

BME Design-Spring 2024 - Neha Kulkarni

Complete Notebook

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Team contact Information

Neha Kulkarni - Jan 30, 2024, 1:46 PM CST

Last Name	First Name	Role	E-mail	Phone	Office Room/Building
Puccinelli	John	Advisor	john.puccinelli@wisc.edu	(608) 890-3573	2132 ECB
Thein-Nissenbaum	Jill	Client	thein@pt.wisc.edu	608.263.6354	5195 MSC
Kulkarni	Neha	Leader	nnkulkarni@wisc.edu	608-512-0204	
Kaur	Simerjot	Communicator	kaur26@wisc.edu	414-793-9967	
Moeller	Allicia	BSAC	aamoeller@wisc.edu	612-760-3247	
Wadzinski	Emily	BWIG	ewadzinski@wisc.edu	608-957-9119	
Fessenden	Colin	BPAG	ckfessenden@wisc.edu	614-318-5945	



Project description

Neha Kulkarni - Jan 31, 2024, 9:23 PM CST

Course Number: BME 301

Project Name: Rowing biomechanics for lower extremities

Short Name: Rowing biomechanics

Project description/problem statement:

Many college rowing athletes, particularly women, are susceptible to lifelong lower back or hip injuries due to disparate weight distributions on each leg while rowing. This issue can be addressed through gathering real-time data on athlete biomechanics, but this data is often difficult to obtain. Collection and analysis of biomechanical data will enable athletes to adapt their technique towards better performance, and will assist coaches and trainers in preventing injury. The client, Dr. Jill Thein-Nissenbaum, has tasked the team with creating a force plate system that can collect biomechanical data from rowers' lower extremities. The team's goal is to create a wireless sensor system in the rowboat that will capture load distribution during time of use and will assess lower extremity asymmetry to establish risk stratification. Additionally, the team aims to translate the force plate system into a user-friendly interface that will enable coaches and athletes to understand essential biofeedback information, thereby improving both performance and safeguarding against potential injuries.

About the client:

Jill Thein-Nissenbaum is a physical therapist who works with UW Crew rowers. Tricia De Souza is an athletic trainer for the UW Women's Rowing Team.



2024/2/2 - Boathouse Preliminary Client Meeting

Title: Boathouse Preliminary Client Meeting**Date:** 2/2/2024**Content by:** Alicia**Present:** Neha, Emily, Colin, Alicia, Jill, Tricia, Adam**Goals:** To introduce Alicia and Colin to the tank and erg machines and to talk about client needs.**Content:**

- Adam gave us a demonstration of how to row in the tank.



- Notes on rowing kinematics:
 - The ball of the foot is positioned directly under the toe strap
 - the order of the drive phase is leg extension (pushing off with the legs), hip extension (leaning the upper body back), then elbow flexion (pulling with the arms).
 - The heels lift off foot plate at the catch (shins perpendicular to the ground).
 - During the drive, the heels push into the force plate (as if the rower is standing up).
 - On the tank, people tend to push more with their inside leg and lean away from the oar side.
 - You want the blade in the water just before you push off with your legs.
 - You want the handle and the seat moving at the same pace
 - Mid-drive is where the most force is occurring
- How do trainers/PTs currently assess rowers?
 - Watch a rower row for 40-100 minutes
 - Assess fatigue - how quickly do they lose their form?
 - Determining their steady-state by looking at their wattage and split (time per 500 meters)
 - Step test: rower must row at increasing wattage levels with 20 second breaks in between
 - Trainers are often looking and ankle and knee ROM when assessing performance/injury to suggest appropriate exercises
 - Quantitative markers used to assess progress include splits, stroke rate, and how long they can row - there is a strict protocol
- Purpose of the product:

- Rowers experience lower back pain, knee pain, hip pain, posterior shoulder pain, and more. This product would be used to assess correlations between asymmetrical loading and any type of pain experienced by the rower.
- This product will be used a tool to track the recovery of rowers after surgery or injury.
- This product would help rowers improve their form and potentially prevent injury/surgical intervention.
- Client wants:
 - They would like to see not only asymmetries in the amount of force applied to each footplate, but the differences in timing of each foot.
 - The clients would like to see how much force is applied by the toe and heel (separately) of the right and left foot and the timing of all four forces. The client wants to be able to measure things like "the rower is pushing off with their right heel 0.5 seconds before their left heel" for example.
 - Different settings: the rower will likely exhibit some asymmetry depending on if they are rowing port or starboard (for sweep rowing). The client wants the ability to set the device to erg (symmetrical), port, or starboard to account for the innate asymmetry.
 - Flashing colors (green, yellow, red) to represent amount of variance between the feet. 5-10% variance would be red. Different percentage between erg and tank.
 - Force output data that can be saved and reviewed after a rowing session. For a longer rowing session (40-100 min), only need data every 15 minutes.
 - The monitor for real-time feedback could go below the erg monitor (if on an erg) or on a monitor sitting in front of the tank.
- Other notes:
 - The older version of the Concept2 RowErg has a footplate more similar to the footplate of the tank. Tricia is working to get this older erg to ECB for our use.

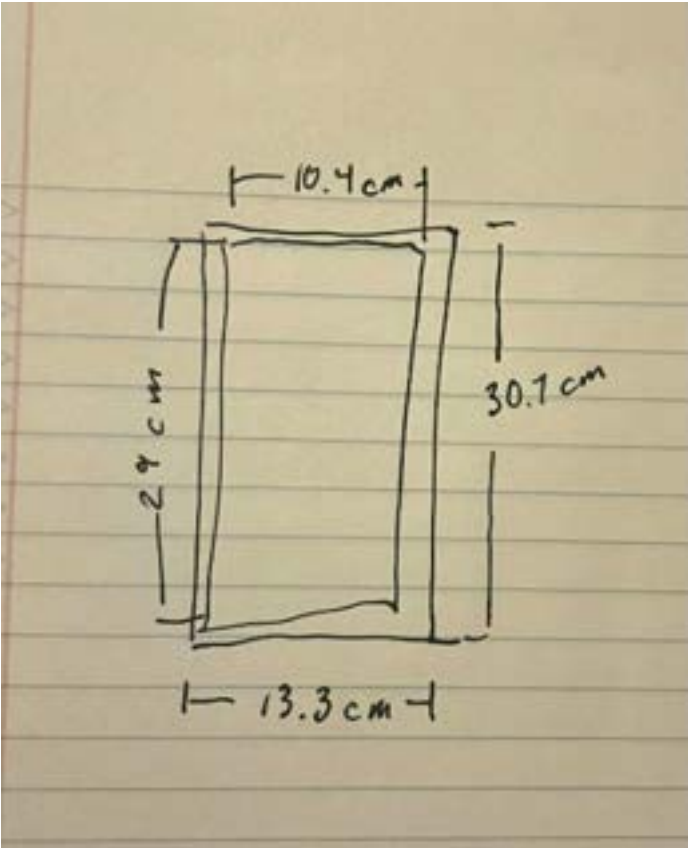
Picture of the newer concept2 footplate:



Picture of the older concept2:



Dimensions of footplate (seen above):





Conclusions/action items:

- Revise the PDS
- Continue background research and research potential design ideas.
- Get rowerg from Tricia



2024/02/09 - Client Zoom Meeting 1

ALLICIA MOELLER - Feb 12, 2024, 8:58 PM CST

Title: Client Zoom Meeting 1**Date:** 2/9/2024**Content by:** Colin Fessenden**Present:** Neha, Emily, Colin, Allicia, Jill, Sarah, Tricia**Goals:** Check-in with the client and figure out when we're getting the erg**Content:**

- Goal for next week:
 - 2 design matrix - display screen + force plate / load cell
 - Must be done Thursday 12:20pm
 - Allicia and Simmi = display matrix
 - Neha, Emily, and Colin = Force plate configuration matrix
 - Meeting at 6-6:30pm on Tuesday to assess design matrices on Zoom.
- Display:
 - Wants display directly in front of the rower so they don't have to rotate their shoulders
- Foot plate
 - Looking at better quality load cells and different shapes ones
 - Much more expensive (\$200-\$300 a piece) - these are the **most** expensive
 - Jill is looking into other steady money sources - she has talked to Dr. P
 - Looping in David Bell on funding
 - Too late for grants
 - Jill doesn't want money to be a hold-up
- Tricia has permission from the coaches about giving us an erg
 - Tricia will bring the erg to ECB on Monday at 2pm at the front glass doors
 - Colin will give Tricia his cell phone number
 - There's a learning curve with wheeling the erg

- Jill and Sarah out of town next weekend - push the meeting out to 2/23
- We sent out the PDS yesterday - let us know if you have any feedback

Conclusions/action items:

- Remind Tricia to bring the older model of the erg.



2024/02/23 - Client Zoom Meeting 2

ALLICIA MOELLER - Feb 23, 2024, 2:24 PM CST

Title: Client Zoom Meeting 2**Date:** 2/23/2024**Content by:** Allicia**Present:** Neha, Allicia, Colin, Tricia, Jill, Sarah, Simmi, Emily, David Bell**Goals:** To introduce the team to David and check-in before we order more materials.**Content:**

- David Bell - runs Wisconsin injury and sports lab - clinical researcher
 - Will be gone for the next 2 weeks, but would like to meet up with us and see the device in person
- We showed our load cell design matrix
- Is there a case where we could remove the flex foot - no. the flexfoot is very important
 - Allicia had a idea for how to test out the separated force plate
- Talked to Jacob Zeuske:
 - The bar load cell can pick up force anywhere on the cell, so orienting two load cells vertically would account for a large range of foot sizes
- Comment from Tricia - let her know if we need people for testing
- Neha talked with Brandon - fabrication of strain gauges (PCB) may be a good idea in the long run, but the load cell is more appropriate for this semester
- GUI + data collection:
 - Key metrics:
 - Peak force
 - How quickly they come to peak force
 - Asymmetry with this timing
 - After two or three minutes, who could set a bar there
 - If you hit 80-90% of it, it would be green
 - The clients liked the rising/falling bar graphs on the GUI
 - If the clients have any thoughts on how they want the GUI to look visually, they should draw it and send it over to us
 - Allicia showed the 4 parts she wants to get ordered from amazon (power cord, hdmi cord, microSD card, and LCD display), Jill said she can reimburse Allicia through venmo

Conclusions/action items:

- Order remaining materials for display (Allicia)
- Finalize the load cell we want to buy
- Look into getting grant for the load cells and other materials?



2024/03/15 - Client Zoom Meeting with Dr. Gruben

Title: Client Zoom Meeting with Dr. Gruben

Date: 3/15/2023

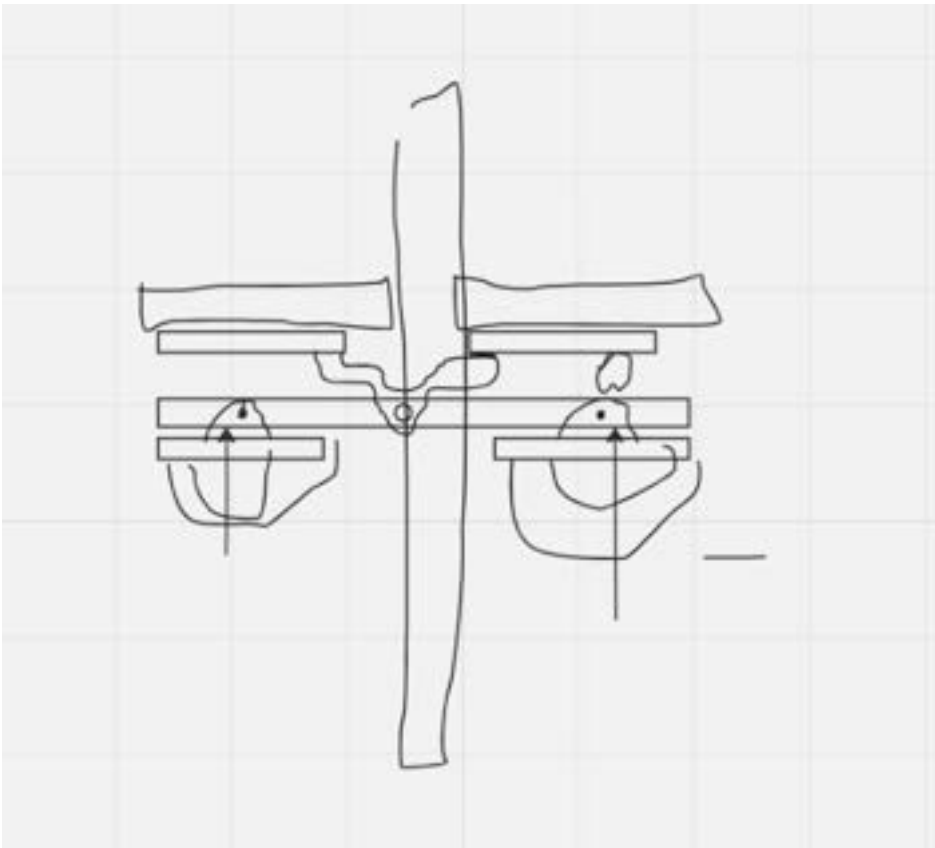
Content by: Allicia

Present: Allicia, Simmi, Emily, Jill, Tricia, Dr. Gruben, Sarah, Dr. Bell


Goals: To discuss the advice Dr. Gruben gave us about our force plate design and choose a path forward.

Content:

- Off - axis loading will cause for major error in force readings.
- Allicia:
 - Could we mitigate the errors of off-axis loading by 1) using button load cells (like last semester) 2) adding clamps along 2-axes to oppose the tangential force components of applied loads
 - We may need to add some kind of rolling/sliding mechanism so that allows normal translation of the plate.
 - This would work!
- Dr. Gruben's design:
 - Operating under the assumption that difference of force is the key data point we are trying to gather
 - Jill and Sarah agree the asymmetry is more important than raw data
 - There are some implementation issues - attaching the shaft
 - Reducing moment arm variability with extra footplates and pivots
 - risk of inversion/eversion of the foot
 - Rigid plate that rotates around a pivot with an angular encoder + 2 more pivots to guarantee COP
 - We could grab hardware from his lab
 - Using the IMU - would be useful to test out granularity of the IMU - may not be good enough



- Alternative to double pivots could be a pressure-sensing insole

- IMU design
-  IMG_5508.jpg

-
- If we could get rid of tangential forces, we could use cheap \$20 single axis load cells.
- Dr. Gruben invited us to his lab to look at ideas for frictionless supports and mounting ideas for the rotational design.

Conclusions/action items:

- Meet with Dr. Gruben 1:30pm Monday



2024/4/5 Client Zoom Meeting

SIMERJOT KAUR - Apr 08, 2024, 4:19 PM CDT

Title: Client Zoom Meeting with Dr. Gruben

Date: 3/15/2023

Content by: Simmi

Present: Simmi, Emily, Neha, Jill, Tricia, Sarah

Goals: To discuss the advice Dr. Gruben gave us about our force plate design and choose a path forward.

Content:

LSI - limb symmetry index - injured leg is 90% of the other leg

Dr. Jacobian,

Typical asymmetry is during the jump (takeoff jump data from healthy and injured athletes)

- This can be comparable to push off during rowing
- As high as a 5% difference
- Badger athletics program- most like rowing
- Healthy asymmetry might be as high 5%
- Can normalize with body weight
- Tricia is collecting rowers to collect data (lightweight, heavyweight, men's rower, openweight)
 - All are healthy
- Determine if a threshold is even necessary for injury
- Have healthy rowers (same class under the same weight)
 - Look at their difference
 - And then assess the other classes and adjust calibration factor
- Factors: weight and height (look at torso length, wingspan), leg mass to total mass ratio

Conclusions/action items:

- Create a testing protocol next week



2024/02/01 - Advisor Meeting 1

Title: Advisor Meeting 1**Date:** 2/1/2024**Content by:** Alicia**Present:** Alicia, Neha, Simmi, Emily, Colin, Sarah (TA), Dr. Puccinelli**Goals:** To discuss the scope of our project with Dr. Puccinelli and our preliminary research**Content:**

- What can we continue from last semester and what should we abandon?
- The project had 3 large components: The display element, the force transducing element, and integrating the force transducer into the foot plate. We want to divide and conquer these aspects of the project.
- Individual research:
 - Neha:
 - researched major differences between the ergs and the tanks and different testing set-ups.
 - Erg biomechanics research tends to utilize optical motion capture to measure kinematics. Could we utilize optical mocap for testing our force plates.
 - Note from Alicia: we could test at different stroke rates (stroke/min), we could also test expert vs non-expert rowers
 - We want to use the tank for our project because it is a more controlled environment, allows for sweep rowing, and tends to be used by PTs to test rowing performance.
 - Researched foil strain gauges and wheatstone bridge configuration for strain gauges (planning to research this more)
 - Emily:
 - Looked at differences between men and women rowers with lower back pain.
 - Note about the display: could we program a labquest?
 - Alicia:
 - Test method idea: Put load cell on top of force plates to test validity.
 - Looked at research on lower back pain in rowers - seems to be a correlation between pelvic tilt at the catch phase between rowers who experience back pain and those who do not.
 - Simmi:
 - python module in Arduino to connect them
 - Did research on texturing the footplate to prevent slippage - looked at if texturing would affect symmetry, comfort, and rowing performance. We should have a large number of rowers qualitatively test this out.
- Notes from Dr. P:
 - Think about your end user: will they be able to use matlab long term? Can we give them storage data in excel?
 - Do research on user interfaces and how to ensure data security.
 - We can ask a PT how they ensure data security.
 - ***Finish Progress reports before advisor meetings
 - ****Add details to the PDS - make sure it is very testable
- Note from Sarah: doing mocap may be beneficial for getting full body kinematic data because LBP may have multiple causes.
- Other notes:
 - Using the single-point load cell did not account for the distributed load of the foot. We want to try a bar load cell which accounts for distributed load by measuring force through moments. We could also try the 'combinator' which uses 4 load cells (like a scale) but that may increase the price beyond a budget.
 - We want to find a way to integrate arduino with matlab/python

Conclusions/action items:

- Finish progress report.
- Tomorrow (2/2), we are meeting with Ms.De Souza at the boat house to talk about project goals with her and investigate the dimensions of the tank.
- Build out a schedule for the semester and divide aspects of the project.



2024/02/08 - Advisor Meeting 2

Title: Advisor Meeting 2**Date:** 2/8/2024**Content by:** Alicia**Present:** Alicia, Neha, Simmi, Emily, Colin, Sarah (TA), Dr. Puccinelli**Goals:** To discuss the PDS and our individual research this week.**Content:**

- Neha:
 - HIPAA
 - Read about HIPAA considerations on privacy and security
 - We would be considered a business associate
 - Any electric transactions must be secure and confidential
 - We should talk to Jill and Tricia about this
 - Dr. P: there is a HIPAA compliance training course - may need permission to take this
 - <https://compliance.wisc.edu/hipaa/coordinators/>
 - Simmi: person in charge of HIPAA training: mitchell.sabesz@wisc.edu
 - Load cells
 - Load cells contain strain gauges
 - Not feasible to make our own load cell/strain gauge
 - Got clarification on strain gauges, potentiometer, pressure transducers, and force sensors
 - Pyfirmata library in IDE
 - Interfacing Arduino and python
 - Plans to test this out this weekend
 - Tkinter GUI
 - Using python to make GUI
 - Dr. P says this is used by Tkinter - imports CSV files - Dr. P says its a pretty nice interface
 - Look into a local webserver and using a browser to display data and information - more robust
 - Link to Dr. P's student's GitHub - <https://github.com/cnguyen0320/CanvasTools>
 - Look at "Canvas Assignment Editor"
 - Simmi:
 - Biological research on injury:
 - Ribs and lower spines are common injuries
 - Standards and specifications
 - ISO 20957 on athlete training equipment
 - Last semester, there was a graph that showed force output, but it was not clear which peaks correlated to which phase of the row
 - Looked at how to combine multiple load cells into one amplifier
 - Looking into make a Wheatstone bridge out of multiple load cells - not sure if this is feasible
 - Probably need to look outside of SparkFun
 - Ask Dr. N
 - Emily
 - Did a deep dive on load cells for the PDS
 - We're moving away from the point-load cell - looked into S shape 200 kg load cells (\$300-400)
 - budget issue
 - Colin
 - PDS:
 - Worked on quantifying the shelf life of our product
 - Found a maximum weight specification for our product
 - Max weight = 143 kg
 - Life in service
 - Found NCAA practice limitations to quantify how often this product will be used.
 - Need to assess how many rowers they have.
 - The integrity of our product should be checked every 250 hours of use
 - Alicia
 - Researched types of displays for Arduino that exist
 - Researched feasibility of touchscreens - uses too many GTIO pins
 - Need a large display screen with a fast refresh rate

- Do NOT need high resolution or color - slows down the display too much
- Will research more displays for the design matrix
- Dr. P will look for resource on how to live stream from Arduino to Google sheets

- Notes from Dr. P:
 - Start work in LabArchives then move it to PDS/other deliverables
 - Can make sub-headings in PDS ("Display", "Force Plate", etc.)
 - Turn marked-up version in on Canvas and upload clean version to website / send to client
 - https://bmedesign.engr.wisc.edu/projects/s18/casting_pressure - this project used some FSRs, may be helpful to this project
 - Could also build an app instead of display?

Conclusions/action items:

- Add headings to PDS, upload the annotated version to Canvas, email the clean version and add it to website.



2024/02/15 - Advisor Meeting 3

ALLICIA MOELLER - Feb 15, 2024, 12:57 PM CST

Title: Advisor Meeting 3

Date: 2/15/2024

Content by: Allicia

Present: Allicia, Neha, Emily, Colin, Sarah (TA), Dr. Puccinelli

Goals: Discuss the design matrices.

Content:

- Notes from Dr. P:
 - Load cell matrix:
 - Interference between load cells may be an issue (heel load cell may pick up force from the toe area)
 - Winning load cell design may not have enough adjustability
 - Show that minimum - maximum rower foot sizes all work
 - Could collect the foot sizes from rowing team
 - Maybe reduce weight of ease of fabrication and increase adjustability weight
 - Display matrix:
 - Do you have to save the data in the RAM before the SD card?
 - Talk to Dr. N about this
 - Surprised we didn't explore a phone app
 - Jacob Zeuske - expert on strain gauges and load cells
 - https://directory.engr.wisc.edu/cee/Staff/Zeuske_Jacob/
 - Might know a good place to buy load cells

Conclusions/action items:

- Start ordering materials now!
- Talk to Dr. N about raspberry pi and talk to Jacob Zeuske about load cells



2024/02/26 - Advisor Meeting 4

ALLICIA MOELLER - Feb 26, 2024, 1:05 PM CST

Title: Advisor Meeting 4

Date: 2/26/2024

Content by: Allicia

Present: Allicia, Emily, Neha, Simmi, Colin

Goals: To discuss our progress this week and discuss the preliminary presentation.

Content:

- It is Colin's birthday!
- Simmi:
 - Looked for bar load cells that would still function with our amplifier (HX711)
 - Found \$20-\$30 Amazon load cells - not sure how reliable they are
 - Load cells need to have 4 wires to be compatible with our current design
 - Note from Dr. P - check the datasheet and the reviews
 - Load cells from more 'reliable' vendors are \$200-\$300
 - May not need this level of accuracy
 - Found a website (circuitso.io) to make a fritzing diagram for the circuit including the load cells, amplifiers, raspberry pi, and display
- Neha:
 - Looked at more expensive bar load cells
 - Looked at manufacturing PCB load cells (made in the ECB clean room) - combined with accelerometer
 - This seemed like future work
 - Got a referral from a grad student for 'interface' load cells
 - Sealed beam load cell - \$375/each
 - Expensive load cells are more appropriate for dynamic loading
 - Plans to call interface to see if they recommend any specific products
 - We will also check-in with the clients to ask what they could budget for
 - Looked at metal plates on Grainger - aluminum should have enough yield strength
 - Planning to get CNC trained to help with fabrication
- Emily
 - Met with Jacob Zeuske on Wednesday
 - He advised that we should use a bar load cell, orient the bars vertically, and separate the toe and heel force plates
 - He offered some load cells for us to use - not sure about capacity
- Allicia
 - Ordered remaining materials for the display: microSD card, HDMI cord, power supply, and display
 - Made a demonstration GUI that shows rising and falling bar graphs that correlate with total foot force (left vs right)
 - Plans to make a new GUI demonstration for the clients with changing colors and a calibration period
- Colin
 - Looked at strength of 3D printed materials for footplates
 - Made a SolidWorks model of the erg footplate
 - Plans to make a SolidWorks representation of the load cell configuration and flex foot - making a full assembly
- Dr. P:
 - Bring a prop to preliminary presentation - bar load cell, GUI?

Conclusions/action items:

- Call interface
- Email Jacob Zeuske about load cells
- Finish preliminary presentation



02/14/2024 - Design Matrix Criteria

Title: Design Matrix Criteria

Date: 2/14/24

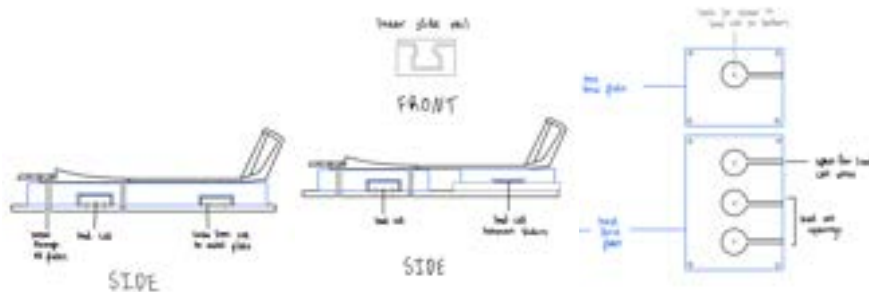
Content by: Colin Fessenden

Present: N/A

Goals: Define the criteria for the design matrix.

Content:

Load Cell Housing Matrix:



Criteria	Weight	Stationary Uniplate		Multi-Plate Slider		Multi-Plate Placer	
		Score (5 max)	Weighted Score	Score (5 max)	Weighted Score	Score (5 max)	Weighted Score
Reliability	25	5	25	4	20	2	10
Adjustability	25	2	10	5	25	3	15
Cost	20	4	16	3	12	4	16
Ease of Fabrication	20	5	20	3	12	4	16
Technique Interference	10	4	8	2	4	3	6
Sum	100	Sum	79	Sum	73	Sum	63

Figure 1: Design matrix used to rank the three Load Cell Housing design ideas. Each category is rated by importance and is used to determine an overall score for each design.

Load Cell Housing Matrix Category Descriptions:

The design matrix to determine the best location to install our device includes the following criteria: Reliability, Adjustability, cost, ease of fabrication, and impedance. Reliability refers to how well the load cell is secure in the housing and if it consistently relays data through the circuit during use of the RowERG. The Adjustability aspect of the matrix is how the load cell can be positioned in correlation to the flex foot positioning.

For rowers with longer feet, the flex foot and thus the load cell would need to be positioned lower. Cost is a criterion to ensure that we are taking into account the budget constraints before moving forward with a design and location. The Ease of fabrication category is how easily the design can be implemented to the current RowERG setup. Lastly, the impedance criterion refers to how the design may possibly hinder the rowing motion of the athlete. The goal of the design is to not inhibit the athlete's natural rowing motion.

Conclusions/action items:

Weigh all the categories with the designs and start ordering materials.



2/14/2024 - Design Matrix

Neha Kulkarni - Feb 14, 2024, 11:26 PM CST

Title: Design Matrix Criteria

Date: 2/14/24

Content by: Team

Present: Team

Goals: Evaluate preliminary designs using a design matrix

Content:

See attached

Conclusions/Action items: Discuss these evaluations with advisor and client, and make adjustments to evaluations as necessary based on their feedback. After discussion, decide on a preliminary design and begin to make fabrication plans to order parts.

Neha Kulkarni - Feb 14, 2024, 11:26 PM CST



DESIGN MATRIX: FORCE SENSOR FOR ROWING BIOMECHANICS

February 13, 2024

2:40:00

Client: Dr. Jill Thain-Stanburn, Ms. Erika De Souza, and Sarah Smith

Advisor: Dr. John Pridemore

Team Members:

Team Leader: Neha Kulkarni

Commissioner: George East

EMG: Zach Walczak

EMG: Colin Pincus

EMG: Allen Mordy

[Download](#)

Design_Matrix_-_Rowing_Biomechanics.pdf (548 kB)



2024/02/15 - Display Design Matrix

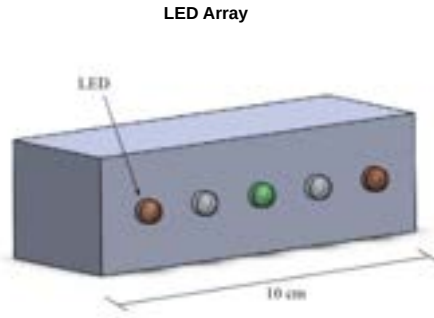
Title: Display Design Matrix

Date: 2/15/2024

Content by: Alicia Moeller

Goals: To brainstorm and research content for the display design matrix

Content:

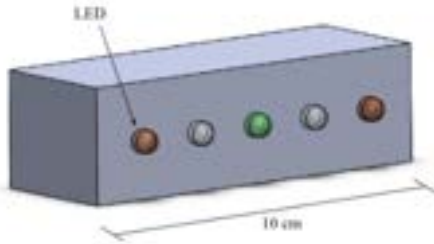


Criteria	Weight	Score	Weighted	Score	Weighted	Score	Weighted
		(5 max)	Score	(5 max)	Score	(5 max)	Score
User experience	35	3/5		5/5		5/5	
Value of data	20	2/5		4/5		5/5	
Frame rate	25	5/5		3/5		5/5	
Ease of Fabrication	10	5/5		3/5		4/5	
Cost	10	5/5		4/5		2/5	
Sum	100	Sum		Sum		Sum	

Criteria:

- User experience
 - User friendly
 - Visual appeal
 - Interpretability - how easily can the user interpret the data
- Refresh rate
 - At least 24 Hz per PDS
- Value of data
 - How rich is the data you are communicating?
 - How easily can you store the data?
- Ease of fabrication
 - Programming and hardware
- Cost

Idea #1: LED Array



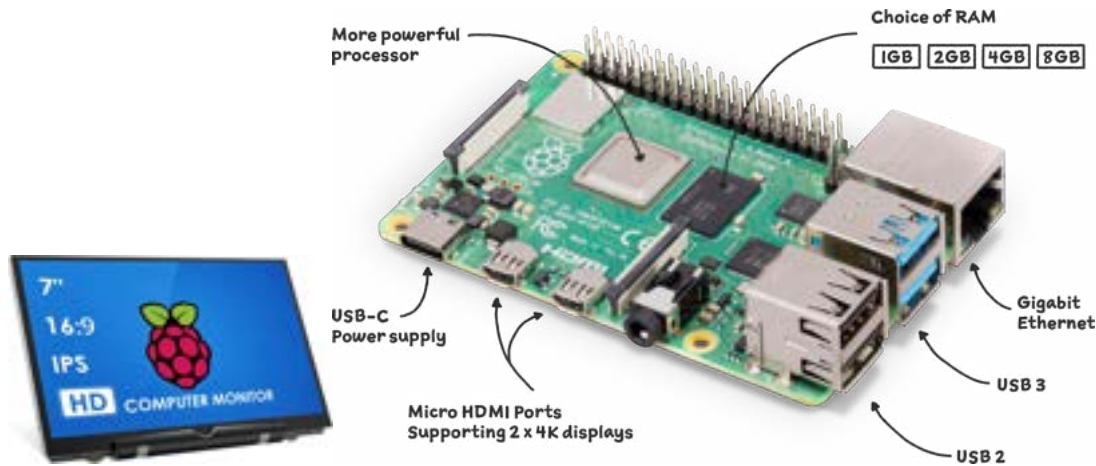
- No monitor, just LEDs connected to the microcontroller to indicate whether you crossed an asymmetry threshold.
- Left red, right red, center green
- Compares full foot force (not toe and heel)
- Strengths:
 - Cheap - basically just the wall adapter
 - Extremely simple
 - Can be integrated into arduino
 - Uses 4-5 GPIO pins (digital)
 - Fast refresh rate
- Weaknesses:
 - Only gives whole foot force data
 - Can only work in the digital (not analog) realm, rower can not see their foot force increasing/decreasing in real-time

Idea #2: Arduino - LCD Display



- Buy a 5" LCD Display that can be connected to a Arduino Uno
- Strengths
 - Can be integrated into current design (Arduino Uno)
 - Much richer data - GUI
- Weaknesses
 - Not sure how easy GUI will be - tkinter to make a basic GUI
 - Lower refresh rate than Raspberry pi - don't have the number so it may not be an issue
 - Cost
 - <https://www.buydisplay.com/tft-5-inch-lcd-display-module-controller-board-serial-i2c-ra8875> - \$35
 - Wall adapter - \$8
 - Uses some of the Arduino GPIO pins (I2C)
 - Smaller display (Arduino can't support very large displays)
 - Arduino on-board storage is still an issue
 - We could look into the microSD card module? - uses more GPIO pins + additional costs
 - Could be difficult to integrate into the tank

Idea #3: Raspberry Pi - HDMI Display



- Buy a 7" LCD Display that can be connected to a Raspberry Pi microcontroller via HDMI
- Build a GUI with TkInter (Neha dub) or any python-based GUI library!
 - shows real-time heel/toe force on the right and left side with graphics
 - Flashes red/yellow/green when to assess symmetry
- Strengths
 - Fast refresh rate (I think 60 Hz)
 - Can provide very rich real-time data because of GUI
 - Easily provide heel/toe differences
 - Probably easy data storage (see below)
 - Large display
 - Leaves 40 GPIO pins open on raspberry pi for force plate
 - Could explore wifi capabilities
 - Can program everything in python - yay
 - A more analog version - can see force increase/decrease in real time
- Weaknesses
 - Cost:
 - Raspberry Pi 4 - 1GB RAM - \$35
 - 7" Non-touch display screen - \$34
 - Wall adapter - \$8
 - Integration could be difficult - may need to build a stand/base (see below)
 - Load cells may not be compatible

Additional ideas:

- The raspberry pi can connect to any monitor with an HDMI port (resolution is the main constraint). We could buy a cheap computer monitor and have it sit in front of t
 - https://discountelectronics.com/miscellaneous-refurbished-19-lcd-monitors/?gad_source=1&gclid=Cj0KCQiAw6yuBhDrARisACf94RWwBDM9HtFhTeJiKc6TLOxgnOxksQYxM9t5Fv4D1Ycn91MUfcoq-v4aApbJEALw_wcB
 - Shop UW
 - Raspberry pi can support 4k resolution at 60 fps
- Do we need 1GB, 2GB, 4GB, or 6GB of RAM for raspberry pi - research this more - greatly affects price
- Explore touchscreen more?

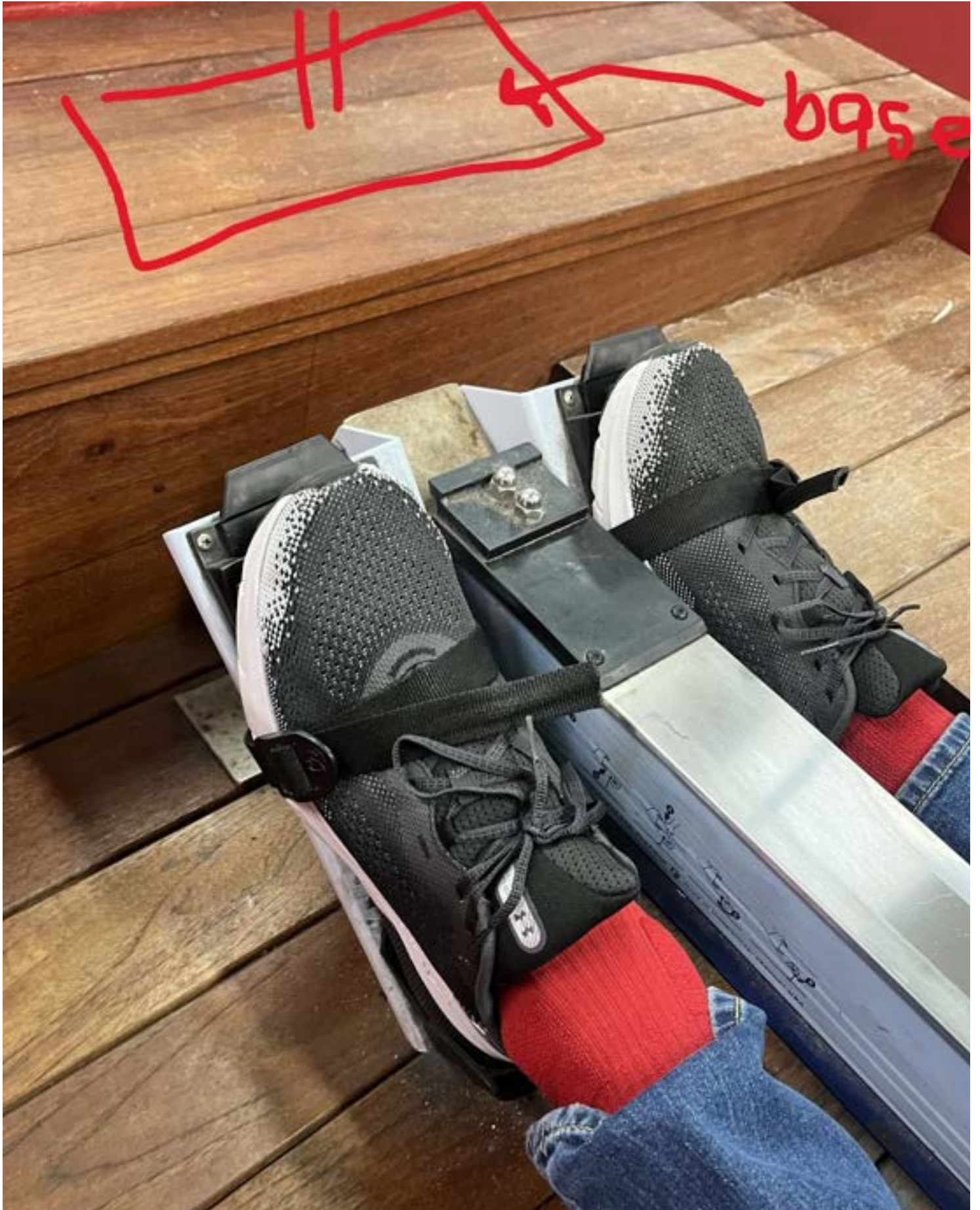
- <https://www.waveshare.com/7inch-HDMI-LCD-C.htm>
- <https://thepihut.com/products/official-raspberry-pi-7-touchscreen-display>
- Raspberry pi seems to have some wifi capabilities - may be helpful with data storage? Look into making a NAS
- [Wall power adapter!](#)

Data storage:

- I'm still a little unclear about storage of the raspberry pi - it seems that you can store local files on the microSD card and insert/remove it.
- There may be a way to plug in a usb drive, save data to it, then remove it and open its files on a computer
 - If we go with this route we should at least write a python/matlab script to analyze/visualize the data and show the clients how to run it
 - Ideally, we would convert our data analysis script into an executable file with a VERY minimal interface - more user friendly.
 - <https://towardsdatascience.com/convert-your-python-code-into-a-windows-application-exe-file-28aa5daf2564>
 - <https://towardsdatascience.com/how-to-easily-convert-a-python-script-to-an-executable-file-exe-4966e253c7e9>
 - I don't know what the security implications are for this.

Integration into tank:

- Not exactly sure how this is going to work!
- I imagine we build some kind of attachment that can clip/screw onto the erg part of the tank and telescope upwards
 - We could 3d print a case for the monitor/LED array and make it attach straight into the post.
- We could just set the display on a stand in front of the tank



Conclusions/action items:

Finalize the scores.



2024/03/19 - Bearing support force plate

Title: Bearing support force plate

Date: 3/19/2024

Content by: Alicia

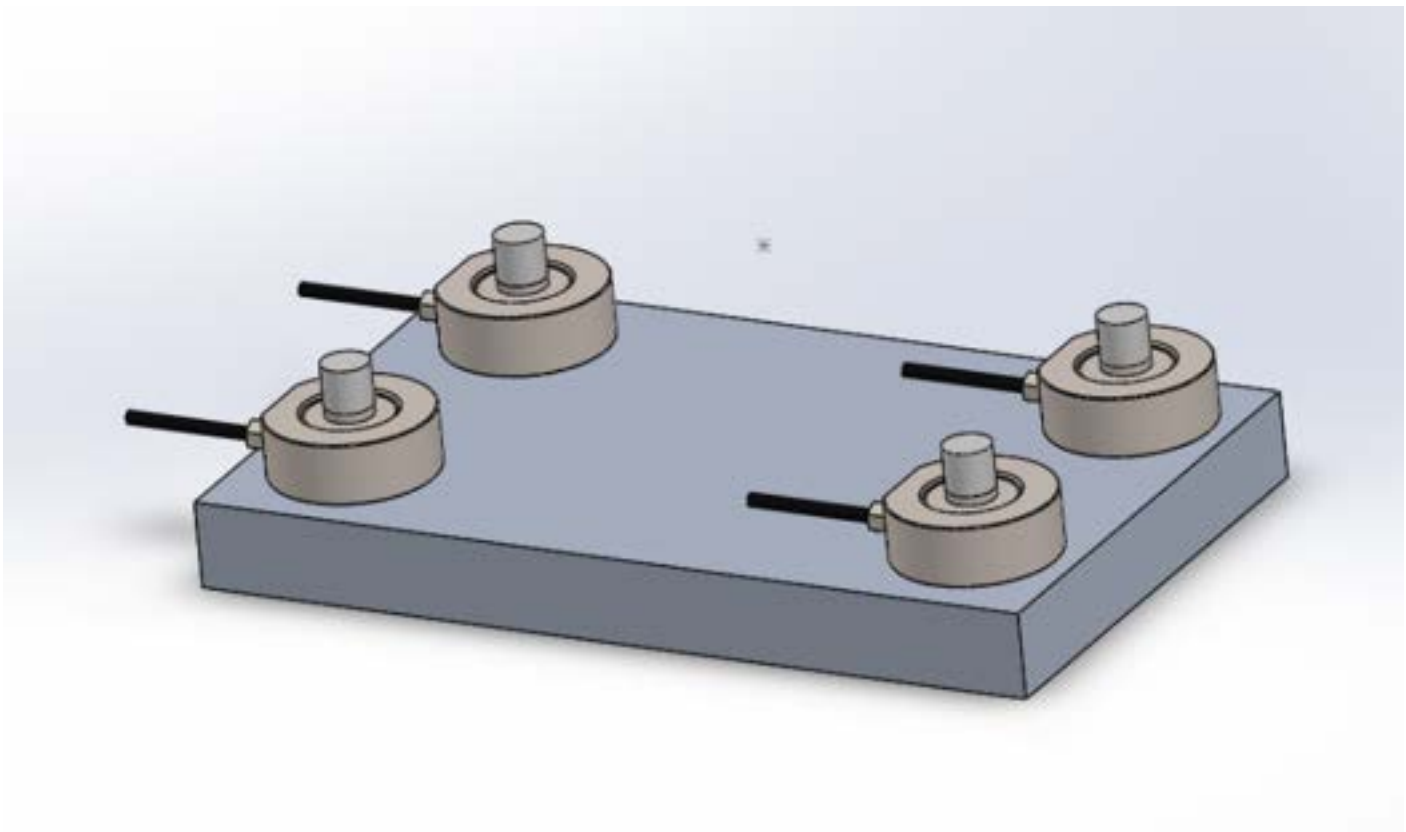
Goals: To visualize a design idea that uses bearing supports to isolate the normal force component on the force plate.

Content:

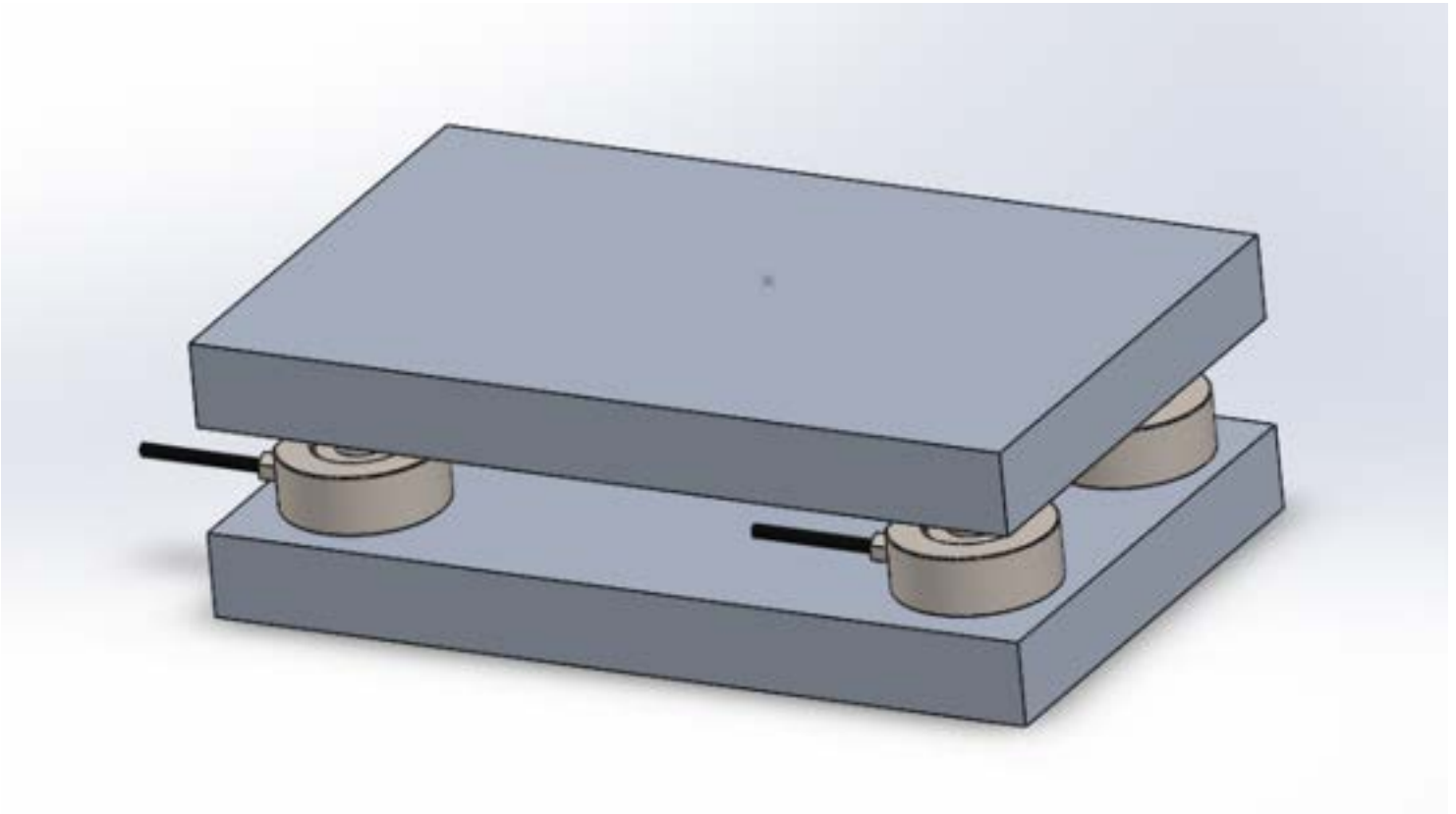
After meeting with Dr. Gruben on Friday, March 15, we discussed the possibility of creating a support structure that utilizes thrust bearings to create frictionless supports that "cancel out" applied tangential force components, so that the load cell(s) only pick up the normal component of the applied force. If implemented correctly, this would solve the issue of off-axis loading.

CAD visualization:

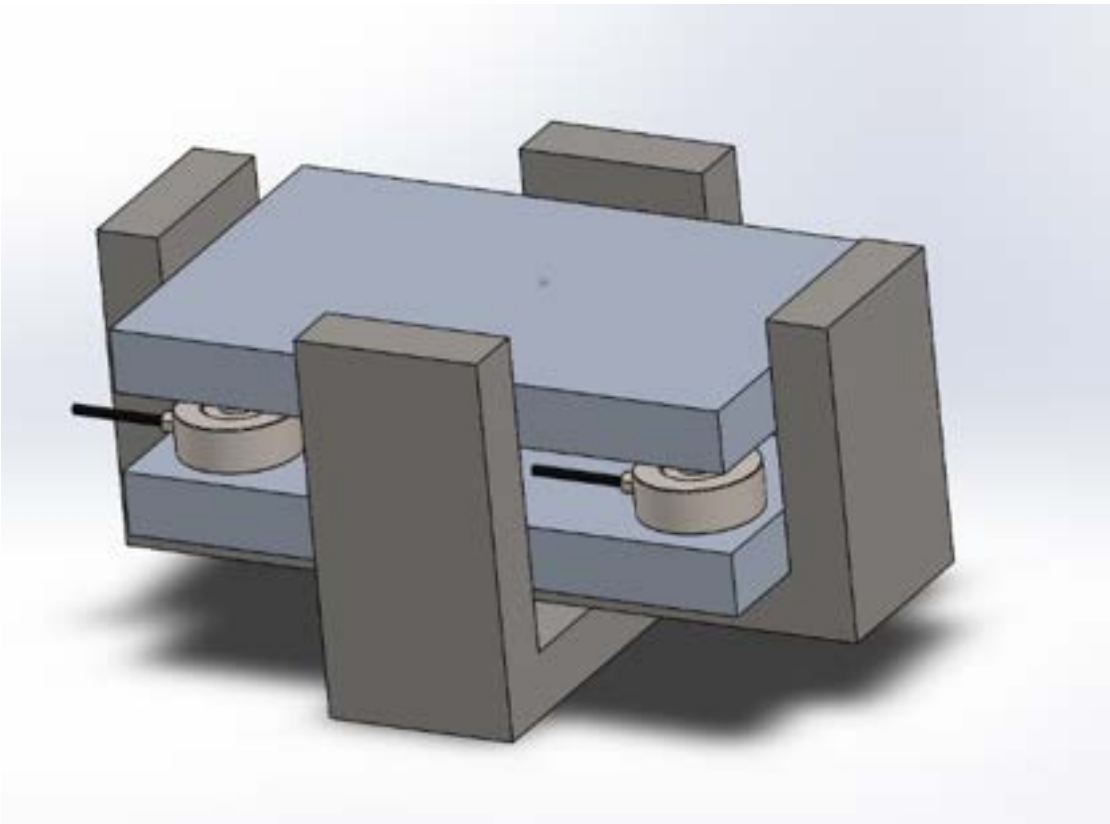
1. First we have a base plate (for one foot) that would be mounted to the erg footplate. In this CAD model, I used 4 button load cells (1 in each corner), then added a small rubber cylinder on top of the force-sensing part of each button load cell to transmit the force correctly.



2. Then we mount a plate on top of this structure. This would be the surface that the rower pushes on with one of their feet. This issue that this creates is that the rower can push on the top plate at a variety of angles, inducing shear forces on the load cells, which causes significant errors in force readings.



3. In order to offset tangential force components, we add 2 rigid supports (one for the x and one for the y direction). These supports would introduce normal reaction forces due to friction, but this can be minimized or eliminated by adding ball bearings to the contact surfaces between the top plate and the rigid supports. Dr. Gruben mentioned we could also add a ball bearing on top of each load cell (between the load cell and top plate) to further eliminate shear forces.



This CAD model is purely for visualization of the concept of force component isolation using supports and bearings. Dr. Gruben verified that this design would work, however, some issues that arise are that thrust bearings will wear over time, and the balls will become less smooth over time. The advantage of this solution is that it retains our ability to read absolute normal force.

Conclusions/action items:

Figure out the materials required to fabricate this design.



2024/03/19 - Pivot design

Title: Pivot Design

Date: 3/19/2024

Content by: Alicia

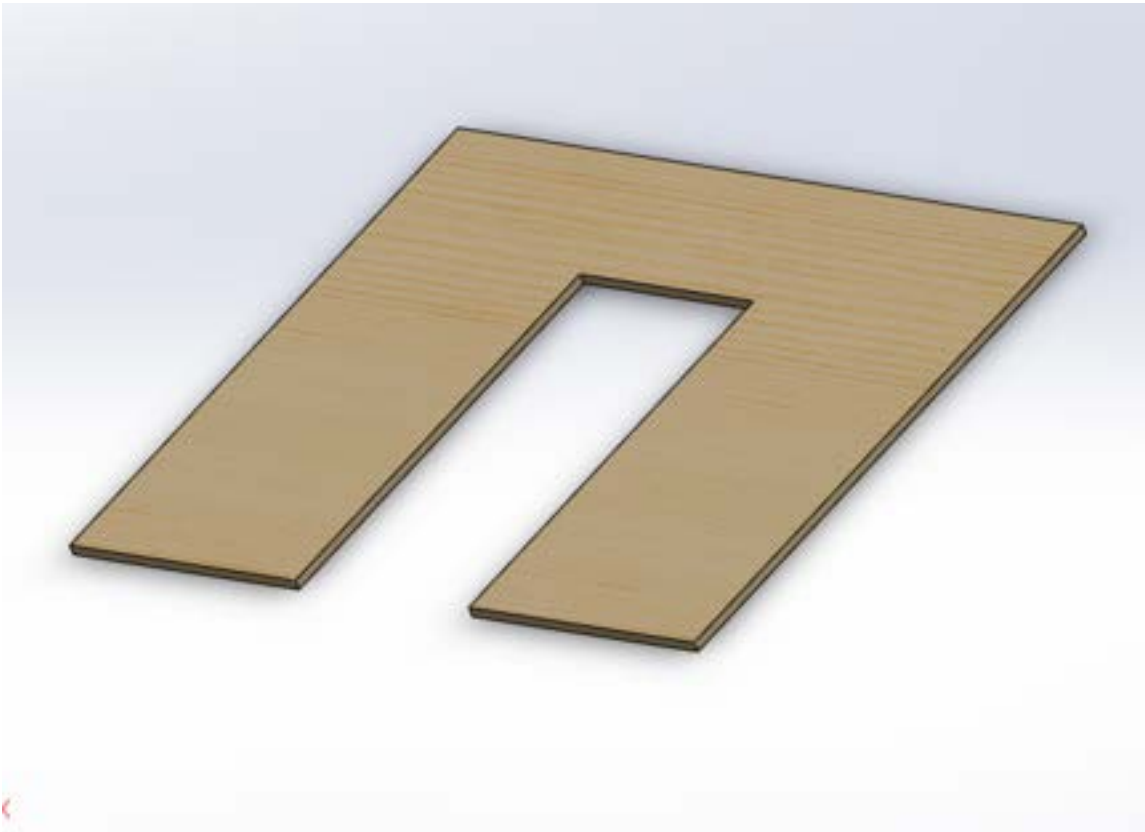
Goals: To make a CAD model of Dr. Gruben's pivot design for prototype fabrication purposes.

Content:

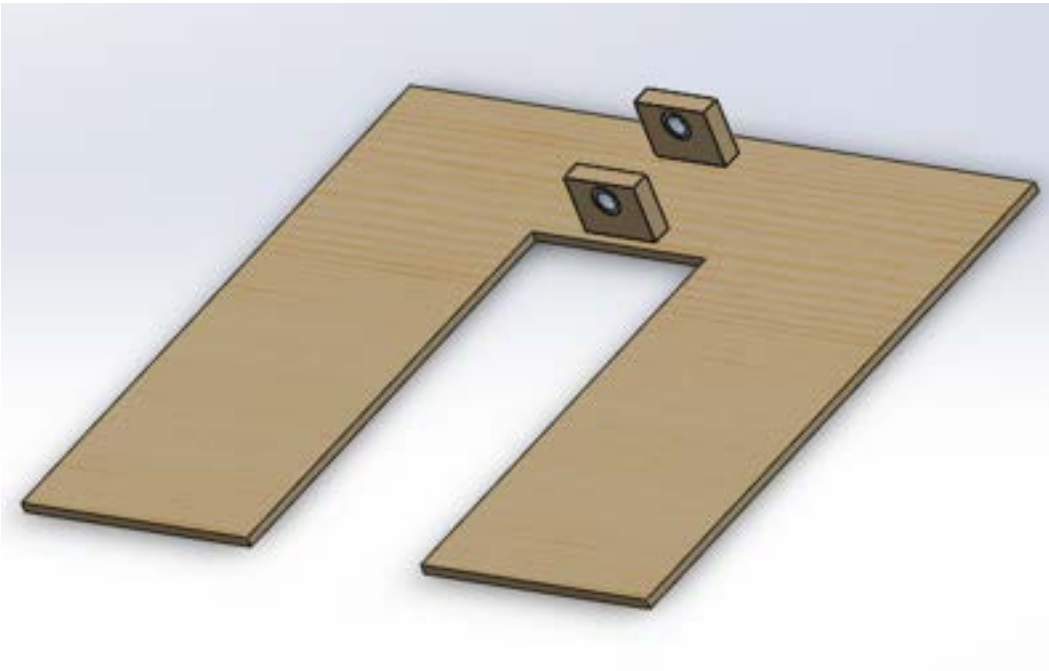
The team has decided to move forward with the pivot design to mechanically isolate normal force difference. To be accurate, the pivot design provides a difference in torque, not force, but we will make the assumption that the rower's force is acting through a medio-lateral COP that is equidistant from the pivot on the right and left. I did not include dimensions, because I want to verify the dimensions when I get a chance to measure the erg again. This CAD model is more of an approximation of a possible first prototype.

CAD model explanation:

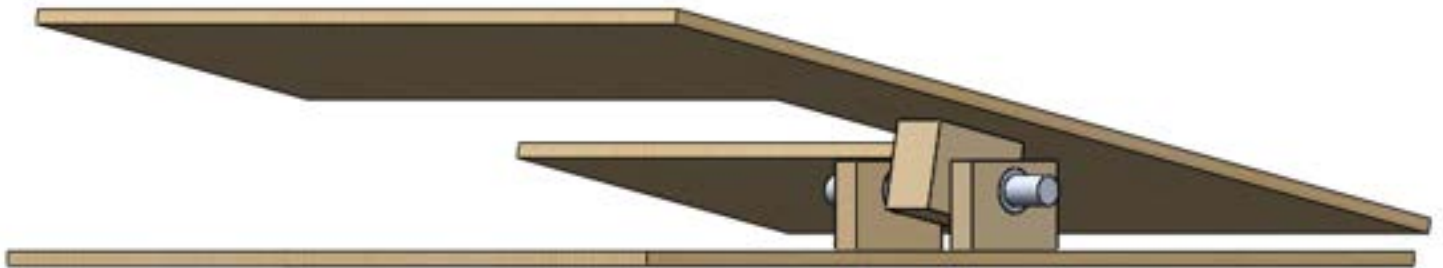
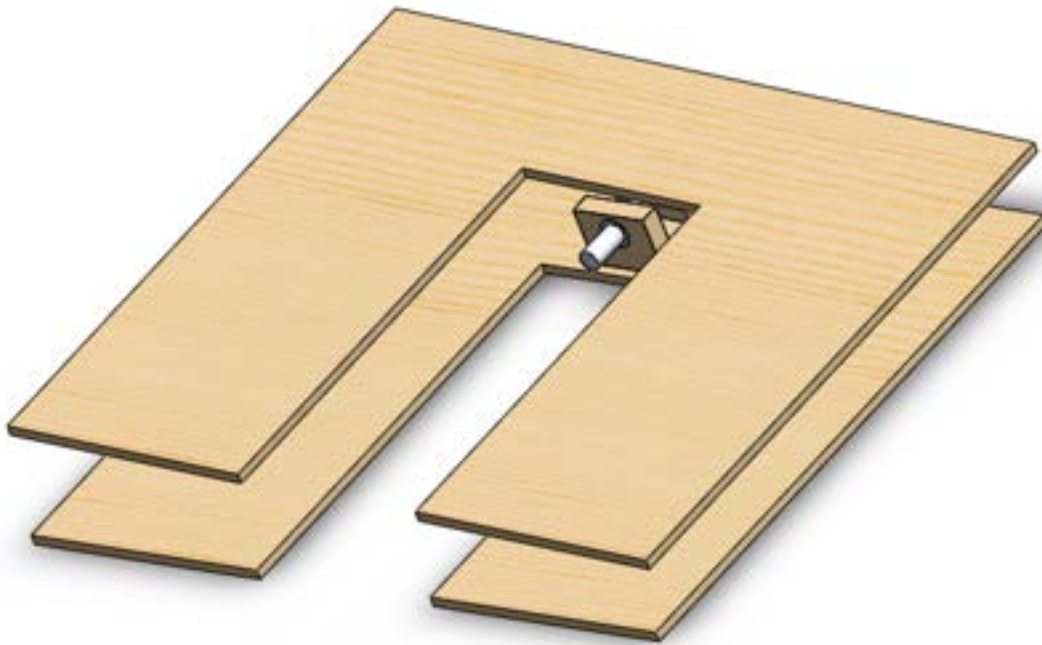
1. We start with a U-shaped plywood base plate that can be mounted to the existing erg footplates.



2. Then we screw 2 bearing collars with ball bearings onto the bridge portion of the base plate. These will hold a shaft and allow frictionless rotation of that shaft.



3. Then we add a top plate with a fixed shaft-collar that rotates with the shaft.



4. Then we will attach the angular encoder to the rotating shaft and sandwich foam or springs between the top plate and the base plate. Dr. Gruben informed us that foam would work essentially the same as a spring, except there would be a damping factor that may cause a miniscule time lag. We plan to prototype with foam (for simplicity) then update it to springs for better accuracy.

Conclusions/action items:

Divide and conquer prototype fabrication!



2024/04/03 - Preliminary Materials

EMILY WADZINSKI - Apr 08, 2024, 9:28 PM CDT

Title: Preliminary Materials and Expenses

Date: 4/3/2024

Content by: Emily

Goals: add expenses

Content:

Item	Description	Manufac-turer	Mft Pt#	Vendor	Vendor Cat#	Date	#	Cost Each	Total	Link
Electronics										
Raspberry Pi	Microcontroller	Raspberry Pi		Sparkfun	DEV-15446	2/15	1	\$45	\$60.43	Link
Raspberry Pi	7" Display Screen	Raspberry Pi		Amazon		2/23	1	\$33.99	\$33.99	
Raspberry Pi	20W 5V 4A Power Supply	Raspberry Pi		Amazon		2/23	1	\$11.99	\$11.99	
MicroSD Card	32GB 3D NAND High Speed MicroSD Card with Adapter	Silicon Power USA		Amazon		2/23	1	\$8.99	\$8.99	
HDMI Cable	4K Micro HDMI to HDMI Cable 1 FT Adapter 2.0	Szsea US		Amazon		2/23	1	\$8.99	\$8.99	
Display Case	7" Raspberry Pi Case Holder	Longruner		Amazon		3/18	1	\$13.99	\$13.99	Link
Raw Materials										
Wood Scrap	TEAM Lab					3/23		\$0.00	\$0.00	
Aluminum Scrap	TEAM Lab					4/3		\$0.00	\$0.00	
								TOTAL:	\$138.38	



2024/04/05 - Footplate Materials

EMILY WADZINSKI - Apr 08, 2024, 9:31 PM CDT

Title: Footplate Materials

Date: 4/5/2024

Content by: Emily

Goals: add expenses

Content:

Undersized Rotary Shaft	4149N15	1/2" diameter, 12" length	Link	\$22.18	1	\$22.18	
Aluminum Easy-Access Base-Mounted Shaft Support	1865K3	Low-Profile T-Shaped, for 1/2" shaft dia.	Link	\$28.20	1	\$28.20	
Low-Profile Mounted Sealed Steel Ball Bearing	5913K6	with Set Screw, for 1/2" shaft dia.	Link	\$10.95	2	\$21.90	
Aluminum Bolt-Together Framing	8809T7-8809T21	1-1/2" Square Rail, 6 ft length	Link	\$47.20	1	\$47.20	
Marine-Grade Plywood Sheet	1125T23	24" x 24" x 3/8"	Link	\$33.71	1	\$33.71	
Corner Surface Bracket	4931T221		Link	\$9.96	8	\$79.68	
Load-Rated Threaded Bumpers	9377K23	2" height	Link	\$26.67	2	\$53.34	*They come in packs of 4 so we are ordering 2 packs of 4
Compression Spring	9657K695	352 max load	Link	\$10.06	8	\$80.48	
Compression Spring	9657K374	124 max load	Link	\$12.96	2	\$25.92	*They come in packs of 6 so we are ordering 2 packs of 6
					total	\$392.61	



2024/05/01 - Expenses sheet

Title: Materials**Date:** 5/1/2024**Content by:** Colin Fessenden**Goals:** add expenses**Content:**

Materials and expenses

Item	Description	Manufacturer	Mft Pt#	Vendor	Vendor Cat#	Date	#	Cost Each	Total	Link
Electronics										
Raspberry Pi	Microcontroller	Raspberry Pi		Sparkfun	DEV-15446	2/15	1	\$45	\$60.43	Link
Raspberry Pi	7" Display Screen	Raspberry Pi		Amazon		2/23	1	\$33.99	\$33.99	
Raspberry Pi	20W 5V 4A Power Supply	Raspberry Pi		Amazon		2/23	1	\$11.99	\$11.99	
MicroSD Card	32GB 3D NAND High Speed MicroSD Card with Adapter	Silicon Power USA		Amazon		2/23	1	\$8.99	\$8.99	
HDMI Cable	4K Micro HDMI to HDMI Cable 1 FT Adapter 2.0	Szsea US		Amazon		2/23	1	\$8.99	\$8.99	
Display Case	7" Raspberry Pi Case Holder	Longrunner		Amazon		3/18	1	\$13.99	\$13.99	Link
Undersized Rotary Shaft	1/2" diameter, 12" length	McMaster Carr	4149N15	McMaster Carr		4/05	1	\$22.18	\$22.18	Link
Aluminum Easy-Access Base-Mounted Shaft Support	Low-Profile T-Shaped, for 1/2" shaft dia.	McMaster Carr	1865K3	McMaster Carr		4/05	1	\$28.20	\$28.20	Link
Low-Profile Mounted Sealed Steel Ball Bearing	with Set Screw, for 1/2" shaft dia.	McMaster Carr	5913K6	McMaster Carr		4/05	2	\$10.95	\$21.90	Link
Aluminum Bolt-Together Framing	1-1/2" Square Rail, 6 ft length	McMaster Carr	8809T7-8809T21	McMaster Carr		4/05	1	\$47.20	\$47.20	Link
Marine-Grade Plywood Sheet	24" x 24" x 3/8"	McMaster Carr	1125T23	McMaster Carr		4/05	1	\$33.71	\$33.71	Link
Corner Surface Bracket		McMaster Carr	4931T221	McMaster Carr		4/05	8	\$9.96	\$79.68	Link
Load-Rated Threaded Bumpers	2" height	McMaster Carr	9377K23	McMaster Carr		4/05	2	\$26.67	\$53.34	Link

Compression Spring	352 max load	McMaster Carr	9657K695	McMaster Carr		4/05	8	\$10.06	\$80.48	Link
Compression Spring	124 max load	McMaster Carr	9657K374	McMaster Carr		4/05	2	\$25.92	\$25.92	Link
Raw Materials										
Wood Scrap	TEAM Lab					3/23		\$0.00	\$0.00	
Aluminum Scrap	TEAM Lab					4/3		\$0.00	\$0.00	
8" Aluminum Rod	TEAM Lab					4/18		\$8.27	\$8.27	
								TOTAL:	\$539.26	



2024/03/20 - Initial Prototyping Brainstorm

Title: First Prototyping Attempt

Date: 3/20/2024

Content by: Emily

Present: All

Goals: To make a preliminary model of the pivot design

Content:

The team headed down to the TEAM Lab to begin modeling our ideas. To start, we measured the footplates and screw locations on scratch paper, then translated these measurements onto cardboard. The cardboard footplate's measurements were double checked by placing it on the ergometer, as seen in the first picture. Then, the cardboard's shape was outlined onto a piece of MDF. The MDF was trimmed with a saw, then sanded down as seen in the second picture with Colin. The MDF was taken back up to the erg, placed on top, and marks for the screw holes were made on the backside. The MDF plate was taken back downstairs for drilling. The piece was clamped and 8 total holes were made using a 5mm drill bit. (Picture 3)



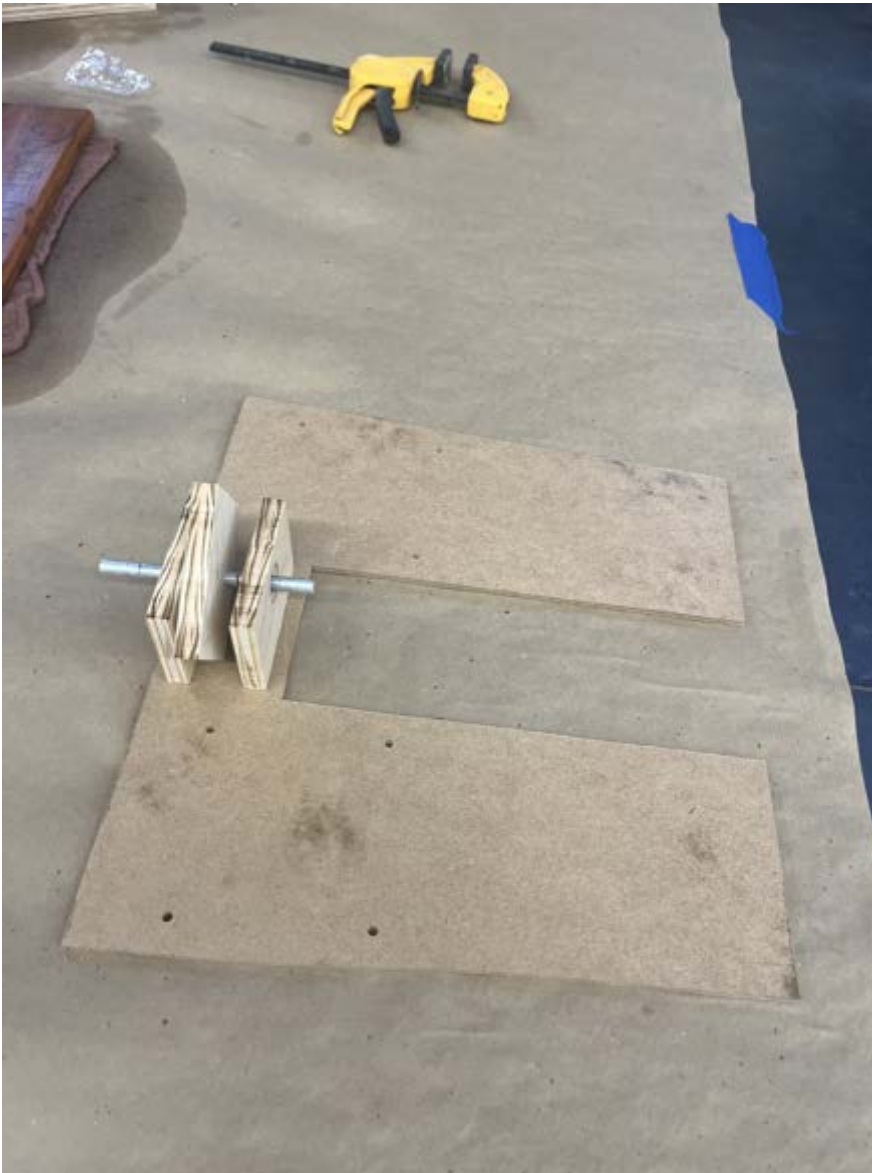




Next, the rotating shaft was fabricated. Three scrap pieces of wood were drilled into to create a hole for bearings. The two bearings were provided by Dr. Gruben. Then the bearings were hammered into 2 wood pieces into their form-fitting holes. A metal rod was then cut to a shorter length and placed inside the bearings as a shaft, as seen in the following pictures. Then the blocks were placed onto the MDF footplate. Holes were drilled into the footplate and wood pieces in order to then screw it all together. (Picture 6)







Conclusion:

Make upper footplate next



2024/04/16 - Prototype Fabrication Day 1

Title: Prototype Fabrication Day 1

Date: 4/16/2024

Content by: Neha

Present: All

Goals: To make a preliminary model of the pivot design

Content:

after unboxing materials yesterday, we got going on fabrication by:

1. Tracing, marking and cutting the scrap we found in the TEAMLab for the baseplate and the top plate to fit the erg dimensions.
2. Drilling holes into the baseplate and top plate to fit the screws for the Flexfoot and ergometer footplate
 1. We used a 5mm drill bit for these.
3. Drilling holes into the baseplate for the bearing mount and finding the right screws and nuts to secure it
 1. We found 1/4-20 round head screws and nylon nuts.
 2. We used a 1/20 drill bit to drill the holes.
4. Creating a coupling for the plate shaft to be attached to the encoder shaft
 1. This was done on the lathe by drilling holes to fit both shafts on either side of round aluminum stock. Holes for set screws were also drilled and set screws were used to secure the shaft.

By the end of day 1, the prototype looked like this:



Conclusion/Action Items to Do on Day 2:

1. make insert on shaft mount to increase its clearance
2. drill holes into top plate and trim because the footplate parts are too wide
3. trim the shaft
4. create spring mounts and/or rubber bumper mounts



2024/04/17 - Prototype Fabrication Day 2

Title: Prototype Fabrication Day 2

Date: 4/17/2024

Content by: Neha

Present: All

Goals: To make a prototype of the pivot design

Content:

after yesterday's progress, today we continued fabrication by:

1. Trimming top plate and drilling holes into it for Flexfoot attachment
 1. Trimmed on the bandsaw, used 5mm drill bit to drill on the drill press
2. Trimming shaft to size on the dropsaw.
3. Creating block to sit. on top of shaft mount to increase its clearance over the bearings
 1. Took aluminum stock and cut it down to size
 2. Drilled two holes to align with purchased shaft mount holes using size 20 drill bit
 3. Used 8-32 pan head screws to secure top plate, clearance block, and shaft mount together
4. Machining spring mount
 1. Turned down large round stock on the lathe to just larger than the diameter of the spring so spring fits over it and can still move up and down
 2. Repeated so there were four spring mounts for four springs
5. Preparing rubber bumpers
 1. Hacksawed threaded ends of rubber bumpers and sanded down sharp edges
6. Attaching prototype to erg - the best method is:
 1. Assemble and screw bearing mounts, shaft, and shaft mount onto baseplate
 2. Screw Flexfoot onto top plate
 3. Screw top plate onto shaft mount with clearance block in between
 4. Screw entire assembly onto erg

By the end of day 2, the prototype looked like this:



Conclusion/Action Items to Do:

1. mount encoder
2. mount springs
3. calibrate force to change in angle
4. make circuit and display look cleaner (solder onto board, circuitry box, display stand?)
5. add support board to top plate because metal was bending?
6. TEST!



2024/04/18 - Final Prototyping

Title: Fabrication of Final Prototype

Date: 4/18/2024

Content by: Emily

Present: All

Goals: To make a prototype of the pivot design

Content:

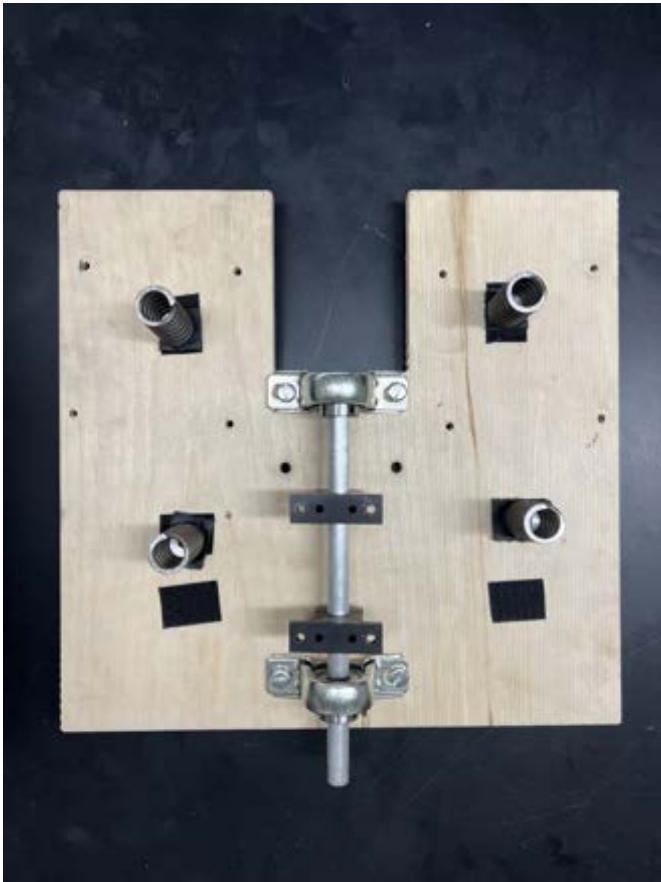
We were advised by TEAM Lab staff that the metal we used for the top footplate is too flimsy and the stability of the device is hindered with the shaft supports only located at the top of the plates. Instead we came up with another iteration that shifts the whole design up the footplate by a couple inches. This displacement allows for the shaft bearings and supports to be located in the center of the plate. We also switched to thicker plywood in which a TEAM Lab staff member nicely used the waterjet to cut out the plates for us. Holes were cut into the wood with the jet as well. Components were mainly attached using bolts and nuts

To mount the encoder to the footplate and secure its base a coupler was made, which attaches to both the footplate's shaft and encoder's shaft. A wooden block and metal bracket was used to secure the base of the encoder.

Two different compression springs were found in the lab and short aluminum supports were made for both of kinds of springs using the lathe. Velcro was used to attach the springs to the footplate and for easy removal to change between spring types.

After discussion with the client, they recommended to heighten the seat since our new design sticks out from the original erg footplate. In order to counteract the design, the seat needs to be upped about 6 inches. Wooden blocks were drilled and put in between the seat and mount to give height.







Conclusion:

Protocol section under Team Activities has the complete fabrication protocol.



2024/04/23 - 2nd Encoder-Shaft Couple

EMILY WADZINSKI - May 03, 2024, 7:29 PM CDT

Title: Final Coupler

Date: 4/23/2024

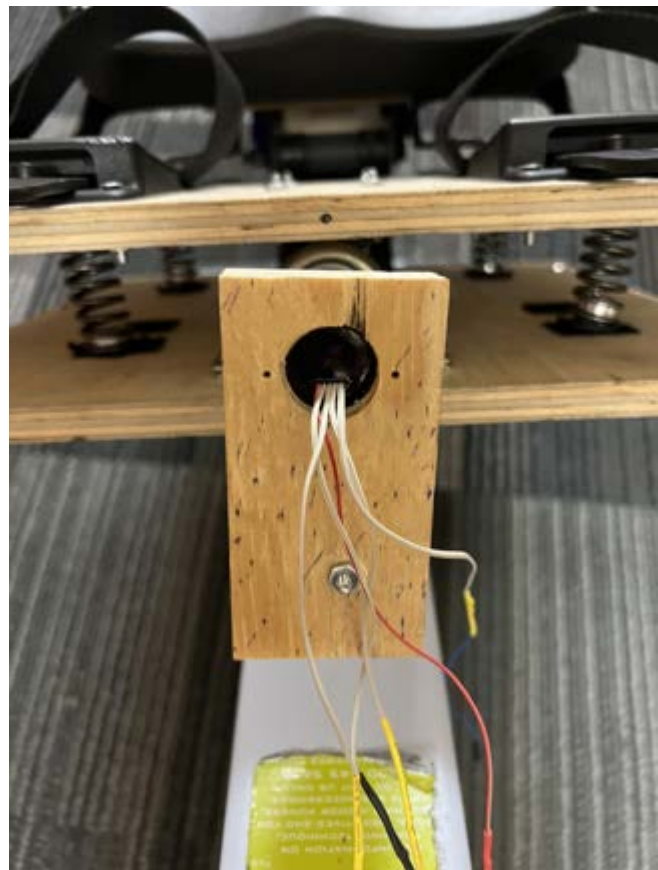
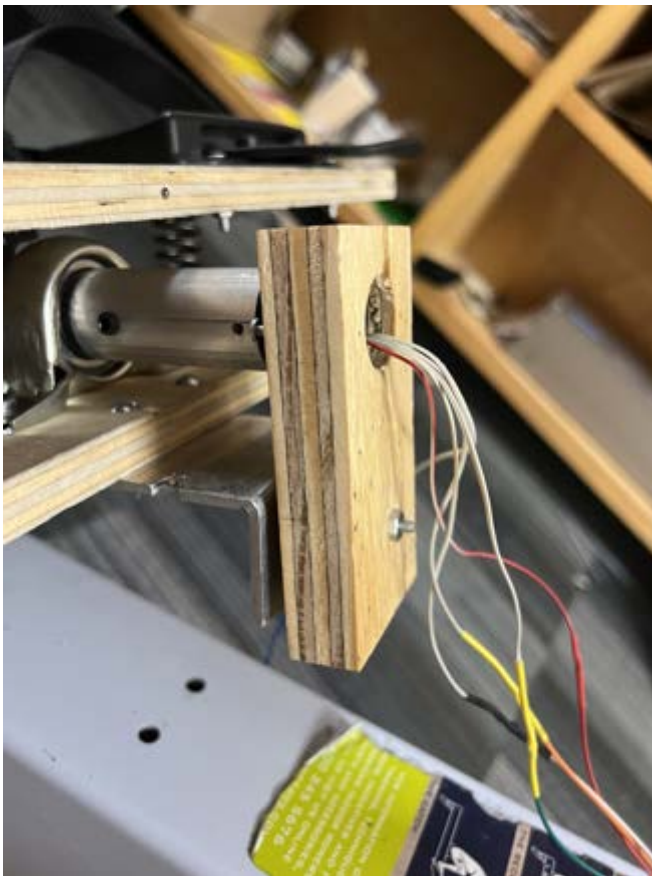
Content by: Emily

Present: All

Goals: To make a new coupler and mount for a different encoder

Content:

After busting our original encoder's shaft, another support had to be made for the new digital encoder we had, due to differences in base diameter. A new wooden block was used and drilled into to stick the encoder into. The encoder end of the couple also had to be adjusted using the mill as the new encoder's shaft was larger than the previous one. The mount was still fixed to the same bracket as before.



Conclusion:

Ready for presentation



2024/04/29 - MA3 Analog Encoder

Title: MA3 Analog Encoder

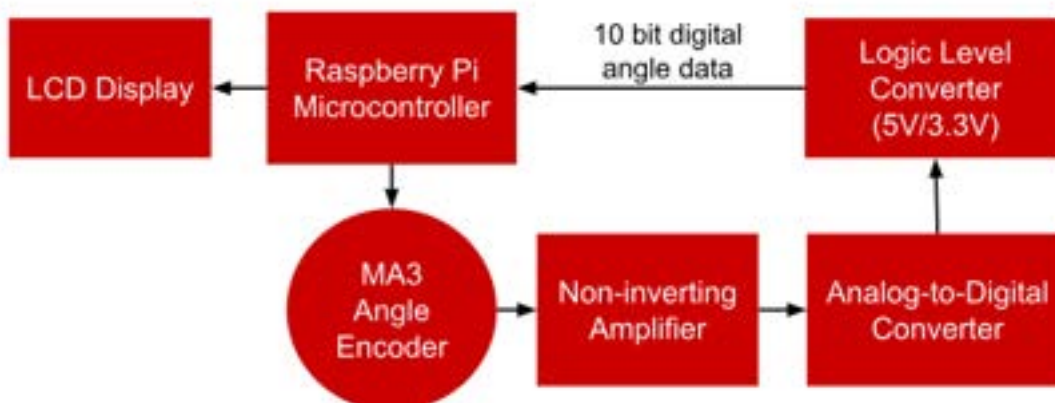
Date: 4/29/2024

Content by: Alicia

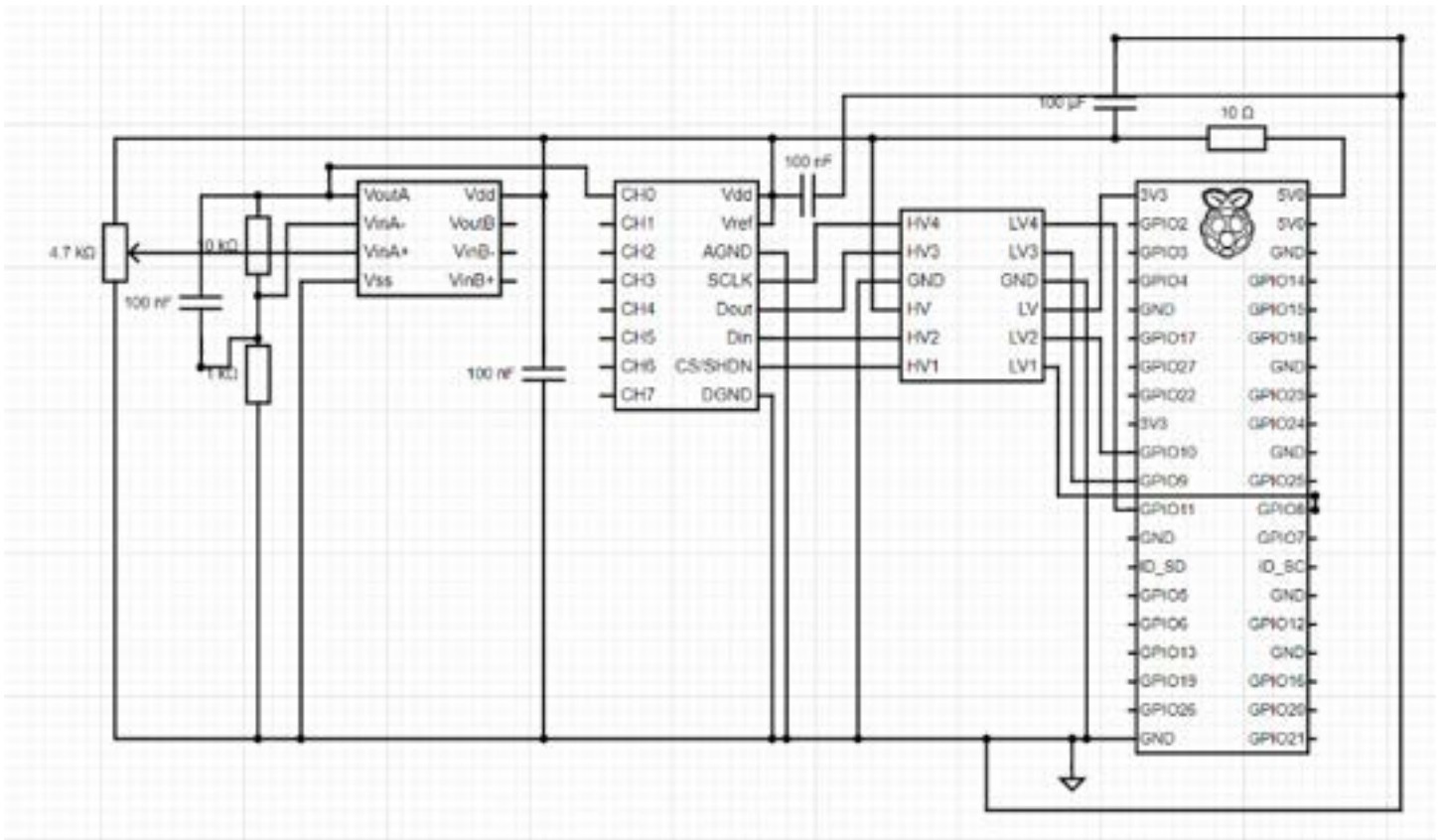
Goals: To design a circuit to integrate the MA3 Angle Encoder with the raspberry pi.

Content:

- Initially, we were going to use the P3 angular encoder with a SPI digital output. We could not figure out how to program this device, so we ordered the MA3 angular encoder with an analog output as a back-up option.
- Because the raspberry pi only has digital input pins, we needed an analog-to-digital converter as well as a level shifter to convert the 5V operating voltage of the angle encoder to the 3.3V logic level voltage of the RPi GPIO pins.
- We also added a non-inverting amplifier to amplify the analog voltage (gain = 11) before its fed into the ADC to increase the resolution of the 30 degree angle range we were aiming to use.



Block diagram explaining the logic of the circuit.



Circuit diagram with all pin connections shown. Angle encoder represented by 4.7 kOhm potentiometer (left).

100 nF capacitors were added at various parts of the circuit to act as low pass filters to reduce circuit noise.

Circuit components (left-to-right):

- MCP607 op amp (non-inverting op amp with gain=11 and low pass filter (cutoff freq = 159.154 Hz)
- MCP3008 ADC
- SparkFun Logic Level Converter - Bi-Directional (High voltage = 5 V, Low voltage = 3.3 V)
- Raspberry pi 4 model B

Conclusions/action items:

Write code to read the angle data from the raspberry pi and integrate it with the GUI



2024/04/29 - P3 SPI digital encoder

Title: P3 SPI Digital Encoder**Date:** 4/29/2024**Content by:** Alicia**Goals:** Read angle data with the p3 encoder**Content:**

- After talking with an engineer at p3 America, I was sent the datasheet (attached below) for the MLX90316 chip on the SPI encoder (the datasheet on the website was incorrect). I tried to write code following the timing diagram on the datasheet but was confused on how to hook-up the wires of the encoder to the microcontroller because there are only 5 wires on the encoder, but there are typically 6 wires for SPI communication. The MISO (Master In/Slave Out) wire and MOSI (Master Out / Slave In) wire seemed to be combined into one line.
- Timing diagram for a data frame of the SPI bus:

15.10. Frame Layer

15.10.1. Command Device Mechanism

Before each transmission of a data frame, the Master should send a byte AAh to enable a frame transfer. The latch point for the angle measurement is at the last clock before the first data frame byte.

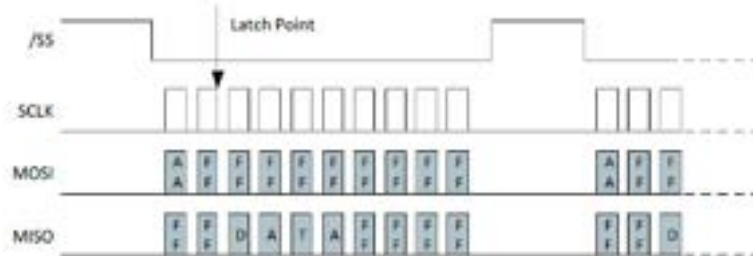


Figure 2 - Timing Diagram

15.10.2. Data Frame Structure

A data frame consists of 10 bytes:

- 2 start bytes (AAh followed by FFh)
 - 2 data bytes (DATA16 – most significant byte first)
 - 2 inverted data bytes (\neg DATA16 – most significant byte first)
 - 4 all-Hi bytes
- After investigating the datasheet further, I found a pinout diagram which showed how to connect the 5 wire system to a 6 wire microcontroller interface by adding a MOSFET and pull-up resistor.

16.4. Serial Protocol

Generic schematics for single slave and dual slave applications are described.

16.4.1. SPI Version – Single Die

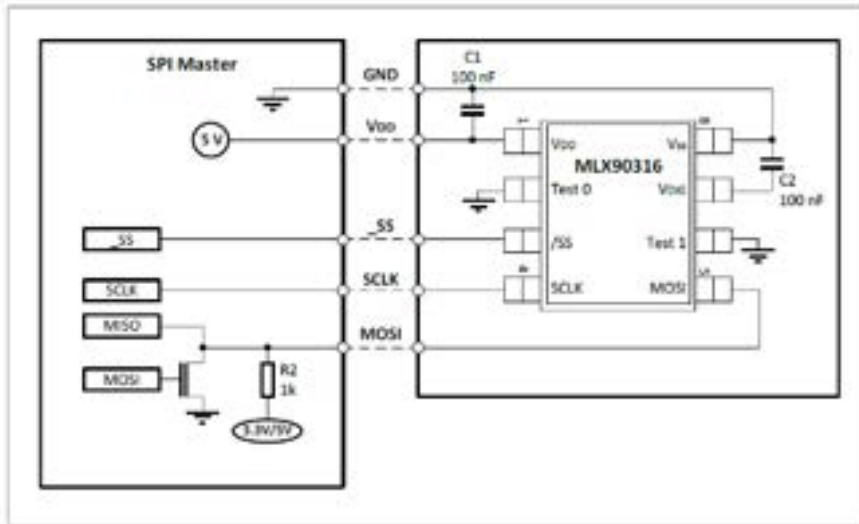
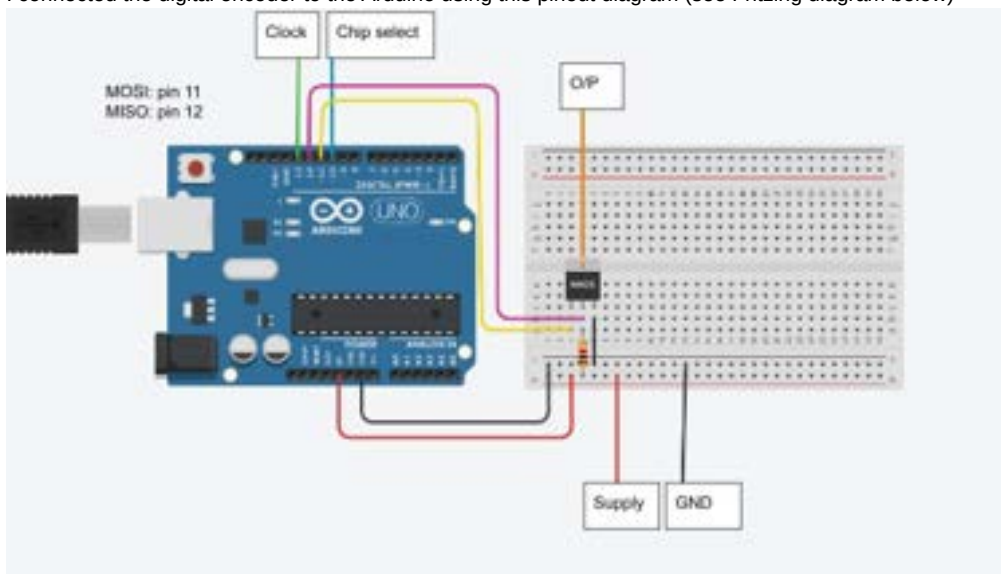
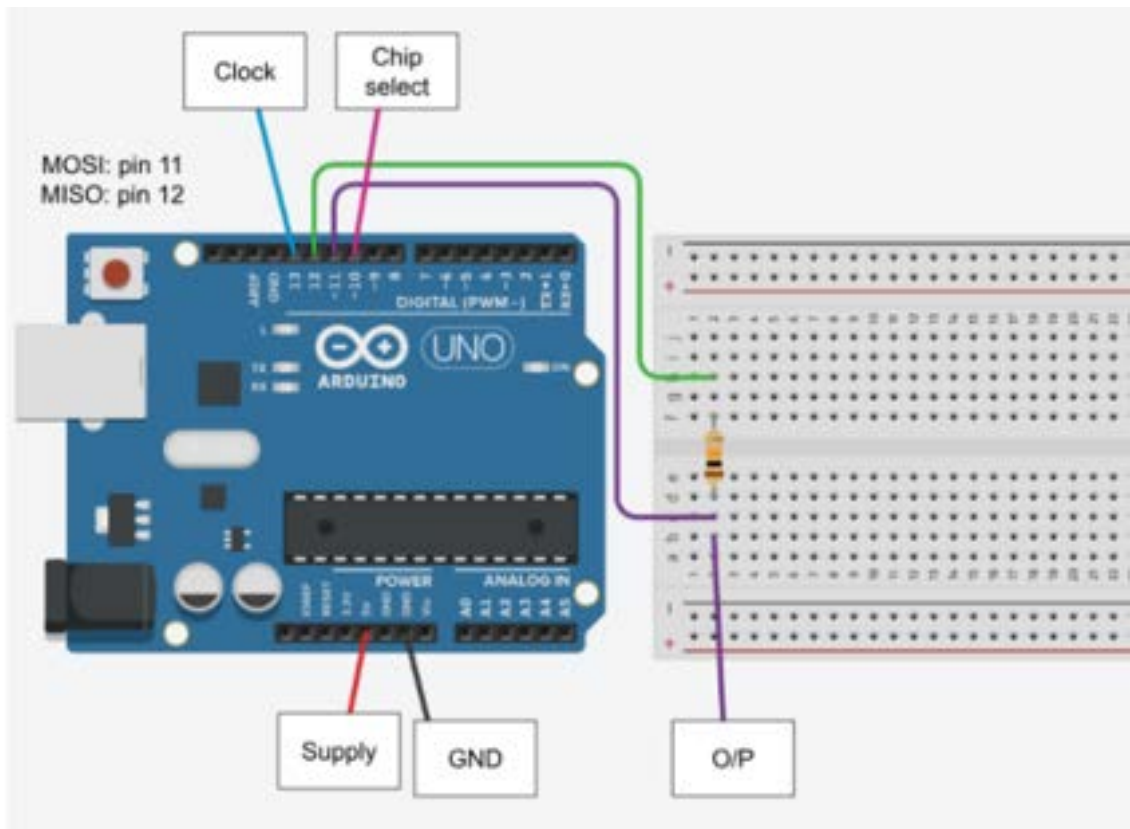


Figure 13 – SPI Version – Single Die – Application Diagram

- o
- o I connected the digital encoder to the Arduino using this pinout diagram (see Fritzing diagram below)



- o
- o This configuration still did not work, likely because the capacitance in the mosfet prevents the voltage jump necessary for the digital signal.
- o Eventually, John Lombardo from the Makerspace got the circuit to work by connecting a 10 kOhm resistor between the MOSI and MISO line (see Fritzing diagram below).



-
- This configuration worked with source code attached below.

Conclusions/action items:

Integrate the angle output with the raspberry pi to control the GUI.

Working Arduino code to read p3 encoder with 10 kOhm resistor hardware configuration:

```
#include <SPI.h>
const uint8_t CS_PIN = 10;
void setup() {
  Serial.begin(9600);
  pinMode(CS_PIN, OUTPUT);
  digitalWrite(CS_PIN, HIGH);
  SPI.begin(); delay(20);
}
void loop() {
  /*A data frame consists of 10 bytes:
  • 2 start bytes (AAh followed by FFh)
  • 2 data bytes (DATA16 - most significant byte first)
  • 2 inverted data bytes (/DATA16 - most significant byte first)
  • 4 all-Hi bytes */
  uint8_t data[10] = {0};
  int index = 0;

  //min time between each bit transfer is 7 microseconds so set to 125kHz which is the lowest
  SPI.beginTransaction(SPISettings(125000, MSBFIRST, SPI_MODE1));

  //Start transaction
  digitalWrite(CS_PIN, LOW);
  delayMicroseconds(20);
  //Send start byte
  data[index++] = SPI.transfer(0xAA);
  delayMicroseconds(50);
  //Send and receive data bytes
  for(uint8_t i = 1; i < 10; i++){
    data[index++] = SPI.transfer(0xFF);
    delayMicroseconds(40);
  }

  //End transaction

  digitalWrite(CS_PIN, HIGH);
  SPI.endTransaction();

  //Extract and calculate angle
  uint16_t data_bytes = (data[2] << 8) | data[3]; // Combine two bytes
  uint16_t first14 = data_bytes >> 2; // Extract first 14 bits
  float value = float(first14 / 16384.0000); // Divide by 2^14 and multiply by 360 to get degrees
  float angle = value * 360.0; Serial.println(angle,6);

  delay(100);
}
```



2024/04/29 - Arduino RPi Serial Communication

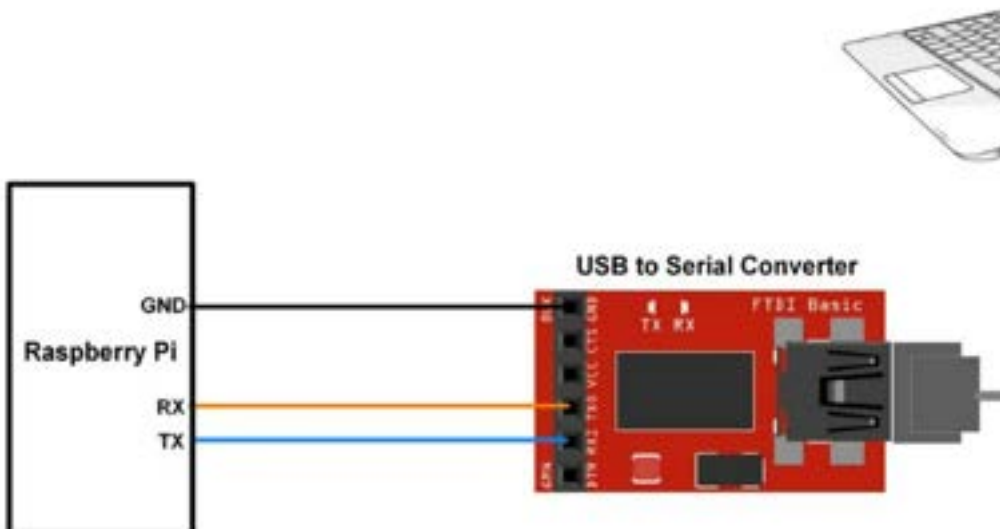
Title: Arduino RPi Serial Communication**Date:** 5/1/2024**Content by:** Alicia**Goals:** To integrate the Arduino p3 encoder output with the raspberry pi**Link:** [Raspberry Pi UART Communication using Python and C | Raspberry Pi \(electronicwings.com\)](https://www.electronicwings.com/raspberry-pi/raspberry-pi-uart-communication-using-python-and-c)**Citation:**

[1 "Raspberry Pi UART Communication using Python and C | Raspberry Pi." Accessed: May 01, 2024. [Online]. Available:] <https://www.electronicwings.com/raspberry-pi/raspberry-pi-uart-communication-using-python-and-c>

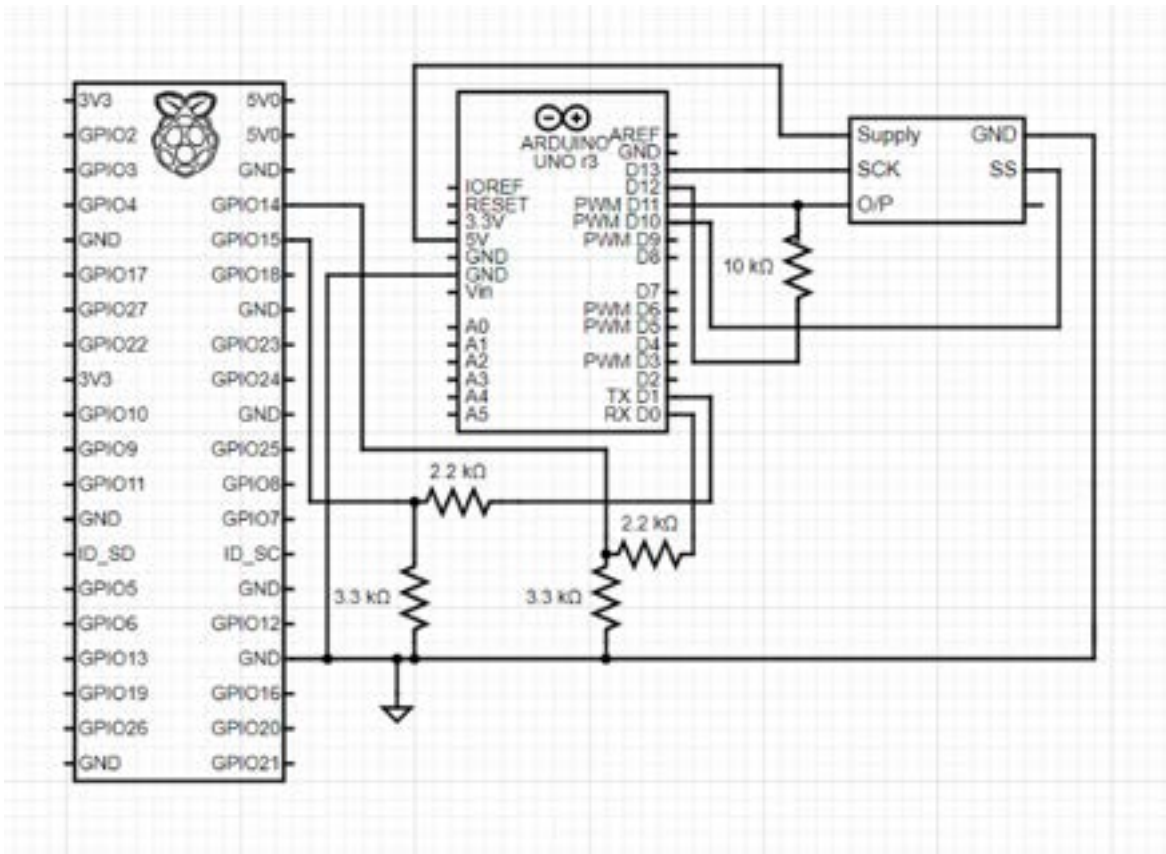
Content:

- Because the Arduino is used to read the encoder, but the raspberry pi is used to power and control the LCD display, the angle data must be transmitted serially from the Arduino to the Raspberry pi.
 - I followed instructions from electronicwings.com to set up this communication.
1. First, I enabled Serial on the raspberry pi
 2. Then i used the command "ls -l /dev" to determine which pins the UART port is mapped to.
 3. Then I used the following code to read the serial monitor from the arduino:

```
import serial
from time import sleep
ser = serial.Serial ("/dev/ttyS0", 9600) #Open port with baud rate
while True:
    received_data = ser.read() #read serial port
    sleep(0.03) data_left = ser.inWaiting() #check for remaining byte
    received_data += ser.read(data_left)
    print (received_data) #print received data
```



I used the RX and TX pins on the raspberry pi and connected them to the TX and RX pins on the Arduino with a voltage divider in between to convert the 5V from Arduino to ~3 V on the raspberry pi.



(Full circuit including UART connection between raspberry pi and Arduino Uno)

Conclusions/action items:

Write code to integrate angle data with the GUI.



2024/05/01 - GUI Code with Encoder

Title: GUI Code with Encoder**Date:** 5/1/2024**Content by:** Alicia**Goals:** To write code that integrates real-time angle data with the graphical user interface (GUI).**Content:**

- After figuring out the hardware and software necessary to read raw angle data from the p3 encoder, we had to integrate that data with the GUI to provide real-time feedback to the rower.
- See comments (#) for code descriptions:

```
import sys
```

```
import pyqtgraph as pg
```

```
from PyQt5 import QtCore, QtGui, QtWidgets
```

```
import pandas as pd
```

```
import math
```

```
import serial
```

```
from time import sleep
```

```
class Ui_MainWindow(object):
```

```
    def setupUi(self, MainWindow):
```

```
        MainWindow.setObjectName("MainWindow")
```

```
        MainWindow.setGeometry(0,0,800,480)
```

```
        MainWindow.setStyleSheet("background-color: #2A2A2A;") #sets background to dark gray
```

```
        self.centralwidget = QtWidgets.QWidget(MainWindow)
```

```
        self.centralwidget.setObjectName("centralwidget")
```

```
        self.verticalLayout = QtWidgets.QVBoxLayout(self.centralwidget)
```

```
        self.verticalLayout.setObjectName("verticalLayout")
```

```
        self.frame_3 = QtWidgets.QFrame(self.centralwidget)
```

```
        self.frame_3.setFrameShape(QtWidgets.QFrame.NoFrame)
```

```
        self.frame_3.setFrameShadow(QtWidgets.QFrame.Raised)
```

```
        self.frame_3.setObjectName("frame_3")
```

```
        self.horizontalLayout_2 = QtWidgets.QHBoxLayout(self.frame_3)
```

```
        self.horizontalLayout_2.setObjectName("horizontalLayout_2")
```

```
        self.label = QtWidgets.QLabel(self.frame_3)
```

```
        font = QtGui.QFont()
```

```
        font.setFamily("DejaVu Serif Condensed")
```

```
        font.setPointSize(18)
```

```

self.label.setFont(font)

self.label.setStyleSheet("color: rgb(255, 255, 255);")

self.label.setObjectName("label")

self.horizontalLayout_2.addWidget(self.label, 0, QtCore.Qt.AlignHCenter)

self.verticalLayout.addWidget(self.frame_3, 0, QtCore.Qt.AlignTop)

# Create PlotWidget

self.plotWidget = pg.PlotWidget()

self.verticalLayout.addWidget(self.plotWidget)

self.plotWidget.setBackground("#2A2A2A")

MainWindow.setCentralWidget(self.centralwidget)

self.menubar = QtWidgets.QMenuBar(MainWindow)

self.menubar.setGeometry(QtCore.QRect(0, 0, 767, 26))

self.menubar.setObjectName("menubar")

MainWindow.setMenuBar(self.menubar)

self.statusbar = QtWidgets.QStatusBar(MainWindow)

self.statusbar.setObjectName("statusbar")

MainWindow.setStatusBar(self.statusbar)

self.retranslateUi(MainWindow)

QtCore.QMetaObject.connectSlotsByName(MainWindow)

def retranslateUi(self, MainWindow):
    _translate = QtCore.QCoreApplication.translate
    MainWindow.setWindowTitle(_translate("MainWindow", "MainWindow"))
    self.label.setText(_translate("MainWindow", "Angle of Foot Plate")) #adds "Angle of Foot Plate" to top of the screen

class MainWindow(QtWidgets.QMainWindow, Ui_MainWindow):

    def __init__(self):
        super(MainWindow, self).__init__()

        self.setupUi(self)

        self.line = None # Initialize line plot item

        self.circle = None # Initialize circle plot item

        self.count = 0

        self.plotWidget.setRange(xRange=[-6, 6], yRange=[-6, 6])

        self.plotWidget.getAxis('bottom').setTicks([],[]) # Remove x-axis ticks

        self.plotWidget.getAxis('left').setTicks([],[]) # Remove x-axis ticks

        self.timer = QtCore.QTimer(self)

```

```

self.timer.timeout.connect(self.update_plot)

# Start the plot directly without the need for user interaction

self.start_plot()

def start_plot(self):

    self.count = 0

    self.timer.start(round(1000/24)) # Start timer with interval of 24 ms

def update_plot(self):

    threshold = 10.0

    ser = serial.Serial ("/dev/ttyS0", 9600) #Open serial port with baud rate

    received_data = ser.readline() #read serial port

    try:

        angle = float(bytes(received_data)) - 180 #subtract 180 from the angle to reset the angle range from 0-360 to -180-180

        print(angle)

        if angle > 30:

            angle = 30 # sets angle values above 30 to 30 to set rotation limits on the GUI

        if angle < -30:

            angle = -30 # sets angle values below -30 to -30 to set rotation limits on the GUI

        rad_angle = angle * (math.pi / 360) #converts degrees to radians

        if self.line is not None:

            self.plotWidget.removeItem(self.line) # Remove previous line

        if self.circle is not None:

            self.plotWidget.removeItem(self.circle) # Remove previous circle

        if angle > 0:

            left_point = (-5*math.cos(abs(rad_angle)), 5*math.sin(abs(rad_angle)*5)) #uses sine and cosine to translate the angle into rectangular
coordinates
            right_point = (5*math.cos(abs(rad_angle)), -5*math.sin(abs(rad_angle)*5))

        elif angle < 0:

            left_point = (-5*math.cos(abs(rad_angle)), -5*math.sin(abs(rad_angle)*5))

            right_point = (5*math.cos(abs(rad_angle)), 5*math.sin(abs(rad_angle)*5))

        else:

            left_point = (-5, 0)

            right_point = (5, 0)

        if abs(angle) > threshold: #turns green line red if the angle crosses the threshold set in the code

            color = 'red'

        else:

```

```
        color = 'green'

        self.line = pg.PlotCurveItem(x=[left_point[0], right_point[0]], y=[left_point[1], right_point[1]], pen={'color': color, 'width': 4})

        self.plotWidget.addItem(self.line) # Add updated line plot item to plotWidget

        self.circle = pg.ScatterPlotItem(x=[0], y=[0], pen=None, brush=(255, 255, 255), size=10) # White circle at (0, 0)

        self.plotWidget.addItem(self.circle) # Add white circle plot item to plotWidget

        self.count += 1

    except:

        pass

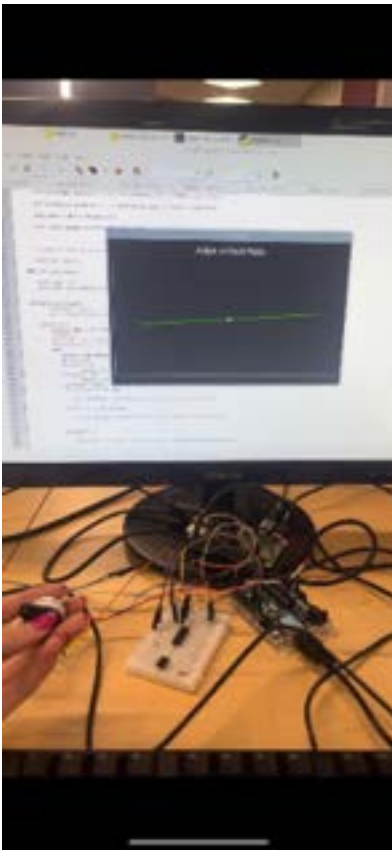
if __name__ == "__main__":

    app = QtWidgets.QApplication(sys.argv)

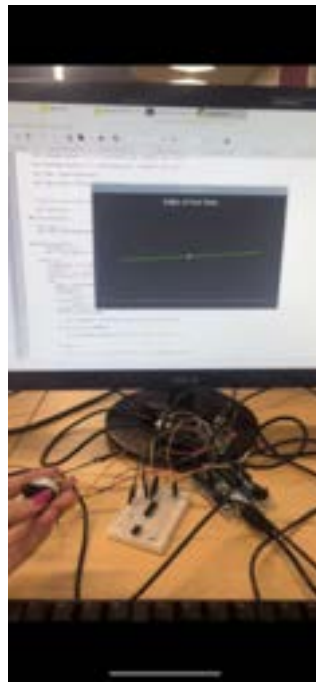
    window = MainWindow()

    window.show()

    sys.exit(app.exec_())
```

**Conclusions/action items:**

Attach encoder to the foot plate shaft.



[Download](#)

GUI_picture.jpeg (9.54 MB)



2024/4/22 - Testing at Boathouse

Title: Testing at the Boathouse

Date: 4/22/2023

Content by: All

Present: Simmi, Emily, Neha, Jill, Tricia, Sarah, UW Rowing Staff

Goals: Test the device on different rowers and get their feedback.

Content:

- team arrived to boathouse and mounted the footplate to the ergometer in the tank



- meanwhile, Alicia attempted to get code and angular encoder started but we realized the angular encoder shaft was bent and therefore was not outputting accurate values
- team then decided to begin with qualitative testing and take a side view of the front edge of plate to analyze angle in Kinovea since angular encoder failed

Rower Testing Procedure

- rowers rowed for about 3 minutes on the stiff and compliant springs and were asked the following questions:
 - is the plate comfortable for your feet?
 - most said yes, because flexfoot is same
 - are you able to row as normal?
 - most said the plate was too high up and needed the spacer plus the butt pads, so not ideal
 - can you feel the plate rotating underneath your feet when you drive?
 - most said yes
 - said they could feel it less for stiff
 - lightweight rower said she couldn't really feel it
 - are the springs hindering your ability to push off with force?
 - all said no
 - (after showing GUI): does this make sense to you and would you be able to interpret this?
 - yes
- rowers were then asked to do a left leg and right leg emphasis on the stroke to feel the plate rotate more on both sides.
- Neha recorded videos on her phone of a side view:



Conclusions/action items: Analyze the videos recorded in Kinovea.



2024/5/1 - Results

Title: Testing Results

Date: 5/1/2024

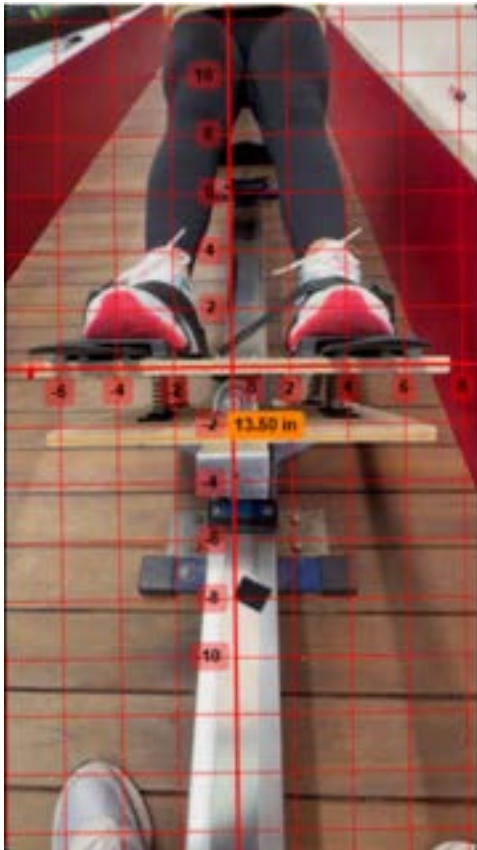
Content by: All

Present: All

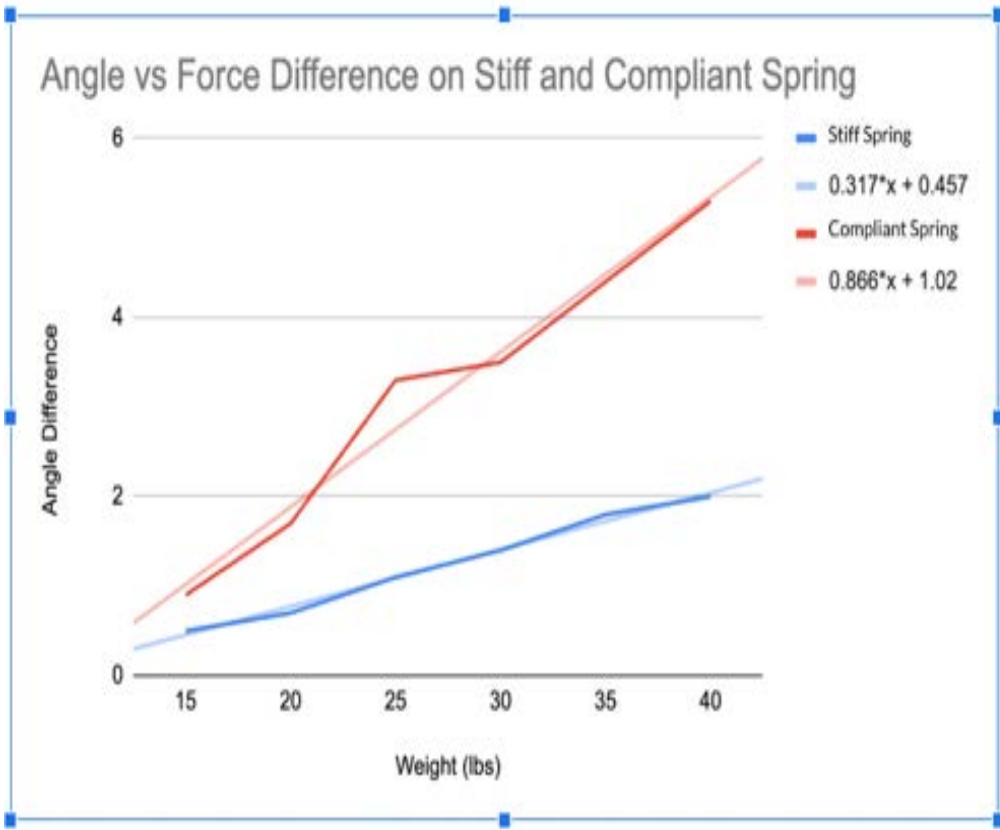
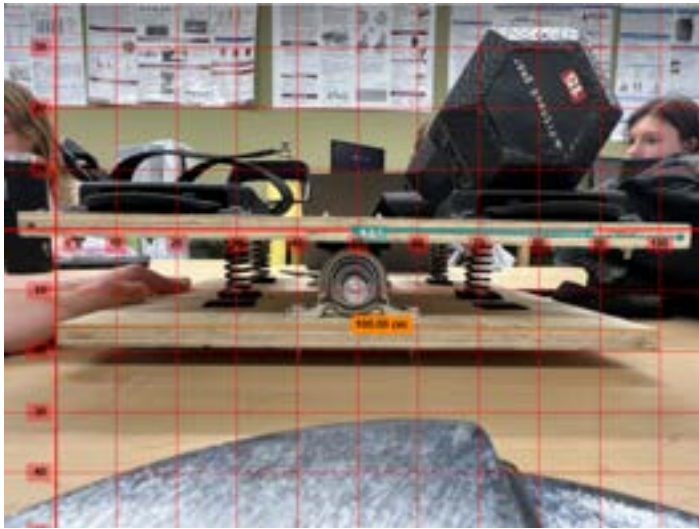
Goals: Plot the data obtained from testing and interpret it

Content:

- Data analysis method:
 - 30-second clip from steady state rowing was extracted from long video
 - motion tracking on Kinovea of right edge of footplate --> coordinates

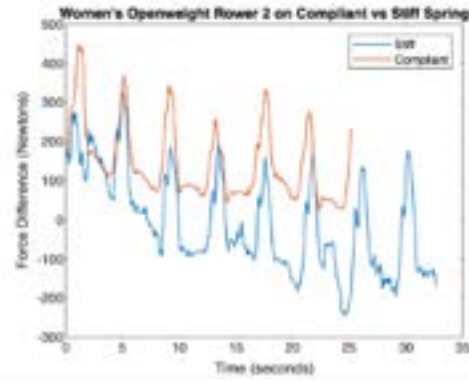
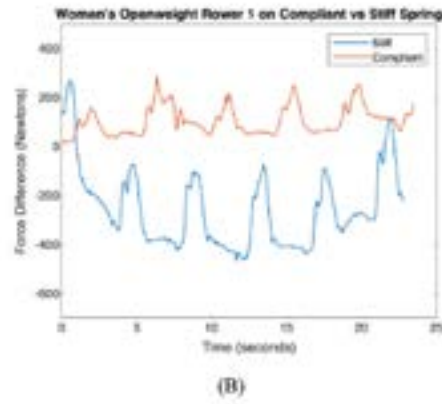
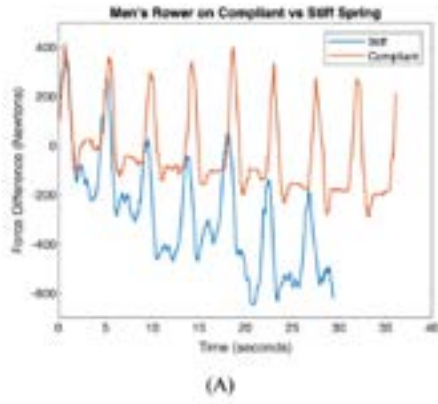


- code: $\tan(y/x) = \text{angle}$
- calibration curve for force created by placing known weights on footplate and measuring angle

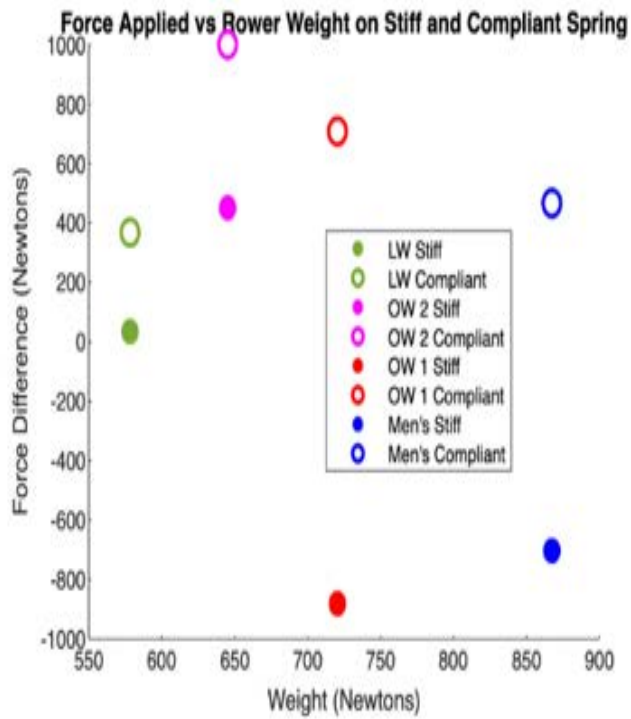


- plots

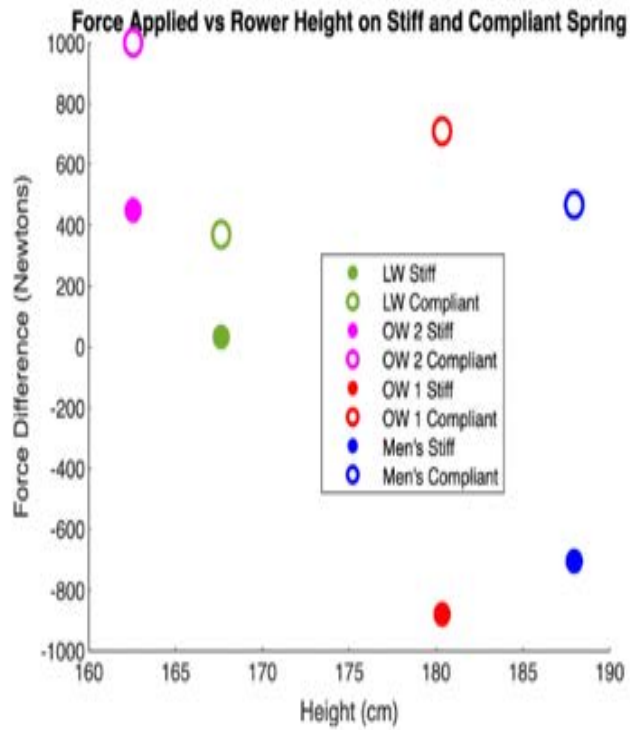
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- statistical analysis: t test on peak force diff between stiff and compliant for each rower

Athlete	P-Value ($\alpha = 0.05$)
Men's Rower	0.1879
Openweight 1	0.0052
Openweight 2	0.0045
Lightweight	0.6006

Conclusions:

- most rowers put more force on oarside foot

- significant p-value for 2 of 4 rowers --> need to match springs to each rower for optimal measurement and comfort
- no clear correlation between weight/height and asymmetry



2024/5/1 Testing Analysis Code

Title: Testing Analysis Code

Date: 5/1/2023

Content by: Simmi

Present: all

Content:

Data Analysis MATLAB Code

```
%Hard Spring Angles

data = readtable('HansStiff.xlsx');

x = data.x;

y = data.y;

time = data.t;

rad = tan(y./x);

deg = rad .* (180/3.14);

force = ((15.6.*deg)+ 7.96) * 4.4482216153

[pksHans,locs] = findpeaks(force, MinPeakProminence=25);

plot(time,force,time(locs),pksHans,"o", Linewidth=1);

title("Men's Rower on Stiff Spring");

xlabel('Time (seconds)');

ylabel('Force Difference (lbs)');

%%

data1 = readtable('VickyStiff.xlsx');

x1 = data1.x;

y1 = data1.y;

time1 = data1.t;

rad1 = tan(y1./x1);

deg1 = rad1 .* (180/3.14);

force1 = ((15.6.*deg1)+ 7.96) * 4.4482216153

[pksV,locsV] = findpeaks(force1, MinPeakProminence=10);

plot(time1,force1,time1(locsV),pksV,"o", Linewidth=1);

title("Women's Openweight 1 on Stiff Spring");

xlabel('Time (seconds)');

ylabel('Force Difference (lbs)');

%%
```

```
data2 = readtable('ToriStiff.xlsx');

x2 = data2.x;

y2 = data2.y;

time2 = data2.t;

rad2 = tan(y2./x2);

deg2 = rad2 .* (180/3.14);

force2 = ((15.6.*deg2)+ 7.96) * 4.4482216153

[pksT, locsT] = findpeaks(force2, MinPeakProminence=10);

plot(time2, force2, time2(locsT), pksT, "o", LineWidth=1);

title("Women's Lightweight on Stiff Spring");

xlabel('Time (seconds)');

ylabel('Force Difference (lbs)');

%%

data3 = readtable('Maddy stiff.xlsx');

x3 = data3.x;

y3 = data3.y;

time3 = data3.t;

rad3 = tan(y3./x3);

deg3 = rad3 .* (180/3.14);

force3 = ((15.6.*deg3)+ 7.96) * 4.4482216153

[pksM, locsM] = findpeaks(force3, MinPeakProminence=20);

plot(time3, force3, time3(locsM), pksM, "o", LineWidth=1);

title("Women's Openweight 2 on Stiff Spring");

xlabel('Time (seconds)');

ylabel('Force Difference (lbs)');

%Soft Spring Angles

datas = readtable('HansSoftSpring.xlsx');

xs = datas.x;

ys = datas.y;

times = datas.t;

times = times - 23.88;

rads = tan(ys./xs);

degs = rads .* (180/3.14);

forces = ((15.6.*degs)+ 7.96) * 4.4482216153

[pksHanss, locss] = findpeaks(forces, MinPeakProminence=12);
```

```
plot(times,forces,times(locss),pkSHanss,"o", Linewidth=1);

title("Men's Rower on Compliant Spring");

xlabel('Time (seconds)');

ylabel('Force (lbs)');

%%

data1s = readtable('VickySoftSpring-Edited.xlsx');

x1s = data1s.x;

y1s = data1s.y;

time1s = data1s.t;

time1s = time1s - 5

rad1s = tan(y1s./x1s);

deg1s = rad1s .* (180/3.14);

force1s = ((5.62.*deg1s)+ 9.62) * 4.4482216153

[pksVs,locsVs] = findpeaks(force1s, MinPeakProminence=8);

plot(time1s,force1s,time1s(locsVs),pkVs,"o", Linewidth=1);

title("Openweight Rower 1 Compliant Spring");

xlabel('Time (seconds)');

ylabel('Force (lbs)');

%%

data2s = readtable('ToriSoftSpringEdited.xlsx');

x2s = data2s.x;

y2s = data2s.y;

time2s = data2s.t;

rad2s = tan(y2s./x2s);

deg2s = rad2s .* (180/3.14);

force2s = ((5.62.*deg2s)+ 9.62) * 4.4482216153

[pksTs,locsTs] = findpeaks(force2s, MinPeakProminence=7);

plot(time2s,force2s,time2s(locsTs),pkTs,"o", Linewidth=1);

title("Women's Lightweight on Compliant Spring");

xlabel('Time (seconds)');

ylabel('Force (lbs)');

%%

data3s = readtable('Maddy soft.xlsx');

x3s = data3s.x;

y3s = data3s.y;
```

```
time3s = data3s.t;  
  
rad3s = tan(y3s./x3s);  
  
deg3s = rad3s .* (180/3.14);  
  
force3s = ((5.62.*deg3s)+ 9.62) * 4.4482216153  
  
[pksMs, locsMs] = findpeaks(force3s, MinPeakProminence=8);  
  
plot(time3s, force3s, time3s(locsMs), pksMs, "o", LineWidth=1);  
  
title("Women's Openweight 2 on Compliant Spring");  
  
xlabel('Time (seconds)');  
  
ylabel('Force (lbs)');
```

Conclusions/action items: Produced graphs from testing data.



2024/05/03-Protocols

EMILY WADZINSKI - May 03, 2024, 6:55 PM CDT

Title: All Protocols

Date: 5/3/2024

Content by: All

Present: All

Goals: Write steps for how we completed parts of the project.

Content:

See attached pdf.

Conclusions/action items:

Document these steps for future reference.

Neha Kulkarni - May 03, 2024, 7:23 PM CDT

Title										Author	Editor

Appendix C: Protocols

Fungus Fertilization Protocol

Materials

1. Fungus Inoculation Slurry
2. Pipet
3. Cylindrical aluminum shell
4. Aluminum rod
5. Shell bearings, rollers, and support axles
6. Wooden block
7. Glassware (beaker)
8. Scale and weights
9. Filter
10. Compression Springs

Methods

1. Tightly seal/fit the slurry's control panel's programming.
2. Mount a 1" thick piece of plywood to back with clamps and line up the jet to the rotating point on the wheel.

[Download](#)

protocols2.pdf (156 kB)



2023/01/31 - Meeting 1

Title: Meeting 1**Date:** 1/31/2023**Content by:** Alicia**Present:** Neha, Simmi, Colin, Alicia**Goals:** Set goals for the semester**Content:**

End goal: Make dual force plate system for the tank with a biofeedback.

Three components: circuit, display, design of the footplate

- We should abandon the current device
- Combinator board - 4 load cells
- May not be necessary to get all directions of force (just the normal force)

Order:

1. Making sure the force measurement is accurate
 - Which load cell
 - How load cell is configured
 - Continue working with load cell under toe (not heel)
2. Get both feet working together.
3. Digital interface
 - there's a way to send arduino data directly to Matlab
 - Wattbike interface?
 - storing the Force vs Time graph may be helpful for a PT, but immediate feedback is more helpful for the trainer
4. Create housing for configuration
 - Could we make a whole new footplate? Something that screws into the footplate?
5. Electronics housing
5. Waterproofing?

Questions:

- Can we write the code in python or Matlab?

Conclusions/action items:

- Meet at the Boat House with Ms. De Souza to see the tank and ergometer (Alicia and Colin) and to talk through expectations/goals for the team this semester



2024/02/21 - Universal Design Entry

ALLICIA MOELLER - Feb 21, 2024, 2:00 PM CST

Title: Universal Design Entry

Date: 2/21/2024

Content by: Allicia

Present: Colin, Simmi, Emily, Allicia, Neha (in spirit)

Goals: To assess what components of our design could be more universal/inclusive.

Content:

- Our product aims to serve woman rowers, but we can be inclusive in foot size
 - Right now, we are basing it off the average woman's foot size on the rowing team (size 10), but we can improve our design by making sure it works with the smallest and largest foot size.
- BMES principles:
 - Principle 3: Simple and intuitive use
 - Display graphics will be very simple to understand
 - Device will have a simple on/off switch
 - Principle 4: Perceptible Information
 - Device must be usable for people with color blindness or reading disabilities
 - Display graphics will have high contrast and large characters
 - Principle 7: Size and space for approach and use:
 - The footplate not cause the user's foot to slip.
 - The footplate must be adjustable for different foot sizes.
 - If we can't make it adjustable for all foot size, what percentage of the range can we cover
 - The height of the display should be adjustable for varying body proportions.
- How can we make these improvements?
 - We can ask different rowers with different foot sizes to test out our design and ask for feedback.

Conclusions/action items:

- Explore ways to make footplate adjustable to different foot sizes.



2023/03/12 - Dr. Gruben meeting

SIMERJOT KAUR - Mar 13, 2024, 1:29 PM CDT

Title: Dr. Gruben Meeting

Date: 3/12/2024

Content by: Allicia

Present: Dr. Gruben, Dr. Bell, Neha, Simmi, Emily, Colin

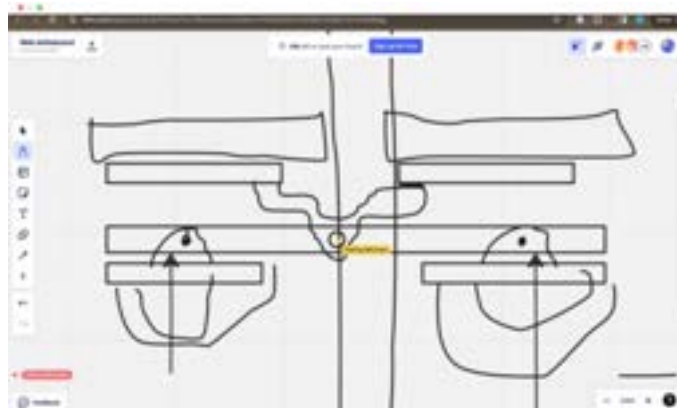
Goals: To get advice from Dr. Gruben about load cell configuration

Content:

- Dr. Gruben:
 - The foot can generate forces in many different directions, the net force has a center of pressure and an orientation.
 - A single-axis force sensor is sensitive to one particular axis in space. Depending on the type of sensor, if you apply force off-center or off-axis, you can have huge errors. Some sensors are made to measure moments and can calculate center of pressure and x, y, z forces, but they can still have errors and are thousands of dollars
 - The problem: if we use a single-axis force sensor and we don't mechanically ensure the loads are applied in the correct axis and at the intended point, we will have huge errors.
 - Dynamic loading would not be an issue with high-quality sensors
 - Design 10 failed prototypes!
 - Build! Build! Build! Use wood, glue, and nails and make multiple prototypes.
 - There are other mechanisms for force shielding
- Neha:
 - Called Interface and asked if budget was not a constraint, what would be the recommended force sensor and they said 3-axis load cells

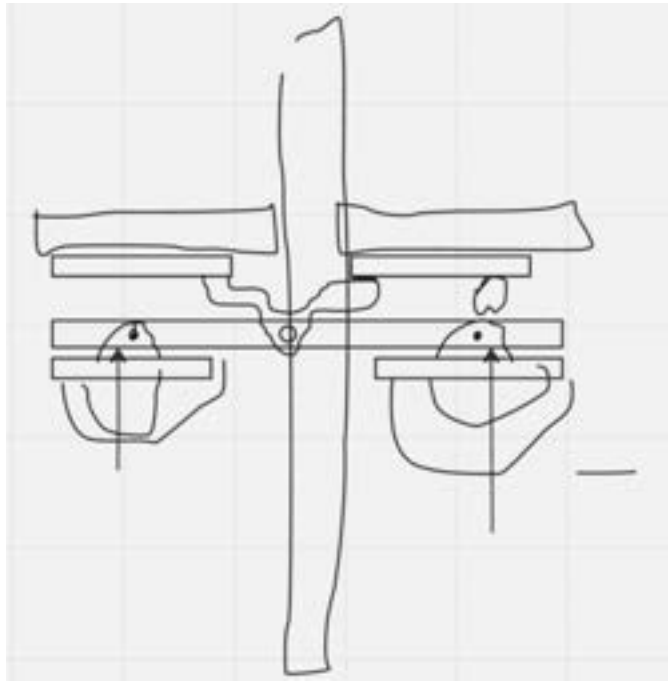
Conclusions/action items: Consider Dr. Gruben's idea and modify as needed to fit client requirements.

Neha Kulkarni - Mar 12, 2024, 12:54 PM CDT



[Download](#)

DrGrubenSketch.png (1.74 MB)



[Download](#)

Screenshot_2024-03-12_at_2.31.53_PM.png (318 kB)



2024/03/13 - Protocol Brainstorm

EMILY WADZINSKI - Mar 14, 2024, 11:05 AM CDT

Title: Protocol Testing Ideas

Date: 3/13/2024

Content by: Emily

Present: Simmi, Neha, Emily, Allicia

Goals: To discuss different kinds of protocols and testing

Content:

see attached

EMILY WADZINSKI - Mar 14, 2024, 11:07 AM CDT

Input/output together
 time
 Equilibrium: use w or without test
 Cell
 testing (how)

 accuracy/precision

 - compare to true value accuracy
 - w/w/out (often?)

 - put on scale of known weights
 to test testing, accuracy & precision.
 more weights put in bucket plots (scatter)
 slope

 - slope range or how many bits

 Input weight with known detected
 adjust cell threshold to deal w/ cell char on testing

[Download](#)

Note_Mar_13_2024.pdf (265 kB)



2024/03/13 - Angle encoder idea session

Title: Angle Encoder Idea Session

Date: 3/13/2024

Content by: Alicia

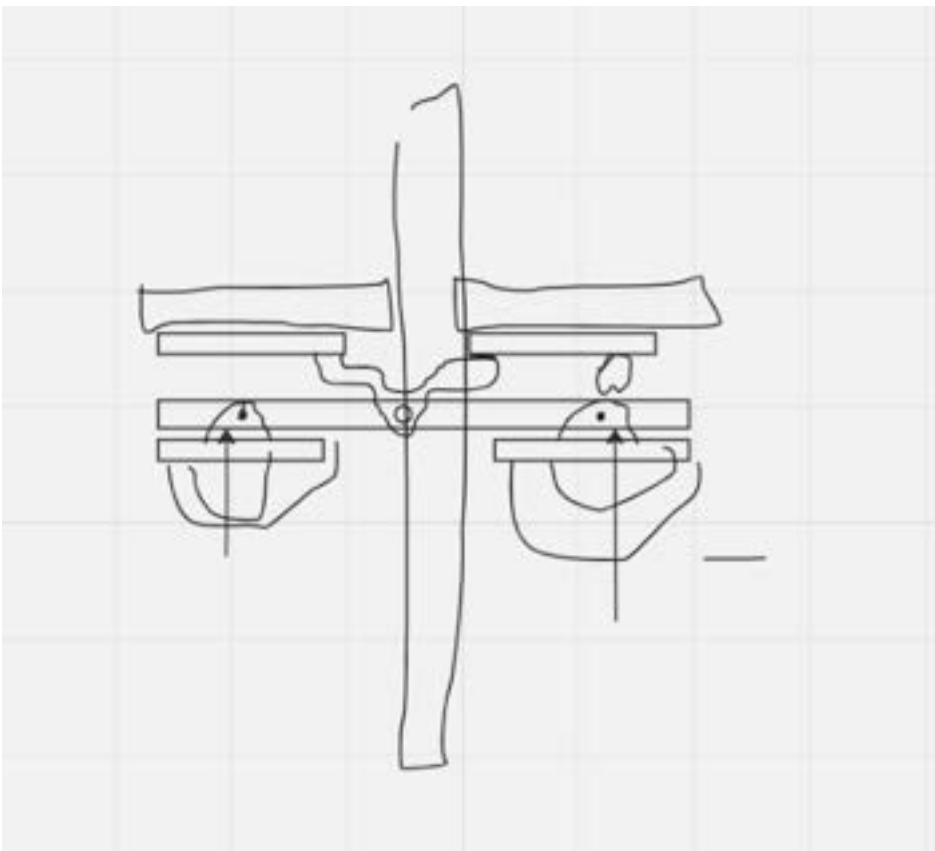
Present: Simmi, Neha, Emily, Alicia

Goals: To discuss feasibility and designs for Dr. Gruben's angle encoder design suggestion.

Content:

- Dr. Gruben brought a massive problem with our design to our attention, which is that the load cells that we can afford for this project (even with the \$1000 budget) will be highly-sensitive to off-axis loads and likely give massive errors if the force is not directed perfectly on-axis relative to the load cell. To account for this, Dr. Gruben suggested we move away from load cells and instead made two plates which can rotate about a pivot with an angular encoder that can read the angle between them to backsolve for the difference in force on each plate. We can put springs behind each plate to limit compression.
- Angular encoders: there are shaft-style angular encoders and hollow style
- The main issue with the angular encoder / pivot:
 - Does the shaft/collar need to be fixed in space? Is net displacement towards the footplates an issue?
 - Pushing so hard on both plates, would the shaft snap?
- Could we use an IMU such as MPU6050 to measure roll, pitch, and yaw of the plates instead of angle about the shaft? Would we still need the pivot?
- Big issue: rowing form. We could probably only allow the plate to move inward about 1 inch (2.54 cm)
- We would like to meet with Dr. Gruben again to discuss the issue of net inward displacement, ask if the pivot is absolutely necessary as opposed to a rigid plate an IMU on springs?

Dr. Gruben's sketch:



We are meeting with the client's on Friday to discuss switching our design. The advantages that this design provides over our load cell design is much higher accuracy in force difference (about the normal axis), but the disadvantages are that it cannot calculate absolute force (Dr. Gruben's design but

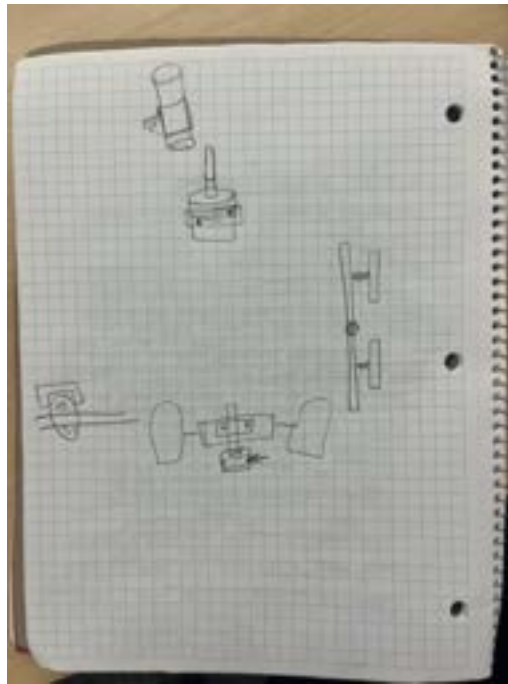
our adjusted IMU design cannot) and the springs and plates may interfere with normal rowing technique, which is not ideal.

The other aspect of this design that needs to be accounted for is center of pressure (COP). Dr. Gruben suggests that we build out two more footplates on top of the rigid plate with a pivot under each foot so that the rower can only comfortably row when they align their COP exactly on the pivot. This unifies the COP medio-laterally, but we do not love this solution because it makes the foot plate bulkier and interferes with rowing technique. We would like to explore the technology behind pressure-mapping insoles to see if there is a solution that would give us a number for COP that can be fed into our calculations.

Conclusions/action items:

1. Meet with clients to discuss this major project change.
2. Meet with Dr. Gruben to ask if the pivotless IMU design would work or if we are failing to account for anything.
3. Research angular encoders, angular encoder mounting systems, and pressure-sensing insole technology (how accurate is it? What kind of sensors do they use? Could we find one that uses SPI/I2C?)

ALLICIA MOELLER - Mar 13, 2024, 6:14 PM CDT



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IMG_5510.jpg (3.27 MB)

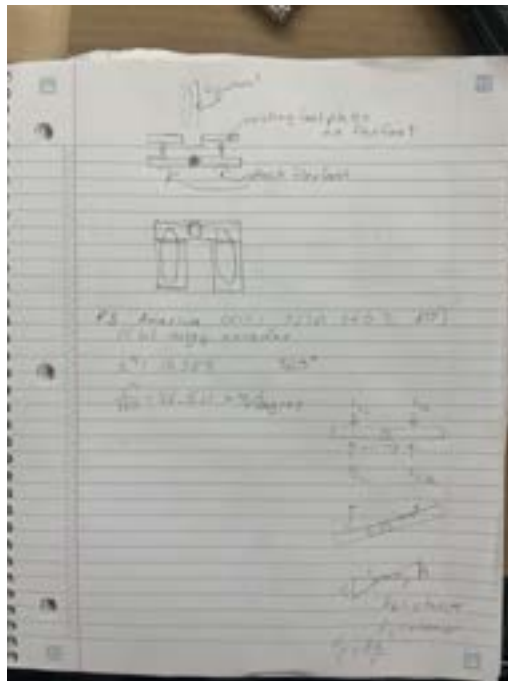
ALLICIA MOELLER - Mar 15, 2024, 1:33 PM CDT



[Download](#)

IMG_5508.jpg (3.31 MB)

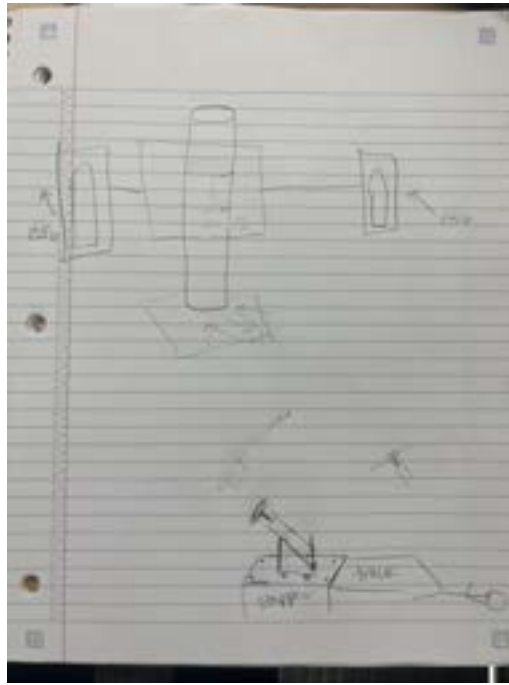
ALLICIA MOELLER - Mar 13, 2024, 6:14 PM CDT



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IMG_5509.jpg (2.68 MB)

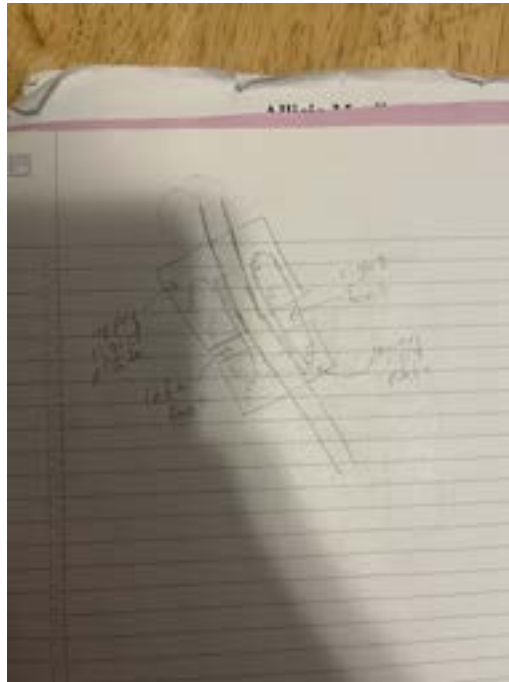
ALLICIA MOELLER - Mar 13, 2024, 6:14 PM CDT



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IMG_5511.jpg (2.61 MB)

ALLICIA MOELLER - Mar 13, 2024, 6:14 PM CDT



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IMG_5512.jpg (3.54 MB)



2024/03/17 - To-do Rest of Semester

Title: To-do Rest of Semester

Date: 3/17/2024

Content by: Alicia

Present: Alicia, Simmi, Emily, Neha

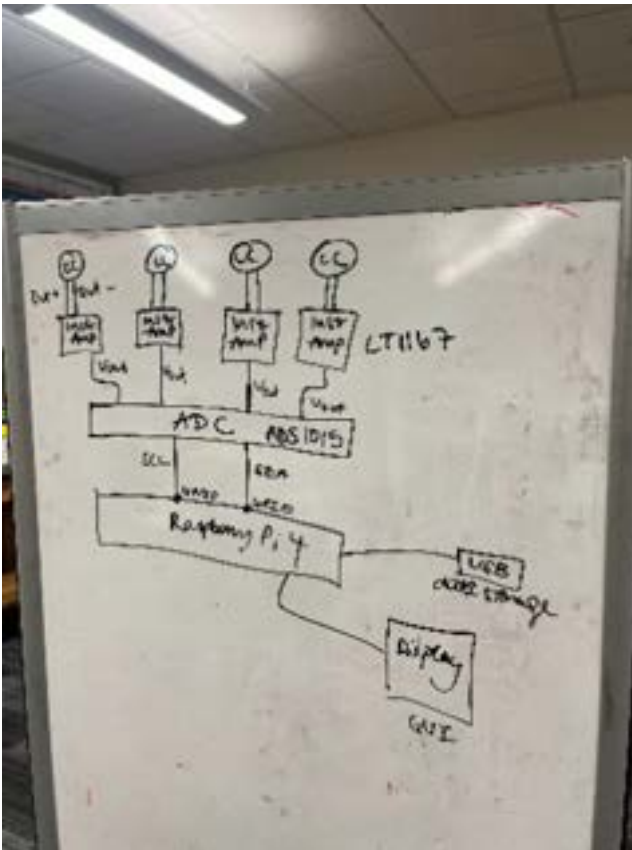
Goals: Establish a to-do list for the rest of the semester.

Content:

ORDER ALL MATERIALS:

- 4 additional button load cells
- 2 16-bit ADCS
- 8 LT1167 op amps (look into multi-channels)
- USB Drive
- LCD display case
- Tripod/stand for display
- Any necessary parts for clamps/supports

To-do:



- Force plates:
 - Meet with Gruben to verify design
 - Write fabrication protocol of the force plates
 - Calibrate each load cell (8 total)

- Fabricate 2 force plates
- Write testing protocol for testing final force plate
- Test force plates with compressive loads, eccentric loads, and shear loads
- Mount the flex foot to the force plate
- Mount the two force plates to the erg with screw holes
- Circuitry:
 - Finalize circuit block diagram with Dr. Gruben and Dr. Van de Weide (Alicia's circuits prof)
 - Design LT spice diagram
 - Fabricate circuit
- Coding:
 - Write code to integrate ADC with RPi
 - Code the output data to the GUI
 - Code features that identify USB drive - writes data to USB
 - Code the boot code so that the GUI runs automatically when it powers on.
- Integration:
 - Attach force plates to the tank
 - Configure the display
 - Write testing protocol for qualitative rowing testing
 - Have 3-5 rowers test the force plates

Conclusions/action items:

Meet with Dr. Gruben! Get materials ordered.



2024/04/10 - Ethics in Engineering

Title: Ethics in Engineering**Date:** 4/10/2024**Content by:** Neha**Present:** Neha, Emily, Colin**Goals:** Record group ethical discussion**Content:****Medical Device Dilemma**

1. The Guidant VPs could justify their case by arguing that there is still a net positive effect to their device. It is still helping a lot of people and saving lives, so the moral justification of their argument is that they don't want to jeopardize the positive impact of the device in the future. There is also a profit incentive for the company; reporting the issues with the device could jeopardize the company's prosperity and if the device is shut down, many people could be laid off. Protecting the company's employees is part of the company's responsibility and they do have an ethical obligation to do so.
2. The patients and physicians could argue that clarity and transparency is really important to keep themselves informed. They deserve full disclosure so they can make the right decisions for themselves. Doctors also take the hippocratic oath to do no harm. Without all the information about the device and procedure, they cannot ethically adhere to this oath. They also want to protect themselves from malpractice or disciplinary actions.
3. The design engineers can make their case to those higher up than the VPs and argue that the device is harming people and they don't want to be involved in that. They could also push for an internal review or audit. Being involved in a scandal like this could also jeopardize their careers. If no one within the company is listening to them, they could leave their job and be a whistleblower, either in the company or in the media.
4. The stakeholders in this case are the patients, physicians, the VPs, and the higher-ups. The option to go over the heads of the VPs would positively affect the patients and the physicians because the design engineers would be arguing for their benefit. However, going over the VPs might negatively affect the VPs because they would be implicated in the scandal. The higher-ups would now also be implicated since they would be faced with the decision of what to do. This option passes the publicity test because the design engineers would want to draw attention to their decision. This decision also upholds Section 2 of the BMES Code of Ethics which calls for meticulous, accurate, and transparent record-keeping to maintain public trust. The design engineers could also anonymously whistleblow to the FDA. This would positively affect the patients and physicians, and wouldn't affect the design engineers themselves because it would be anonymous. However, this would harm the company so they might face consequences there, either financially or career-wise. Still, this option upholds Section 2 of the BMES Code of Ethics and would pass the Publicity Test. It might not pass the Harm Test as compared to the first option because getting the FDA involved jeopardizes the entire company, as opposed to just the VPs, and might also take the device out of practice which would prevent people from potentially being helped by it. The final option is to whistleblow anonymously not to the FDA but to the public. This would have the same effects as the previous option for the stakeholders, but would also greatly diminish public trust in medical devices as a whole. This option definitely passes the Publicity Test and Social Justice Test because it will bring the most attention to the issue and allows for the most possible transparency. This option also upholds Section 2 of the BMES Code of Ethics. In our opinion, we would take this action since it will definitely create waves and prevent more harm from being done.

Application of Ethics to Our Design Project

1. What components of your design have ethical dimensions (be specific and list at least 2)?

The patient data outputted from the prototype isn't exactly secure and has the possibility to be breached which would violate HIPPA rules. Also, using the prototype with a physical therapist vs during practice is a blurred line because the device usage may contribute to NCAA practice hour limits as outlined in NCAA Bylaws Article 17.

2. How will your team address the ethical dimensions? (What is your action plan?)

The team will have the data recorded on an encrypted flash drive that only our client (physicians) has access to. We will also make an official agreement with our client to only use with physicians present/supervision so it doesn't count as practice time.

Conclusion:

Submit in canvas



2024/04/10 - Executive Design Summary

EMILY WADZINSKI - Apr 11, 2024, 10:11 AM CDT

Title: Executive Design Summary

Date: 4/10/2024

Content by: Emily

Present: Neha, Emily, Colin

Goals: Draft for BME Design Excellence Award

Content:

BME 301 - Excellence Award - #44 - Rowing_Biomechanics - Executive Summary

Asymmetry Force Sensor for Rowing Biomechanics

Emily Wadzinski, Colin Fessenden, Allicia Moeller, Neha Kulkarni, Simerjot Kaur

Many members of the University of Wisconsin Women's Rowing team have been dealing with lower back pain and other injuries, possibly due to asymmetric force output while rowing. Rotational twisting at the hips and torso are the lead causes for back pain in rowers, but is currently only qualitatively studied by the University of Wisconsin personal trainers. Many rowers experience back injury due to various reasons: consistently exerting force when the back is flexed, repetition of the rowing movement, and not properly adapting to the size of the ergometer or boat.

The client, Dr. Jill Thein-Nissenbaum, has tasked the team with creating a force plate system that can collect biomechanical data from rowers' lower extremities and display it to a rower in real-time as biofeedback. Current devices on the market include the Bertec Force Plate, which cannot be mounted to the ergometer that is used by the UW Rowing Team, or the BioRow Force Sensor, which is far too expensive for the client's needs and cannot be mounted to the existing ergometer. These devices also do not provide real-time data specifically regarding asymmetry of force between the rower's lower extremities.

The team had initially proposed a design involving the use of load cells, but after consulting with a load cell manufacturer's design engineer, decided not to move forward with this prototype due to cost and accuracy constraints. Load cells would not have worked for this application due to their sensitivity to dynamic and off-axis loading, which are heavily involved in rowing. The team then pivoted to an indirect force-sensing method using a rotating plate. The new proposed design involves a plate attached to a shaft in the center. The rower places their feet on either side of the shaft, and if they apply more force to one foot than the other, the shaft will rotate. This rotation will be sensed by an angular encoder, which can convert the angle into force difference and display this using a graphical user interface providing real time data. The team built an initial prototype using scrap wood to gauge the feasibility and investigate the fabrication process before ordering final materials.

Testing of the device involved both qualitative and quantitative analysis of the device's efficacy. Rowers from the lightweight, openweight, and men's divisions of the UW Rowing Team will row on the device at steady state for two minutes to collect baseline data, then row harder on their right foot for one minute, then harder on their left foot for one minute. Afterwards, they will return to steady state for one minute. This will allow rowers to see the graphical user interface at all configurations and will allow the physicians to see both symmetrical and asymmetrical data.

The design provides the client with clinically relevant data that can be used to treat injury. The force difference, as calculated by the device, can be normalized by patient factors such as height, body weight, torso to leg length ratio so physicians can investigate the root cause of asymmetry. This will help physicians identify rowers at higher risk of back pain and force asymmetry so they can be targeted for special training using the device. The biofeedback from the device will allow these high-risk rowers to adapt their technique and row symmetrically, thereby reducing their risk for injury.

Conclusion:

Submit draft to canvas



1/30/2024 - Spinal and Pelvic Kinematics During Prolonged Rowing on Ergometer vs Indoor Tank

Neha Kulkarni - Jan 31, 2024, 9:26 PM CST

Title: Spinal and Pelvic Kinematics During Prolonged Rowing on Ergometer vs Indoor Tank

Date: 1/30/2024

Content by: Neha

Present: Neha

Goals: Understand key differences between erg rowing and tank rowing

Search term: PubMed - rowing ergometer

Link: https://journals.lww.com/nsca-jscr/fulltext/2021/09000/spinal_and_pelvic_kinematics_during_prolonged.40.aspx

Citation: K. Trompeter *et al.*, "Spinal and Pelvic Kinematics During Prolonged Rowing on an Ergometer vs. Indoor Tank Rowing," *The Journal of Strength & Conditioning Research*, vol. 35, no. 9, p. 2622, Sep. 2021, doi: [10.1519/JSC.0000000000003187](https://doi.org/10.1519/JSC.0000000000003187).

Content:

- Data collected using infrared cameras
- Rowing req large amt of lumbar flexion which is major risk for back pain
- Phases: catch, drive, finish, recovery
- High volume of erg training connected to low back pain
- Ideal form: greater pelvic rotation and lesser lumbar flexion/extension at either end of stroke
- Tested 1 hr of continuous rowing on concept2 erg and in tank
 - 18 strokes per min followed by two 5-min interval phases of higher intensity
- Lumbopelvic ratio
 - Divide lumbar ROM by pelvic ROM
 - Value of 1 → equal contributions from lumbar and pelvic spine
- Statistical analysis
 - T-test to see differences between rowing conditions
 - Bonferroni correction bc values were collected at five timepoints, ie n = 5
- Thoracic region did not show differences between conditions
- Less posterior tilt on erg at the catch
- Lumbar spine had greater ROM on erg and less flexed at finish compared to tank
- Differences between training methods attributed to:
 - Differences in angle of footplate relative to seat
 - Differences in handle between erg and tank
 - Flow dynamics of air wheel vs water
- Differences in form over time attributed to fatigue, esp of erector spinae muscles
- Sex not taken into account

Conclusions/action items: Consider testing our device on the erg and the tank; consider motion capture as a tool for analysis; standardize stroke rate and resistance for testing as done in this study. Research reference 8.



1/29/2024 - Instrumentation of erg to monitor reliability of rowing performance

Title: Instrumentation of erg to monitor reliability of rowing performance

Date: 1/29/2024

Content by: Neha

Present: Neha

Goals: Understand how an erg can be instrumented for collections and analysis of biofeedback

Link: <https://www.tandfonline-com.ezproxy.library.wisc.edu/doi/epdf/10.1080/026404197367434?needAccess=true>

(cited by the Spinal and Pelvic Kinematics article)

Citation: "Instrumentation of an ergometer to monitor the reliability of rowing performance." Accessed: Jan. 30, 2024. [Online].

Available: <https://www.tandfonline.com/doi/epdf/10.1080/026404197367434?needAccess=true>

Content:

- Goal of study: develop portable data-acquisition system that could objectively describe rower performance
- Used concept2 erg
- Measurements gathered: heart rate, force at feet, force and velocity at hands
- Force plate at feet

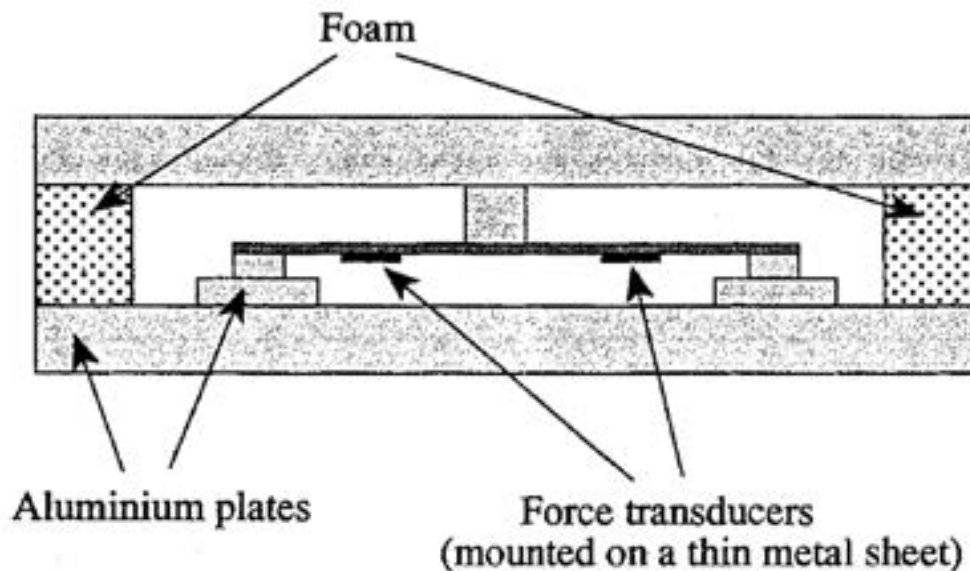


Figure 2 Cross-sectional schematic diagram of the footplates, showing position of the force transducers.

-
- Used four foil strain gauges in a wheatstone bridge crossover design
 - Output was sum of force applied to both plates
 - Output was amplified and low-pass filtered at cutoff frequency of 10 Hz
- Calibration of footplate
 - Loading middle of plate with four known masses 20-86 kg at frequency simulating stroke rate
 - Found straight line relationship between voltage output and masses
 - Measured application of force at a single point 3cm apart, representing differences in sizes of ball of foot at size 6 and size 10. Found 6% difference
- Did not measure pure force, but measured power

- Also measured stroke rate

Conclusions/action items: Research foil strain gauges, look into how this fabrication worked and how something that looks like this could be mounted on the erg footplate.



2/1/2024 - Gap in funding for women's sports

Neha Kulkarni - Feb 02, 2024, 10:56 AM CST

Date: 2/1/2024

Content by: Neha

Present: Neha

Goals: Understand differences in investment in women's sports at the collegiate level.

Search term: investment in college sports by gender - google

Link: <https://www.npr.org/2022/06/24/1107242271/the-ncaa-says-that-funding-for-women-in-college-sports-is-falling-behind>

Citation: T. A. Press, "A new NCAA report show the stark gap in funding for women's sports," *NPR*, Jun. 24, 2022. Accessed: Feb. 02, 2024. [Online]. Available: <https://www.npr.org/2022/06/24/1107242271/the-ncaa-says-that-funding-for-women-in-college-sports-is-falling-behind>

Content:

- In 2022, NCAA report recognizing 50th anniversary of Title IX
- Growth in participation in women's sports
- Men's programs received more than double the resources than that of women's programs in 2020
- College sports has become more business-oriented
 - Women's sports don't make as much money as D1 football → less investment
- Women account for 54% of undergraduate student body in D1 compared to 47% participation in sports
 - Gap shows lack of full Title IX compliance
- Fewer women are in head-coaching roles
 - Lack of WOC in leadership roles

Conclusions/action items: Lack of funding for women's athletics means cost constraints on the product are important to consider. The final product should be cost effective so that women's rowing teams have the budget for it. The final product can also address the inequities in women's sports participation as a device that seeks to make learning to row easier and prevent injury makes the sport more accessible and approachable to newcomers, especially considering the large number of walk-ons on the UW Crew team.



2/2/2024 - HIPAA Considerations

Neha Kulkarni - Feb 08, 2024, 12:22 PM CST

Title: HIPAA Considerations

Date: 2/2/2024

Content by: Neha

Present: Neha

Goals: Understand what elements of HIPAA we need to consider for the project

Link: <https://www.cdc.gov/phlp/publications/topic/hipaa.html#:~:text=HIPAA%20Privacy%20Rule,-The%20Privacy%20Rule&text=A%20major%20goal%20of%20the,public's%20health%20and%20well%2Dbeing.>

Citation: "Health Insurance Portability and Accountability Act of 1996 (HIPAA) | CDC." Accessed: Feb. 02, 2024. [Online]. Available: <https://www.cdc.gov/phlp/publications/topic/hipaa.html>

Content:

- Privacy rule
 - Make sure health info is properly protected
 - Esp for electronic transactions
- Covered entities
 - Healthcare providers
 - Health plans
 - Health clearinghouses
 - Business associates
- Security Rule
 - Covered entities must
 - Ensure confidentiality, integrity and availability of e-PHI
 - Detect and safeguard against anticipated threats
 - Certify compliance by their workforce

Conclusions/action items: I think our team would be considered a business associate of the clients, who are healthcare providers; therefore, we would be a covered entity of HIPAA. The Security Rule is the most relevant to the project as the data the device will collect will be electronic and measures must be taken to ensure it is secured and private. This could include storing it on a secure local device or deleting it immediately after use.



2/7/2022 - Load Cells

Neha Kulkarni - Feb 08, 2024, 10:02 AM CST

Title: Load cells

Date: 2/7/2024

Content by: Neha

Present: Neha

Goals: Learn about basics of load cells

Link: <https://www.omega.com/en-us/resources/load-cell-faq#:~:text=A%20load%20cell%20is%20a,sensors%20measure%20the%20force%20directly.>

Citation: "Load Cell FAQ," <https://www.omega.com/en-us/>. Accessed: Feb. 07, 2024. [Online]. Available: <https://www.omega.com/en-us/resources/load-cell-faq>

Content:

- Need load cell summing box to combine inputs from multiple load cells and sum them together
- Need signal conditioner for signal conversion, filtering, linearization, amplification
- Accuracy of a load cell is Class C (for mechanical/civil engineering) or D (for produce/meat)
- Can have USB load cells, with powered by computer
- Load cell vs strain gauge: load cell contains four strain gauges, two wired in compression, two in tension
- Load cell vs potentiometer: load cell is more accurate in sensing changes than potentiometer
- Load cell vs pressure transducer: load cell measures force directly, but pressure transducer uses indirect methods. Load cell is much more accurate
- Load cell vs force transducer: load cell and transducer do the same thing, but force transducer uses piezoresistive force sensors. Transducers are less expensive but also less accurate.
- Load cell falls under umbrella term of force sensor.

Conclusions/action items: Load cells are a good option for our prototype since they already contain the strain gauges. It would be far easier to purchase a load cell than to build our own strain gauge.



2/7/2024 - Interfacing Arduino and Python

Title: Interfacing Arduino and Python**Date: 2/7/2024****Content by:** Neha**Present:** Neha**Goals:** Understand how to interface Arduino with python**Link:** <https://realpython.com/arduino-python/>**Citation:** R. Python, "Arduino With Python: How to Get Started – Real Python." Accessed: Feb. 07, 2024. [Online].Available: <https://realpython.com/arduino-python/>**Content:**

- Firmata can control Arduino through serial connection
 - Install Firmata sketch on Arduino → in built-in examples
- Install pyFirmata package with pip
- Sample blink syntax in python:

```
Python
1 import pyfirmata
2 import time
3
4 board = pyfirmata.Arduino('/dev/ttyACM0')
5
6 while True:
7     board.digital[13].write(1)
8     time.sleep(1)
9     board.digital[13].write(0)
10    time.sleep(1)
```

- Line 4: establish serial connection using board obj. Configure port by passing argument to pyfirmata.Arduino()
- Board.digital is list whole elements represent digital pins
 - .read() and .write() methods
- Infinite loop while True, just like Arduino
- Reading digital inputs: push button example
 - Turn on LED if button is pressed

Python

```
1 import pyfirmata
2 import time
3
4 board = pyfirmata.Arduino('/dev/ttyACM0')
5
6 it = pyfirmata.util.Iterator(board)
7 it.start()
8
9 board.digital[10].mode = pyfirmata.INPUT
10
11 while True:
12     sw = board.digital[10].read()
13     if sw is True:
14         board.digital[13].write(1)
15     else:
16         board.digital[13].write(0)
17     time.sleep(0.1)
```

- Line 4: set connection with board
- Line 6: iterator used to read status of inputs of circuit
- Line 7: start iterator. Keeps loop running in parallel with main code, execute board.iterate() to update input values obtained from Arduino
- Line 9: set pin 10 as digital input
- Line 11: infinite while loop
- Line 12: read status of input pin, store in sw
- Lines 13-16: if sw is True, button is pressed so turn LED on, else don't
- Line 17: sleep for 0.1 s
- More compact syntax for above code:

```
1 import pyfirmata
2 import time
3
4 board = pyfirmata.Arduino('/dev/ttyACM0')
5
6 it = pyfirmata.util.Iterator(board)
7 it.start()
8
9 digital_input = board.get_pin('d:10:i')
10 led = board.get_pin('d:13:o')
11
12 while True:
13     sw = digital_input.read()
14     if sw is True:
15         led.write(1)
16     else:
17         led.write(0)
18     time.sleep(0.1)
```

- board.get_pin() creates pin obj
 - Pass argument "<type of pin>:<pin number>:<pin mode>"
 - "a" or "d" for analog or digital
 - "i" or "o" for input or output pin mode
- Reading analog inputs
 - Use board.get_pin
- Tkinter can create graphical user interface with python, works with Firmata too

Conclusions/action items: Play around with running the sample code in this article, to see how it works. If it works this would be a good option. Also look into Tkinter.



2/7/2024 - Tkinter GUI

Neha Kulkarni - Feb 08, 2024, 10:03 AM CST

Title: Tkinter and Python

Date: 2/7/2024

Content by: Neha

Present: Neha

Goals: Understand how Tkinter works

Link: <https://realpython.com/python-gui-tkinter/>

Citation: R. Python, "Python GUI Programming With Tkinter – Real Python." Accessed: Feb. 07, 2024. [Online].

Available: <https://realpython.com/python-gui-tkinter/>

Content:

- Python has a lot GUI frameworks but Tkinter is only framework built into standard Python library
- Cross-platform
- GUIs look outdated → downside
- Lightweight and painless to use → upside
- With python running, import tkinter as tk
- tk.Tk() creates window
- greeting = tk.Label(text="hello world") saves text to add to window
- greeting.pack() adds text to window
- Widget Classes
 - Label → used to display text or images
 - Button → button that can contain text and can perform an action when clicked
 - Entry → text entry widget that allows only a single line of text
 - tk.Entry.get() → retrieves text
 - tk.Entry.delete() → deletes text
 - tk.Entry.insert() → inserts text
 - Text → text entry widget allowing multiline text entry
 - Same methods as Entry
 - Do .get(1.0, tk.END) to extract all text
 - Frame → rectangular region used to group related widgets or provide padding between widgets
- ttk submodule has more, updated widgets
- For visual organization, use frames
 - .pack() puts them where keyword args specify
 - .place() controls precise location
 - .grid() creates grid
- Can make interactive applications using event handlers
 - Ex. command arg to button obj

Conclusions/action items: Tkinter could be a good way to prototype a design interface since it's pretty easy to work with, but we might need something more advanced for real-time feedback from the Arduino. Reading the Tkinter documentation should provide more info on if real-time feedback is possible.



3/12/2024 - US digital Angular Encoders

Neha Kulkarni - Mar 14, 2024, 11:56 AM CDT

Title: US Digital Angular Encoders

Date: 2/13/2024

Content by: Neha

Present: Neha

Goals: Look into some encoder options

Link: <https://www.usdigital.com/products/encoders/absolute/>

Citation: "Absolute," US Digital. Accessed: Mar. 14, 2024. [Online]. Available: <https://www.usdigital.com/products/encoders/absolute/>

Content:

- Need an absolute encoder because want exact position, not change in position
 - More helpful data to client
- Kit-style
 - Fit on existing shaft assemblies
 - [MAE3](#)

Shaft style

- [MA3](#)

Conclusions/action items: think about whether we need our shaft to rotate or the assembly on the shaft to rotate. Then pick encoder accordingly



3/12/2024 - US Digital MA3

Neha Kulkarni - Mar 14, 2024, 11:55 AM CDT

Title: US Digital MA3 Angular Encoder

Date: 3/12/2024

Content by: Neha

Present: Neha

Goals: Look at specifications of MA3 encoder as recommended by Dr. Gruben and see if they are suitable for our application

Link: <https://www.usdigital.com/products/encoders/absolute/shaft/ma3/>

Citation: "MA3 Miniature Absolute Magnetic Shaft Encoder," US Digital. Accessed: Mar. 12, 2024. [Online].

Available: <https://www.usdigital.com/products/encoders/absolute/shaft/ma3/>

Content:

- This encoder recommended by Dr. Gruben
- Absolute encoder → measures angles true position without zero reference needed
- Max shaft speed = 100 rpm → should be ok since typical stroke rates are 30 strokes per min
 - As speed increases, fewer readings per revolution
- Max shaft loading = 2 lb but we are not directly loading the shaft
- Made of stainless steel and brass
- Power supply typically 5 V, 16mA current (20mA max)
- PWM or analog output → tricky bc Raspberry Pi cannot read analog input or PWM

Conclusions/action items: Look into how to get a readable voltage value from PWM on the Raspberry Pi, and/or consider other encoders that have digital output



3/12/2024 - ADC with Raspberry Pi

Neha Kulkarni - Mar 14, 2024, 11:56 AM CDT

Title: Raspberry Pi Compatible ADCs

Date: 3/12/2024

Content by: Neha

Present: Neha

Goals: Find some ADCs compatible with Raspberry Pi so we can order the digital encoder

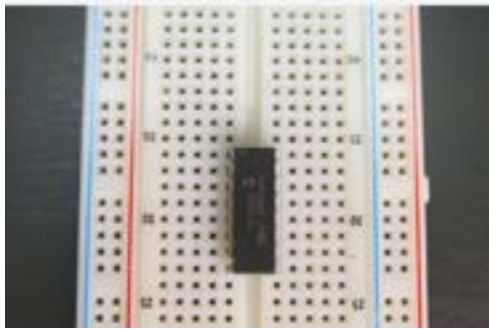
Link: <https://www.digikey.com/en/maker/projects/raspberry-pi-analog-to-digital-converters/72388f5f1a0843418130f56c53a1276c#:~:text=The%20ADS1015%20and%20ADS1115%20are,bit%20ADC%20with%204%20channels.>

Citation: "Raspberry Pi Analog to Digital Converters," DigiKey. Accessed: Mar. 12, 2024. [Online].

Available: <https://www.digikey.com/en/maker/projects/72388f5f1a0843418130f56c53a1276c>

Content:

- Option 1: MCP3008



- 10-bit ADC (like Arduino Uno)
- Connects to Raspberry Pi via SPI connection (hardware or software)
- Has a [python library](#)
- Raspberry pi must be connected to internet
- Option 2: ADS1015 / ADS1115
 - Uses I2C
 - Adjustable large gain
 - [Python library](#)

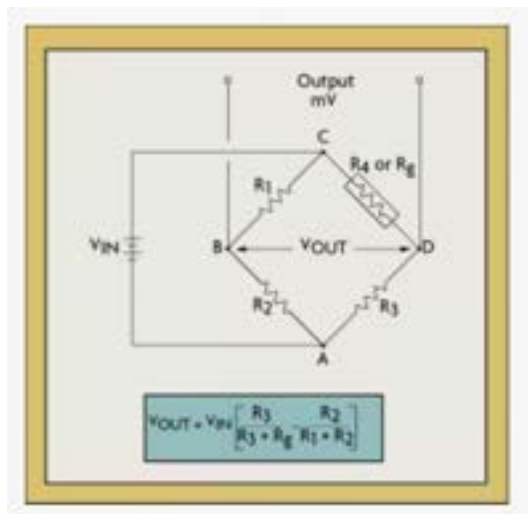
Conclusions/action items: choose an ADC that will work for us depending on the sensor we choose.



1/31/2024 - Wheatstone Bridge for Strain Gauges

Title: Wheatstone Bridge for Strain Gauges**Date:** 1/31/2024**Content by:** Neha**Present:** Neha**Goals:** Understand more about how to configure and use strain gauges in a wheatstone bridge.**Link:** <https://www.omega.com/en-us/resources/wheatstone-bridge>

(found via hyperlink in previous article)

Citation: "Wheatstone bridge for strain gauges," <https://www.omega.com/en-us/>. Accessed: Jan. 31, 2024. [Online].Available: <https://www.omega.com/en-us/resources/wheatstone-bridge>**Content:**

$$V_{OUT} = V_{CD} - V_{CB}$$

- A sensor can occupy one, two, or four arms of Wheatstone Bridge

$$\text{Strain} = (\Delta R_g / R_g) / GF$$

•

- GF = gauge factor

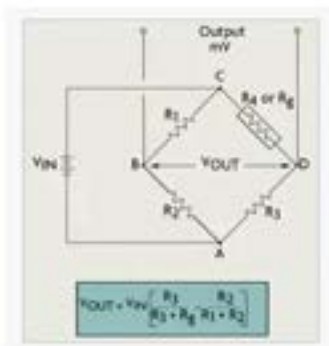
Conclusions/action items: Consider the wheatstone bridge configuration for our circuit and look into how to use it as a force transducer



1/31/2024 - Strain Gauges

Title: Strain Gauges**Date:** 1/31/2024**Content by:** Neha**Present:** Neha**Goals:** Understand how we can use strain gauges in addition to/instead of load cells as force transducers.**Search term:** Google - foil strain gauge**Link:** <https://www.omega.com/en-us/resources/strain-gages>**Citation:** "Strain Gauges," <https://www.omega.com/en-us/>. Accessed: Jan. 31, 2024. [Online]. Available: <https://www.omega.com/en-us/resources/strain-gages>**Content:**

- Strain gauge = sensor whose resistance varies with applied force
- Transducer-quality strain gauges
 - Feature tighter tolerances
- Karma strain gauges
 - Have good long term stability
 - Can be used in wide temperature range (-75 → 200 celsius)
 - Karma is a Ni-Cr alloy
- Strain gauge selection considerations
 - Gauges length
 - Number of gauges in gauge pattern
 - Arrangement of gauges in gauge pattern
 - Gird resistance
 - Strain-sensitive alloy
 - Carrier material
 - Gauge width
 - Solder tab type
 - Configuration of solder tab
 - Availability
- Measuring strain gauge circuits
 - Transducers employ four strain gauge elements that are electrically connected to form Wheatstone Bridge



-
- Output is expressed at mV per V input

Conclusions/action items: Look into the Wheatstone Bridge configuration and availability/capacities of strain gauges.



2/13/2024 - Load Cell Housing Brainstorm Sketches (copy)

Neha Kulkarni - Feb 14, 2024, 10:23 PM CST

Title: Brainstorm Load Cell Housing

Date: 2/13/24

Content by: Emily, Colin, Neha

Present: Emily, Colin, Neha

Goals: brainstorm ideas for the design matrix

Content:

See attached

Conclusion:

Redraw and dimension for matrix

Neha Kulkarni - Feb 14, 2024, 10:23 PM CST

Load Cell Housing



Sketch #1)



→



[Download](#)

301_holder_sketches.pdf (4.19 MB)



2/13/2024 - Design Matrix Drawings (copy)

Neha Kulkarni - Feb 14, 2024, 10:23 PM CST

Title: Design Matrix Housing Drawings

Date: 2/13/24

Content by: Emily

Present: Emily, Colin, Neha

Goals: redraw the designs were brainstormed for the matrix

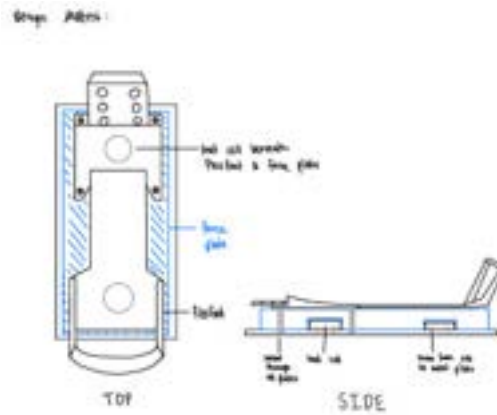
Content:

See attached

Conclusion:

Need to dimension for report

Neha Kulkarni - Feb 14, 2024, 10:23 PM CST



[Download](#)

Matrix_housing_designs_.pdf (501 kB)



2/14/2024 - HX711 to Raspberry Pi

Title: HX711 to Raspberry Pi**Date:** 2/14/2024**Content by:** Neha**Present:** Neha**Goals:** Understand how to hook up an HX711 to a Raspberry Pi, and compare it to the Arduino process.**Link:** https://www.youtube.com/playlist?list=PLAmif_espMWkZZSdUxLtZqEol_XKO2g5Y**Citation:** 05 Connecting HX711 load cell amplifier to Raspberry Pi, (Feb. 07, 2023). Accessed: Feb. 14, 2024. [Online Video].Available: https://www.youtube.com/watch?v=Ode_Z4jxVPU**Content:**

- Can buy a raspberry pi with a keyboard
- Use ribbon cable and GPIO extension cable to hook up to breadboard
- Strain gauges
 - Coiled wire
 - Works like resistors
 - When bent, resistance changes
- Bar load cell with four strain gauges in wheatstone bridge
 - $V_{in} = 3V$
- Load cell hooked up to HX711 board (board is on breadboard)
 - $E+ = 3V$
 - $E- = GND$
 - $A- =$ node voltage
 - $A+ =$ node voltage
 - $VCC = 3V$
 - SCK = a GPIO pin (serial clock)
 - DT = GPIO pin (data out)
 - GND = GND
- Install [HX711 library](#) into python using pip
- Use Thonny IDE to program

```
import RPi.GPIO as GPIO to be able to read/write from pins
```

```
from hx711 import HX711
```

```
GPIO.setmode(GPIO.BCM)
```

```
hx = HX711(dout_pin = 6, sck_pin = 5)
```

```
hx.zero()
```

```
input('Place known weight on scale and press Enter: ')
```

```
reading = hx.get_data_mean(readings = 100)
```

```
known_weight_g = input('Enter known weight in grams & press Enter: ')
```

```
value = float(known_weight_g)
```

```
ratio = reading / value
```



```
hx.set_scale_ratio(ratio)
```

```
while True:
```

```
    weight = hx.get_weight_mean()
```

```
    print(weight)
```

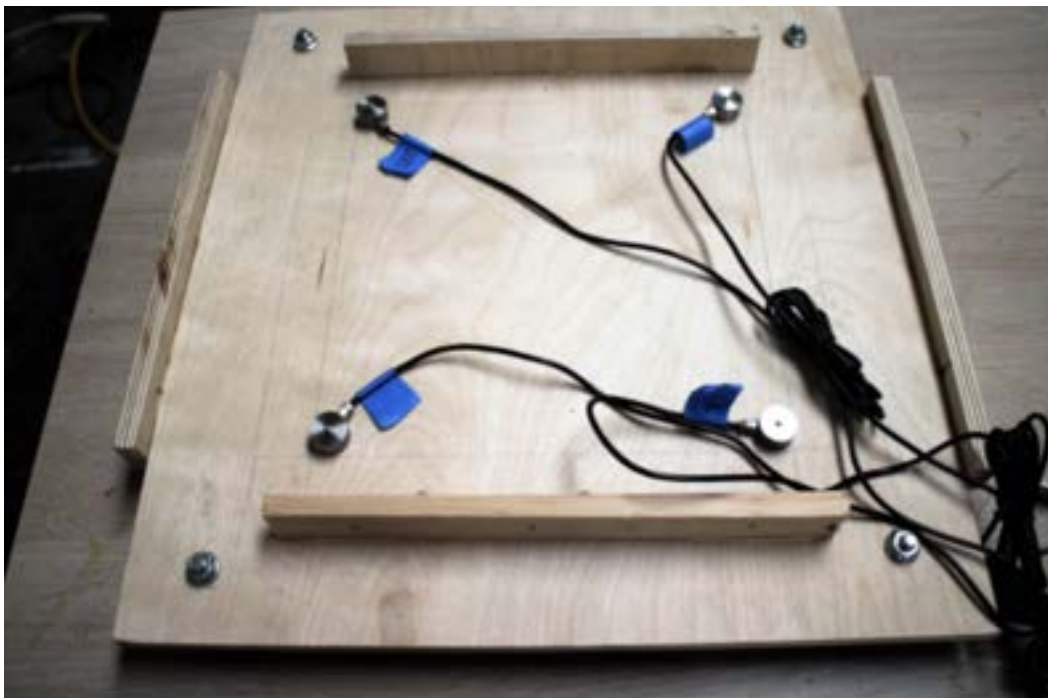
Conclusions/action items: Find the HX711 load cell that we bought and see if we can use the same amplifier we bought to hook it up with the Raspberry Pi.



2/16/2024 - IoT Industrial Scale

Title: IoT Industrial Scale Guide**Date:** 2/16/2024**Content by:** Neha**Present:** Neha**Goals:** Understand how to create an industrial scale**Link:** <https://learn.sparkfun.com/tutorials/iot-industrial-scale#build-the-base-and-case>**Citation:** "IoT Industrial Scale - SparkFun Learn." Accessed: Feb. 22, 2024. [Online]. Available: <https://learn.sparkfun.com/tutorials/iot-industrial-scale#build-the-base-and-case>**Content:**

- [Materials used](#)
 - Used same 200 kg load cells we used last semester
 - Used OpenScale board that can be programmed (this wouldn't work for us)
- Housing
 - Four load cells
 - Installed in corners 1" from sides, equidistant and on the same plane
 - Screwed into base plate, pin up
 - Add walls
 - Add plate on top of walls



- Alas, the OpenScale is intended for constant loads and the fastest print rate is 505 ms, which is too slow to get accurate readings on impact force.

Conclusions/action items: Though we might not be using four load cells, this plate fabrication method is adaptable to our product. We need to make sure we get load cells better for changing loads.



2/20/2024 - Footplate materials

Neha Kulkarni - Feb 23, 2024, 7:27 PM CST

Title: Footplate Materials

Date: 2/20/2024

Content by: Neha

Present: Neha

Goals: Look at materials we can order to fabricate our footplate out of

Link: <https://www.grainger.com/category/group/fasteners-hardware-raw-materials>

Citation: "Grainger.com." Accessed: Feb. 22, 2024. [Online]. Available: <https://www.grainger.com/category/group/fasteners-hardware-raw-materials>

Content:

- Aluminum plates for baseplate
 - Yield strength of 4930 psi → good enough for us
 - Come in all sizes → we would probably use 10x12 in plates
 - Thicknesses between 0.25-1.5 in (price increases with thickness)
 - We would probably want something thinner, closer to the 0.25 in
 - Easy to machine
- Also have textured aluminum plates, could be good for the top
 - These are thinner, more expensive.

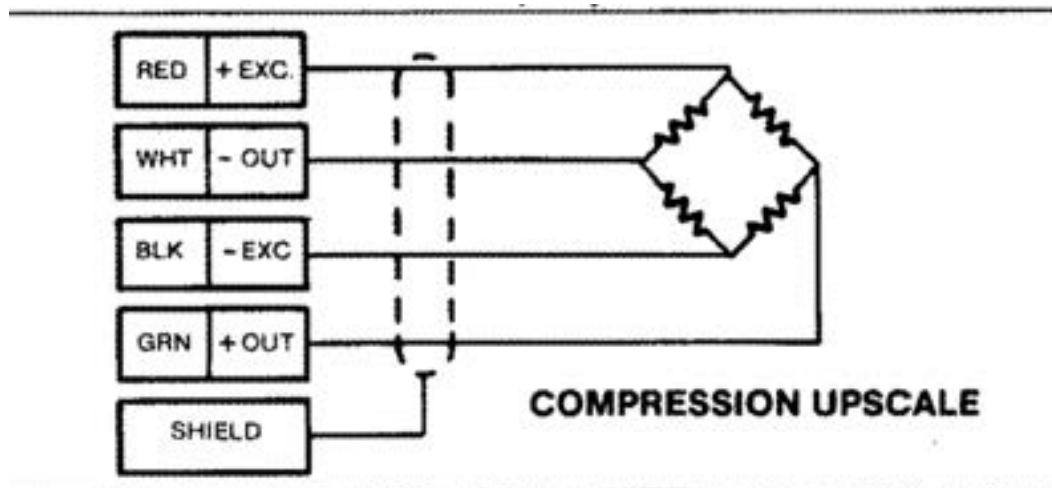
Conclusions/action items: These aluminum plates are a really good option for the stationary uniplate design because they will be easy to fabricate with and also will be strong enough for our application.



2/25/2024 - Interface Load Cells

Title: Interface Load Cells**Date:** 2/25/2024**Content by:** Neha**Present:** Neha**Goals:** Look at interface load cells and find the best one for our application.**Link:** <https://www.interfaceforce.com/interface-mini-load-cell-selection-guide/>**Citation:** "Interface Mini™ Load Cell Selection Guide," Interface. Accessed: Feb. 25, 2024. [Online].Available: <https://www.interfaceforce.com/interface-mini-load-cell-selection-guide/>**Content:**

- We want a beam type load cell
- [SSB Sealed Load Cell](#) has the capacity we need
 - [Datasheet](#)
 - [Installation Guide](#)
 - 4 wire load cell → compatible with our amplifier!!



- This load cell is also designed for outside use → we could ask if it's waterproof
 - Mounting surface needs to be machined, surface 125 roughness or better and load cell needs to be screwed in FLAT
 - 10ft integral cable included
-
- Interface also makes some displays
-
- Looked at [Interface Solutions for Test and Measurement](#), to see what Interface suggested for different applications
 - Interface suggested a client use their product and [interface it with a Raspberry Pi](#)
 - Interface used SSB Beam load cells to measure [GRFs on a treadmill](#)

Portable Displays



9325-NU Portable Sensor Display
Portable, Digital, Hand Held, Battery Powered, TEDS Ready



9320 Battery Powered High-Speed Data Logging Indicator
Digital, Hand Held, Battery Powered, TEDS Ready

LED Displays



WTS-LD1 Wireless Large LED Display
Large Screen with 4-digit 4 in (102 mm) LED display



WTS-LD2 Wireless Large LED Display
Large Screen with 6-digit 4 in (102 mm) LED display

Weighing Instrumentation



1280 Programmable Weight Indicator and Controller
150+ built-in functions for programming
USB, Ethernet TCP/IP, Wi-Fi Direct[®] and Bluetooth[®] ports



480 Bidirectional Weight Indicator
Powers up to 10 Load Cells
Measurement Rate up to 40Hz



920 Programmable Weight Indicator and Controller
Power for 16, 250 ohm load cells per
A/D board, Peak Hold
32 scale accumulators

^^ could be potentially useful for a boat application

Conclusions/action items: Get a quote and potentially order these.



2/26/2024 - Interface Load Cell Consultation

Neha Kulkarni - Mar 06, 2024, 4:51 PM CST

Title: Interface Load Cell Consultation

Date: 2/26/2024

Content by: Neha Kulkarni

Present: Neha

Goals: Get an opinion on which Interface Load Cell we should use from their application engineer.

Content:

- Spoke with Lee
 - Ljaramillo@interfaceforce.com
- Jamie is our local Field Engineer for southern Wisconsin
- If budget is not a constraint
 - 3 axis load cell
- Otherwise, off axis loading is a real issue
- Low Profile Load cells can compensate for eccentric loading
- SSB Beam Type?
 - Good form factor but not what we're looking for
 - Shear beam type style
- Super SC with compression calibration is their recommendation
 - Eccentric loading OK
 - Dynamic loading not as good
 - 500 lbf is \$150 but additional \$100 or so for compression calibration
 - 4 wire - unclear if HX711 compatible
 - Excitation voltage 15V → don't use <10
- Signal processing will probably require use of their products → additional costs
 - Wasn't super helpful on how to process the raw analog signal

Conclusions/action items: This is a very expensive option that would require a lot of additional workarounds. I don't think this is viable for the semester.



4/3/2024 - Footplate Materials to Order

Title: Footplate Materials to Order**Date:** 4/3/2024**Content by:** Neha Kulkarni**Present:** Neha**Goals:** Finalize materials and order them**Content:****Bottom plate attached to erg:** use existing one from show and tell prototype. It fits, no need to re-fabricate.**Top plate to be attached to Flexfoot (rowing plate):** Make out of wood and attach to aluminum frame**Bearings and bearing mounts:**

[Mounted ball bearings](#) -- might need the extra clearance ones to account for foam/silicone/spring height. No need to get high-speed ones because we're doing that many RPMs. Extra clearance ones also have set screws which we need since we are rotating in both directions.

Aluminum Frame for top plate:

[Bolt-together framing](#) -- good because will allow mounting on both sides

Shaft support:

[Shaft mount](#) -- good bc can mount from top or bottom on top plate depending on the clearance we need

Shaft:

[Undersized rotary shaft](#) -- good bc will fit in bearing

Shaft coupling for attaching shaft to rotary encoder:

[Clamping, precision flexible shaft coupling](#)

Middle padding material(s):

[Rubber sheets?](#)

[Foam sheets?](#)

[Cut up a kneeling pad?](#)

[springs?](#)

Conclusions/action items: Discuss w team and client, then order these materials.



2023/03/28 - Green Permit

Neha Kulkarni - Mar 28, 2023, 10:59 PM CDT

Title: Green Permit

Date: 03/28/2023

Content by: Neha Kulkarni

Present: Neha Kulkarni

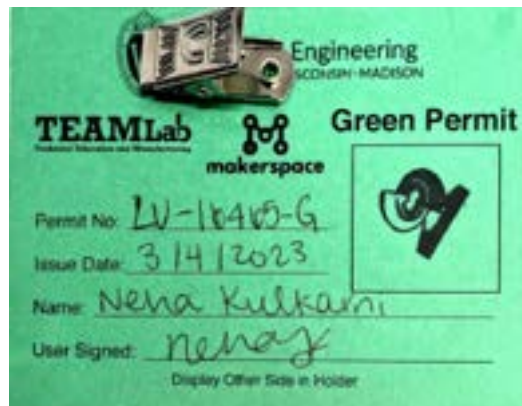
Goals: Obtain a green permit for fabrication of the sample holder.

Content:

A photo of the green permit is attached.

Conclusions/action items: Use the permit for fabrication of the sample holder.

Neha Kulkarni - Mar 28, 2023, 11:01 PM CDT



[Download](#)

greenpermit.pdf (391 kB)



2024/2/1 Textured Foot Plate for Ergometer

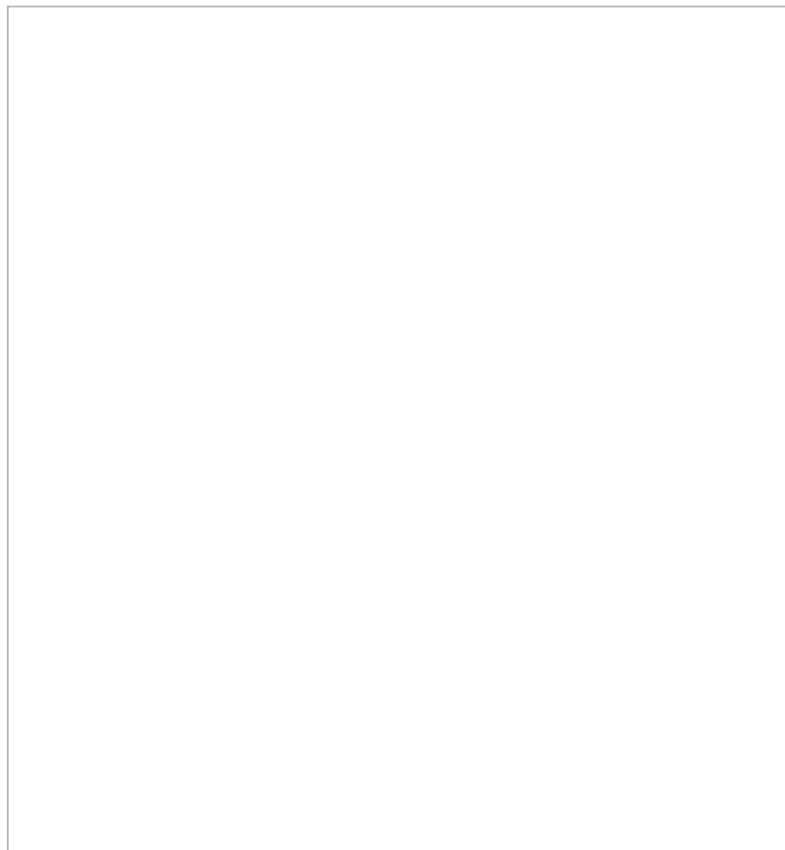
Title: Foot Pressure while Indoor Rowing**Date:** 1/31/2024**Content by:** Simmi**Citation:**

Vieira T;Botter A;Gastaldi L;Sacco ICN;Martelli F;Giacomozzi C;, "Textured insoles affect the plantar pressure distribution while elite rowers perform on an indoor rowing machine," PloS one, <https://pubmed.ncbi.nlm.nih.gov/29095908/> (accessed Feb. 1, 2024).

Keywords: Rowing, Foot Pressure**Link:** <https://pubmed.ncbi.nlm.nih.gov/29095908/>**Goals:** Learn more about the location of the center of pressure while rowing to understand where to place load cell.**Content:**

- foot positioning on the foot stretcher is very important in ensuring optimal force transmission.
- This study focuses on whether passive foot mechano-transducer can improve foot loading patterns and ensure symmetry while rowing.
- A main effect was observed for force and contact area, with the high-density insoles providing greatest values ($P < 0.035$).
- No interaction was observed between side and insole ($P > 0.190$), even though symmetry was higher with high-density insoles.
- Kinematics ($P = 0.800$) and rowing performance were not affected by insole type; not statistically significant increase in mean travelled distance was observed for denser insoles ($P > 0.21$)





- the nodes on the surface were 3 mm high

-before testing, athletes were able to practice with the 3 insoles and asked if the insoles felt comfortable (11 elite rowers were a part of testing)

-IMU sensors were securely to handle for acceleration measurements and pressure data was sampled from the Pedar-X system

Conclusions/action items: Adding a textured surface to our design will result in a greater foot force and greater area contact with the foot and foot stretcher. Left and right foot differences will decrease only slightly.



2024/2/7 Common Injuries in D1 Women Rowers

SIMERJOT KAUR - Feb 08, 2024, 8:42 AM CST

Title: Common Injuries in D1 Women Rowers

Date: 2/7/2024

Link: <https://www.tandfonline.com/doi/abs/10.1080/00913847.2021.1931526>

Source:

J. Treloar *et al.*, "Update on injury epidemiology in rowing: Our experience with female NCAA Division I athletes and a systematic review of the literature," *The Physician and Sportsmedicine*, vol. 50, no. 3, pp. 189–196, Jul. 2021. doi:10.1080/00913847.2021.1931526

Goals: Verify the most common injury locations from lower extremities in collegiate women rowers in order to ensure design is able to address major injury points.

Content:

Epidemiology based study- case series

-One-hundred and thirty-seven injuries were recorded in 92 female rowers over 5 years.

-Among the 92 injured athletes, 38% sustained injury to the lower back, while 23% and 16% of these athletes had injury to the ribs and hip–groin area.

Most studies reported injuries to the lower spine (80%)

-Most injuries recorded in a single team of female NCAA Division I athletes occurred in the lower back followed by injuries to the ribs and the hip.

-No conclusions can be made regarding the most common injuries in rowers based on the current evidence because there has been a lot of heterogeneity on injury reporting methods

Article was very brief and mainly provided statistics on common injuries for D1 women rowers but didn't go into depth on why that is.

Conclusions/action items: Lower back injuries end up causing athletes to be more susceptible to injuries in ribs and hips. It is important to understand lasting effects of lower back injuries as it can provide insight onto how the design should measure asymmetries in the lower extremities.



2024/4/25 Limb Asymmetry Index

Title: Limb Asymmetry Index

Date: 4/25/2023

Content by: The one person who wrote the content

Goals: Learn more about limb asymmetry index that clients mentioned in our meeting.

Citation: "Assessing limb asymmetry," Knowledge Base, <https://success.spartascience.com/en/knowledge/assessing-limb-asymmetry> (accessed April 25, 2024).

Content:

-limb asymmetry is the comparison of performance between the right and left anatomical limbs which is usually presented as a percentage of one limb to the other.

-is of interest in healthy populations for assessing functional and dysfunctional asymmetries, as well as in injured populations for comparing affected and unaffected limbs during rehabilitation and continuous monitoring.

-measurements for single limb strength include max effort single leg hop for distance test (rehabilitative testing), more isolated assessments are also used (single joint isokinetic dynamometry to assess single leg strength and there are many other single limb tests like balance, range of motion and strength assessments

-tests that are the most simple and mimic real world functional movement (walking, running, hopping and jumping) are considered the most clinically useful

-below is an example of how single limb asymmetry is quantified- there are different equations for defining limb asymmetry so it is important to stick to one standard equation; for the one below, asymmetry of less than 80% is considered problematic

Different equations for calculating asymmetries using hypothetical jump height scores of 25 and 20 cm (taken from Bishop et al. (7) and reused with permission)			
Asymmetry name	Equation	Asymmetry (%)	Reference
LSI-1	$(NDL/DL) \times 100$	80	Ceroni et al. (10)
LSI-2	$(1 - NDL/DL) \times 100$	20	Schiltz et al. (25)
LSI-3	$(Right - Left)/0.5 (Right + left) \times 100$	22.22	Bell et al. (4), Marshall et al. (19)
BSA	$(Stronger\ limb - Weaker\ limb)/Stronger\ limb \times 100$	20	Nunn et al. (21), Impellizzeri et al. (14)
BAI-1	$(DL - NDL)/(DL + NDL) \times 100$	11.11	Kobayashi et al. (15)
BAI-2	$(2 \times [DL - NDL]/[DL + NDL]) \times 100$	22.22	Wong et al. (30), Sugiyama et al. (28)
AI	$(DL - NDL)/(DL + NDL/2) \times 100$	22.22	Robinson et al. (23), Bini et al. (6)
SI	$(High - Low)/Total \times 100$	11.11	Shorter et al. (26), Sato and Heise, (24)
SA	$(45^\circ - \arctan [L/R])/90^\circ \times 100$	7.04	Zifchock et al. (31)

AI = asymmetry index; BAI = bilateral asymmetry index; BSA = bilateral strength asymmetry; DL = dominant limb; LSI = limb symmetry index; NDL = nondominant limb; SA = symmetry angle; SI = symmetry index.

Example: Triple Hop Test for Distance

	Unaffected Limb	Affected Limb
Trial 1	26.5 cm	22.5 cm
Trial 2	27	25
Trial 3	28.5	25
Average	27.33	24.17

Limb Symmetry Index (LSI) =

$$\frac{[\text{affected limb (avg score)} \div \text{unaffected limb (avg score)}] \times 100}{100}$$

$$\text{LSI} = [24.17 \div 27.33] \times 100 = 88\%$$

-to determine viable asymmetry, it is best to perform multiple asymmetry exams as there is a lot of human variability in how the stronger and weaker limb will respond to different exercise tests (e.g. bilateral squat and single leg jump)

- these scores are then used to implement rehabilitation where the patient is still assessed for LSI frequently and monitored overtime to address if the asymmetry has improved.

Conclusions/action items: In the upcoming semesters it could be useful to have the clients test some of their rowers who are healthy and asymmetrical perform some exercise tests (like jump: test, single leg hop, bilateral squat) and then quantify asymmetry through using the equations above. These numbers can then be compared to the the force difference they achieve on the our angular encoder design while rowing. This could be a possible method of verifying if our design is accurate to the standards of the limb asymmetry index.



2024/2/1 Rowing Tank vs Ergometer

SIMERJOT KAUR - Feb 08, 2024, 11:25 AM CST

Title: Tank Rowing vs Ergometer

Date: 2/1/2024

Content by: Simmi

Citation:

K. Trompeter *et al.*, "Spinal and pelvic kinematics during prolonged rowing on an ergometer vs. indoor tank rowing," *Journal of Strength and Conditioning Research*, vol. 35, no. 9, pp. 2622–2628, Sep. 2021. doi:10.1519/jsc.0000000000003187

Keywords: rowing tank, ergometer

Link: <https://pubmed.ncbi.nlm.nih.gov/31373977/>

Goals: Learn about the main difference between tank rowing and ergometer. Consider any design constraint specific to tank rowing.

Content:

-high volume of ergometer training is suggested to be a risk factor for low back pain, especially in combination with fatigue and resulting changes in technique, such as increased spinal motion

-Considering the results of recent investigations and the high prevalence of low back pain and thoracic pain in rowers, it needs to be clarified whether changes in lumbopelvic and thoracic motion occur during the time progression of routine training sessions. In addition, it remains unclear whether changes occur during rowing training using other methods, such as the rowing tank.

-As lumbar flexion significantly increases during ergometer training, but not during open-water rowing (37), spinal kinematics and rowing technique might also not significantly change during training in the rowing tank. Hence, rowers might be able to compensate better for high spinal loads during rowing tank training compared with ergometer training.

-The thoracic region did not show differences between the 2 rowing conditions at any of the 5 timepoints ($p > 0.05$). However, on the ergometer, the pelvis showed a less posterior tilt at the catch ($p < 0.05$), and the lumbar spine had a greater ROM and was less flexed at the finish compared with in the rowing tank

-The present results gave the first indication that there is a difference in spinopelvic kinematics between rowing on the ergometer vs. in the rowing tank.

-In the rowing tank, the drive phase extended over time in relation to the entire rowing stroke, whereas the recovery phase abbreviated. We assume that the rowers fatigued over time and were unable to maintain the velocity of the blades and thus the pressure on the blades; therefore, the drive phase extended. To reach the required stroke rate, the recovery phase had to be abbreviated, which might further increase fatigue.

Conclusions/action items: Main findings were rowing tank displays more range of motion compared to erg and the catch and recovery phase are different.



2024/3/12 Incremental vs Absolute Rotary Encoder

SIMERJOT KAUR - May 03, 2024, 5:38 PM CDT

Title: Incremental vs Absolute Rotary Encoder

Date: 3/12/2023

Content by: Simmi

Goals: Learn about the types of angle encoders and what specific kind works for our application.

Content:

Incremental Rotary Encoder:

- Incremental encoders generate a series of pulses as the shaft rotates, typically in the form of square wave signals.
- These pulses are used to determine the relative motion or change in position of the shaft from a reference point.
- They do not inherently provide information about the absolute position of the shaft, but rather the changes in position since a starting point.
- To determine absolute position, the system needs to keep track of the starting position and count the incremental pulses. They are often used in applications where continuous monitoring of position changes is more critical than knowing the absolute position, such as speed control systems or servo motors.

Absolute Rotary Encoder:

- Absolute encoders provide a unique digital code for each position of the shaft within a full revolution, directly indicating the absolute position.
- They typically use a series of binary or Gray code tracks to represent the position.
- Absolute encoders can provide position information instantly upon power-up without the need for a reference point or initialization.
- They are suitable for applications where knowing the exact position is crucial, such as precision machinery, robotics, or CNC machines.
- Absolute encoders are often more complex and expensive than incremental encoders due to the additional circuitry required to generate and interpret the absolute position data.

Conclusions/action items: The absolute rotary encoder will be the most suitable for our application.



2024/2/7 Athlete Testing Equipment Standard

SIMERJOT KAUR - Feb 08, 2024, 11:26 AM CST

Title: Athlete Testing Equipment Standard

Date: 2/7/2024

Link: <https://www.iso.org/standard/39903.html#:~:text=ISO%2020957%2D1%3A2005%20is,control%20are%20specifically%20regulated%20by>

Source: "ISO/DIS 20957-1(en) General safety requirements and test methods," ISO, <https://www.iso.org/obp/ui/en/#iso:std:81908:en>

Goals: Find clear guidelines for athletic testing equipment to apply to our design.

Content:

- ISO 20957 is a set of international standards that provides specifications for athletic testing equipment, including requirements related to sensing force.

- "Strength training equipment - Safety requirements and test methods" -addresses safety requirements and testing procedures for strength training equipment, which includes force-sensing capabilities.

-Specifies requirements for the accuracy of force sensors integrated into athletic testing equipment. Ensures that force measurements are reliable and consistent for accurate performance evaluation.

-Ensures the equipment can capture variations in force during different phases of exercise.

-Defines the maximum weight that the equipment can safely support. Ensures that the equipment is structurally sound and can withstand the stress imposed by users of varying weights.

-Specifies testing protocols to assess the long-term durability of the equipment.

-Ensures that the equipment maintains its structural integrity and performance over extended periods of use.

-Mandates clear and comprehensive user instructions for the proper use of the equipment, including any limitations or precautions.

-Addresses the ability of the equipment to measure dynamic forces, simulating real athletic movements.

-Outlines procedures for testing the equipment under conditions exceeding normal usage.

-Verifies that the equipment can withstand occasional overloading without compromising safety.

Conclusions/action items: The standards mentions a lot of important considerations regarding functionality of the design such as withstanding the strenuous activity of rowing. Most importantly, in order to make the design inclusive, it should be easy to use. Our team should consider writing a protocol on using the device and how to best interpret the data that is provided in the format we create it in. We should also look into a creating a structured testing procedure involving how long the rowers should row at steady state as to maintain accuracy and reliability.



2024/4/20 MA3 Absolute Encoder

Title: MA3 Absolute Encoder

Date: 4/20/2024

Goals: Learn more the specifications of the MA3 absolute encoder recommended by Dr. Gruben

Citation:

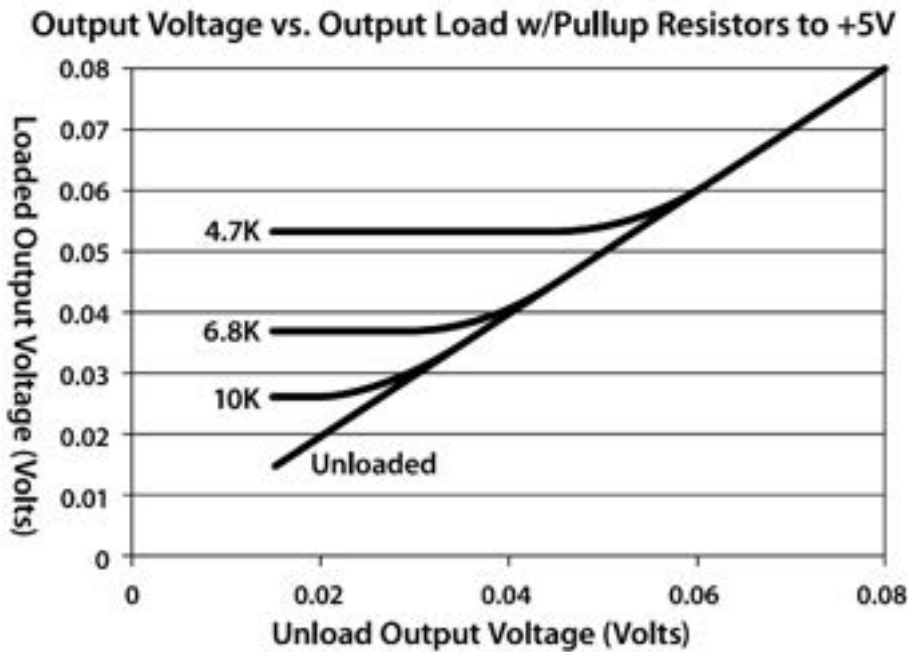
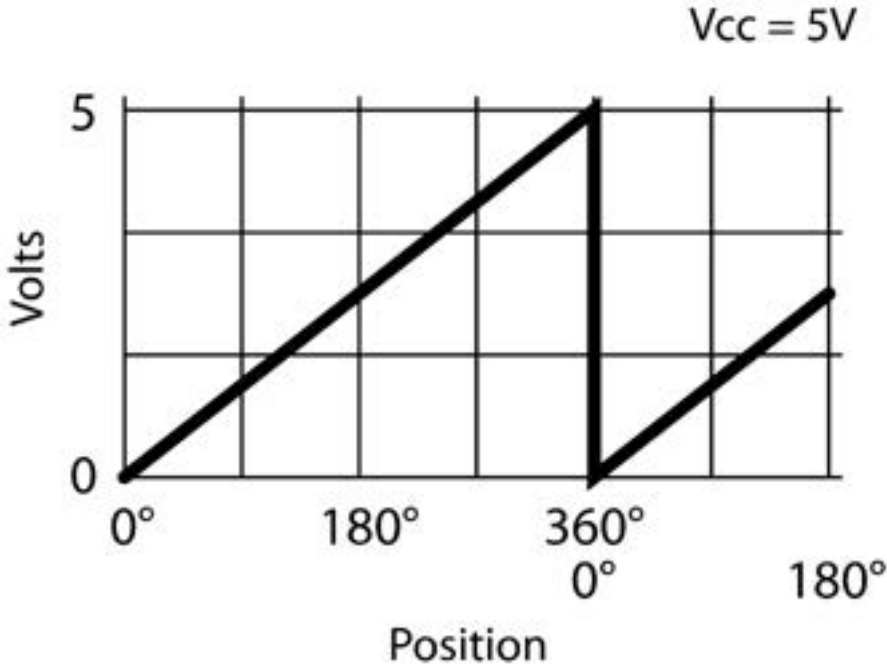
"MA3 miniature absolute magnetic shaft encoder," US Digital, <https://www.usdigital.com/products/encoders/absolute/shaft/ma3/> (accessed April 20, 2024).

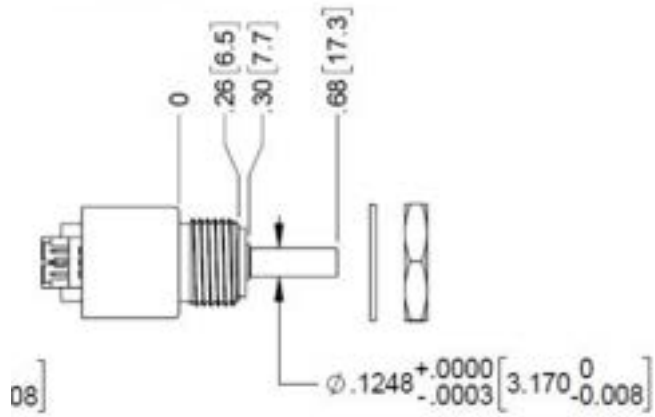
Content:

-output: analog 10 bit (0.35 degree resolution)

-the encoder will be a ball bearing torque meaning that it will be frictionless so when the top plate pivots the encoder pivots seamlessly without causing any friction

-due to the fact the raspberry pi only takes digital values- we will need to use a level converter to get the output



BALL BEARING - 1/8" SHAFT

There are 3 wires:

ANALOG OUTPUT (MA3-A):

PIN	NAME	DESCRIPTION
1	5	+5VDC power
2	A	Analog output
3	G	Ground

Conclusions/action items: Figure out how to connect the GUI with the output of encoder



2024/2/1 Arduino --> Python

SIMERJOT KAUR - Feb 08, 2024, 11:26 AM CST

Title: Serial Communication between Arduino and Python

Date: 2/1/2024

Content by: Simmi

Citation:

"Serial communication between Python and Arduino," projecthub.arduino.cc, <https://projecthub.arduino.cc/ansh2919/serial-communication-between-python-and-arduino-663756> (accessed Feb. 1, 2024).

Keywords: Arduino, Python

Link: <https://projecthub.arduino.cc/ansh2919/serial-communication-between-python-and-arduino-663756>

Goals: Learn how to translate arduino code into python for easier interpretation. Write down steps for connecting python and arduino.

Content:

PySerial is a Python API module which is used to read and write serial data to Arduino or any other Microcontroller. To install on Windows, simply visit \$ PySerial's Download Page \$ and following the steps below :

1. Download the PySerial from the link above or Open CMD and type pip install pyserial
2. Install it by keeping the setting as the default. You should be sure that Pyserial worked correctly, To check this you can open IDLE and type in import serial If you are not getting any error, it means you installed it correct, else you can check your installation.
- 3: Python Code First up, we need a simple program to get the Python sending data over the serial port. # Importing Libraries import serial import time
arduino = serial.Serial(port='COM4', baudrate=115200, timeout=.1) def write_read(x): arduino.write(bytes(x, 'utf-8')) time.sleep(0.05) data = arduino.readline() return data while True: num = input("Enter a number: ") # Taking input from user value = write_read(num) print(value) # printing the value
4. To initiate a connection with the Arduino from Python, figure out which COM Port the Arduino is on. We can simply see in which port our Arduino is on.

Conclusions/action items: Action items are to download PySerial and set up the connection with Arduino and Python.



2024/2/7 HX711 with Four Load Cells

SIMERJOT KAUR - Feb 08, 2024, 12:18 PM CST

Title: HX711 with Four Load Cells

Date: 2/7/2024

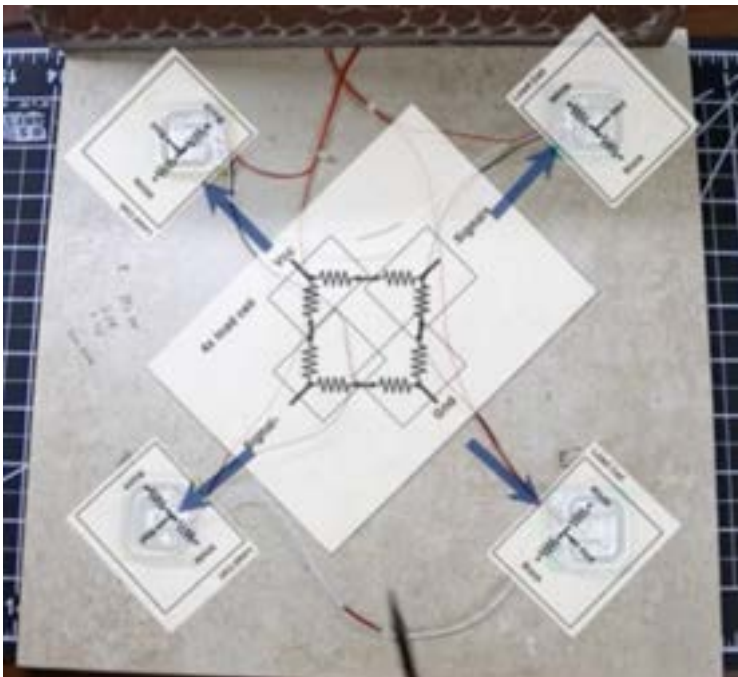
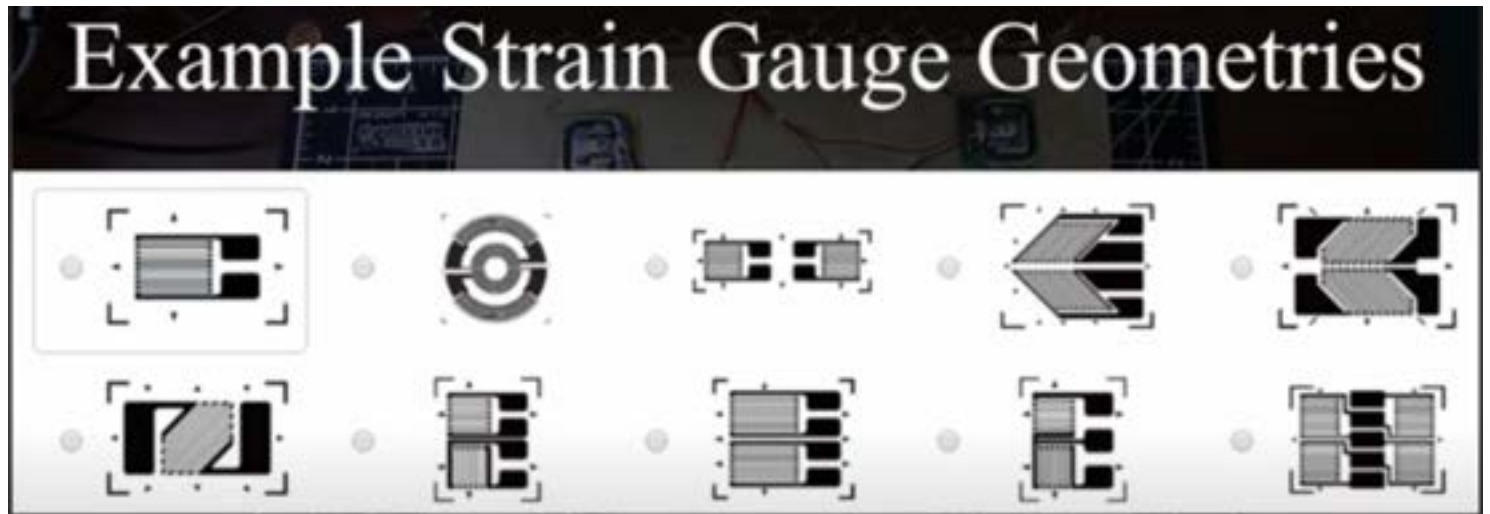
Content by: Simmi

Link (video): <https://www.youtube.com/watch?v=dNiVZBTvwxS>

Goals: Learn how to combine multiple load cells into one amplifier and other materials needed for circuit

Content:

-need load cells that dont have 4 wires meaning they are already in a wheatstone bridge configuration



-in the video, the person used a square ceramic tile and load cells were glued on top of a 3D printed square that had a hole in the middle allowing it to flex up and down when force was applied to the load cell

-edited sample code from library and combined with github code: <http://robotresearchlab.com/2020/08/28/four-load-cell-with-hx711-programming/>

-calibration was done by using known weights and adjusting the calibrating factor until the reading was accurate.

Conclusions/action items: In conclusion, knowing how to make this configuration could be useful. Action items are to find a load cells with a capacity of 200 kg that aren't already in a wheatstone configuration.



2024/2/15 Raspberry Pi Basics

SIMERJOT KAUR - Feb 16, 2024, 10:11 AM CST

Title: Raspberry Pi Basics

Date: 2/15/2024

Content by: Simmi

Goals: Learn about the benefits of using Raspberry Pi over Arduino and basics of getting started.

Link: <https://www.simplilearn.com/tutorials/programming-tutorial/what-is-raspberry-pi#:~:text=The%20Raspberry%20Pi%20is%20a,a%20modified%20version%20of%20Linux.>

Citation:

R. A. S, "What is Raspberry Pi? here's the best guide to get started: Simplilearn," Simplilearn.com, <https://www.simplilearn.com/tutorials/programming-tutorial/what-is-raspberry-pi#:~:text=The%20Raspberry%20Pi%20is%20a,a%20modified%20version%20of%20Linux.> (accessed Feb. 16, 2024).

Content:

What is raspberry pi?

- a small low cost computer, size of credit card, can access the internet, can watch videos, access spreadsheets, can be used in music machines and parent detectors

-has a processor, memory and graphic driver

Use Cases

- can create a simple desktop using a raspberry pi, microSD card, power source, HDMI cable, suitable display

-can create a robotics controller (interface and control robot)

-other uses include printing, game servers, and gaming machines (16 bit games)

Types of Raspberry Pi

-different models with different functions (8 total models)

Advantages

-inexpensive, efficient for use as a server, ideal for adaptive technology, microcomputer

Conclusions/action items: Raspberry Pi has a higher memory and processor than an Arduino Uno which makes it more suitable for our application. Action items are learn how to pair multiple load cells onto one board.



2024/2/15 Combining Load Cells with Raspberry Pi

Title: Combining Load Cells with Raspberry Pi

Date: 2/15/2023

Content by: Simmi

Link: <https://raspberrypi.stackexchange.com/questions/96422/connecting-4-hx711-to-one-raspberry-pi>

<https://tutorials-raspberrypi.com/digital-raspberry-pi-scale-weight-sensor-hx711/>

Citation:

[1] user101375user101375 1111 silver badge22 bronze badges and tfong01tfong01 4, "Connecting 4 HX711 to one Raspberry pi," Raspberry Pi Stack Exchange, <https://raspberrypi.stackexchange.com/questions/96422/connecting-4-hx711-to-one-raspberry-pi> (accessed Feb. 16, 2024).

[2] Jude et al., "Build a digital raspberry pi scale (with weight sensor HX711)," Tutorials for Raspberry Pi, <https://tutorials-raspberrypi.com/digital-raspberry-pi-scale-weight-sensor-hx711/> (accessed Feb. 16, 2024).

Goals: Figure out how to combine two HX711 amplifiers to one Raspberry Pi board in order to continue using the load cell models from Sparkfun as they come in the correct force capacity.

Content:

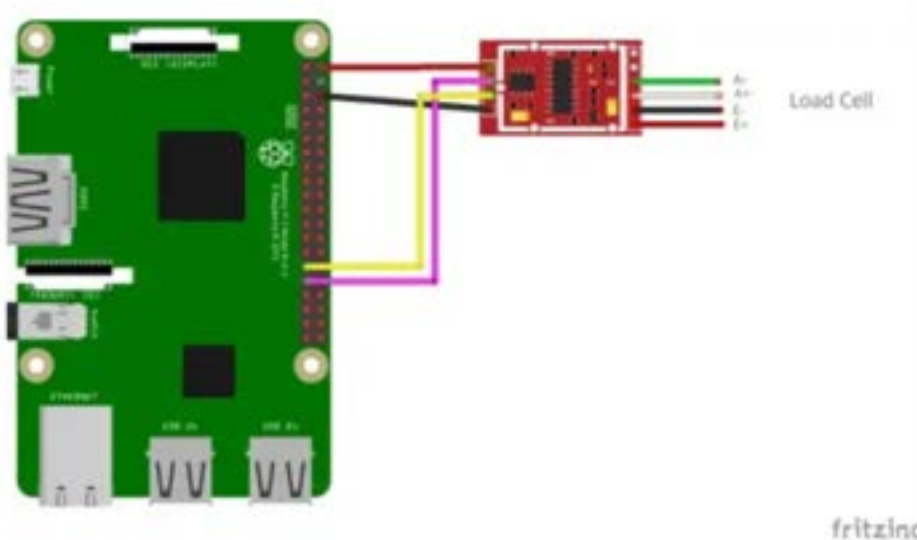
The Rpi (or its digital buffers/level converters/IO port extenders) can use 8 GPIO lines, 2 each to read 1 HX711.

How to read HX711: HX711 has 1 clock input and 1 results output. By applying 25-27 clock pulses to set gain at the PD_SCK pin, data will shift out from the DOUT output pin.

The second article uses a green model of the HX711 but both red and green are compatible with the tutorial

- GND to Raspberry Pi Pin 6 (GND)
- DT to Raspberry Pi Pin 29 (GPIO 5)
- SCK to Raspberry Pi Pin 31 (GPIO 6)

Schematically, the connection to a **Raspberry Pi 3*** then looks as follows:



The amplifier used in the above picture has 6 connections but we only need to use 4.

In the article they also show the raspberry pi connected to an LCD display which can be a possible choice for us too.

Conclusions/action items: Action items are to ensure if the raspberry pi can be paired with a LCD display while being paired to two HX711 amplifiers.



2024/2/22 Load Cells

SIMERJOT KAUR - Feb 26, 2024, 12:18 PM CST

Title: Load Cell Manufacturer

Date: 2/22/2024

Goals: Find some load cells to possibly order that can be paired with the HX711 amplifier. My goal is to find load cells that are very inexpensive but match the capacity of 200kg.

Content:

Load cells:

https://usa.banggood.com/200KG-Electronic-Platform-Scale-Load-Cell-Pressure-Balanced-Cantilever-Load-Weight-Sensor-p-1098085.html?utm_source=googleshopping&utm_medium=cpc_organic&gmcCountry=US&utm_content=minha&utm_campaign=aceng-pmax-usg-pc¤cy=USD&cur_warehouse=CN&createTmp=1

<https://www.amazon.com/Electronic-Platform-Pressure-Balanced-Cantilever/dp/B07PF4W73Y>

<https://www.amazon.com/Sensitivity-Aluminum-Electronic-Industrial-Production/dp/B0B1RPN812>

Conclusions/action items: Action items are to present the load cell designs to team members.



2024/2/22 How to find Load Cells Compatible with HX711

SIMERJOT KAUR - Feb 26, 2024, 12:13 PM CST

Title: How to find load cells compatible with HX711

Date: 2/24/2023

Content by: Simerjot Kaur

Goals: Learn how to find load cells that will work with our current amplifier if load cell manufacture doesn't specify

Content:

- The HX711 is a precision 24-bit analog-to-digital converter (ADC) designed for weigh scales and industrial control applications. It is commonly used with load cells to measure weight.
- Load cells typically have four wires, and they can be either strain gauge-based or piezoelectric. If your load cell has four wires, it is likely a strain gauge-based load cell.
- In general, strain gauge load cells can be compatible with the HX711 amplifier as long as they have the same electrical characteristics and match the specifications supported by the HX711.
- **Connecting the wires:**
- HX711: Connect the red and black wires of the load cell to the E+ and E- terminals on the HX711. These wires are for excitation voltage.
- Connect the white and green (or blue) wires of the load cell to the A- and A+ terminals on the HX711. These wires carry the signal from the load cell.
- Connect the HX711 to your microcontroller or other interface using the appropriate digital pins.
- **When choosing a load cell to work with the HX711 amplifier, key specifications to look for:**
- Excitation Voltage: The HX711 provides an excitation voltage to the load cell for operation. The typical excitation voltage for HX711 is 5V.
- Sensitivity: Sensitivity represents the change in output voltage per unit change in applied load.
- Rated Output: This specification indicates the maximum output signal the load cell can produce relative to its rated capacity. Make sure the rated output of the load cell is within the acceptable range for the HX711.
- Capacity: The maximum load or force the load cell can measure.
- Bridge Resistance (Ohms): The HX711 is compatible with load cells that have a specific bridge resistance.
- Zero Balance: The load cell's zero balance is the output signal when no load is applied.

Citation: [1] HX711 Datasheet by Sparkfun Electronics | Digi-Key Electronics, <https://www.digikey.com/htmldatasheets/production/1836471/0/0/1/hx711.html> (accessed Feb. 26, 2024).

[2] Canelasarduino, "Can this load cell be used with this load cell amplifier module?," Arduino Forum, <https://forum.arduino.cc/t/can-this-load-cell-be-used-with-this-load-cell-amplifier-module/1006500> (accessed Feb. 26, 2024).

Link: Microsoft Word - hx71_english.doc

Conclusions/action items: In conclusion, when looking at load cells online, I will see if the load cells have 4 wires and matches the specs of the HX711 datasheet.



2024/2/22 What gets plugged into Raspberry Pi

Title: What gets plugged into Raspberry Pi

Date: 2/22/2024

Content by: Simerjot

Goals: Figure out what to order for raspberry pi.

Citation: [1] Buy A raspberry pi 15W USB-C power supply – Raspberry Pi, <https://www.raspberrypi.com/products/type-c-power-supply/> (accessed Feb. 23, 2024).

Content:

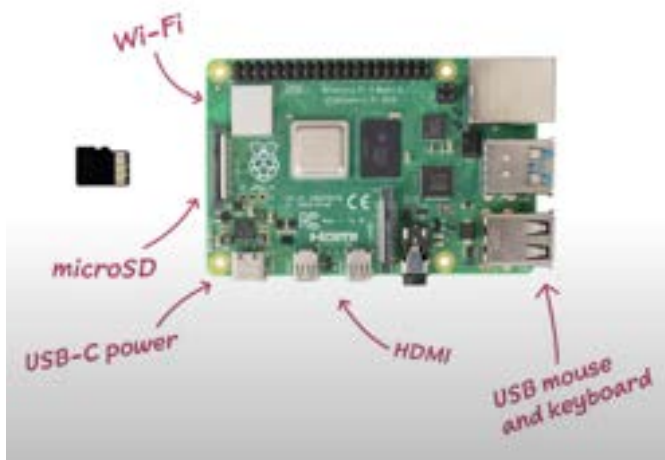
You will need

- A 15W USB-C power supply – we recommend the official [Raspberry Pi USB-C Power Supply](#)
- Micro SD card with Raspberry Pi OS installed (buy a pre-loaded SD card along with your Raspberry Pi, or install Raspberry Pi OS using [Raspberry Pi imager](#))
- A [keyboard](#) and [mouse](#)
- Cables to connect to one or two displays via Raspberry Pi 4's micro HDMI ports

Raspberry Pi 4 Model B5V/3A15W USB-C power supply

How to set up raspberry pi:

Flash microSD card using PI imager



Comes with bluetooth connectivity

To install an operating system on a storage device for your Raspberry Pi, you'll need:

- a computer you can use to image the storage device into a boot device
- a way to plug your storage device into that computer

You can install Imager in the following ways:

Download the latest version from [raspberrypi.com/software](https://www.raspberrypi.com/software) and run the installer.

Conclusions/action items: Items for purchase are mirco SD card, USB-C power and HDMI.



2024/2/27 GUI on Spyder using PyQt5

SIMERJOT KAUR - Mar 04, 2024, 1:49 PM CST

Title: GUI on Spyder using PyQt5

Date: 2/27/2023

Content by: Simmi

Goals: Learn how to use PyQt5 and make a basic GUI.

Source: <https://www.youtube.com/watch?v=rZcdhles6vQ>

Content:

For making a GUI, I used the module recommended by Alicia which is PyQt5. I also watched a video on basics of GUI using PyQt3. Attached is the code for the GUI I designed.



My GUI was a pop up from Spyder terminal. It only outputs the peak forces which in this trial run, I manually put in random values for each leg.

Overall thoughts on this is the gui can be a bit bigger so it is more clear to see. I also couldn't figure out how to make the bars vertical and it would be nice to include the actual peak forces on the graph. I also think it is important to include the expected peak force on the bars and a way to tell when the assymetry in the peak force is a problem.

Conclusions/action items:

Look into other softwares that allow me to manually make the aesthetics for the GUI as I saw that there is a way to make your GUI more appealing through a secondary website.

```
#!/usr/bin/env python3
# -*- coding: utf-8 -*-
"""
Created on Mon Feb 26 23:34:18 2024

@author: simerjotkaur
"""
import sys
import time
from PyQt5.QtWidgets import QApplication, QMainWindow, QVBoxLayout, QWidget, QPushButton,
QProgressBar, QLabel
from PyQt5.QtCore import Qt, QThread, pyqtSignal

class WorkerThread(QThread):
    update_signal = pyqtSignal(int, int)

    def __init__(self, values):
        super(WorkerThread, self).__init__()
        self.values = values

    def run(self):
        for right_leg_value, left_leg_value in zip(self.values['right_leg'],
self.values['left_leg']):
            time.sleep(1) # Simulate some processing time
            self.update_signal.emit(right_leg_value, left_leg_value)

class MainWindow(QMainWindow):
    def __init__(self):
        super(MainWindow, self).__init__()

        self.initUI()

    def initUI(self):
        self.setWindowTitle('Leg Force Exertion')

        # Create a central widget
        central_widget = QWidget(self)
        self.setCentralWidget(central_widget)

        # Create layout
        layout = QVBoxLayout(central_widget)

        # Create progress bars for right and left legs
        self.right_leg_bar = QProgressBar(self)
        self.left_leg_bar = QProgressBar(self)

        self.right_leg_label = QLabel('Right Leg', self)
        self.left_leg_label = QLabel('Left Leg', self)

        # Set color for progress bars
        self.right_leg_bar.setStyleSheet("QProgressBar {color: green;}")
```

```
self.left_leg_bar.setStyleSheet("QProgressBar {color: blue;}")

layout.addWidget(self.right_leg_label)
layout.addWidget(self.right_leg_bar)
layout.addWidget(self.left_leg_label)
layout.addWidget(self.left_leg_bar)

# Create start button
start_button = QPushButton('Start', self)
start_button.clicked.connect(self.start_animation)
layout.addWidget(start_button)

def start_animation(self):
    values = {
        'right_leg': [50, 60, 50, 63, 42, 55, 69, 63, 62],
        'left_leg': [51, 59, 42, 58, 48, 52, 67, 69, 57],
    }

    self.worker_thread = WorkerThread(values)
    self.worker_thread.update_signal.connect(self.update_leg_bars)
    self.worker_thread.start()

def update_leg_bars(self, right_leg_value, left_leg_value):
    self.right_leg_bar.setValue(right_leg_value)
    self.left_leg_bar.setValue(left_leg_value)

if __name__ == '__main__':
    app = QApplication(sys.argv)
    mainWin = MainWindow()
    mainWin.show()
    sys.exit(app.exec_())
```



1/31/24 - Understanding Foot Force

Title: Understanding Foot Force Graphs

Date: 1/31/24

Content by: Emily

Present: N/A

Goals: learn what the peaks mean for our force plate

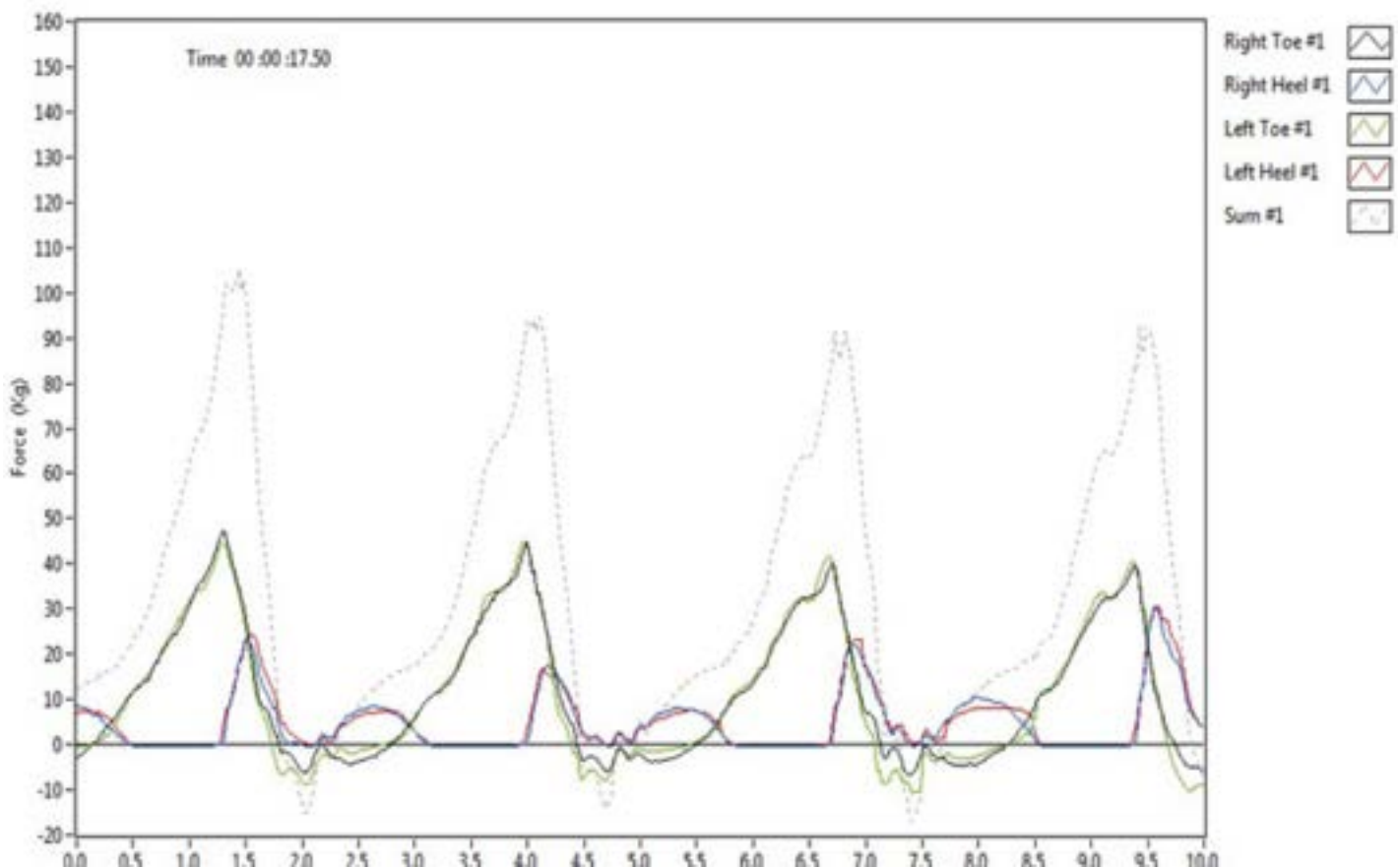
Link: <https://batlogic.net/understanding-foot-force/>

Search term: force plate on rowing machine (Google)

Citation:

D. E. Wittich, "Understanding Foot Force - BAT Logic - Improve Performance, Reduce Injury, Enhance Ease Of Use," BAT Logic. Accessed: Jan. 31, 2024. [Online]. Available: <https://batlogic.net/understanding-foot-force/>

Content:



- Gate force is a key metric in rowing for assessing the rower's output.
- Focus has been on foot force and its role in overall force generation and boat speed improvement.
- Foot force is not about the power of the feet but how well they transfer hip and leg muscle force to the stretcher.
- During the drive, force is created through hip and knee extension, transferred via ankles and feet, reaching the handle through the upper body.
- Foot force depends on blade load, being minimal without a loaded handle, and acts as an 'energy transfer link' in the stroke.

- A stable foot enhances force transfer, and a greater surface area at contact increases energy transfer efficiency.
- Graphs show a relationship between heel timing and peak force, emphasizing the importance of a stable foot structure.
- Rowing differs from sprinting in force application due to rowers being on their toes with dorsiflexed ankles in the catch position.
- The catch position in rowing may compromise efficiency and effective foot force due to the foot's dynamic and less stable position.
- Contrastingly, a stable foot position with a fully engaged heel improves stability, comfort, muscle engagement, and foot force, contributing to boat speed.
- Increasing foot force can enhance speed without the need to row harder.

Conclusion:

Compare to the graphs from our poster last semester

EMILY WADZINSKI - Feb 01, 2024, 10:18 AM CST



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Understanding_Foot_Force_-_BAT_Logic_-_Improve_Performance_Reduce_Injury_Enhance_Ease_Of_Use.pdf (532 kB)



2/1/2024 - Forces Applied on a Ergometer

Title: Forces Applied on Rowing Ergometer Concept2

Date: 2/1/24

Content by: Emily

Present: N/A

Goals:

Link: http://bionics.seas.ucla.edu/education/Rowing/Biomechanics_2008_01.pdf

Search term: force plate on rowing machine (Google)

Citation:

Content:

- The study focuses on the resistance of a rowing ergometer (Concept2®) to forces applied at different frequencies of practice.
- Four contact points on the ergometer were examined: the handle, the seat, and the two foot-stretchers.
- Forces are measured using specific materials at each contact point
- An expert rower, practicing more than twice a week and an international level rower was analyzed
- Initial results indicate that forces do not significantly change with an increase in stroke rate.
- Forces under the seat are not constant due to the inertial parameter of the rower's trunk and upper limbs.
- Forces on foot-stretchers vary due to the inertial effect of the whole body at the end of recovery.
- The study suggests that the structure of the Concept2® ergometer can be optimized and changed based on force measurements, potentially reducing costs.

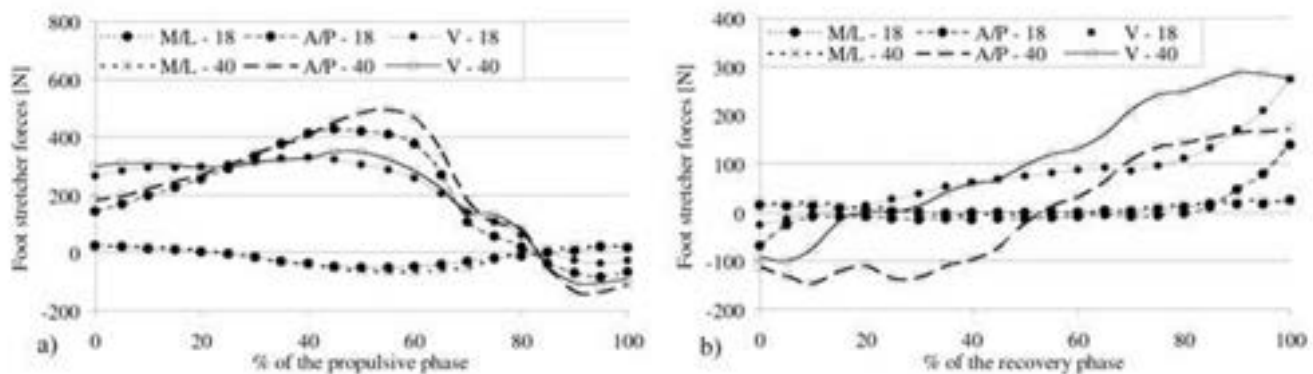


Figure 5 - Force measured under the right foot stretcher during propulsion (a) and recovery (b) rowing phase.

1. Forces During Propulsion (Figure 5a):

- During the initial 50% of the propulsive phase, the Anterior/Posterior (A/P) force increases up to 500N.
- The Vertical (V) force stays nearly constant at 300N during this phase.
- The A/P force is comprehensive because it represents the rower pushing against the foot-stretchers.

2. End of Propulsion (Figure 5a):

- Towards the end of the propulsion phase, there is a transition to negative A/P and V forces.
- This suggests that the rower is now pulling on the foot-stretchers to compensate for the trunk inclination at this moment.
- The rower adjusts body segment posture to stop the inertia of the body segments.

3. Recovery Phase (Figure 5b):

- During the recovery phase, both V and A/P forces increase.
- This occurs as the rower places his body segments near the foot-stretchers.
- The rower returns to the catch position to initiate a new rowing cycle.

Conclusion:

During the propulsive phase, the rower exerts a pushing force against the foot-stretchers, with the A/P force being the most significant. Towards the end of propulsion and during the recovery phase, there is a shift to pulling forces, suggesting a dynamic adjustment of body posture. These findings are crucial for designing foot-stretchers that can withstand both pushing and pulling forces during different phases of the rowing cycle. We may need to consider these forces for optimizing the structure and materials used in the foot-stretchers of rowing ergometers.

EMILY WADZINSKI - Feb 01, 2024, 10:33 AM CST

Forces Applied on Rowing Ergometer Concept2®: a Kinetic Approach for Development (P94)

Nicolas Delcroix¹, David Babin², Philippe Poth³, Philippe Goss¹

Topic: Sport sciences

Abstract: Concept2 rowing ergometer is characterized by many facts. One of them is that it must create the forces applied on the athletes in the beginning movement, and also the space in an apartment or a room. A good first world of most aspect from this topic was made in this study on force measurement of several rowing specialists in the catch position on the rowing ergometer Concept2® at different frequency of practice. The goal is to reveal which structure modification could be offered in order to improve conception. There are four contact points on this ergometer: "the handle, the seat and the two feet stretchers". On each point, forces are measured with a specific support. On the handle, two stretchers are used. Under the seat, and by the feet stretchers, six force plates are used. Their measurements are called "rowing expert" over the practice on Concept2® ergometer from the catch to the seat and in an international and rowing club. One rowing club is selected for each professional club from 10 to 15 athletes per club. This study does therefore an in-depth analysis of the forces in rowing. Secondly, some professional rowers were interviewed. An Internet questionnaire explores the measurement of the mechanical power, moment of the catch and the seat force. Finally, some other data, from an all force measurement of Concept2® rowing club, help in the analysis of the forces. The structure of Concept2® ergometer can be optimized, changed and possibly combined with other force measurement techniques for developing a rowing ergometer.

Keywords: rowing ergometer, applied force, kinetics and performance

1- Introduction

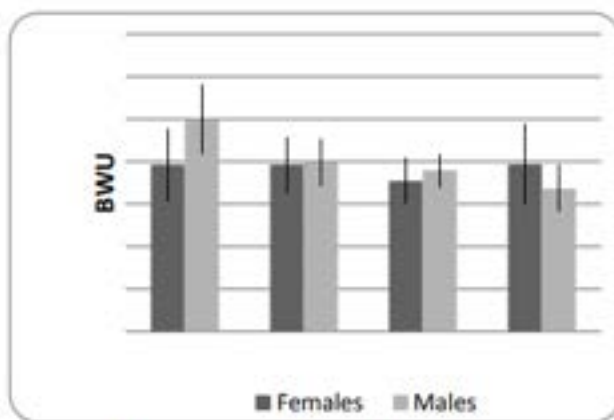
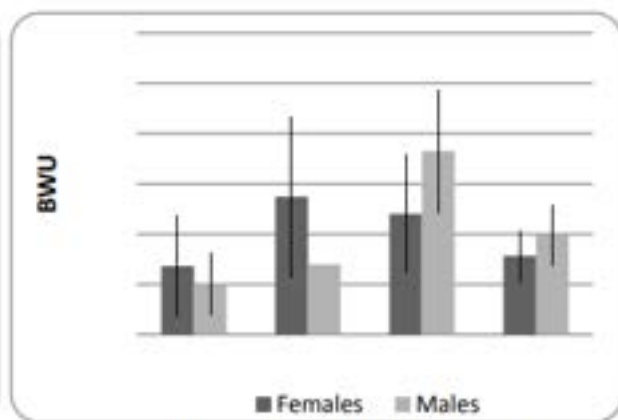
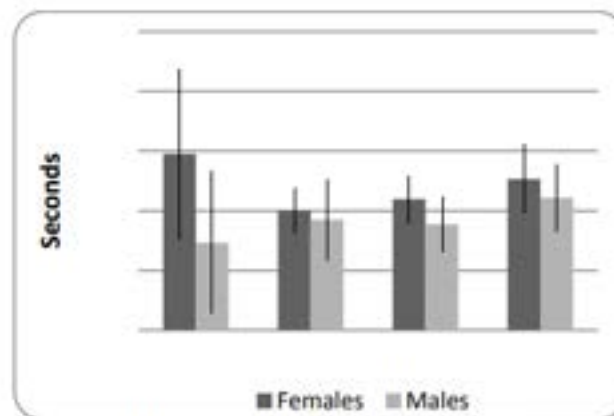
The design of sport ergometers requires thorough knowledge of the studied sport. The design is characterized by the dimensions space and weight equipment versus resistance to the athlete. Mechanically, it has to resist to the efforts developed by the athletes. This

[Download](#)

Biomechanics_2008_01.pdf (271 kB)



2/1/2024 - Gender Differences in GRFs

Title: Male vs Female results in continual ground reaction forces**Date:** 2/1/24**Content by:** Emily**Present:** N/A**Goals:** Understand the possible genetic difference in results/analysis of our design**Link:** <https://ojs.uib.uni-konstanz.de/cpa/article/view/5213/4788>**Search term:** men vs women force plate differences (Google)**Citation:****Content:****Figure 4: Mean Peak Vertical Forces****Figure 5: Mean Peak Medial/Lateral Forces****Figure 6: Mean Contact Time**

- Interaction effects between gender and agility motions were observed in vertical force, medial/lateral force, and contact time ($p=0.005$, $p=0.046$, $p=0.026$, respectively).

- Despite significant interaction effects, consistent differences in peak forces between genders were not found in the vertical ($p=0.220$) and medial/lateral ($p=0.972$) directions across movements.

- Kinematic differences between genders have been documented, but gender-related force differences in ground reaction forces are not established.

- Interaction effects between gender and agility motions were observed in vertical force, medial/lateral force, and contact time ($p=0.005$, $p=0.046$, $p=0.026$, respectively).
- Despite significant interaction effects, consistent differences in peak forces between genders were not found in the vertical ($p=0.220$) and medial/lateral ($p=0.972$) directions across movements.
- Significant interaction effects occurred between gender and agility movements, suggesting gender-specific responses to agility tasks.
- Females maintained constant peak vertical force across different movements, while males exhibited a decrease in vertical force with more severe changes in direction, indicating potential technique influence.
- Ground reaction forces are influenced by various factors such as footwear, joint angles, neuromuscular performance, and technique.
- The study did not examine lower body kinematics, and differences between males and females may have occurred but were not measured.
- Previous research suggests that females execute running and cutting differently, with variations in knee angles and neuromuscular performance.
- Future research should focus on developing protocols to assess technique differences between genders and determine their impact on ground reaction forces.
- It is suggested that compensatory mechanisms may exist to achieve similar ground reaction forces between genders while stressing different components of the lower body kinematic system.

Conclusion:

The study concludes that ground reaction forces were not different between genders, but males and females reacted differently to agility-type motions.

EMILY WADZINSKI - Feb 01, 2024, 11:29 AM CST



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sarahclarke_5213-14844-1-CE_1_.pdf (177 kB)



2/1/2024 - LabQuest Interface

EMILY WADZINSKI - Feb 01, 2024, 11:46 AM CST

Title: LabQuest 3

Date: 2/1/24

Content by: Emily

Present: N/A

Goals: Figure out apps/devices that we can use to interface our design

Link: <https://www.vernier.com/product/labquest-3/>

Search term: apps for force plate testing (Google)

Citation:

"LabQuest 3," Vernier. Accessed: Feb. 01, 2024. [Online]. Available: <https://www.vernier.com/product/labquest-3/>

Content:

There are apps available for their own force plates to see visual performance. Since the apps are specific to their own brands, the LabQuest came up in my search, which I remember using in chem 103/104. I'm thinking we can maybe interface it with our design since it seems more universal. Here is a blurb from the website:

Connectivity to Chromebooks, Computers, iPad® tablets, and Mobile Devices

Students can share real-time data with multiple devices for a truly hands-on, collaborative learning experience. Use LabQuest 3 to transfer data wirelessly to computers, Chromebooks, or mobile devices running **Graphical Analysis™**.

USB Sensor Interface

If you want to use your own computer or Chromebook™ to collect data, use LabQuest 3 as a conduit between our LabQuest sensors and these devices. LabQuest 3 works as a USB sensor interface with our **Logger Pro® software** or **Graphical Analysis app**.

Conclusion:

Look further into this/talk with group



2/7/2024 - 200kg Load Cells

Title: 200kg Load Cells

Date: 2/7/24

Content by: Emily

Present: N/A

Goals: Research size and product differences on the market

Link: <https://www.sentranllc.com/products/load-cells/low-profile.htm>

Search term: load cell average thickness 200kg (Google)

Citation:

“Sentran LLC | Load cells, force transducers and weighing systems solutions.” Accessed: Feb. 09, 2024. [Online]. Available: <https://www.sentranllc.com/products/load-cells/low-profile.htm>

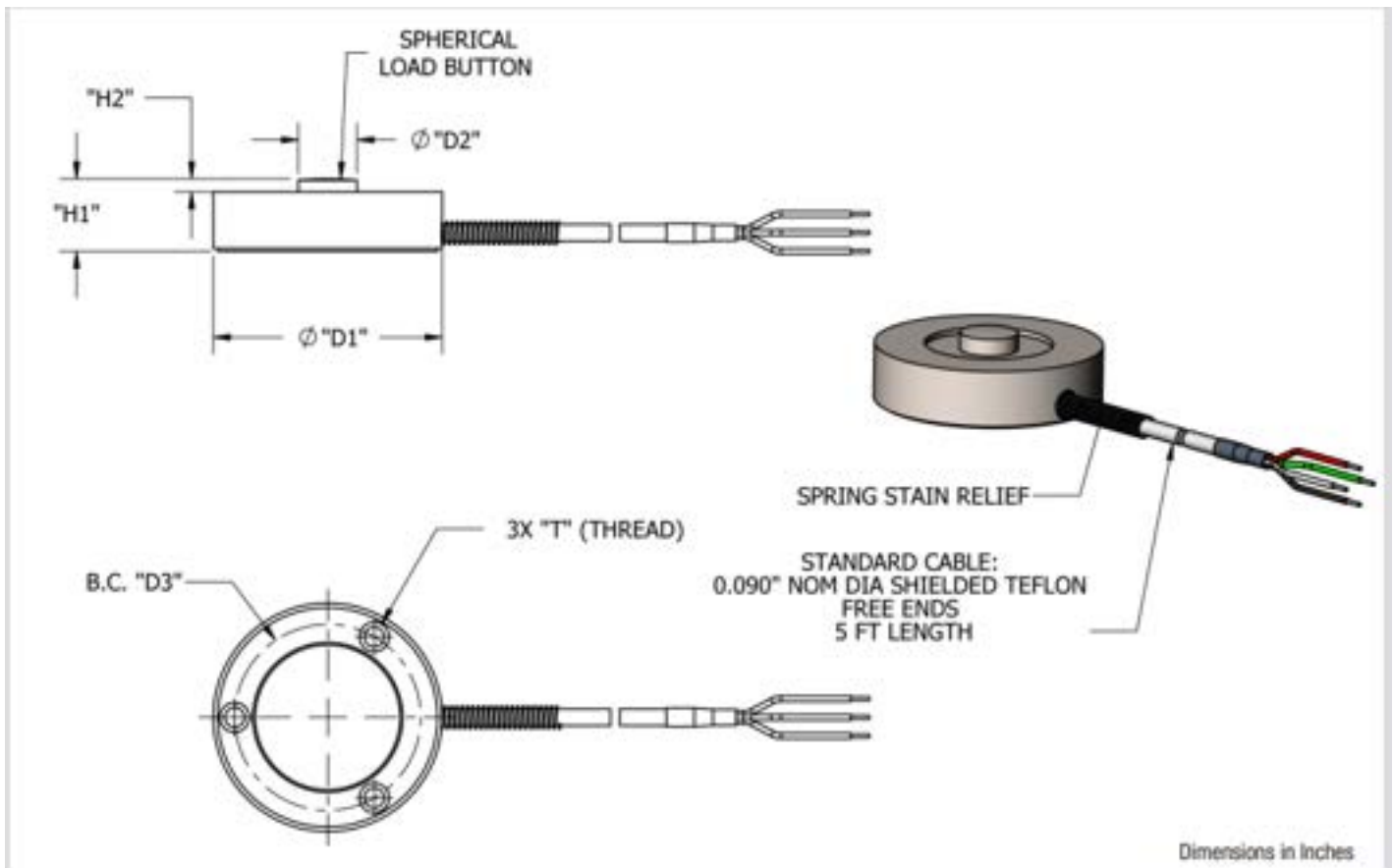
Content:

For my section of the PDS, I needed to figure out the average dimensions and weight for our specifications. For load cells with higher capacities (200kg and greater) I found a site with cells close to our client's needs.

Sentran is a company that has numerous types of strain gage load cells. Below are a couple of specifications across a few series that I referenced in the PDS.








PA Series:

"The PA Series is a miniature, low profile, strain gage load cell constructed of stainless steel. The PA Series is designed to accurately measure compression loads ranging from 0-100 lbs. to 0-50,000 lbs."



Capacity (LB)	H1	H2	D1	D2	D3	T	Deflect	Weight
DIMENSIONS (INCHES)								
100	0.62	0.05	1.00	0.21	0.75	4-40 UNC X 0.22 DP	0.001"	1.0 LB
250, 500, 1K, 2K	0.39	0.07	1.25	0.32	1.00	6-32 UNC X 0.25 DP	0.001"	1.0 LB
3K, 4K, 5K, 7.5K, 10K	0.63	0.08	1.50	0.40	1.25	6-32 UNC X 0.25 DP	0.001"	1.0 LB
15K, 20K, 30K	1.00	0.12	2.00	0.60	1.63	6-32 UNC X 0.25 DP	0.002"	1.0 LB
50K	1.50	0.18	3.00	0.78	2.38	6-32 UNC X 0.25 DP	0.003"	1.0 LB

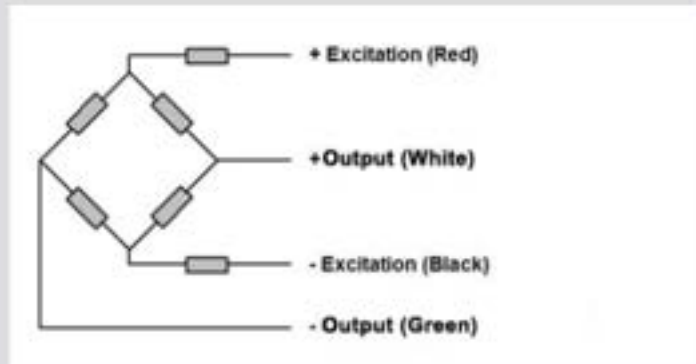
PA Typical System Configuration

SENSING LOAD CELL(S)	SIGNAL CONDITIONING	OUTPUT OPTIONS
	Analog Transmitters 	0-5 VDC
	Serial Transmitters 	0-10VDC
	Digital Indication 	±5 VDC
	Process Control 	±10 VDC
	Batch Control 	4-20 mA
	Data Acquisition 	0-20 mA
		RS-232
		RS-422
		RS-485
		20 mA Serial Loop
		Ethernet
		Profibus DP
		DeviceNet
		CANOpen
		ControlNet
		Modbus RTU
		Wireless

www.sentranllc.com

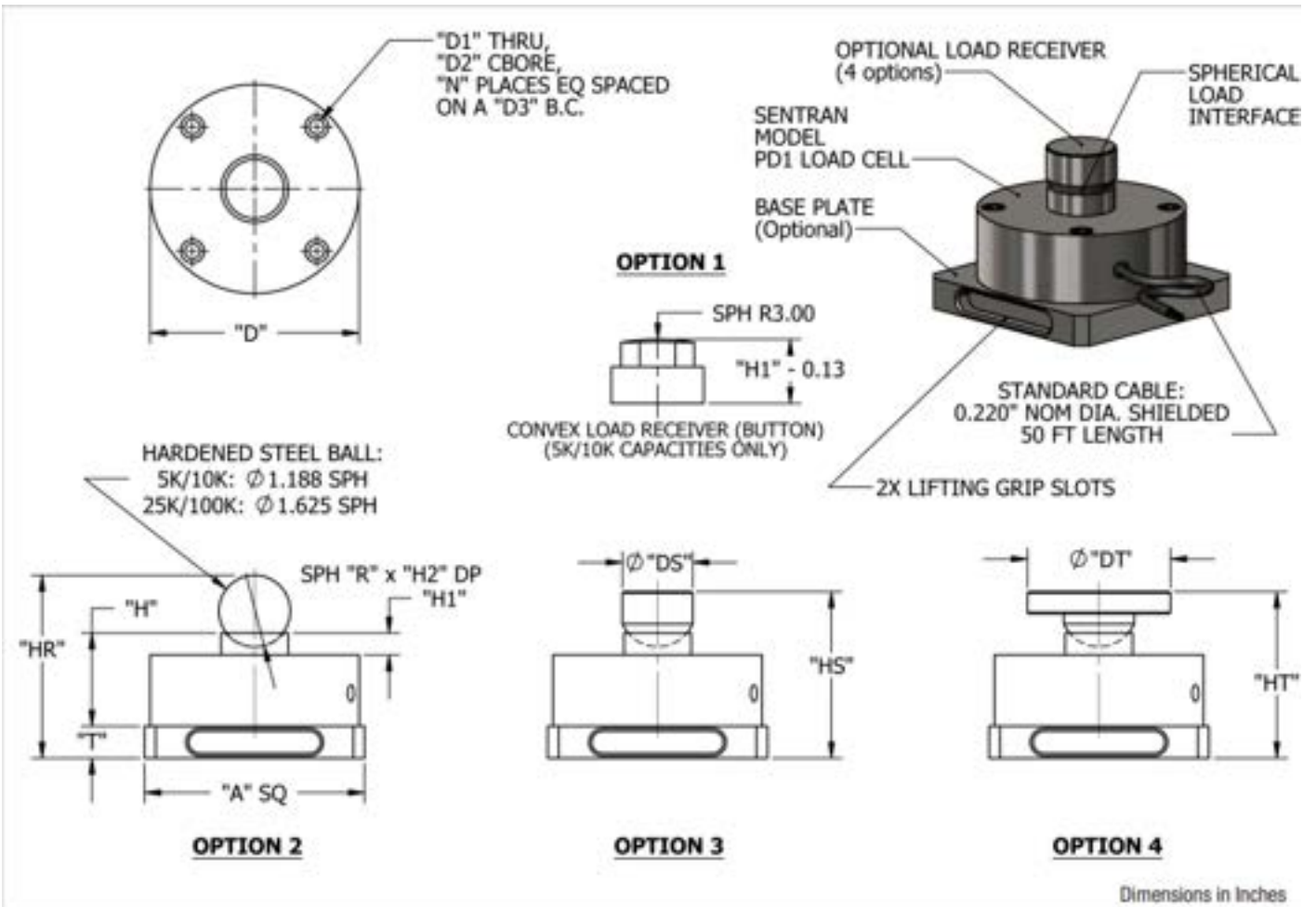
DG-PA-00-101

PA Wiring Diagram



PD Series:

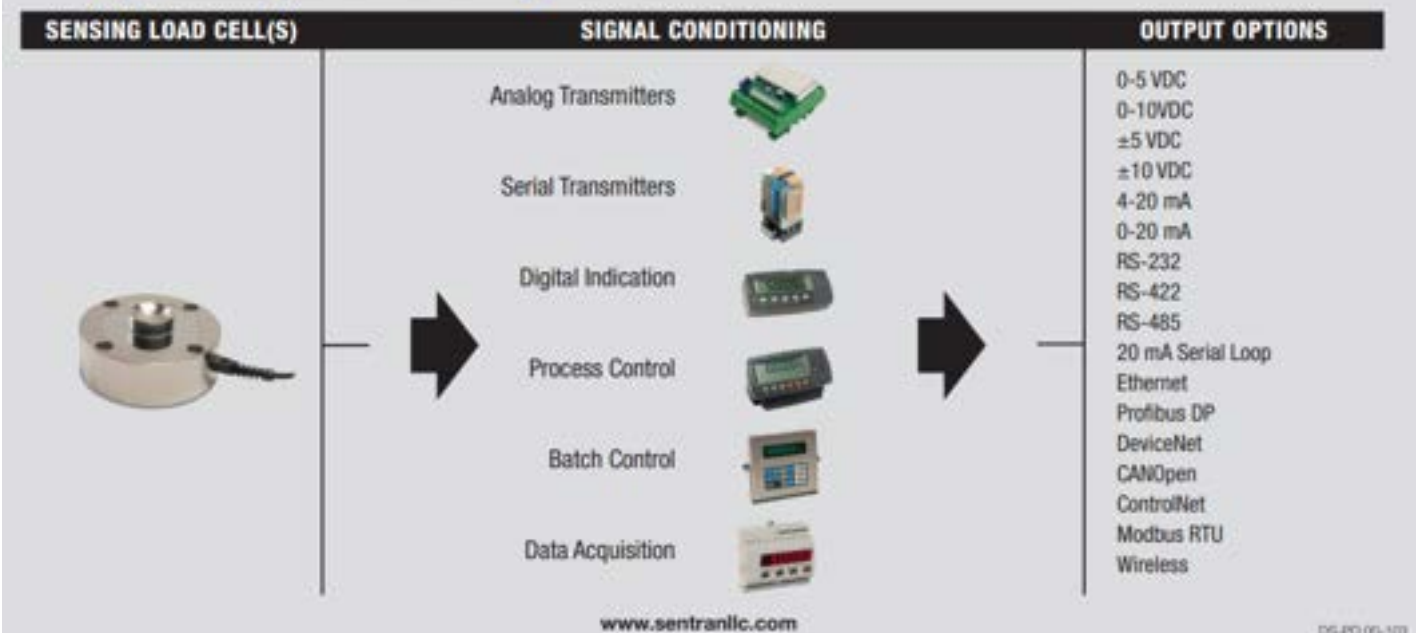
"The PD Series is a high performance, low profile, strain gage load cell constructed of heat-treated alloy tool steel. The PD Series is designed to accurately measure compression loads ranging from 0-5000 lbs. to 0-100,000 lbs."



Dimensions in Inches

Capacity (LB)	D	H	H1	H2	R	D1	D2	D3	N	A	DS	DT	HR	HS	HT	T	Deflect	Weight
DIMENSIONS (INCHES)																		
5K, 10K	4.12	1.37	0.12	0.25	0.625	0.28	.41 X .28 DP	3.50	8	4.50	1.00	2.75	3.41	2.81	3.25	0.60	0.010"	4.0 LBS
25K, 50K	4.75	2.12	0.50	0.31	0.875	0.34	.51 X .38 DP	4.00	4	5.00	1.60	3.25	4.17	3.29	3.79	0.72	0.010"	7.5 LBS
100K	5.43	2.25	0.25	0.31	0.875	0.41	.63 X .40 DP	4.60	8	6.00	1.60	4.25	4.55	3.67	4.42	0.97	0.010"	11.0 LBS

PD Typical System Configuration



Conclusion:

Update PDS

EMILY WADZINSKI - Feb 09, 2024, 2:18 PM CST



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Sentran_LLC__Load_cells_force_transducers_and_weighing_systems_solutions.pdf (756 kB)

EMILY WADZINSKI - Feb 09, 2024, 2:18 PM CST



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20180327140213_DSPD00103_180326.pdf (1.58 MB)

SENTRAN

Low Profile Load Cell

PA Series

The PA Series is a miniature, low profile, strain gage load cell constructed of stainless steel. The PA Series is designed to accurately measure compression loads ranging from 0-100 lbs. to 0-50,000 lbs.

The PA Series is a high performance, stainless steel, low profile, strain gage load cell with a low profile design. The PA Series is designed to accurately measure compression loads in a compact design ranging from 0-100 lbs. to 0-50,000 lbs. The PA Series is constructed with a precision ground stainless steel body and a stainless steel strain gage. The PA Series is designed to accurately measure compression loads ranging from 0-100 lbs. to 0-50,000 lbs. The PA Series is constructed with a precision ground stainless steel body and a stainless steel strain gage. The PA Series is designed to accurately measure compression loads ranging from 0-100 lbs. to 0-50,000 lbs. The PA Series is constructed with a precision ground stainless steel body and a stainless steel strain gage.

FEATURES

- Precision stainless steel
- Precision strain gage
- Precision load cell
- Precision output
- Precision accuracy
- Precision stability
- Precision repeatability
- Precision linearity
- Precision hysteresis
- Precision creep
- Precision zero drift
- Precision temperature stability
- Precision shock resistance
- Precision vibration resistance
- Precision corrosion resistance
- Precision long life
- Precision low cost

APPLICATIONS

- Industrial process control
- Material testing
- Quality control
- Research and development
- Manufacturing
- Packaging
- Food processing
- Pharmaceutical
- Chemical
- Aerospace
- Defense
- Medical
- Agriculture
- Mining
- Construction
- Transportation
- Energy
- Environmental
- Marine
- Offshore
- Power
- Water
- Wastewater
- Sewer
- Stormwater
- Solid waste
- Hazardous waste
- Air quality
- Water quality
- Soil quality
- Noise
- Vibration
- Seismic
- Structural
- Geotechnical
- Environmental
- Industrial
- Commercial
- Residential
- Public works
- Transportation
- Energy
- Environmental
- Marine
- Offshore
- Power
- Water
- Wastewater
- Sewer
- Stormwater
- Solid waste
- Hazardous waste
- Air quality
- Water quality
- Soil quality
- Noise
- Vibration
- Seismic
- Structural
- Geotechnical

For more information call 1-800-545-6958

SENTRAN USA INC. 1000 W. 10th St. P.O. Box 1000
Wichita, KS 67201-1000 USA
www.sentrantools.com

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20180327140123_DSPA00101_180326.pdf (1.79 MB)



2/7/2024 - Possible Load Cells to Purchase

Title: 200kg Load Cell Preliminary Choice

Date: 2/7/24

Content by: Emily

Present: N/A

Goals: Find load cells for purchase

Link: <https://www.tinytronics.nl/shop/index.php?route=product/search&search=load%20cell%20200kg>

Search term: load cell average thickness 200kg (Google)

Citation:

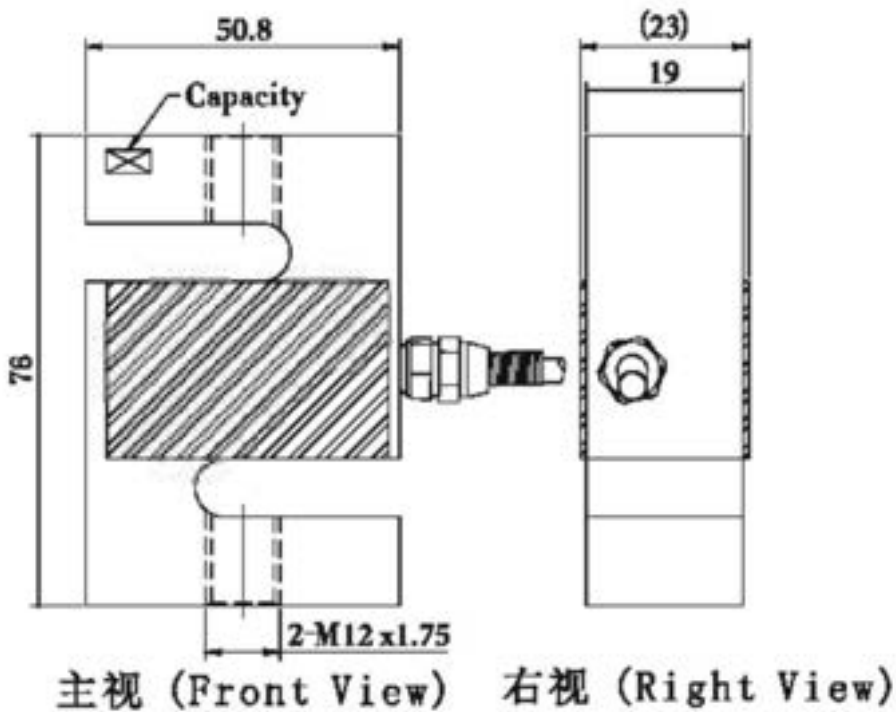
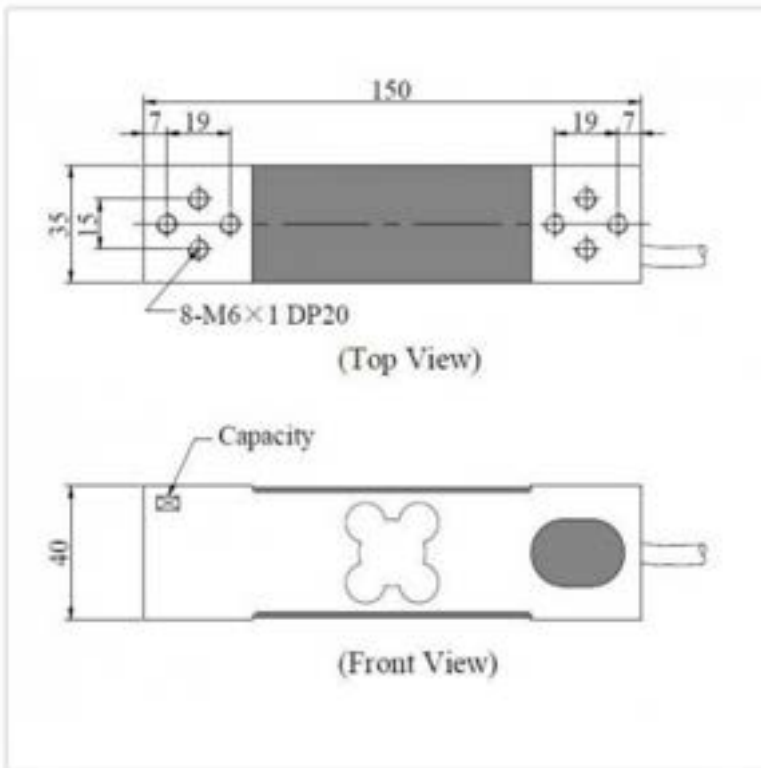
“TinyTronics.” Accessed: Feb. 09, 2024. [Online]. Available: <https://www.tinytronics.nl/shop/>

Content:

Cheapest options I have seen so far!

I also used these dimensions for part of my PDS section.





After last semester our team does not want to do a point load cell, and instead one that handles a more distributed load. On this website, the description under the Mavin Load Cell states, "With this load cell mass can be measured." whereas the Mavin Load Cell - S Type says, "With this load cell mass can be measured. The S shape makes it well suited for crane scales, for example." so maybe this exact s shape cell should not be used for our design.

They both also require a load cell amplifier (which is pretty common for all load cells).

Conclusion:

Share with group, use in preliminary brainstorm design. Keep searching for ones in a similar price range



[Download](#)

Search_-_load_cell_200kg.pdf (442 kB)



2/22/2024 - Raspberry Pi

Title: Raspberry Pi Basics**Date:** 2/22/24**Content by:** Emily**Present:** N/A**Goals:** Research raspberry pi components**Link:** <https://www.raspberrypi.com/products/raspberry-pi-5/>**Search term:** "raspberrypi" (Google)**Citation:**

R. P. Ltd, "Buy a Raspberry Pi 5," Raspberry Pi. Accessed: Feb. 26, 2024. [Online]. Available:
<https://www.raspberrypi.com/products/raspberry-pi-5/>

Content:

Specifications:

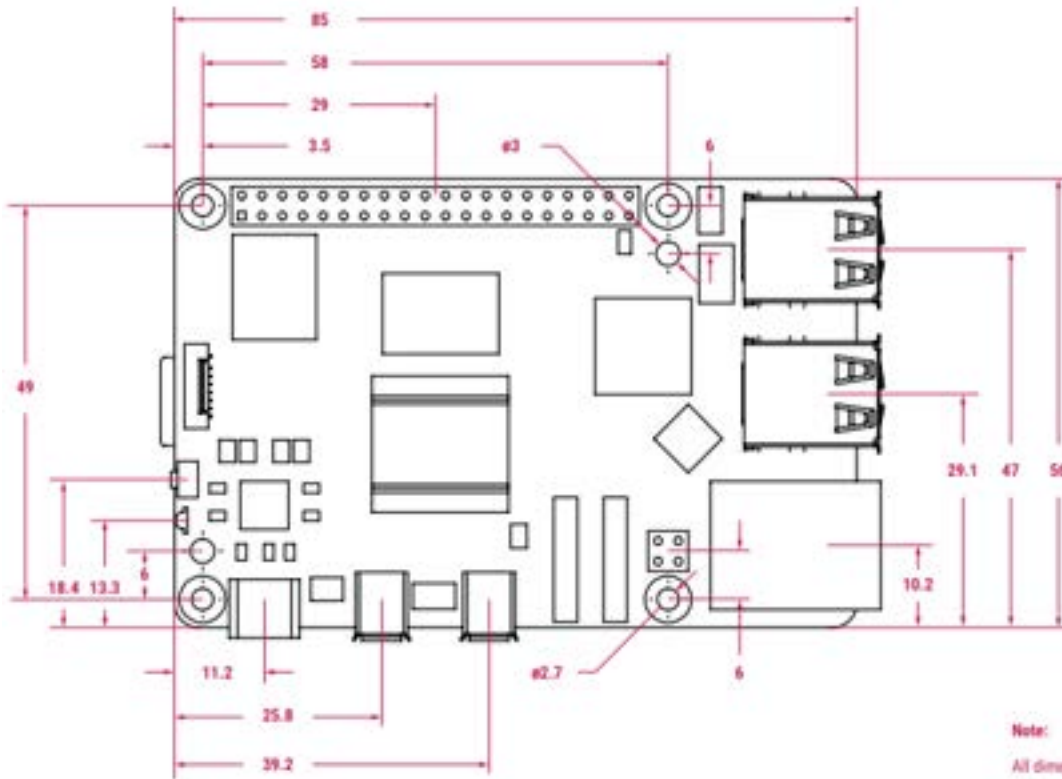
- Broadcom BCM2712 2.4GHz quad-core 64-bit Arm Cortex-A76 CPU, with cryptography extensions, 512KB per-core L2 caches and a 2MB shared L3 cache
- VideoCore VII GPU, supporting OpenGL ES 3.1, Vulkan 1.2
- Dual 4Kp60 HDMI® display output with HDR support
- 4Kp60 HEVC decoder
- LPDDR4X-4267 SDRAM (4GB and 8GB SKUs available at launch)
- Dual-band 802.11ac Wi-Fi®
- Bluetooth 5.0 / Bluetooth Low Energy (BLE)
- microSD card slot, with support for high-speed SDR104 mode
- 2 × USB 3.0 ports, supporting simultaneous 5Gbps operation
- 2 × USB 2.0 ports
- Gigabit Ethernet, with PoE+ support (requires separate PoE+ HAT)
- 2 × 4-lane MIPI camera/display transceivers
- PCIe 2.0 x1 interface for fast peripherals (requires separate M.2 HAT or other adapter)
- 5V/5A DC power via USB-C, with Power Delivery support
- Raspberry Pi standard 40-pin header
- Real-time clock (RTC), powered from external battery
- Power button

notes:

- product should be operated in a well ventilated environment, and if used inside a case, the case should not be covered

- While in use, it should be firmly secured or should be placed on a stable, flat, non-conductive surface, and should not be contacted by conductive items.

Physical specification



Note:

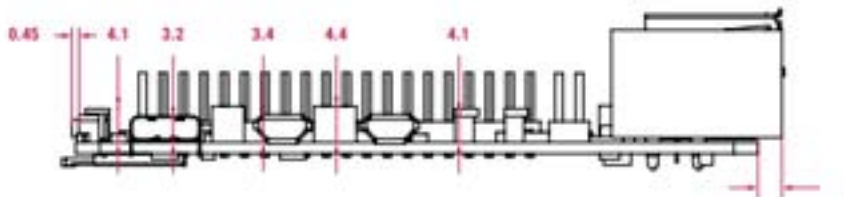
All dimensions in mm

All dimensions are approximate and for reference purposes only. The dimensions shown should not be used for producing production data

The dimensions are subject to part and manufacturing tolerances

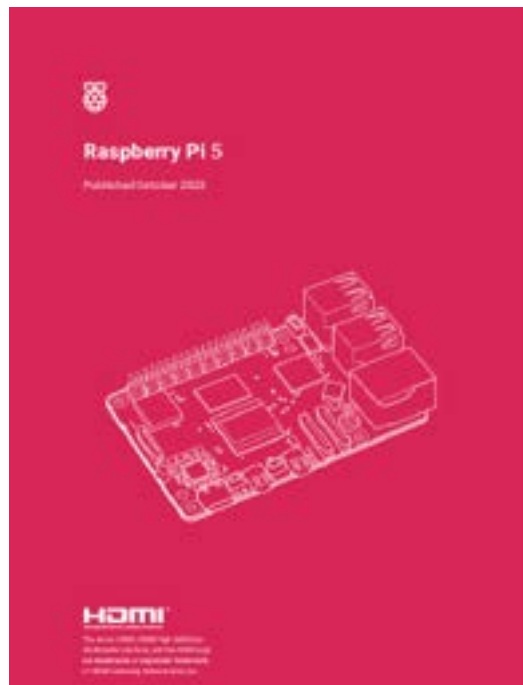
Not all of the board components are shown. Please reference a physical board for representation of componentry

Dimensions may be subject to change



Conclusion:

Figure out connections



[Download](#)

raspberrypi-5-product-brief.pdf (1.39 MB)



2/22/2024 - Strain Sensor Mounting

Title: Bar Load Cell Mounting

Date: 2/22/24

Content by: Emily

Present: N/A

Goals: Learn the best ways to mount a bar load cell

Link: <https://www.baumer.com/us/en/service-support/setup-installation/mounting-of-strain-sensors/a/mounting-strain-sensors#:~:text=The%20strain%20sensor%20should%20be%20placed%20in%20positions%20where%20measurable,well%20as%20pull%2Fcompressive%20stress.>

Search term: "how to set up bar strain gages" (Google)

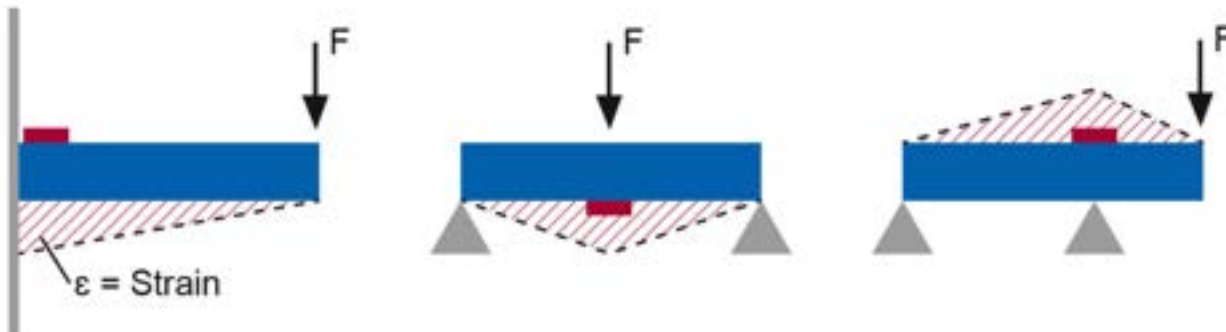
Citation: "Mounting of strain sensors | Baumer USA." Accessed: Feb. 26, 2024. [Online]. Available: <https://www.baumer.com/us/en/service-support/setup-installation/mounting-of-strain-sensors/a/mounting-strain-sensors>

Content:

What strains are favorable for positioning?

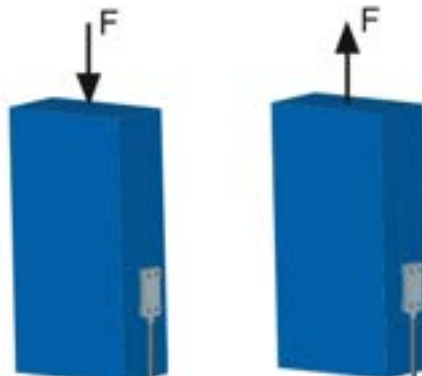
Strain through bending:

When strain sensors are positioned, surface strains that are caused by bending are easy to determine and thus favorable. The diagrams below present some examples of the points at which the largest measurable strains can be expected for bending.



Strain from pull or compressive stress:

Usually a monitored machine exhibits combined strains from bending, pull/compressive stress, torsion, etc. These can be easily determined by a finite element calculation. In practical application, however, it also becomes apparent that a simple mechanical consideration is sufficient to identify suitable points on the structure where strains occur and are measurable. The precise strains can be determined by comparison with known stresses for the measured strains. Of course, it is also possible to first glue strain gauges on positions of interest to facilitate suitable positioning of the strain sensor.

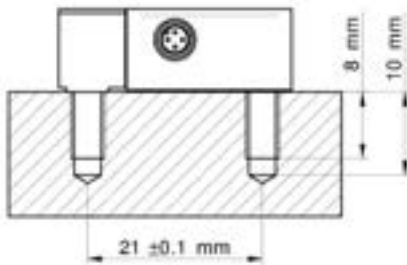


Installation tips:

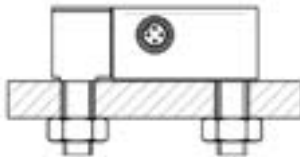
- screw in sensors with fastening screws
- used blind holes or clearance holes
- clean away grease and oil first
- install on a level surface
- be aware of the surface roughness

What fastening options are available?**Option 1:**

Strain sensors can be attached to the structure to be monitored with fastening screws in clearance holes.

**Option 2:**

In thinner structures, strain sensors can be fastened in through holes using a nut.

**Conclusion:**

Look into the integrated amplifier mentioned on the website



[Download](#)

Mounting_of_strain_sensors__Baumer_USA.pdf (1.27 MB)



3/8/2024 - Statistical testing

Title: Statistical Testing**Date:** 3/8/2024**Content by:** Emily**Goals:** Figure out what statistics to run**Link:** <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8483143/>**Citation:**

A. Najmi, B. Sadasivam, and A. Ray, "How to choose and interpret a statistical test? An update for budding researchers," *J Family Med Prim Care*, vol. 10, no. 8, pp. 2763–2767, Aug. 2021, doi: [10.4103/jfmprc.jfmprc_433_21](https://doi.org/10.4103/jfmprc.jfmprc_433_21).

Content:

I first started with table, then dived deeper into which one we should pick:

Tests of significance	
Parametric tests	Nonparametric tests
Paired t-test	Wilcoxon signed-rank test
Unpaired t-test	Mann-Whitney U test
One-way ANOVA	Kruskal-Wallis test
Multiple measure ANOVA	Friedman's test
Pearson's correlation	Spearman's correlation
Linear regression	Nonparametric regression
Regression analysis	Chi-Square test

Parametric - data is normally distributed and not skewed

Nonparametric - data is not normally distributed

t-test - compares two means, used for small samples

unpaired t-test - two independent groups

ANOVA test - three or more groups, across different categories. One-way anova is for groups that are defined by one factor

correlation coefficient test - linear relationship between variables (association, not causation)

Regression test - dependent relationship between groups (dependent and independent)

Wilcoxon test - Wilcoxon signed rank and Mann–Whitney U test are counterparts of paired and unpaired *t*-test for nonparametric test.

Kruskal–Wallis test - This is counterpart of one-way ANOVA for nonparametric test.

Friedman's test -This is counterpart of repeated measure ANOVA for nonparametric test.

Spearman's rank correlation - This test is counterpart of Pearson correlation test for nonparametric test.

Chi-square test - This nonparametric test is used for binomial or dichotomous data, which is summarized as percentage or proportions. For example, to compare the proportion of death and survival in vaccinated and nonvaccinated children with respiratory tract infections. There is no parametric counterpart for Chi-square test.

Selecting a statistical test

Type of data	Comparison Analysis				Correlation Analysis (Column 5)	Regression Analysis (Column 6)
	2 data sets		More than 2 data sets			
	Paired Column 1	Unpaired Column 2	Paired Column 3	Unpaired Column 4		
Row 1 Normally distributed continuous data (summarized as mean)	Paired t- test	Unpaired t- test	Repeated measures ANOVA	One-way ANOVA	Pearson's correlation	Linear regression
Row 2 Ranks, scores, and non normally distributed continuous data summarized as median	Wilcoxon signed- rank test	Mann- Whitney U test	Friedman's test	Kruskal- Wallis test	Spearman's rank correlation	Non parametric regression
Row 3 Dichotomous data summarized as proportion	Mc Nemar's test	Fishers test or Chi- square test	Cochrane Q	Chi-square test	Contingency coefficient	Logistic regression

Conclusion:

Probably do a linear regression test



3/8/2024 - ANOVA

Title: Coding ANOVA in Python**Date:** 3/8/2024**Content by:** Emily**Goals:** Learn what an ANOVA test is and how to code it**Link:** <https://www.kaggle.com/code/hamelg/python-for-data-26-anova>**Citation:**

"Python for Data 26: ANOVA | Kaggle." Accessed: Mar. 14, 2024. [Online]. Available: <https://www.kaggle.com/code/hamelg/python-for-data-26-anova>

Content:

ANOVA = a statistical inference test that lets you compare multiple groups at the same time. (analysis of variance)

One way ANOVA:

- tests whether the mean of some numeric variable differs across the levels of one categorical variable
- answers if any of the group means differ from one another
- compare the test statistic to a critical value based on a probability distribution = f-distribution

Code example:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import scipy.stats as stats

np.random.seed(12)

races = ["asian", "black", "hispanic", "other", "white"]

# Generate random data
voter_race = np.random.choice(a= races,
                              p = [0.05, 0.15 ,0.25, 0.05, 0.5],
                              size=1000)

voter_age = stats.poisson.rvs(loc=18,
                              mu=30,
                              size=1000)

# Group age data by race
voter_frame = pd.DataFrame({"race":voter_race, "age":voter_age})
groups = voter_frame.groupby("race").groups

# Etract individual groups
asian = voter_age[groups["asian"]]
black = voter_age[groups["black"]]
```



```
hispanic = voter_age[groups["hispanic"]]
other = voter_age[groups["other"]]
white = voter_age[groups["white"]]

# Perform the ANOVA
stats.f_oneway(asian, black, hispanic, other, white)
```

Another way to code: use statsmodels library

- allows you to specify a model with a formula syntax

ex)

```
import statsmodels.api as sm
from statsmodels.formula.api import ols

model = ols('age ~ race',          # Model formula
            data = voter_frame).fit()

anova_result = sm.stats.anova_lm(model, typ=2)
print (anova_result)
```

- can also perform separate t-tests for each pair of groups to adjust pairwise t-tests so significance is not overestimated = divide the statistical significance level by the number of comparisons made

- Bonferroni correction and Tukey tests can account for the multiple comparisons problem that may end up rejecting results that are actually significant

Conclusion:

This test might not be relevant because we have a comparison between two of the same type of variables, not different categories



3/8/2024 - Effect Sizes

Title: Effect Sizes in Statistics**Date:** 3/8/2024**Content by:** Emily**Goals:** Learn what effect sizes are after it was mentioned in client meeting**Link:** <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2791668/#:~:text=It%20is%20a%20dimensionless%20measure,two%20treatments%20is%20clinically%20relevant.>**Citation:**

J. J. McGough and S. V. Faraone, "Estimating the Size of Treatment Effects," *Psychiatry (Edgmont)*, vol. 6, no. 10, pp. 21–29, Oct. 2009.

Content:

Effect sizes = measures the strength of relationship between two variables

- "It is a dimensionless measure of the difference in outcomes under two different treatment interventions. Effect sizes thus inform clinicians about the magnitude of treatment effects. Some methods can also indicate whether the difference observed between two treatments is clinically relevant."

- provides an interpretable value of direction and magnitude of effect

- can use different methods to calculate:

Cohen's d (Standardized Mean Difference):

- Used in studies with continuous measurements.

- Calculated from two mean values and their standard deviations.

Relative Risk:

- Ratio of patients responding to one treatment compared to another (or placebo).

- Useful in prospective clinical trials for assessing treatment differences.

Odds Ratio:

- Used in retrospective case-control studies.

- Estimates the risk of side effects by comparing outcome probabilities with and without a specified condition.

Number Needed to Treat:

- Represents the number of subjects treated with one agent to expect one more success (or one less failure) compared to another agent.

Area Under the Curve (Drug-Placebo Response Curve):

- Assesses medication effects on both worsening and improvement.

- Measures the probability of a better outcome with medication compared to placebo.

Limitations:

- certainty that studies are similar on features that can alter the effect size (know exact controls)

- the methods above cannot assess significance, direction, magnitude, or relevance alone

Conclusion:

Cohen's d test may be useful for our application



3/14/2024 - Angle Encoders

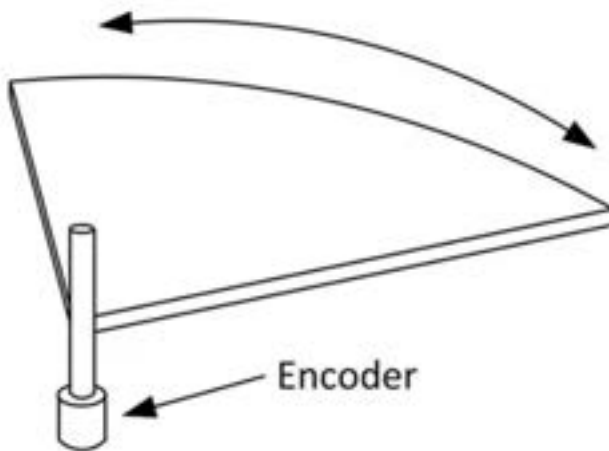
Title: Angle Encoders**Date:** 3/14/2024**Content by:** Emily**Goals:** Learn about angle encoders for our possible design idea**Link:** https://www.dynapar.com/knowledge/applications/angle_encoders/**Citation:**

Dynapar, "Angle Encoders | Measuring Angles with Encoders | Dynapar." Accessed: Mar. 14, 2024. [Online]. Available: https://www.dynapar.com/knowledge/applications/angle_encoders/

Content:

Three ways to use an encoder:

- Direct angle measurement with an encoder mounted to the pivot point of the load.



$$\alpha = \frac{P}{PPR} \times 360$$

where P equals the number of pulses and PPR equals pulses per revolution

In the case of an absolute encoder, the angle α can be expressed as

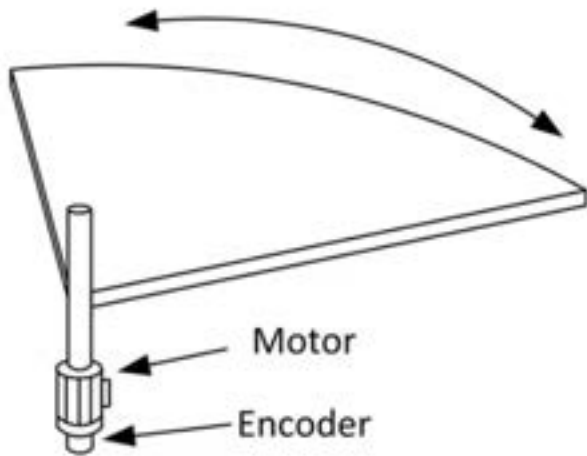
$$\alpha = \frac{C}{CPR} \times 360$$

where C equals counts and CPR equals counts per revolution.

mounted on center pivot point of load

displacement pulses (incremental) or initial and final absolute positions (absolute)

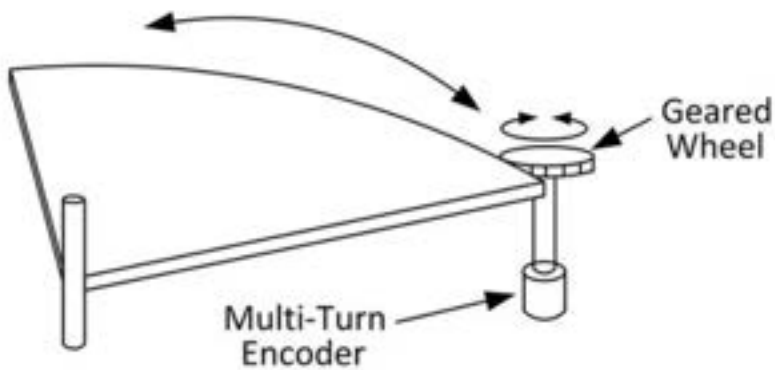
- Indirect angle measurement with an encoder mounted to the motor driving rotation



monitors motor shaft

does not accurately track movement of load

- Indirect angle measurement with a multi-turn encoder mounted along the circumference of the load



$$R_F = R_B \times N$$

tracks along circumference

as band on load moves past, turns wheel and movement is registered by encoder

Error sources include: mechanical couplings, backlash from gearbox, shaft runout and de-centering, belt slippage, etc

Popular Angle Encoder Models:



Incremental angle encoders can only register displacement from some arbitrarily defined home position that is established at startup.

An absolute angle encoder outputs a unique digital word for each position of the code disc. no need for homing and the information is not lost when the device is powered down.

higher res: Interpolating the signal of a quadrature angle encoder can also deliver a significant performance boost. Quadrature angle encoders also allow the direction of that rotation to be monitored.

Conclusion:

Discuss w group and advisor



2/7/2024 - Monitor Display Through App Usage

Title: App Displays**Date:** 2/7/24**Content by:** Emily**Present:** N/A**Goals:** Research what's currently on the market for load cell displays**Link:** <https://www.mar-systems.co.uk/wireless-force-platforms/force-plates-software-app/><https://physio.kinvent.com/product-page/>**Search term:** force plate software (Google)**Citation:**

Suz, "force-plates-software-app," Motion Analysis Resource Systems. Accessed: Feb. 09, 2024. [Online]. Available:

<https://www.mar-systems.co.uk/wireless-force-platforms/force-plates-software-app/>"Product Pages Archive," Kinvent Physio. Accessed: Feb. 09, 2024. [Online]. Available: <https://physio.kinvent.com/product-page/>**Content:**

- When researching how best to display our data to the user, I came across a couple iPhone apps designed by force place companies for their products

- If possible, we could try to find a universal app that we connect to our own load cells

- If the apps are very company specific, we could design our based on a simplified version of others.

Hawkin Dynamics Capture:

- "With a simple workflow and minimal interaction – coaches and others can quickly and easily capture jump data, report immediate feedback on a few key parameters for each test, and move forward in their testing program. Users can also manage their database, add and remove athletes, and organize athletes into groups – all within the app."

- Protocols include: countermovement jump, squat jump, drop jump, and isometric test

- requires a Hawkin Dynamic's login and password

Picture on Google Play Store:

Kinvent Physio:

- "The App, together with the devices is measuring forces, balance and movement. The targeted exercises with real time biofeedback, the display of progress and the quantified measurements inspire confidence and motivation to the health professionals and their patients."

- Some of the app's features heavily align with our client's concerns, and would be ideal to have for our display.

- Pictures from the app store:



(useful to see weight distribution)



Conclusion:

Research if there are any universal apps for general load cell data display

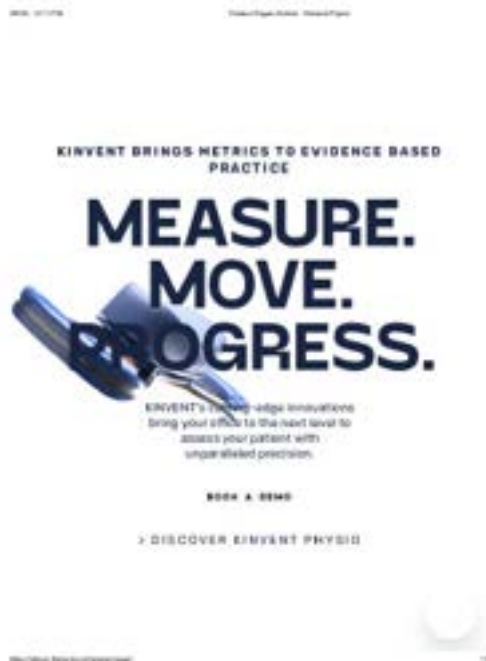
EMILY WADZINSKI - Feb 09, 2024, 12:17 PM CST



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force-plates-software-app - Motion Analysis Resource Systems.pdf (709 kB)

EMILY WADZINSKI - Feb 09, 2024, 12:17 PM CST



[Download](#)

Product Pages Archive - Kinvent Physio.pdf (1.97 MB)



2/7/2024 - Loadstar Sensors Interface System

Title: Loadstar Load Cells

Date: 2/7/24

Content by: Emily

Present: N/A

Goals: Research what's currently on the market for load cell displays

Link: <https://www.loadstarsensors.com/products/sensors/load-cells.html#tension>

Search term: load cell software system (Google)

Citation:

"Load Cells," Loadstar Sensors. Accessed: Feb. 09, 2024. [Online]. Available: <https://www.loadstarsensors.com/products/sensors/load-cells.html>

Content:

This site gives you a step by step process to make a load cell kit. Among the many load cells listed on the website, I dove into the single point cells, specifically the RAP4/RAP3 model.

SINGLE POINT LOAD CELLS

The single point load cells are one of the most accurate load cells we offer and are particularly good for building scales that need to bear off center loads. They are used widely to build weight scales and are one of the most common load cells available in the market. They can be used to measure compression forces or tension forces if calibrated in both directions. We offer them in various sizes and capacities and some with NTEP certifications.

RAPG



This is the smallest single point Load Cell we offer
Capacities: 100 g (0.25 lb), 300 g (0.7 lb), 1 kg (2.2 lb), 2 kg (4.4 lb) & 3 kg (6.6 lb)
Accuracy Class: 0.02% of full scale
Compensated Temp Range: -10C to 40C

RSP1



This is the most popular Single Point Load Cell we offer
Capacities: 3 kg (6.6 lb), 5 kg (11 lb), 10 kg (22 lb), 20 kg (44 lb), 50 kg (110 lb)
Accuracy Class: 0.02% of full scale
Compensated Temp Range: -10C to 40C

RAP4/RAP3



This single point Load Cell is used to construct larger scales > 12" x 12"
Capacities: ~50 kg (RAP4, 110 lb), 250 kg (RAP4, 220 lb) and 750 kg (RAP3, 1650 lb)
Accuracy Class: 0.02% of full scale
Compensated Temp Range: -10C to 40C

RRP1/RRP2



These are the two NTEP Load Cells we offer.
Capacities: RRP1 up to 100 kg (220 lb) & RRP2 up to 600 kg (1250 lb)
Accuracy Class: 0.02% of full scale
Compensated Temp Range: -10C to 40C

Some of the listed highlights of the RAP4/RAP3 cells include:

UART/USB Output

- Connects to Arduino or other microprocessors. Other outputs can also connect to USB load cell interface to PCs.

Wireless Output

- "Via XBee (802.15.4) Industrial Strength wireless of WiFi or BLE for easy connectivity with PCs, Tablets and SmartPhones"

In the kit, you can choose across different options. Some of them include: mounting options, load cell configurations, LCD display, wireless display, and analog.

I thought it would be interesting to look if we could possibly implement one of these displays since there is a wide range shown, however when I click "Build Your Order", the cost of each accessory was too expensive. The options and prices are attached in the second pdf.

Conclusion:

It might be worth it to look into the software and accessories but from a different brand.

EMILY WADZINSKI - Feb 09, 2024, 8:11 PM CST



**RAP4 SINGLE POINT LOAD
CELL**



Learn a Message

[Download](#)

RAP4.pdf (8.28 MB)

RAP4 ([rap4-single-point-load-cell.htm](#)) and **RAP3** ([rap3-single-point-load-cell.htm](#)) are some of the most accurate and versatile load cells we offer at very reasonable prices. They are ideal for testing scales because of their unique ability to withstand off-axis and off-center loading. They are also temperature compensated from -130 to 400 and offer accuracies of +/- 0.02% of full scale. The RAP4 load cells are low profile and are available in 50 kg, 250 kg and 300 kg capacities.

The **RAP3** ([rap3-single-point-load-cell.htm](#)) is larger in height and is available in 150 kg capacity. For smaller capacities and smaller sizes take a look at the **RSP1** ([rap1-single-point-aluminum-load-cell.htm](#)) and **RAPG** ([rapg-low-capacity-single-point-aluminum-load-cell.htm](#)) load cells. For NTEP rated scales take a look at the **RWP1** ([rap1-single-point-rtp-load-cell.htm](#)) and **RWP2** ([rap2-single-point-rtp-load-cell.htm](#)) load cells.

Just connect the load cell to the **Digital Interface** ([products/sensor-interfaces.htm](#)) and start measuring using **LoadVIEW** ([products/software/loadview-pro.htm](#)), **SensorVIEW** ([products/software/sensorview.htm](#)) or **ControlVIEW** ([products/software/controlview.htm](#)) **loadcell** software ([software.htm](#)). Or display force, load or weight on our touch screen load cells ([displays](#)) ([displays.htm](#)).

[Download](#)

RAP4_and_RAP3_Single_Point_Load_Cell_Build_and_Buy.pdf (4.23 MB)



2/22/2024 - Bar Load Cell Configurations

Title: H-type Scale Frame**Date:** 2/22/24**Content by:** Emily**Present:** N/A**Goals:** Figure out best way to set up new load cells**Link:** <https://community.hiveeyes.org/t/h-type-scale-frame-steel/251><https://community.hiveeyes.org/t/open-hive-scale-bar-for-single-side-weighting/595><https://community.hiveeyes.org/t/h-frame-or-two-bar-frames/3607>**Search term:** "two bar load cell design" (Google)**Citation:** "H-type scale frame (steel) - Hardwareentwicklung / hardware development / Scale design," Hiveeyes. Accessed: Feb. 26, 2024. [Online]. Available: <https://community.hiveeyes.org/t/h-type-scale-frame-steel/251>**Content:**

According to the person on this site, a two-bar approach allows the figure to stand firmly on the ground with less wiggling than one load cell. The setup is also easy by using aluminum, spacer plates, and zero welding required.

However, an H-frame setup is also an accurate way to measure load. A more stable frame is needed though, and only one load cell is required.

H-frame:



People reported that using four load cells in parallel was hard to balance and setup. "I have then switched to Bosche H40 single load cell in a double H frame." I wonder if our group doesn't have to use four total if we make a configuration as such. Not sure if we could still get two separate toe and heel readings though.

Conclusion:

Talk to group to see their thoughts on continuing to use 4.

EMILY WADZINSKI - Feb 26, 2024, 10:05 AM CST



[Download](#)

H-type_scale_frame_steel_-_Hardwareentwicklung__hardware_development__Scale_design_-_Hiveeyes.pdf (9.27 MB)



3/6/2024 - HIPAA

Title: HIPAA Standards

Date: 3/6/24

Content by: Emily

Goals: Note the standards we must follow

Link: <https://aspe.hhs.gov/reports/health-insurance-portability-accountability-act-1996>

Search term: "HIPAA standards" (Google)

Citation:

"Health Insurance Portability and Accountability Act of 1996," ASPE. <https://aspe.hhs.gov/reports/health-insurance-portability-accountability-act-1996> (accessed Mar. 6, 2024).

Content:

HIPAA = law requiring the creation of national standards to protect sensitive patient health information from being disclosed without the patient's consent or knowledge.

- issued by US Department of Health and Human Services

what's subjected to the privacy rule:

- healthcare providers -> any electronically transmitted health information

- health plans

- healthcare clearinghouses

- business associates: "A person or organization (other than a member of a covered entity's workforce) using or disclosing individually identifiable health information to perform or provide functions, activities, or services for a covered entity". This includes data analysis, which is where we come in.

Permitted uses of their information:

- Disclosure to the individual (if the information is required for access or accounting of disclosures, the entity MUST disclose to the individual)
- Treatment, payment, and healthcare operations
- Opportunity to agree or object to the disclosure of PHI
 - An entity can obtain informal permission by asking the individual outright, or by circumstances that clearly give the individual the opportunity to agree, acquiesce, or object
- Incident to an otherwise permitted use and disclosure
- Limited dataset for research, public health, or healthcare operations
- Public interest and benefit activities—The Privacy Rule permits use and disclosure of PHI, without an individual's authorization or permission, for 12 national priority purposes

HIPAA Security Rule:

- Ensure the confidentiality, integrity, and availability of all e-PHI
- Detect and safeguard against anticipated threats to the security of the information
- Protect against anticipated impermissible uses or disclosures that are not allowed by the rule
- Certify compliance by their workforce

Conclusion:

Follow these or we could be sued.



3/6/2024 - HIPAA and FERPA

Title: HIPAA & FERPA

Date: 3/6/24

Content by: Emily

Goals: Learn more about the federal laws

Link: <https://www.cdc.gov/phlp/publications/topic/healthinformationprivacy.html>

Search term: "HIPAA standards" (Google)

Citation:

"Health Information & Privacy: FERPA and HIPAA | CDC." Accessed: Mar. 07, 2024. [Online]. Available: <https://www.cdc.gov/phlp/publications/topic/healthinformationprivacy.html>

Content:

FERPA

The **Family Educational Rights and Privacy Act (FERPA)** is a federal law enacted in 1974 that protects the privacy of **student education records**.

The Act serves two primary purposes:

1. Gives parents or eligible students more control of their educational records
2. Prohibits educational institutions from disclosing "personally identifiable information in education records" without written consent



Who must comply?



- **Any public or private school:**
 - Elementary
 - Secondary
 - Post-secondary
- **Any state or local education agency**

Any of the above must receive funds under an applicable program of the US Department of Education

Protected Information



Student Education Record: Records that contain information directly related to a student and which are maintained by an educational agency or institution or by a party acting for the agency or institution

Permitted Disclosures ¹



- School officials
- Schools to which a student is transferring
- Specified officials for audit or evaluation purposes
- Appropriate parties in connection with financial aid to a student
- Organizations conducting certain studies for or on behalf of the school
- Accrediting organizations

- Appropriate officials in cases of health and safety emergencies
- State and local authorities, within a juvenile justice system, pursuant to specific state law
- To comply with a judicial order or lawfully issued subpoena

HIPAA

The **Health Insurance Portability and Accountability Act (HIPAA)** is a national standard that protects sensitive **patient health information** from being disclosed without the patient's consent or knowledge. Via the Privacy Rule, the main goal is to

- Ensure that individuals' health information is properly protected while allowing the flow of health information needed to provide and promote high quality health care and to protect the public's health and well-being.



Who must comply?



- Every healthcare provider who electronically transmits health

information in connection with certain transactions

- Health plans
- Healthcare clearinghouses
- Business associates that act on behalf of a covered entity, including claims processing, data analysis, utilization review, and billing

Protected Information



Protected Health Information²:

Individually identifiable health information that is transmitted or maintained in any form or medium (electronic, oral, or paper) by a covered entity or its business associates, excluding certain educational and employment records

Permitted Disclosures ¹



- To the individual
- Treatment, payment, and healthcare operations
- Uses and disclosures with opportunity to agree or object by asking the individual or giving opportunity to agree or object
- Incident to an otherwise permitted use and disclosure
- Public interest and benefit activities (e.g., public health activities, victims of abuse or neglect,

decedents, research, law enforcement purposes, serious threat to health and safety)

- Limited dataset for the purposes of research, public health, or healthcare operations

Conclusion:

FERPA laws also apply since we are at a post-secondary educational institution



2/13/2024 - Load Cell Housing Brainstorm Sketches

EMILY WADZINSKI - Feb 14, 2024, 12:24 PM CST

Title: Brainstorm Load Cell Housing

Date: 2/13/24

Content by: Emily, Colin, Neha

Present: Emily, Colin, Neha

Goals: brainstorm ideas for the design matrix

Content:

See attached

Conclusion:

Redraw and dimension for matrix

EMILY WADZINSKI - Feb 13, 2024, 8:16 PM CST

Load Cell Housing



Sketch #1)



[Download](#)

301_holder_sketches.pdf (4.19 MB)



2/13/2024 - Design Matrix Drawings

EMILY WADZINSKI - Feb 29, 2024, 11:37 AM CST

Title: Design Matrix Housing Drawings

Date: 2/13/24

Content by: Emily

Present: Emily, Colin, Neha

Goals: redraw the designs that were brainstormed for the matrix

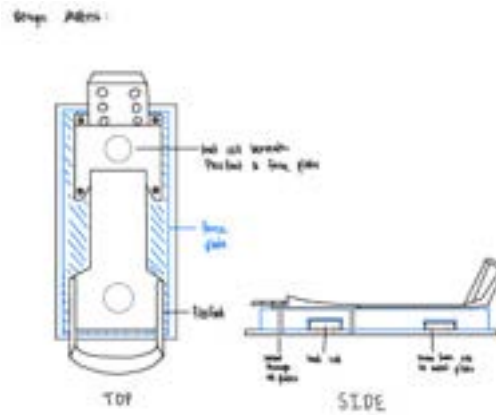
Content:

See attached

Conclusion:

Need to dimension for report

EMILY WADZINSKI - Feb 14, 2024, 12:29 PM CST



[Download](#)

Matrix_housing_designs_.pdf (501 kB)



2/28/2024 - Dimensioned Sketches

EMILY WADZINSKI - Feb 29, 2024, 11:38 AM CST

Title: Designs with Dimensions

Date: 2/28/24

Content by: Emily

Present: N/A

Goals: redraw the designs to meet the guidelines for the prelim presentation and report

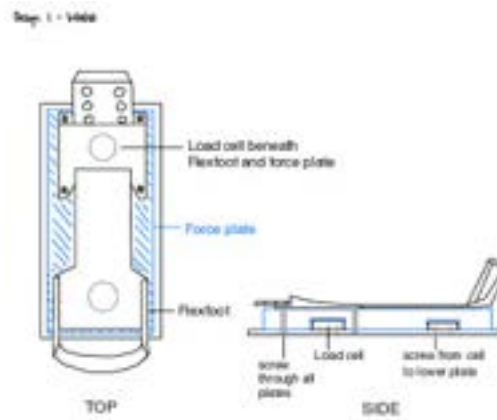
Content:

See attached

Conclusion:

CAD?

EMILY WADZINSKI - Feb 29, 2024, 11:39 AM CST



[Download](#)

Redone_sketches.pdf (1.22 MB)



4/4/2024 - Footplate Material Research

Title: Possible Footplate Materials

Date: 4/4/24

Content by: Emily

Goals: figure out materials need to buy for second round of prototyping

Content:

Our current design for the footpad (what the flexfoot is screwed into) is made up of a wood composition. For our second prototype, we want to make it out of metal and alternative materials. Instead of MDF, I was thinking we could have an acrylic footplate as I have used it for past design projects, and researched some possible options on McMaster-Carr.

The first option I saw was this "Choose-a-Color Acrylic"

<https://www.mcmaster.com/products/sheets/choose-a-color-acrylic/>

Choose-a-Color Acrylic

- Color: See table
- Temperature Range: -40° to 170° F
- Tensile Strength: 10,500 psi (Good)
- Impact Strength: 0.04-0.5 ft.-lbs./in. (Poor)
- Hardness: Rockwell M100 (Hard)
- For Use Outdoors: Yes

The combination of high strength and water resistance, along with a variety of color choices, makes these opaque cast acrylic sheets useful for outdoor signs and containers. This material is also known as Lucite and Plexiglas® Acrylic.

For technical drawings and 3-D models, click on a part number.

Thick.	Thick. Tolerance	Choose a Color	12" x 12"	12" x 24"	12" x 48"	24" x 24"	24" x 36"	36" x 48"
			Each	Each	Each	Each	Each	Each
1/4"	-0.03" to 0.007"	Black, Blue, Green, Red, White, Yellow	8506K741 \$7.71	8506K742 \$15.40	8506K743 \$29.96	8506K744 \$29.96	8506K745 \$36.48	8506K746 \$81.04

There are different sizes starting from 12" by 12" and only 8 bucks. We could even make it badger colored if we wanted!

I also found an acrylic that was scratch and UV-resistant, which I thought were relevant qualities to our design specifications.

<https://www.mcmaster.com/products/sheets/clear-scratch-and-uv-resistant-acrylic-sheets-and-bars/?s=acrylic+sheet>

Clear Scratch- and UV-Resistant Acrylic Sheets and Bars

Often used for windows, signs, and windshields, these extruded acrylic sheets and bars offer nearly the same performance as cast acrylic at a lower price. They're a better choice for outdoor use than polycarbonate because they are UV and scratch resistant and will maintain clarity over time.

Matte sheets have a non-glare finish on one side, the other side is glossy.

For technical drawings and 3-D models, click on a part number.

Sheets

- Color: Clear
- Temperature Range: 32° to 180° F
- Tensile Strength: 9,105-11,030 psi (Good)
- Impact Strength: 0.040 ft.-lbs./in. (Poor)
- Hardness: Rockwell M89-M90 (Hard)
- For Use Outdoors: Yes
- Specifications Met: UL 94 HB

Thick.	Thick. Tolerance	Appearance	12" x 12"	12" x 24"	12" x 48"	24" x 24"	24" x 48"	48" x 48"	48" x 96"
			Each	Each	Each	Each	Each	Each	Each
1/16"	-0.005" to 0.004"	—	8509K11 \$4.67	8509K12 \$8.91	8509K311 \$16.85	8509K13 \$16.85	8509K14 \$31.63	8509K12 \$57.04	8509K15 \$103.70
1/4"	-0.005" to 0.01"	—	8509K21 4.52	8509K22 9.29	8509K313 17.88	8509K23 17.69	8509K24 32.12	8509K14 60.09	8509K25 109.26
3/32"	-0.004" to 0.015"	—	8509K31 4.97	8509K32 9.39	—	8509K33 17.32	8509K34 31.41	8509K15 60.69	8509K35 110.34
1/8"	-0.019" to 0.019"	Matte+Glossy	1178T11 13.59	—	—	1178T12 48.31	—	—	1178T13 331.17
1/8"	-0.013" to 0"	—	8509K41 6.09	8509K42 11.06	8509K516 20.47	8509K43 20.47	8509K44 37.26	8509K17 68.89	8509K45 127.07
3/16"	-0.02" to 0"	—	8509K51 7.66	8509K52 13.44	—	8509K53 24.07	8509K54 45.26	8509K18 84.96	8509K55 154.48
1/4"	-0.020" to 0"	—	8509K81 9.73	8509K82 17.60	8509K919 32.57	8509K83 32.57	8509K84 60.08	8509K21 111.28	8509K85 202.29
3/8"	-0.038" to 0.038"	—	8509K322 14.40	8509K323 26.11	8509K324 48.31	8509K325 48.31	8509K326 89.12	8509K327 165.04	8509K328 300.08

The price of the sheets are also fairly cheap and can be quite thin, which would decrease impedance. I do think it being clear is unnecessary as this plastic is meant more for windows, but it is made for outdoors/possibly a boat.

A third option I found is wear-resistant, but its usage is not quite meant for our design.

<https://www.mcmaster.com/products/sheets/wear-resistant-nylon-sheets-bars-and-strips/?s=small+acrylic+sheet>

Wear-Resistant Nylon Sheets, Bars, and Strips



With a slippery surface that reduces friction, these wear-resistant nylon 6/6 sheets, bars, and strips are often machined into bearings, gears, and valve seats.

CAD For technical drawings and 3-D models, click on a part number.

Adhesive-Back Strips

- Color: Off-White
- Temperature Range: -40° to 185° F
- Tensile Strength: 11,200-12,300 psi (Good)
- Impact Strength: 0.6-1.4 ft.-lbs./in. (Poor)
- Hardness: Rockwell R108-R121 (Hard)
- For Use Outdoors: No
- Specifications Met: ASTM D5779

Thick.	Thick Tolerance	Type	Adhesive Temperature Range	Lengths, ft.	4" Wd.		6" Wd.		12" Wd.	
					Part No.	Per Ft.	Part No.	Per Ft.	Part No.	Per Ft.
0.031"	-0.003" to 0.003"	Acrylic	-40° to 185° F	1, 2, 5, 10, 20	8730K14	\$5.05	8730K19	\$7.27	8730K25	\$13.39
0.062"	-0.005" to 0.005"	Acrylic	-40° to 185° F	1, 2, 5, 10, 20	8730K31	8.61	8730K36	11.90	8730K42	22.08
.18"	-0.005" to 0.005"	Acrylic	-40° to 185° F	1, 2, 5, 10, 20	8730K47	13.66	8730K59	18.97	8730K78	36.54

All of the acrylics have poor impact strength, but I am unsure how much the tensile strength matters over the impact (especially if the feet don't leave).

Conclusion:

share with team



4/5/2024 - Finalized Materials Ordered

Title: Screws and Misc. Footplate Materials

Date: 4/5/24

Content by: Emily

Present: Emily, Neha

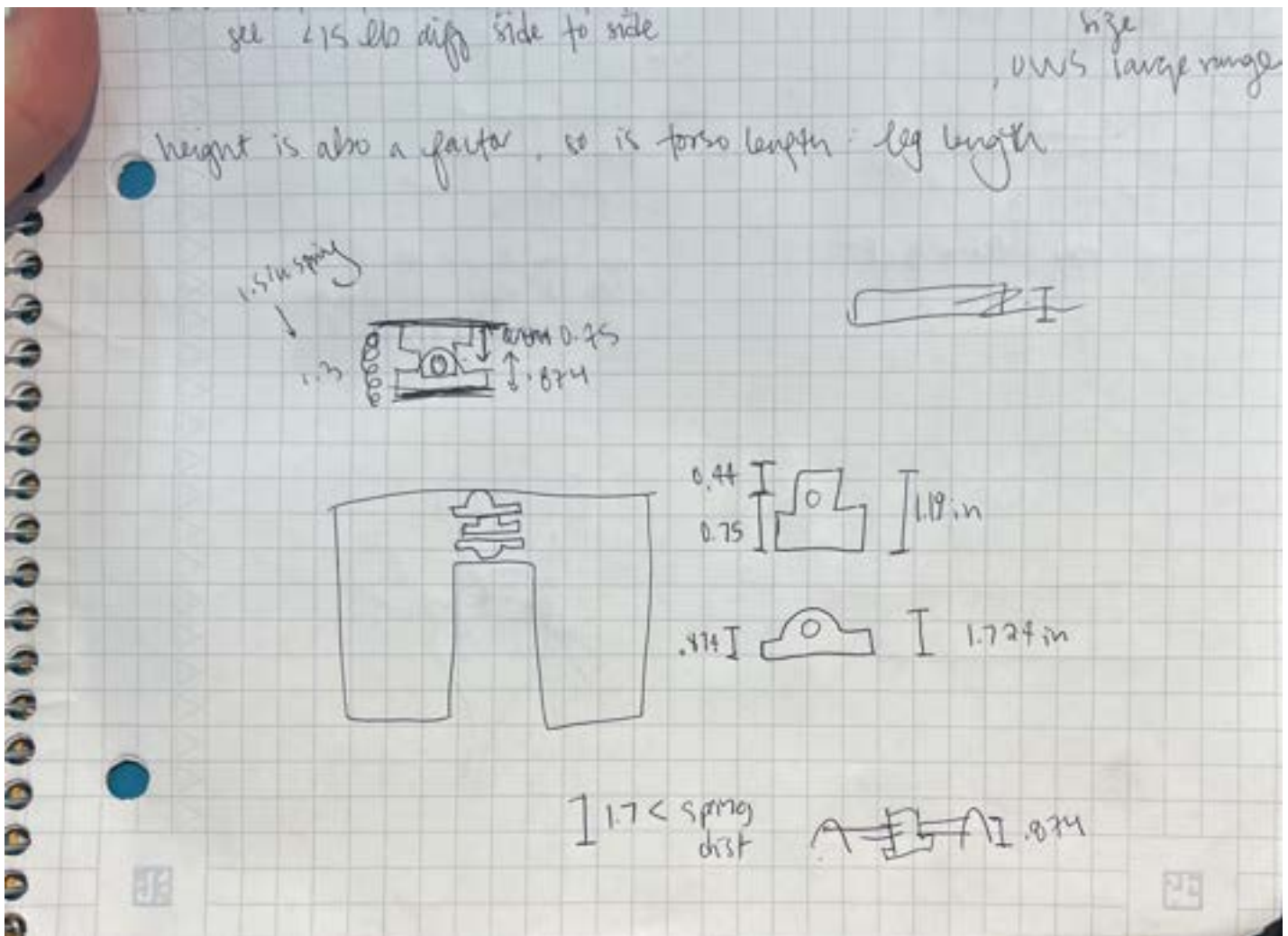
Goals: Finalize footplate materials

Content:

I went over the materials Neha found with her before we sent them to the client. Our biggest shopping concern was finding the right compression springs. We looked on the McMaster website for a while and discussed max load versus compressed length.

<https://www.mcmaster.com/products/compression-springs/compression-springs-7/>

From looking at my own therapy recovery results, we found that I exerted around 700 and 1000N of down and up force in each leg during a single leg jump assessment. This translates to a max of 250 lbs. Therefore, we ordered a pack of one of the only few that had a capacity over that. We also ordered springs with a lower capacity if we assume the force gets distributed among the four springs on each force. We did some math on the maximum distance the spring must be and determined a range we thought would be good for ordering.



We also checked the Team Lab for what they had downstairs. Unfortunately, they didn't have any springs that were labeled. With any information. We felt more confident about the springs we ordered since we know their constants and stuff, but we also took a couple



Conclusion:

wait for materials to come in



4/23/2024 - Kinovea Rowing Analysis

Title: Kinovea Testing

Date: 4/23/2024

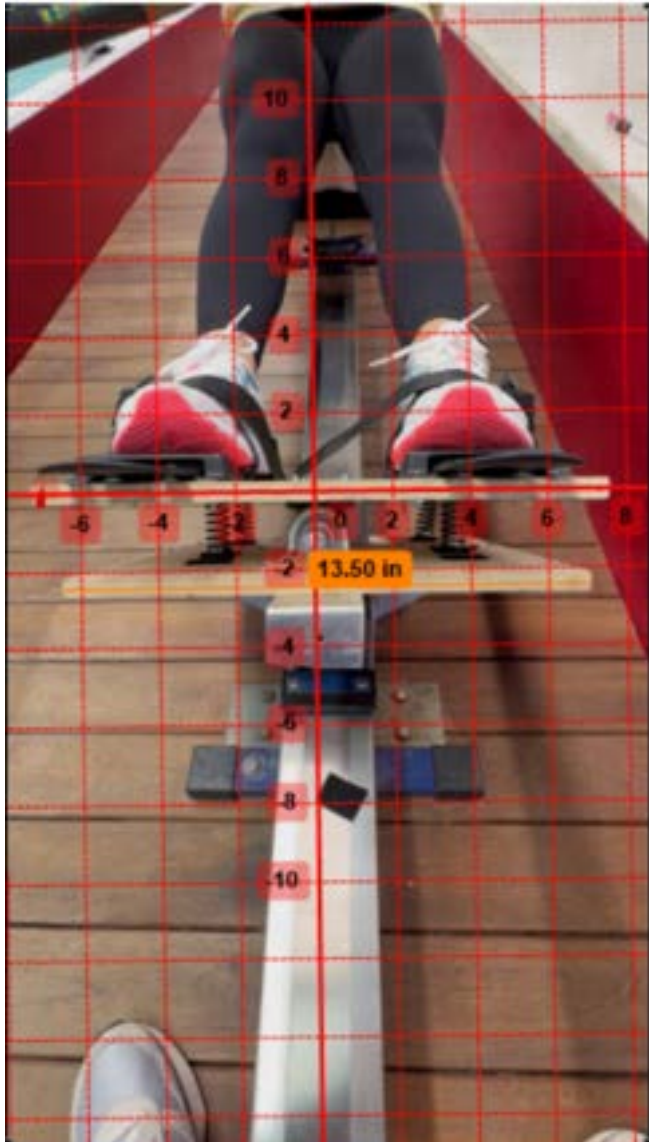
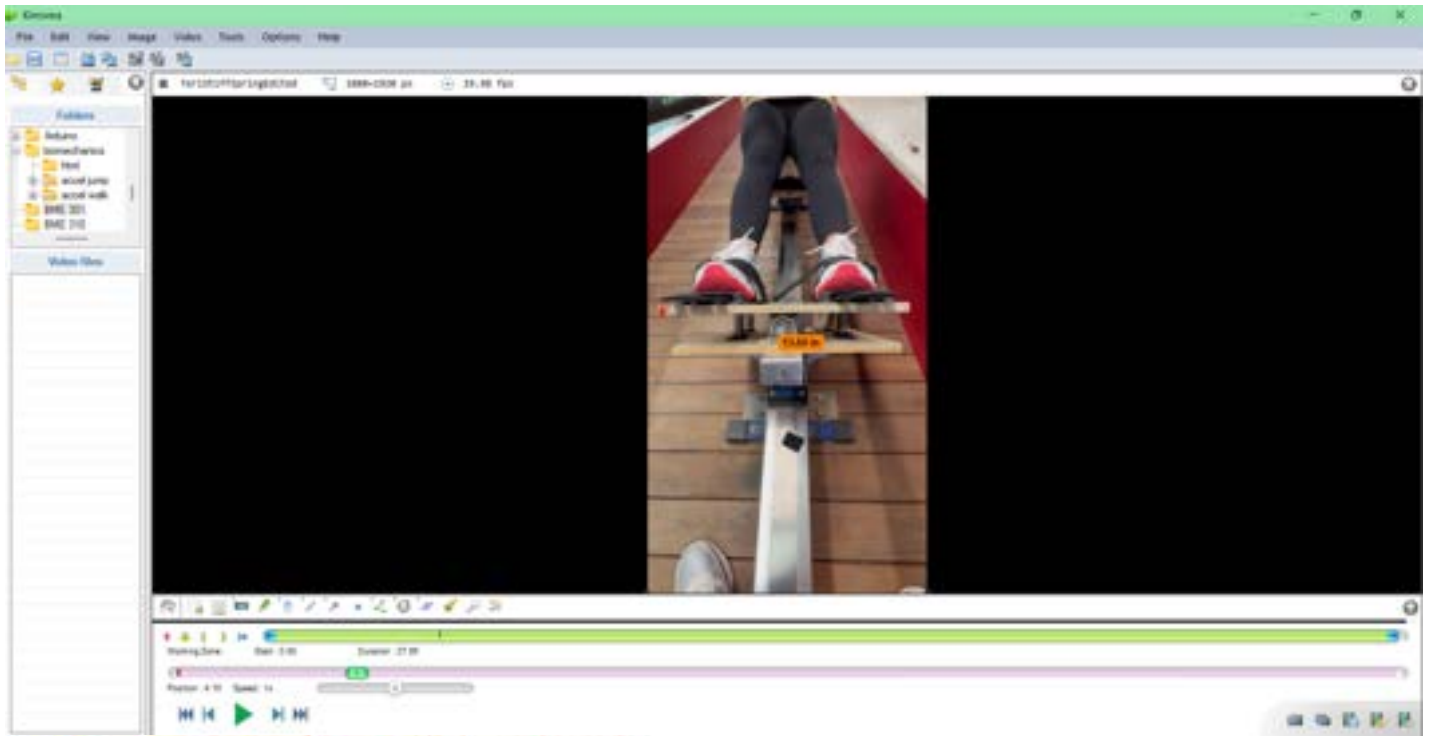
Content by: Emily

Present: All

Goals: To get the angle of the plate from videos taking during testing

Content:

After busting the encoder before we could ever start testing, Allicia had the brilliant idea to use video analysis instead. 2 videos of each of the 4 rowers were taken and uploaded to Kinovea. It took me a bit to remember how to use the software from 315 but I eventually was able to track the angle for about 30 seconds of each. For each video analysis I started with a reference distance of the top footplate in order base the coordinate system off of. A sharpie marked dots onto the center and ends of the top footplate for the system to be able to better track the points. One end point was picked to be tracked and each video had around 1100 frames to go through to double check the tracking accuracy. After repeating the process for all 8 videos the coordinates of the moving point with respect to the coordinate's axis were uploaded into excel sheets and shared with the group to use for data analysis.



Conclusion:

Make graphs of data and run t-tests.



2023/09/27 - Biosafety and Chemical Safety Documentation

EMILY WADZINSKI - Jan 28, 2023, 1:16 PM CST

Title: Training Documentation

Date: 1/28/2023

Content by: Emily

Present: N/A

Goals: Show documentation of lab training

Content:

Linked below:

Conclusions/action items:

Ready to be in the lab!

EMILY WADZINSKI - Jan 28, 2023, 1:16 PM CST

Course	Assignment	Completion	Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2023	1/23/2023	1/23/2023
Chemical Safety: The CTRIA Lab	Final Quiz	1/23/2023	

Download Expires: 1/23/2023 11:16 AM

[Download](#)

Training_Information_Lookup_Tool.pdf (92.8 kB)



2023/09/27 - Green Pass

EMILY WADZINSKI - Mar 11, 2023, 8:02 PM CST

Title: Green Pass Documentation

Date: 3/4/2023

Content by: Emily

Present: N/A

Goals: Show completion of pass

Content:

Displayed below:

Conclusions/action items:

Ready to use the shop

EMILY WADZINSKI - Mar 11, 2023, 8:04 PM CST



[Download](#)

green_pass.pdf (1.17 MB)



Title: Force Sensors

Date: 01/31/2024

Content by: Colin Fessenden

Present: N/A

Goals: Find force sensors that are applicable to the force measurements the team wants to acquire from the UW rowers.

Content:

Citation:

G. K. Barratt, C. Bellenger, E. Y. Robertson, J. Lane, and R. G. Crowther, "Validation of Plantar Pressure and Reaction Force Measured by Moticon Pressure Sensor Insoles on a Concept2 Row 21, no. 7, Art. no. 7, Jan. 2021, doi: [10.3390/s21072418](https://doi.org/10.3390/s21072418).

Search Term: Measuring rowing force using foot force sensors

- Moticon pressure sensor insoles
 - Sensor insoles have been used to determine plantar pressure and reaction force data



Figure 2. Moticon insoles and the number of sensors covering the insole area (not to

Conclusions/action items:

The team could laterally move from this idea and apply it the project. Specifically, how the sensor categorizes the forces into zones for more accuracy.



02/01/2024 - Health Demographics of Female Rowers

Colin Fessenden - Feb 01, 2024, 1:25 PM CST

Title: Exploring Health Demographics of Female Collegiate Rowers

Date: 2/1/2024

Content by: Colin Fessenden

Present: N/A

Goals: Understand the sample size and demographics of women rowers as a whole for further testing. (Satisfy 4b. on the rubric)

Content:

Citation:

M. Walsh, N. Crowell, and D. Merenstein, "Exploring Health Demographics of Female Collegiate Rowers," *Journal of Athletic Training*, vol. 55, no. 6, pp. 636–643, May 2020, doi: [10.4085/1062-6050-132-19](https://doi.org/10.4085/1062-6050-132-19).

Search Term: how many collegiate women rowing athletes are there

- The prevalences of stress fractures and menstrual irregularities did not differ between lightweight and openweight rowers, whereas a history of an eating disorder was more prevalent among the former (25.7%) than the latter (13%).
 - Lightweight rowers: <130 lbs
 - openweight rowers: >130 lbs and there is no weight limit
- Perceived stress levels did not differ between weight classes.
- Injured rowers scored higher on the Perceived Stress Scale than did uninjured rowers; athletic identity and perceived stress were moderately correlated among those who were currently injured.
- The Female Athlete Triad refers to a spectrum of three interrelated conditions commonly observed in female athletes, particularly those involved in sports emphasizing leanness or weight control. The three components of the triad are:
 - Energy Deficiency (Disordered Eating):
 - Inadequate caloric intake relative to the energy expended during exercise.
 - It may involve restrictive eating, excessive exercise, or other disordered eating patterns.
 - Menstrual Dysfunction:
 - Irregular or absent menstrual cycles.
 - Hormonal disruptions due to low energy availability can lead to disturbances in the menstrual cycle.
 - Bone Density Loss (Osteoporosis or Osteopenia):
 - Weakened bones due to a lack of estrogen, often associated with menstrual dysfunction.
 - Increased risk of stress fractures and long-term bone health issues.

Conclusions/action items:

Components of the female athlete triad were more prevalent in lightweight than in openweight rowers. Lightweight rowers were more likely to report a history of an eating disorder and dietary-restriction practices, but the weight classes did not differ in pathogenic weight-control practices, weight fluctuations, or menstrual irregularities.



02/01/2024 - The Growth of NCAA Women's Rowing: A Financial, Ethical and Legal Analysis

Colin Fessenden - Feb 01, 2024, 1:56 PM CST

Title: The Growth of NCAA Women's Rowing: A Financial, Ethical and Legal Analysis

Date: 02/01/2024

Content by: Colin Fessenden

Present: N/A

Goals: Understand the ethics and financials behind women's collegiate rowing. (satisfy 2b./4b. on the rubric)

Content:

Citation:

S. R. Rosner, "The Growth of NCAA Women's Rowing: A Financial, Ethical and Legal Analysis," *Seton Hall J. Sport L.*, vol. 11, no. 2, pp. 297-330, 2001.

Search Term: how many collegiate women rowing athletes are there

- The annual cost of a women's rowing program ranges from \$120,000 to \$250,000, depending on the size of the program
 - The NCAA allows for the equivalent of twenty full athletic scholarships to be awarded in women's rowing. This is the largest of any women's sport.
- Title IX of the Education Amendments of 1972 is a federal law prohibiting sex discrimination in education programs and activities receiving or benefiting from federal funding.
 - The Office for Civil Rights looks at whether an institution's participation opportunities for its male and female students are substantially proportionate to their full-time undergraduate enrollments.
 - The growth of women's rowing in the NCAA is primarily attributable to its positive impact on institutions attempting to comply with the interests and abilities aspect of Title IX via the substantial proportionality.

Conclusions/action items:

Women's rowing has had a significant effect on college athletics since becoming an NCAA sport. Athletic administrators must recognize the legal, financial, and ethical impact of the sport on their athletics programs in order to make a well-informed sponsorship decision about women's rowing.



02/01/2024 - Rowing Injuries

Colin Fessenden - Feb 01, 2024, 5:06 PM CST

Title: Rowing Injuries

Date: 2/1/2024

Content by: Colin Fessenden

Present: N/A

Goals: Understand the demographic of womens rowing and injuries associated with them

Content:

Citation:

J. S. Thornton *et al.*, "Rowing Injuries: An Updated Review," *Sports Med*, vol. 47, no. 4, pp. 641–661, Apr. 2017, doi: [10.1007/s40279-016-0613-y](https://doi.org/10.1007/s40279-016-0613-y).

Search Term: injuries in womens rowing

Junior rowers (age under 19 years) compete at the same race distance and train with similar frequency and duration as elite senior rowers, yet data related to injuries are scarce.

A survey of competitors at the 2007 Junior and Senior World Championships found that junior rowers have a higher annual aggregate injury rate than senior rowers (2.1 vs. 1.75 injuries per 1000 training sessions). This is partly owing to a lack of rowing experience, inappropriate training, and a significantly higher incidence of traumatic low back injuries among sweep rowers who changed rowing side during the season. Training volume was significantly associated with injury, with those averaging more than seven training sessions/week during a rowing season at higher risk.

This is important because a lot of freshmen and some sophomores on the UW crew team are considered junior rowers.

Conclusions/action items:

Junior rowers exhibit a higher annual aggregate injury rate compared to elite senior rowers highlighting factors such as limited rowing experience, inappropriate training, and a notable increase in traumatic low back injuries among sweep rowers who change sides during the season. This shows the significance of considering injury prevention strategies, especially for freshmen and some sophomores on the UW crew team who fall into the junior rower category.



02/01/2024 - Effects of Socialization

Colin Fessenden - Feb 01, 2024, 5:21 PM CST

Title: Race and rowing

Date: 2/1/2024

Content by: Colin Fessenden

Present: N/A

Goals: Understand the effects of socialization on women's rowing

Content:

Citation:

"Rowing race: a qualitative study of the effects of socialization, education and mass media of the rowing experiences of female racial minority rowers - Washington State University." Accessed: Feb. 01, 2024. [Online]. Available: <https://rex.libraries.wsu.edu/esploro/outputs/graduate/Rowing-race-a-qualitative-study-of/99900525275501842>

Search Term: societal view on womens rowing

- Past research indicates challenges for racial minority student-athletes in academic, athletic, and social pursuits.
- Rowing, historically perceived as a "WASP" (White Anglo-Saxon Protestant) activity, has received limited scholarly attention.
- This study explores experiences of seven racial minority female rowers with diverse racial identifications. In-depth interviews delve into the impact of socialization, education, and mass media on their rowing experiences.
- Socialization plays a crucial role in maintaining their engagement in rowing. While parents were supportive, some participants felt pressured by their parents to participate in the sport.

Conclusions/action items:

Past research identifies challenges for racial minority student-athletes, and this study, exploring the experiences of seven racial minority female rowers, uncovers the impact of socialization, education, and mass media on their engagement in rowing. Discovered primarily during university years, rowing participation is influenced by parental support, while high costs and limited exposure present barriers. Critical Race Theory highlights the impact of rowing's "White sport" stereotype on racial minority individuals. Participants embrace their uniqueness but express discomfort without racial diversity on the team. The findings emphasize the need to present rowing as an inclusive sport for racial minority athletes.



02/08/2024 - Collegiate rowing career

Colin Fessenden - Feb 08, 2024, 5:18 PM CST

Title: Life in Service

Date:

Content by: Colin Fessenden

Present: N/A

Goals: Understand the amount of hours that a collegiate rower trains.

Content:

Citation:

“What is the rowing training volume of elite programs? - Sparks.” Accessed: Feb. 07, 2024. [Online]. Available: <https://sparksrowing.com/blog/what-is-the-rowing-training-volume-of-elite-programs>

Search Term: How long is a collegiate rowing career

- The NCAA in-season hourly practice limitation is no more than 20 hours per week and roughly 8 months out of the year or about 34 weeks.
- The typical career of a collegiate rower is 4 years. This equates to roughly 6,800 - 8,160 hours.

Conclusions/action items:

Important to understand this data to help with the life in service of the device. This information will be applied to the PDS.



02/08/2024 - Important Concept2 RowERG specs

Colin Fessenden - Feb 08, 2024, 5:50 PM CST

Title: Concept2 RowERG

Date: 02/08/2024

Content by: Colin Fessenden

Present: N/A

Goals: Investigate the specs of the RowERG

Content:

Citation:

“Service,” Concept2. Accessed: Feb. 05, 2024. [Online]. Available: <https://www.concept2.com/service/monitors/pm3/how-to-use/understanding-stroke-rate>

Search Term: Concept2 RowERG specs

The Concept2 RowERG® requires all screws and connections to be thoroughly checked every 250 hours of use.

Maximum user weight for the RowERG is 227 kg.

Conclusions/action items:

Will keep this in mind when developing product and will use this information to create constraints in the PDS.



02/08/2024 - Rower size

Colin Fessenden - Feb 08, 2024, 6:09 PM CST

Title: Size demographics

Date: 02/08/2024

Content by: Colin Fessenden

Present: N/A

Goals: understand the demographics of the athletes.

Content:

Citation:

“The Height & Weight of Female Rowers,” SportsRec. Accessed: Feb. 07, 2024. [Online]. Available:<https://www.sportsrec.com/6665309/the-height-weight-of-female-rowers>

Search Term: size of collegiate womens rowers

U.S. Rowing reports that the average woman rower is approximately 6 feet. A review of the 2013 U.S. Senior National Team shows that the female open rowers range between 5 feet 4 inches to 6 feet 3 inches, with weight between 110 and 185 pounds. The lightweight squad tips the scales between 121 and 130 pounds, with heights between 5 feet 5 inches and 5 feet 10 inches.

Conclusions/action items:

Incorporate this info into the PDS to understand how the size of the rower can impact the product.



2/26/2003 - Load cell integrated with 3d print material

Colin Fessenden - Feb 26, 2024, 11:14 AM CST

Title: Load Cell/3D Print integration

Date: 2/26/2003

Content by: Colin Fessenden

Present: N/A

Goals: See what materials are sufficient for 3D printing

Content:

Citation:

S. B. Kesner and R. D. Howe, "Design Principles for Rapid Prototyping Forces Sensors Using 3-D Printing," *IEEE/ASME Trans. Mechatron.*, vol. 16, no. 5, pp. 866–870, Oct. 2011, doi: [10.1109/TMECH.2011.2160353](https://doi.org/10.1109/TMECH.2011.2160353).

Search Term: load cells inserted into 3d printed material site:.edu

The document outlines the design principles for creating custom force sensors using 3D printing technology, focusing on the benefits of rapid prototyping for developing sensors that are inexpensive, customizable, and suitable for various applications. It emphasizes the use of metal flexures in 3D printed structures for their superior elastic properties, allowing for the measurement of different force ranges and enhancing sensor performance with minimal size and cost. The paper illustrates these principles through the development of a miniature force sensor for a robotic catheter system, demonstrating the sensor's ability to measure forces accurately within a specific range.

Conclusions/action items:

Action Items: Research what materials will be best for 3D printing the load cell housing.



05/02/2024 - Mechanical properties of wood

Title: Mechanical properties of wood**Date:** 05/02/2024**Content by:** Colin Fessenden**Present:** N/A**Goals:** See if plywood is strong enough for the design of footplates**Content:****Citation:**

["Wood, Panel and Structural Timber Products - Mechanical Properties." Accessed: May 01, 2024. [Online]. Available:

1 https://www.engineeringtoolbox.com/timber-mechanical-properties-d_1789.html

]

Search Term: Compressive strength of bone

Wood	Density - ρ - (kg/m^3) (lb/ft^3)	Fibre Stress at Elastic Limit - σ_y - (MPa) (psi)	Modulus of Elasticity - E - (GPa) (psi)	Compressive Strength parallel to Grain - σ - (MPa) (psi)	Shear Strength parallel to grain - τ - (MPa) (psi)
Alder, red	410	68	9.5	40.1	7.4
Ash - Black, Blue, Green, Oregon, White	490 - 600	87 - 103	9.4 - 12	41.2 - 51.1	10.8 - 14
Aspen - Bigtooth, Quaking	390	63	9.9	36.5	7.4
Baldcypress	460	73	9.9	43.9	6.9
Baswood, American	370	60	10.1	32.6	6.9
Beech, American	640	103	11.9	50.3	13.9
Birch - Paper, Sweet, Yellow	550 - 620	85 - 114	11 - 15	39.2 - 58.9	8.3 - 15.4
Butternut	380	56	8.1	36.2	8.1
Cedar - Atlantic White, Eastern Red, Incence, Northern White, Port-Orford, Western Red, Yellow	310 - 470	45 - 88	5.5 - 11.7	27.3 - 43.5	5.5 - 9.4
Cherry, black	500	85	10.3	49	11.7
Chestnut, American	430	59	8.5	36.7	7.4
Cottonwood - Balam Poplar, Black, Eastern	310 - 400	27 - 59	7.6 - 9.4	27.7 - 33.9	5.4 - 7.2

Conclusions/action items:

the cedar wood we used has a compressive strength of 27.3-43.5 MPa.



2/13/2024 - Load Cell Housing Brainstorm Sketches

Colin Fessenden - Feb 13, 2024, 9:59 PM CST

Title:

Date: 2/13/24

Content by: Emily, Colin, Neha

Present: Emily, Colin, Neha

Goals: brainstorm ideas for the design matrix

Content:

See attached

Conclusion:

Redraw and dimension for matrix

Colin Fessenden - Feb 13, 2024, 9:59 PM CST

Load Cell Housing



Sketch #1)



[Download](#)

301_holder_sketches.pdf (4.19 MB)



2/13/2024 - Design Matrix Drawings

Colin Fessenden - Feb 14, 2024, 3:26 PM CST

Title: Design Matrix Housing Drawings

Date: 2/13/24

Content by: Emily

Present: Emily, Colin, Neha

Goals: redraw the designs were brainstormed for the matrix

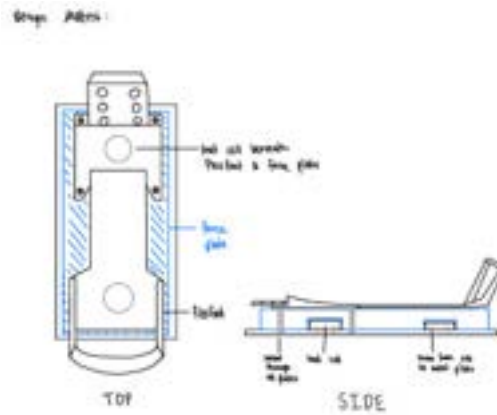
Content:

See attached

Conclusion:

Need to dimension for report

Colin Fessenden - Feb 14, 2024, 3:26 PM CST



[Download](#)

Matrix_housing_designs_.pdf (501 kB)



3/7/2024 - SolidWorks for Load cell housing

Colin Fessenden - Mar 07, 2024, 10:30 AM CST

Title: SolidWorks models for load cell housing

Date: 3/7/2024

Content by: Colin Fessenden

Present: N/A

Goals: Model the load cell housing to 3D print

Content:

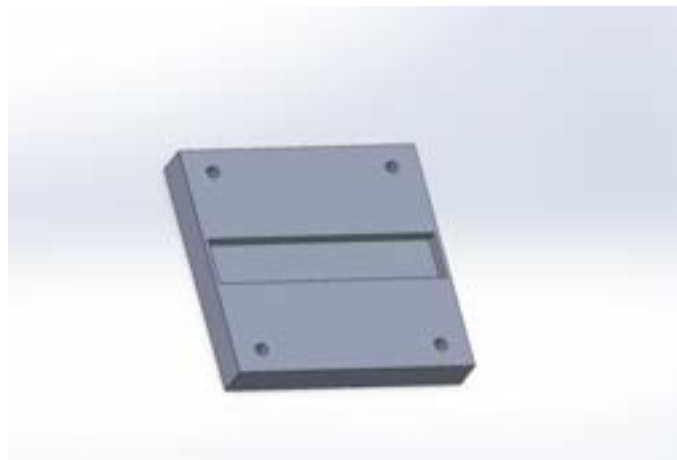
See attached image.

Pictured is the Toe housing for the load cell. The heel load cell is essentially the same model just the load cell orientation is flipped to be vertical.

Conclusions/action items:

Action Items: Start 3D Printing.

Colin Fessenden - Mar 07, 2024, 10:29 AM CST



[Download](#)

Toe_housing.png (133 kB)

**3/7/2024 - Materials for Load cell housing**

Colin Fessenden - Mar 07, 2024, 10:41 AM CST

Title: Load Cell Housing Material selection**Date:** 3/7/2024**Content by:** Colin Fessenden**Present:** N/A**Goals:** Find the best material to fabricate the load cell housing out of.**Content:****Search Term:** cheap metals for easy fabrication site:edu**Citation:**

"EML2322L -- Materials and material selection." Accessed: Mar. 07, 2024. [Online]. Available:
<https://mae.ufl.edu/designlab/Class%20Projects/Background%20Information/Materials%20and%20material%20selection.htm>

Material	Ultimate Tensile Strength (psi)	Yield Strength (psi)	Modulus of Elasticity (ksi)	Elongation at Break (%)	Rockwell Hardness	Density (lb/in3)	Specific Yield Strength (Yield Strength / Density)	Specific Stiffness (Modulus / Density)
1018 mild (low-carbon) steel	63,800	53,700	29,000	50	B71	0.283	190000	102000
ASTM A36 (low-carbon) steel	58,000	36,300	29,000	20	B67	0.284	128000	102000
1144 ("stressproof") steel	102,000	60,900	29,000	8	B95	0.284	214000	102000
12L14 ("free machining") steel	78,000	60,000	29,000	10	B84	0.286	210000	101000
4130 ("chromoly") normalized alloy steel	97,200	63,100	29,000	25	B92	0.284	222000	102000
4130 ("chromoly") heat treated alloy steel	230,000	205,000	29,000	10	C60	0.284	722000	102000
4340 normalized alloy steel	186,000	125,000	29,000	12	B100	0.284	440000	102000
4340 heat treated alloy steel	319,000	277,000	29,000	12	C60	0.284	975000	102000
5052 aluminum alloy	40,000	35,000	10,000	8	B45	0.097	361000	103000
6061-T6 aluminum alloy	45,000	40,000	10,000	17	B60	0.098	408000	102000
6105-T5 aluminum alloy	45,000	35,000	10,000	20	B60	0.098	357000	102000
7075 aluminum alloy	83,000	73,000	10,000	11	B87	0.097	753000	103000

Only need around 6000 PSI or 40 MPa for the plates. So aluminum is most likely the best option. Need to talk to the TeamLab to see what material is readily available.

Conclusions/action items:

Action Items: Talk with Neha and start fabricating the footplates.



5/1/2024 - SolidWorks Drawing of footplate

Colin Fessenden - May 01, 2024, 7:29 PM CDT

Title: Solidworks drawing of footplate

Date: 5/1/2024

Content by: Colin Fessenden

Present: n/a

Goals: Make solidworks drawing to send to the team lab

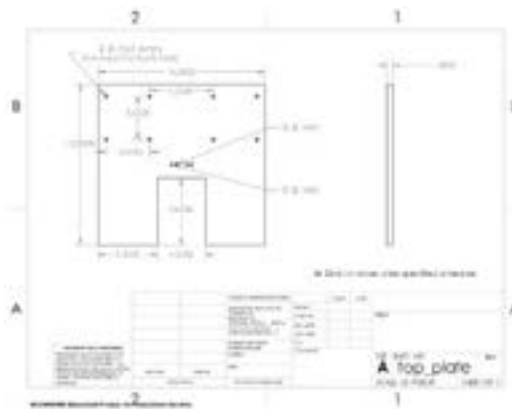
Content:

see attached

Conclusions/action items:

Get this fabricated by the teamlab via water jet cutter

Colin Fessenden - May 01, 2024, 7:30 PM CDT



[Download](#)

top_plate.pdf (56 kB)



3/21/2024 - Fabrication Recap

Colin Fessenden - Mar 21, 2024, 11:30 AM CDT

Title: Fabrication

Date: 3/21/2024

Content by: Colin Fessenden

Present: Neha, Emily, Allicia, Simi

Goals: Recap the fabrication session of the prototype.

Content:

See pictures below

I fabricated a template for the base that screws into the metallic base of the erg out of card board then created it out of wood. This involved cutting with the band saw, sanding with the band sander, and drilling with the mill. We then created housing for the bearings and inserted the rod thru to finish the base

Conclusions/action items:

Our action items are to finish the top portion of the prototype and begin doing qualitative testing.

Colin Fessenden - Mar 21, 2024, 11:35 AM CDT



[Download](#)

fabrication_bearing_conformation.jpg (766 kB)

Colin Fessenden - Mar 21, 2024, 11:35 AM CDT



[Download](#)

fabrication_drill.jpg (627 kB)

Colin Fessenden - Mar 21, 2024, 11:35 AM CDT



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fabrication_sander.jpg (726 kB)

Colin Fessenden - Mar 21, 2024, 11:35 AM CDT



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fabrication_template.jpg (1.01 MB)

Colin Fessenden - Mar 21, 2024, 11:42 AM CDT



[Download](#)

fabrication_prototype.jpg (1.7 MB)



2023/1/29 - Last Semester's Work

Title: Last Semester's Work**Date:** 1/29/2023**Content by:** Alicia**Goals:** As a new team member, I want to fully understand the work that my team completed last semester.**Content:**

Poster presentation:

- The team made a force plate with one load cell embedded into HDPE and covered with a metal plate that can be attached to a Concept2 RowErg with velcro and duct tape. After having a former rower test out the force plate, they were able to get data on the amount of force transmitted onto the load cell for the right and left leg (separately).
- 200kg-capacity HX711 load cell was used
- Design criteria: "Must be compatible with Concept2 RowErg, Must not impede natural rowing motion, must follow shape of ergometer, Must be within dimensions of ergometer (61 cm width), Force magnitude must be measured within margin of error of 5%, Service life of 10-12 years, Must withstand temperatures from 8.3 degrees Celsius to 22.2 degrees Celsius, Must be reproducible"
- In the future work section, the team expressed that they want to test out different configurations of multiple load cells for better accuracy

PDS:

- "This product should not cause any electrical shocks to the rower's and have minimal large cords in close proximity to the rower. The device needs to be plugged into an outlet with standard voltage of 120 V [4]." This makes sense for indoor rowing use, but does not make sense for use on the boat. Should we explore battery options, or just commit to a rowerg compatible product.

- "

- Temperature Range: 8.3° C to 22.2° C
- Humidity: 62% - 73%
- Rain Levels: 2.9 cm - 5.44 cm"

"On their own, the Concept2 RowErg® weighs between 25.9 and 30.8 kg [8]. The device should be able to withstand this weight." I'm confused by this line. Why does the device need to be able to withstand the weight of the rowerg itself?

- laser direct writing for waterproofing - research this

"The device must not interfere with the construction of the Concept2 RowErg® such that it fails to comply with the ASTM Standard Specifications for Fitness Equipment (ASTM F2276 – 23) [15].

Specifies that edges should be free of burrs and sharp edges, and corners should be chamfered

Specifies that the ergometer should withstand 1560 on/off cycles

Specifies that the footplate should be slippage-resistant

Specifies that the ergometer should be able to withstand 136 kg or the maximum user weight, whichever is greater

The device must also comply with the ASTM Standard Specification for Universal Design of Fitness Equipment for Inclusive Use by Persons with Functional Limitations and Impairments (ASTM 3021-17), such that rowers with functional limitations and impairments can use the device [16].

Specifies that color contrast on any visual display must be greater than or equal to 70%

Specifies that font size should be at least 10 mm

Specifies that the display should continue to display visual feedback at least 5 seconds after exercise has stopped."

- the section above is very well done, this team did a good job finding a quantified applicable standard.

Final Report:

- Data was saved in the Arduino EEPROM

Loading [MathJax]/extensions/Safe.js

- In the problem statement, the team writes that they want to make a user-friendly interface for coaches and rowers to use to assess the results. Has the team considered making a user interface other than a computer and communicating the info in a method other than force vs time graphs. The force vs. time graphs seem like valuable data to store, but they don't seem like they would benefit a rower in real time. We could make a system that shows the amount of force on the left and right plate in real time with a bar graph representation and color coded system. For example, if the left and right force plate are within 2 pounds of each other, the system appears green, but if they are further apart it could flash red.
- The rowers forefoot is strapped to the footrest, but their heel is free to move.
- design matrix: Force-resistive sensors, miniature load cells, and silicone-magnetic force sensors
- Based on the final report, it seems that team wants the final product to use force-resistive sensors on the tank, but due to time constraints they opted to make a prototype out of load cells on the ergometer. I wonder if the team wants to continue with the load cells or attempt to use an FSR

Conclusions/action items:

Questions for the team:

- Do you have accuracy data recorded yet? Like a bar graph comparing the measure vs actual weight on the force plate. If we develop a good protocol for measuring accuracy, we could repeat this process with several different load cell configurations to determine the optimal configuration. Note: I found this in the results section of the final report.
- Is there any advantage to measuring force in multiple directions for this application? Or are we just interested in the normal direction?
- Was the top of the load cell in-line with the HDPE? If so, wouldn't the weight be distributed over both the load cell and the plastic instead of only on the load cell?
- I saw that the FSR 'won' in the design matrix, would you guys like to explore this option or do you want to continue working with load cells? I also read about the straight bar load cell in the final report, is this something you want to try.
- Was the final design adjustable on the footrest in order to get the load cell under the ball of the foot?

**Title: Biomechanics of Lower Back Pain in Rowers****Date:** 1/31/2024**Goals:** To learn about what kinematic activities and muscle group activations cause LBP in rowers.**Search term:** "lower back pain" OR "LBP" AND "row*" in Scopus

Link: https://www-scopus-com.ezproxy.library.wisc.edu/record/display.uri?eid=2-s2.0-85099233764&origin=resultslist&sort=plf-f&src=s&sid=a7b9d23158fa6e16f5bc1c29d2892f2c&sot=a&sdt=a&s=TITLE-ABS-KEY%28%22lower+back+pain%22+OR+%22LBP%22+AND+%22row*%22%29&sl=52&sessionSearchId=a7b9d23158fa6e16f5bc1c29d2892f2c&relpos=15

Citation:

[1 F. J. Nugent, A. Vinther, A. McGregor, J. S. Thornton, K. Wilkie, and F. Wilson, "The relationship between rowing-related low back pain and rowing] biomechanics: A systematic review," *British Journal of Sports Medicine*, vol. 55, no. 11, pp. 616–630, 2021, doi: [10.1136/bjsports-2020-102533](https://doi.org/10.1136/bjsports-2020-102533).

Content:

- This article is meta-analysis of 22 studies involving rowing kinematics and lower back pain.

Lower back pain is common in rowers and understanding rowing biomechanics is important for helping to prevent injury and improve rehabilitation.


- Rowing tends to demand a lot from the lumbar spine. LBP is a common symptom for rowers (pain from the lower rib margin to the buttock creases and can be accompanied by pain in one or multiple legs). LBP affects up to 53% of international rowers per year. Reducing initial risk of LBP is a priority for clinicians and coaches.

Biomechanics:

- Rowing involves repetitive flexion and loading of the lumbar spine. (Lumbar flexion is forward curvature of the spine). Lumbar flexion increases as training session duration and intensity increases, which may lead to an increased risk of LBP.

- Across studies it was reported that rowing kinematics were influenced by fatigue, resulting in both sagittal and frontal plane motion of the lumbar spine. An increase in lumbar spine motion was accompanied by a decrease in hip ROM and less anterior pelvic rotation at the catch, and an increase in hip ROM and posterior pelvic rotation at the finish position.

- Rowers who do not report LBP have distinct rowing kinematics. At the catch, healthy rowers hold neutral or anterior pelvic rotation (see image below), and at the finish, they hold a flat low back spinal position. Healthy rowers tend to have a greater hip ROM. Trunk strength training has been shown to increase performance in rowers in that peak force at the handle increased, stroke length increased, anterior pelvic rotation at the catch also increased.

 **Figure 2**

- Findings: in order to reduce LBP in rowers, trainers/coaches should help them focus on greater hip range of motion and neutral or anterior pelvic rotation at the catch. Fatigue results in increased spinal flexion at the catch. Training the trunk muscles may be a consideration for the risk reduction of LBP in rowing.

Conclusions/action items:

Lower back pain is a frequent symptom experienced by rowers (53% worldwide). The meta analysis looked at 22 different studies and found that across these studies, rowers with and without lower back pain had different rowing kinematics. Pelvic rotation at the catch seems to be a major factor that separates healthy rowers from those who experience LBP. Understanding the nuances of these kinematics may help prevent LBP in rowers and rehabilitate those who currently experience it.



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biomechanics_LBP.pdf (1.17 MB)



2024/01/31 - Biomechanical Analysis of Rowing on an Ergometer

ALLICIA MOELLER - Jan 31, 2024, 10:17 PM CST

Title: Biomechanical Analysis of Rowing on an Ergometer

Date: 1/31/2024

Goals: To learn about how other researches have gathered foot force data on ergometers and how they analyzed this data.

Search term: Reference 14 from "The measurement setup for real-time biomechanical analysis of rowing on an ergometer"

Link: <https://link-springer-com.ezproxy.library.wisc.edu/article/10.1007/BF02844130>

Citation:

[1 P. Pudlo, A. Pinti, and F. X. Lepoutre, "Experimental laboratory apparatus to analyze kinematics and 3D kinetics in rowing," *Sports Eng*, vol. 8, no. 1, pp. 39–46, Mar. 2005, doi: [10.1007/BF02844130](https://doi.org/10.1007/BF02844130).

Content:

Biomechanical factors that influence rowing performance include "the length of the stroke, the duration and ratio of the stroke phases, the forces of the stroke on the handle and the foot stretcher, the power of the stroke, the trajectory of the handle motion, the angles between body segments and the joint loads."

- modified rowing ergometers that provide real-time biofeedback have become an increasingly popular tool to help rowers correct their form and optimize their performance.

- Rowing is typically not completely symmetric to the sagittal plane due to different oar motions, but asymmetry is even more relevant in sweep-oar rowing.

- in this article a rowing ergometer was sensorized to provide real-time feedback on the force of the arm pull (load cell), the foot reaction force (six-axis sensor JR3, measuring range was +1200 N with an accuracy of 0.25% at maximum load), length of chain pull (incremental encoder), position of the seat (wire incremental encoder). An optical motion capture system was also used to measure kinematics.

- In this study, expert and non-expert rowers used the ergometer and data was collected and graphed to show the differences in rowing kinematics between expert and non-expert rowers.

Conclusions/action items:

In this article, researchers added multiple sensors to a rowing ergometer to measure the force of the hand pull, the reaction force on the foot stretcher, the length of the chain pull, the movement of the seat position, and the real-time movement of the knee, hip, shoulder, and elbow joints using optical motion capture. In our project, we may want to consider a six-axis sensor like the JR3 to measure foot reaction force.



2024/01/31 - Lower Back Pain (LBP)

ALLICIA MOELLER - Feb 01, 2024, 2:06 PM CST

Title: Lower Back Pain

Date: 2/1/2024

Goals: To learn about LBP and what effects it has on patients' lives.

Search term: "Lower back pain" in PubMed

Link: <https://www-clinicalkey-com.ezproxy.library.wisc.edu/#!/content/playContent/1-s2.0-S0025712519301312?returnurl=null&referrer=null>

Citation:

[1 A. Popescu and H. Lee, "Neck Pain and Lower Back Pain," *Med Clin North Am*, vol. 104, no. 2, pp. 279–292, Mar. 2020, doi:] [10.1016/j.mcna.2019.11.003](https://doi.org/10.1016/j.mcna.2019.11.003).

Content:

Relevant statistics about occurrence of LBP:

"Lower back pain is the leading cause of disability and productivity loss worldwide with a lifetime prevalence of up to 84% for the adult patient population."

"The prevalence of activity limiting lower back pain that significantly interferes with work and quality of life for at least 1 day is 12%. "

"One-month prevalence of lower back pain was estimated to be 20% to 26%. ⁴² Patients with acute lower back pain who present for medical care can have resolution of their symptoms in 70% to 90% of cases. "

- Prior episodes of lower back pain are major predictors of future episodes of lower back pain, it tends to be a recurring issue. About 4% of patients who seek medical care for lower back pain have vertebral compression fractures.

- Nontraumatic lower back pain has a wide variety of causes. It can be related to intervertebral disc, facet joints, sacroiliac joints, infection and inflammation. Lower back pain can also be related to renal disease, pelvic organ pathology, aortic aneurism, or GI disease.

- Radicular vs axial back pain: radicular back pain radiates into the lower limb, but axial back pain occurs exclusively in the back.

- Disc-related pain is often worsened by physical activities

Conclusions/action items:

01/31/2024

Head Office: 1-800-461-9049

 ClinicalKey

Full Text Article

Neck Pain and Lower Back Pain

Author(s): [Lynn M. Chaffin, MD](#)
Journal: *Journal of Orthopaedic & Sports Physical Therapy*, 2024; 54(1): 1-10. [https://doi.org/10.1016/j.jospt.2023.11.014](#)

Neck pain is the fourth leading cause of disability, while neck pain largely precedes within 3 months. History and physical examination play a key role in ruling out cause of the most serious causes for neck pain. The evidence for pharmacologic interventions for acute and chronic musculoskeletal neck pain is limited. Lower back pain is the leading cause of disability and productivity loss. Consistent with epidemiological evidence and orthopedic spine specialist within 48 hours for acute pain and within 30 days for all patients with lower back pain may significantly decrease rate of surgical interventions and increase patient satisfaction.

Key points

- History and physical examination play a key role in ruling out serious causes for neck pain.
- Current imaging study like MRI should be considered in patients with history of cancer, red flag signs, progressive neurologic deficits, deteriorating motor strength, and/or progressive or generalized weakness.
- The patients with acute neck pain who receive appropriate treatment, but if symptoms persist over a period of weeks to months.
- Pharmacologic interventions of treatment in patients with subacute or chronic lower back pain symptoms are guided patient's response and physical therapy program.
- Being a physician or spine specialist within 48 hours of symptoms onset can increase patient satisfaction, decrease use of care and reduce rates of back spine surgery for patients with lower back pain.

Neck pain

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Neck_Pain_and_Lower_Back_Pain_-_ClinicalKey.pdf (511 kB)



2024/01/31 - Moticon and Novel Pedar-x Pressure Sensing

ALLICIA MOELLER - Jan 31, 2024, 8:29 PM CST

Title: Moticon and Novel Pedar-x Pressure Sensing**Date:** 1/31/2024**Goals:** To learn about plantar pressure sensing systems and how they are validated**Search term:** 'Force sensor rowing' in Google Scholar**Link:** <https://www.mdpi.com/1424-8220/21/7/2418>**Citation:**

[1 G. K. Barratt, C. Bellenger, E. Y. Robertson, J. Lane, and R. G. Crowther, "Validation of Plantar Pressure and Reaction Force Measured by] Moticon Pressure Sensor Insoles on a Concept2 Rowing Ergometer," *Sensors*, vol. 21, no. 7, Art. no. 7, Jan. 2021, doi: [10.3390/s21072418](https://doi.org/10.3390/s21072418).

Content:

This article tested 2 different insole pressure sensing systems (Moticon and Novel Pedar-x) on a Concept2 ergometer. This article can give me insight on two current competing devices and also how a system like this should be tested.

Testing protocol: 19 participants performed 4 500 m trial of ergometer rowing at 22-24 strokes/min, two trials with the Moticon insoles and two trials with the Pedar-x insoles.

Statistical analysis:

- A test-retest analysis was performed to analyze the reliability of each insole system, and both had strong results (intraclass correlation coefficient = 0.57-0.92). We may want to consider doing test-retest with our final product to gauge reliability.

- A t-test demonstrated a significant difference between Moticon and Pedar-x insoles, and a Pearson's correlation ($r < 0.37$) showed poor agreement for all plantar pressure and reaction force variables. Moticon insoles demonstrated poor validity in comparison to Pedar-x insoles. Both of the insoles were compared against real force plate data to determine validity. This may be an option for our testing: put our entire load cell configuration on a force plate and find discrepancies between the force plate and load cell data.

Conclusions/action items:

- For our final testing, we should test for validity by putting our load cell configuration on top of a force plate and applying various loads to test for validity, and for reliability we should perform test-retest analysis and determine the intraclass correlation coefficient.



2023/02/07 - Arduino Touchscreen Display Video

Title: Arduino Touchscreen Display Video**Date:** 2/7/2024**Content by:** Alicia**Goals:** To learn how to wire and program Arduino-compatible LCD displays.**Citation:**

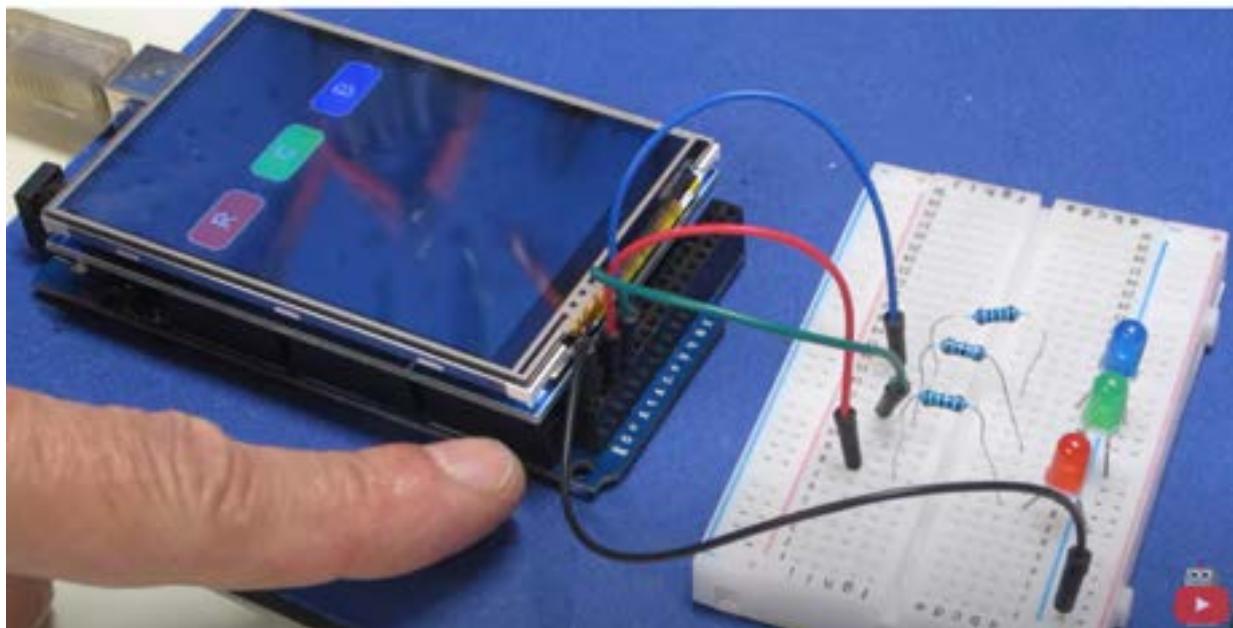
[1 *Arduino Touchscreen Display - Using a Resistive Touchscreen*, (Aug. 12, 2019). Accessed: Feb. 08, 2024. [Online Video]. Available: https://www.youtube.com/watch?v=_GT_sgbKQrc]

Link: https://www.youtube.com/watch?v=_GT_sgbKQrc**Search Term:** Arduino LCD Display on YouTube**Content:**

- model: Kuman 3.5" TFT LCD Shield with Arduino Uno
- screen, resistive touchscreen membrane, microSD card

Touchscreen display technology:

- Two main types of touchscreens: resistive and capacitive.
 - Resistive:
 - inexpensive and very common
 - two thin layers separated by a small gap.
 - Top layer is flexible and transparent
 - Conductive side of layers face each other
 - Pressing on top layer changes overall resistance
 - 4-Wire Analog: each layer has 2 wires
 - 5-Wire Analog: top has 4, bottom has 1
 - 8-Wire Analog: 4 each
 - Lower cost to manufacture
 - Higher sensor resolution
 - Can use gloves
 - Any hard object can activate the screen
 - More resistive to heat
 - Capacitive:
 - Made of transparent conductive material
 - Material placed onto a glass surface
 - electrodes on each corner
 - Touching the screen with your hand causes current to flow into you hand (current trying to reach ground) because your finger is capacitive.
 - Sensors under the screen measure the change and location
 - More durable - can function with cracks
 - Produces sharper images and better contrast
 - Multi-touch sensing
 - More reliable
 - More sensitive
- You can insert a microSD card to put images on the screen
- Programming:
 - Find the datasheet of the shield so that you know the pin output
 - Find an Arduino library to drive the LCD - check display website
 - Find a library to read the touchscreen membrane - check display website
 - LCD wiki (lcdwiki.com) - libraries and datasheets for all kinds of Raspberry Pi and Arduino LCDs
 - Look for demo sketches to test you display
- Building a touchscreen interface - the only pins leftover on Arduino Uno are pins 0, 1 and A5, because the touchscreen takes up most of the Arduino pins
 - include Adafruit core graphics library and LCD library and touchscreen library and MCUfriend library



-
- In this video, a digital user interface was made to light up the red, green, and blue LEDs.

Conclusions/action items:

After learning about Arduino touchscreen shields, I think using a touchscreen would be unnecessary for this project and they would use too many Arduino GTIO pins. Overall, this video was helpful to understand how these LCD displays are wired and programmed and how the touchscreen technology works. Going forward, I am going to work on a design matrix for potential non-touchscreen LCD displays that would be appropriate for this project.



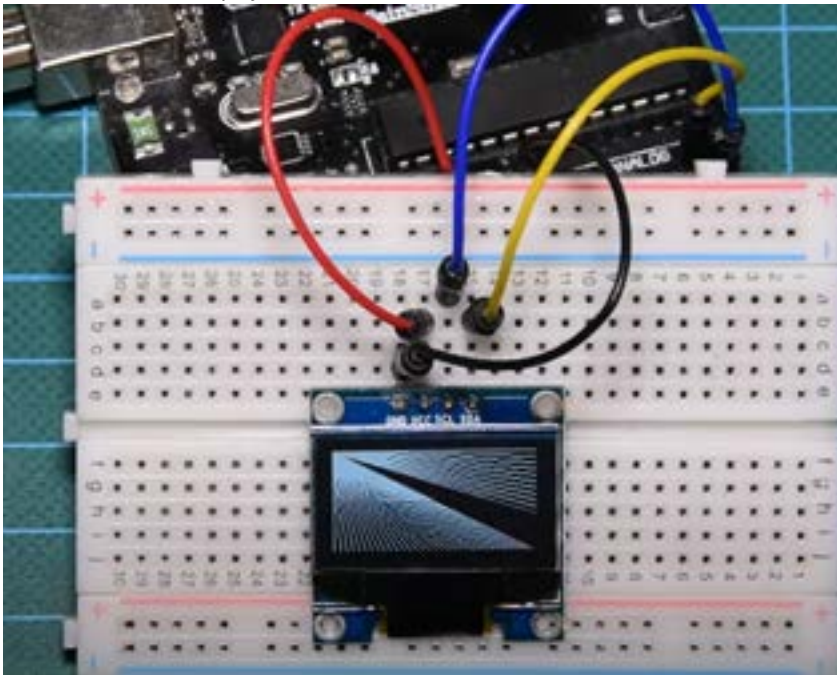
2023/02/08 - Top 5 Arduino Displays Video

Title: Top 5 Arduino Displays Video**Date:** 2/8/2024**Content by:** Alicia**Goals:** To learn about common Arduino-compatible displays on the market.**Citation:**

[1 *Top 5 Arduino Displays*, (Dec. 31, 2016). Accessed: Feb. 08, 2024. [Online Video]. Available: https://www.youtube.com/watch?v=E6quVf1_Blg]

Link: https://www.youtube.com/watch?v=E6quVf1_Blg**Search Term:** Arduino LCD Display on YouTube**Content:**

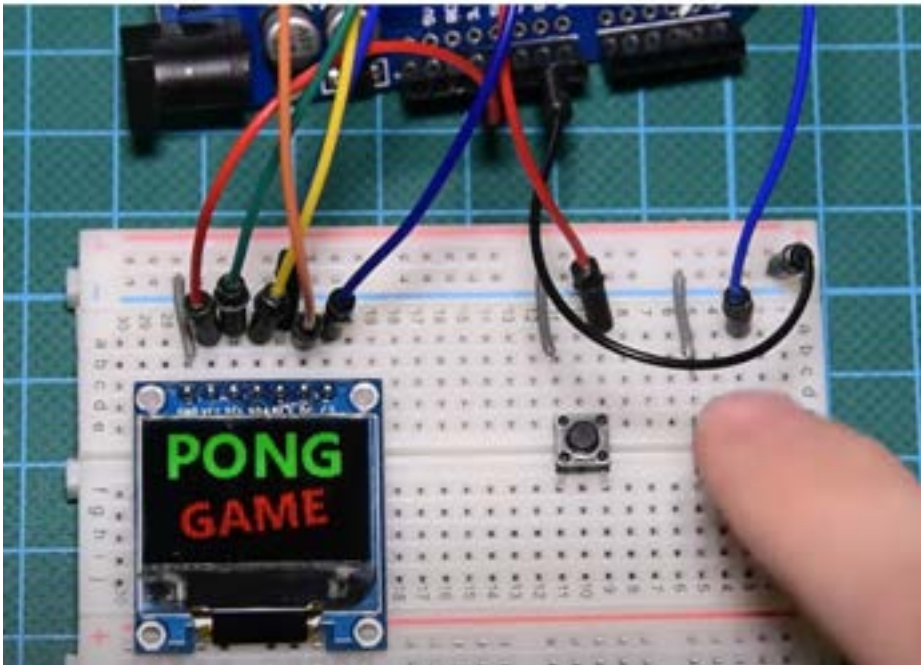
- 3.5" Colo TFT display with ILI9481 driver:
 - High res: 480x320 pixels
 - 65,000 colors
 - Comes as a shield - Arduino Uno or Mega
 - MicroSD chip to store data and images
 - \$11
 - low speed because 8bit Arduino struggles to drive the high resolution
- 0.96" monochrome OLED display:



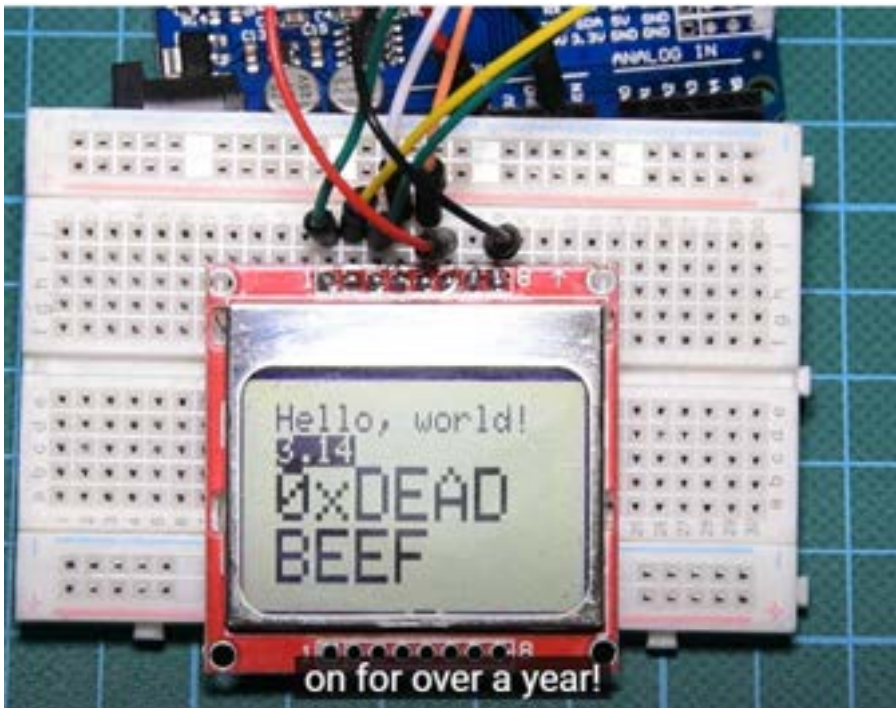
- 128x64 pixels
- I2C interface - only needs two wires
- Good contrast, brightness, low power consumption
- \$6
- Very small size :(
- 3.18" Color TFT ST7735



-
- \$6
- 160x120 pixels
- 65,000 colors
- works with every arduino
- MicroSD card
- SPI Color OLED



-
- \$11
- Very bright, high contrast, low power consumption
- low resolution (96x64 pixels)
- SPI interface (8 wires to connect to Arduino)
- Nokia 5110 LCD Display



-
- \$4
- Easy to use
- Visible under sunlight
- low power consumption (0.4A)
- Low resolution (84x48) pixels
- monochromatic
- Can be powered by battery

Conclusions/action items:

- Display requirements for the project:
 - Large size (ideally 5-7")
 - Compatible with Arduino (ideally)
 - Very fast refresh rate
 - Decent contrast - will be used in a light room
 - Not extremely expensive ~\$20
- Things we don't need:
 - High resolution
 - Color
 - Touchscreen



2023/02/13 - Raspberry Pi 4 GUI 7" Touchscreen video

Title: Raspberry Pi 4 GUI 7" Touchscreen video**Date:** 2/13/2024**Content by:** Alicia**Goals:** To learn how to make a GUI for a Raspberry Pi LCD display.**Citation:**

[1 *Raspberry Pi 4 Data Visualization GUI On 7" Touchscreen Display* | FullPageOS, (Mar. 23, 2020). Accessed: Feb. 13, 2024. [Online Video].
] Available: <https://www.youtube.com/watch?v=rHwrwz3kv5o>

Link: <https://www.youtube.com/watch?v=rHwrwz3kv5o>

Search Term: Raspberry Pi HDMI Display**Content:**

- Raspberry Pi microcontrollers may be a more appropriate choice for this project than the Arduino because:
 1. They have 26 GPIO pins - enough to support 4 load cells and the LCD display
 2. They have greater processing power than an Arduino and much more memory power
 3. They have a microHDMI port that can connect to HDMI displays - these tend to come in the sizes we are looking for (5"-7" diagonal)
- In this youtube video, someone made a GUI that scrapes data from a website on covid-19 death data, then integrates it into a custom website using JavaScript and Google Charts API to plot the data, then runs the webpage on a 7-inch Raspberry Pi touchscreen display.
- Hardware:
 - components: Raspberry pi 4, black microSD card, raspberry pi 7-inch touchscreen display, protective case to hold everything together
 - Connect display to drive, connect driver to raspberry pi and insert SD card into raspberry pi. Cover with protective case (could we purchase or 3D print something like this and include an attachment to integrate it into the erg/tank?)



- Software:
 - Process: Download FullPageOS, connect microSD card to USB port of the computer, flash the downloaded image to the SD card, modify text files files so that the OS can connect to local WiFi, eject SD card
 - Once you connect power to the raspberry pi, the FullPageOS should run immediately on the LCD screen. It will boot up and the welcome screen will pop up.
 - Login in remotely to the local server with ssh (more videos on account)
 - see default scripts
 - navigate into html directory and add your own directory and add your own html file
 - enter the name of the directory into your computer's browser as a url to see the page you created

- display the webpage on the display screen by modifying the FullPageOS text file in the boot directory
- When you reboot, your webpage will show up
- clone your github repository and move you demo to the html sub-directory
 - this user wrote a python script to query data from the World Health Organization website
 - used bootstrap css frame work for GUI styling and Google Charts API for creating a craft
- wrote code to refresh the page (crontab) to refresh the page every 5 minutes
 - We want a much fast refresh rate

Conclusions/action items:

- This youtube video gave an overview on his personal project where he wrote a script to display a GUI on his raspberry pi 7" touchscreen display.
- Aspects of this that are applicable to our project include: all the hardware included (although we may not need a touchscreen just a standard display), and possibly writing an html web page to show on the display and burning a microSD card.
- The main questions I still have are:
 - Can the raspberry pi only take 'instructions' on display from a microSD chip, or can we utilize the chip for data storage?
 - Because we don't need to scrape data from the web, but just format our sensor data, can this method allow for a 24 Hz screen refresh rate?



2023/02/13 - Raspberry Pi TkInter GUI

ALLICIA MOELLER - Feb 13, 2024, 2:18 PM CST

Title: Raspberry Pi TkInter GUI

Date: 2/13/2024

Content by: Alicia

Goals: To learn how to make a GUI for a Raspberry Pi with TkInter.

Citation:

[1 *Raspberry Pi Workshop - Chapter 4 - Your First GUI with TkInter and Python*, (Mar. 26, 2017). Accessed: Feb. 13, 2024. [Online Video]. Available:] <https://www.youtube.com/watch?v=ap-ABFNcBoE>

Link: <https://www.youtube.com/watch?v=ap-ABFNcBoE>

Search Term: Raspberry Pi GUI

Content:

- This user made a very simple GUI (with TkInter in python) for a raspberry pi display to turn an LED on/off.
- Hardware:
 - Raspberry Pi
 - Breadboard
 - LED wired to a GPIO pin
 - HDMI cord connecting raspberry pi to computer
 - USB powering raspberry pi
- Software - python script
 - import statements:
 - `from tkinter import *`
 - `import tkinter.font`
 - `from gpiozero import LED`
 - `import RPi.GPIO`
 - use GPIO LED function to define LED
 - make the GUI window object by calling Tk()
 - assign a title
 - you can set fonts
 - Make widgets - in this video only buttons were made
 - write a function to toggle the LED
 - create an exit button to trigger the closure of the interface and the clean-up method of GPIO

Conclusions/action items:

- TkInter seems like the appropriate application for building our GUI. Even though this video did display the GUI on a display, this can be done by running the python script from the screen.
- Raspberry Pi seems to be the appropriate microcontroller for this project.



2023/02/14 - Display Design Matrix notes

Title: Display Design Matrix notes**Date:** 2/14/2024**Content by:** Alicia Moeller**Goals:** To brainstorm and research content for the display design matrix**Content:**

Criteria:

- Interpretability (find better word for this)
 - How easy is it to interpret this feedback in real-time
- Integration (how easy it is to attach it to on the tank)
- Refresh rate
 - At least 24 Hz per PDS
- Value of data
 - How rich is the data you are communicating?
- Safety
- Cost

Idea #1: LED Array

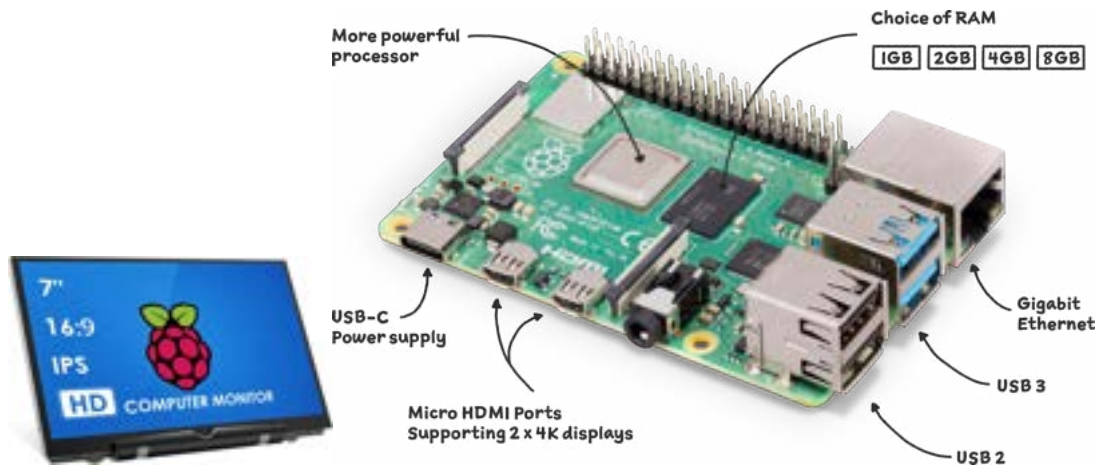
- No monitor, just LEDs connected to the microcontroller to indicate whether you crossed an asymmetry threshold.
- Left red, right red, center green
- Compares full foot force (not toe and heel)
- Strengths:
 - Cheap - basically just the wall adapter
 - Extremely simple
 - Can be integrated into arduino
 - Only uses 3 GPIO pins (digital)
 - Fast refresh rate
- Weaknesses:
 - Only gives whole foot force data
 - Can only work in the digital (not analog) realm, rower can not see their foot force increasing/decreasing in real-time

Idea #2: Arduino - LCD Display

- Buy a 5" LCD Display that can be connected to a Arduino Uno
- Strengths
 - Can be integrated into current design (Arduino Uno)
 - Much richer data - GUI
- Weaknesses
 - Not sure how easy GUI will be
 - Lower refresh rate than Raspberry pi - don't have the number so it may not be an issue
 - Cost
 - <https://www.buydisplay.com/tft-5-inch-lcd-display-module-controller-board-serial-i2c-ra8875> - \$35
 - Wall adapter - \$8
 - Uses some of the Arduino GPIO pins (I2C)
 - Smaller display (Arduino can't support very large displays)
 - Arduino on-board storage is still an issue

- We could look into the microSD card module? - uses more GPIO pins + additional costs
- Could be difficult to integrate into the tank

Idea #3: Raspberry Pi - HDMI Display



- Buy a 7" LCD Display that can be connected to a Raspberry Pi microcontroller via HDMI
- Build a GUI with TkInter (Neha dub)
 - shows real-time heel/toe force on the right and left side with graphics
 - Flashes red/yellow/green when to assess symmetry
- Strengths
 - Fast refresh rate (I think 60 Hz)
 - Can provide very rich real-time data because of GUI
 - Easily provide heel/toe differences
 - Probably easy data storage (see below)
 - Large display
 - Leaves 40 GPIO pins open on raspberry pi for force plate
 - Could explore wifi capabilities
 - Can program everything in python - yay
 - A more analog version - can see force increase/decrease in real time
- Weaknesses
 - Cost:
 - [Raspberry Pi 4 - 1GB RAM](#) - \$35
 - [7" Non-touch display screen](#) - \$34
 - Wall adapter - \$8
 - Integration could be difficult - may need to build a stand/base (see below)
 - Load cells may not be compatible

Additional ideas:

- The raspberry pi can connect to any monitor with an HDMI port (resolution is the main constraint). We could buy a cheap computer monitor and have it sit in front of t
 - https://discountelectronics.com/miscellaneous-refurbished-19-lcd-monitors/?gad_source=1&gclid=Cj0KCQiAw6yuBhDrARIsACf94RWwBDM9HtFhTeJiKc6TLOxgnOxksQYxM9t5Fv4D1Ycn91MUfcoq-v4aApbJEALw_wcB
 - Shop UW
 - Raspberry pi can support 4k resolution at 60 fps

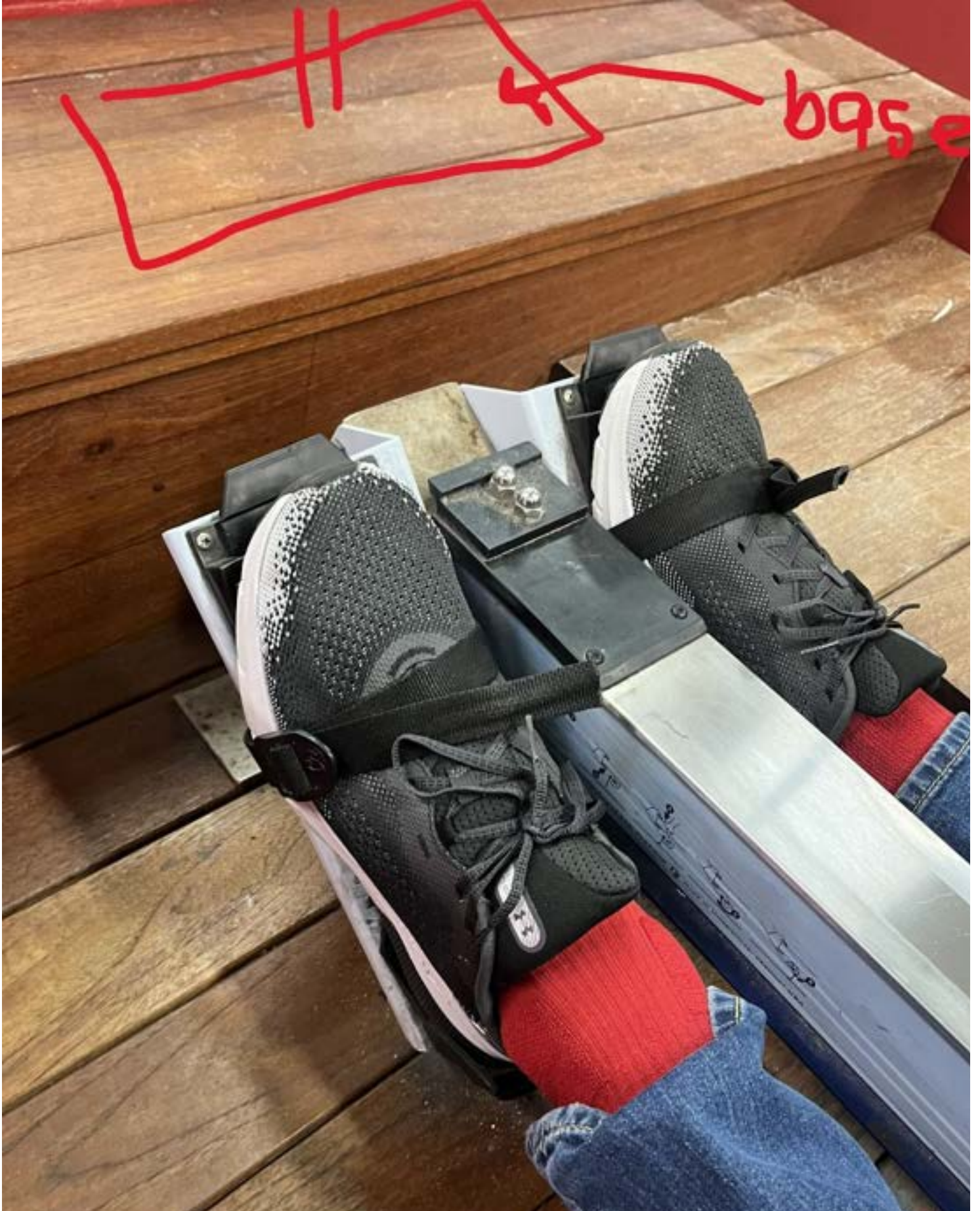
- Do we need 1GB, 2GB, 4GB, or 6GB of RAM for raspberry pi - research this more - greatly affects price
- Explore touchscreen more?
 - <https://www.waveshare.com/7inch-HDMI-LCD-C.htm>
 - <https://thepihut.com/products/official-raspberry-pi-7-touchscreen-display>
- Raspberry pi seems to have some wifi capabilities - may be helpful with data storage? Look into making a NAS
- [Wall power adapter!](#)

Data storage:

- I'm still a little unclear about storage of the raspberry pi - it seems that you can store local files on the microSD card and insert/remove it.
- There may be a way to plug in a usb drive, save data to it, then remove it and open its files on a computer
 - If we go with this route we should at least write a python/matlab script to analyze/visualize the data and show the clients how to run it
 - Ideally, we would convert our data analysis script into an executable file with a VERY minimal interface - more user friendly.
 - <https://towardsdatascience.com/convert-your-python-code-into-a-windows-application-exe-file-28aa5daf2564>
 - <https://towardsdatascience.com/how-to-easily-convert-a-python-script-to-an-executable-file-exe-4966e253c7e9>
 - I don't know what the security implications are for this.

Integration into tank:

- Not exactly sure how this is going to work!
- I imagine we build some kind of attachment that can clip/screw onto the erg part of the tank and telescope upwards
 - We could 3d print a case for the monitor/LED array and make it attach straight into the post.
- We could just set the display on a stand in front of the tank



Conclusions/action items:

Convert these notes into matrix form.



2024/2/20 - Raspberry Pi Set-up Info

ALLICIA MOELLER - Feb 20, 2024, 10:09 PM CST

Title: Raspberry Pi Set-up Info

Date: 2/20/2024

Content by: Alicia

Present: N/A

Goals: To understand which additional parts need to be ordered to get the raspberry pi working and how I will set it up. **Citation:**

[1 "Setting up your Raspberry Pi | Coding projects for kids and teens." Accessed: Feb. 20, 2024. [Online].
] Available: <https://projects.raspberrypi.org/en/projects/raspberry-pi-setting-up/0>

Search Term: Raspberry Pi 4 set-up

Content:

The official raspberry pi website has a detailed page on how to set up your device for the first time.

Materials needed:

- A USB-c power supply (at least 3 amps).
- SD card with at least 8GB storage - some sellers sell SD cards with raspberry pi OS already burned on it - <https://www.amazon.com/Silicon-Power-Speed-MicroSD-Adapter/dp/B07Q384TPK?tag=georiot-us-default-20&ascsubtag=tomshardware-us-1059309472951678300-20&geniuslink=true>
- USB keyboard and mouse for set-up - not exactly sure why this is necessary
- TV or computer screen to set up OS environment
- Either an HDMI - microHDMI cord or a standard HDMI cord and a micro converter

Setting up the SD card:

- Download and launch the Raspberry Pi Imager
- Insert your SD card
- Write the raspberry pi OS to the SD card by running the imager

Connecting electronics:

- Insert SD card into the microSD slot
- Connect the USB mouse to the raspberry pi
- Connect the USB keyboard to raspberry pi
- Connect your raspberry pi to your plugged-in screen via HDMI (used HDMI0 not HDMI1)
- Optional: connect the raspberry pi to ethernet
- Connect your power supply to socket and plug into raspberry pi
- Red light will flash
- Welcome to Raspberry Pi Application will pop up

Conclusions/action items:

- Acquire a power source, SD card, HDMI-microHDMI cord, and possibly a USB keyboard (I have a USB mouse).

ALLICIA MOELLER - Feb 21, 2024, 3:38 PM CST

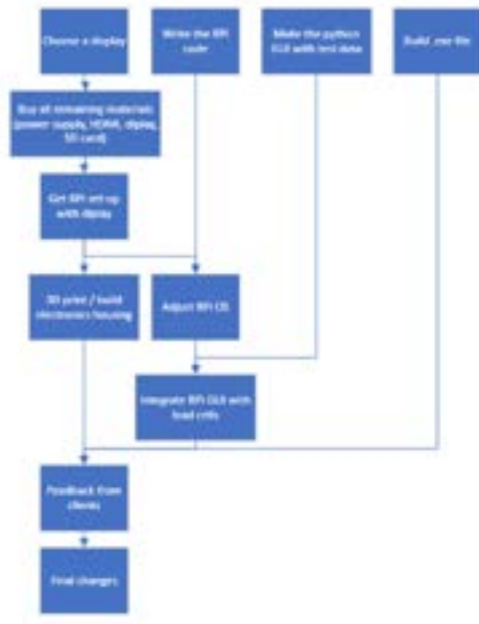
Great video on setting up the Raspberry pi and without a monitor/mouse/keyboard and viewing the rpi desktop on your pc via VNC connector: https://www.youtube.com/watch?v=0_D1mOHLagE



2024/02/21 - Display Project Roadmap

Title: Display Project Roadmap**Date:** 2/21/2024**Content by:** Alicia**Goals:** To organize my thoughts about the display into an ordered to-do list.**Content:**

- Things to do for the display:
 - Decide exactly what LCD display to get - 7" HDMI, computer monitor with HDMI, etc.
 - What SD card to get
 - Needs at least 8GB
 - Will ask Dr. P if there are extra in from BME 201
 - <https://www.amazon.com/Silicon-Power-Speed-MicroSD-Adapter/dp/B07Q384TPK?tag=georiot-us-default-20&ascsubtag=tomshardware-us-1059309472951678300-20&geniuslink=truehttps://www.amazon.com/Silicon-Power-Speed-MicroSD-Adapter/dp/B07Q384TPK?tag=georiot-us-default-20&ascsubtag=tomshardware-us-1059309472951678300-20&geniuslink=true>
 - Power cord
 - We will need the raspberry pi wall adapter for our final product, so we should order that right away
 - Can we use a normal USB - USB-c cord plugged into computer to power raspberry pi in the meantime? - maybe? if the RPi is not connected to a display or USB device it w require less power
 - https://www.amazon.com/GeeekPi-Supply-Raspberry-Orange-Adapter/dp/B0BMBGJNSVS/ref=sr_1_1_sspa?dib=eyJ2ljojMSJ9.9ZNU7cXh9UjiJNrzft7ZpUSVJgkOOz-KCgr50XnRFZIO5rZbXqLjy4ZnLlqWR_xJX3KLTBn8_aOfhS_ooJv99kO4AEmZAekzONm04dOw_h2YvQAnW7hJkOOBynoID7vPfkOAKAIDCFWEUJog-KNahHJ7vNJQncUzj_C6nAXRuVGN_cT9DhYt17FioihNjd9v84VTeSgmmsFq2KyXDTBJjuWnURtt0pG5hqj5VN4hwnKHY.GRVd5a19Vs_wl2uErLdnW8mGlyQuQqqOfT-IEio9jxA&dib_tag=se&keywords=Raspberry+Pi+4+Power+Supply&qid=1708550587&sr=8-1-spons&sp_csd=d2lkZ2V0TmFtZT1zcF9hdGY&psc=1
 - HDMI cord
 - Either an HDMI - microHDMI cord or an HDMI cord and an adapter
 - https://www.amazon.com/Highwings-Braided-Adapter-Compatible-Monitor/dp/B0CP5CBDBY/ref=sr_1_1_sspa?dib=eyJ2ljojMSJ9.r-FrG6_qhH73Z1pu6Rt53vR4Q3FmlZuJoSrc0-Y1aM-D1faSyjmlMSC1DYH8c91QZO53KvdbK5Aki_VEFcqQwGcdllZBThJz3uaKtSVaae_dx0dR6BFJRZ22uQ_ovabQzryuuVz25MtNSmKcBQhymSicuhdETvLBQJP-eYJ42-JpSrcsJzGhxlV7YmOeonVL05R4R5C1DwqsXANmMj5hWUOEPYfATMHXeXgBNERzSonmkrTusPVk0cHFFW0d9PR-SZLYyqaDFSGYW0Ju4Ylrfg7TbiQx9AcSkr0FYW-ks.lx82wZQJDj6dEO5bP-agPsFN_KgSUUOAGY2dwGpgiDw&dib_tag=se&hvadid=557459490879&hvdev=c&hvlvcphy=9018948&hvnw=g&hvmqmt=e&hvrnd=3454524587259903879&hvtargid=kv47718057084&hydadcr=18888_13357672&keywords=hDMI%2Bto%2Bmicro-hDMI&qid=1708550217&s=electronics&sr=1-1-spons&sp_csd=d2lkZ2V0TmFtZT1zcF9hdGY&th=1
 - GUI
 - Can work on this right away!!!
 - Need to create a python based graphical user interface to show real-time force data from the 4 load cells
 - Finish this on computer with fake data for show and tell to get feedback
 - Working with the RPi
 - Either need to hook RPi up to display to visualize the OS or use VNC connector to open the raspberry pi on a PC window
 - Look into remote SSH connection
 - Does the RPi always need to be connected to internet?
 - Integration into erg:
 - RPi must not be fully sealed off because it can heat up - may need a heat sink
 - Characters on the screen need to be readable
 - Data logging/storage
 - Current idea is to write files directly to a USB flash drive
 - Could write a python script to find
 - Data analysis (post-processing)
 - .exe file that allows user to select a txt or csv file and spits our a report for them - graphs, max force output, average force output, etc.
 - May need to use ML to identify stroke phases if we want to get really fancy
 - Can probably use matplotlib
 - Data security
 - Look into whether USB flash drive storage is secure
 - Errors and bug fixes
 - When we get the display working, we need to brainstorm how this device could break and take preventative measures. Could we code specific error messages to pop-up to warn the user?
- Order of operations:



- How to split this up with Simmi:
 - Maybe we can each work on the GUI right now to get two different options and maximize our knowledge of building GUIs
 - Work on the code for raspberry pi and data logging together
 - One of us can do the .exe file - if that is the path we choose
 - One of us can make a fritzing diagram / circuit diagram for all the display stuff (for prelim report)

Conclusions/action items:

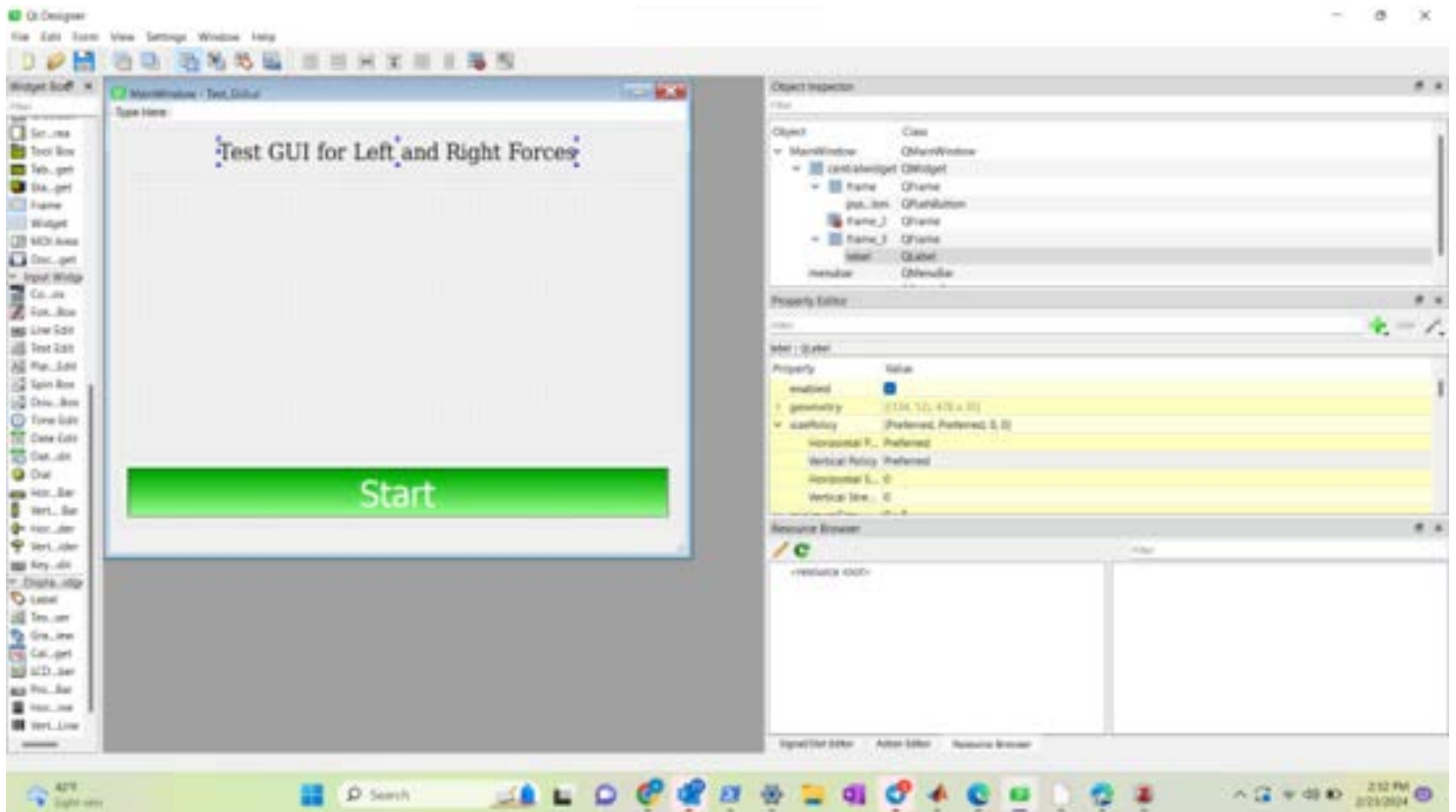
- Choose a display, split up work with Simmi



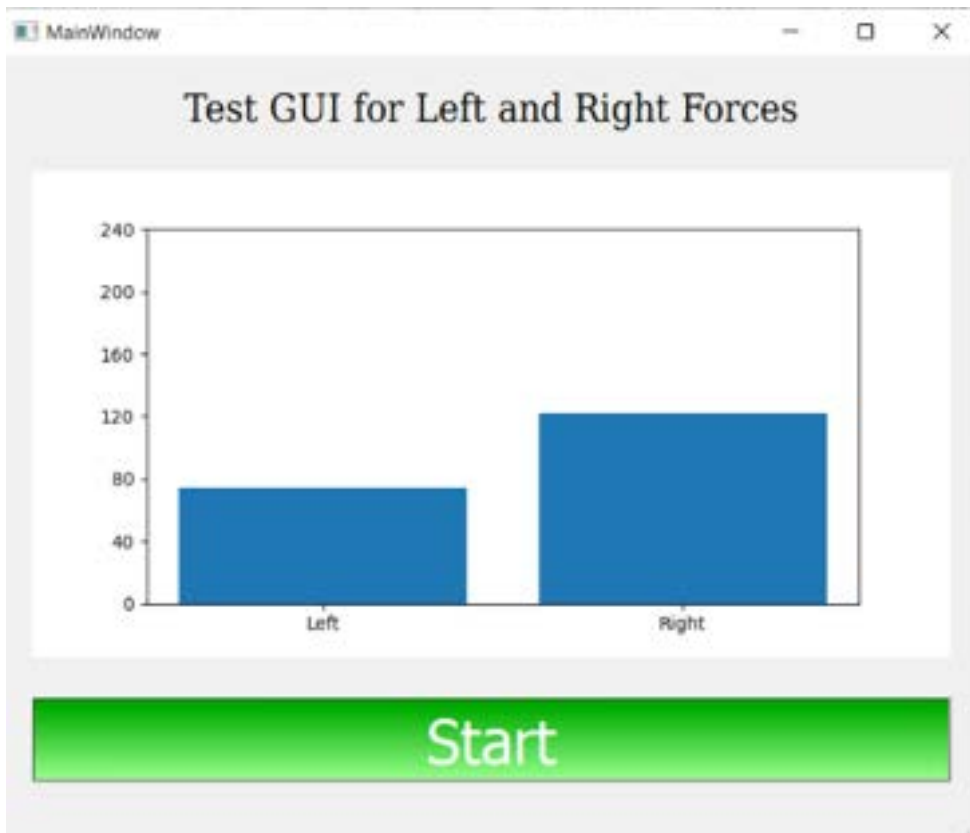
2024/2/21 - PyQt5 GUI Practice

Title: PyQt4 GUI Practice**Date:** 2/21/2024**Content by:** Alicia**Present:** N/A**Goals:** To practice making GUIs with PyQt5**Content:**

- I used this video to practice making a GUI with PyQt5: <https://www.youtube.com/watch?v=GxnWPY9GCrw>
- PyQt5 has an application called QT Designer which allows you to drag widgets into a frame to automate the coding of the GUI
 - I dragged a push button that says "start" onto the bottom of the window and a label that says "Test GUI for Right and Left Forces" to the top of the window.
 - I used 'layout vertically' and 'layout horizontally' to arrange the frames
 - I left the middle frame empty for a matlab plot



- I used the command prompt "pyuic5 -x Test_GUI.ui -o test2.py" to convert the .ui file into a .py file (I later renamed it GUI_testing.py)
- Then, I wrote some code to embed a matlab animation into the empty frame with the .py file
 - I had to hard code the axes ticks of the bar graphs to keep them static (this could be a problem for rowers with very different peak forces) - we may need to implement a calibration phase to generate the plots correctly for each rower
- See full code below



Screenshot of animated GUI (the bar graphs are rising and falling)

Citation:

[1 *Integrate Plots into PyQt5 Applications with Qt Designer, Matplotlib, and Numpy*, (Feb. 14, 2022). Accessed: Feb. 23, 2024. [Online Video]. Available:] <https://www.youtube.com/watch?v=GxnWPY9GCrw>

Search Term: "PyQt5 matplotlib" on Youtube

Link: <https://www.youtube.com/watch?v=GxnWPY9GCrw>

Conclusions/action items:

- Continue refining the GUI code
- Make a version with two bar charts (toe and heel)
- Maybe code a calibration phase?

```
#Code for animated test GUI:
```

```
%matplotlib notebook
```

```
from matplotlib.animation import FuncAnimation
```

```
import pandas as pd
```

```
from time import sleep
```

```
df_left = pd.read_csv('test_data_left.txt', sep=',', header=0)
```

```
df_right = pd.read_csv('test_data_right.txt', sep=',', header=0)
```

```
values_left = df_left['Force (lbs)']
```

```
values_right = df_right['Force (lbs)']
```

```
fsamp = 24
```

```
dt = 1/fsamp
```

```
import sys
```

```
import matplotlib.pyplot as plt
```

```
from matplotlib.backends.backend_qt5agg import FigureCanvasQTAgg as FigureCanvas
```

```
from matplotlib.figure import Figure
```

```
from PyQt5 import QtCore, QtGui, QtWidgets
```

```
class Ui_MainWindow(object):
```

```
    def setupUi(self, MainWindow):
```

```
        MainWindow.setObjectName("MainWindow")
```

```
        MainWindow.resize(767, 600)
```

```
self.centralwidget = QtWidgets.QWidget(MainWindow)

self.centralwidget.setObjectName("centralwidget")

self.verticalLayout = QtWidgets.QVBoxLayout(self.centralwidget)

self.verticalLayout.setObjectName("verticalLayout")

self.frame_3 = QtWidgets.QFrame(self.centralwidget)

self.frame_3 setFrameShape(QtWidgets.QFrame.StyledPanel)

self.frame_3 setFrameShadow(QtWidgets.QFrame.Raised)

self.frame_3.setObjectName("frame_3")

self.horizontalLayout_2 = QtWidgets.QHBoxLayout(self.frame_3)

self.horizontalLayout_2.setObjectName("horizontalLayout_2")

self.label = QtWidgets.QLabel(self.frame_3)

font = QtGui.QFont()

font.setFamily("DejaVu Serif Condensed")

font.setPointSize(18)

self.label.setFont(font)

self.label.setObjectName("label")

self.horizontalLayout_2.addWidget(self.label, 0, QtCore.Qt.AlignHCenter)

self.verticalLayout.addWidget(self.frame_3, 0, QtCore.Qt.AlignTop)

# frame 2 = plots

self.frame_2 = QtWidgets.QFrame(self.centralwidget)

sizePolicy = QtWidgets.QSizePolicy(QtWidgets.QSizePolicy.Preferred, QtWidgets.QSizePolicy.Expanding)

sizePolicy.setHorizontalStretch(0)

sizePolicy.setVerticalStretch(0)

sizePolicy.setHeightForWidth(self.frame_2.sizePolicy().hasHeightForWidth())

self.frame_2.setSizePolicy(sizePolicy)

self.frame_2 setFrameShape(QtWidgets.QFrame.StyledPanel)

self.frame_2 setFrameShadow(QtWidgets.QFrame.Raised)

self.frame_2.setObjectName("frame_2")
```

```
#create a horizontal layout
```

```
self.horizontalLayout_3 = QtWidgets.QHBoxLayout(self.frame_2)
```

```
self.horizontalLayout_3.setObjectName("horizontalLayout_3")
```

```
##Canvas Here
```

```
self.figure = plt.figure()
```

```
self.canvas = FigureCanvas(self.figure)
```

```
###end of canvas
```

```
##add canvas
```

```
self.horizontalLayout_3.addWidget(self.canvas)
```

```
###end of horizontal layout
```

```
self.verticalLayout.addWidget(self.frame_2)
```

```
self.frame = QtWidgets.QFrame(self.centralwidget)
```

```
self.frame.setFrameShape(QtWidgets.QFrame.StyledPanel)
```

```
self.frame.setFrameShadow(QtWidgets.QFrame.Raised)
```

```
self.frame.setObjectName("frame")
```

```
self.horizontalLayout = QtWidgets.QHBoxLayout(self.frame)
```

```
self.horizontalLayout.setObjectName("horizontalLayout")
```

```
self.pushButton = QtWidgets.QPushButton(self.frame_2, clicked = lambda : self.plotOnCanvas())
```

```
font = QtGui.QFont()
```

```
font.setPointSize(28)
```

```
self.pushButton.setFont(font)
```

```
self.pushButton.setStyleSheet("QPushButton{\n"
```

```
"background-color: qlineargradient(spread:pad, x1:0.1989, y1:0, x2:0.194, y2:1, stop:0.0945274 rgba(0, 170, 0, 255), stop:1 rgba(151, 255, 139, 255));\n"
```

```
"color:rgb(255, 255, 255)}\n"
```

```
"\n"
```

```
"QPushButton:hover{\n"
```

```
"background-color: qlineargradient(spread:pad, x1:0.1989, y1:0, x2:0.194, y2:1, stop:0.0945274 rgba(25, 71, 25, 255), stop:1 rgba(151, 255, 139, 255));\n"
```



```
time = df_left["Time (s)"]
```

```
self.animation = FuncAnimation(self.figure, self.update_animation, frames=time, repeat=False, interval=1000/24)
```

```
self.canvas.draw()
```

```
def update_animation(self, sec):
```

```
    plot_labels = ['Left', 'Right']
```

```
    left_val = df_left[df_left["Time (s)"] == sec].iloc[0]["Force (lbs)"]
```

```
    right_val = df_right[df_right["Time (s)"] == sec].iloc[0]["Force (lbs)"]
```

```
    values = [left_val, right_val]
```

```
    self.ax.clear()
```

```
    self.ax.bar(plot_labels, values)
```

```
    self.ax.yaxis.set_ticks([i for i in range(0,280,40)])
```

```
if __name__ == "__main__":
```

```
    import sys
```

```
    app = QtWidgets.QApplication(sys.argv)
```

```
    MainWindow = QtWidgets.QMainWindow()
```

```
    ui = Ui_MainWindow()
```

```
    ui.setupUi(MainWindow)
```

```
    MainWindow.show()
```

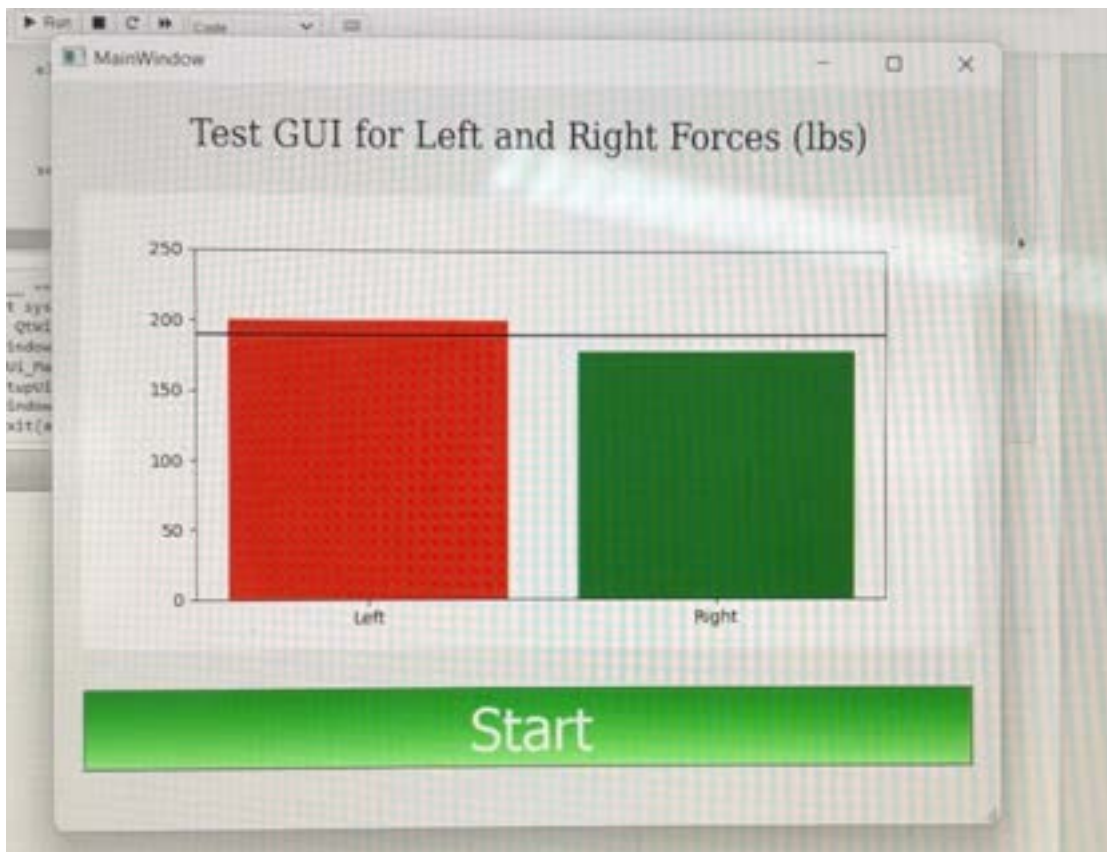
```
    sys.exit(app.exec_())
```

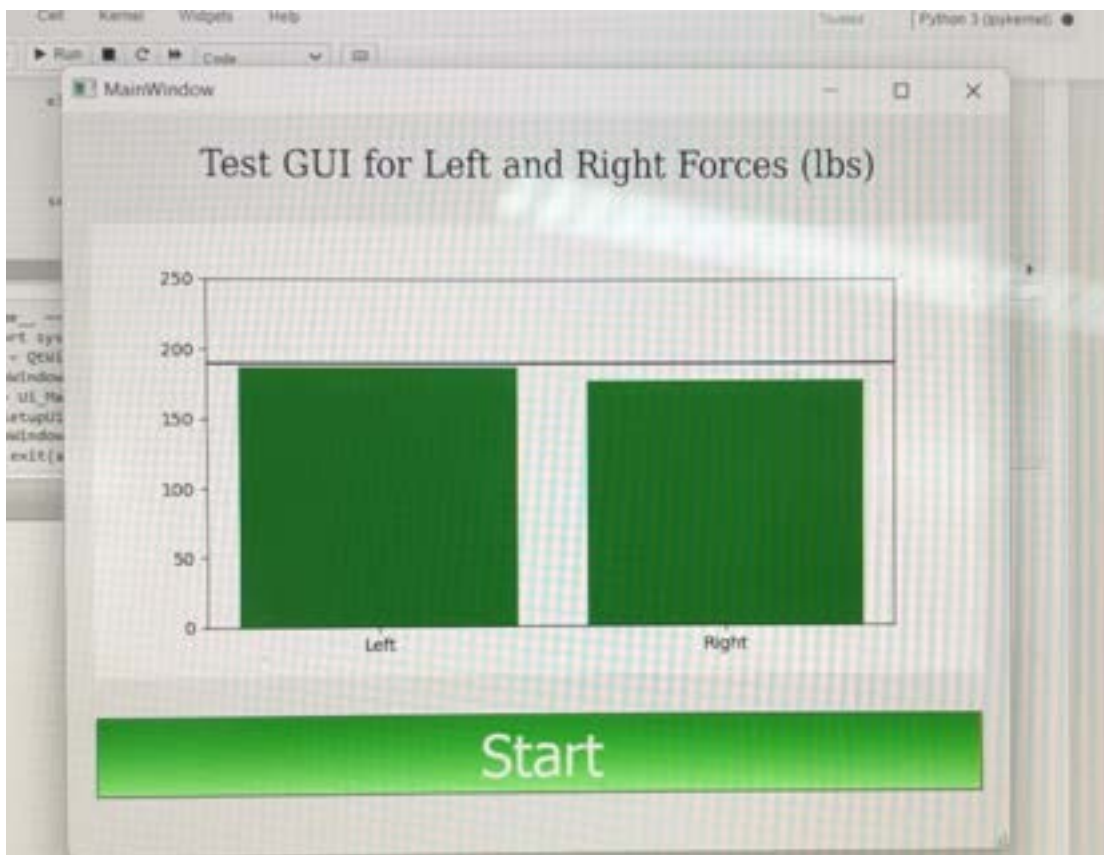
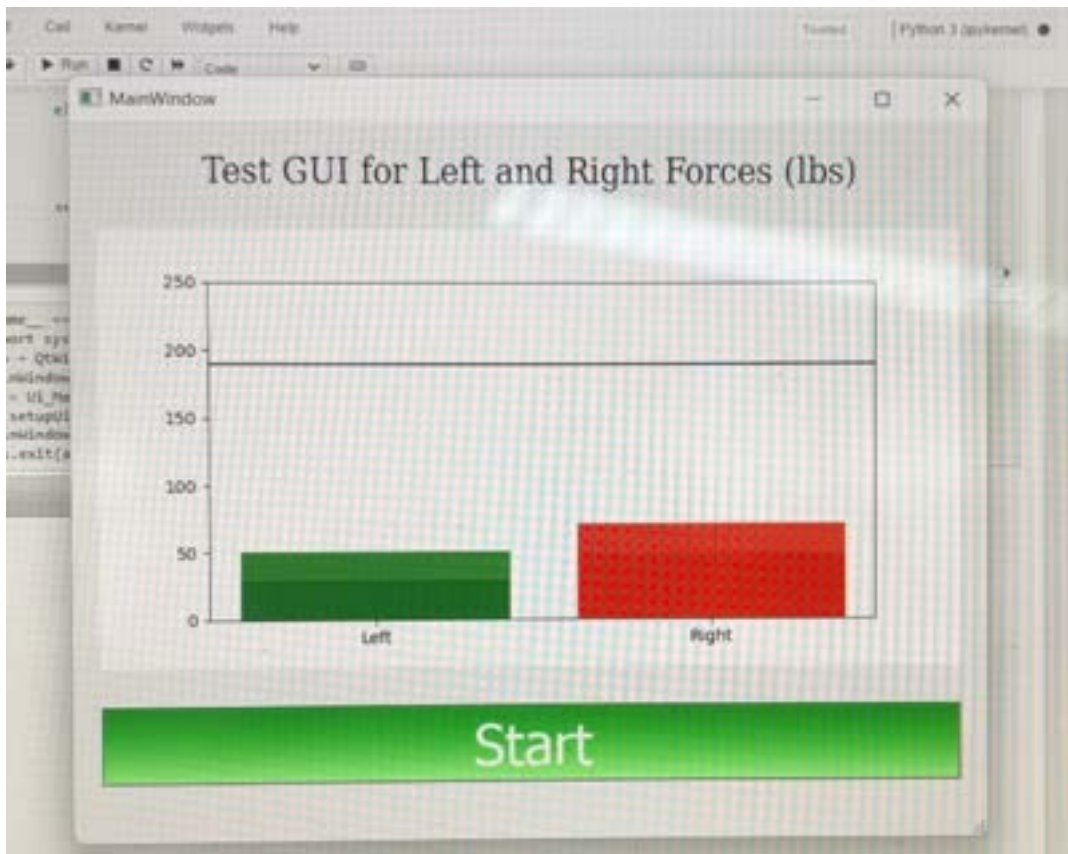


2023/03/07 - Color-chanigng GUI

Title: Color Changing GUI**Date:** 3/7/2024**Content by:** Alicia**Goals:** To add a threshold bar and color-changing features to the demo GUI.**Content:**

I made a new GUI demo that allows for a calibration period where maximum peaks are averaged, then a threshold bar appears across the screen at that average. Additional conditional statements check if the peak forces are greater than 10 apart from each other and the higher bar turns red, while the other bar remains green. This demo was a little bit laggy compared to the last one which I imagine is because more computation is necessary with each loop. I am unsure if lag will be an issue when this code pulls real data from the load cells and displays it on the LCD screen.





The threshold bar may be seen as confusing because it makes it look like the bars turn red when they surpass the threshold (which is not the case), but regardless of if we keep the threshold bar, the calibration period is essential for setting the axes for the bar plot.

Conclusions/action items:

Get feedback from the clients on this GUI demo.



2024/03/13 - Dark Mode demo GUI

Title: Dark Mode demo GUI

Date: 3/13/2024

Content by: Alicia

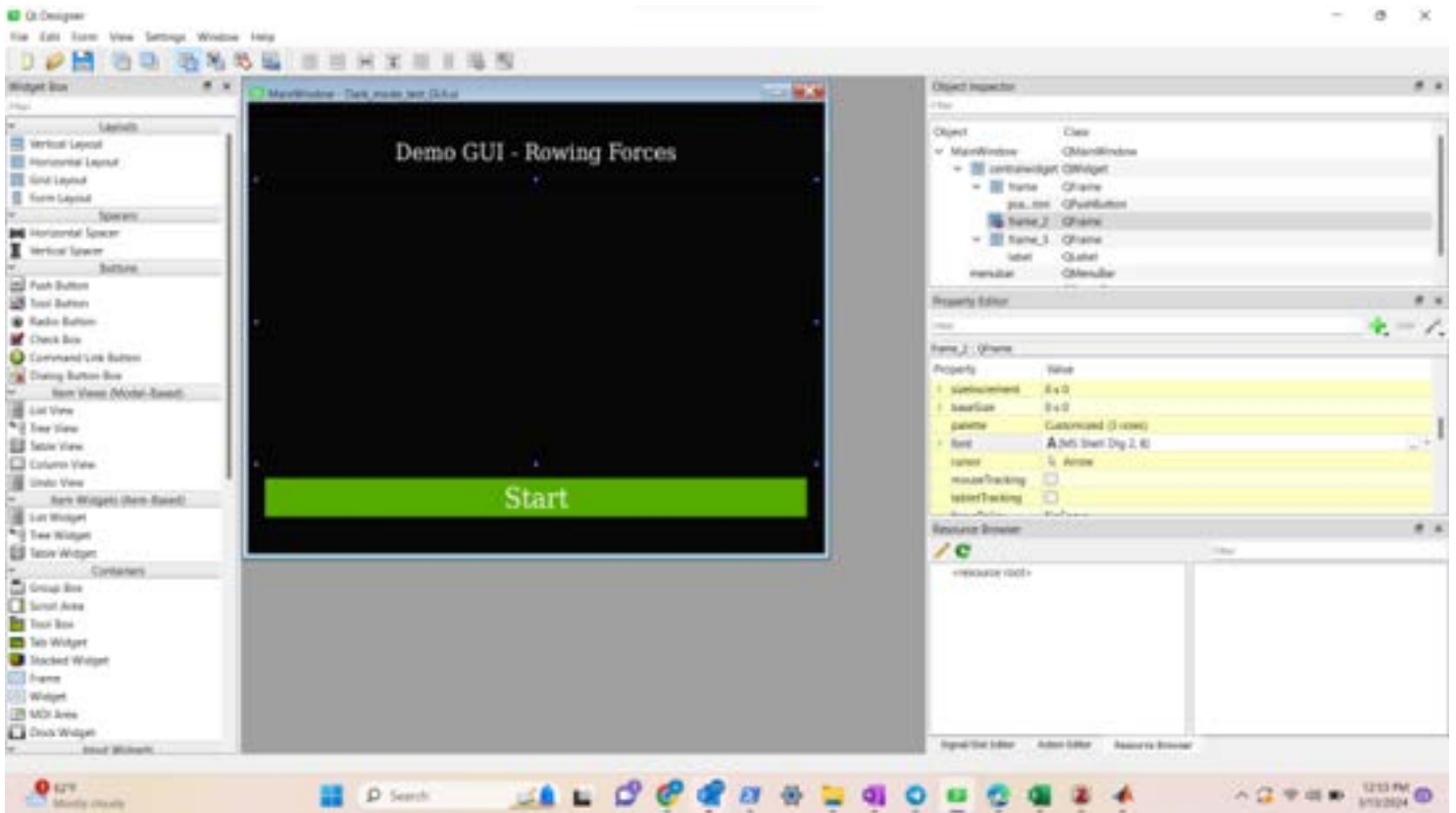
Goals: To make a new demo GUI using test data with a "dark mode" theme and not using matplotlib.animation to see if I can minimize lag.

Content:

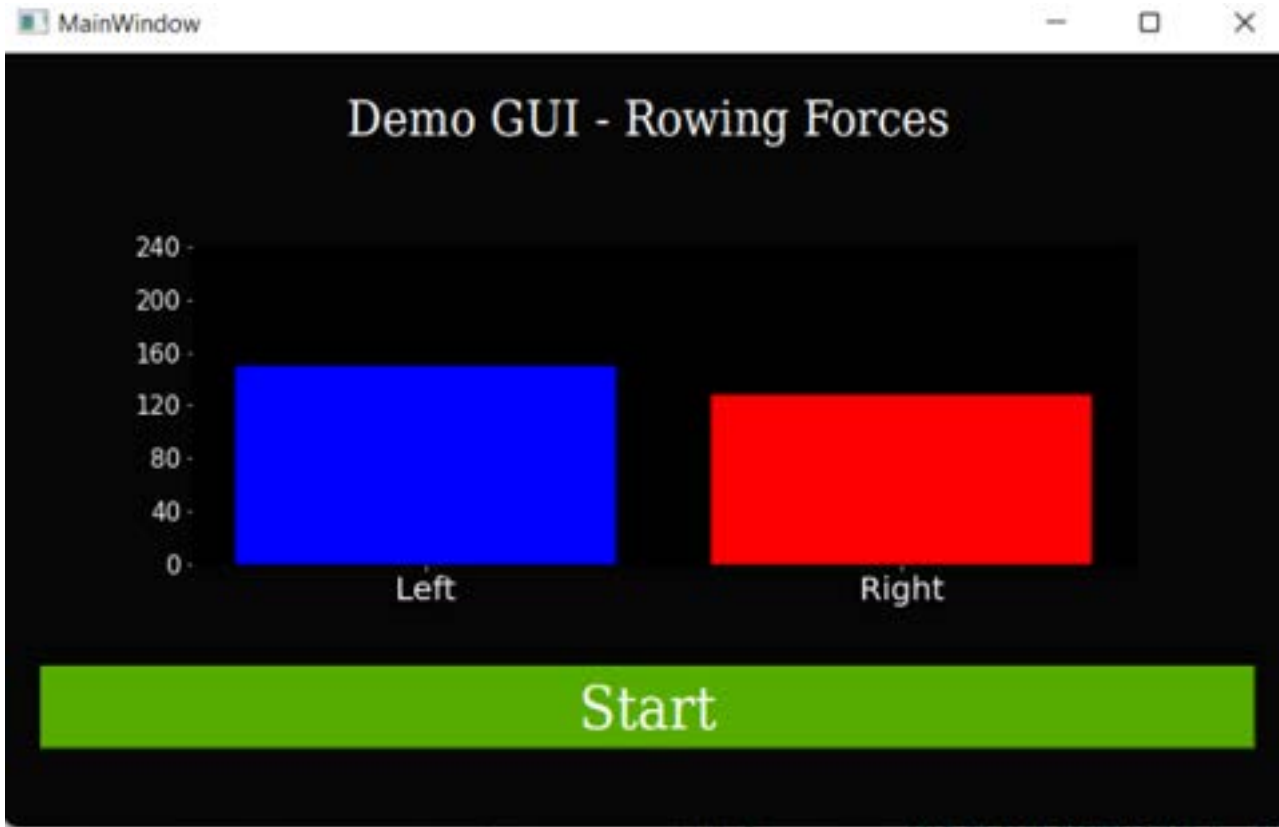
In my last two demonstration GUIs, I used a matplotlib library called animation and the function FuncAnimation(). I've noticed that when I reduce the frame rate to the desired 24 Hz (per the PDS), it looks a little laggy (probably because of too much demand on my computer's CPU). This lag is worse on the raspberry pi. Before I move forward with more GUI designs, I want to see if I can eliminate this lag but keep the high frame rate by using a different python library and writing the code more efficiently. If I do not see a difference in lag, I will try removing unnecessary programs on rpi to free up memory space. If that does not work, the frame rate of the display may need to be reduced.

I also want to redesign my GUI with a dark background because I think it looks cool :)

1. First, I edited my GUI design in PyQt5 Designer.



1. I saved my GUI as a .ui file
2. I ran "pyuic5 -x Dark_mode_test_GUI.ui -o Dark_mode_test_GUI.py" in my terminal to convert the .ui to a .py file.
3. I made further adjustments to the code to embed the matplotlib plot into frame 2 (see code attached below with comments)



1. I used chat gpt to make the def update_plot() code more efficient, but the output still looks laggy on the raspberry pi 4.
2. When I run htop on the rpi terminal while I run the GUI, I see that it is using 100% of the computer's CPU.
3. My next course of action will be to rewrite the code using pyqtgraph instead of matplotlib.

Conclusions/action items:

I began writing the code with pyqtgraph because it is supposedly better-suited for live plotting and less demanding on the CPU, however, I am having difficulty install the pyqtgraph package on the rpi4.

```
from PyQt5 import QtCore, QtGui, QtWidgets

import matplotlib

import matplotlib.pyplot as plt #import matplot lib

matplotlib.use('agg') #this needs to be here for some reason

from matplotlib.backends.backend_qt5agg import FigureCanvasQTAgg #integrated matplotlib with tkinter

import pandas as pd #used to read the test data

df_left = pd.read_csv('test_data_left.txt', sep=',', header=0)

df_right = pd.read_csv('test_data_right.txt', sep=',', header=0)

values_left = df_left['Force (lbs)'] #pandas Series of data fpoints or left foot

values_right = df_right['Force (lbs)'] #pandas Series of data points for right foot

class Ui_MainWindow(object):

    def setupUi(self, MainWindow):

        MainWindow.setObjectName("MainWindow")

        MainWindow.setGeometry(0,0,800,480)

        #MainWindow.showMaximized()

        #MainWindow.showFullScreen()

        #uncomment line above to make GUI take up full screen on the rpi with no exit button

        MainWindow.setStyleSheet("background-color: rgb(6, 6, 6);")

        self.centralwidget = QtWidgets.QWidget(MainWindow)

        self.centralwidget.setObjectName("centralwidget")

        self.verticalLayout = QtWidgets.QVBoxLayout(self.centralwidget)

        self.verticalLayout.setObjectName("verticalLayout")

        self.frame_3 = QtWidgets.QFrame(self.centralwidget)

        self.frame_3.setFrameShape(QtWidgets.QFrame.StyledPanel)

        self.frame_3.setFrameShadow(QtWidgets.QFrame.Raised)

        self.frame_3.setObjectName("frame_3")
```

```
self.horizontalLayout_2 = QtWidgets.QHBoxLayout(self.frame_3)

self.horizontalLayout_2.setObjectName("horizontalLayout_2")

self.label = QtWidgets.QLabel(self.frame_3)

font = QtGui.QFont()

font.setFamily("DejaVu Serif Condensed")

font.setPointSize(18)

self.label.setFont(font)

self.label.setStyleSheet("color: rgb(255, 255, 255);")

self.label.setObjectName("label")

self.horizontalLayout_2.addWidget(self.label, 0, QtCore.Qt.AlignHCenter)

self.verticalLayout.addWidget(self.frame_3, 0, QtCore.Qt.AlignTop)

#frame 2 is where the plot is embedded

self.frame_2 = QtWidgets.QFrame(self.centralwidget)

sizePolicy = QtWidgets.QSizePolicy(QtWidgets.QSizePolicy.Preferred, QtWidgets.QSizePolicy.Expanding)

sizePolicy.setHorizontalStretch(0)

sizePolicy.setVerticalStretch(0)

sizePolicy.setHeightForWidth(self.frame_2.sizePolicy().hasHeightForWidth())

self.frame_2.setSizePolicy(sizePolicy)

self.frame_2 setFrameShape(QtWidgets.QFrame.StyledPanel)

self.frame_2 setFrameShadow(QtWidgets.QFrame.Raised)

self.frame_2.setObjectName("frame_2")

#set horizontal layout for plot

self.horizontalLayout_3 = QtWidgets.QHBoxLayout(self.frame_2)

self.horizontalLayout_3.addWidget(self.frame_2)

self.horizontalLayout_3.setObjectName("horizontalLayout_3")

#add figure and canvas
```



```

self.canvas = FigureCanvasQTAgg(self.figure)

### add canvas to frame

self.horizontalLayout_3.addWidget(self.canvas)

# add ax object

self.ax = self.figure.add_subplot(111)

self.ax.set_facecolor('black') #make background of plot black

self.verticalLayout.addWidget(self.frame_2)

self.frame = QtWidgets.QFrame(self.centralwidget)

self.frame.setFrameShape(QtWidgets.QFrame.StyledPanel)

self.frame.setFrameShadow(QtWidgets.QFrame.Raised)

self.frame.setObjectName("frame")

self.horizontalLayout = QtWidgets.QHBoxLayout(self.frame)

self.horizontalLayout.setObjectName("horizontalLayout")

#self.pushButton = QtWidgets.QPushButton(self.frame)

#add command to run update_plot() when button is pushed

self.pushButton = QtWidgets.QPushButton(self.frame_2, clicked = lambda : self.start_plot())

font = QtGui.QFont()

font.setFamily("DejaVu Serif Condensed")

font.setPointSize(22)

self.pushButton.setFont(font)

self.pushButton.setStyleSheet("QPushButton{\n"

"background-color: rgb(86, 172, 0);\n"

"color:rgb(255, 255, 255)}\n"

"\n"

"QPushButton:hover{\n"

"background-color: rgb(70, 130, 44);\n"

"color:rgb(255, 255, 255)}\n"

```

```

"QPushButton:pressed{\n"
"background-color: rgb(85, 85, 85);\n"
"color: rgb(255, 255, 255);}")

    self.pushButton.setObjectName("pushButton")
    self.horizontalLayout.addWidget(self.pushButton)
    self.verticalLayout.addWidget(self.frame)
    MainWindow.setCentralWidget(self.centralwidget)
    self.menubar = QtWidgets.QMenuBar(MainWindow)
    self.menubar.setGeometry(QtCore.QRect(0, 0, 767, 26))
    self.menubar.setObjectName("menubar")
    MainWindow.setMenuBar(self.menubar)
    self.statusbar = QtWidgets.QStatusBar(MainWindow)
    self.statusbar.setObjectName("statusbar")
    MainWindow.setStatusBar(self.statusbar)

    self.retranslateUi(MainWindow)

    QtCore.QMetaObject.connectSlotsByName(MainWindow)

```

```
def retranslateUi(self, MainWindow):
```

```

    _translate = QtCore.QCoreApplication.translate
    MainWindow.setWindowTitle(_translate("MainWindow", "MainWindow"))
    self.label.setText(_translate("MainWindow", "Demo GUI - Rowing Forces"))
    self.pushButton.setText(_translate("MainWindow", "Start"))

```

```
def start_plot(self):
```

```

    #start button initiates this method

    #starts a timer and runs self.update_plot() every 24 ms

    self.count = 0 #start a counter for indexing test data

```

```
self.timer.setInterval(round((1/24)*1000))
```

```
self.timer.timeout.connect(self.update_plot)
```

```
self.timer.start()
```

```
def update_plot(self):
```

```
    if self.count < len(values_left) and self.count < len(values_right):
```

```
        left_val = values_left[self.count]
```

```
        right_val = values_right[self.count]
```

```
        self.ax.clear()
```

```
        colors = ['blue', 'blue'] # Default color
```

```
        if left_val == right_val:
```

```
            colors = ['blue', 'blue']
```

```
        elif left_val == 0:
```

```
            colors = ['red', 'blue']
```

```
        elif right_val == 0:
```

```
            colors = ['blue', 'red']
```

```
        elif left_val > right_val and (left_val - right_val) / right_val >= 0.1:
```

```
            colors = ['blue', 'red']
```

```
        elif right_val > left_val and (right_val - left_val) / left_val >= 0.1:
```

```
            colors = ['red', 'blue']
```

```
        self.ax.bar(["Left", "Right"], [left_val, right_val], color=colors)
```

```
        self.ax.yaxis.set_ticks([i for i in range(0, 280, 40)])
```

```
        self.ax.tick_params(axis='x', colors='white', labelsz=20)
```

```
        self.ax.tick_params(axis='y', colors='white', labelsz=15)
```

```
        self.canvas.draw()
```

```
if __name__ == "__main__":  
    import sys  
  
    app = QtWidgets.QApplication(sys.argv)  
  
    MainWindow = QtWidgets.QMainWindow()  
  
    ui = Ui_MainWindow()  
  
    ui.setupUi(MainWindow)  
  
    MainWindow.show()  
  
    sys.exit(app.exec_())
```

Title: Dark Mode demo GUI - pyqtgraph

Date: 3/14/2024

Content by: Alicia

Goals: To make a new demo GUI using pyqtgraph instead of matplotlib to see if this eliminates the lag

Content:

I installed pyqtgraph on my raspberry pi by cloning the git repository. Here are the terminal command lines I used:

```
sudo apt-get update
```

```
sudo apt-get install python3-dev python3-pyqt5 python3-pyqt5.qtwebengine python3-pyqt5.qtsvg python3-pyqt5.qtserialport python3-numpy python3-opengl
```

```
git clone https://github.com/pyqtgraph/pyqtgraph.git
```

```
cd pyqtgraph
```

```
sudo python3 setup.py install
```

Then, I verified my install with the following command:

```
python3 -c "import pyqtgraph"
```

I ran a basic version of my existing GUI with pyqtgraph instead of matplotlib (still have to set the axes and configure the colors of the bars) but after installing the package on my rpi and running it the bars change MUCH more smoothly than they did with matplotlib. I ran "htop" in my command window to track the CPU and memory usage while the raspberry pi is running each version and when the matplotlib version is running, it uses ~102% CPU, and when the pyqtgraph version is running it uses ~50% CPU. I think using this package for the bar graph will allow smooth updating with real-time data. Yay!

Code for the basic pyqtgraph GUI is pasted below.

Conclusions/action items:

Work on the pyqtgraph GUI so that it has color changing features, static axes, and the correct color background.

```
import sys

import pyqtgraph as pg

from PyQt5 import QtCore, QtGui, QtWidgets

import pandas as pd

class Ui_MainWindow(object):

    def setupUi(self, MainWindow):

        MainWindow.setObjectName("MainWindow")

        MainWindow.setGeometry(0,0,800,480)

        MainWindow.setStyleSheet("background-color: rgb(6, 6, 6);")

        self.centralwidget = QtWidgets.QWidget(MainWindow)

        self.centralwidget.setObjectName("centralwidget")

        self.verticalLayout = QtWidgets.QVBoxLayout(self.centralwidget)

        self.verticalLayout.setObjectName("verticalLayout")

        self.frame_3 = QtWidgets.QFrame(self.centralwidget)

        self.frame_3 setFrameShape(QtWidgets.QFrame.StyledPanel)

        self.frame_3 setFrameShadow(QtWidgets.QFrame.Raised)

        self.frame_3.setObjectName("frame_3")

        self.horizontalLayout_2 = QtWidgets.QHBoxLayout(self.frame_3)

        self.horizontalLayout_2.setObjectName("horizontalLayout_2")

        self.label = QtWidgets.QLabel(self.frame_3)

        font = QtGui.QFont()

        font.setFamily("DejaVu Serif Condensed")

        font.setPointSize(18)

        self.label.setFont(font)

        self.label.setStyleSheet("color: rgb(255, 255, 255);")

        self.label.setObjectName("label")

        self.horizontalLayout_2.addWidget(self.label, 0, QtCore.Qt.AlignHCenter)
```

```
self.verticalLayout.addWidget(self.frame_3, 0, QtCore.Qt.AlignTop)

# Create PlotWidget

self.plotWidget = pg.PlotWidget()

self.verticalLayout.addWidget(self.plotWidget)

self.frame = QtWidgets.QFrame(self.centralwidget)

self.frame.setFrameShape(QtWidgets.QFrame.StyledPanel)

self.frame.setFrameShadow(QtWidgets.QFrame.Raised)

self.frame.setObjectName("frame")

self.horizontalLayout = QtWidgets.QHBoxLayout(self.frame)

self.horizontalLayout.setObjectName("horizontalLayout")

self.pushButton = QtWidgets.QPushButton(self.frame)

font = QtGui.QFont()

font.setFamily("DejaVu Serif Condensed")

font.setPointSize(22)

self.pushButton.setFont(font)

self.pushButton.setStyleSheet("QPushButton{\n"

"background-color: rgb(86, 172, 0);\n"

"color:rgb(255, 255, 255)}\n"

"\n"

"QPushButton: hover{\n"

"background-color: rgb(70, 130, 44);\n"

"color:rgb(255, 255, 255)}\n"

"\n"

"QPushButton:pressed{\n"

"background-color: rgb(85, 85, 85);\n"

"color: rgb(255, 255, 255);}")

self.pushButton.setObjectName("pushButton")

self.horizontalLayout.addWidget(self.pushButton)
```

```
self.verticalLayout.addWidget(self.frame)

MainWindow.setCentralWidget(self.centralwidget)

self.menubar = QtWidgets.QMenuBar(MainWindow)

self.menubar.setGeometry(QtCore.QRect(0, 0, 767, 26))

self.menubar.setObjectName("menubar")

MainWindow.setMenuBar(self.menubar)

self.statusbar = QtWidgets.QStatusBar(MainWindow)

self.statusbar.setObjectName("statusbar")

MainWindow.setStatusBar(self.statusbar)

self.retranslateUi(MainWindow)

QtCore.QMetaObject.connectSlotsByName(MainWindow)
```

```
def retranslateUi(self, MainWindow):
```

```
    _translate = QtCore.QCoreApplication.translate

    MainWindow.setWindowTitle(_translate("MainWindow", "MainWindow"))

    self.label.setText(_translate("MainWindow", "Demo GUI - Rowing Forces"))

    self.pushButton.setText(_translate("MainWindow", "Start"))
```

```
class MainWindow(QtWidgets.QMainWindow, Ui_MainWindow):
```

```
    def __init__(self):

        super(MainWindow, self).__init__()

        self.setupUi(self)

        self.pushButton.clicked.connect(self.start_plot)

        self.df_left = pd.read_csv('test_data_left.txt', sep=',', header=0)

        self.df_right = pd.read_csv('test_data_right.txt', sep=',', header=0)
```



```
self.df_left['Force (lbs)'] = pd.to_numeric(self.df_left['Force (lbs)'], errors='coerce')

self.df_right['Force (lbs)'] = pd.to_numeric(self.df_right['Force (lbs)'], errors='coerce')

self.values_left = self.df_left['Force (lbs)']

self.values_right = self.df_right['Force (lbs)']

self.timer = QtCore.QTimer(self)

self.timer.timeout.connect(self.update_plot)

self.count = 0

def start_plot(self):

    self.timer.start(round(1000/24)) # Start timer with interval of 100 ms

def update_plot(self):

    if self.count < len(self.values_left) and self.count < len(self.values_right):

        left_val = self.values_left[self.count]

        right_val = self.values_right[self.count]

        self.plotWidget.clear()

        bar = pg.BarGraphItem(x=[2, 3], height=[left_val, right_val], width=0.6)

        self.plotWidget.addItem(bar)

        self.count += 1

if __name__ == "__main__":

    app = QtWidgets.QApplication(sys.argv)

    window = MainWindow()

    window.show()
```




2024/04/04 - Asymmetry GUI

ALLICIA MOELLER - Apr 04, 2024, 9:48 AM CDT

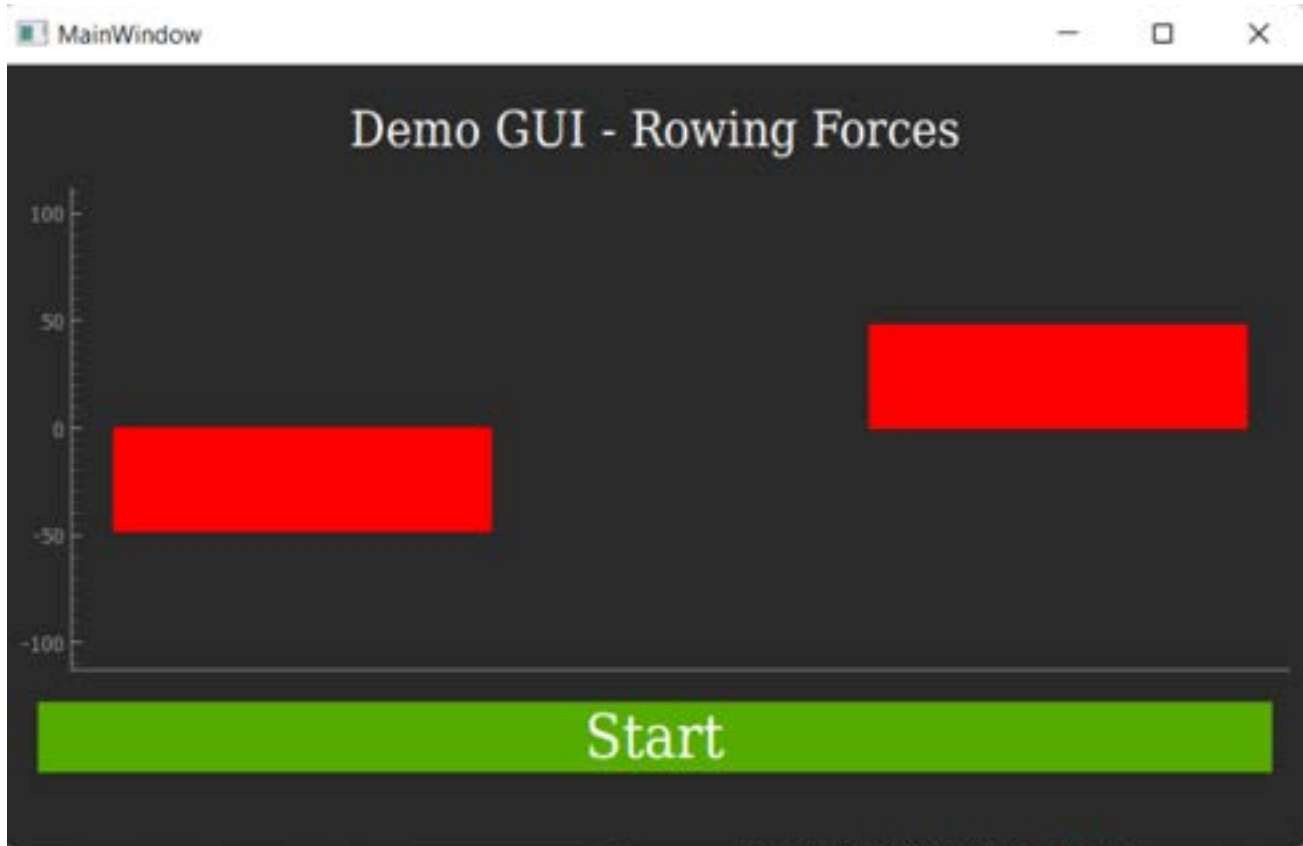
Title: Asymmetry GUI

Date: 4/4/2024

Content by: Alicia

Goals: To adjust the dark mode GUI so that it shows force asymmetry rather than force magnitudes.

Content:



- Because our design has been changed to only measure torque (assumed force) difference between the left and right foot plates, the GUI had to be updated. I altered the code so that the bar graphs are always equal and opposite and represent the magnitude of force asymmetry between the feet, with the positive bar graph indicating the higher force. At show and tell, someone suggested doing coloring changing bars that start green and turn red when they pass a threshold, but we are not exactly sure where to set this threshold because our design can only give us magnitude of force asymmetry, so it cannot tell us the percent difference between the left and right feet.

Conclusions/action items:

Show this GUI to the clients. Start writing code to integrate the digital angular encoder with the GUI.



2024/03/07 - Meeting with Simmi

ALLICIA MOELLER - Mar 07, 2024, 1:02 PM CST

Title: Meeting with Simmi

Date: 3/7/2024

Content by: Alicia

Present: Alicia and Simmi

Goals: To get a keyboard working with the Raspberry pi

Content:

In order for Simmi to work on the raspberry pi in her apartment, we need to be able to connect the raspberry pi to her local wifi, but we need a keyboard so that Simmi can put her wifi password in.

I downloaded the Matchbox keyboard and the Onboard keyboard widgets onto the raspberry pi, but after troubleshooting for a few hours, we could not get these widgets to actually interact with the text field in the pi. We have decided to keep the raspberry pi at my apartment for now and look for a USB keyboard on amazon.

Simmi and I configured one of the small load cells to the HX711 and the raspberry pi. The code to read data from the HX711 requires a python library called HX711 which is not compatible with raspberry pi 4, so we started looking at that code to understand how it works so that we can write our own python library.

Conclusions/action items:

We uncovered two major problems: the virtual keyboard widget not working and the HX711 module being unavailable for rpi4.



2024/03/11 - HX711 Github

ALLICIA MOELLER - Mar 11, 2024, 3:40 PM CDT

Title: HX711 GitHub

Date: 3/11/2023

Content by: Alicia

Goals: To get the Hx711 library to work with the load cell on the rpi.

Content:

1. First, I downloaded the source code of the HX711 repository by Marcel Zak from github: <https://github.com/gandalf15/HX711>
2. Then, I extracted the zip file and used an scp (secure copy) command with my rpi's IP address to copy the files to the rpi. "scp -r Documents/BME_301/HX711-master pi@192.168.0.11:/home/pi/BME_301"
3. I ran the simple_example.py on the rpi IDE, geany, but kept getting an error message because the rpi could not find the HX711 module.
4. After some troubleshooting, I adapted the import statement as follows and this resolved the error:

```
import sys

sys.path.append("/home/pi/BME_301")

from HX711_master.HX711_Python3.hx711 import HX711 # import the class HX711
```

I have tried to run a the simple_example.py script, and it gave me a large integer output (likely the raw amplified reading), but the first run it has been giving me a reading of "False".

I have yet to get the example.py script to run.

Conclusions/action items:

Overall, the HX711 library seems to be compatible with rpi4, even though it does not specify that on the GitHub, but I still need to work on understanding how the code for each method works and what the error messages mean.