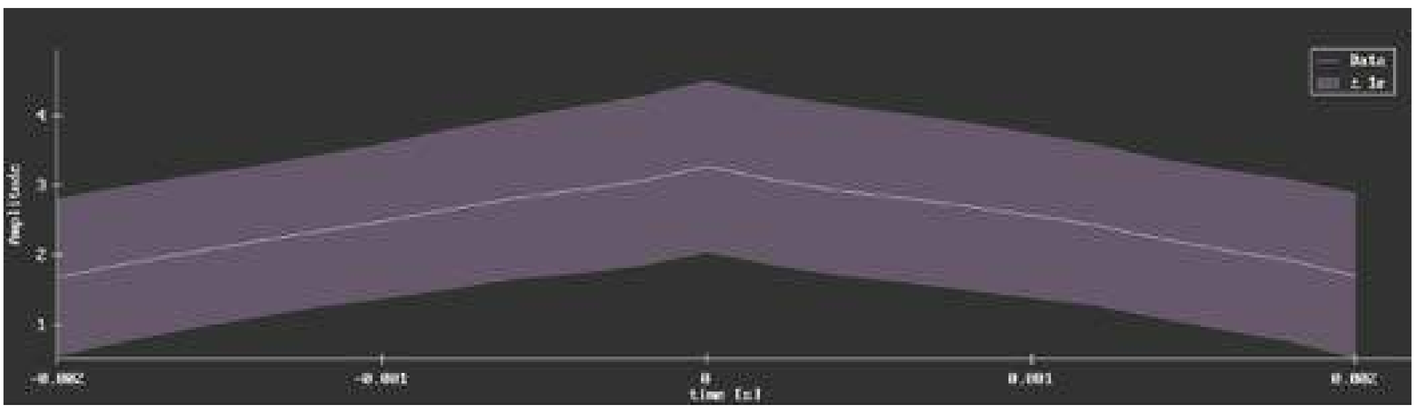
    - SSL7
        - Max around 7.5

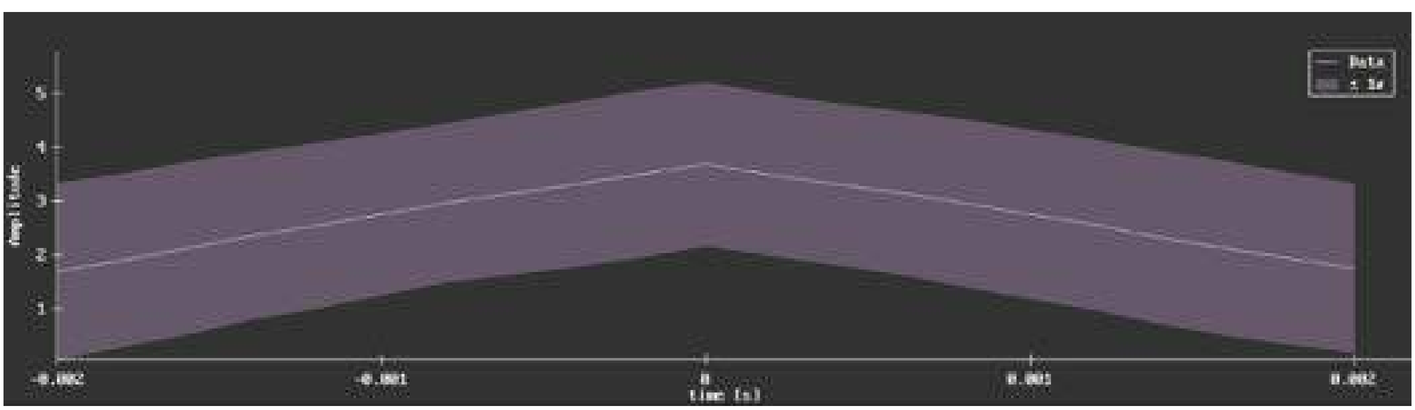
- 

  - SSL9
    - Max around 7.5

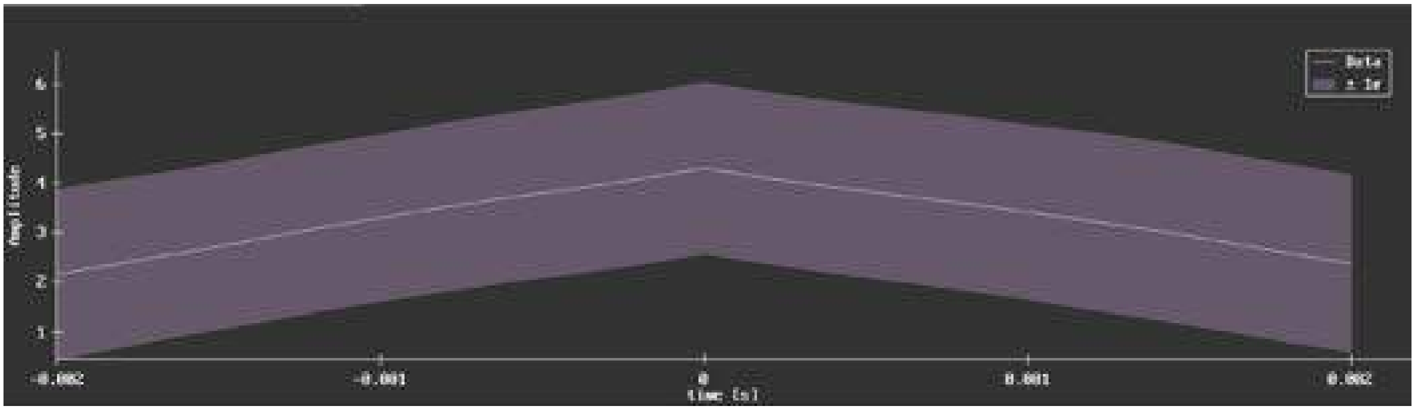
Adaptive Latissimus Dorsi

- 

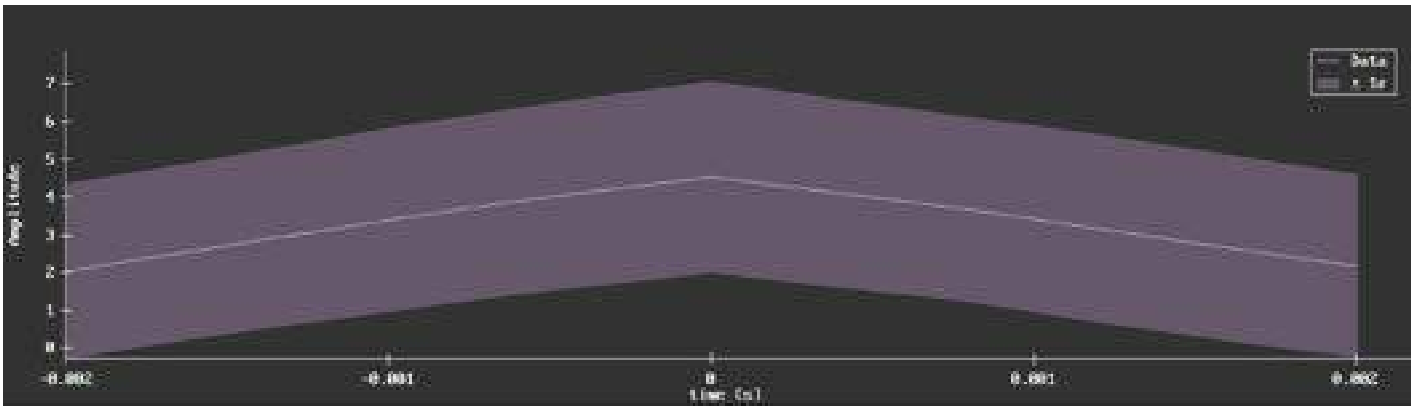
  - ASL1
    - Max around 3
- 

  - ASL3
    - Max around 3
- 

  - ASL5
    - Max around 4

- 

  - ASL7
    - Max around 4.5

- 

  - ASL9
    - Max around 5

Conclusions/action items:

All of the average waveform graphs were captured and each maximum amplitude was noted for each trial. This data will be used for the analysis section of our EMG testing. Ultimately, we wa there are differences in activation between the standard and adaptive sides in addition to increases in activation for increases in resistance.

Action items:

- Analyze the EMG data and note trends

04/20/2023 EMG Testing Analysis and Results

SAMUEL SKIRPAN - Apr 20, 2023, 3:12 PM CDT

Title: EMG Testing Analysis and Results

Date: 4/20/23

Content by: Sam

Present: Sam

Goals: Analyze the collected EMG data.

Content:

Analysis of EMG testing data will focus on the general trends for each particular muscle with increases in resistance and from standard to adaptive side. Overall general trends in max amplitude of average waveform will be analyzed.

Standard Side

- Bicep
    - From R1 to R9: 5, 5.5, 6, 7.5, 8
- Rear Delt
    - From R1 to R9: 4.5, 5, 6, 5, 6
- Lat
    - From R1 to R9: 4, 3.5, 4.5, 7.5, 7.5

Adaptive Side

- Bicep
    - From R1 to R9: 5, 5.5, 7, 6.5, 6
- Rear Delt
    - From R1 to R9: 4.5, 5.5, 4.5, 6, 6
- Lat
    - From R1 to R9: 3, 3, 4, 4.5, 5

Analysis and trends:

- Standard side
    - Increasing resistance on standard side led to increase in activation for following muscles:
        - Bicep and lat
    - Not much of a correlation for increase in resistance on standard side to activation of rear delt
- Adaptive side
    - Not much of a correlation between increase in resistance and muscle activation for bicep
    - Small, weak correlation for increase in resistance and increase in muscle activation for rear delt and lat

- Comparison
  - Activation levels on standard side were higher for the lat than for the adaptive side
  - No strong difference between activation for bicep and rear delt between both sides

Conclusions:

- Difficult to draw overall conclusion between levels of activation when increasing resistance for different muscle groups. There was a fairly consistent increase in exertion for the following when increasing the resistance: standard side bicep, standard side latissimus dorsi, and adaptive side latissimus dorsi. Also, there was not much of a difference between the level of activation for respective muscle groups between the standard and adaptive sides. However, one notable difference between the standard and adaptive sides was the level of activation of the latissimus dorsi. The latissimus dorsi group had higher levels of activation on the standard side than on the adaptive side for each respective resistance level.

Limitations in testing:

- Only tested one individual, so having limited number of participants could lead to inaccuracy with results
- Data capture only lasted approximately 10-15 seconds per trial
- Inconsistency with rowing rate and exertion of the course of a given trial
  - Tried to use the metronome to keep this as constant as possible, but there still could have been some errors
- Improper setting of the frequency filters when using the EMG machine to capture results could have led to missing data points throughout the testing period

Ways to improve:

- Include more users in the EMG testing
- Have data capture last for a longer period of time to get consistency between rowing strokes
  - Would also help with the inconsistency of the rowing rate
- Use the same frequency cutoffs for each muscle group when completing the testing

Conclusions/action items:

I analyzed the results from the EMG data and noticed that there were not many distinct conclusions we can draw from our testing. One interesting conclusion we noticed was that we had higher levels of activation on the standard side than adaptive side for the latissimus dorsi trials.

Action items:

- Share these results with the team

04/22/2023 Magnet Housing Angle Analysis

SAMUEL SKIRPAN - Apr 22, 2023, 12:15 PM CDT

Title: Magnet Housing Angle Analysis

Date: 4/22/23

Content by: Sam

Present: Sam

Goals: Analyze the angle of resistance mechanism for Annabel.

Content:

- 

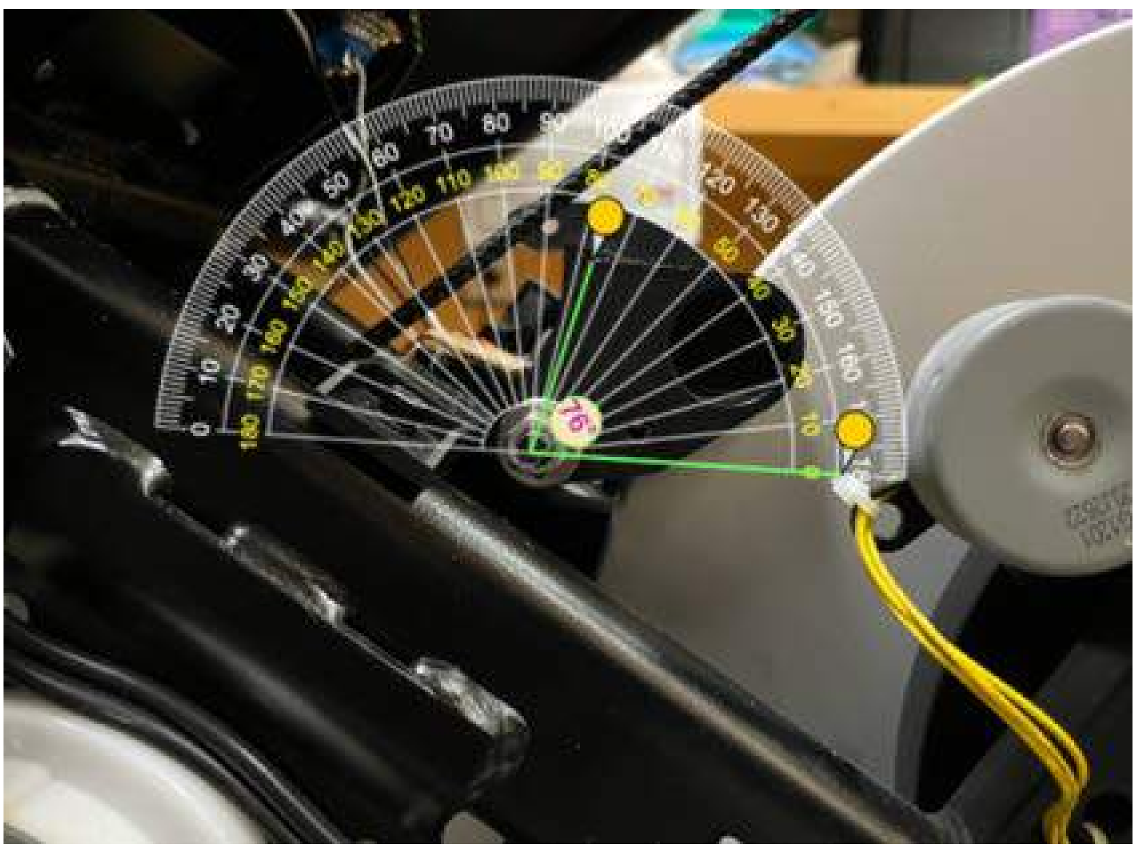
    - R1

- 

    - R2
- 

    - R3

- 

  - R4
- 

  - R5

- 

    - R6
- 

    - R7

- 

    - R8
- 

    - R9

- 
  - R10
- Analysis:
  - Changes between different resistance levels
    - 1 to 2: 1 degree
    - 2 to 3: 4 degrees
    - 3 to 4: 1 degree
    - 4 to 5: 2 degrees
    - 5 to 6: 1 degree
    - 6 to 7: 2 degrees
    - 7 to 8: 1 degree
    - 8 to 9: 2 degrees
    - 9 to 10: 2 degrees
  - Average change: 16 degree change / 9 changes = 1.78 degrees per change
  - Standard deviation: .97 degrees

- 

  - R1
- 

  - R2

- 

    - R3

- 

    - R4

- 

    - R5

- 

    - R6

- 

  - R7
- 

  - R8

- 

    - R9
- 

    - R10
- Analysis:
    - Changes between different resistance levels

    - 1 to 2: 1 degree
    - 2 to 3: 4 degrees
    - 3 to 4: 1 degree
    - 4 to 5: 2 degrees
    - 5 to 6: 1 degree
    - 6 to 7: 2 degrees
    - 7 to 8: 1 degree
    - 8 to 9: 2 degrees
    - 9 to 10: 2 degrees
- Average change: 16 degree change / 9 changes = 1.78 degrees per change
- Standard deviation: .97 degrees

Conclusions/action items:

I will share these angle results with Annabel. There was approximately 1.78 degrees of change per change in resistance. Annabel will use these results to compare to the desired 3 degree change.

04/23/2023 Work on Final Poster for Future Work

SAMUEL SKIRPAN - Apr 23, 2023, 12:40 PM CDT

Title: Work on Final Poster for Future Work

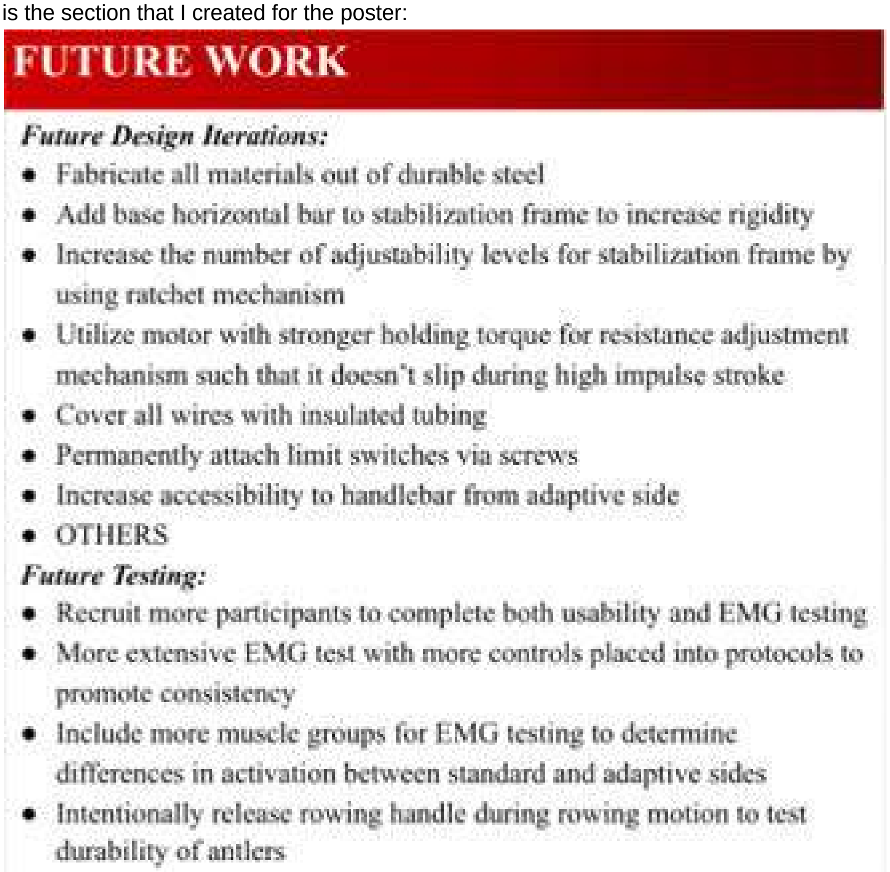
Date: 4/23/23

Content by: Sam

Present: Sam

Goals: Complete future work section of poster and enter work into notebook.

Content:

- I was assigned the section of future work for the poster
- Below is the section that I created for the poster:
    - 

FUTURE WORK

Future Design Iterations:

- Fabricate all materials out of durable steel
- Add base horizontal bar to stabilization frame to increase rigidity
- Increase the number of adjustability levels for stabilization frame by using ratchet mechanism
- Utilize motor with stronger holding torque for resistance adjustment mechanism such that it doesn't slip during high impulse stroke
- Cover all wires with insulated tubing
- Permanently attach limit switches via screws
- Increase accessibility to handlebar from adaptive side
- OTHERS

Future Testing:

- Recruit more participants to complete both usability and EMG testing
- More extensive EMG test with more controls placed into protocols to promote consistency
- Include more muscle groups for EMG testing to determine differences in activation between standard and adaptive sides
- Intentionally release rowing handle during rowing motion to test durability of antlers

Conclusions/action items:

Here is the future work section that I created for the final poster.

Action items:

- Create script for the future work section of poster
- Meet with team to edit poster

4/27/2023 Script for Final Poster and Design Excellence

SAMUEL SKIRPAN - May 01, 2023, 10:35 PM CDT

Title: Script for Final Poster and Design Excellence

Date: 4/27/23

Content by: Sam

Present: Sam

Goals: Come up with what I want to say for both presentations

Content: The following is the work/brainstorming that I did for the presentations we had for our poster and design excellence.

Future Design Iterations:

- Fabricate console motor holder and resistance motor box out of steel
- Connect stabilization frame to pulley plates to increase rigidity
- Increase the number of adjustability levels for stabilization frame by using ratchet mechanism
- Utilize motor with stronger holding torque for resistance adjustment mechanism such that it does not slip during high impulse strokes
- Investigate methods for improving resistance increment consistency
- Cover all wires with insulated tubing
- Permanently attach limit switches via screws
- Increase accessibility to handlebar from adaptive side

Thanks Roxi, for future work, we can first start with future design iterations. In addition to the the other components, we would fabricate the econsole motor holder and resistance motor box out of steel. Additionally, we would add a connection between the stabilization frame and pulley plates to increase the rigidity of the frame. Since one common comment we received during testing was to increase adjustability levels, we would include a ratchet mechanism to our stabilization frame. We would also include a motor with a stronger holing torque in the future for the resistance adjustment mechanism so that it doesn slip when a user takes a high impulse pull. Our team would plan on investigating further methods for improving the increment consistency of the resistance mechanism. Additionally, all wires around the frame would be covered in an insulated tubing and all limit switches would be screwed in to the frame. Lastly, we would try to investigate further ways to increase the accessibility to the handlebar from the adaptive side.

Future Testing:

- Recruit more participants to complete usability and EMG testing
- More extensive EMG testing with more controls to promote consistency
- Include more muscle groups for EMG testing to determine differences in activation between standard and adaptive sides
- Conduct comprehensive design verification tests

In terms of future testing we would like to complete, overall we would like to have more participants come in and use our design for usability testing and EMG testing. For future EMG testing, we would likely increase the number of controls involved in the protocol such that we increase the consistency of each trial completed. Additionally, we would test more muscle groups for the EMG testing. For the verification of the entire design, we would also conduct additional comprehensive design verification tests.

I would like to take this time to thank all of those that helped us out with the project, with a special shoutout to our advisor Dr. Tracy Jane Puccinelli, our client, Ms. Staci Quam, and Johnson Health Tech.

Testing and Results:

To verify the specifications of our device against our PDS, we completed 3 main tests: a SolidWorks simulation to test the strength of the antlers/pulley plates, a series of usability tests, and an EMG test. For the SolidWorks simulation, we applied a max 400 N load with a safety factor of 2 to the top of the antlers and measured their displacement and stress. There was a max displacement of 19.14 mm and a max stress of 891.8 MPa. ______. For usability tests, we recruited both users that do and do not require the use of a wheelchair to use the rowing machine. We collected data on their perceived safety, comfort, workout, and interaction with the machine during the test and the overall results show that the rower performed well. Lastly, we completed EMG testing to determine the ability of the machine to give a comparable upper body workout between both sides. THe results of the EMG testing show that there weren't any large differences in muscle activation between respective muscle groups on both sides, but there was a slight increase in activation _____. Overall, our team is very pleased with how our device performed, and if we had extra time, we would take some of the feedback we received from testing and usee it to improve our design. Thank you very much for listening, and now we canopen it up for any questions.

To verify the specifications we set out in our PDS, our team conducted 3 separate test: a solidworks simulation, usability testing, and and EMG test.

For the solidworks simulation, we tested the strength and ruability of the pulley plates/antlers by placing a 400 N load at the top of the anterl. The results show that there was minimal deformation of the top of the antlers and that the max stress experienced was slightly over the yield stress. However, in reality, the extreme loads placed upon the antlers are unlkiely to occur during an actual workout, which leads us ot be confident in the performance of our design.

For usability tests, we recruited both users that do and do not require the use of a wheelchair to use the rowing machine. We collected data on their perceived safety, comfort, workout, and interaction with the machine during the test and the overall results show that the rower performed well.

For the final test, we completed an EMG analysis to determine the differences in muscle activation between the standard and adaptive sides. The EMG results show that the standard and adaptive sides gave comparable levels of muscle activation between both sides and therefore similar upper body workout.

Overall, our team is very pleased with how our device performed, and if we had extra time, we would take some of the feedback we received from testing and usee it to improve our design. Thank you very much for listening, and now we canopen it up for any questions.

Conclusions/action items:

See above for the information I wanted to say for both presentations. I ran these scripts by the team before actually presenting them.

05/01/2023 Work on Final Journal Article

SAMUEL SKIRPAN - May 01, 2023, 10:43 PM CDT

Title: Work on Final Journal Article

Date: 5/1/23

Content by: Sam

Present: Sam

Goals: Enter all work completed on Final Journal Article into notebook

Content:

- For the journal article, I was responsible for the EMG testing section
    - I added in the purpose for the testing, all of the results, the representative images that we used, and the possible errors and how to improve them
- I also added another appendix for all of the average waveforms for all of the EMG pics that we captures
- I also went through the final journal article and all of the appendices and left notes for us to address as a team

Conclusions/action items:

For the journal article, I was responsible for the EMG section. I wrote about the results and possible errors, and how to improve in the future.

Action items:

- fill our peer evaluations

01/27/23 Standard Side Testing Protocol

SAMUEL SKIRPAN - Jan 27, 2023, 6:57 AM CST

Title: Standard Side Testing Protocol

Date: 27JAN2023

Content by: Sam

Present: Sam

Goals: Create testing protocol for the standards side of the rowing machine for IRB application including EMG use.

Content:

Below is the protocol that I made for the use of the rowing machine for testing trials on the standards side:

Protocol for Standard Side:

1. Enter the testing room and approach the standard side of the rower slowly.
2. Have the user grab the handlebar with both hands and remove it from the handlebar supports, placing it in the original Matrix rower handlebar resting position.
3. Have the user sit on the sliding seat on the standard side of the rowing machine and strap their feet into place using the foot straps.
4. Plug the power cord of the ____ machine into a power source/outlet. Plug ___ (number of electrodes) electrodes into the ___ machine (name of machine). Make sure they are connected to the correct polarization nodes.
5. Have the user clean their _____ (part of body where electrode is) with an alcohol sterilization wipe.
6. Remove the plastic from the EMG electrode. Place a pea-sized amount of electrode gel on top of the electrode. Spread the gel over the entire electrode surface evenly.
7. Place the electrode on the skin over the top of the user's _____ (muscle group name) group.
8. Adjust the settings on the console to display the desired information (stroke rate, distance traveled, speed, etc.).
9. Set resistance dial to 1.
10. Turn on the ____ (machine name). MORE INFO ABOUT SPECIFICS OF EMG MACHINE AND INTERFACE
11. Have the user lean forward to grab the handlebar with two hands from its position in the original Matrix rower handlebar resting position.
12. Have the user pull the handlebar towards the middle of their chest while extending their legs as far as possible while still maintaining a microbend. The user should try to keep their torso vertical while pulling the handlebar backward. Have them pause briefly. Then, the user should extend their arms forward again while bending their legs to reorient back to the original position. Repeat this motion for one minute.
    1. The user should try to maintain a constant and steady stroke rate between 25-30 rpm, or at a level deemed comfortable for the individual.
13. Once the minute trial is complete, slowly and gently place the handlebar back in the supports.
14. Rest for two minutes.
15. Repeat steps 11-14 at resistance levels 5 and 10.
16. After placing the handlebar back in the original Matrix rower handlebar resting position, have the user undo the straps that secure their feet in place. The user should stand up from the sliding seat on the rowing machine.
17. Have the user complete the survey.
18. Have the user leave the testing room.

Notes for protocol:

- Need actual name of the EMG we are using and the process for turning the machine on, analyzing results, etc.
- Josh and I made sure our protocols for the standard and adapted side are parallel to one another in terms of actions

Conclusions/action items:

I was responsible for creating the protocol for the user on the standard side of the rowing machine. We will use this protocol for the IRB application and eventually follow it whenever we are ready to test the rowing machine. After following the testing protocol, we will take a survey to give our thoughts on the machine and experience.

Action items: Edit the IRB deliverables with the team. Go to JHT to take apart the rowing dial.

02/09/2023 Updated Stabilization Frame Creation

SAMUEL SKIRPAN - Feb 09, 2023, 3:55 PM

Title: Updated Stabilization Frame Creation

Date: 2/9/2023

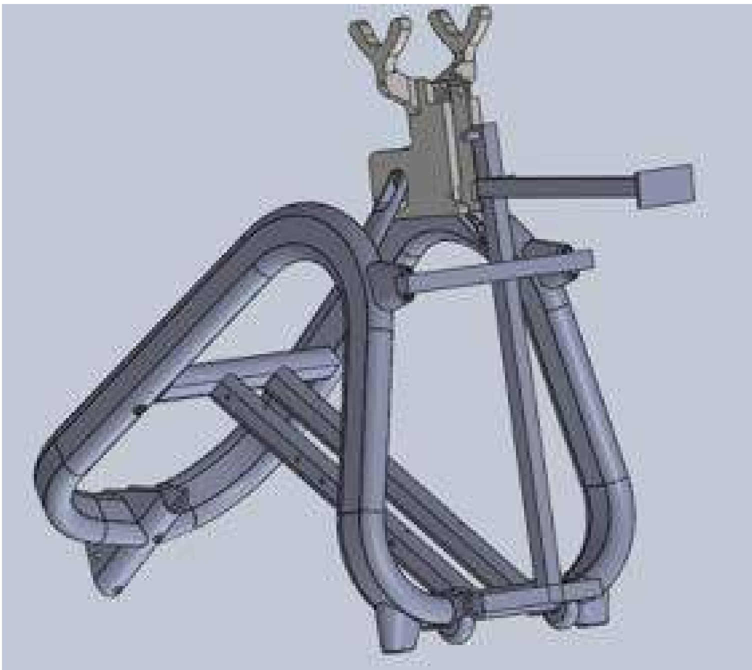
Content by: Sam

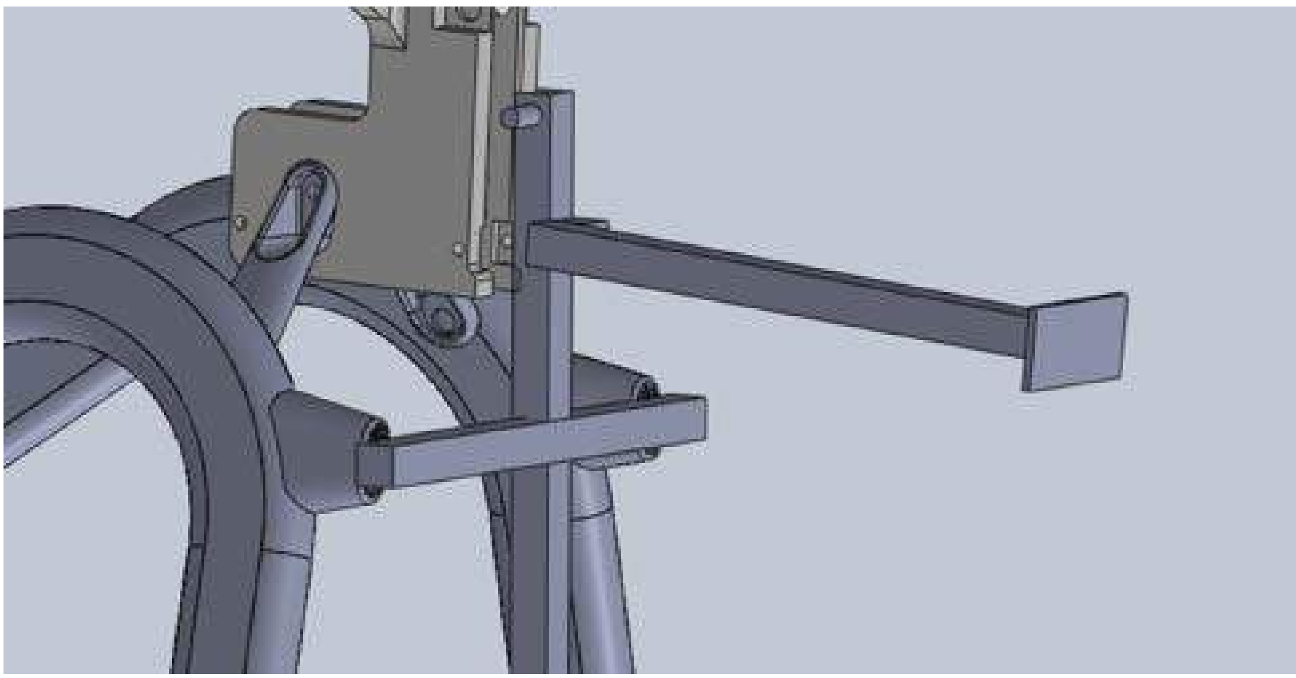
Present: Sam

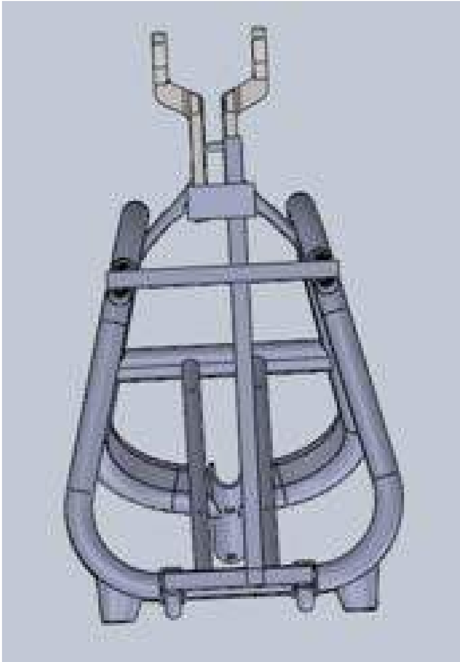
Goals: Create updated version of stabilization frame.

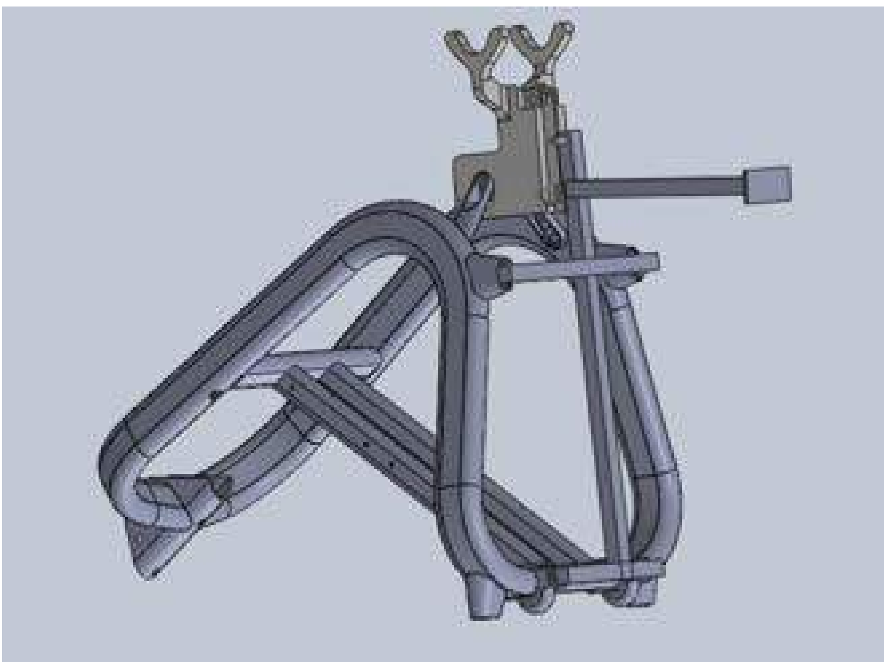
Content:

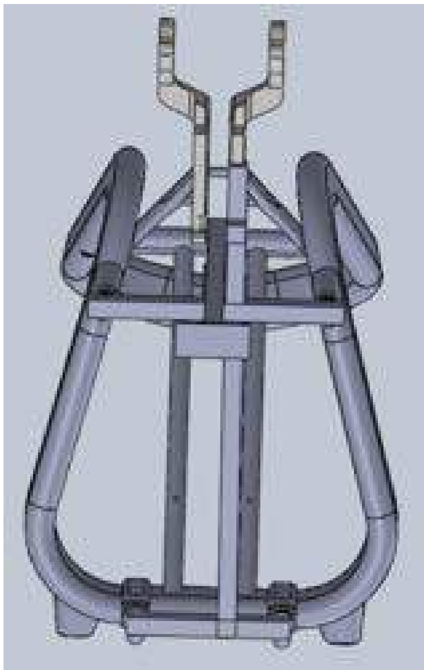
- After meeting with Staci at JHT, we noted that I should recreate the stabilization frame with a few new features:
  - The vertical bar should be in plane with both support bars
  - There should only be one horizontal bar that sticks out to reach the pad
  - Add in a plate at the end of the horizontal bar that the pad will attach to
  - Create the stop mechanism on the design
- Notes:
  - A lot of the SolidWorks work required mating many structures, so I learned a lot about mating while doing this
  - It was nice to be able to keep the frame permanently contacted to the stabilization frame
  - The plate on the end will eventually have holes drilled into it to attach the pad
    - The pad will be a little bit less wide that the original pad
  - I was able to get every bar to match up well with the corresponding holes
    - I did not make any holes in the design, but the design team at JHT will likely be able to do that when they start to fabricate
- Below are pictures of the work that I completed. This took me approximately 2.5 hours to complete since I am not great with SolidWorks, but I am learning!

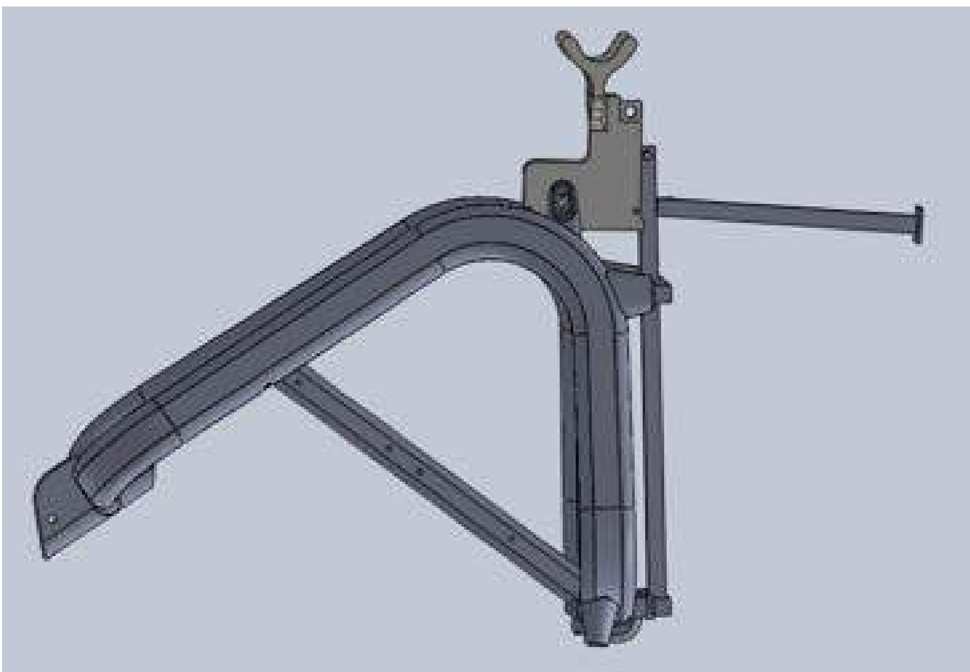


- 









Conclusions/action items:

I am happy that I was able to finish the stabilization frame work in SolidWorks. I think this model looks very nice and now accounts for the stopper mechanism and a plate which will attach the pad.

Action items: share this idea with Staci and make necessary edits. Create drawings for the design and send to Staci.

02/15/2023 Creation of Pin Mechanism

SAMUEL SKIRPAN - Feb 15, 2023, 9:41 PM CST

Title: Creation of Pin Mechanism

Date: 2/15/23

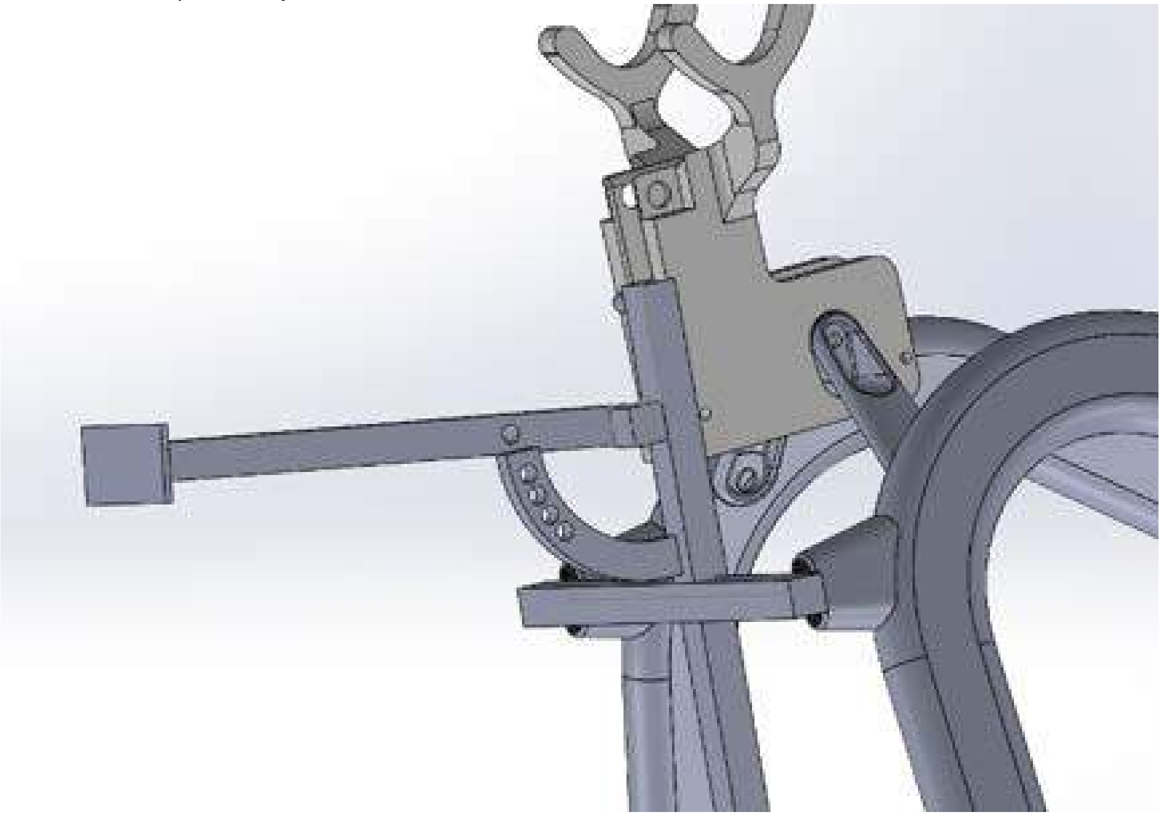
Content by: Sam

Present: Sam

Goals: Enter work completed on stabilization frame to notebook.

Content:

- Today, I spent about 2 hours working on SolidWorks for the development of the pin-adjustability mechanism for the stabilization frame
- I first created the pin-slider part
  - This involved spacing holes along the part evenly
  - I used a lot of the mating tool when I entered this into the assembly
  - I also placed a hole on the bar that will hold the pad; this is where the pin will go
- Big takeaways from SolidWorks session at E-hall
  - The pin size used is arbitrary; can change depending on what JHT has available
  - Ask Staci about the rotation mechanism
- Pictures of the work I completed today:



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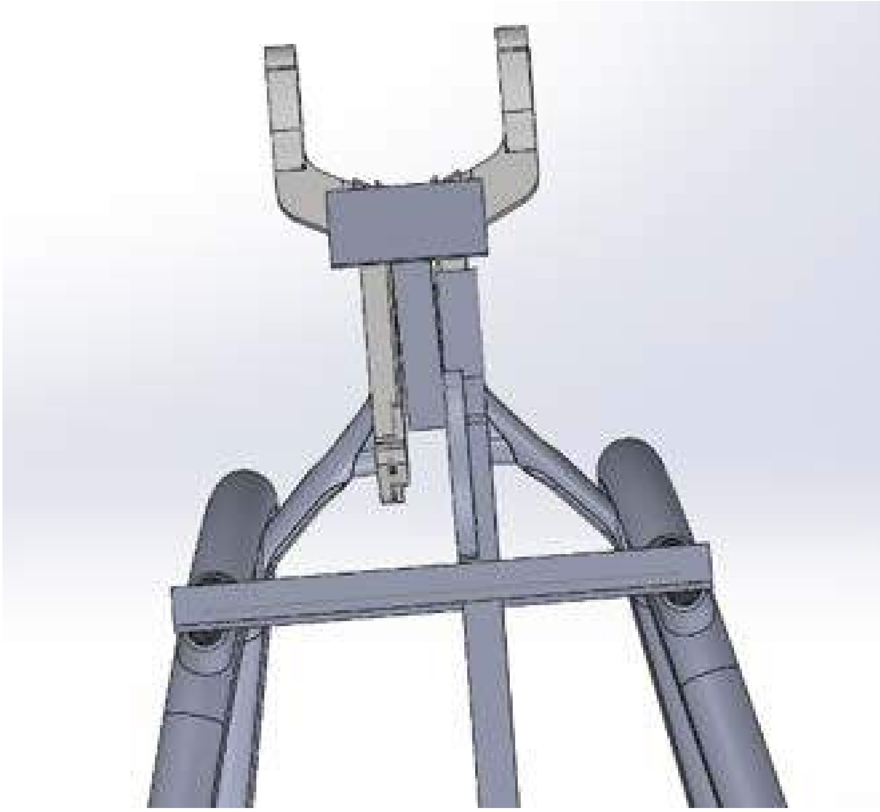
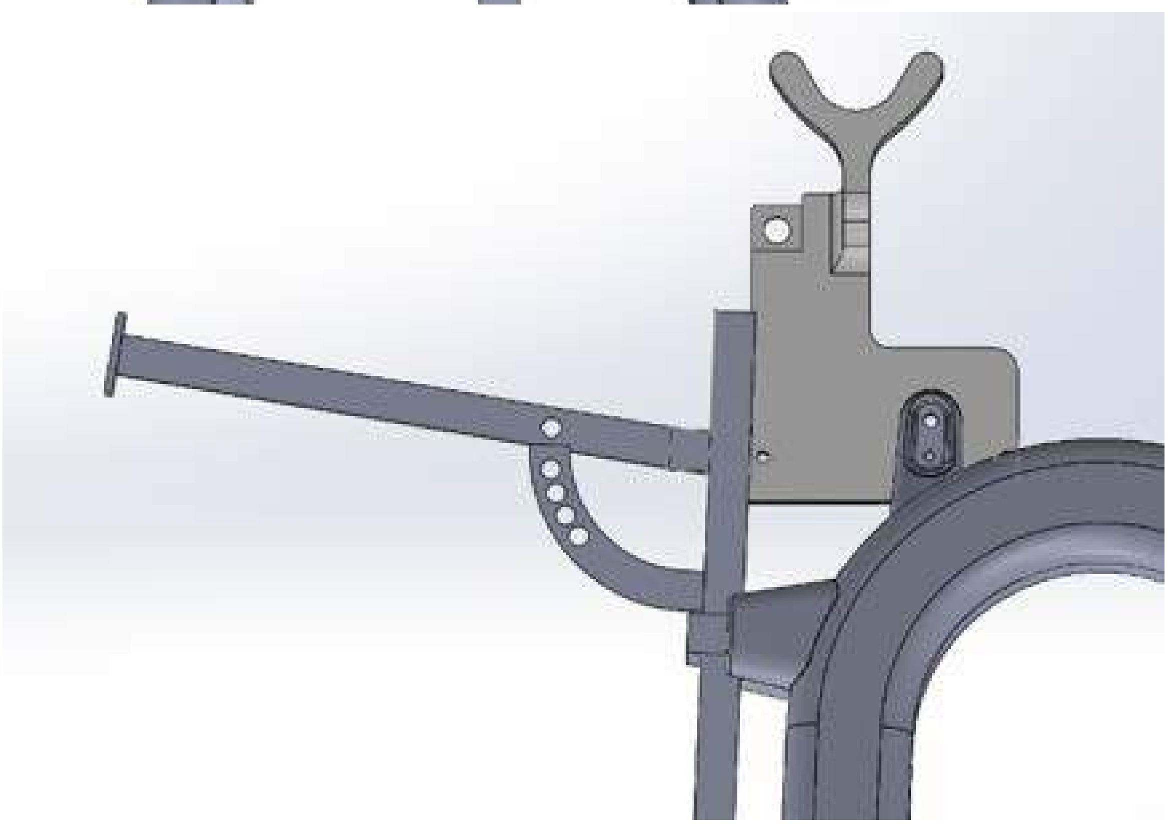
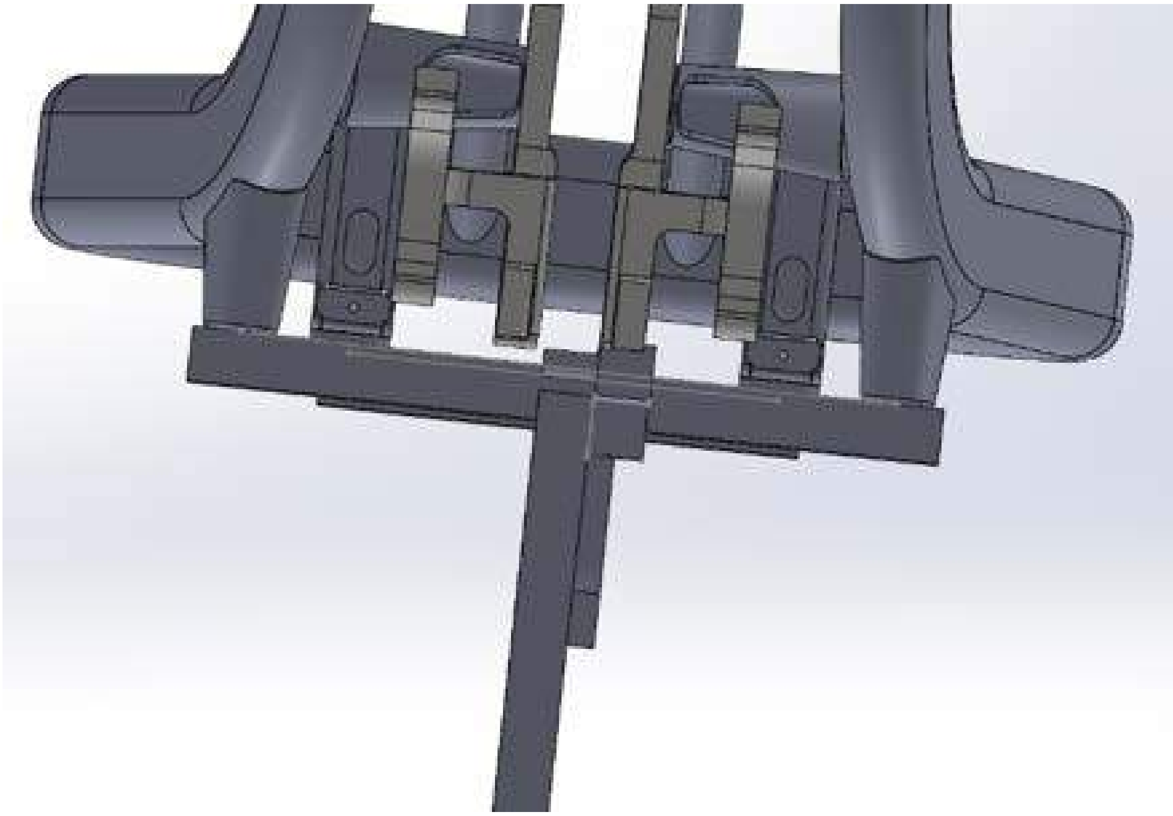
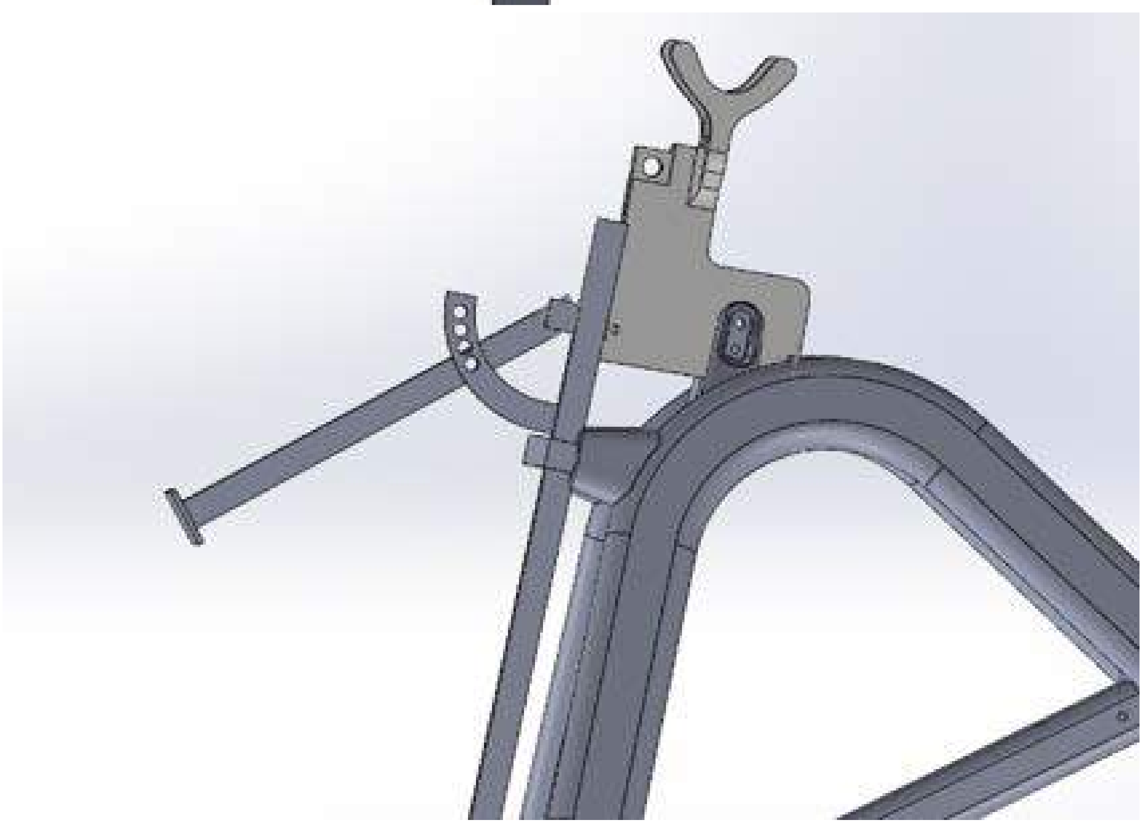
- 
- 

- 
- 

* These pictures show different angles of the pin mechanism and the model that I created today

Conclusions/action items:

After modeling the pin mechanism today in CAD, I realized there may be some ways we can make the design more efficient. This may include making the pin mechanism a full semi-circle with a hole at the top where the lap pad bar can rest while the machine is not in use.

Action items: updated the pin mechanism SolidWorks model. Create drawings for the various parts.

02/23/2023 Updating of Stabilization Frame and Pin Mechanism

SAMUEL SKIRPAN - Feb 23, 2023, 4:14 PM CST

Title: Updating of Stabilization Frame and Pin Mechanism

Date: 2/23/23

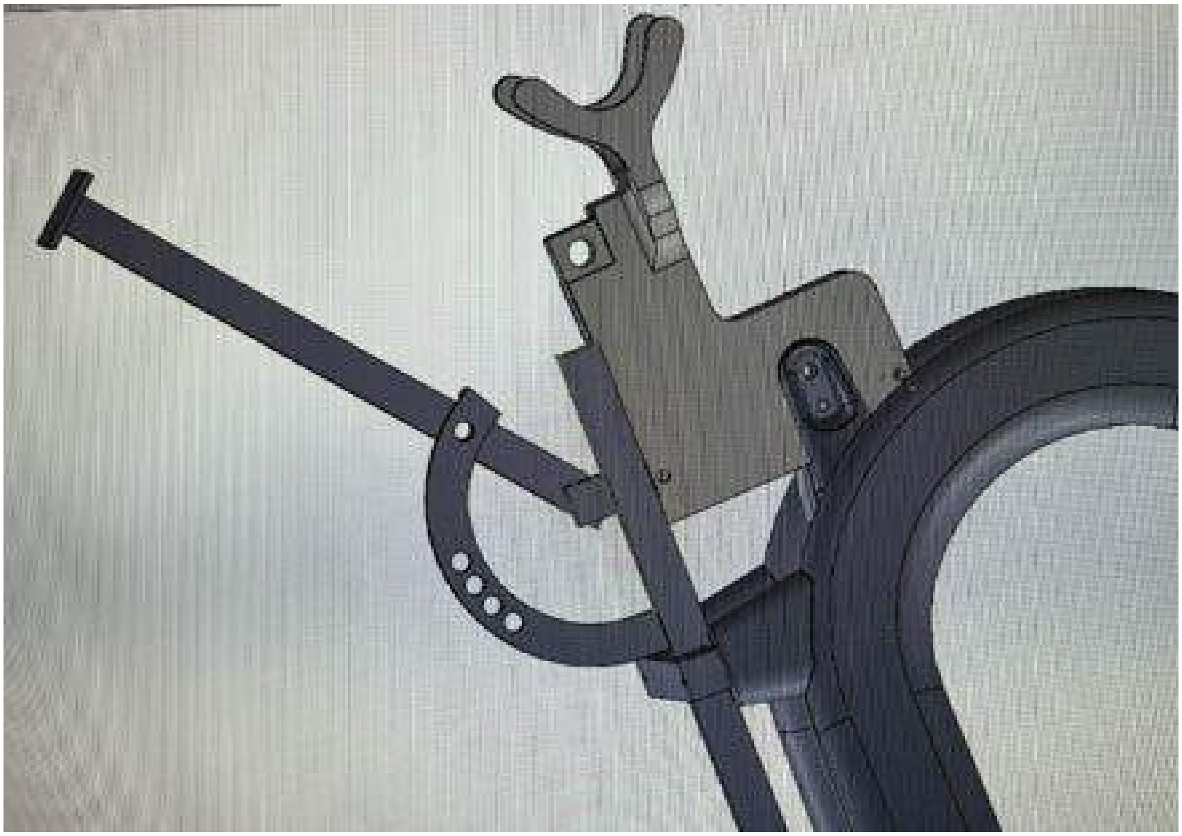
Content by: Sam

Present: Sam

Goals: Shorten the vertical bar for the stabilization frame. Change the angle pin mechanism so that it includes a "rest" position and a physical stop.

Content:

- I spent approximately 2.5 hours in the computer lab yesterday working on the stabilization frame SolidWorks
- I focused on making small edits to the frame and the pin mechanism
    - The pin mechanism was going to be updated to include a top rest hole where the lap pad can rest while not in use
    - Also, the pin mechanism now includes a physical stop such that it doesn't go past a certain point and can also hold the limit switch
    - I also added all the necessary holes to the horizontal support bars in addition to making the vertical bar shorter
- Here are some pictures of the design:
    - 

- 
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- 

Conclusions/action items:

At E-hall yesterday, I was able to update all of the SolidWorks models for the stabilization frame, including the pin mechanism and making holes for the screws. See above for pictures.

Action items: receive feedback from Staci regarding design.

02/23/2023 Drawings of Stabilization Frame SolidWorks

SAMUEL SKIRPAN - Feb 23, 2023, 4:20 PM CST

Title: Drawings of Stabilization Frame SolidWorks

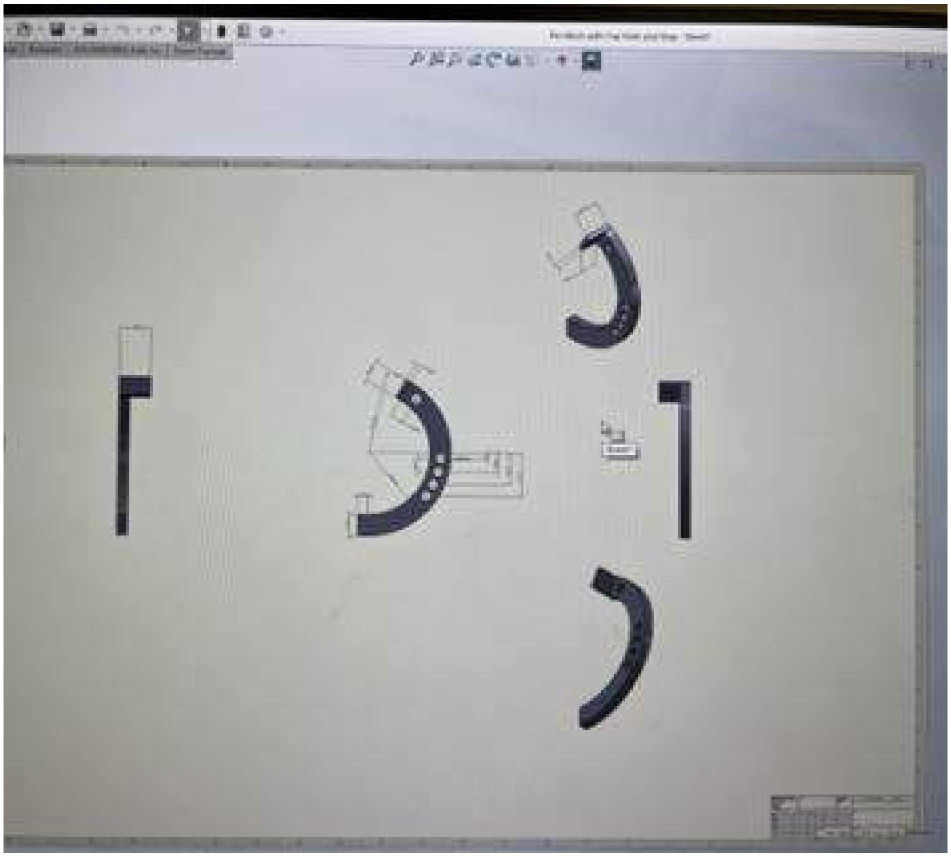
Date: 2/23/23

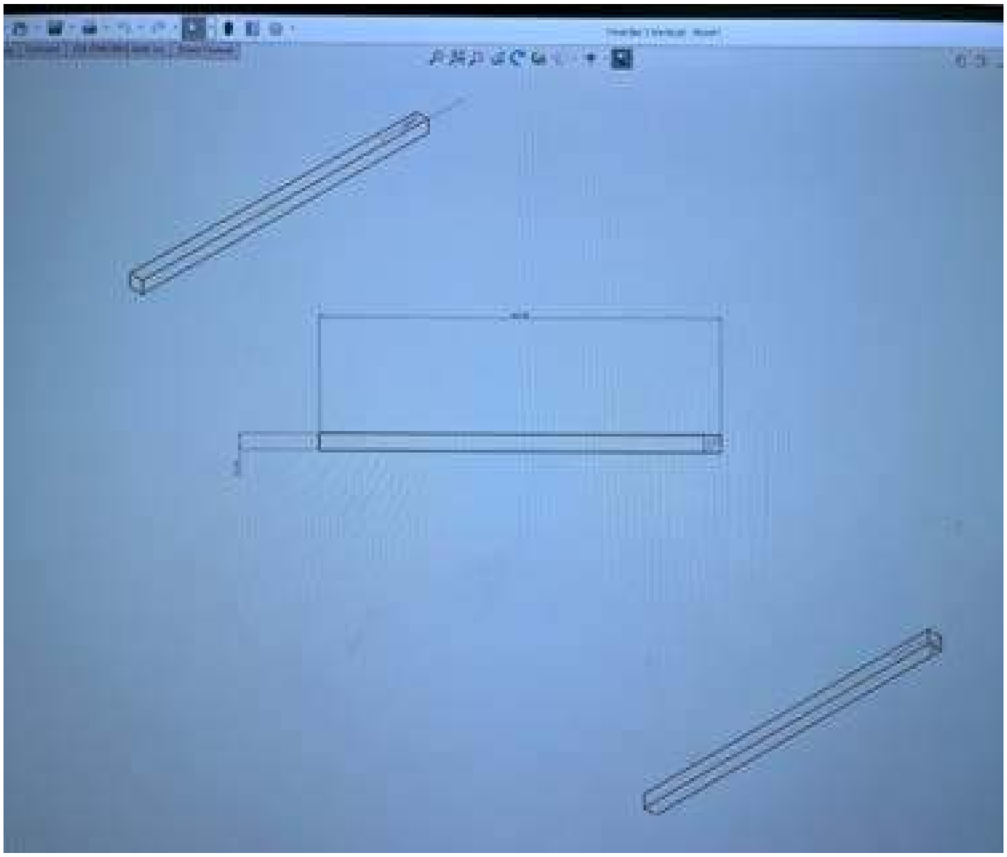
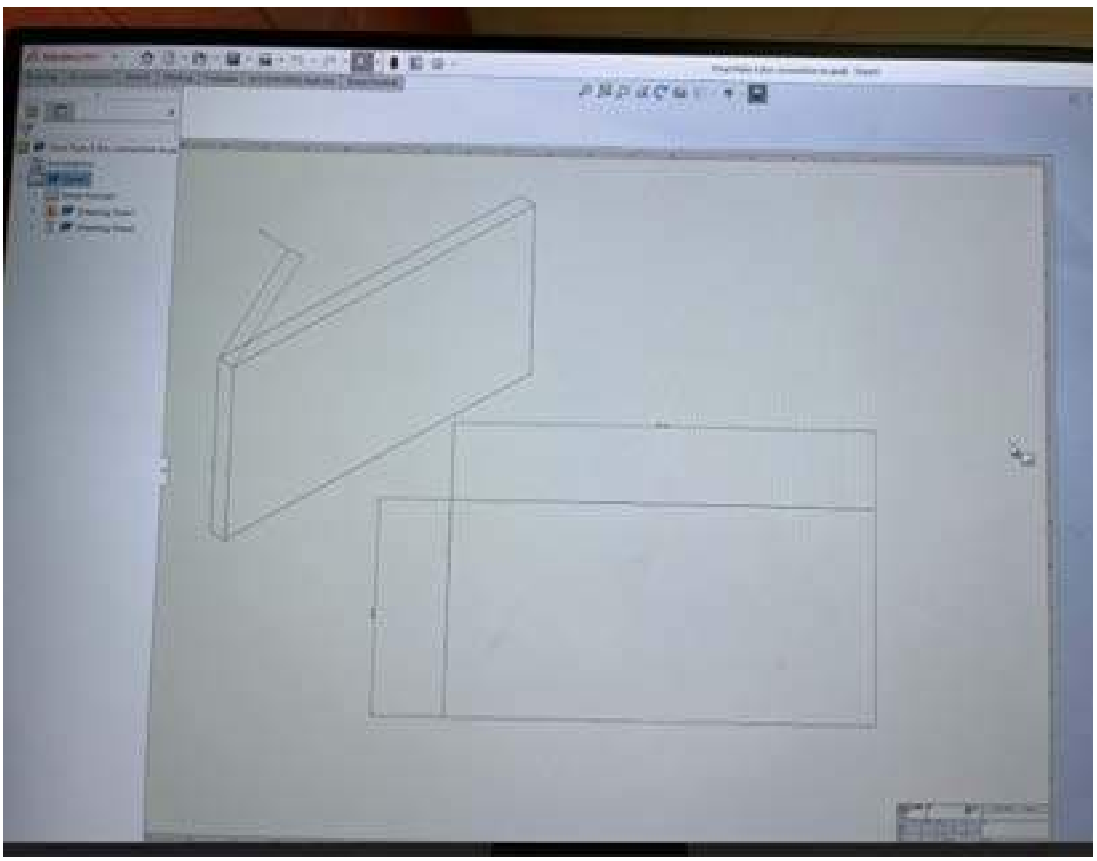
Content by: Sam

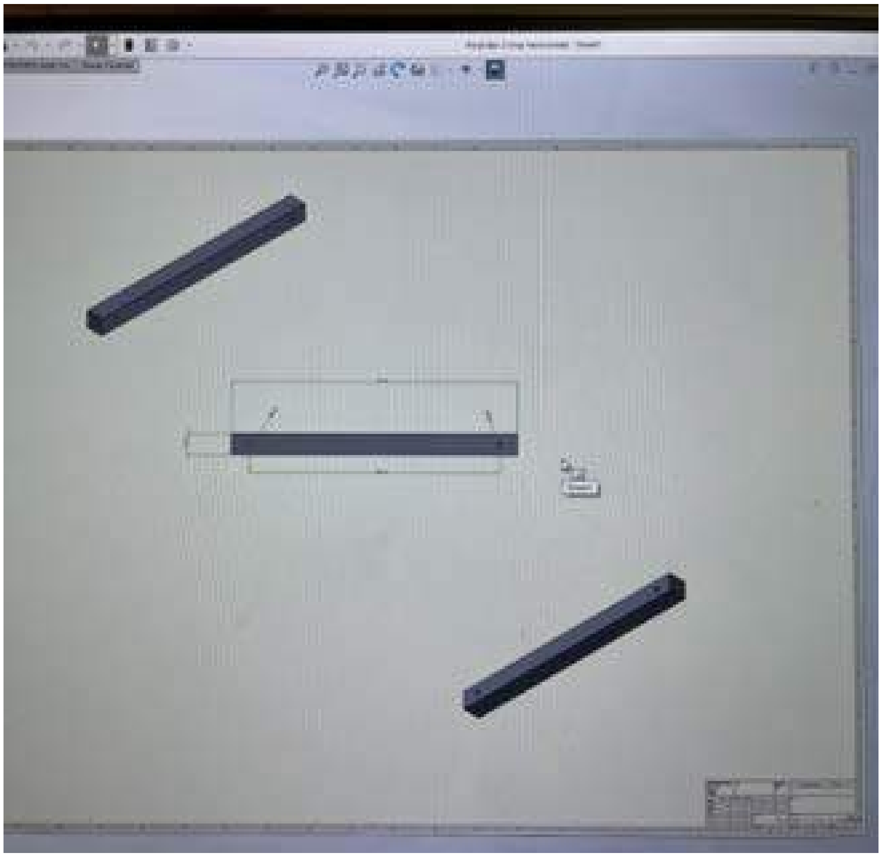
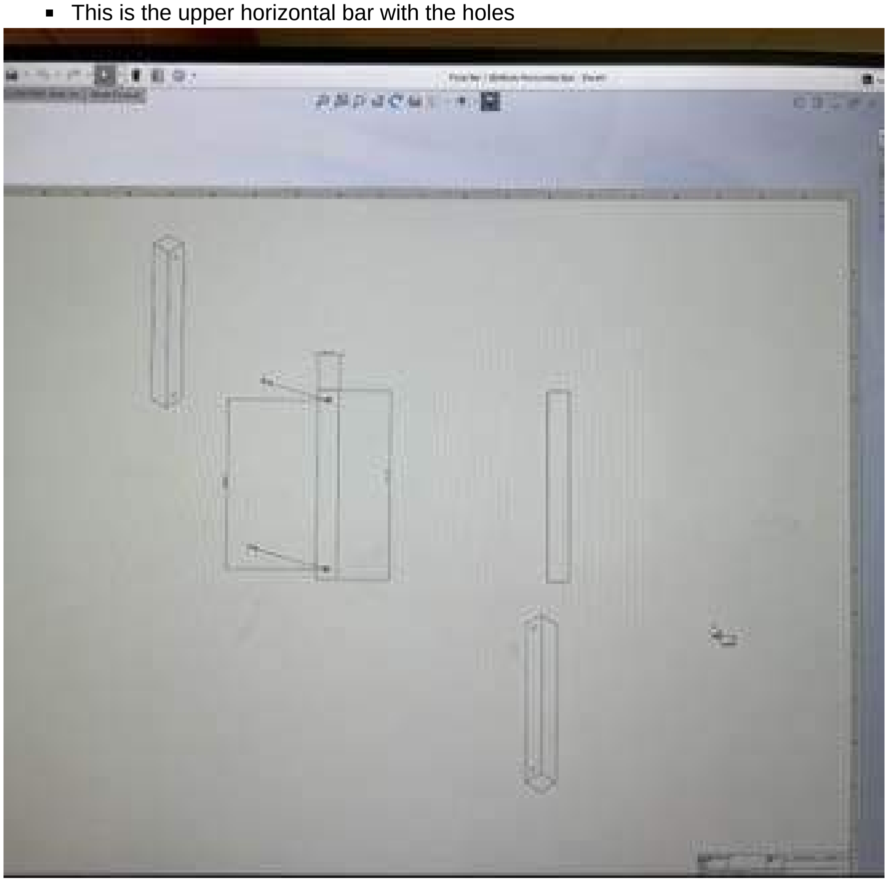
Present: Sam

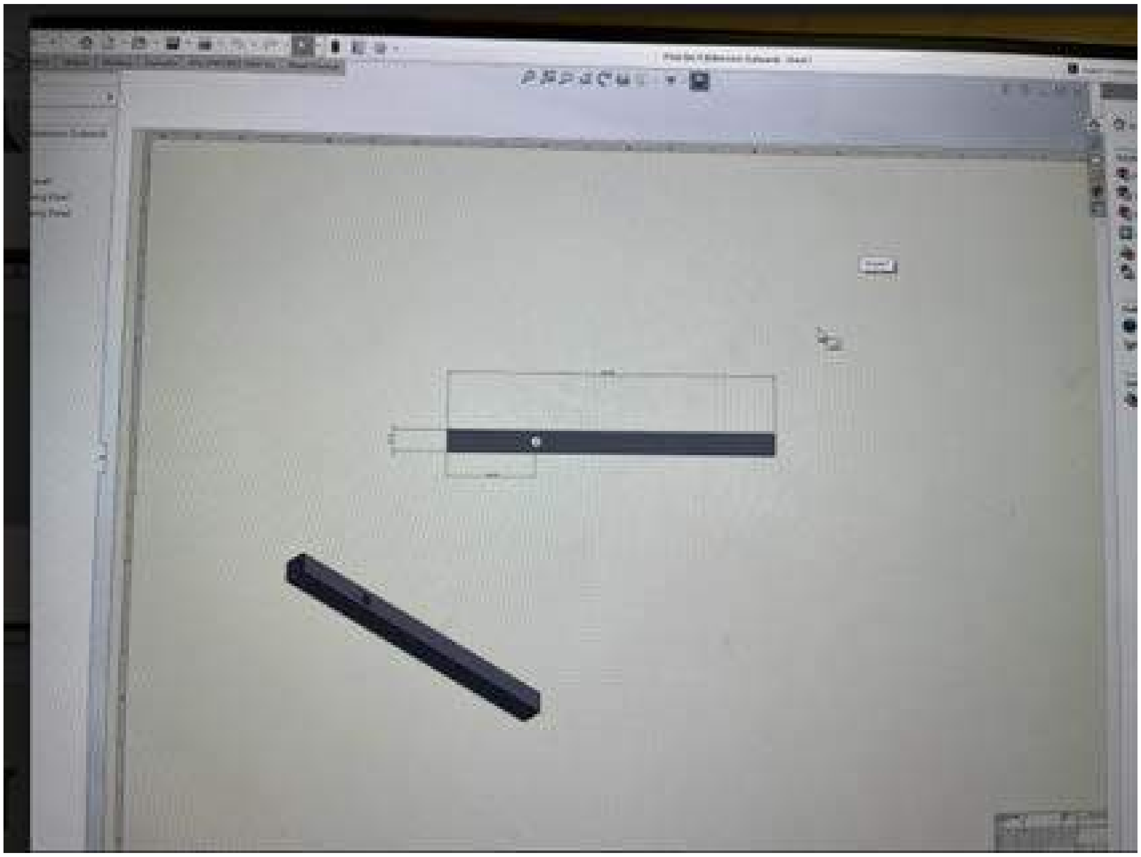
Goals: Enter drawings of each bar and part into lab notebook.

Content:

- The following are the drawings for the 6 various bars and angle mechanism that encompass the stabilization frame
    - 
        - This is the pin mechanism

- 
  - This is the vertical bar
- 
  - This is the plate where the pad will attach to the pad bar

- 
  - This is the upper horizontal bar with the holes
- 
  - This is the lower horizontal bar with holes

- 
  - This is the lap pad bar that will attach to the plate

Conclusions/action items:

The drawings were created to be sent to Staci so she can fabricate them in the JHT shop. I labeled all of the necessary dimensions in each drawing so that these bars and parts can be created.

Action items: NA

03/06/2023 Step Increment for Magnets for Resistance Mechanism

SAMUEL SKIRPAN - Ma

Title: Step Increment for Magnets for Resistance Mechanism

Date: 3/6/23

Content by: Sam

Present: Sam

Goals: Determine the angle step increment that the magnet moves when you change the resistance dial.

Content:

- I was assigned with finding the angle step for the magnets on the resistance dial
- To do this, I took a video of the resistance dial changing from level 1 to level 10
- Then, I took screenshots of each level, from 1 to 10
- I uploaded these screenshots into an online angle measurement website
- For each screenshot, I measured the angle that the magnet holder was with respect to the larger white piece near the flywheel
    - 

        - Here is an example picture of one of the angles that I measured
- I went from resistance level pictures 1 to 10 and captured each angle in a spreadsheet, then measured how much the angel change between each resistance
- Here are the results:
Resistance	Angle	Step	Avg step	2.111111111
1	73			
2	71	2		
3	68	3		
4	66	2		
5	64	2		
6	62	2		
7	60	2		
8	58	2		
9	56	2		
10	54	2		
    - The average angle step was around 2.1 degrees
    - However, we may just use 2 degrees as the step increment for simplicity sake

Conclusions/action items:

I will share the angle measurement results with the team during our next meeting. The magnet holder rotated by about 2 degrees for every increment. This increment will be built into the code the stepper motor rotates by this increment each time.

Action items: share the step angle with the team and Annabel so she can build it into the code.

03/29/23 Integration of Design and Tapping of 3D Prints in TEAM Lab

SAMUEL SKIRPAN - Mar 30, 2023, 9:20 AM CDT

Title: Integration of Design and Tapping of 3D Prints in TEAM Lab

Date: 03/29/23

Content by: Sam

Present: Sam

Goals: Meet with Josh to make necessary changes to stabilization frame and tap out the various holes on the 3D printed parts.

Content:

- I met with Josh at ECB to work a little further on the integration of the components with the rowing machine
- Things that we wanted to get finished:
    - Make attachment holes of the stabilization frame support bar a little less wide
    - Add two additional holes to the stabilization frame arc such that it can fit people with wider legs
    - Tap out many holes for the 3D printed parts
- When I tried to attach the stabilization frame again without doing any additional adjustments, it actually fit on the rower this time
    - Action item: The only other thing we need to do is get M6 1 inch screws (2 total) so that we can attach the stabilization frame to the rowing machine back
        - The current screws are a little too long
- Josh and I went down to the TEAM Lab to do many things
    - First, I used a compass to sketch out the arch for the adjustment locations along the stabilization frame
        - Action item: Using a 9/16 inch drill bit, drill out two additional holes on frame once we have them marked in correct locations
    - I also assisted Josh in the placement of the drill when he was drilling out holes in the 3D printed parts
    - Additionally, I obtained some of the screws that we needed for the attachment of the 3D printed parts to the rower frame
        - I made sure the screws we got from the TEAM Lab fit in every location they needed to
    - I used a threading tool to thread 4 1/4-20 holes on the electronics box while Josh was drilling

Conclusions/action items:

Josh and I met at ECB to work a little bit further on integration. We were able to tap out holes on the 3D printed materials and get some of the screws for the parts. I was able to mark out the radius of the arc for the stabilization frame adjustment holes

Action items:

- Get M6 1 inch screws (2 total) so that we can attach the stabilization frame to the rowing machine back
- Using a 9/16 inch drill bit, drill out two additional holes on frame once we have them marked in correct locations
- Check out hand drill and drill holes out on the rower frame for attachment of the magnet housing

03/30/23 Further Integration of Design with Rower Frame

SAMUEL SKIRPAN - Mar 31, 2023, 8:57 AM CDT

Title: Further Integration of Design with Rower Frame

Date: 3/30/23

Content by: Sam

Present: Sam and Josh

Goals: Further integrate the design with the rowing machine. Attach the stabilization frame and console 3D printed part.

Content:

- After my BME 430 lab yesterday, I helped Josh out for about 30 minutes with integration
- He was having trouble with 2 main things:
    - The stabilization frame was not screwing in because one of the threads for the right-most screw was not going in all the way/had a problem
    - The console holder was not screwing into the pulley plates due to a problem with the threading
- I was eventually able to get the stabilization frame to screw in when I used a lot of force and the perfect sized hex wrench
    - We had to be very careful not to strip the screw because there would have been no way to get it out if we did so
    - I believe we used 1 inch M5 screws and had to use a M3 wrench to screw them in
    - Note: whenever we did attach the frame, it seemed like it was wobbling a little bit upward and downward with a lot of force applied
        - This could be since we removed the lower half of the frame (Staci's decision to do so)
- With the improper threading of the pulley plate bottom for the monitor 3D print, we had a lot of trouble getting the screws in
    - We were only able to get 1 screw to go in perfectly; 2 were not able to go in at all; and 1 was able to in at an angle, so it looks slightly weird
    - Once we did get the monitor holder in place, it looked as if it was slightly crooked compared to the rest of the design

Conclusions/action items:

I met with Josh for a little yesterday to help him with some problems he had with integration. I was able to attach the stabilization frame to the rower frame using 1 inch M5 screws when I applied a lot of force to insert the screws. I also was able to get 2 out of the 4 screws to go into the 3D printed monitor holder, even though one of them was crooked.

Action item:

- Meet with team to go over executive summary
- Find wheelchair test participants

04/12/2023 Drilling of Holes for Button Placement

SAMUEL SKIRPAN - Apr 12, 2023, 9:25 AM CDT

Title: Drilling of Holes for Button Placement

Date: 4/12/23

Content by: Sam

Present: Sam, Roxi, Annabel

Goals: Drill holes in the plastic frame of the rower and the 3D printed console holder for the placement of the buttons.

Content:

- Last night, I met with Roxi and Annabel in ECB to work on the rowing machine
- It was my job to use the drill to drill out the holes where the buttons would go permanently
    - I used a 7/8th inch drill bit and a centering bit to create the holes
    - I also used a file to clean up the holes after I made them
        - This took about an hour or two to complete
- Here are pictures from my work and of the final button placement:
    - 

- 
- 
- These pics show the buttons from both sides of the rowing machine
- There are a total of 4 buttons:
  - one for up and down on each side

- After I placed the buttons, Annabel wired them to the rest of the electronics

Conclusions/action items:

Last night, I was able to permanently attach the buttons such that they are in place on the rowing machine. I used a drill and a file to do this.

Action items:

- Recruit participants for testing

4/13/23 Surface EMG Procedure

Title: Surface EMG Procedure

Date: 4/13/23

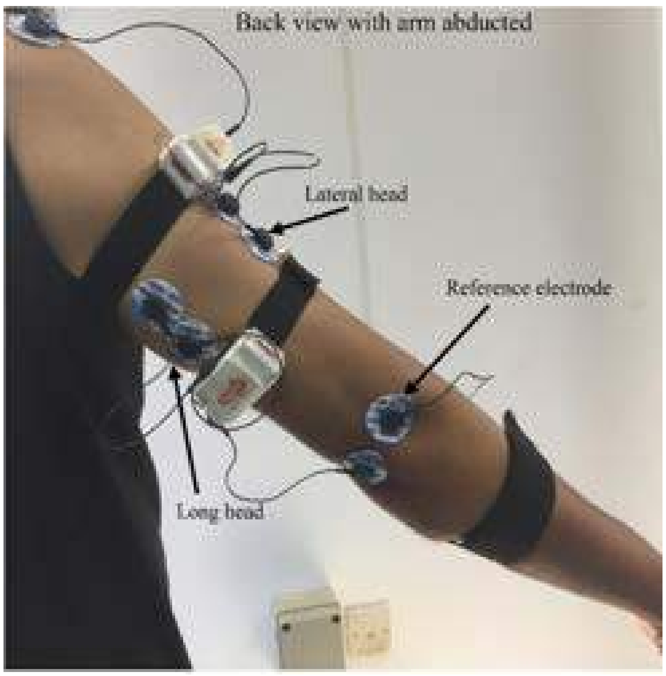
Content by: Tim

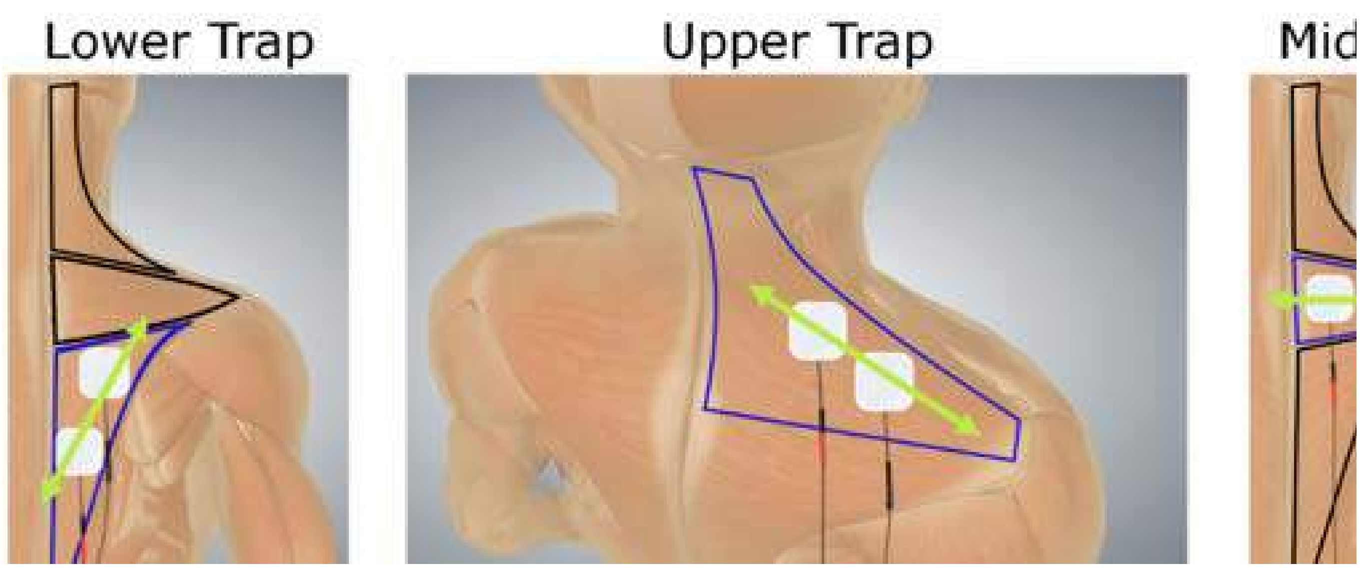
Present: Tim

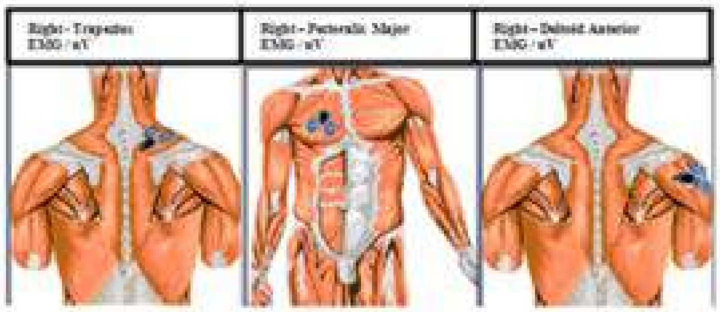
Goals: Present findings on standard EMG setup and lead placements

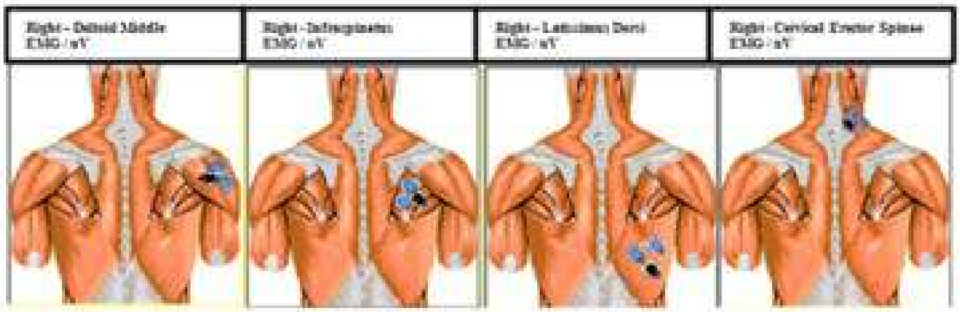
Content:

EMG procedure starts with a skin preparation. Surface EMG can only take readings of surface muscles

- Skin Preparation
  - Remove dead skin cells from location where leads will be placed
  - Remove moisture on skin - wipe skin with alcohol.
- EMG placement - 2 active electrodes + 1 reference electrode
  - The surface EMG electrodes should be placed between the motor unit and the tendinous insertion of the muscle, along the longitudinal midline of the muscle
    - longitudinal means running lengthwise rather than across
  - Reference electrode is placed on electrically neutral tissue / far away from detecting surface
- Triceps
  - 

- Trapezius
  - 





Do EMG on Tricep, Latissimus Dorsi, Abs, Trapezius

Conclusions/action items:

https://www.intechopen.com/chapters/40131

https://www.frontiersin.org/articles/10.3389/fphys.2020.00112/full

2/4/2023 Dial Brainstorming

Tim TRAN - Feb 04, 2023, 9:22 PM CST

Title: Resistance Dial Brainstorming

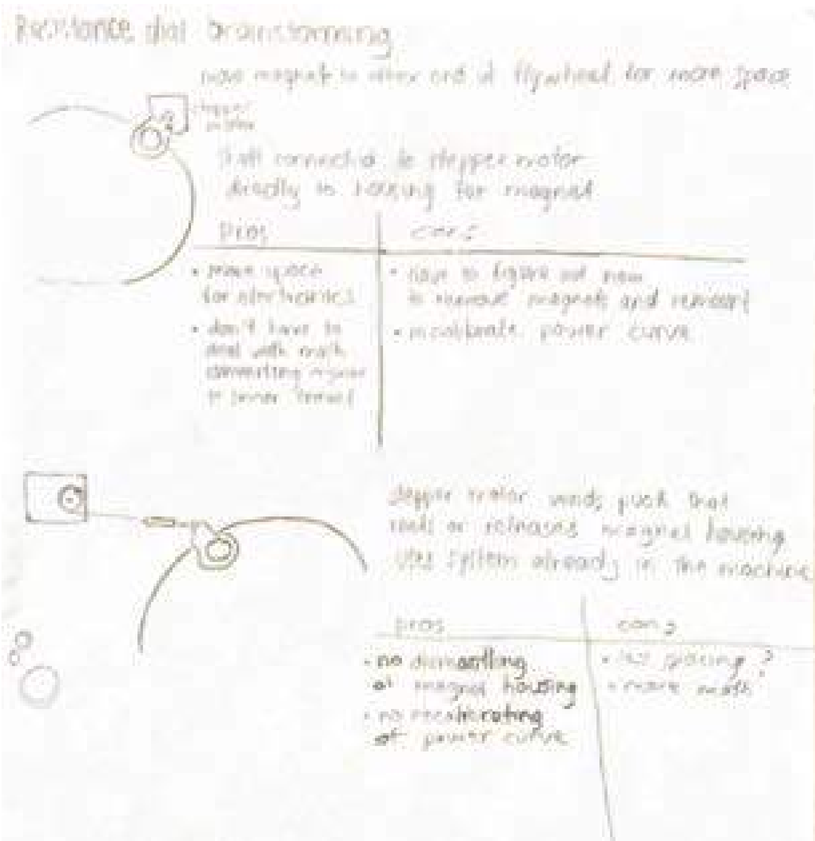
Date: 2/4/2023

Content by: Tim

Present: Tim

Goals: present brainstorming ideas about resistance dial

Content:



The stepper motor will be controlled with touch pads located on both the adaptive and standard sides. The touchpad will have two buttons to up and lower the resistance.

Conclusions/action items:

Compile all team mate's ideas and decide on the best solution.

2/17/23 Stepper Motor Location/Mount Brainstorm

Tim TRAN - Feb 17, 2023, 12:40 PM CST

Title: Stepper Motor Location/Mount Brainstorm

Date: 2/17/23

Content by: Tim

Present:

Goals: brainstorm possible locations and mounts for the stepper motor in the internals of the rower.

Content:

There is a support bar above and behind the magnet housing. There is already a screw hole in the bar that we can use as an attachment point for our stepper motor mount.

In the magnet housing, there are 2 holes that go through the whole housing originally intended for calibrating the resistance, however, I envision we could use this hole to rotate the housing with our stepper motor.

In the first brainstorming session for the resistance dial, the team thought of linking the stepper motor into the hinge that it is screwed into, however, upon closer inspection, I don't believe the motor could rotate the housing in the hinge.

I think the best solution would be to create a linkage similar to the ones seen on train wheels, with one end on the stepper motor and the other end through the holes used for calibration.

Conclusions/action items:

2/3/23 Device Documentation - Safety Features

Tim TRAN - Feb 03, 2023, 1:03 PM CST

Title: Device Documentation - Safety Features

Date: 2.3.23

Content by: Tim

Present: Tim

Goals: Complete the assigned portion of device documentation

Content:

SAFETY RISK FEATURES

Many efforts were made to ensure the safety of the Matrix Adaptive Rowing Machine. These include: a stability frame with a lap pad restraint that limits the movement of the user and their wheelchair, 3D printed housing for electronics to minimize the risk of shock, and removal and smoothing out of sharp edges and surfaces to diminish risks for abrasions and lacerations.

Conclusions/action items:

Look over and make corrections to device documentation doc on sunday 2/5/2023

4/27/23 Updates to testing protocols

Tim TRAN - May 02, 2023, 5:56 PM CDT

Title: Updates to testing protocols

Date: 4/27/23

Content by: Tim

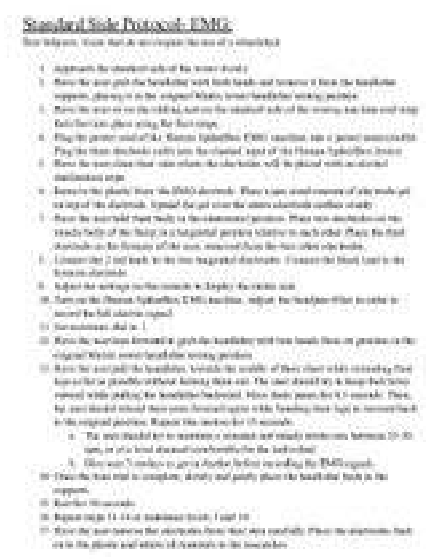
Present: Tim

Goals: Update testing protocols to reflect procedures on testing day.

Content:

Provided PDFs of new protocols.

Tim TRAN - May 02, 2023, 5:56 PM CDT


Standard Side Protocol- EMG:

Download

Standard_Side_Protocol_-_EMG.pdf (42.1 kB)

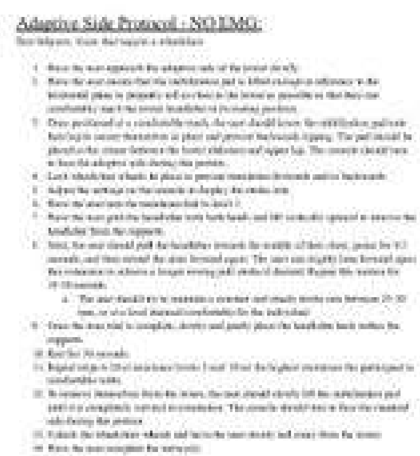
Tim TRAN - May 02, 2023, 5:56 PM CDT


Standard Side Protocol - NO EMG:

Download

Standard_Side_Protocol_-_No_EMG_.pdf (37.6 kB)

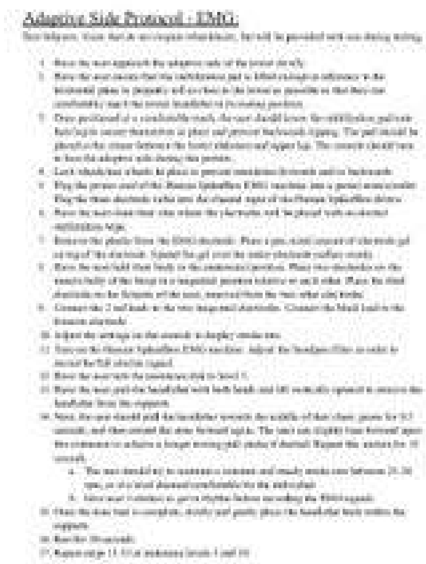
Tim TRAN - May 02, 2023, 5:56 PM CDT


Adaptive Side Protocol - NO EMG:

Download

Adaptive_Side_Protocol_-_NO_EMG.pdf (78.9 kB)

Tim TRAN - May 02, 2023, 5:56 PM CDT


Adaptive Side Protocol - EMG:

Download

Adaptive_Side_Protocol_-_EMG.pdf (43.2 kB)

2/10/23 Prelim Presentation

Tim TRAN - Feb 17, 2023, 11:14 AM CST

Title: Prelim Presentation Talking Points

Date: 2/10/23

Content by: Tim

Present: Tim

Goals: Jot down the main points I want to get across in the preliminary 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. This semester, the team will be working to implement the ability to adjust the rowing resistance from both the adaptive and standard sides of the machine.

Motivation:

This product is critical to create because of the many potential consumers. It is estimated that there are 5.5 million wheelchair users in the U.S. and 81% of individuals with disabilities feel uncomfortable in fitness centers due to a lack of adaptive exercise equipment. 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.

Physiological research:

A common complaint among wheelchair users is shoulder pain and research has shown that regular upper body exercise can alleviate these problems, especially rowing which targets the shoulder, back, and oblique muscles groups

PDS

Conclusions/action items:

2/23/23 Journal Prelim - Intro + Stabilization Frame (Appendix)

Tim TRAN - Feb 27, 2023, 1:04 AM CST

Title: Journal Prelim - Intro + Stabilization Frame (Appendix)

Date: 2/23/23

Content by: Tim

Present: Tim

Goals: Write journal intro and appendix sections

Content:

Purpose

To present the details of a rowing ergometer adapted for wheelchair use with applications for rehabilitation.

Intro

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.

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]. Common complaints among the wheelchair community include a lack of space between equipment for wheelchair access and concern about needing or requesting external assistance in fitness centers. To solve this issue, modifications must be made to currently manufactured machines. A standard Matrix rowing machine will be adapted to accommodate wheelchair users while retaining its original functionality for non-wheelchair users [1]. This modified design will allow wheelchair users to use the rowing machine without external assistance, ensure the proper rowing form is maintained, and ultimately help to improve the overall well being of wheelchair users through exercise.

Physiology

A common issue for wheelchair users is shoulder pain [10]. It is important to note that shoulder pain could potentially be due to a lack of proper training and implementation of gradual increases in a workout regimen. Other factors that affect shoulder pain include age, weight, and BMI. In addition, increased intensity, frequency, and duration of a load may lead to shoulder pain. However, proper increases in resistance and form can reduce pain in this area [10].

The rowing motion allows an individual to actively exercise many of the essential muscle groups needed to refine both core and upper body strength. These muscles include the triceps, biceps, abdominals, back muscles, and lower back muscles [11].

There are 4 phases in the rowing motion. The first phase is the catch, and it primarily activates the triceps and the flexor muscles in the fingers. During this phase, the abdominal muscles are engaged and allow the user to flex the torso in a forward motion. The following phase is called the drive. In standard rowing, this phase includes the contraction of the hamstrings while the user propels themselves backward. However, for an adaptive user, it will activate the biceps as they pull the handle towards their abdomen. The back muscles will also contract as the torso swings backward. The drive's movement is completed by the finish phase. This phase is the final pull where the abdominals and lower back stabilize the body and the biceps engage to help keep the torso in place. The full rowing motion is completed during the recovery phase, which occurs when the individual returns to the catch phase. The triceps engage to push the arms away from the body while the abs flex the torso forward. The four phases, all together, allow for a complete workout that strengthens the shoulder complex and upper body muscles [11].

Description of Adaptations

Pulley Plate / 2nd Pulley

An additional pulley to guide the rowing rope to the backside of the machine. This reverses the direction of rowing and allows for the standard function of the machine to stay unaltered. The pulley plate contains the second pulley and is mounted using the same connection points the original pulley uses.

Antlers

This feature alters where the rowing handlebar is stowed. The antlers relocate the rowing handlebar to the middle of the machine, equidistant from the standard and adaptive sides. Increases the ease of setup for adaptive function users.

Stabilization Frame

Frame to secure the user of the adaptive side. The frame features a lap pad restraint to resist translation and rotation of the wheelchair.

Console Motor Rotation

The console is now controlled by a stepper motor, and its orientation is determined by whether the standard or adaptive side is in use. A limit switch tracks the position of the lap pad restraint. When the standard side is in use, the lap pad restraint will be stowed, depressing the limit switch. When the adaptive side is in use, the limit switch will be released, activating the stepper motor, and rotating the console to face the adaptive side.

Resistance Dial

Implemented stepper motor to resistance dial mechanism to alter it from mechanical to electronic. Rowing resistance levels are now altered with remotes on both the standard and adaptive sides. The remotes are also equipped with a display to indicate resistance level.

Appendix - BME 402 Updates to Stabilization Frame

The main goal for the stabilization frame this semester was to modify it to be manufacturable and to attain a more professional look. To achieve this goal, unnecessary segments of the frame were removed, and the material of the frame was changed to reflect the final production. The vertical support bar is shifted to now be inplane with the two horizontal support bars. This change increases the strength of the frame in addition to improving its silhouette. Replacing the bolt and screw stop, which was the previous method for providing rotation to the lap pad restraint, is a metal arc with holes at specific increments and a spring-loaded pin. The pin and plate combination is a common adjustment mechanism for exercise equipment. This change resolves the issue of the lap pad restraint hinge being too firm to move or too loose that it would rotate too quickly. The metal arc/plate contains a physical stop to control the stowing position of the lap pad restraint.

Conclusions/action items:

2/23/23 Edge Cases for Resistance Dial Electronics

Tim TRAN - Feb 23, 2023, 5:30 PM CST

Title: Edge Cases for Resistance Dial Electronics

Date: 2/23/23

Content by: Tim

Present: Annabel / Roxi

Goals: Present some cases where potential problems can arise in the electronics/code

Content:

- Power goes out, will the resistance level be remembered?
  - Reset resistance level to 1 if the power ever goes out
- Power goes out, will the calibration of the stepper motor stay accurate?
  - Implement limit switches to define resistance levels 1 and 10
- Will the calibration stay accurate if the user cycles through resistance levels faster than the stepper motor can go?
  - Cycles all the way up then back down a few
- Will calibration be accurate if the resistance level is changed often and quickly?

Conclusions/action items:

Annabel will implement limit switches to track the location of the magnet housing to resolve some of these edge cases. The rest of the cases will be tested once the code and electronics are set up to observe how the code everything will interact

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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BME Design - Fall 2022 - Notebook

ANNABEL FRAKE - Jan 26, 2023, 10:25 PM CST

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