BME Design-Fall 2024 - Jackson Jarrett
Complete Notebook

PDF Version generated by

Jackson Jarrett

on

Dec 11, 2024 @02:33 PM CST

Table of Contents

Team contact Information

Jackson Jarrett - Sep 19, 2024, 7:32 PM CDT

Last Name	First Name	Role	E-mail	Phone	Office Room/Building
Murphy	William	Advisor	wlmurphy@wisc.edu		
Gold	Robert	Client	bob.gld@gmail.com		
McClellan	Kai	Communicator	kamcclellan@wisc.edu	(920)-376-4973	
Schmeling	Luke	BSAC	laschmeling@wisc.edu	608-518-5527	
Jarrett	Jackson	Leader, BWIG	jrjarrett2@wwisc.edu	(815)-222-8032	
Gruber	Gavin	BPAG	gtgruber@wisc.edu	715-864-0695	

Project description

Jackson Jarrett - Dec 11, 2024, 2:30 PM CST

Course Number: BME 300

Project Name: Preventing weightlifting injuries by barbell modifications

Short Name: Barbell Modifications

Project description/problem statement:

Up to 27,000 injuries occur while weightlifting every year. Injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. The team has been tasked with designing a biomedical device that can prevent weight lifting injuries by targeting, identifying, and correcting improper form. This biomedical device must track the barbell path across all 3 axes during kinetic motion, allowing the user to note and make necessary changes to their form in order to prevent injury.

2024/9/8 Client Meeting 1

KAI MCCLELLAN - Sep 08, 2024, 11:11 AM CDT

Title: Client Meeting 1

Date: 9/8/24

Content by: Kai McClellan

Present: Mr. Gold

Goals: Establish intentions for the project and determine where to begin.

Content:

- Focus more on the muscle possibly
- Motion microscope (software)
- Sensor system to evaluate muscle output (EMG ?)
- It could be combined with the previous teams designs to prevent injuries

Research:

- What's been done?
- What's on the market?
- Emerging technologies?
- Does other Ultrasound tech exist?
- Other muscle sensing software?

Look into biomechanics professors, kinesiology professors, etc.

Talk to comp sci professor about motion microscope.

Conclusions/action items:

Would love to focus more on the muscle behavior and its relation to the barbell movement. Must first determine feasibility of quantifying this relationship.

Advisor Meeting #1 Notes 9/13/2024

Jackson Jarrett - Sep 19, 2024, 5:04 PM CDT

Title: Advisor Meeting Notes

Date: 9/13/2024

Content by: Jackson

Present: All

Goals: To meet our advisor, discuss any primary questions, and establish ground rules and expectations

Content:

- Camera buzz system to correct form
- Testing shows muscles specifics, voltage
- Testing shows muscle strain with bad form
- Client Meeting Questions before PDS
  Begin PDS
- Keep 200s involved
- Will review drafts in advance, 2 days in advance
- Meet every Friday 1 pm, don’t have to meet with Advisor if we’re to busy
- Will let us know week in advance before he checks notebooks
- Notebook should be detailed, if you do it, should be in notebook
- Bullet points are fine

Conclusions/action items:

We will move forward with the creation of our first PDS, which will continue to be updated as the semester goes on. We will meet with our advisor again on 9/20/2024.

Advisor Meeting #2 Notes 9/20/2024

Jackson Jarrett - Sep 27, 2024, 12:52 PM CDT

Title: Advisor Meeting Notes

Date: 9/20/2024

Content by: Jackson

Present: All

Goals: To meet our advisor, discuss any primary questions, and establish ground rules and expectations

Content:

- Avoid ranges, look to standard deviations, specific target
- PDS, specifications to be tested.
- Water spray
- Camera test
- Safety test
- Performance tests need to be testable
- Meet with client to discuss ideas and ask questions
- Criteria to differentiate ideas need to be specific
- **Coordinate system to track barbell movement to track correct form**
- **Look into known data of literature values of muscle activation**
- Good test to test a 5'0, 6'0, 7'0
- Angle measure not distance?
- Camera Resloution? Or a laser
- AI?

Conclusions/action items:

We will move forward with the creation of our design matrix. We will meet with our advisor again on 9/27/2024.

Advisor Meeting #3 Notes 9/27/24

Jackson Jarrett - Sep 27, 2024, 1:11 PM CDT

Title: Advisor Meeting Notes

Date: 9/27/2024

Content by: Jackson

Present: All

Goals: To meet our advisor, discuss any primary questions, and establish ground rules and expectations

Content:

- Over label drawings
- SolidWorks, grab OnShape drawing

Conclusions/action items:

We will move forward with our preliminary design presentation. We will meet with our advisor again on 10/4/2024.

Advisor Meeting #4 Notes 10/18/24

Jackson Jarrett - Oct 18, 2024, 1:06 PM CDT

Title: Advisor Meeting #4 Notes

Date: 10/18/24

Content by: Jackson

Present: All

Content:

- Final Report
  - statistics
  - testing - met or not met a specification
  - graphs
- Command strip, don't over do the aesthetics
- Consider peer review at show n tell

Conclusions/action items:

Advisor Meeting #5 Notes 11/26/2024

Jackson Jarrett - Nov 26, 2024, 11:12 AM CST

Title: Advisor Meeting

Date: 11/26

Content by: Jackson

Present: Jackson, Kai, Luke

Goals: Wrap up goals, ideas for final deliverables

Content:

- PDS specs specific testing. Show results
- Not moving data
- Moving data
- Detection data vs accuracy data
- Acceleration data
- Graph what is relevant
- Make the graph obvious
- Go to the Nick grab a flick

Conclusions/action items:

11/26/24 Final Prototype

Jackson Jarrett - Dec 07, 2024, 6:13 PM CST

Title: Final Prototype

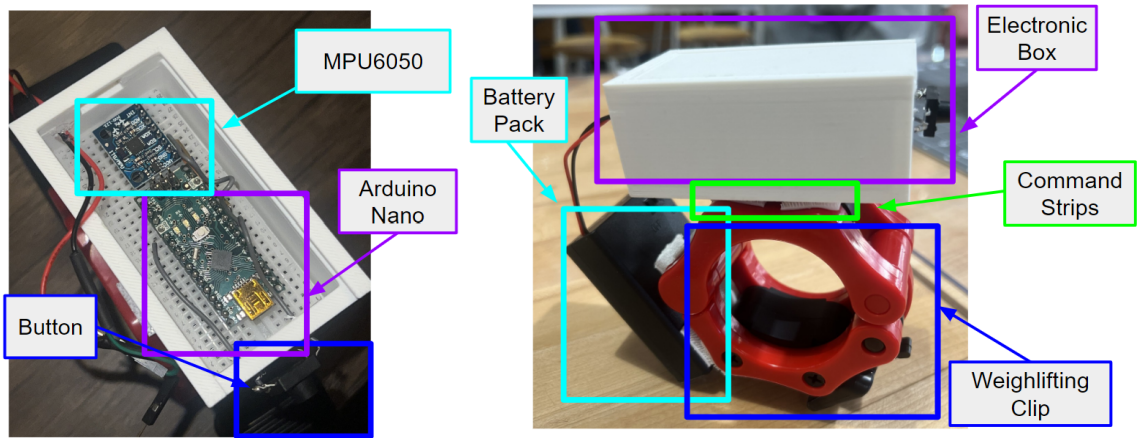
Date: 11/26/24

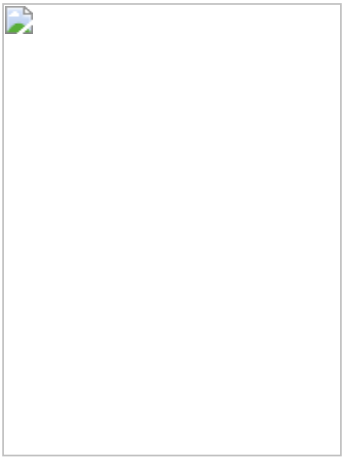
Content by: Jackson

Present: All

Goals: To showcase our final prototype

Content:





Conclusions/action items:

This is the final prototype that we will move forward with for testing.

Expense Spreadsheet

GAVIN GRUBER - Dec 09, 2024, 5:43 PM CST

Title: Expense Table

Date: 10/31/24

Content by: Jackson, Gavin

Goals: Outline our project expenses

Content:

Item	Description	Manufacturer	Mft Pt#	Vendor	Date	QTY	Cost Each	Total	Link
Non-Electronics									
Tough PLA	Ultimaker Tough PLA	Makerspace				500 g	$0.08/g	$40.00	https://making.engr.wisc.edu/3d-printers/
Arduino Nano	Arduino Nano	Arduino	A000005	Arduino	10/13/2024	2	$26.73	$53.46	https://store
MPU6050	IMU	Arduino	SEN-10937	SparkFun	10/13/2024	2	$8.05	$16.10	https://www
Breadboard	Breadboard	Breadboard - Self-Adhesive		SparkFun	10/13/202	2	$10.39	$20.78	https://ww
Barbell Clamp	Barbell Clamp	GW tech	661757455	Amazon	10/17/2024	1	$15.77	$15.77	https://www
PU6050 Module	Holder for the MPU 6050	HiLetGo	B00LP25V1A	Amazon		1	$10.99	$10.99	https://www
Command Strip	ttachment of our box to the clip	3M	B073XR4X7	Amazon	10/30/2024	1	$16.90	$16.90	https://www
8 AA Batteries	batteries	Amazon Basic	$840,083,632	Amazon	10/30/2024	11	$7.66	$7.66	https://www
Battery Cell Box	Holder for the batteries	Goweewon	GW-3AA	Amazon	10/30/2024	1	$10.60	$10.60	https://www
							TOTAL:	**$146.11**	

Conclusions/action items:

The spreadsheet is a living document, provided in the link below.

GAVIN GRUBER - Dec 09, 2024, 5:42 PM CST

Download

BPAG_Expense_Spreadsheet_-_Sheet1.pdf (91.2 kB)

3D Print Clip vs. Pre-Fabricated Clips

Jackson Jarrett - Oct 31, 2024, 2:22 PM CDT

Title: Design Decision, 3D Printed Clip vs. Pre-Fabricated Clips

Date: 10/14/24

Content by: Jackson

Goals: Outline an important design decision

Content:

Originally, the team wanted to fabricated a modified version of the weightlifting clip, that had the technology in a modified addition to the current OnShape file. After speaking with the makerspace staff, the team decided that it would be best to order pre fabricated weightlifting clips, that are already fully functional, and find a way to attach the method of housing the technology. We will move forward with the use of command strips for now, but will test to ensure that this is a valid connection method for the time being.

Conclusions/action items:

The team will order command strips, and will use them to attach the battery and technology housing system.

2024/10/21-First Test Print for Sliding Box Lid

GAVIN GRUBER - Nov 03, 2024, 7:32 PM CST

Title: First Test Print for Sliding Box Lid

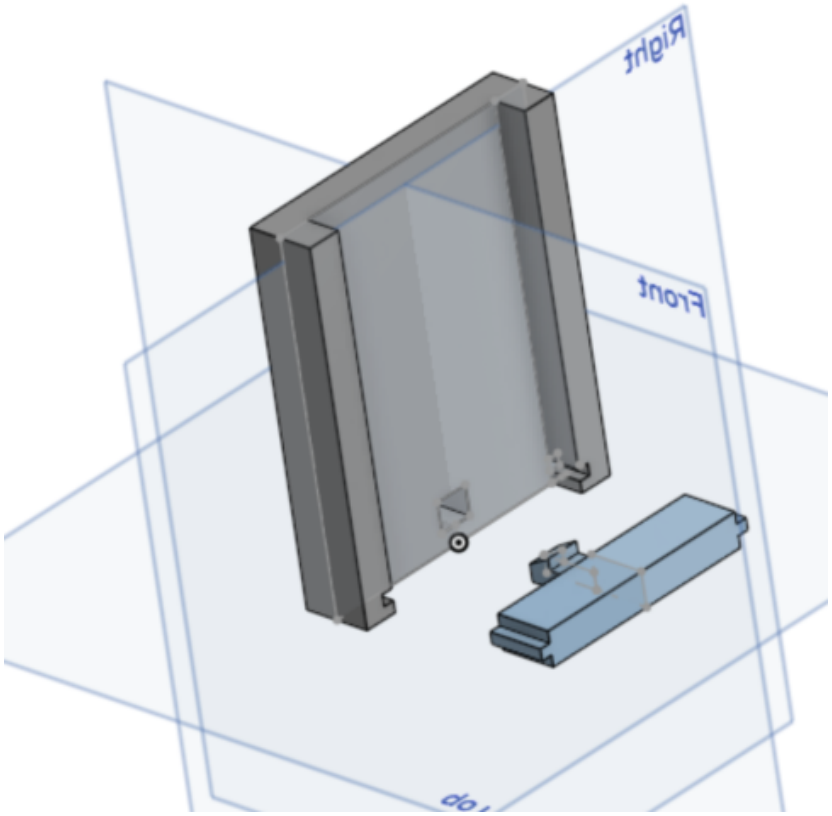
Date: 2024/10/21

Content by: Gavin Gruber

Present: Gavin Gruber, Luke Schmeling

Goals: To create a preliminary 3D print that will show that our sliding box design will work and that it latches.

Content:



This model will accurately show if the sliding and latching mechanisms that will be used in the 3d printed box will work. These 2 items were printed and were collected and then we removed the supports that were used to 3D print it. The sliding channels on this print didn't have any tolerance and the channels were the same size as the rails on the lid. This meant that the lid didn't actually slide. It was very hard to insert the lid into the channels on the walls. It did fit when we used a rubber mallet to slide it in. Then after getting the lid into the channels the latch mechanism was too big and you had to put too much force on the latch to open it. The latch broke after we tried to get it open.

Conclusions/action items:

The channel needs to be larger so the rails on the lid can easily slide in and out of the channels. The lip on the latch also has to be smaller so there is less force needed to open it. This will greatly reduce the risk of it snapping off because there will be less force exerted on it. We will do another test print to solve these problems before we print the whole box.

2024/10/25-Latch and Sliding Lid Test #2

GAVIN GRUBER - Nov 03, 2024, 7:56 PM CST

Title: Latch and Sliding Lid Test #2

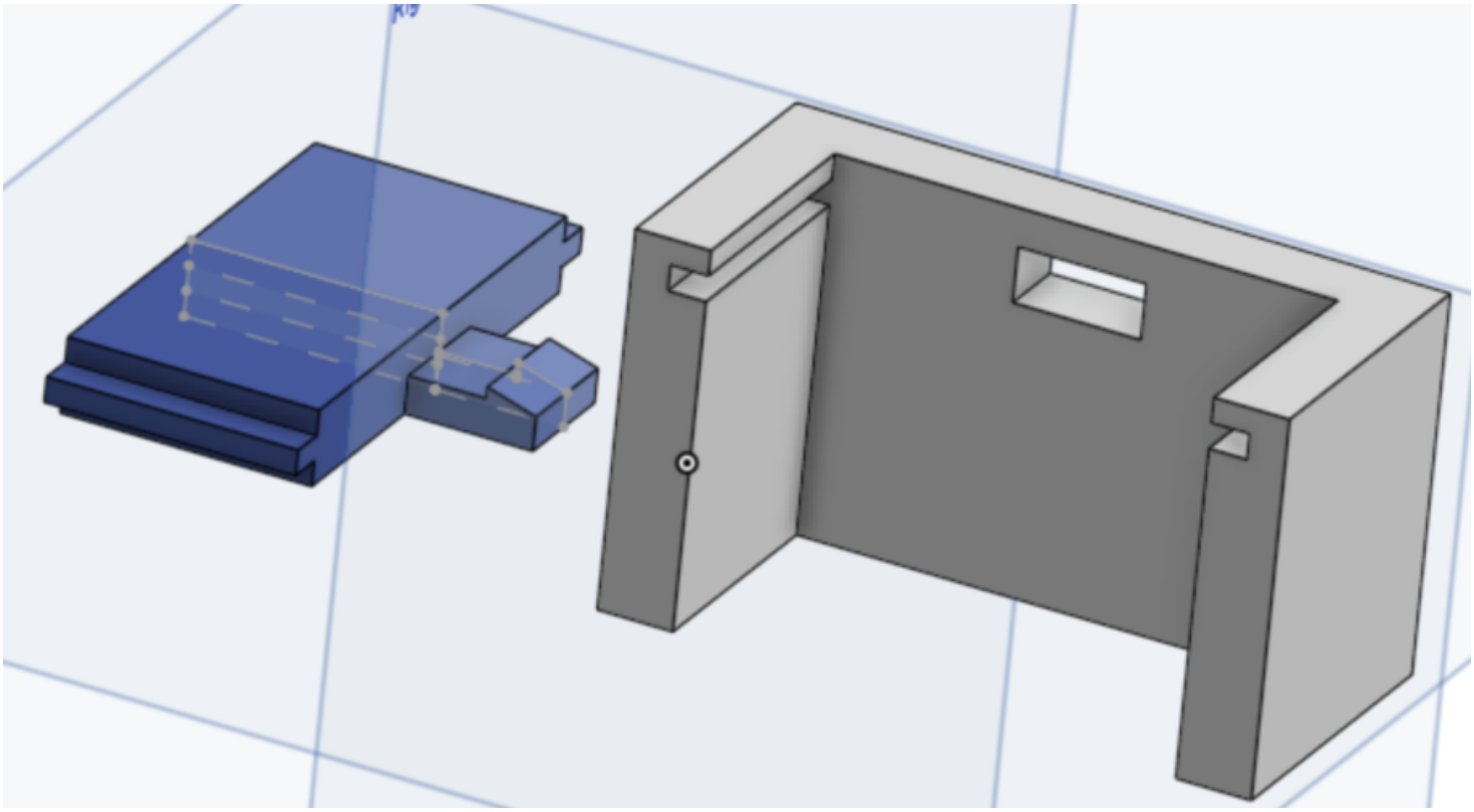
Date: 2024/10/25

Content by: Gavin Gruber

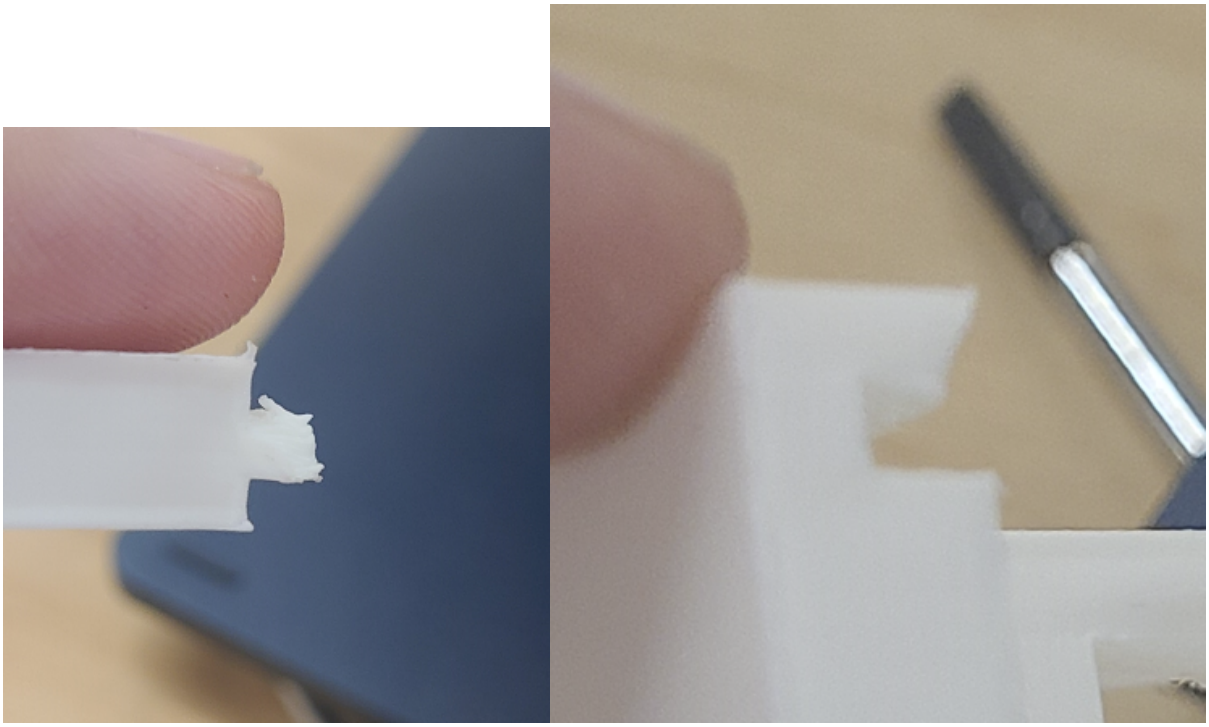
Present: Gavin Gruber Luke Schmeling

Goals: To 3D print a latch and sliding lid that works well so we can 3D print the whole box and use it for prototyping and testing.

Content:



This is the second variation that we are trying. We have increased the channel width and length as well as decreased the lip on the latching mechanism. We 3D printed these prints in the ultimaker printers. When the print was completed we removed all of the supports. The precision of this print was much worse than the one before. The corners of the channel and the rail on the walls and lid were very messy and had pieces sticking out (as shown below).



To see if the measurements that we printed it with would work we sanded down the edges and tried to make remove the pieces sticking out. After sanding it down it was still very hard to have the rail into the channel. When it was in the channel the latch did work properly.

We talked to the workers at the maker space and they said the bamboo printers, which we used for the first test print, were more accurate and wouldn't leave these pieces hanging off.

Conclusions/action items:

We decided that our measurements for this print were good for the latch but we would widen the channel a little bit. We are also going to use the bamboo printers when we print the full box to reduce the risk of a bad print. We will make the full box with the dimensions we are going to use and use the same measurements of this test print for the latching mechanism. We will widen the channel by .05 inches. so the lid slides better.

2024/10/30-Full Box First Print

GAVIN GRUBER - Nov 03, 2024, 8:05 PM CST

Title: Full Box First Print

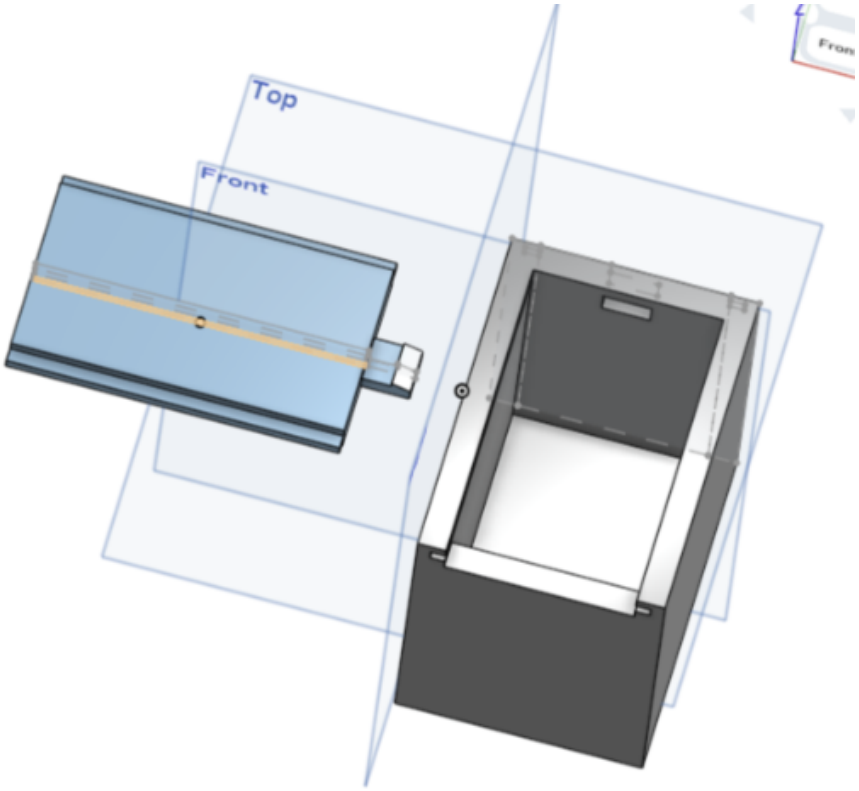
Date: 2024/10/30

Content by: Gavin Gruber

Present: Luke Schmeling, Jackson Jarrett, Kai McClellan, and Gavin Gruber

Goals: To 3d print the full box we will use for prototyping and testing.

Content:



The full box print turned out well, and all of the mechanisms work well. After the 3D print, we removed the supports the 3D printer put on and everything worked well. We did decide to make the box 2 inches shorter because we decided to have an external battery pack instead of having the batteries inside. This will remove a lot of the mass because the box is very bulky compared to the clip.

Conclusions/action items:

We will make the box 2 inches shorter and 3D print another one that we will use for our prototyping and testing. We will then use these 2 new boxes and permanently attach them to the clamps and we will also connect the batteries to the box and the clamp.

2024/11/07-Final Prototype Box

GAVIN GRUBER - Dec 09, 2024, 5:56 PM CST

Title: Final Prototype Box

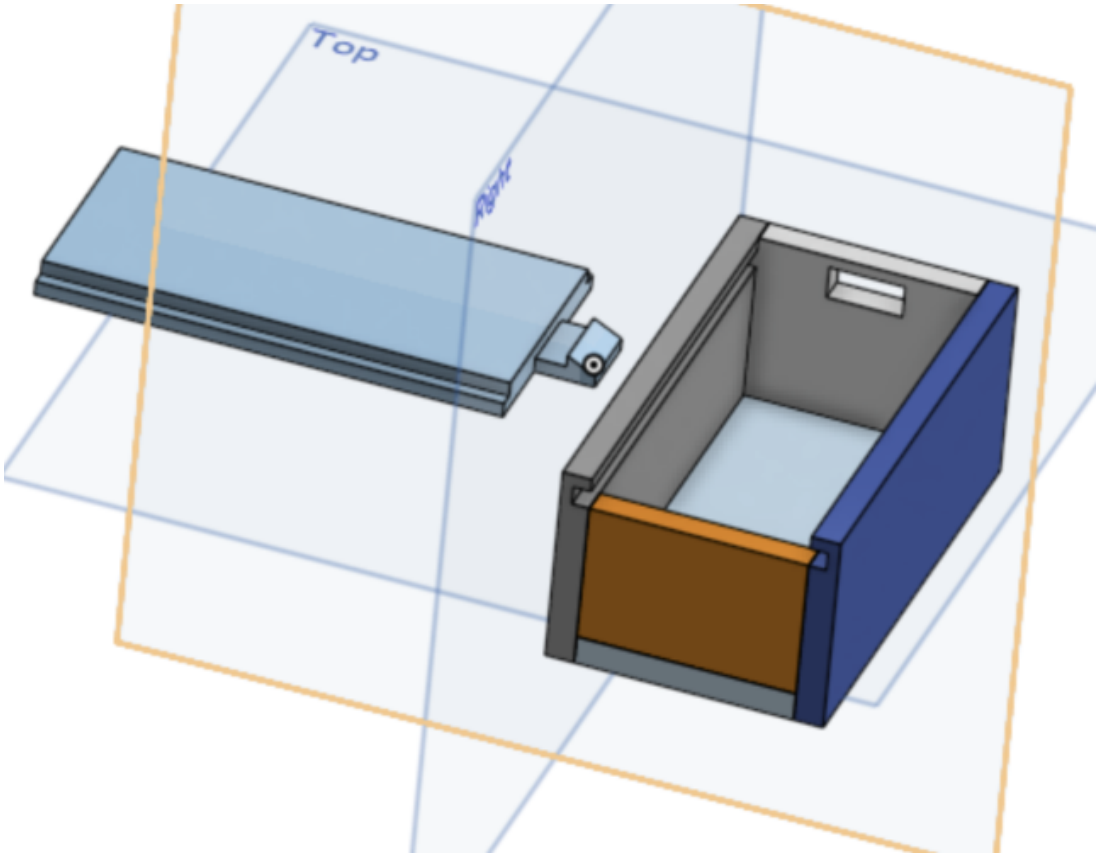
Date: 11/07/2024

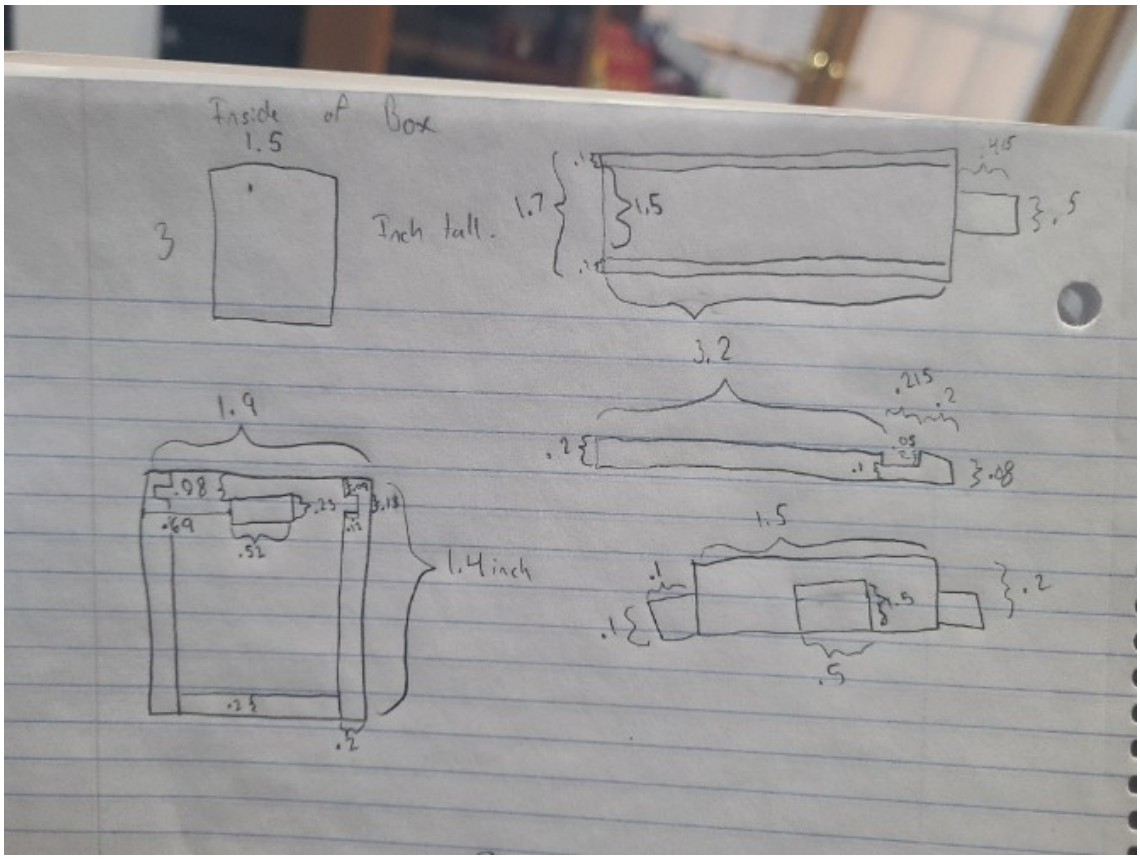
Content by: Gavin Gruber

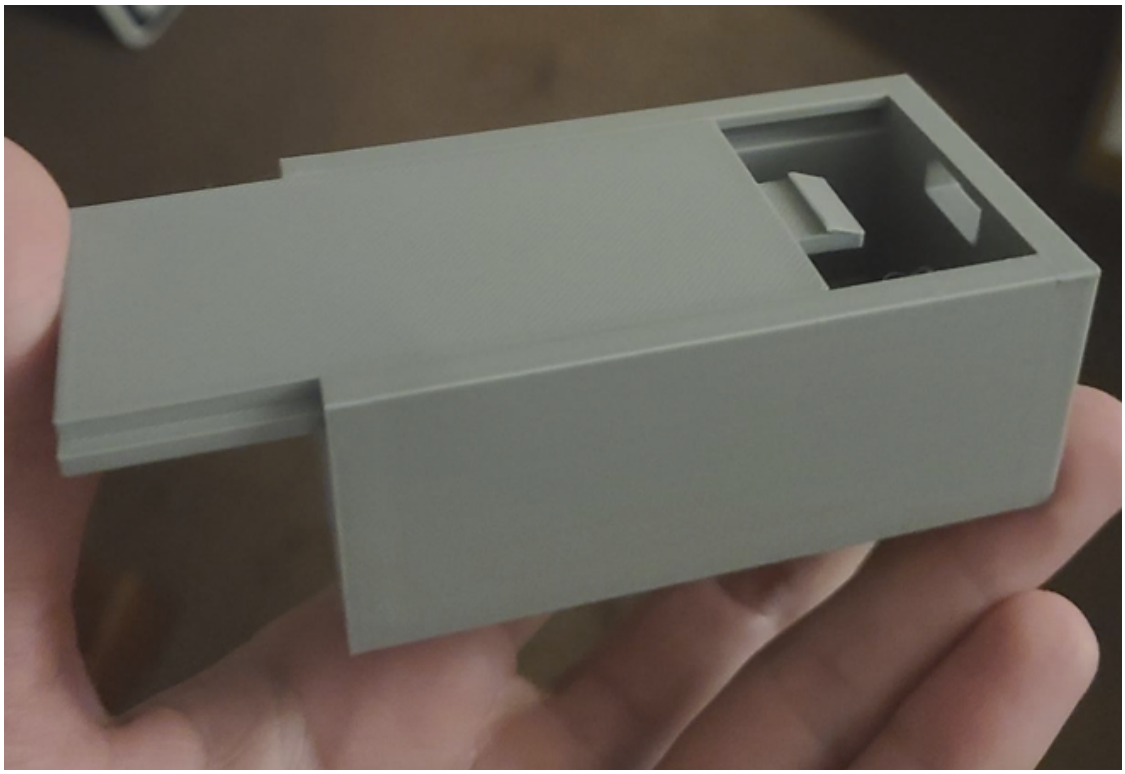
Present: Gavin Gruber, Luke Schmeling

Goals: To create our final prototype box on Onshape, then 3D print it

Content:







The box came out of the print very well. There was some supports that we had to remove but those were removed easily and didn't damage any of the box. The sliding mechanism works as intended and the lid snaps closed when its shuts all the way. We will move forward using this box to house our electronics.

Conclusions/action items:

This box works very well and we will use this as our prototype for building the rest of our product. We need to put together the IMU, breadboard, batteries, and other components and attach them to our barbell clips. We also need to print a second box so we can build our second prototype as well.

Battery Testing

Jackson Jarrett - Dec 08, 2024, 6:04 PM CST

Title: Battery Testing Protocol

Date: 11/25/24

Content by: Jackson

Present: Jackson and Kai

Goals: To document the protocol for battery testing

Content:

- The average battery life of 3 AA batteries powering 5 volts of power is in the 3-5 hour range. To test this, we will:
  - 1. Put brand new batteries into the battery pack, and power the device
  - 2. We will leave the battery pack on, and every 30 minutes we will check to make sure that the batteries are still powering the device for the first 3 hours
    - After the first 3 hours, we will check the device more frequently to ensure that we can get a more accurate value of the battery life of the 3 AA batteries
  - 3. Once we reach a point in which the device is no longer, powered, we will note the approximated battery life of the 3AA batteries.

Conclusions/action items:

Once we have this approximated battery life of the battery pack powering our device, we will compare it to the length of the average workout.

Water Protection Testing

Jackson Jarrett - Dec 08, 2024, 6:27 PM CST

Title: Water Protection Testing

Date: 11/25/24

Content by: Jackson

Present: Jackson, Kai, and Luke

Goals: To document the protocol

Content:

Our prototype will not be completely waterproof. We understand that this is not ideal, but in order to ensure the success of our device, we will test the device with 50 mL of water being emitted from a spray bottle. We will also test the device with wet hands in order to replicate the effects of dealing with the device with sweaty hands during a workout.

Sweat Test

1. Test to ensure device is working and powered
2. Apply 50 mL of water to hands
3. Handle device
4. Dry off device
5. Test to ensure device is working and powered

Spray Test

1. Test to ensure device is working and powered
2. Fill spray bottle with 50 mL of water
3. Spray device evenly from approximately 2 feet away, using all 50 mL of water
4. Dry off device
5. Test to ensure device is working and powered

Conclusions/action items:

Although we cannot ensure complete waterproof of our prototype, we will follow this testing protocol to see if the device can withstand natural sweat emissions from the body during a workout, because sweat or small amounts of liquid are reasonable and possible obstacles that we must ensure protection against.

Accuracy Testing

Jackson Jarrett - Dec 08, 2024, 6:37 PM CST

Title: Accuracy Testing Protocol

Date: 11/25/24

Content by: Jackson

Present: Jackson, Kai, and Luke

Goals: To document the accuracy testing protocol

Content:

Accuracy testing was always going to be the staple piece of our testing. Based on our goals and what the prototype looks to accomplish, it holds the most weight. We looked to test and record the displacement vs. time data of bench press repetitions over three trials:

1. Load the weight clips on to the barbell
2. With Luke on the bench, Kai and I pressed the button to begin data collection.
3. Luke performed 5 reps of the bench press
4. Data Collection ends
5. MATLAB collects data from Arduino, and graphs position (displacement) over time

Conclusions/action items:

We will use the results of this accuracy testing as the focal point behind our poster and the progress of our device.

Battery Testing Results

Jackson Jarrett - Dec 08, 2024, 5:50 PM CST

Title: Battery Testing Results

Date: 11/26/24

Content by: Jackson

Present: Jackson, Kai, and Luke

Goals: To document the results of the Battery Testing

Content:

- The results of the battery testing were conclusive. After 4 approximately 4 and a half hours, the battery pack stopped powering the device

Test 1	Test 2	Test 3
~4.42hrs	~4.49hrs	~4.59hrs

Conclusions/action items:

- This is a successful result. The average workout last approximately 45-60 minutes. These results show that not only will the batteries power the device for up to 4 hours and definitely the entire deration of a workout if for some reason needed, but with the use of the on and off button, you will get 4 hours of battery life that can be conserved over the span of multiple workouts.

Water Protection Testing Results

Jackson Jarrett - Dec 07, 2024, 5:31 PM CST

Title: Water Protection Testing Results

Date: 11/26/24

Content by: Jackson

Present: Jackson, Kai, and Luke

Goals: To document the results of the water protection testing

Content:

- The results of the water protection testing were positive. After spraying 50 mL of water on the device, it still retained power and function.

Conclusions/action items:

- Although we can't ensure complete waterproof of this prototype, this is a step in the right direction. For future work with more time and resources, this is a high priority.

Accuracy Testing Results

Jackson Jarrett - Dec 07, 2024, 5:52 PM CST

Title: Accuracy Testing Results

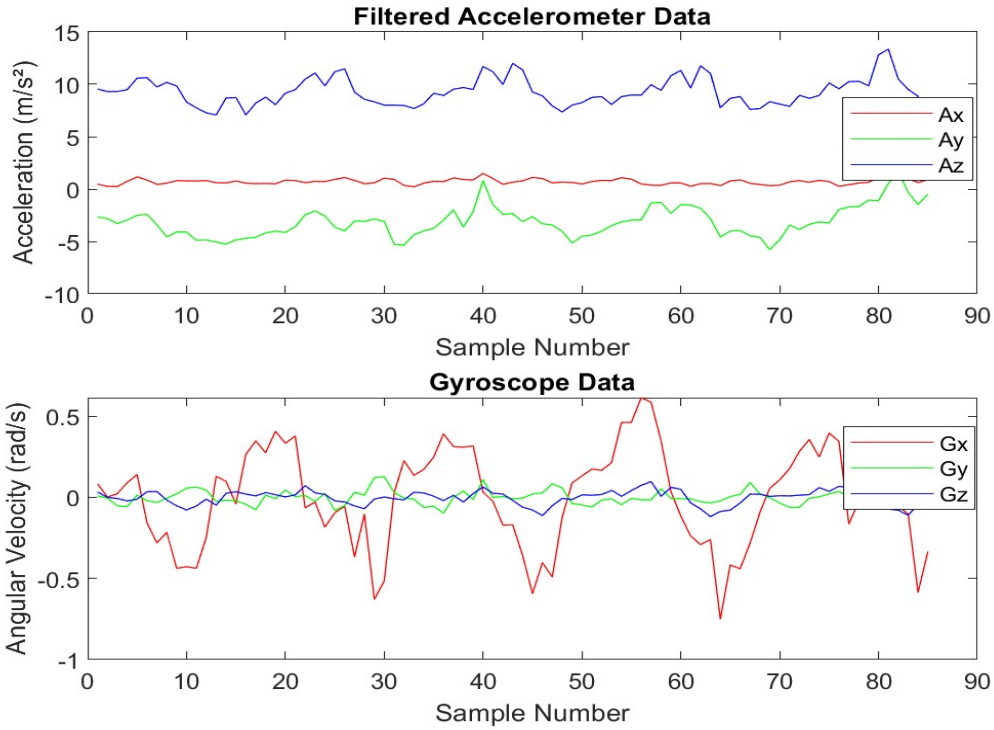
Date: 11/26/24

Content by: Jackson

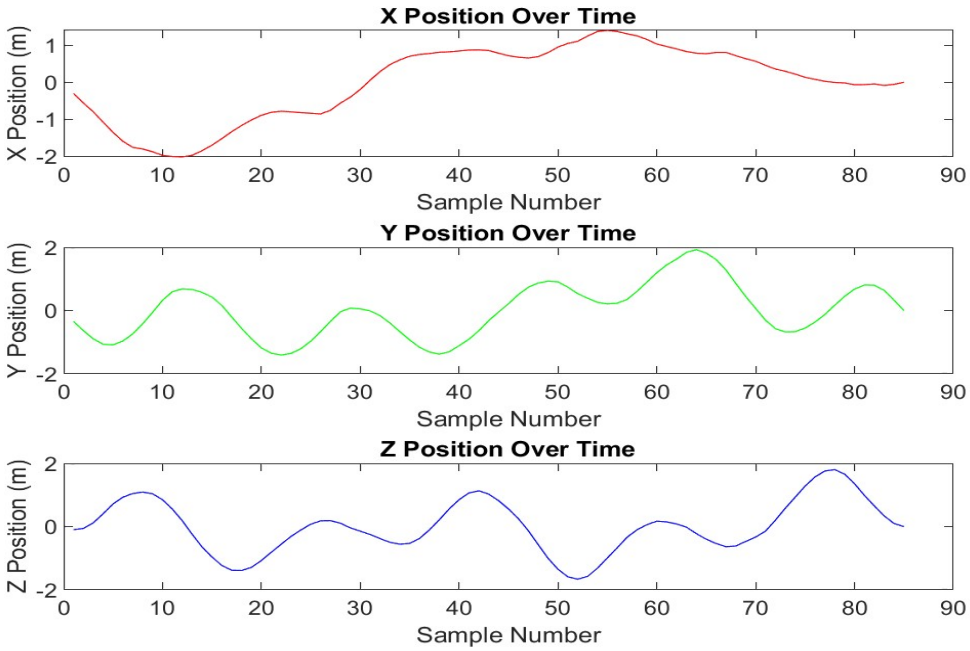
Present: Jackson, Kai, and Luke

Goals: To document the accuracy results which will be used and showed heavily in the poster presentation as well as the final report to document the success of our prototype.

Content:



This figure depicts the acceleration and angular velocity data collected from the testing. The MPU-6050 collects this data, and is stored via Arduino EEPROM.



This figure depicts the displacement data in the X, Y, and Z axis. This data is collected by the double integration of the acceleration data.

Conclusions/action items:

Overall, this data supports the movement of the barbell per repetition. There is little to no movement in the x-axis, which follows our understanding. We will continue to analyze this data and look for methods of improvement for the future work of this project.

9/19/2024 PDS

Jackson Jarrett - Sep 19, 2024, 8:59 PM CDT

Title: Product Design Specifications

Date: 9/19/2024

Content by: All

Present: All

Goals: To create a document that outlines qualitative and quantitative design specifications for our project: Preventing Weightlifting Injuries via Barbell Modifications

Content:

Product Design Specifications: Preventing Weightlifting Injuries by Barbell Modifications

September 19th, 2024

Biomedical Engineering 200/300: Biomedical Engineering Fundamentals & Design

Client: Mr. Robert Gold

Advisor: Prof. William Murphy

Team Members:

Jackson Jarrett jrjarrett2@wisc.edu (Leader and BWIG)

Kai McClellan kamcclellan@wisc.edu (Communicator)

Gavin Gruber gtgruber@wisc.edu (BPAG)

Luke Schmeling lascmeling@wisc.edu (BSAC)

Function:

Over one million weightlifters experience serious injuries every year. These injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. Incorrect loading while weight training can lead to sprains,

strains, fractures and other painful injuries[1]. The team has been tasked with designing a biomedical device that can diagnose this strain on the body in coordination with specific muscles in use.

Client Requirements:

1. Quantify strain on specific muscles when used in complex weightlifting movements such as the barbell bench press
2. Create a sensor system to evaluate activated electronic signals in active muscle fibers
3. Utilize motion technology and camera tracking to develop a service that can track proper weightlifting form
4. Explore emerging software opportunities while building upon previous years progression

Design Requirements:

1. Physical and Operational Characteristics:

a. Performance Requirements:

1. The sensor system will be attached to the barbell in the form of weight clips, with one sensor on each end. This will allow for use on every repetition of a compound weight lifting movement
2. Camera software will be implemented and set to track the user on every repetition of a compound weight lifting movement.
3. Motion tracking will be able to follow direct movements, and follow a designated track in order to ensure proper form when performing these complex movements.

b. Safety:

1. Any modifications to the barbell must abide by safety regulations put in place by the gym or institution in which the technology is being used
2. A sound system will be implemented with motion technology in order to alert the user of malpractice when performing a complex lift such as the barbell bench press
3. Electronic compartments will have no exposed electronic parts to prevent interaction with water or other fluids. Proper cover will ensure no malfunction to injury prevention technology

c. Accuracy and Reliability:

1. The muscle strain software will be able to quantify electronic signals released by active muscle fibers when performing complex lifts
2. The motion tracking system will follow direct movements by the user and follow a designated track in order to ensure proper form when performing complex lifts
3. All barbell modifications will be established on the basis of repeatability, in which actions can be performed upon every lift by the user

d. Life in Service

1. The barbell modifications will have ample power in order to be active for 45-60 minutes, the average time of complete workout [2].
2. The technology will be cased and able to travel via car, airplane, boat, etc.

e. Shelf Life:

1. This device should be stored inside in a climate-controlled environment, around 20-25℃. It should have minimal exposure to, and not be stored in outside conditions such as rain and snow.
2. The device should have a shelf life of at least 10 years while in storage and not being used.
3. If there are any batteries they should be replaced whenever they are dead or every 5 years.

f. Operating Environment:

1. This device will primarily be used inside at a weightlifting gym but can be used outside as long as there is no rain, snow, or extreme conditions (temperatures below 5℃ or above 30℃ or extreme winds)
2. The device should also be dust and dirt-resistant and be strong enough to withstand small impacts like being dropped from 1 meter.

g. Ergonomics:

1. This device should be usable by all people of all heights and weights given that they can use a barbell to do the weightlifting movement.
2. This device should be usable for squatting and benching with a 20kg barbell.
3. This device should be able to be transported by one person easily, and can be brought between different gyms and locations.

h. Size:

1. This product should be able to fit through standard doors and be moved by one person.

i. Weight:

1. This product should be able to be transported by one person so all total components should be less than 10kg.
2. Any barbell attachments should be less than 5 kg, and if the barbell attachment weighs more than 1 kg that weight should be recorded on the outside of the product so the user can accurately see how much weight they have on the bar with the added weight of the attachment.

k. Materials:

1. The materials should be durable enough so they can be dropped from 1 m and light enough to meet the requirements given above.
2. The materials should be safe to touch and should not react with common cleaning chemicals (bleach, alcohol, ammonia), sweat, or water.

l. Aesthetics, Appearance, and Finish:

1. This product shouldn’t have any exposed electronics.
2. The product should not have any excessively sharp edges

2. Product Characteristics:

a. Quantity:

1. Only one of these devices should be needed per barbell.
2. Can be scaled to the amount of barbells that are in the gym .

b. Target Product Cost:

1. The cost of competitors products are in the range of $700-$900. We believe we can undercut this cost by triple and sell it for ideally $150-200. However with a budget of $300 the product will even at maximum cost be well under competition price range.

3. Miscellaneous:

a. Standards and Specifications:

1. Under section 520(o)(1)(B) of the FD&C Act, software that is intended "for maintaining or encouraging a healthy lifestyle and is unrelated to the diagnosis, cure, mitigation, prevention, or treatment of a disease or condition" is not a device under section 201(h) of the FD&C Act. This also indicates that it is generally excluded form CPSC’s authority over consumer products under the Consumer Product Safety Act.[3]
2. If we use EMG technology, the device is considered to be a diagnostic electromygraph (Definition: [A] device intended for medical purposes, such as to monitor and display the bioelectric signals produced by muscles, to stimulate peripheral nerves, and to monitor and display the electrical activity produced by nerves, for the diagnosis and prognosis of neuromuscular disease). This is classified as a Class II device and is exempt from

the premarket notification procedures in subpart E of part 807 of this chapter subject to § 890.9. This device is considered noninvasive for testing and therefore does not need premarket approval and is exempt from Section 510(k).[4]

3. If the device does not use EMG technology, it is then classified as a “Low Risk Device” (Class I)and does not need premarket approval, clearance by the FDA, and is exempt from Section 510(k).[5]

b. Customer:

1. There are not many competing designs on the market, but there are many systems that function in a similar fashion. Thus, the intended goal is to combine the technology used in other fields with the knowledge and devices in the fitness industry to make a one of one device that fine-tunes a user's form.
2. Cost effectiveness will be a major concern with this device, as current products with much less capabilities are ranged from $100 and up which is subpar given the population of people who could benefit from this technology.
3. It would be desired to have the device give a digital readout indicating their deviation from what will be considered their optimal range of motion. Other beneficial readouts would be which muscles were under the most strain during the lift and recommendations to improve their performance.

c. Patient-Related Concerns:

1. Since it is classified as a “Low Risk Device” there are minimal concerns for usage of it. There will be no need for sterilization since the device is noninvasive and strictly a biomechanical analysis tool.
2. Accuracy and precision will be crucial for the success of this type of device. The complexity and usability will have to be mitigated as much as possible as well.
3. The device will have a large amount of data to observe, analyze, and compute. This means that it will require robust software and computational resources.
4. Integrating this technology with EMG tools may increase the complexity of its analysis and must be considered when designing.

d. Competition:

1. “FLEX” , a barbell velocity tracker, provides real-time display, giving immediate feedback on every rep and set, watches velocity and power, and scrutinizes technique and refines movement patterns. Accuracy of these values is unknown.[6]
2. “ Bar Sensei” is another barbell velocity tracker that measures your bar speed, displacement, and power output while performing a lift. It is a device that attaches directly to the barbell and takes measurements based on the displacement of the device itself.[7]
3. “InertiaCube® 4” , a 3 DOF sensor, uses MEMS technology to sense angular rate of rotation, gravity and earth magnetic field along three perpendicular axes. The angular rates are integrated to obtain the orientation (yaw, pitch, and roll) of the sensor. Gravitometer and compass measurements are used to prevent the accumulation of gyroscopic drift through advanced sensor fusion algorithms. This technology offers very low latency, unlimited range, precise factory calibration, smooth, jitter-free tracking, in situ static & dynamic magnetic compensation algorithms.[8]

References:

[1] “Weight training: Do’s and don’ts of proper technique - Mayo Clinic.” Accessed: Sep. 19, 2024. [Online]. Available: https://www.mayoclinic.org/healthy-lifestyle/fitness/in-depth/weight-training/art-20045842

[2] M. Staniszewski, J. Tkaczyk, A. Kęska, P. Zybko, and A. Mróz, “Effect of rest duration between sets on fatigue and recovery after short intense plyometric exercise,” *Sci. Rep.*, vol. 14, no. 1, 2024, doi: 10.1038/s41598-024-66146-2.

[3] C. for D. and R. Health, “Examples of Software Functions That Are NOT Medical Devices,” *FDA*, Sep. 2022, Accessed: Sep. 19, 2024. [Online]. Available: https://www.fda.gov/medical-devices/device-software-functions-including-mobile-medical-applications/examples-software-functions-are-not-medical-devices

[4] “CFR - Code of Federal Regulations Title 21.” Accessed: Sep. 19, 2024. [Online]. Available: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=890.1375

[5] C. for D. and R. Health, “General Wellness: Policy for Low Risk Devices.” Accessed: Sep. 19, 2024. [Online]. Available: https://www.fda.gov/regulatory-information/search-fda-guidance-documents/general-wellness-policy-low-risk-devices

[6] flexadmin, “FLEXStronger | Velocity Based Training Made Simple,” FlexStronger. Accessed: Sep. 19, 2024. [Online]. Available: https://www.flexstronger.com/

[7] “Bar Sensei.” Accessed: Sep. 19, 2024. [Online]. Available: http://files.assess2perform.com/barsensei.html

[8] “InertiaCube® 4 | InterSense.” Accessed: Sep. 19, 2024. [Online]. Available: https://www.intersense.com/inertiacube4

Conclusions/action items:

We will continue to monitor and change this dynamic document throughout the semester.

9/27/2024 Design Matrix

Jackson Jarrett - Sep 27, 2024, 4:35 PM C

Title: Design Matrix

Date: 9/27/2024

Content by: All

Present: All

Goals: To compare and contrast the methods in which we will house our sensing technology. We worked together to decipher what categories would be best suited for comparison, and then mo forward with completion of the design matrix based on a weight system that fits our clients needs.

Content:

Design Matrix: Preventing Weightlifting Injuries by Barbell Modifications

September 26, 2024

Biomedical Engineering 200/300: Biomedical Engineering Fundamentals & Design

Client: Mr. Robert Gold

Advisor: Prof. William Murphy

Team Members:

Jackson Jarrett jrjarrett2@wisc.edu (Leader and BWIG)

Kai McClellan kamcclellan@wisc.edu (Communicator)

Gavin Gruber gtgruber@wisc.edu (BPAG)

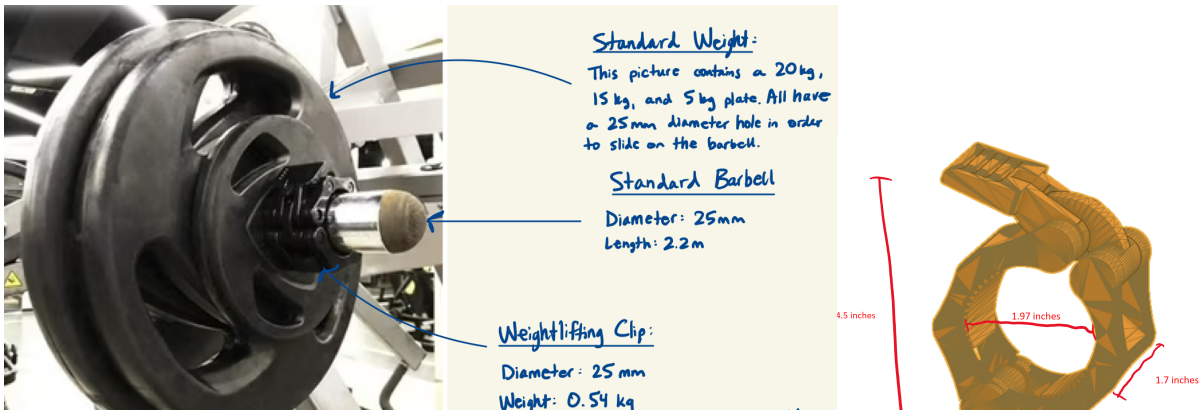
Luke Schmeling lascmeling@wisc.edu (BSAC)

Design Matrix:

Design Categories (Weight/100)	**Motion System**		**Barbell Weight Clips**		**Wrist Straps**	
Precision (30)	5/5	30	4/5	24	4/5	24
User Comfort (25)	5/5	25	5/5	25	3/5	15
Ease of Use (20)	2/5	8	5/5	20	4/5	16
Maintenance (10)	3/5	6	5/5	10	4/5	8
Ease of Fabrication (10)	2/5	4	4/5	8	3/5	6
Cost (5)	1/5	1	3/5	3	4/5	5
Total Points:	74		90		74	

Designs:

Figure 1. Motion System Design. A camera will be set up to track direct movement of the user, and this data will be recorded.



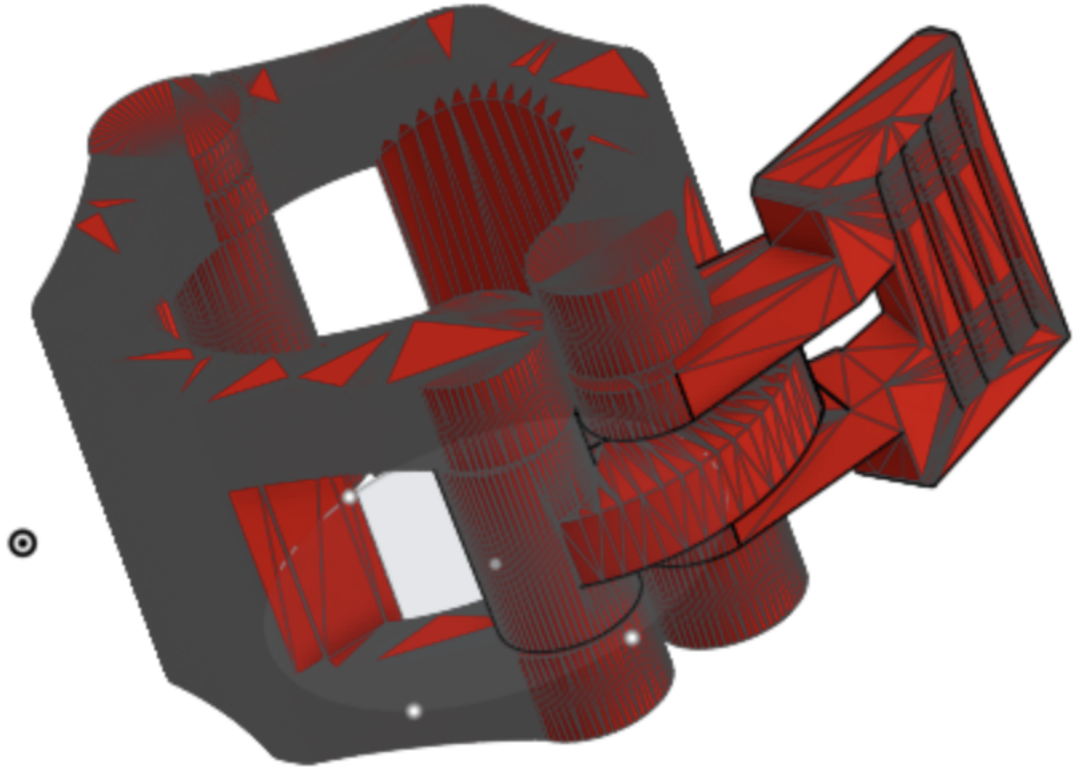


Figure 2. Barbell Weight Clips Design. An accelerometer will be housed within a modified but functional weight lifting clip that is used to clasp weight in place on the barbell.

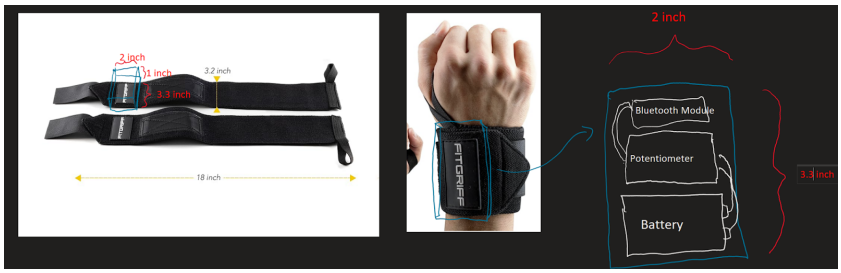


Figure 3. Wrist Straps Design. An accelerometer will be housed within a modified set of functional wrist straps that are used for wrist support when performing complex lifts such as the ba bench press.

Design Category Descriptions and Evaluations:

Precision:

The precision category depicts how well the device tracks the movement of the barbell. Using existing literature and technical data, an exponential relationship will be expressed as the line best fit. This line of best fit will represent the path of the barbell that will result in the best form and lowest injury rate when performing a complex lift such as the barbell bench press. Depe on the design model, this data will be collected in different ways. The precision of the injury prevention device will be quantified in inches, with an acceptable range of ±0.5 inch from the determined line of best fit. Precision is the category that holds the most weight due to its crucial impact on the project. A narrow range is required to ensure the success of the product, as we the wellbeing and safety of the user.

The Motion System was scored a 5/5 and assessed a 30 for its weighted score in the precision category on the design matrix. The Motion system as shown is a proven technology that can diagnose and assess data at the highest level. Quantitatively, this technology would succeed our requirements of precision. Both the barbell weight clips and wrist strap designs are comparal the precision category of the design matrix. The Barbell weight clips design as well as the wrist strap design would both utilize Arduino microcontroller and accelerometer technology in orc assess and track barbell movement. This technology will be successful and will be tested to be within the acceptable range of ±0.5 inch, thus we scored both designs with a ⅘ and a weight score of 24. Solely looking from a precision standpoint, the motion system would be the ideal design to move forward with.

User Comfort:

The user comfort category represents the degree to which the device is noticeable to the user while performing the lift. Comfort is a universal necessity when designing a product to be used by the human body. This classification is especially important because of the environment in which the device will be used. When undergoing a complex movement such as the barbell benc press, the user will be putting their body under great stress by pushing their physical limits. With the prevention of injury as our primary goal, the comfort of the user while undergoing these actions have been highlighted as a very important class within our design matrix.

The Motion system was scored a 5/5 and assessed a 25 for its weighted score in the user comfort category on the design matrix. The Motion system involves no contact with the user itself, giving it no way to discomfort the user in any way from a physical standpoint. The same goes for the barbell weight clips design, which was also scored a 5/5 and assessed a 25 for its weigh score. The weight clips design would be attached to the barbell itself, and would not have any contact with the user while performing a repetition. The wrist straps design was scored a ⅗ ar assessed a 15 for its weighted score in this category. This difference stems from the direct contact between the user arm and the wrist strap. Wrist straps, when functional, can make a positiv impact on the user's wrist stability when performing a lift such as the barbell bench press. However, it is material dependent in terms of user comfort, and with the addition of the sensor technology being added to the wrist strap, we have assessed the design lower when compared to the motion sensor and barbell weight clips design. Solely looking from a user comfort stand either the barbell weight clamps or the motion system would be the ideal designs to continue forward with.

Ease of Use:

The ease of use category represents how easy it is for the user to both setup and use while lifting. Making our product easy to use is important because we want our product to be readily available for all users. We also want our product to be able to be used in regular commercial gyms, so our product can't take too much time to set up or use, otherwise it would hinder the us lifting experience.

The Motion system scored a ⅖ for this category and had an 8 for its weighted score. This is because in order to use the motion system, you would need to set up a camera in the gym and sure it won't be disturbed and it can see you at the right angle when you are benching. It would be a struggle to find enough space to put the camera at a suitable distance away from the ben many commercial gyms. This is not the case for the barbell weight clip design which scored a 5/5 and a 20 weighted score in this category. The barbell weight clip design wouldn't take any work to use than using a regular bench clip. All you would have to do is bring the clips into the gym and slide them on the barbell. The one problem with this is many people don't like benc with clips on without a spotter because it can be more dangerous, however, you can just slide the clips on without clamping them onto the bar which would allow the weight to slide off if ne The wrist strap design scored a ⅘ and a weighted score of 16. This design would like to be easy to use in any gym as it doesn't take up any space, you would just need to bring it into your The reason it isn't a 5/5 is that you need to learn how to put on wrist straps and how to bench with wrist straps. This is not hard to learn or do, but it is one extra thing the user would have to before using the design. Looking only from a ease of use perspective, the barbell weight clamps would be the ideal design to continue with.

Maintenance:

The maintenance category represents how hard and how much work the design would be to maintain and keep working. Making sure our product doesn't require too much maintenance is important because it would deter a lot of people from using it, and if there was a lot of maintenance it would be much harder for our client to use for a long time. While maintenance isn't th most important category it is still essential to make sure our product isn't hard to maintain and will not break easily.

The motion system scored a ⅗ in this category. The motion system has some things that would regularly need to be maintained. The camera lenses need to be cleaned if they are ever dirt it needs to be stored inside where the camera would not be broken. You would also have to check to make sure the camera software is working properly with the camera, and it would be ver hard to fix anything if it breaks. The barbell weight clamp scored a 5/5 in this category because there is almost nothing you would need to do to maintain it. The only thing that would need t replaced is the batteries whenever they run out of charge. The wrist strap design scored a ⅘ because the materials for the strap on the wrist strap need to be replaced whenever there is any damage to them or if there is to much wear and tear on them. The wrist straps would get worn out much quicker because there is tension on the straps whenever they are in use so the materi would eventually deteriorate, and would need to be replaced. Solely looking from a maintenance standpoint, the barbell weight clamps would be the ideal design to continue with.

Ease of Fabrication:

The ease of fabrication is a necessary constraint to consider. If there is an easy, realistic, and valid design that does not take any shortcuts or lack taking any variables into consideration whi works just as well if not better than an equally valid design, which takes high amounts of time and requires an abundance of trial and error to fabricate, the design to be selected will most assuredly be the former.

The motion system scored a ⅖ in this category. The idea centered around using code referred to us by our client that centered around cameras which was believed to be applicable to this pr
Upon further review the code was determined to be beyond the scope of our knowledge and possibly not even able to be applied to our system and situation in a realistic manner. The barbel
clamp received a ⅘ in the ease of fabrication category. With limited technology needed to determine a coordinate system with which barbell movement can be tracked and a fabrication pro
as simple as trying to find a way to attach a little chip in the proper orientation to a barbell clip, this option is a very realistic possibility. The wrist straps received a ⅗ in the ease of fabricat
category. This in large part was due to the larger variability in being able to receive accurate measurements due to the possibility of unequal placement of the wrist straps on the wrist. The te
would also need to find a way to attach the motion chips needed to track movement into the wrist straps without hindering mobility of the wrist or making them too bulky which is not as mı
a concern regarding the barbell clamps. Solely looking from the ease of fabrication perspective the barbell clamps would be the ideal route to take.

Cost:

The cost category represents the expenses that will be incurred in the production of the design. Due to our allotted budget of $300, it is imperative that we do not exceed this amount in or
create a fully functional and thoroughly tested device. While this category may not be a pressing concern for some ideas brought forward in the design matrix, it remains nonetheless import
keep in mind currently in the decision making process, but also throughout the duration of prototyping, fabrication, testing, and final design.

The motion system scored a ⅕ in the cost category. This was in large part due to the costs that would be incurred buying two suitable cameras for the software as well as tripods on whicl
(the cameras) must stand. The estimated cost for the cameras alone would be somewhere in the range of $600 to $1000 which makes the motion system unrealistic for this aspect of the proj
The barbell weight clips scored a ⅗ in the cost category and the wrist straps scored a ⅘ . The decision behind the rankings for these two housing forms was comparative. While neither opt
incredibly cheap (hence why no housing form received a 5/5 ranking), purchasing wrist straps is cheaper than the purchase of two barbell clamps. From a solely cost effective perspective tl
leaves wrist straps as the ideal route to take.

Conclusions/action items:

We will move forward with the winning design, and will now begin our preliminary presentation to share the exciting beginning of our project.

10/9/2024 Preliminary Report

Jackson Jarrett - Oct 12, 2024, 2:35 PM CDT

Title: Preliminary Report

Date: 10/9/24

Content by: All

Goals: To document our design progress and our future fabrication plans

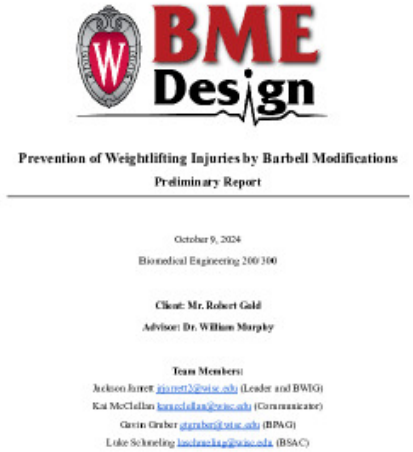
Content:

The Preliminary Report is included in a PDF below

Conclusions/action items:

We will move forward with the fabrication plans of our final design.

Jackson Jarrett - Oct 12, 2024, 2:35 PM CDT



Prevention of Weightlifting Injuries by Barbell Modifications

Preliminary Report

October 9, 2024

Biomedical Engineering 200/300

Client: Mr. Robert Gold

Advisor: Dr. William Murphy

Team Members:

Jackson Jarrett jjarrett2@wisc.edu (Leader and BWIG)

Kai McClellan kamcclellan@wisc.edu (Communicator)

Gavin Gruber gtgruber@wisc.edu (BPAG)

Luke Schneeling lschneeling@wisc.edu (BSAC)

Download

Preliminary_Report_Prevention_of_Weightlifting_Injuries_by_Barbell_Modifications.pdf (3.88 MB)

12/6/2024 Final Poster

Jackson Jarrett - Dec 07, 2024, 5:57 PM CST

Title: Final Poster

Date: 12/6/24

Content by: Jackson

Present: All

Goals: To document our final poster

Content:

Final poster included inTIF below

Conclusions/action items:

After the completion of our final poster presentation, we will move forward with our final report as we wrap up this fall semester.

Jackson Jarrett - Dec 07, 2024, 5:57 PM CST

Final_Poster_Preventing_Weightlifting_Injuries_via_Barbell_Modificaitons.pptx.tif

Download

Final_Poster_Preventing_Weightlifting_Injuries_via_Barbell_Modificaitons.pptx.tif (48.4 MB)

12/11/2024 Final Report

Jackson Jarrett - Dec 11, 2024, 2:28 PM CST

Title: Final Report

Date: 12/11

Content by: Jackson

Present: All

Goals: To document our final report which guides the reader through the design process of the device

Content:

Included in PDF below

Conclusions/action items:

This was the conclusion of this semester long project. We had a blast learning and growing as groupmates and engineers.

Jackson Jarrett - Dec 11, 2024, 2:28 PM CST

Download

Prevention_of_Weightlifting_Injuries_via_Barbell_Modifications_Final_Report.pdf (6.23 MB)

9/12/2024 Progress Report

Jackson Jarrett - Sep 19, 2024, 9:03 PM CDT

Title: Progress Report Week 1

Date: 9/12/2024

Content by: All

Present: All

Goals: To report our progress on the project to both our client and advisor

Content:

Date: 9/12/2024

Project Title: Preventing Weightlifting Injuries by Barbell Modifications

Client: Mr. Robert Gold

Advisor: Prof. William Murphy

Team Members (full names with team role)	Email
Jackson Jarrett (Leader and BWIG)	jrjarrett2@wisc.edu
Luke Schmeling (BSAC)	laschmeling@wisc.edu
Gavin Gruber (BPAG)	gtgruber@wisc.edu
Kai McClellan (Communicator)	kamcclellan@wisc.edu

Problem Statement:

Over one million weightlifters experience serious injuries every year. These injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. The team has been tasked with designing a biomedical device that can diagnose this strain on the body in coordination with specific muscles in use.

Brief Status Update: (describe in 3-4 complete sentences concisely what the team accomplished in the last week.)

Last Friday, we collectively chose to begin this project. We were able to choose our team roles, and begin discussing our steps moving forward. We highlighted available meeting times, while also conversing about our available resources. Kai and Gavin met our client Mr. Robert Gold, as they talked over the direction that we will follow as a team this semester.

Difficulties/Advice Requests: (request advice from your client and explain any other difficulties – only fill out if there are difficulties or questions. If you have any pressing questions, be sure to also include them in the body of the email to your client.)

N/A

Current Design: (include detailed description of design (2-3 complete sentences) and detailed drawings, pictures, or 3D models with labels and dimensions—update this every week as needed)

N/A

Materials and Costs (update as you place orders):

N/A

Total Cost to Date: $0

Team Goals (Current week):

- Meet with our Advisor Prof. Murphy on Friday
- Begin preliminary research
- Deepen understanding of Motion Microscope software
- Look into emg device approach and its benefits/disadvantages
- Discuss meeting times
- Converse about direction and preliminary design
- Begin PDS

Timeline

Week #	Task
1	Choose project Assign roles
2	Finish first progress report BSAC meeting First client meeting
3	PDS, Brainstorm, Research
4	Brainstorm, Literature Search, Design matrix criteria and design ideas (at least three) due
5	Preliminary Oral Presentation
6	Preliminary Report, Electronic Notebook, Peer/Self Evaluation, Decide on final design
7	Final Design
8	Order materials, consider submitting invention disclosure
9	Fabrication, show and tell
10	Fabrication
11	Fabrication

12	**Design Testing and Modification, Poster Draft Review**
13	**Design Testing and Modification, Final Report**
14	**Poster Presentation, Final Report, Final Electronic Notebook, Team Evaluation, Peer/Self Evaluation**

Individual Goals for the upcoming week (each team member individually fills out their goals/plans that they hope to accomplish in the next week. Replace “Team member #” with your name):

Team Member Luke Schmeling- To find statistical data of what regions of the lower body are weakest on an average human being and would give out first in a compound lift such as back squat. Perhaps could even be expanded upon further as to what areas of the body are under the most strain in compound lifts. Short Answer: Research.

Team Member Jackson Jarrett- This upcoming week, I look forward to continuing my preliminary research on muscle strain and injury when weight lifting. I will also begin to look at microcontrollers that can read and relay the data necessary to accomplish our design goals. I will also coordinate our first meeting as team members so we can be decisive in our research and begin our PDS in the coming week.

Team Member Kai McClellan- Cost numbers of EMG’s will have to be evaluated with additional research on them to determine how to quantify their readouts so that they may be related to barbell movement devices from the previous project group. Research should go into the Motion Microscope software mentioned by the client and how it may help us with our testing and computations. Long term goals will include how to perform a computational analysis of data from the software combined with the EMG’s and data from the previous prototypes that attach to the barbell.

Team Member Gavin Gruber- In this upcoming week I will do more research on how muscle tears and injuries occur during lifting, and what the best preventative measures people use. I also want to look at ways to measure muscle tension when you are lifting.

Individual Accomplishments from previous week (each team member individually fills out the tasks/accomplishments that they completed during the last week. Replace “Team member #” with your name):

Team Member Luke Schmeling- Attended the upcoming BSAC meeting. Went to the Nickolas Davis recreation center and did some of the compound lifts we hope to focus on this semester, actively thinking about the muscles I felt under significant stress when lifting increasingly heavy weight.

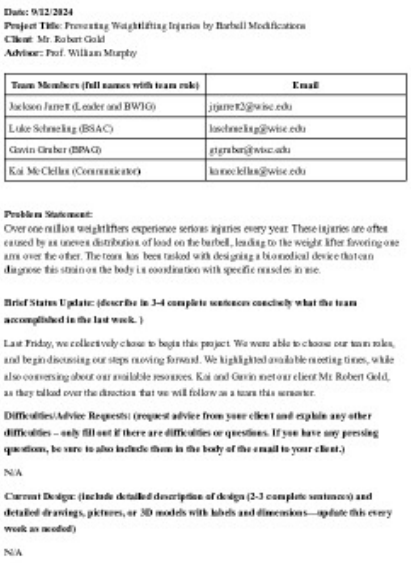
Team Member Gavin Gruber- I read over the previous year's final report about their design and what they were trying to accomplish. I also did some research on products that track muscle tension during lifts as well as how most lifting injuries occur.

Team Member Jackson Jarrett- This past week, Kai and I began talking about our goals for this project and what we hope to accomplish this semester. I read through the notes from the client meeting and continued my brainstorming process based on his specific direction. I created and shared the Progress Report template, and met with our advisor Prof. Murphy on Friday.

Team Member Kai McClellan- I had the opportunity to talk with our client about his goals and means of approach for this attempt at the barbell modification project. He mentioned that he wanted to focus more on the physical muscles involved and evaluate their strain during lifting and see if “Motion Microscope”, a software he mentioned, would be beneficial in our testing and evaluation of muscle tension. I was able to get the information from other departments such as professors in Kinesiology, computer science, and biomechanics and plan on discussing important factors that should be considered with our desired approach.

Conclusions/action items:

We look forward to following through with our goals for the upcoming week and continuing the project.



Date: 9/12/2024
Project Title: Preventing Weightlifting Injuries by Barbell Modifications
Client: Mr. Robert Gold
Advisor: Prof. William Murphy

Team Members (full names with team role)	Email
Jackson Jarrett (Leader and BWIG)	jtjarrett2@wisc.edu
Luke Schneiing (BSAC)	laschneiing@wisc.edu
Gavin Gruber (BPAG)	gtgruber@wisc.edu
Kai McClellan (Communicator)	kamcclellan@wisc.edu

Problem Statement:
Over one million weightlifters experience serious injuries every year. These injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. The team has been tasked with designing a biomedical device that can diagnose this strain on the body in coordination with specific muscles in use.

Brief Status Update: (describe in 3-4 complete sentences concisely what the team accomplished in the last week.)

Last Friday, we collectively chose to begin this project. We were able to choose our team roles, and begin discussing our steps moving forward. We highlighted available meeting times, while also conversing about our available resources. Kai and Gavin met our client Mr. Robert Gold, as they talked over the direction that we will follow as a team this semester.

Difficulties/Advice Requests: (request advice from your client and explain any other difficulties – only fill out if there are difficulties or questions. If you have any pressing questions, be sure to also include them in the body of the email to your client.)

N/A

Current Design: (include detailed description of design (2-3 complete sentences) and detailed drawings, pictures, or 3D models with labels and dimensions—update this every week as needed)

N/A

Download

Preventing_Weight_Lifting_Injuries_Progress_Report_1_-_9_12_2024.docx.pdf (93 kB)

9/19/2024 Progress Report

Jackson Jarrett - Sep 27, 2024, 2:26 PM CDT

Title: Progress Report Week 2

Date: 9/19/2024

Content by: All

Present: All

Goals: To document our progress from the past week, as well as lay out our goals for the next week in coordination with our advisor and client.

Content:

Preventing Weightlifting Injuries by Barbell Modifications

September 16 - September 20, 2024

Client: Mr. Robert Gold

Advisor: Prof. William Murphy

Team Members:

Jackson Jarrett jrjarrett2@wisc.edu (Leader and BWIG)

Kai McClellan kamcclellan@wisc.edu (Communicator)

Gavin Gruber gtgruber@wisc.edu (BPAG)

Luke Schmeling lascmeling@wisc.edu (BSAC)

Problem Statement

Over one million weightlifters experience serious injuries every year. These injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. The team has been tasked with designing a biomedical device that can diagnose this strain on the body in coordination with specific muscles in use.

Brief Status Update

The team met on Monday to discuss broad project ideas, divide research, and divy parts to complete the Product Design Specifications document. This document will be dynamic, and we will continue to update and specify requirements both quantitatively and qualitatively. We look forward to continuing research, and begin brainstorming design ideas in the coming week.

Team Goals

- Continue to research and add to the PDS in terms of quantitative specifics
- Meet with our advisor to discuss the PDS and next steps for brainstorming design ideas
- Contact the client with follow up questions for clarity
- Begin brainstorming design ideas for the upcoming design matrix

Individual Accomplishments and Goals

Jackson: This week I created the PDS shell document and completed my section of the PDS document, as well as sharing the progress report and finishing my weekly report. I continued my preliminary research with common weightlifting injuries, and in the coming weeks I look forward to expanding on this research. I will work with the team to coordinate a meeting time as we will work to create our first preliminary designs for the design matrix.

Kai: Worked on the PDS report with the team. Found MATLAB code for the motion software to make quantitative observations of very small muscular movements. Researched types of cameras to use with the software. Since our device is considered “Low Risk” by FDA regulations we have a lot of options for our design and don’t need premarket approval or meet section 510(k) standards. Using EMG technology does change the classification to a class II device, but the regulations and premarket approval status stay the same. I plan on researching methods of combining technologies and speaking with experts in biomechanics and computer science to determine the ease of fabrication and feasibility of using EMG tech in unison with the sensors.

Luke: Worked on standards and specifications for PDS report. Did research on EMG application to studies regarding muscle activation and what would be some of the major muscle groups being used in an activity similar to back squat (deadlift). For the upcoming week I plan to do research with Kai on the cameras used for the software we might possibly use to look at muscle activation.

Gavin: I worked on the physical and operation section of the PDS. I also did some research on how the path of a barbell on benchpress affects what muscles are more active, and what muscles are more at risk of injury. In the upcoming week I will continue on my research and focus more on ways to track the barbell or other ways to look at muscle activation and risk of injury.

Design Accomplishments

None

Weekly/Ongoing Difficulties:

None

Project Timeline:

Week #	Task
1	Choose project Assign roles
2	Finish first progress report BSAC meeting First client meeting
3	PDS, Brainstorm, Research
4	Brainstorm, Literature Search, Design matrix criteria and design ideas (at least three) due
5	Preliminary Oral Presentation

6	**Preliminary Report, Electronic Notebook, Peer/Self Evaluation, Decide on final design**
7	**Final Design**
8	**Order materials, consider submitting invention disclosure**
9	**Fabrication, show and tell**
10	**Fabrication**
11	**Fabrication**
12	**Design Testing and Modification, Poster Draft Review**
13	**Design Testing and Modification, Final Report**
14	**Poster Presentation, Final Report, Final Electronic Notebook, Team Evaluation, Peer/Self Evaluation**

Expenses BPAG Expense Spreadsheet

Conclusions/action items:

We look forward to accomplishing our goals and moving forward with the progression of our project.

9/26/2024 Progress Report

Jackson Jarrett - Oct 03, 2024, 10:58 PM CDT

Title: Progress Report Week 3

Date: 9/26/2024

Content by: All

Present: All

Goals: To document our progress from the past week, as well as lay out our goals for the next week in coordination with our advisor and client.

Content:

Preventing Weightlifting Injuries by Barbell Modifications

September 23 - September 27, 2024

Client: Mr. Robert Gold

Advisor: Prof. William Murphy

Team Members:

Jackson Jarrett jrjarrett2@wisc.edu (Leader and BWIG)

Kai McClellan kamcclellan@wisc.edu (Communicator)

Gavin Gruber gtgruber@wisc.edu (BPAG)

Luke Schmeling lascmeling@wisc.edu (BSAC)

Problem Statement

Over one million weightlifters experience serious injuries every year. These injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. The team has been tasked with designing a biomedical device that can diagnose this strain on the body in coordination with specific muscles in use.

Brief Status Update

The design team met on Monday to discuss the design matrix. The team had an in depth, very successful brainstorming session in which we talked over dozens of ideas and possible directions with which we could follow. We worked to complete the design matrix, which highlights these categories and designs and our related thoughts.

Team Goals

Now that the team has honed in on a design, we look forward to expanding on this idea. We will explore bioinstrumentation concepts with the accelerometer and data collection, as well as connecting sensors via Arduino. We will look to begin a 3D printing process, and begin brainstorming ideas to house the necessary technology.

Individual Accomplishments and Goals

Jackson: This week, Kai and I were lucky enough to have the opportunity to meet with our Biomechanics professor, Dr. Christa Wille. We discussed a large range of topics within the biomechanics sphere, including the ratios of height and wingspan with arm lengths. These anthropometric ratios will be crucial to have in literature and research moving forward with our project, and we continue to use Dr. Willie as a resource. For the upcoming week, I look forward to diving into researching the accelerometer and the future derivation from acceleration to position that we will have to do, as well as looking to begin the 3D printing process of a technology housing system that resembles and retains the functionality of a weight lifting clip.

Kai: Jackson and I were able to meet with our biomechanics professor and discussed methods of analyzing and calculating the range of motion of a person during a bench press using IMUs to track the elbow flexion. We also discussed anthropometry relationships to accommodate for users of varying heights and weights/wingspans. Some research was done regarding optimal form and the ideal angles for each joint. I also helped with the design matrix and made solidworks drawings of the designs. In the coming days I hope to find how to display the flexion angles on our device from the IMUs and do some early testing.

Luke: Brought forth the idea to pursue a coordinate system with a calibrated origin from which we can document the data that would be needed to then recommend critiques to the user of the device. I played with different bar orientations and hand grasps to determine the best distance of the hands that they can be from each other so that we are informed when we begin barbell calibration. This upcoming week I plan to do a large amount of research on form and possible coding we can pursue for the clips if we decide to take that route. Also planning to continue to discuss with the group what project would be the best to move forth with and discuss the merits of each.

Gavin: Worked on the design matrix and brainstormed some ideas for the project before we met on monday. I also looked at similar designs and mobile apps that do similar things to what we are trying to accomplish. I did some more research on how bench form correlates to muscle activation, and the strain on your muscles, especially the shoulder muscles. In the following week, I hope to find out more about how we can code our devices and what specific microcontrollers we will need for our designs.

Design Accomplishments

Design Matrix:

Weekly/Ongoing Difficulties:

N/A

Project Timeline:

Week #	Task
1	Choose project
	Assign roles
2	Finish first progress report
	BSAC meeting
	First client meeting
3	PDS, Brainstorm, Research

4	**Brainstorm, Literature Search, Design matrix criteria and design ideas (at least three) due**
5	**Preliminary Oral Presentation**
6	**Preliminary Report, Electronic Notebook, Peer/Self Evaluation, Decide on final design**
7	**Final Design**
8	**Order materials, consider submitting invention disclosure**
9	**Fabrication, show and tell**
10	**Fabrication**
11	**Fabrication**
12	**Design Testing and Modification, Poster Draft Review**
13	**Design Testing and Modification, Final Report**
14	**Poster Presentation, Final Report, Final Electronic Notebook, Team Evaluation, Peer/Self Evaluation**

Expenses **BPAG Expense Spreadsheet**

Conclusions/action items:

We look forward to accomplishing our goals and moving forward with the progression of our project.

10/3/2024 Progress Report

Jackson Jarrett - Oct 03, 2024, 10:59 PM CDT

Title: Progress Report Week 4

Date: 10/3/2024

Content by: All

Present: All

Goals: To document our progress from the past week, as well as lay out our goals for the next week in coordination with our advisor and client.

Content:

Preventing Weightlifting Injuries by Barbell Modifications

September 30 - October 3, 2024

Client: Mr. Robert Gold

Advisor: Prof. William Murphy

Team Members:

Jackson Jarrett jrjarrett2@wisc.edu (Leader and BWIG)

Kai McClellan kamcclellan@wisc.edu (Communicator)

Gavin Gruber gtgruber@wisc.edu (BPAG)

Luke Schmeling lascmeling@wisc.edu (BSAC)

Problem Statement

Thousands of weightlifting injuries occur every year. These injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. The team has been tasked with designing a biomedical device that can prevent weight lifting injuries by targeting, identifying, and correcting improper form.

Brief Status Update

The team met on Monday and Thursday this week to discuss the final design and the upcoming preliminary presentation, where we will present our progress to our peers and advisor.

Team Goals

We look forward to moving forward with the fabrication of our design, beginning with the ordering of necessary materials, beginning the 3D printing process of the weightlifting clip, and creating the code that connects the Arduino Nanos with the MPU6050 to establish the coordinate system.

Individual Accomplishments and Goals

Jackson: This week I really dove into the technology aspect of our design. After talking with my biomechanics professor Dr. Willie, she highly recommended moving forward with an IMU to do the necessary tracking of data that our design requires. I researched the pairing Arduino Nanos that we will also utilize, and began my search to find code that will connect the Arduino Nanos to the MPU6050 in order to establish the coordinate

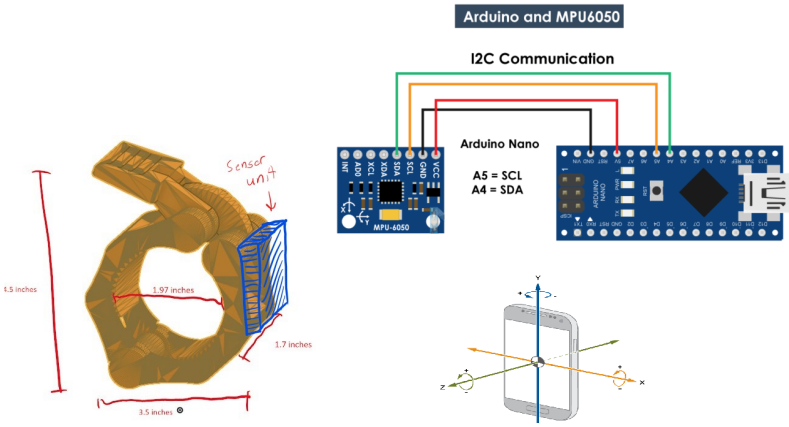
system that we need to track the barbell path. I completed my slides on the preliminary presentation, and look forward to sharing our ideas with our peers, advisor, and client. I look forward to beginning the 3D printing process of the weightlifting clip, and adding the necessary element that will house our technology.

Kai: This week I focused heavily on the circuitry elements that our team wants to use for our design. Jackson and I met with our biomechanics professor Dr. Wille and mentioned IMU sensors as opposed to accelerometers because they incorporate both accelerometers and gyroscopes to calculate angular velocity. Dr. Wille said that this would be much more efficient in tracking elbow movement which is the most significant factor in bench form. I also worked with the team to complete our presentation slides that we are presenting this friday and discussed our plans for purchasing materials to begin fabrication soon.

Luke: This week I researched exactly how shoulder impingements and tears in the shoulder occur during bench press and learned the technical ways on the scientific level as to what variables and variations of technique for bench press minimize the risk of injury. I also continued research on the biology and physiology of the shoulder which worked hand in hand with my research about shoulder impingements. This upcoming week I want to bring myself up to speed on the technologies being used for this device and learn how the IMU chip's work and how we are going to create relevant computer code for them.

Gavin: Worked on completing our preliminary presentation and figuring out what we would be saying in our presentation. I also did a little deeper research on some of the competing designs. I did a bit more research on how to correct an uneven barbell when you are benching both in the vertical direction and staying parallel to your shoulders. In the coming days, I hope to further finalize our design and figure out all of the exact components and sizes. I also plan to look more at how we are going to code our device to track all of the data and display it.

Design Accomplishments



The team will move forward with the 3D printing of a functional weight lifting clip with necessary housing for the following technology. We will utilize an Arduino Nano in each clip, paired with a MPU6050. The arduino nanos will collect data and pair with each other via bluetooth, and the MPU6050 will collect data in terms of angular velocity and acceleration. We will derive this data to displacement, and establish a coordinate system and line of best fit of the barbell path from there.

Weekly/Ongoing Difficulties:

N/A

Project Timeline:

Week #	Task

1	**Choose project** **Assign roles**
2	**Finish first progress report** **BSAC meeting** **First client meeting**
3	**PDS, Brainstorm, Research**
4	**Brainstorm, Literature Search, Design matrix criteria and design ideas (at least three) due**
5	**Preliminary Oral Presentation**
6	**Preliminary Report, Electronic Notebook, Peer/Self Evaluation, Decide on final design**
7	**Final Design**
8	**Order materials, consider submitting invention disclosure**
9	**Fabrication, show and tell**
10	**Fabrication**
11	**Fabrication**
12	**Design Testing and Modification, Poster Draft Review**
13	**Design Testing and Modification, Final Report**
14	**Poster Presentation, Final Report, Final Electronic Notebook, Team Evaluation, Peer/Self Evaluation**

Expenses **BPAG Expense Spreadsheet**

Conclusions/action items:

We look forward to accomplishing our goals and moving forward with the progression of our project.

10/10/2024 Progress Report

Jackson Jarrett - Oct 24, 2024, 1:55 PM CDT

Title: Progress Report Week 5

Date: 10/10/2024

Content by: All

Present: All

Goals: To document our progress from the past week, as well as lay out our goals for the next week in coordination with our advisor and client.

Content:

Preventing Weightlifting Injuries by Barbell Modifications

October 7th - October 11th, 2024

Client: Mr. Robert Gold

Advisor: Prof. William Murphy

Team Members:

Jackson Jarrett jrjarrett2@wisc.edu (Leader and BWIG)

Kai McClellan kamcclellan@wisc.edu (Communicator)

Gavin Gruber gtgruber@wisc.edu (BPAG)

Luke Schmeling lascmeling@wisc.edu (BSAC)

Problem Statement

Thousands of weightlifting injuries occur every year Injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. The team has been tasked with designing a biomedical device that can prevent weight lifting injuries by targeting, identifying, and correcting improper form.

Brief Status Update

The team met on Monday to discuss the preliminary report, and how we would divide the sections in order to complete. Together we completed the report to document our progress on the project so far.

Team Goals

Our goals include beginning the 3D printing fabrication process, as well as ordering our necessary electronics. In the meantime, we will continue researching coding IMUs and Arduinos to get a headstart on the process.

Individual Accomplishments and Goals

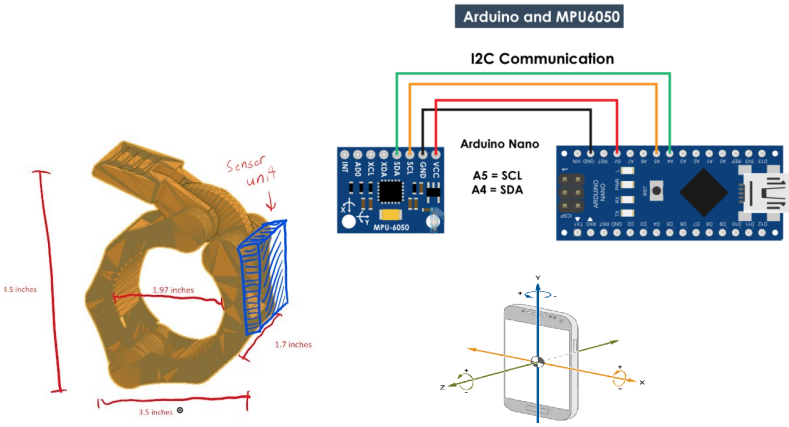
Jackson: This week we met on Monday, where Kai and I explained our goals for the report and this coming week given everyone’s schedules and midterms. I was able to do some additional research on the Arduino Nano as well as tough PLA as I completed my sections for the preliminary report. I worked with Gavin to create the BPAG spreadsheet, as he will place these orders within the coming days. I look forward to tackling the coding portion of this project as we look to pair the IMUs and Arduinos, and collect data to create a barbell path.

Kai: This week I spoke with my biomechanics professor about how to use IMUs and she showed me ones that are used for a lab. I was able to understand how to use them and did some testing in the ECB lab and was able to display data in 3D for the first time using MATLAB. This means that doing testing with our prototype is definitely possible and we will already have code that is very similar to what we want to do. Jackson and I laid out our goals for the next few weeks and let the rest of the team give feedback and we made modifications accordingly. I hope to have a prototype in the next 7 days and be able to do testing on that as well.

Luke: At the beginning of this week I read through my teammates Kai's research he had done on the function of IMU chips and how we are going to be using code to determine the position of our barbell relative to an origin by converting the reading we get from IMU chips which will be angular velocity into position. I tried to find the exact code that would be able to do these computations, but I unfortunately wasn't able to find anything that seemed applicable for our purposes. This upcoming week I will discuss with my group mates if we already have what we need for this code and how it actually works, perhaps learn a basic thing or two about the language of code we are going to use, which I believe will be python.

Gavin: This week I worked on the preliminary report and creating the BPAG spreadsheet with Jackson. I have also done some more research on how we will physically connect all of our electronics and set up our devices. In the upcoming days, I will order all of the parts and electronics that we need for prototyping. I also plan to start the 3D printing process for the shell of our design, so when the electronics are delivered we can start building our prototype right away, and start testing. I will also help work on the coding of our device.

Design Accomplishments



The team will move forward with the 3D printing of a functional weight lifting clip with necessary housing for the following technology. We will utilize an Arduino Nano in each clip, paired with a MPU6050. The arduino nanos will collect data and pair with each other via bluetooth, and the MPU6050 will collect data in terms of angular velocity and acceleration. We will derive this data to displacement, and establish a coordinate system and line of best fit of the barbell path from there.

Weekly/Ongoing Difficulties:

N/A

Project Timeline:

Week #	Task
1	Choose project

	Assign roles
2	**Finish first progress report** **BSAC meeting** **First client meeting**
3	**PDS, Brainstorm, Research**
4	**Brainstorm, Literature Search, Design matrix criteria and design ideas (at least three) due**
5	**Preliminary Oral Presentation**
6	**Preliminary Report, Electronic Notebook, Peer/Self Evaluation, Decide on final design**
7	**Final Design**
8	**Order materials, consider submitting invention disclosure**
9	**Fabrication, show and tell**
10	**Fabrication**
11	**Fabrication**
12	**Design Testing and Modification, Poster Draft Review**
13	**Design Testing and Modification, Final Report**
14	**Poster Presentation, Final Report, Final Electronic Notebook, Team Evaluation, Peer/Self Evaluation**

Expenses **BPAG Expense Spreadsheet**

Conclusions/action items:

We look forward to accomplishing our goals and moving forward with the progression of our project.

10/17/2024 Progress Report

Jackson Jarrett - Oct 24, 2024, 1:58 PM CDT

Title: Progress Report Week 6

Date: 10/10/2024

Content by: All

Present: All

Goals: To document our progress from the past week, as well as lay out our goals for the next week in coordination with our advisor and client.

Content:

Preventing Weightlifting Injuries by Barbell Modifications

October 14th - October 18th, 2024

Client: Mr. Robert Gold

Advisor: Prof. William Murphy

Team Members:

Jackson Jarrett jrjarrett2@wisc.edu (Leader and BWIG)

Kai McClellan kamcclellan@wisc.edu (Communicator)

Gavin Gruber gtgruber@wisc.edu (BPAG)

Luke Schmeling lascmeling@wisc.edu (BSAC)

Problem Statement

Thousands of weightlifting injuries occur every year Injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. The team has been tasked with designing a biomedical device that can prevent weight lifting injuries by targeting, identifying, and correcting improper form.

Brief Status Update

The team has finalized its design, ordered necessary parts, and will begin fabrication of the weightlifting clip and coding the MPU-6050 and Arudino.

Team Goals

We look forward to fabricating the weightlifting clip via 3D printing and beginning testing on this subject, as well as beginning the coding and pairing of the MPU-6050 and Arduino.

Individual Accomplishments and Goals

Jackson: This week, I coordinated the ordering of our parts, as well as worked with the team to decide on meeting times so that we could move forward with fabrication. As a team, we all agreed on the importance of this “off” time to really focus on the development of our final design. We

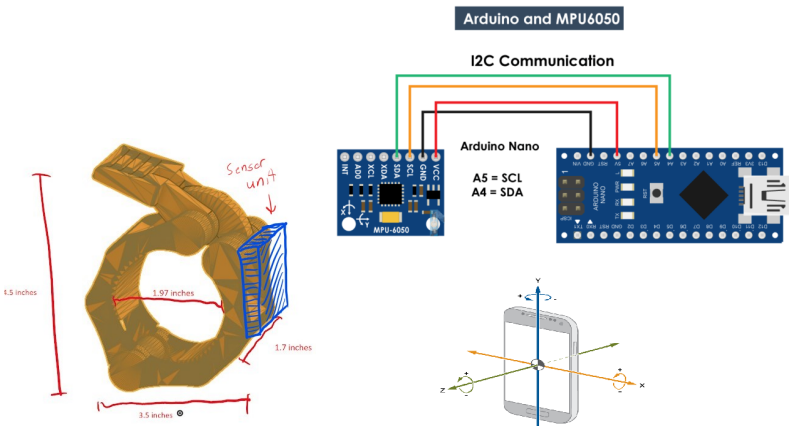
met on Thursday night to begin the 3D printing process, and to talk with the Makerspace staff in order to hear their advice on our project. Kai and I worked with IMU's in BME 315 lab on Wednesday, and this really helped us visualize what we will have to be doing in the coming weeks to create the barbell tracking portion of the project.

Kai: Throughout the week the team and I met a few times to discuss our plan for fabrication and ended up ordering parts for our first prototype. I also met with the team in the makerspace and began early stages of fabrication by uploading code onto the arduino nanos. Jackson and I's 315 lab allowed us to play around with bluetooth IMU's to get a sense for how they collect data and what noise filters may be necessary. Looking forward, I'm hoping the team will have a finished prototype and some elementary testing done in the next week or so.

Luke: This week I looked deep into how frequency, a gyms ambient noise, and sudden acceleration would affect the raw data output of the arduino IMU. I looked into solutions to these problems, which caused me to find the topic of complementary filters for turning raw data from the IMU into a more optimized output that I believe may possibly be a necessity and an easy addition to our code for this project. I discussed this with Kai and we will look into it further and how it may apply to this project. This coming week I am going to look into the sketch processing software "6th Degree of Freedom" animation through MathWorks. I also am looking forward to learning more circuitry and 3D printing from the 300's in our group these upcoming weeks.

Gavin: This week I ordered and picked up the parts we needed. We will also be meeting on Thursday to work on our fabrication, especially 3-D printing the clips, and hardwiring our electrical devices. I also did some research on the strength of 3-D printed materials to see if 3-D printing the clamp will work well. In this coming week, we will focus heavily on fabrication, and we will be meeting a few times this next week to fabricate our product.

Design Accomplishments



The team will move forward with the 3D printing of a functional weight lifting clip with necessary housing for the following technology. We will utilize an Arduino Nano in each clip, paired with a MPU6050. The arduino nanos will collect data and pair with each other via bluetooth, and the MPU6050 will collect data in terms of angular velocity and acceleration. We will derive this data to displacement, and establish a coordinate system and line of best fit of the barbell path from there.

Weekly/Ongoing Difficulties:

N/A

Project Timeline:

Week #	Task
1	Choose project Assign roles
2	Finish first progress report BSAC meeting First client meeting
3	PDS, Brainstorm, Research
4	Brainstorm, Literature Search, Design matrix criteria and design ideas (at least three) due
5	Preliminary Oral Presentation
6	Preliminary Report, Electronic Notebook, Peer/Self Evaluation, Decide on final design
7	Final Design
8	Order materials, consider submitting invention disclosure
9	Fabrication, show and tell
10	Fabrication
11	Fabrication
12	Design Testing and Modification, Poster Draft Review
13	Design Testing and Modification, Final Report
14	Poster Presentation, Final Report, Final Electronic Notebook, Team Evaluation, Peer/Self Evaluation

Expenses **BPAG Expense Spreadsheet**

Conclusions/action items:

We look forward to accomplishing our goals and moving forward with the progression of our project.

10/24/2024 Progress Report

Jackson Jarrett - Oct 29, 2024, 6:36 PM CDT

Title: Progress Report Week 7

Date: 10/24/2024

Content by: All

Present: All

Goals: To document our progress from the past week, as well as lay out our goals for the next week in coordination with our advisor and client.

Content:

Preventing Weightlifting Injuries by Barbell Modifications

October 21st- October 25th, 2024

Client: Mr. Robert Gold
Advisor: Prof. William Murphy

Team Members:

Jackson Jarrett jrjarrett2@wisc.edu (Leader and BWIG)

Kai McClellan kamcclellan@wisc.edu (Communicator)

Gavin Gruber gtgruber@wisc.edu (BPAG)

Luke Schmeling lascmeling@wisc.edu (BSAC)

Problem Statement

Thousands of weightlifting injuries occur every year Injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. The team has been tasked with designing a biomedical device that can prevent weight lifting injuries by targeting, identifying, and correcting improper form.

Brief Status Update

The team has made progress with the coding of the Arduino and MPU-6050, and is currently working on graphing on MATLAB. We have fabricated a test casing for the technology via 3D print, and now look forward to fabricating the actual casing of the technology.

Team Goals

Examine test casing for technology, and make necessary adjustments for the actual final design. Continue coding and working on MATLAB, as well as outline testing.

Individual Accomplishments and Goals

Jackson: This week I coordinated with the team to land on a meeting time, where we could begin fabrication of the final design. Kai and I came to the conclusion that we would focus on the coding aspect, because we had more experience in that sphere, while allowing Luke and Gavin freedom in the 3D printing and fabrication of the technology casing. Kai and I worked to pair the arduino and MPU-6050, and were able to see coordinate data on Arudino. Looking forward, we look to translate this data on to MATLAB, as well as begin planning testing procedures

Kai: This week I met with my TA's and professor for biomechanics and spoke about some of the coding involved with calibrating the IMU sensor and how to properly track data from it. We also discussed the wiring and proper voltage to ensure that the circuit functions properly. I met with the team in the makerspace to work on our fabrication for the first prototype and successfully printed our first box element for the circuitry. The next steps for the team is to fine tune the coding to translate into MATLAB for digital analysis and provide data feedback for us to examine. We will also aim to assemble the components of the prototype to have a finished product for show and tell next friday.

Luke: This week I was able to have the opportunity with Gavin to learn about the process of 3D printing. I unfortunately was not fluent in any program so I had to do a little bit of research watching youtube videos in order to gain a better understanding which I can now use for future reference. I went into solid works and created a basic design as well for the compartment's latch, however, Gavin's was much better so we ended up going with his. I am going to continue to expand my knowledge regarding solid works this week as I play around with it, and depending on the plan with the 300's in the group for this upcoming week I might learn about some of the coding and circuitry of our design. I also plan to perhaps come up with some backup designs for the compartment if we decide to do more designing for that, as well as be ready to 3D print any other parts that would be necessary for us to consider for this project.

Gavin: This week I designed a latch and sliding cover for the container that will house the electronics. Luke and I made a 3-D Model that we will use to test the latching mechanism and the sliding cover. I 3D printed our first model but we didn't put in any tolerance for the sliding mechanism so it would jam and we couldn't test the latch. I redid the 3-D model and it is in the process of being printed, it should be done by tonight. In this upcoming week I hope to test the latch and if it is successful Luke and I will make a 3-D model for the whole containment unit and 3-D print it. If it doesn't work we will adjust it until it works then 3-D print the whole unit.

Design Accomplishments

Test model for technology casing. The weightlifting clips have arrived. We have calibrated the MPU-6050 to show coordinates on Arduino. We have made beginning progress on MATLAB coordination.

Weekly/Ongoing Difficulties:

N/A

Project Timeline:

Week #	**Task**
1	**Choose project**

	Assign roles
2	**Finish first progress report** **BSAC meeting** **First client meeting**
3	**PDS, Brainstorm, Research**
4	**Brainstorm, Literature Search, Design matrix criteria and design ideas (at least three) due**
5	**Preliminary Oral Presentation**
6	**Preliminary Report, Electronic Notebook, Peer/Self Evaluation, Decide on final design**
7	**Final Design**
8	**Order materials, consider submitting invention disclosure**
9	**Fabrication, show and tell**
10	**Fabrication**
11	**Fabrication**
12	**Design Testing and Modification, Poster Draft Review**
13	**Design Testing and Modification, Final Report**
14	**Poster Presentation, Final Report, Final Electronic Notebook, Team Evaluation, Peer/Self Evaluation**

Expenses **BPAG Expense Spreadsheet**

Conclusions/action items:

We look forward to accomplishing our goals and moving forward with the progression of our project.

10/31/2024 Progress Report

Jackson Jarrett - Nov 08, 2024, 12:05 PM CST

Title: Progress Report Week 8

Date: 10/31/2024

Content by: All

Present: All

Goals: To document our progress from the past week, as well as lay out our goals for the next week in coordination with our advisor and client.

Content:

Preventing Weightlifting Injuries by Barbell Modifications

October 28st- November 1st, 2024

Client: Mr. Robert Gold

Advisor: Prof. William Murphy

Team Members:

Jackson Jarrett jrjarrett2@wisc.edu (Leader and BWIG)

Kai McClellan kamcclellan@wisc.edu (Communicator)

Gavin Gruber gtgruber@wisc.edu (BPAG)

Luke Schmeling lascmeling@wisc.edu (BSAC)

Problem Statement

Thousands of weightlifting injuries occur every year Injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. The team has been tasked with designing a biomedical device that can prevent weight lifting injuries by targeting, identifying, and correcting improper form.

Brief Status Update

The team has made progress with the coding of the Arduino and MPU-6050, and is currently working on graphing on MATLAB. We have fabricated a test casing for the technology via 3D print, and have begun the 3D printing of the final technology housing.

Team Goals

Examine test casing for technology, and make necessary adjustments for the actual final design. Continue coding and working on MATLAB, as well as outline testing.

Individual Accomplishments and Goals

Jackson: This week I continued to research and work on the transfer of Arduino coordinates into MATLAB. I outlined a meeting time where as a team we would discuss the answers provided for us by our advisor, as well as what we were looking to achieve with the Show & Tell this upcoming

Friday. We will discuss testing procedures, and in the next weeks we look forward to beginning testing on our product in preparation for final deliverables.

Kai: This week I met with the team and met to continue our fabrication process, continued editing the code for the data transfer to MATLAB, and discussed what the necessary materials were for show and tell tomorrow. In the coming week, the team hopes to finish our first prototype, get beneficial feedback from other teams during show and tell, and modify our prototype as needed.

Luke: This week I struggled my way through Solidworks content. After consultation with Gavin by simply looking at the ease with which he could use onshape, I decided this is probably a much more viable option for us and our 3D printing needs. I also brought up two good points to the group one of which was a tweak to our design idea which included two boxes on two joints of the clip as opposed to one very large box, as well as the consideration that we should keep in mind that we should bias the compartments away from the weight so the important breadboards are not bearing the load of the bar. This upcoming week I plan to start drafting our testing and put the plans in the PDS.

Gavin: This week collected the 2nd test print for the sliding lid, the print wasn't very good because the printer messed it up, but the measurements and specs that it was printed with worked. I designed the full box on onshape with the help of Luke. I then printed the box with the 3D printers. As a group, we also prepared for our Show & Tell. In the upcoming week I hope to do some tests with our box, and attach it to the clips.

Design Accomplishments

Test model for technology casing. The weightlifting clips have arrived. We have calibrated the MPU-6050 to show coordinates on Arduino. We have made beginning progress on MATLAB coordination.

Weekly/Ongoing Difficulties:

N/A

Project Timeline:

Week #	Task
1	Choose project
	Assign roles
2	Finish first progress report
	BSAC meeting
	First client meeting
3	PDS, Brainstorm, Research
4	Brainstorm, Literature Search, Design matrix criteria and design ideas (at least three) due
5	Preliminary Oral Presentation
6	Preliminary Report, Electronic Notebook, Peer/Self Evaluation, Decide on final design

7	**Final Design**
8	**Order materials, consider submitting invention disclosure**
9	**Fabrication, show and tell**
10	**Fabrication**
11	**Fabrication**
12	**Design Testing and Modification, Poster Draft Review**
13	**Design Testing and Modification, Final Report**
14	**Poster Presentation, Final Report, Final Electronic Notebook, Team Evaluation, Peer/Self Evaluation**

Expenses BPAG Expense Spreadsheet

Conclusions/action items:

We look forward to accomplishing our goals and moving forward with the progression of our project.

11/7/2024 Progress Report

Jackson Jarrett - Nov 08, 2024, 12:05 PM CST

Title: Progress Report Week 9

Date: 11/7/2024

Content by: All

Present: All

Goals: To document our progress from the past week, as well as lay out our goals for the next week in coordination with our advisor and client.

Content:

Preventing Weightlifting Injuries by Barbell Modifications

November 4th- November 8th, 2024

Client: Mr. Robert Gold

Advisor: Prof. William Murphy

Team Members:

Jackson Jarrett jrjarrett2@wisc.edu (Leader and BWIG)

Kai McClellan kamcclellan@wisc.edu (Communicator)

Gavin Gruber gtgruber@wisc.edu (BPAG)

Luke Schmeling lascmeling@wisc.edu (BSAC)

Problem Statement

Thousands of weightlifting injuries occur every year Injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. The team has been tasked with designing a biomedical device that can prevent weight lifting injuries by targeting, identifying, and correcting improper form.

Brief Status Update

The team has made progress with the coding of the Arduino and MPU-6050, and is currently working on graphing on MATLAB. We have fabricated a test casing for the technology via 3D print, and have begun the 3D printing of the final technology housing.

Team Goals

Examine test casing for technology, and make necessary adjustments for the actual final design. Continue coding and working on MATLAB, as well as outline testing.

Individual Accomplishments and Goals

Jackson: After Show and Tell on Friday, the team received a good number of suggestions which we will build on. More specifically, the question of surface area and how we will attach our technology was brought up. We will outline testing in order to determine the best way to move forward with attachment. Another valuable piece of information that we took away from our peers was the need to solder wire connections. This will aid with our connection issues. Moving forward, we will perform necessary testing and begin final coding and MATLAB performance in the coming weeks.

Kai: This week the team met to adjust the dimensions of the housing box for the circuitry. We were also able to gain some valuable information from other groups during the show and tell on Friday. Some key takeaways from show and tell were to potentially split up the box element into two sections to optimize the height of the box relative to the clips. The wiring could then be across the hinge of the clip and water-tightened with rubber/caulk of some type to maintain sweat resistance. Soldering the IMU to fix inconsistent readings was another topic of discussion. The team took all of this into consideration and we plan to solidify our prototype and get some data results for our final presentation.

Luke: This week on Thursday I met with Gavin in order to discuss the future of the design of the compartments for our electronics and batteries. We discussed certain design changes we could apply in the future for our final design and spoke about how we can improve the design that we will use for testing next week. We kept the main idea for the 3D print design the same but were able to shrink down the dimensions due to the idea we came up with last week regarding two separate compartments on the clip, one for the breadboard and the other for the batteries. We then began the 3D printing process for this new design and it should be ready Friday when the makerspace reopens. This upcoming week we plan to make testing procedures and begin the testing process.

Gavin: This week Luke and I designed a new smaller box with bigger channels and started the 3D print on that box. I have also received all of the parts we ordered in the mail. After the print for the new box is done we will start attaching our components to the barbell clamps we have. In this next week we will be starting our testing with our prototype.

Design Accomplishments

Test model for technology casing. The weightlifting clips have arrived. We have calibrated the MPU-6050 to show coordinates on Arduino. We have made beginning progress on MATLAB coordination.

Weekly/Ongoing Difficulties:

N/A

Project Timeline:

Week #	Task
1	Choose project
	Assign roles
2	Finish first progress report
	BSAC meeting

	First client meeting
3	**PDS, Brainstorm, Research**
4	**Brainstorm, Literature Search, Design matrix criteria and design ideas (at least three) due**
5	**Preliminary Oral Presentation**
6	**Preliminary Report, Electronic Notebook, Peer/Self Evaluation, Decide on final design**
7	**Final Design**
8	**Order materials, consider submitting invention disclosure**
9	**Fabrication, show and tell**
10	**Fabrication**
11	**Fabrication**
12	**Design Testing and Modification, Poster Draft Review**
13	**Design Testing and Modification, Final Report**
14	**Poster Presentation, Final Report, Final Electronic Notebook, Team Evaluation, Peer/Self Evaluation**

Expenses **BPAG Expense Spreadsheet**

Conclusions/action items:

We look forward to accomplishing our goals and moving forward with the progression of our project.

11/14/2024 Progress Report

Jackson Jarrett - Dec 05, 2024, 6:08 PM CST

Title: Progress Report Week 10

Date: 11/14/2024

Content by: All

Present: All

Goals: To document our progress from the past week, as well as lay out our goals for the next week in coordination with our advisor and client.

Content:

Preventing Weightlifting Injuries by Barbell Modifications

November 11th- November 15th, 2024

Client: Mr. Robert Gold

Advisor: Prof. William Murphy

Team Members:

Jackson Jarrett jrjarrett2@wisc.edu (Leader and BWIG)

Kai McClellan kamcclellan@wisc.edu (Communicator)

Gavin Gruber gtgruber@wisc.edu (BPAG)

Luke Schmeling lascmeling@wisc.edu (BSAC)

Problem Statement

Thousands of weightlifting injuries occur every year Injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. The team has been tasked with designing a biomedical device that can prevent weight lifting injuries by targeting, identifying, and correcting improper form.

Brief Status Update

The team has made considerable progress with coding, as well as completed the soldering of our arduino connection. The 3D printing final fabrication is complete, as we look forward to testing in the coming week.

Team Goals

We want to complete testing protocols and testing in the coming week, as well as fastening of the technology to the weightlifting clip via screws.

Individual Accomplishments and Goals

Jackson: This week, I began by outlining the rest of the schedule for the group. I highlighted due dates, important dates, and goals for fabrication, testing, and working on our final poster. I began testing protocols, and in the next week we look forward to meeting as a team to finalize and perform these tests. Kai and I met with our biomechanics TA on Thursday afternoon, where we were able to gain some valuable information

regarding the transformation of point data into MATLAB. I look forward to beginning testing, finalizing fabrication, and beginning final deliverables work.

Kai: This week I spent a lot of time fine tuning the Arduino and Matlab coding and was able to achieve successful transfer of data between the two with the ability to record data without the IMU being directly connected to a serial monitor. The only issue now is that the IMU, being on the cheaper side, experiences a lot of noise and will not graph very accurately even with strong filters in the matlab code and with calibrating the sensor in arduino first. I want to perform testing this weekend, but the graphing needs to perform correctly or else testing will be nearly impossible to achieve anything valuable. This will be my focus for the next few days with the goal being to get testing data this weekend or by next weekend.

Luke: This week I began some drafts for the testing plans outlining what aspects we want to test as well as how we are going to measure these criteria in a way that minimizes the need for qualitative description. This upcoming week I look forward to finalizing testing plans with the team and beginning to test and improve our design.

Gavin: This week I picked up the newest 3-D printed box which worked great and we are proceeding to test using it. I also started working on our testing protocols which we will perform in the next week. I also started to assemble some of the parts and attached the command strips to our components. Next week we will finish assembling by attaching everything to the clip and soldering the battery pack onto the Arduino. We will also start working on our final deliverables in the upcoming weeks.

Design Accomplishments

The 3D fabricated components are complete and ready for testing. We have a coordinate system shown on Arduino and MATLAB, and look forward to gathering test data in order to have a basis of comparison.

Weekly/Ongoing Difficulties:

N/A

Project Timeline:

Week #	Task
1	Choose project
	Assign roles
2	Finish first progress report
	BSAC meeting
	First client meeting
3	PDS, Brainstorm, Research
4	Brainstorm, Literature Search, Design matrix criteria and design ideas (at least three) due
5	Preliminary Oral Presentation

6	**Preliminary Report, Electronic Notebook, Peer/Self Evaluation, Decide on final design**
7	**Final Design**
8	**Order materials, consider submitting invention disclosure**
9	**Fabrication, show and tell**
10	**Fabrication**
11	**Fabrication**
12	**Design Testing and Modification, Poster Draft Review**
13	**Design Testing and Modification, Final Report**
14	**Poster Presentation, Final Report, Final Electronic Notebook, Team Evaluation, Peer/Self Evaluation**

Expenses **BPAG Expense Spreadsheet**

Conclusions/action items:

We look forward to accomplishing our goals and moving forward with the progression of our project.

11/21/2024 Progress Report

Jackson Jarrett - Dec 05, 2024, 6:08 PM CST

Title: Progress Report Week 11

Date: 11/21/2024

Content by: All

Present: All

Goals: To document our progress from the past week, as well as lay out our goals for the next week in coordination with our advisor and client.

Content:

Preventing Weightlifting Injuries by Barbell Modifications

November 18th- November 22th, 2024

Client: Mr. Robert Gold

Advisor: Prof. William Murphy

Team Members:

Jackson Jarrett jrjarrett2@wisc.edu (Leader and BWIG)

Kai McClellan kamcclellan@wisc.edu (Communicator)

Gavin Gruber gtgruber@wisc.edu (BPAG)

Luke Schmeling lascmeling@wisc.edu (BSAC)

Problem Statement

Thousands of weightlifting injuries occur every year Injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. The team has been tasked with designing a biomedical device that can prevent weight lifting injuries by targeting, identifying, and correcting improper form.

Brief Status Update

We have completed our 3D printing portion of the project, and made additional adjustments to the lid so that the clip is more functional.

Team Goals

We are looking to implement a button into the Arduino coding in order to start and stop the collection of Arduino data so that we aren’t taking an infinite amount of data sources. We will complete testing as well as move forward with starting our poster for the upcoming poster presentation.

Individual Accomplishments and Goals

Jackson: This week Kai and I met to implement a button in the Arduino code in order to stop and start the collection of data, in order for the EEPROM data storage system to not fill up with data immediately. We also met with Dr. Wille in order to look into further filters that we can implement in order to gather more linear data that aligns with the direct movement of the accelerometer. We completed testing this week, and in the

upcoming week we look forward to finalizing our product, and then moving into the creation of our poster and pitch for the upcoming poster presentation.

Kai: This week Jackson and I worked on adding a button system to the circuitry so that a new trial could be run and stored in the EEPROM without needing to be directly plugged into a serial port. We also worked with our biomechanics professor regarding trend filtering on our data as it appeared to have some noticeable drift when recording. In the coming days the team will make sure both sensors work properly and will work on our poster for the presentation after thanksgiving, as well as the other deliverables that will be due at that time.

Luke: This week I researched some testing techniques with which we can test the box that would be applicable. I started to write out some drafts that we could put into the final report for this project. Other than that it was a busy week and there was difficulty with our group finding a time to meet. However, next week as our exams begin to wind down before break we will be meeting both with our advisor and with each other to implement the tests we have planned as well as to test the usability of this device.

Gavin: This week I printed a new sliding lid for our 3D printed box as well as printed a second 3D box. I also worked on attaching the 3D-printed box and battery pack to our barbell clips. This week I also made a hole in the 3D-printed box and put the wire through it, then I sealed it with hot glue. We also met and completed testing. In the upcoming weeks we will be working on our final poster and other final deliverables.

Design Accomplishments

We made a necessary change to the lid of our box, which included a bigger lip in order to lock in place. We drilled holes in the box for the battery wires to be able to power the technology, and we created a button start in order for data collection to be started, and then timed, in order to not fill our data collection EEPROM.

Weekly/Ongoing Difficulties:

N/A

Project Timeline:

Week #	Task
1	Choose project
	Assign roles
2	Finish first progress report
	BSAC meeting
	First client meeting
3	PDS, Brainstorm, Research
4	Brainstorm, Literature Search, Design matrix criteria and design ideas (at least three) due
5	Preliminary Oral Presentation

6	**Preliminary Report, Electronic Notebook, Peer/Self Evaluation, Decide on final design**
7	**Final Design**
8	**Order materials, consider submitting invention disclosure**
9	**Fabrication, show and tell**
10	**Fabrication**
11	**Fabrication**
12	**Design Testing and Modification, Poster Draft Review**
13	**Design Testing and Modification, Final Report**
14	**Poster Presentation, Final Report, Final Electronic Notebook, Team Evaluation, Peer/Self Evaluation**

Expenses BPAG Expense Spreadsheet

Conclusions/action items:

We look forward to accomplishing our goals and moving forward with the progression of our project.

11/25/2024-12/6/2024 Progress Report

Jackson Jarrett - Dec 05, 2024, 6:08 PM CST

Title: Progress Report Weeks 12 and 13

Date: 11/25-12/6

Content by: All

Present: All

Goals: To document our progress from the past week, as well as lay out our goals for the next week in coordination with our advisor and client.

Content:

Preventing Weightlifting Injuries by Barbell Modifications

November 25th - December 6th, 2024

Client: Mr. Robert Gold

Advisor: Prof. William Murphy

Team Members:

Jackson Jarrett jrjarrett2@wisc.edu (Leader and BWIG)

Kai McClellan kamcclellan@wisc.edu (Communicator)

Gavin Gruber gtgruber@wisc.edu (BPAG)

Luke Schmeling lascmeling@wisc.edu (BSAC)

Problem Statement

Thousands of weightlifting injuries occur every year Injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. The team has been tasked with designing a biomedical device that can prevent weight lifting injuries by targeting, identifying, and correcting improper form.

Brief Status Update

We completed testing and the fabrication of our prototype for this semester-long project. We look forward to presenting our ideas, successes, and moments of learning and improvement during our Final Poster Presentation on Friday.

Team Goals

Complete poster presentation, and begin working on Final Report.

Individual Accomplishments and Goals

Jackson: Before we went home for Thanksgiving, we were able to complete the fabrication of the prototype at the makerspace. We soldered the wires for the battery pack and the button. After the prototype was complete, we performed our stationary and kinetic testing. We performed the stationary testing at the makerspace, and then went to the Nic Recreation Center in order to test the prototype in a gym environment. After the completion of the prototype and testing, I began work for the presentation, including the creation of the skeleton document, and then my work on

the testing procedures, future work, design specifications, and modeled pictures. I look forward to presenting our ideas on Friday, and then wrapping up the semester with the final report.

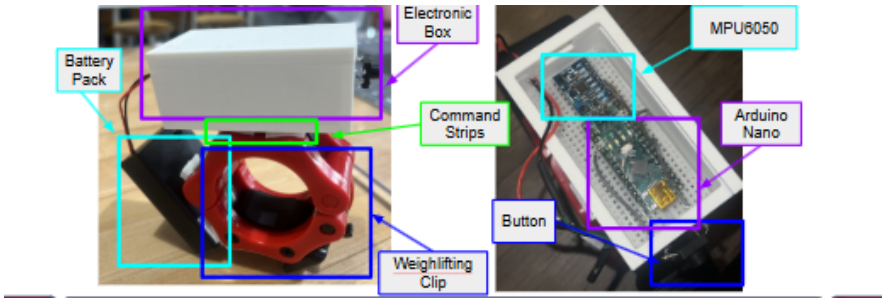
Kai: The team was able to finish testing before Thanksgiving break, which set us up nicely for simply focusing on the poster and presentation for this Friday. For testing, the team met at the Nic Recreation Center and put our prototypes on one of the benches with weight on it to get the most accurate data collection possible for our goals. We completed 5-8 separate tests after some trial and error with transferring the data properly and correcting the prototype orientation on the bar. The results supported our theories for what the data should look like, with some noise errors due to the quality of our prototype components. After break, I completed my speaking portion of the poster which includes testing and results, and modified the document after receiving feedback from Dr. Murphy to ensure proper formatting and layout prior to printing. I am excited to present our hard work on Friday, and after presentations the team will be completing the final deliverables for the project.

Luke: This week I made entries for our fabrication that took place before the break began as well as some of our testing. I also did my part for the poster board and we began the creation of the poster after getting feedback. This upcoming week especially over the weekend I plan to type a lot for the final report in order to get feedback from the advisor.

Gavin: This week I worked on our final presentation and the poster we will use for it. I worked on the problem statement and the background information. I also have been working on our presentation. We will have our presentation on Friday. In this next week, we will work on completing our final report and finishing up our project.

Design Accomplishments

Final Prototype:



Weekly/Ongoing Difficulties:

N/A

Project Timeline:

Week #	Task
1	Choose project Assign roles
2	Finish first progress report

	BSAC meeting **First client meeting**
3	**PDS, Brainstorm, Research**
4	**Brainstorm, Literature Search, Design matrix criteria and design ideas (at least three) due**
5	**Preliminary Oral Presentation**
6	**Preliminary Report, Electronic Notebook, Peer/Self Evaluation, Decide on final design**
7	**Final Design**
8	**Order materials, consider submitting invention disclosure**
9	**Fabrication, show and tell**
10	**Fabrication**
11	**Fabrication**
12	**Design Testing and Modification, Poster Draft Review**
13	**Design Testing and Modification, Final Report**
14	**Poster Presentation, Final Report, Final Electronic Notebook, Team Evaluation, Peer/Self Evaluation**

Expenses **BPAG Expense Spreadsheet**

Conclusions/action items:

We look forward to accomplishing our goals and moving forward with the progression of our project.

12/13/2024 Progress Report

Jackson Jarrett - Dec 11, 2024, 12:07 PM CST

Title: Progress Report Week 14

Date: 12/13

Content by: All

Present: All

Goals: To document our progress from the past week, as well as lay out our goals for the next week in coordination with our advisor and client.

Content:

Preventing Weightlifting Injuries by Barbell Modifications

December 8th - December 13th, 2024

Client: Mr. Robert Gold

Advisor: Prof. William Murphy

Team Members:

Jackson Jarrett jrjarrett2@wisc.edu (Leader and BWIG)

Kai McClellan kamcclellan@wisc.edu (Communicator)

Gavin Gruber gtgruber@wisc.edu (BPAG)

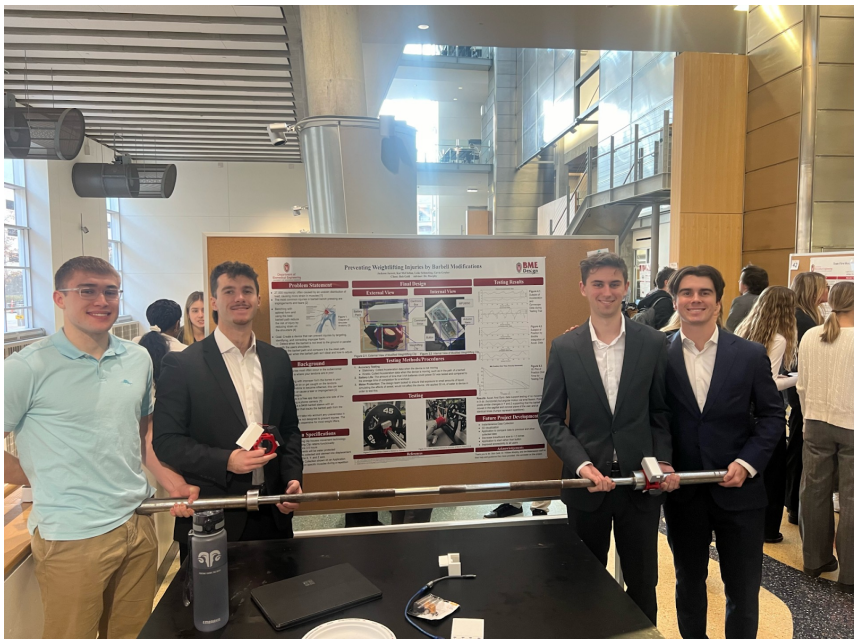
Luke Schmeling lascmeling@wisc.edu (BSAC)

Problem Statement

Up to 27,000 injuries occur while weightlifting every year. Injuries are often caused by an uneven distribution of load on the barbell, leading to the weight lifter favoring one arm over the other. The team has been tasked with designing a biomedical device that can prevent weight lifting injuries by targeting, identifying, and correcting improper form.

Brief Status Update

The design team has completed the poster presentation, which went very well. We were grateful for the experience of being able to present our ideas, findings, and areas of growth to our advisors and peers. This week, we look forward to wrapping up the semester with the Final Report.



Team Goals

This week we will finish the Final Report, submit our Final Design Notebook, and complete our peer and team evaluations.

Individual Accomplishments and Goals

Jackson: This week I created the skeleton of the progress report as well as the final report, and attached our preliminary report work with the comments left by Dr. Murphy into the Final Report for further adjustments. I updated the PDS document, and put that into the Final Report. I worked primarily on the Testing section, the Appendices, and the Final Design section. Finally, I completed the peer feedback evaluation, and look forward to seeing the group poster feedback as well as my own personal feedback to wrap up another great semester of BME Design.

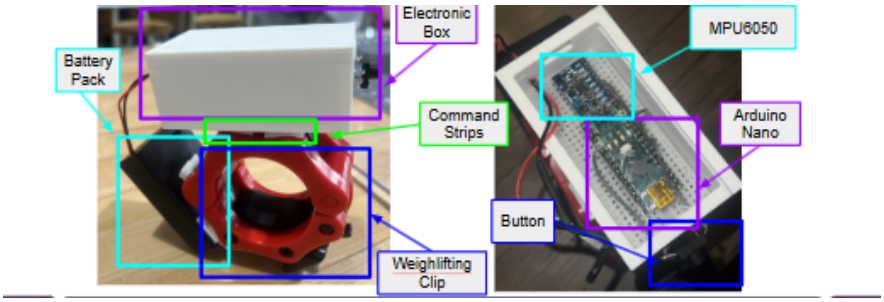
Kai: In the final week of BME design the team collaborated and completed the final deliverables for the project. I helped out with updating the PDS document, completing the testing results and future work section of the Final Report, and the code Appendices. I have been actively working on adding notebook entries and also completed the poster and peer review feedbackfruits.

Luke: This week I did my part to contribute to the final report and ensure everything was completed to a high degree of satisfaction for the team. I also gave feedback on the team in feedback fruits and will be seeing if there is anything else I need to add to the team lab archives before we submit everything for evaluation.

Gavin: This week I worked on completing our final report along with the rest of our team. I worked primarily on the fabrication sections and the appendix about 3D printing, as well as completing the materials. I also have given feedback for the team feedback fruit and the posters I saw during the poster presentation.

Design Accomplishments

Final Prototype:



Weekly/Ongoing Difficulties:

N/A

Project Timeline:

Week #	Task
1	Choose project Assign roles
2	Finish first progress report BSAC meeting First client meeting
3	PDS, Brainstorm, Research
4	Brainstorm, Literature Search, Design matrix criteria and design ideas (at least three) due
5	Preliminary Oral Presentation
6	Preliminary Report, Electronic Notebook, Peer/Self Evaluation, Decide on final design
7	Final Design

8	**Order materials, consider submitting invention disclosure**
9	**Fabrication, show and tell**
10	**Fabrication**
11	**Fabrication**
12	**Design Testing and Modification, Poster Draft Review**
13	**Design Testing and Modification, Final Report**
14	**Poster Presentation, Final Report, Final Electronic Notebook, Team Evaluation, Peer/Self Evaluation**

Expenses **BPAG Expense Spreadsheet**

Conclusions/action items:

This is the conclusion of our project.

2024/9/13 Motion Microscope

KAI MCCLELLAN - Sep 13, 2024, 12:45 PM CDT

Title: Motion Microscope Software

Date: 9/13/24

Content by: Kai McClellan

Present: N/A

Goals: Understand the software's capabilities and evaluate its potential for analyzing minute body movements.

Content:

- Motion microscopy is a computational technique to visualize and analyze meaningful but small motions. The microscope's motion enables the inspection of tiny motions as optical microscopy enables the inspection of tiny forms. We demonstrate its utility in three disparate problems from biology and engineering: visualizing motions used in mammalian hearing, showing vibration modes of structures, and verifying the effectiveness of designed metamaterials.
- . In addition to visualizing tiny motions, we quantify both the object's subpixel motions, and the errors introduced by camera sensor noise (5). Thus, the user can see the magnified motions and obtain their values, with variances, allowing for both qualitative and quantitative analyses.
- The motion microscope characterizes and amplifies tiny local displacements in a video by using spatial local phase. It does this by transforming the captured intensities of each frame's pixels into a wavelet-like representation where phase shifts of windowed complex sine waves represent displacements.
- Fleet and Jepson have shown that contours of constant phase in image subbands such as those in the complex steerable pyramid approximately track the motion of objects in a video (7). We make a similar phase constancy assumption, in which the following equation relates the phase of the frame at time 0 to the phase of future frames:

$$\phi_{r,\theta}(x, y, 0) = \phi_{r,\theta}(x - u(x, y, t), y - v(x, y, t), t), \quad \textbf{[S1]}$$

where $\mathbf{V}(x, y, t) := (u(x, y, t), v(x, y, t))$ is the motion we seek to compute. We Taylor-expand the right-hand side around (x, y) to get

$$\Delta\phi_{r,\theta} = \left(\frac{\partial\phi_{r,\theta}}{\partial x}, \frac{\partial\phi_{r,\theta}}{\partial y}\right) \cdot (u, v) + O(u^2, v^2), \quad \textbf{[S2]}$$

where $\Delta\phi_{r,\theta}(x, y, t) := \phi_{r,\theta}(x, y, t) - \phi_{r,\theta}(x, y, 0)$, arguments have been suppressed and $O(u^2, v^2)$ represents higher order terms in the Taylor expansion. Because we assume the motions are small, higher order terms are negligible and the local phase variations are approximately equal to only the linear term,

$$\Delta\phi_{r,\theta} = \left(\frac{\partial\phi_{r,\theta}}{\partial x}, \frac{\partial\phi_{r,\theta}}{\partial y}\right) \cdot (u, v). \quad \textbf{[S3]}$$

Motion Microscopy for Visualizing and Quantifying Small Motions (mit.edu)

Conclusions/action items:

2024/9/19 - FDA Regulations for Fitness Software

KAI MCCLELLAN - Sep 19, 2024, 6:37 PM CDT

Title: FDA Regulations for Fitness Software

Date: 9/19/24

Content by: Kai McClellan

Present: N/A

Goals: Understand the regulations of non-invasive medical tools that are not considered a device

Content:

Examples of Software Functions That Are NOT Medical Devices | FDA

1. **Software functions that are intended for individuals to log, record, track, evaluate, or make decisions or behavioral suggestions related to developing or maintaining general fitness, health or wellness**, such as those that:
    - Provide tools to promote or encourage healthy eating, exercise, weight loss, or other activities generally related to a healthy lifestyle or wellness;
    - Provide dietary logs, calorie counters, or make dietary suggestions;
    - Provide meal planners and recipes;
    - Track general daily activities or make exercise or posture suggestions;
    - Track a normal baby's sleeping and feeding habits;
    - Actively monitor and trend exercise activity;
    - Help healthy people track the quantity or quality of their normal sleep patterns;
    - Provide and track scores from mind-challenging games or generic "brain age" tests;
    - Provide daily motivational tips (for example, via text or other types of messaging) to reduce stress and promote a positive mental outlook;
    - Use social gaming to encourage healthy lifestyle habits; and
    - Calculate calories burned in a workout.
2. General Wellness: Policy for Low Risk Devices | FDA
    1. FD&C Act. Section 520(o)(1)(B) of the FD&C Act, states that software that is intended "for maintaining or encouraging a healthy lifestyle and is unrelated to the diagnosis, cure, mitigation, prevention, or treatment of a disease or condition" is not a device under section 201(h) of the FD&C Act.
    2. If a product is a device under section 201(h) of the FD&C Act, it is generally excluded from CPSC's authority over "consumer products" under the Consumer Product Safety Act

Conclusions/action items:

KAI MCCLELLAN - Sep 19, 2024, 6:45 PM CDT

1. Identification. A diagnostic electromyograph is a device intended for medical purposes, such as to monitor and display the bioelectric signals produced by muscles, to stimulate peripheral nerves, and to monitor and display the electrical activity produced by nerves, for the diagnosis and prognosis of neuromuscular disease.

    CFR - Code of Federal Regulations Title 21 (fda.gov)

    (b) Classification. Class II (performance standards).

KAI MCCLELLAN - Sep 19, 2024, 6:49 PM CDT

1. Sec. 890.1925 Isokinetic testing and evaluation system.

    (a) Identification. An isokinetic testing and evaluation system is a rehabilitative exercise device intended for medical purposes, such as to measure, evaluate, and increase the strength of muscles and the range of motion of joints.

(b) Classification. Class II (special controls). The device is exempt from the premarket notification procedures in subpart E of part 807 of this chapter subject to § 890.9.

CFR - Code of Federal Regulations Title 21 (fda.gov)

1. It is considered noninvasive testing and therefore does not need premarket approval and is exempt from Section 510(k)

2024/10/4 - Arduino Accelerometer

KAI MCCLELLAN - Oct 04, 2024, 7:25 PM CDT

Title: Arduino Accelerometer

Date: 10/4/24

Content by: Kai McClellan

Present: N/A

Goals: Understand the usage of the accelerometer for usage on our project

Content:

The article from Random Nerd Tutorials explains how to use the MPU-6050 accelerometer and gyroscope with an Arduino. The MPU-6050 is a 6-axis IMU (Inertial Measurement Unit) that includes a 3-axis accelerometer and a 3-axis gyroscope, which can measure acceleration and angular velocity in three dimensions.

Here are the key steps and concepts:

1. Wiring the MPU-6050 to Arduino: The guide shows how to connect the module to an Arduino board using the I2C protocol, which only requires two wires: SCL (clock) and SDA (data).
2. Programming with Arduino IDE: It provides example code to read the accelerometer and gyroscope values using the MPU-6050 library. You can get real-time readings of acceleration and rotational motion in the x, y, and z axes.
3. Calibration: Calibration is important to ensure accurate readings from the sensor. The tutorial demonstrates how to perform this using the library functions.
4. Data Interpretation: The accelerometer provides values in terms of g-forces (gravitational force), and the gyroscope provides angular velocities in degrees per second.

Conclusions/action items:

This setup can be used in applications like detecting orientation, tilt, or motion, and is particularly useful for projects like drones, robots, or wearable devices.

KAI MCCLELLAN - Oct 07, 2024, 4:30 PM CDT

Arduino Guide for MPU-6050 Accelerometer and Gyroscope | Random Nerd Tutorials

2024/10/04 - IMU vs. Accelerometer

KAI MCCLELLAN - Oct 04, 2024, 7:27 PM CDT

Title: IMU vs. Accelerometer

Date: 10/4/24

Content by: Kai McClellan

Present: N/A

Goals: Understand the difference between an IMU device and an accelerometer component

Content:

In the field of robotics, Inertial Measurement Units (IMUs) play a crucial role by combining accelerometers, gyroscopes, and sometimes magnetometers to measure motion and orientation. Accelerometers detect linear acceleration, gyroscopes measure angular velocity, and magnetometers assess the Earth's magnetic field, making these components essential for tracking the movement of robotic systems.

IMUs are extensively used in various industries like consumer electronics, automotive, aerospace, and robotics. For instance, in robotics, they help with navigation, positioning, and maintaining stability in drones or robotic arms. They are integral to autonomous vehicles for navigation and stability control. However, IMUs do face limitations such as errors from sensor drift, which may require additional sensors like GPS or cameras for correction.

Conclusions/action items:

Despite these challenges, IMUs offer advantages like their small size, cost-effectiveness, and compatibility with other sensors, making them ideal for systems where motion detection and orientation tracking are vital.

KAI MCCLELLAN - Oct 07, 2024, 4:32 PM CDT

https://intorobotics.com/accelerometer-gyroscope-and-imu-sensors-in-robotics/

2024/9/8 Motion Microscope

KAI MCCLELLAN - Sep 08, 2024, 11:02 AM CDT

Title: Motion Microscope

Date: 9/8/24

Content by: Kai McClellan

Present: N/A

Goals: Understand the potential idea of motion microscope software to evaluate muscle movement with barbell placement.

Content:

Motion microscope can detect extremely small movements that are otherwise invisible. It can track blood movement under the skin with the ability to accurately track one's heart rate. (see attached PowerPoint shared by our client).

Conclusions/action items:

Has the potential to track minute movements in a lifter's muscles, and the correlation between their form and muscle strain can be quantified to detect possibilities of injury.

KAI MCCLELLAN - Sep 08, 2024, 10:57 AM CDT

Download

CHF_detection_with_the_motion_microscope_7-14-2024_.pptx (629 kB)

2024/10/04 - Code and design for Circuitry

KAI MCCLELLAN - Oct 04, 2024, 7:49 PM CDT

Title: Design code and circuitry

Date: 10/04/24

Content by: Kai McClellan

Present: Kai McClellan

Goals: Establish proper code for the Arduino uno to read data from the IMU device

Content:

The article explains how to build a 3D motion tracker using an IMU sensor, Arduino, Babylon.js, and GridDB. It covers the wiring and circuitry of the **MPU-6050 IMU sensor** connected to an Arduino. The sensor is wired to the **SDA and SCL pins** for I2C communication. After setting up the Arduino, data from the sensor (angular velocities and acceleration) is streamed and processed. Babylon.js visualizes the motion in 3D, while GridDB stores the sensor data for time-series analysis.

Code:

Reading Sensor Data:

```
#include "MPU9250.h"

// an MPU9250 object with the MPU-9250 sensor on I2C bus 0 with address 0x68
MPU9250 IMU(Wire,0x68);
int status;

void setup() {
  // serial to display data
  Serial.begin(115200);
  while(!Serial) {}

  // start communication with IMU
  status = IMU.begin();
  if (status < 0) {
    Serial.println("IMU initialization unsuccessful");
    Serial.println("Check IMU wiring or try cycling power");
    Serial.print("Status: ");
    Serial.println(status);
    while(1) {}
  }
}

void loop() {
  // read the sensor
  IMU.readSensor();
  // display the data
  Serial.print("ax:");
  Serial.print(IMU.getAccelX_mss(),6);
  Serial.print("\t");
  Serial.print("ay:");
  Serial.print(IMU.getAccelY_mss(),6);
  Serial.print("\t");
  Serial.print("az:");
  Serial.print(IMU.getAccelZ_mss(),6);
  Serial.print("\t");
  Serial.print("gx:");
```

```
  Serial.print(IMU.getGyroX_rads(),6);
  Serial.print("\t");
  Serial.print("gy:");
  Serial.print(IMU.getGyroY_rads(),6);
  Serial.print("\t");
  Serial.print("gz:");
  Serial.print(IMU.getGyroZ_rads(),6);
  Serial.print("\t");
  Serial.print("mx:");
  Serial.print(IMU.getMagX_uT(),6);
  Serial.print("\t");
  Serial.print("my:");
  Serial.print(IMU.getMagY_uT(),6);
  Serial.print("\t");
  Serial.print("my:");
  Serial.print(IMU.getMagZ_uT(),6);
  Serial.print("\t");
  Serial.print("s:");
  Serial.println(IMU.getTemperature_C(),6);
  delay(100);
}
```

Data Processing:

```
function parseSensorData(data) {
 // Parse the data string
 const sensorValues = data.split('\t').map(val => parseFloat(val.split(':')[1]));

 // The order of the data is ax, ay, az, gx, gy, gz, mx, my, mz
 const [ax, ay, az, gx, gy, gz, mx, my, mz, s] = sensorValues;

 // Normalize accelerometer data if needed (currently in m/s², convert to g's if necessary)
 const accel = {
  x: ax / 1000,
  y: ay / 1000,
  z: az / 1000
 };

 // Gyroscope data is in rad/s, which is what the Madgwick filter expects, so no conversion needed
 const gyro = { x: gx, y: gy, z: gz };

 // Magnetometer data is in microteslas (uT), convert to Teslas by dividing by 1,000,000 if necessary
 const mag = {
  x: mx / 1000000,
  y: my / 1000000,
  z: mz / 1000000
 };

 const temp = { s }

 return { accel, gyro, mag, s };
}
```

Babylon.js Display:

```
<!DOCTYPE html>
<html>
<head>
    <meta charset="utf-8" />
    <title>3D Sensor Visualization</title>
    <script src="https://cdn.babylonjs.com/babylon.js"></script>
    <style>
```

```
        #renderCanvas {
            width: 100%;
            height: 100vh;
            touch-action: none;
        }
    </style>
</head>

<body>
    <canvas id="renderCanvas"></canvas>
    <script>
        window.addEventListener('DOMContentLoaded', () => {
            const canvas = document.getElementById('renderCanvas');
            const engine = new BABYLON.Engine(canvas, true);

            const createScene = () => {
                const scene = new BABYLON.Scene(engine);
                const camera = new BABYLON.ArcRotateCamera("camera", -Math.PI / 2, Math.PI / 2.5, 10, new BABYLON.Vector3(0, 0, 0), scene);
                camera.attachControl(canvas, true);
                new BABYLON.HemisphericLight("light", new BABYLON.Vector3(1, 1, 0), scene);
                const box = BABYLON.MeshBuilder.CreateBox("box", { size: 2 }, scene);
                return { scene, box };
            };

            const { scene, box } = createScene();

            const ws = new WebSocket('ws://localhost:3000');
            ws.onmessage = (event) => {
                const sensorData = JSON.parse(event.data);
                const { gyro } = sensorData;

                // Update cube rotation with gyro data in radians/s
                // Assume you're receiving data at a rate of 60Hz (or adjust as per your rate)
                box.rotation.x += gyro.x / 10; // Update rotation based on gyro data
                box.rotation.y += gyro.y / 10;
                box.rotation.z += gyro.z / 10;
            };

            engine.runRenderLoop(() => {
                scene.render();
            });

            window.addEventListener('resize', () => {
                engine.resize();
            });
        });
    </script>
</body>

</html>
```

Conclusions/action items:

This code will track the motion of the bar path and we will be able to display its motion in a 3D software

KAI MCCLELLAN - Oct 04, 2024, 7:59 PM CDT

Arduino Uno Board	1	Microcontroller platform for the project.
GY-91 IMU Sensor Module	1	Provides inertial measurement data.
USB Cable	1	Connects Arduino to a computer for power and programming.
Jumper Wires	4	2 for power, 2 for I2C communication.
Breadboard	1	Platform for prototyping and testing circuits.

KAI MCCLELLAN - Oct 07, 2024, 4:29 PM CDT

Building a 3D Motion Tracker: Integrating IMU, Arduino, Babylon.js, and GridDB | GridDB: Open Source Time Series Database for IoT

2024/11/12 - Updated Arduino IDE Code

Jackson Jarrett - Nov 20, 2024, 3:23 PM CST

Title: Updated Arduino IDE Code to store data in EEPROM and give availability for MATLAB to read data

Date: 11/12/24

Content by: Kai McClellan

Present: N/A

Goals: N/A

Content:

Arduino Code

```
#include <EEPROM.h>
#include "I2Cdev.h"
#include "MPU6050.h"

MPU6050 mpu;

/* OUTPUT FORMAT DEFINITION */
#define OUTPUT_READABLE_ACCELGYRO
//#define OUTPUT_BINARY_ACCELGYRO

int16_t ax, ay, az;
int16_t gx, gy, gz;
bool blinkState;
int eepromAddress = 0;  // To track EEPROM storage position

void clearEEPROM() {
   // Clear all EEPROM contents by writing 0 to each address
   for (int i = 0; i < EEPROM.length(); i++) {
      EEPROM.write(i, 0);
   }
   eepromAddress = 0;  // Reset the storage address for the new test
}

void setup() {
   /*--Start I2C interface--*/
   #if I2CDEV_IMPLEMENTATION == I2CDEV_ARDUINO_WIRE
      Wire.begin();
   #elif I2CDEV_IMPLEMENTATION == I2CDEV_BUILTIN_FASTWIRE
      Fastwire::setup(400, true);
   #endif

   Serial.begin(115200); //Initialize Serial for 8MHz/16MHz

   /* Initialize device and check connection */
   Serial.println("Initializing MPU...");
   mpu.initialize();
   Serial.println("Testing MPU6050 connection...");
   if (!mpu.testConnection()) {
      Serial.println("MPU6050 connection failed");
      while (true);
   } else {
      Serial.println("MPU6050 connection successful");
   }

   /* Use the code below to change accel/gyro offset values */
   Serial.println("Updating internal sensor offsets...\n");
```

```
    mpu.setXAccelOffset(131);
    mpu.setYAccelOffset(185);
    mpu.setZAccelOffset(980);
    mpu.setXGyroOffset(-6677);
    mpu.setYGyroOffset(-1063);
    mpu.setZGyroOffset(-243);
    Serial.print("\t");
    Serial.print(mpu.getXAccelOffset());
    Serial.print("\t");
    Serial.print(mpu.getYAccelOffset());
    Serial.print("\t");
    Serial.print(mpu.getZAccelOffset());
    Serial.print("\t");
    Serial.print(mpu.getXGyroOffset());
    Serial.print("\t");
    Serial.print(mpu.getYGyroOffset());
    Serial.print("\t");
    Serial.print(mpu.getZGyroOffset());
    Serial.print("\n");

    /* Configure board LED pin for output */
    pinMode(LED_BUILTIN, OUTPUT);

    /* Clear EEPROM at the beginning of each test */
    clearEEPROM();
    Serial.println("EEPROM cleared. Starting new test...");
}

void storeDataInEEPROM(int16_t ax, int16_t ay, int16_t az, int16_t gx, int16_t gy, int16_t gz) {
    // Store each value in EEPROM only if space is available
    if (eepromAddress + 12 <= EEPROM.length()) {
        EEPROM.put(eepromAddress, ax); eepromAddress += 2;
        EEPROM.put(eepromAddress, ay); eepromAddress += 2;
        EEPROM.put(eepromAddress, az); eepromAddress += 2;
        EEPROM.put(eepromAddress, gx); eepromAddress += 2;
        EEPROM.put(eepromAddress, gy); eepromAddress += 2;
        EEPROM.put(eepromAddress, gz); eepromAddress += 2;
    } else {
        Serial.println("EEPROM full, data storage stopped.");
    }
}

void sendEEPROMData() {
    // Read and send stored EEPROM data
    for (int i = 0; i < eepromAddress; i += 2) {
        int16_t value;
        EEPROM.get(i, value);  // Retrieve each stored value (2 bytes each)
        Serial.println(value);  // Send each value as a newline-separated list
    }
    Serial.println("End of EEPROM data");  // Indicate the end of data transmission
}

void loop() {
    /* Read raw accel/gyro data from the module */
    mpu.getMotion6(&ax, &ay, &az, &gx, &gy, &gz);

    /* Print the obtained data in the defined format */
    #ifdef OUTPUT_READABLE_ACCELGYRO
        Serial.print("a/g:\t");
        Serial.print(ax); Serial.print("\t");
        Serial.print(ay); Serial.print("\t");
        Serial.print(az); Serial.print("\t");
        Serial.print(gx); Serial.print("\t");
        Serial.print(gy); Serial.println(gz);
    #endif
```

```
    #ifdef OUTPUT_BINARY_ACCELGYRO
        Serial.write((uint8_t)(ax >> 8)); Serial.write((uint8_t)(ax & 0xFF));
        Serial.write((uint8_t)(ay >> 8)); Serial.write((uint8_t)(ay & 0xFF));
        Serial.write((uint8_t)(az >> 8)); Serial.write((uint8_t)(az & 0xFF));
        Serial.write((uint8_t)(gx >> 8)); Serial.write((uint8_t)(gx & 0xFF));
        Serial.write((uint8_t)(gy >> 8)); Serial.write((uint8_t)(gy & 0xFF));
        Serial.write((uint8_t)(gz >> 8)); Serial.write((uint8_t)(gz & 0xFF));
    #endif

    /* Store the IMU data in EEPROM */
    storeDataInEEPROM(ax, ay, az, gx, gy, gz);

    /* Check for a request from MATLAB to send stored EEPROM data */
    if (Serial.available() > 0) {
        char command = Serial.read();
        if (command == 'R') {  // 'R' for Read EEPROM
            sendEEPROMData();
        }
    }

    /* Blink LED to indicate activity */
    blinkState = !blinkState;
    digitalWrite(LED_BUILTIN, blinkState);

    delay(1000);  // Adjust delay to control data sampling rate
}
```

Conclusions/action items:

- **EEPROM**: Can use EEPROM for short tests, but it is limited to about 85 seconds at 1 Hz sampling.
- **SD Card Module**: For extended data logging without a computer connection, an SD card is the best option. It provides much more storage, allowing you to record data for hours or even days at higher sampling rates if needed.

2024/11/12 - Updated MATLAB Code

KAI MCCLELLAN - Nov 12, 2024, 1:01 PM CST

Title: Updated MATLAB Code to read data stored in Arduino Nano's EEPROM storage

Date: 11/12/24

Content by: Kai McClellan

Present: N/A

Goals: N/A

Content:

MATLAB Code:

```
clear;
clc;

% Define the serial port and baud rate (adjust as needed)
serialPort = 'COM6';  % Replace with your Arduino's COM port
baudRate = 115200;    % Ensure this matches the Arduino code

% Create the serial object
serialObj = serialport(serialPort, baudRate);

% Request EEPROM data
writeline(serialObj, 'R');  % Send 'R' command to Arduino

% Initialize arrays to store data
ax = [];
ay = [];
az = [];
gx = [];
gy = [];
gz = [];
counter = 1;

% Read data line-by-line until we reach the end marker
while true
    dataLine = readline(serialObj);

    if strcmp(dataLine, "End of EEPROM data")
        break;  % Stop reading when the end marker is found
    end

    % Convert string to numeric and store in the appropriate array
    value = str2double(dataLine);

    % Use counter to assign each value to the appropriate array
    switch mod(counter - 1, 6) + 1
        case 1
            ax(end + 1) = value;
        case 2
            ay(end + 1) = value;
        case 3
            az(end + 1) = value;
        case 4
            gx(end + 1) = value;
        case 5
            gy(end + 1) = value;
```

```
        case 6
            gz(end + 1) = value;
    end
    counter = counter + 1;
end

% Close the serial port
clear serialObj;

% Number of readings
numReadings = length(ax);

% Plot accelerometer and gyroscope data
figure;
subplot(2,1,1);
plot(1:numReadings, ax, 'r', 1:numReadings, ay, 'g', 1:numReadings, az, 'b');
title('Accelerometer Data');
legend('Ax', 'Ay', 'Az');

subplot(2,1,2);
plot(1:numReadings, gx, 'r', 1:numReadings, gy, 'g', 1:numReadings, gz, 'b');
title('Gyroscope Data');
legend('Gx', 'Gy', 'Gz');
```

Conclusions/action items:

The subplots will display the data of the six individual data components, so this portion might change again after successful testing to obtain 3D graphs of the sensors motion, but the individual subplots may be useful as well to show which plane had the greatest deviation.

2024/11/12 - Possible Code for MATLAB with deviation integration

KAI MCCLELLAN - Nov 12, 2024, 1:03 PM CST

Title: Possible Code for MATLAB with deviation integration

Date: 11/12/24

Content by: Kai McClellan

Present: N/A

Goals: N/A

Content:

```
clear;
clc;

% Define the serial port and baud rate (adjust as needed)
serialPort = 'COM6';  % Replace with your Arduino's COM port
baudRate = 115200;    % Ensure this matches the Arduino code

% Load or define the optimal trial data (replace with your actual data)
optimal_ax = [0, 10, 20, 30, 40];
optimal_ay = [0, -10, -20, -30, -40];
optimal_az = [16384, 16380, 16378, 16385, 16390];
optimal_gx = [0, 5, -5, 10, -10];
optimal_gy = [0, -5, 5, -10, 10];
optimal_gz = [0, 3, -3, 2, -2];

% Create the serial object
serialObj = serialport(serialPort, baudRate);

% Request EEPROM data
writeline(serialObj, 'R');  % Send 'R' command to Arduino

% Initialize arrays to store new trial data
ax = [];
ay = [];
az = [];
gx = [];
gy = [];
gz = [];
counter = 1;

% Read data line-by-line until we reach the end marker
while true
    dataLine = readline(serialObj);

    if strcmp(dataLine, "End of EEPROM data")
        break;  % Stop reading when the end marker is found
    end

    % Convert string to numeric and store in the appropriate array
    value = str2double(dataLine);

    % Use counter to assign each value to the appropriate array
    switch mod(counter - 1, 6) + 1
        case 1
            ax(end + 1) = value;
        case 2
            ay(end + 1) = value;
```

```
        case 3
            az(end + 1) = value;
        case 4
            gx(end + 1) = value;
        case 5
            gy(end + 1) = value;
        case 6
            gz(end + 1) = value;
    end
    counter = counter + 1;
end

% Close the serial port
clear serialObj;

% Ensure trial data and optimal data have the same length
numOptimal = length(optimal_ax);
numTrial = length(ax);

% If lengths are different, truncate or interpolate trial data
if numTrial > numOptimal
    % Truncate if trial data is longer than optimal
    ax = ax(1:numOptimal);
    ay = ay(1:numOptimal);
    az = az(1:numOptimal);
    gx = gx(1:numOptimal);
    gy = gy(1:numOptimal);
    gz = gz(1:numOptimal);
elseif numTrial < numOptimal
    % Interpolate if trial data is shorter than optimal
    xq = linspace(1, numTrial, numOptimal);
    ax = interp1(1:numTrial, ax, xq);
    ay = interp1(1:numTrial, ay, xq);
    az = interp1(1:numTrial, az, xq);
    gx = interp1(1:numTrial, gx, xq);
    gy = interp1(1:numTrial, gy, xq);
    gz = interp1(1:numTrial, gz, xq);
end

% Calculate deviations from optimal values over time
deviation_ax = abs(ax - optimal_ax);
deviation_ay = abs(ay - optimal_ay);
deviation_az = abs(az - optimal_az);
deviation_gx = abs(gx - optimal_gx);
deviation_gy = abs(gy - optimal_gy);
deviation_gz = abs(gz - optimal_gz);

% Identify the time point with the largest deviation for each axis
[max_dev_ax, time_ax] = max(deviation_ax);
[max_dev_ay, time_ay] = max(deviation_ay);
[max_dev_az, time_az] = max(deviation_az);
[max_dev_gx, time_gx] = max(deviation_gx);
[max_dev_gy, time_gy] = max(deviation_gy);
[max_dev_gz, time_gz] = max(deviation_gz);

% Display the largest deviations
disp(['Max deviation for Ax: ', num2str(max_dev_ax), ' at time ', num2str(time_ax)]);
disp(['Max deviation for Ay: ', num2str(max_dev_ay), ' at time ', num2str(time_ay)]);
disp(['Max deviation for Az: ', num2str(max_dev_az), ' at time ', num2str(time_az)]);
disp(['Max deviation for Gx: ', num2str(max_dev_gx), ' at time ', num2str(time_gx)]);
disp(['Max deviation for Gy: ', num2str(max_dev_gy), ' at time ', num2str(time_gy)]);
disp(['Max deviation for Gz: ', num2str(max_dev_gz), ' at time ', num2str(time_gz)]);

% Plot deviation data over time
numReadings = length(ax);
```

```
figure;
subplot(2,1,1);
plot(1:numReadings, deviation_ax, 'r', 1:numReadings, deviation_ay, 'g', 1:numReadings, deviation_az, 'b');
title('Deviation from Optimal Accelerometer Data');
legend('Deviation Ax', 'Deviation Ay', 'Deviation Az');

subplot(2,1,2);
plot(1:numReadings, deviation_gx, 'r', 1:numReadings, deviation_gy, 'g', 1:numReadings, deviation_gz, 'b');
title('Deviation from Optimal Gyroscope Data');
legend('Deviation Gx', 'Deviation Gy', 'Deviation Gz');
```

Conclusions/action items:

This code should be able to take a set of "optimal" data and compare it to the data recorded from each trial stored in the Arduino's EEPROM

2024/11/15 - Note of shield breadboard for Arduino

KAI MCCLELLAN - Nov 15, 2024, 6:40 PM CST

Title: Arduino Shield for Arduino Nano

Date: 11/15/24

Content by: Kai McClellan

Present: Jackson Jarret

Goals: N/A

Content:

- shield is a smaller breadboard that connects to the top of the Arduino to make the components much smaller. Possible to make future prototype much smaller

Conclusions/action items:

It will probably not be purchased this semester due to time constraints, but it will be placed into future work in the event that this project gets carried out further.

2024/9/11 Lecture 1

KAI MCCLELLAN - Sep 11, 2024, 1:54 PM CDT

Title: Lecture 1 Notes

Date: 9/11/24

Content by: Kai McClellan

Present: Jackson Jarret

Goals: Discuss CO-OP opportunities, job search tips, etc.

Content:

- Keep track of what you do - ECS tracking sheet (ecs.wisc.edu)
- Quality of source matters (Handshake, LinkedIn, Indeed...)
- Think beyond the title: focus on skills, industry, exposure
- Connect BEFORE you are a candidate
    - all connections are good connections

Resume Tips

- Tailor your resume to the position - quick changes
    - ex: project experiences, emphasize portions relevant to the job
- Create balance - show a full picture of your experience
- Use MS Word - ATS proofed
- no columns, charts, colors
- Design projects WITHOUT years/semesters - what did you do?
- Technical skills and coursework
- Jobs - Organization + location, Position title + Dates

Cover Letter Tips

- ALWAYS based on the job position, custom to each job, not required for career fair

Career Fair Advice for BME

- Identify your purpose - more than just an internship
- Looking beyond the obvious - overlap with other disciplines
- Research the employer - feedback from our partners
- Develop your "added value" statement - why you?
- Sell yourself, don't go in with the deficit model "I know I'm not the perfect fit, but..."

Different employers on each day!

Conclusions/action items:

Modify your resume, don't sell yourself short.

Look at job roles, look at ANYTHING relevant, not the perfect job.

2024/9/18 - Lecture 2

KAI MCCLELLAN - Sep 18, 2024, 2:02 PM CDT

Title: Leadership Styles

Date: 9/18/24

Content by: Angela Kita

Present: BME 300

Goals: Learn important values and characteristics related to leadership and the many ways it can be represented.

Content:

- Three examples of styles of leadership
  - Power model
    - Great man theory - only certain people are born to lead
    - being in control is the most important thing
    - "Someone has to take control here, and it should be me"
    - Appears as a hierarchy/command
  - Servant Model
    - "It's not about me and my needs, the needs of my followers are most important"
    - Qualities: Being of service to others
    - sharing power
    - listening and understanding
    - Appears as empathetic, empowering, and shared decision making
  - Authentic model
    - "By being my genuine self, I will gain and build trust"
    - Qualities: Building self-esteem and self-awareness
    - honesty and transparency
    - genuineness
- People-Oriented leader
  - glue that holds the team together, skilled at trust
- process-oriented leader
  - Set the pace for the team, create systems
- Thought-oriented leader
  - looks into the future, big picture ideas
- impact-oriented leader
  - sets the bar high and motivates for the best possible performance

How do you want to lead?

- Self-Assess
  - what you enjoy, what you're good at, what drives you
- Observe and Reflect
  - What tasks and experiences give you a sense of accomplishment? Where do you show up well? How do you get in your way?
- Feedback
  - Where do you succeed most? Where do you fail most? What's the best way to improve?

Conclusions/action items:

My goals:

Team Goal - I want my team to function in an authentic and powerful model. I think that these options are good for a team where half of us have more experience than the other half, but we still want overall success as a team and individually, so being honest and transparent about situations and processes is essential to ensure the best for the team. I can contribute to this by being the thought-oriented and impact-oriented leader I am, laying out the future, and motivating everyone to do their absolute best.

Self-Goal - I want to develop more adaptability and time management because these are the two most detrimental qualities in a team setting. A chain is only as strong as its weakest link, so if one person is behind or fails to accommodate their personal lives, it inevitably sets the entire team behind. I am practicing this by writing more things down

2024/9/25 - Lecture 3

KAI MCCLELLAN - Sep 25, 2024, 2:09 PM CDT

Title: BME Advising Lecture Part III: Fall Post Graduation Planning

Date: 9/25/24

Content by: Kai McClellan

Present: BME 300

Goals: Gain an understanding of good tips for students looking to expand their experience after undergraduate school.

Content:

- **Writing your story**
  - **Leave out personal topics on cover letter/ personal statement**
  - **Start with what you want to do**
  - **say narrow experiences and how they apply to your broad interest**
    - **specific to each position or place which you apply**
- **Personal statement: show a reasonable idea of what**
  - **you achieved at University X**
  - **what you want afterwards**
  - **name the faculty there who are in your field of interest**
- **Options**
  - **Masters, MS**
    - **steppingstone/change directions/gain depth/expand credentials for future**
      - **medical school**
      - **PhD programs**
    - **Industry focused**
    - **Generally, ONE YEAR**
    - **Reasons:**
      - **rewrite your story**
      - **MD: need time to prep for MCAT or apply for med schools**
      - **PhD: cannot find a foundering**
    - **MS will make you more desirable**
      - **Fill gaps in your resume**
      - **Higher level of skills - teaching, mentoring, research thesis**
      - **Older, more maturity**
    - **Apply online, deadline of 12/5, no letters of recommendation needed**
    - **need 3.0 overall or 3.0 in last 60 credits**
  - **Doctoral, PhD**
    - **Desire to be an independent researcher**
    - **Write research grants**
    - **Work in academia**
    - **Lead projects in industry, startups, and consulting**
- **Do your Homework/Research!!**
  - **Follow your passion**
  - **Network**
  - **Conferences, conferences, conferences!!!**
  - **Utilize your lab PI here at Madison = Collaborators**
  - **Build your resume/CV**
  - **Research is a must**
- **NSF GRFP**

Conclusions/action items:

KAI MCCLELLAN - Nov 06, 2024, 5:56 PM CST

Conclusion:

This lecture was very beneficial to me because I was on the fence about which graduate level education I wished to pursue. As a first-generation student, I know very little about how any graduate level education works and frequently feel lost and don't know to talk to about research opportunities, summer jobs, and other things that will help with finding a career job. These lectures definitely help with this.

2024/10/02 - Lecture 4

KAI MCCLELLAN - Oct 02, 2024, 2:09 PM CDT

Title: BME 300 Lecture 4

Date: 10/02/24

Content by: Kai McClellan

Present: BME 300

Goals: Understand the importance of mentoring in the BME department

Content:

Why do we mentor the 200s?

- Design support
- emotional support
- Leadership skills
- Communication
- Break the ice for students who are just fully getting into BME

Benefits

- mentoring boosts self-esteem and confidence and patience
- build positive habits
- foster personal growth
- identify gaps in knowledge

What makes a good mentor?

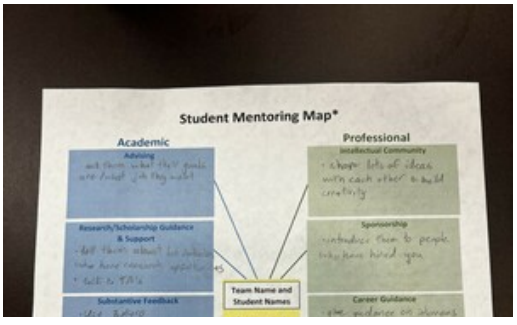
- Building trust
- psychological safety
- reliability
- support/enthusiasm
- being available
- transparency
- humanizing their challenges
- good listening

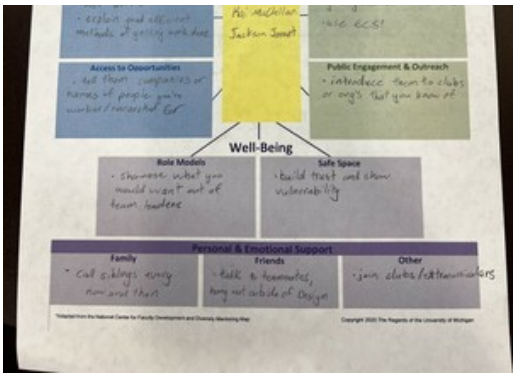
List of topics, resources, advice, etc. that I wish I knew in BME 200

- Don't be afraid to speak out about troubles or emotions
- Use Zotero for citations
- Work hard to develop strong connections with your group, they can be really great resources later on

Conclusions/action items:

KAI MCCLELLAN - Oct 02, 2024, 2:10 PM CDT





Download

mentor_map.jpg (589 kB)

KAI MCCLELLAN - Nov 06, 2024, 5:52 PM CST

Conclusion:

Mentoring is very important in any department, but this is especially true in BME. If I had gotten more mentorship in my first year in BME I think my transition would have been more seamless than it actually was. This lecture has led me to keep an open mind with the 200s in my design group to give them as much guidance as I can.

2024/10/9 - Lecture 5

KAI MCCLELLAN - Oct 09, 2024, 2:05 PM CDT

Title: Lecture 5

Date: 10/9/24

Content by: Kai McClellan

Present: BME 300

Goals: Explore sustainability and its importance in engineering and how to apply it to our projects

Content:

- What is sustainability? Why do I care as an engineer?
    - Circular economy
        - Keep things out of the landfill, keep things recycled in the economy going from consumer to user
        - Fix one thing, something else happens. A constant game of whack-a-mole
        - Life cycle Assessments - Calculation that leads to carbon footprint
            - Resources, Conservation, and Recycling
- Brainstorming
    - make weightlifting clip recyclable
    - Use recyclable circuitry components
    - Use the device to fight obesity in America

Conclusions/action items:

Think carefully when fabricating and designing about what environmental impacts exist by using certain materials, where the materials come from/their environmental impacts, etc.

2024/10/16 - Lecture 6

KAI MCCLELLAN - Oct 16, 2024, 2:19 PM CDT

Title: BME 300 Lecture 6

Date: 10/16/24

Content by: Kai McClellan

Present: BME 300

Goals: Learn about patenting, WARF, IP, and licensing

Content:

- **WARF**
  - **Mission -** support scientific research at UW Madison by providing financial support, managing assets, and moving innovations to the marketplace
  - **Technology Transfer:** moving research results from campus out into the market, facilitating securing IP rights and commercial licenses
    - ex: intellectual property licenses, industry-sponsored research, consulting arrangements, fee for service
      - **Types of IP:** Patents, Copyrights, Trademarks, Trade Secrets
        - **WARF specific:** Biomaterials, Technique and know-how, data
        - **Copyrights:** Protection for creative works that are expressed in a tangible medium. Cover wide range of subject matter, including software code
        - **Trademarks:** Protection for names, marks, logos, dress, etc. Requires use in commerce. Source-identifying function
        - **Trade Secrets:** Can be used to protect anything of value. Protection is good so long as the concept is not generally known.
        - **Patents:** Property rights granted by a government agency. 3 types, Design, plant, and utility.
          - Requirements: Must be eligible (not found in nature), must be new, and must not be a combination of other existing inventions.
      - **Disclosing Innovation to WARF:** Describe the innovation, identify its advantages and potential applications, and name contributors.
        - IP considerations: Types, potential breadth and strength of IP protection, public disclosure, stage of development
        - Licensing considerations: Applications, likelihood of identifying a commercial partner, likely return from licensing
      - **Value of Licensing**:
        - **Benefits to the company**: reduced R&D costs, improved time to market, the opportunity to enter new markets and expand your company quickly, new features or products provided additional revenue opportunities
    - **Ai and IP:** Can Ai invent? (no)
      - Can it assist in inventing? (yes) under Pannu Factors

Conclusions/action items:

KAI MCCLELLAN - Nov 06, 2024, 5:39 PM CST

Conclusion:

Understanding how patents and other forms of licensing work is very valuable information for someone who aims to attain one of these in their engineering career. Whether or not it happens is one thing, but being prepared and informed on the subject puts me in a good position if it comes.

2024/10/23- Lecture 7

Jackson Jarrett - Oct 24, 2024, 1:35 PM CDT

Title: Basics of Human Participants Research Requirements (IRB)

Date: 10/23/24

Content by: Kai McClellan

Present: BME 300

Goals: Understand the requirements, what they mean to me, and how to learn more.

Content:

- **IRB - Institutional Review Board**
  - conducts ethical and regulatory reviews of human research
- **Infamous studies:** WWII Nazi prisoner experiments--Nuremberg Trials-- 1947 Nuremberg Code
- **Institutional Review Boards**
  - Instituted by Common Rule and FDA regulations
  - Review research studies to ensure they meet regulatory codes and standards
- **UW Madison:**
  - **Minimal Risk IRB** - Biomedical, Education, Social/Behavioral research.
    - Secondary analysis of data, survey research
  - **Health Sciences IRB** - Biomedical, interventional, any risk level
    - All FDA-regulated and VA-regulated research
- **Does my project need IRB review?**
  - Is it research under the **Common Rule?**
    - **Research** means a systematic investigation, including research development, testing, and evaluation, designed to develop or contribute to generalizable knowledge
  - Does it involve **human subjects**?
    - Obtains information or biospecimens through intervention or interaction, and uses, studies, or analyzes information or biospecimens
    - Or obtains/uses/studies/analyzes/generates identifiable private information or identifiable biospecimens
  - Is it human research under **FDA device regs**?
    - Device - intended to diagnose, treat, prevent disease, or affect structure/function of the body
    - Research
    - Sample
- **Preparing for IRB review**
  - Complete required training for researchers through CITI
  - Complete annual Outside Activities Reports
  - Develop a Research Plan
    - Identify appropriate Principal investigator and study team
    - Consider participants
    - Consult the FDA-regulated research oversight Program at UW if looking at device safety/effectiveness
    - develop a research question and steps to answer it
    - Collect preliminary data and background information
- **What IRB application will you need?**
  - UW electronic submission system **ARROW**
  - Basic types: **Protocol - based** and **Non - Protocol based**
  - **PBA components:** Protocol document, informed consent form(s), recruitment tools, screening scripts, written assessments
- Resources:
  - IRB website

Conclusions/action items:

This lecture highlighted the importance of ethical principles born from unethical research experiments in the past. The speaker explained which types of IRBs are available at UW-Madison. The characteristics for when a project needs IRB review were also established and defined. She spoke about

how to prepare for an IRB review and all of the pieces necessary to apply for IRB reviews. The review steps were also explained, detailing what could be spoken about during the meeting and any pre-review items needed.

2024/10/30 - Lecture 8

KAI MCCLELLAN - Oct 30, 2024, 2:12 PM CDT

Title:

Date:

Content by: Kai McClellan

Present: BME 300

Goals: Understand FDA Device Regulations to navigate while testing and prototyping.

Content:

- **Medical Device:** Anything intended to improve the health or structure of the body without chemical influence.
  - FDA regulates both traditional and non-traditional medical devices
  - FDA recently made laboratory use mandatory to meet FDA requirements, causing chaos in labs
  - **Applicable FDA Regulations:**
    - Labeling(Part 801)
    - Quality Systems Regulations(Part 820)
    - Medical Devices Reporting(Part 803)
    - Premarket Approval of med. dev. and humanitarian Use
  - **Device Classification Overview**
    - Class I: low risk, exempt from premarket approval(band-aids, floss)
    - Class II: moderate risk, 510(k) showing substantial equivalence(BP cuffs, sutures, catheters)
    - Class III: Highest risk, Premarket Approval (hip joint, pacemaker, replacement heart valve)
  - **Regulatory Controls Key elements**
    - **General controls**
      - registration and listing
      - adverse event reporting
      - general labeling
      - good manufacturing practice
        - design controls
        - document management
        - Production and process controls
        - management responsibility
    - **Special Controls**
      - Performance standards
      - special labeling requirements
      - post-market surveillance
      - potential data requirements
    - **Premarket Approval**
      - data to show safety and effectiveness
  - Market Submission types
    - 510(k) exempt
      - registration and listing only
    - 510(k) - premarket Notification
      - substantial equivalence
    - PMA - Premarket approval
      - Full safety and effectiveness submission
      - manufacturing details
    - De Novo Classification
      - Novel medical devices, no legally marketed predicate

www.accessdata.fda.gov

Conclusions/action items:

The speaker provided very helpful insight into the FDA guidelines, and I intend to use these guidelines when finalizing my design PDS and fabrication protocols.

2024/11/6 - Lecture 9

Jackson Jarrett - Nov 08, 2024, 12:03 PM CST

Title: Framework Guiding Advanced Therapeutic Product Development

Date: 11/6/24

Content by: Professor William Murphy and Cathy Rasmussen

Present: BME 300

Goals: Understand structure of FDA, including laws, regulations, guidelines, and science/engineering career opportunities

Content:

- **FDA Structure:**
  - **Device (CDRH)**
    - PMA - premarket approval
    - 510(k)
    - IDE - Device exemption
  - **Drug (CDER)-Center for drug engineering and research**
    - NDA - New drug application
    - IND - Investigational new drug application
  - **Biologic (CBER)-Center for biological engineering and research**
    - BLA - biologic license agreement
    - IND - Investigational new drug application
  - **Drug vs. Biologic**: Drugs are synthetic, biologics are living things or made by living things
- **FDA Framework from top to bottom**
  - **U.S. Laws made by Congress**
  - **Regulations (CFR Title 21) made by FDA based on laws**
  - **FDA Guidance made with help from public to help industry and the public to interpret regulations**
    - Guidance is helpful because it prevents companies from paying lots of money for clinical trials that aren't FDA approved and also helps speedrun clinical trial process so that researchers can get through trials before they run out of money
- **Implications for HCT/Ps** (Human cell and tissue-based products) **351 vs. 361**
  - **361 -** minimally manipulated, low regulations compared to 351
    - demineralized bone, tendons/ligaments
  - **351** - not minimally manipulated, requires more regulation.
    - taking out a gene and manipulating it to change the performance of a protein and putting it back into the body
- **Target Product Profile**
  - **Product Development Life Cycle**
    - Extremely important to be able to distinguish between studies that are "on the critical path" vs. "Good Research Products"
  - Need Patient Identification, Patient benefits, patient risks
  - **Core**
    - Indication and patients
    - efficacy
    - Safety
    - Dose and regimen
    - route of administration
    - dose form
  - **Clinical Development Planning**
    - Clinical pathway
    - regulatory pathway
    - timelines
    - cost
    - risk
  - **CMC (qTPP : Quality TPP)**
    - Product attributes
      - purity
      - degradants

        - biocompatibility
    - Storage
    - Stability
    - Container
    - Pharmaceutical compliance
- **Quality management System Implementation**
    - **Must think about:**
        - Materials/Input
        - Expansion process/output
        - Monitoring and contamination
        - System
        - Machine/hardware/software
        - Up and down stream process
        - People
- **Career Options within a regulated Environment**
    - Characterization and Analytics
    - Process Development
    - Manufacturing Process
    - Gene delivery

Conclusions/action items:

The information was very valuable for understanding how to process through biological development which is very specific to my desired career path

2024/11/13 - Lecture 10

KAI MCCLELLAN - Nov 13, 2024, 2:11 PM CST

Title: Medical Device Innovation from Prototype to Commercial Clinical Use

Date: 11/13/24

Content by: Kai McClellan

Present: BME 300

Goals: Understand the strategies behind navigating from design and testing into commercial production and market sales

Content:

- **Medical Device FDA Pathways**
  - Class I, Class II, Class III
    - premarket approval increases with specifications as the device class increases
    - if you can get your device to fall into a lower category, the less hoops you have to jump through to meet regulations and get approval
  - If the FDA asks a question within the premarket approval period, the time until approval will reset
- **Reimbursement, Financial incentive, Sales**
  - CPT codes implemented to describe usage of devices and whether or not reimbursement will be issued after particular uses
  - Followed by CMS National insurance decisions, Standards of practices, then you determine National/Regional buying groups which funnels down to Regional/local IDN's or hospitals, then down to the hospital/IDN value analytics groups where they do product evaluations. From there, you establish product distribution terms and can finally provide product implementation into the field.
  - Hospital adoption processes depend on many factors including what they may be trying to market (top in cancer care for example) and will contract technology, tools, and devices accordingly
    - other factors include leading fields, necessities of desired employees, demand of technology in region

Conclusions/action items:

It's very important to know what your biggest clients will be by understanding what certain hospitals and regions are in highest demand of your technology.

2024/11/15 - Tong Lecture

KAI MCCLELLAN - Nov 15, 2024, 12:49 PM CST

Title: Fall Tong Lecture

Date: 11/15/24

Content by: Kai McClellan

Present: BME Department

Goals: Learn the basics of entrepreneurship in BME

Content:

- Inspiration behind LASSO
  - realized that everything would eventually be done at home
  - Went to UW Law and Entrepreneurship Clinic to attain Patent, get logistics of device, etc.
- Advice
  - Get scrappy with funding opportunities - SBIR grants
    - DARPA, NIH are good places to look
  - First prototype was roughly 25 dollars, got a grant from that design for a few thousand dollars
  - Find a key customer
  - aim to solve one specific problem and focus on that, particularly something that is applicable to a large enough crowd for potential for customers
- Scaling up - lessons in quality, culture, and HR
  - quality is key. One bad customer experience can ruin traction
- FDA
  - Read the labels - easy to over analyze what regulators say they "want" to do
    - definition and characteristics of devices can be worked around to lower the number of hoops you have to jump through
    - can take a Class II device and change it to be a Class I device

Conclusions/action items:

Tasso - Italian for Badger.

2024/11/20 - Lecture 12

KAI MCCLELLAN - Nov 20, 2024, 1:35 PM CST

Title: How New Product Development Works at Most Medical Device Companies

Date: 11/20/24

Content by: Kai McClellan

Present: BME 300

Goals: Get detailed information about the logistics and framework of Product Development in the medical field

Content:

- **Introduction**
  - Highly regulated
  - expensive
  - Resource intense
  - Competitive
- **Strategy - Annual Process**
  - Define how a business will sustain itself over the next 3-5 years
  - Define which product categories to develop, sustain, and eliminate
  - Select and prioritize projects to support over the next 1-3 years
  - Allocate budget and resources based on project prioritization
- **Types of NPD Projects**
  - Line Extensions: addition of additional sizes and configurations
  - Product Improvements: Existing product change due to market feedback and/or new customer needs
  - New-to-company: Product line that is not new to market but is new for the company
  - New-to-world: Product line that is new to the market and new to the company
- **Stage-Gate Process**
  - Stage 0 - Ideation: brainstorming
  - Stage 1 - Exploration: lowering down to a few ideas
  - Stage 2 - Concept development: Begin making blueprint designs
  - Stage 3 - Design Development:
  - Stage 4 - Design configuration
  - Stage 5 - Design Transfer and Commercialization
  -

Conclusions/action items:

2024/11/12 - Possible Code for MATLAB with deviation integration

KAI MCCLELLAN - Nov 15, 2024, 6:58 PM CST

Title: Possible Code for MATLAB with deviation integration

Date: 11/12/24

Content by: Kai McClellan

Present: N/A

Goals: N/A

Content:

```
clear;
clc;

% Define the serial port and baud rate (adjust as needed)
serialPort = 'COM6';  % Replace with your Arduino's COM port
baudRate = 115200;    % Ensure this matches the Arduino code

% Load or define the optimal trial data (replace with your actual data)
optimal_ax = [0, 10, 20, 30, 40];
optimal_ay = [0, -10, -20, -30, -40];
optimal_az = [16384, 16380, 16378, 16385, 16390];
optimal_gx = [0, 5, -5, 10, -10];
optimal_gy = [0, -5, 5, -10, 10];
optimal_gz = [0, 3, -3, 2, -2];

% Create the serial object
serialObj = serialport(serialPort, baudRate);

% Request EEPROM data
writeline(serialObj, 'R');  % Send 'R' command to Arduino

% Initialize arrays to store new trial data
ax = [];
ay = [];
az = [];
gx = [];
gy = [];
gz = [];
counter = 1;

% Read data line-by-line until we reach the end marker
while true
    dataLine = readline(serialObj);

    if strcmp(dataLine, "End of EEPROM data")
        break;  % Stop reading when the end marker is found
    end

    % Convert string to numeric and store in the appropriate array
    value = str2double(dataLine);

    % Use counter to assign each value to the appropriate array
    switch mod(counter - 1, 6) + 1
        case 1
            ax(end + 1) = value;
        case 2
            ay(end + 1) = value;
```

```
        case 3
            az(end + 1) = value;
        case 4
            gx(end + 1) = value;
        case 5
            gy(end + 1) = value;
        case 6
            gz(end + 1) = value;
    end
    counter = counter + 1;
end

% Close the serial port
clear serialObj;

% Ensure trial data and optimal data have the same length
numOptimal = length(optimal_ax);
numTrial = length(ax);

% If lengths are different, truncate or interpolate trial data
if numTrial > numOptimal
    % Truncate if trial data is longer than optimal
    ax = ax(1:numOptimal);
    ay = ay(1:numOptimal);
    az = az(1:numOptimal);
    gx = gx(1:numOptimal);
    gy = gy(1:numOptimal);
    gz = gz(1:numOptimal);
elseif numTrial < numOptimal
    % Interpolate if trial data is shorter than optimal
    xq = linspace(1, numTrial, numOptimal);
    ax = interp1(1:numTrial, ax, xq);
    ay = interp1(1:numTrial, ay, xq);
    az = interp1(1:numTrial, az, xq);
    gx = interp1(1:numTrial, gx, xq);
    gy = interp1(1:numTrial, gy, xq);
    gz = interp1(1:numTrial, gz, xq);
end

% Calculate deviations from optimal values over time
deviation_ax = abs(ax - optimal_ax);
deviation_ay = abs(ay - optimal_ay);
deviation_az = abs(az - optimal_az);
deviation_gx = abs(gx - optimal_gx);
deviation_gy = abs(gy - optimal_gy);
deviation_gz = abs(gz - optimal_gz);

% Identify the time point with the largest deviation for each axis
[max_dev_ax, time_ax] = max(deviation_ax);
[max_dev_ay, time_ay] = max(deviation_ay);
[max_dev_az, time_az] = max(deviation_az);
[max_dev_gx, time_gx] = max(deviation_gx);
[max_dev_gy, time_gy] = max(deviation_gy);
[max_dev_gz, time_gz] = max(deviation_gz);

% Display the largest deviations
disp(['Max deviation for Ax: ', num2str(max_dev_ax), ' at time ', num2str(time_ax)]);
disp(['Max deviation for Ay: ', num2str(max_dev_ay), ' at time ', num2str(time_ay)]);
disp(['Max deviation for Az: ', num2str(max_dev_az), ' at time ', num2str(time_az)]);
disp(['Max deviation for Gx: ', num2str(max_dev_gx), ' at time ', num2str(time_gx)]);
disp(['Max deviation for Gy: ', num2str(max_dev_gy), ' at time ', num2str(time_gy)]);
disp(['Max deviation for Gz: ', num2str(max_dev_gz), ' at time ', num2str(time_gz)]);

% Plot deviation data over time
numReadings = length(ax);
```

```
figure;
subplot(2,1,1);
plot(1:numReadings, deviation_ax, 'r', 1:numReadings, deviation_ay, 'g', 1:numReadings, deviation_az, 'b');
title('Deviation from Optimal Accelerometer Data');
legend('Deviation Ax', 'Deviation Ay', 'Deviation Az');

subplot(2,1,2);
plot(1:numReadings, deviation_gx, 'r', 1:numReadings, deviation_gy, 'g', 1:numReadings, deviation_gz, 'b');
title('Deviation from Optimal Gyroscope Data');
legend('Deviation Gx', 'Deviation Gy', 'Deviation Gz');
```

Conclusions/action items:

This code should be able to take a set of "optimal" data and compare it to the data recorded from each trial stored in the Arduino's EEPROM

2024/9/19 - FDA Regulations for Fitness Software

KAI MCCLELLAN - Nov 15, 2024, 6:59 PM CST

Title: FDA Regulations for Fitness Software

Date: 9/19/24

Content by: Kai McClellan

Present: N/A

Goals: Understand the regulations of non-invasive medical tools that are not considered a device

Content:

Examples of Software Functions That Are NOT Medical Devices | FDA

1. **Software functions that are intended for individuals to log, record, track, evaluate, or make decisions or behavioral suggestions related to developing or maintaining general fitness, health or wellness**, such as those that:
    - Provide tools to promote or encourage healthy eating, exercise, weight loss, or other activities generally related to a healthy lifestyle or wellness;
    - Provide dietary logs, calorie counters, or make dietary suggestions;
    - Provide meal planners and recipes;
    - Track general daily activities or make exercise or posture suggestions;
    - Track a normal baby's sleeping and feeding habits;
    - Actively monitor and trend exercise activity;
    - Help healthy people track the quantity or quality of their normal sleep patterns;
    - Provide and track scores from mind-challenging games or generic "brain age" tests;
    - Provide daily motivational tips (for example, via text or other types of messaging) to reduce stress and promote a positive mental outlook;
    - Use social gaming to encourage healthy lifestyle habits; and
    - Calculate calories burned in a workout.
2. General Wellness: Policy for Low Risk Devices | FDA
    1. FD&C Act. Section 520(o)(1)(B) of the FD&C Act, states that software that is intended "for maintaining or encouraging a healthy lifestyle and is unrelated to the diagnosis, cure, mitigation, prevention, or treatment of a disease or condition" is not a device under section 201(h) of the FD&C Act.
    2. If a product is a device under section 201(h) of the FD&C Act, it is generally excluded from CPSC's authority over "consumer products" under the Consumer Product Safety Act

Conclusions/action items:

KAI MCCLELLAN - Nov 15, 2024, 6:59 PM CST

1. Identification. A diagnostic electromyograph is a device intended for medical purposes, such as to monitor and display the bioelectric signals produced by muscles, to stimulate peripheral nerves, and to monitor and display the electrical activity produced by nerves, for the diagnosis and prognosis of neuromuscular disease.

    CFR - Code of Federal Regulations Title 21 (fda.gov)

    (b) Classification. Class II (performance standards).

KAI MCCLELLAN - Nov 15, 2024, 6:59 PM CST

1. Sec. 890.1925 Isokinetic testing and evaluation system.

    (a) Identification. An isokinetic testing and evaluation system is a rehabilitative exercise device intended for medical purposes, such as to measure, evaluate, and increase the strength of muscles and the range of motion of joints.

(b) Classification. Class II (special controls). The device is exempt from the premarket notification procedures in subpart E of part 807 of this chapter subject to § 890.9.

CFR - Code of Federal Regulations Title 21 (fda.gov)

1. It is considered noninvasive testing and therefore does not need premarket approval and is exempt from Section 510(k)

Accelerometer

Jackson Jarrett - Sep 28, 2024, 7:25 PM CDT

Title: Accelerometer

Date: 9/28/24

Content by: Jackson

Goals: To perform research on a device that we will likely use in order to track the motion path of the barbell. We will likely take the acceleration data, and then derive this data to find the position values. Once this coordinate system is applied, we will have a line of best fit that we can track.

Content:

- **Purpose**: Accelerometers measure acceleration, the rate of change in velocity, often used to detect orientation, motion, or vibration.
- **Units of Measurement**: Typically measured in meters per second squared (m/s^2) or g-forces (g), where 1 g = 9.8 m/s^2.
- **Types**:
  - Single-axis: Measures acceleration in one direction.
  - Multi-axis: Often 3-axis accelerometers, which can track movement in multiple dimensions (x, y, z).
- **Use Cases**: Found in devices like smartphones, game controllers, vehicles, and fitness trackers for detecting orientation, movement, or impacts.
- **How it Works**: Accelerometers detect changes in capacitance, piezoelectric effect, or resonant frequency as the device moves, converting these into readable electrical signals.

Conclusions/action items:

We will look to order this device, and in the meantime we will focus on the development of a way to house this technology.

Arduino Nano

Jackson Jarrett - Oct 03, 2024, 8:02 PM CDT

Title: Arduino Nano

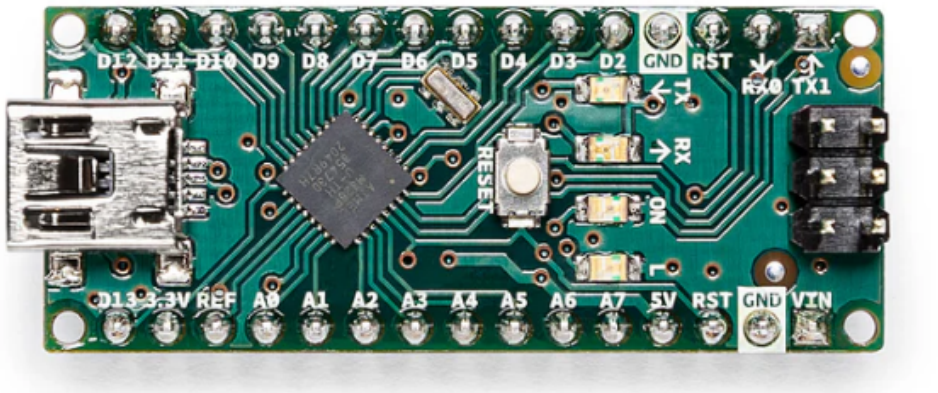
Date: 10/3/2024

Content by: Jackson

Goals: To document the necessary specs on this technology as we will move forward with using this to collect data in our coordinate system

Content:

Microcontroller	ATmega328
Architecture	AVR
Operating Voltage	5 V
Flash Memory	32 KB of which 2 KB used by bootloader
SRAM	2 KB
Clock Speed	16 MHz
Analog IN Pins	8
EEPROM	1 KB
DC Current per I/O Pins	20 mA (I/O Pins)
Input Voltage	7-12V
Digital I/O Pins	22 (6 of which are PWM)
PWM Output	6
Power Consumption	19 mA
PCB Size	18 x 45 mm
Weight	7 g
Product Code	A000005



Conclusions/action items:

We will order two of these Arduino Nanos, and then begin the coding process of connecting these with the IMU technology.

MPU6050

Jackson Jarrett - Nov 14, 2024, 7

Title: The MPU6050

Date: 10/3/24

Content by: Jackson

Goals: To research this technology and determine how we will be utilize it to accomplish our goal, a coordinate system

Content:

- **MPU-6050 Overview**: The MPU-6050 sensor integrates a 3-axis accelerometer and 3-axis gyroscope, allowing measurement of angular velocity and acceleration. It communicates via th protocol.
- **Components Needed**:
  - AVR microcontroller (e.g., ATmega16/32) (Arduino will still be able to be used)
  - MPU-6050 sensor module
  - Pull-up resistors for I2C lines (SCL and SDA)
  - Wires and power supply
- **Connection Setup**:
  - Connect MPU-6050 VCC to 3.3V or 5V - **5V will be used to power Arduino and MPU**
  - Connect MPU-6050 GND to ground
  - SCL and SDA pins of MPU-6050 connect to the respective I2C lines on the MCU
  - Optional: AD0 pin for changing the I2C address (default is 0x68)
- **Software and Libraries**:
  - Use the Wire library to enable I2C communication.
  - Specific libraries like `MPU6050_tockn.h` simplify working with the sensor.
- **Code**:
  - Initialize I2C communication and set up the MPU-6050.
  - The sensor's data (e.g., acceleration, gyroscope readings, angles) can be printed to a serial monitor.
- **Applications**: The sensor is useful in projects involving motion tracking, like robotics or drones, due to its ability to capture real-time data on orientation and movement.

Conclusions/action items:

- The MPU6050 is the technology that we will move forward with to track the movement of the barbell. This accelerometer is perfect for what we will need as a group, and this data will be accessible via Arduino and MATLAB. Once we have this coordinate data, we will be able to display this data.
- **Future coding research link**: https://howtomechatronics.com/tutorials/arduino/arduino-and-mpu6050-accelerometer-and-gyroscope-tutorial/
- **Amazon link to purchase**: https://www.amazon.com/HiLetgo-MPU-6050-Accelerometer-Gyroscope-Converter/dp/B01DK83ZYQ/ref=asc_df_B01DK83ZYQ/?tag=hyprod-20&linkCode=df0&hvadid=692875362841&hvpos=&hvnetw=g&hvrand=6933687929426745630&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9018941&hvtarg 2281435178298&mcid=ff412b8531213b0da2b176b9dfaef599&hvocijid=6933687929426745630-B01DK83ZYQ-&hvexpln=73&th=1

Citation:

[1] RudraNarayanG, "MPU 6050 Gyro,Accelerometer Communication With Arduino (Atmega328p)," Instructables. Accessed: Oct. 03, 2024. [Online]. Available: https://www.instructables.com/Ac MPU-6050-Communication-With-AVR-MCU/

The Bench Press Exercise

Jackson Jarrett - Sep 28, 2024, 7:37 PM CDT

Title: The Bench Press

Date: 9/28/24

Content by: Jackson

Goals: To research an overview of the bench press exercise

Content:

- **Exercise Overview**:
  - Multi-joint upper body exercise used to strengthen the chest, anterior shoulder girdle, and elbow extensors.
  - A basic lift in competitive powerlifting alongside the squat and deadlift.
  - Suitable for both athletes and non-athletes, often used as a test of strength, power, and endurance.
  - Relatively easy to learn, commonly taught in initial strength programs.
- **Muscle Activation**:
  - Key muscles: pectoralis major, anterior deltoid, serratus anterior, pectoralis minor, coracobrachialis, triceps brachii.
  - Study showed significant activation of the latissimus dorsi when lifting 70%-100% of 1RM.
- **Technique**:
  - Two-phase exercise: downward lowering (eccentric) and upward pushing (concentric).
  - Proper alignment: head, shoulders, and hips stay on the bench; feet firmly on the floor.
  - Grip: pronated overhand grip, hands slightly wider than shoulder width.
- **Safety**:
  - Spotters assist with removing/replacing the bar on supports, ensure client safety, and provide assistance during lifts.
  - Beginners should start with lightly loaded or unloaded bars to master form.
  - Lifters should avoid musculoskeletal injuries and have pain-free movement before performing the exercise.
- **Common Mistakes**:
  - Hyperextending the back, placing the hands too far apart, and improper bar placement on the chest.
  - Bouncing the bar off the chest or arching the back during lifts.
- **Teaching Cues**:
  - "Keep back flat," "chest up and out," "squeeze shoulder blades together," "look straight up," and "grip the bar firmly."
- **Spotting**:
  - Spotter uses an alternate grip, stays close to the bar, and provides assistance through all phases of the lift.
  - Common errors: improper bar placement, incorrect spotting technique, or not following the client's signal.
- **Variations**:
  - Can be performed with dumbbells, on Smith machines, or using selectorized machines for seated or standing presses.
  - Adjustments for clients with shoulder pain: use narrower grip, avoid excessive shoulder abduction, or use towel rolls to limit bar descent.

Conclusions/action items:

We will utilize research on the bench press exercise in order to find the best form. Once we find this best form, we will track the line of the barbell path in order to minimize injury.

Citation:

[1] P. Ronai, "The Bench Press Exercise," *ACSM's Health & Fitness Journal*, vol. 22, no. 6, p. 52, Dec. 2018, doi: 10.1249/FIT.0000000000000432.

Tough PLA vs PLA

Jackson Jarrett - Oct 09, 2024, 12:32 PM CDT

Title: Tough PLA vs PLA

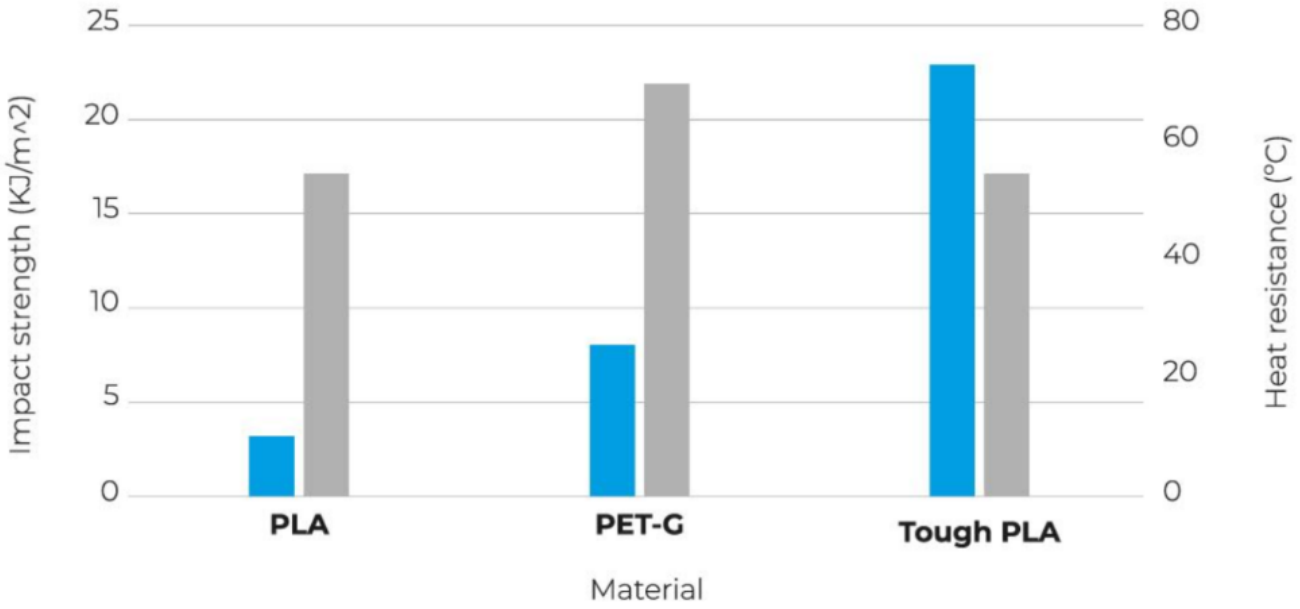
Date: 10/9/24

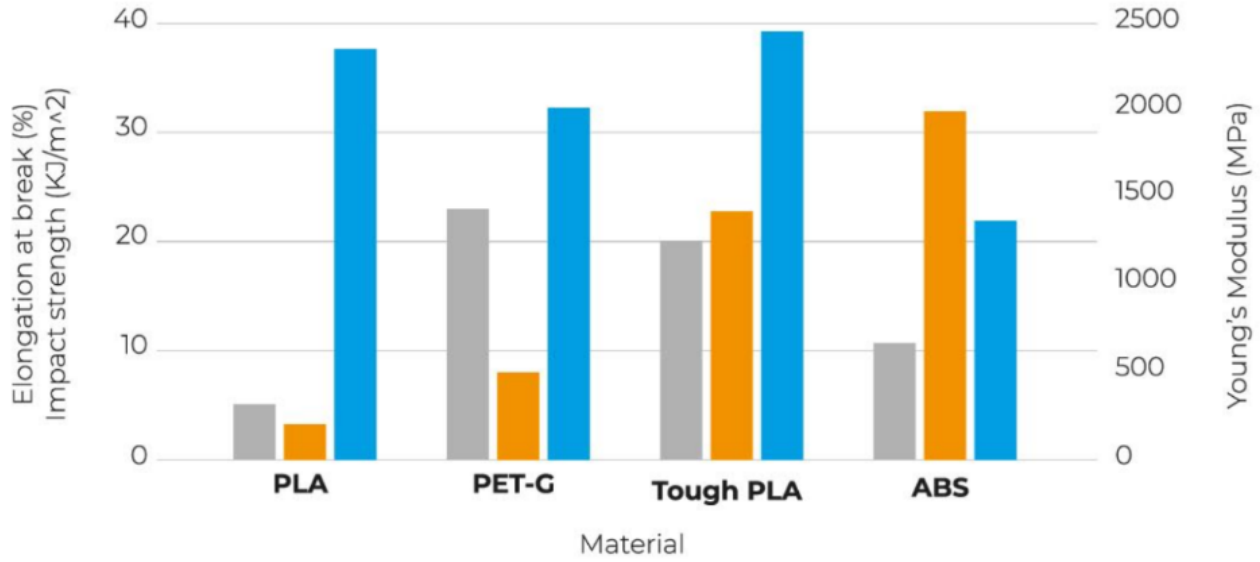
Content by: Jackson

Goals: To research the material that we will use to 3D print our weightlifting clip prototype

Content:

- **PLA**: Easy to print, shiny surface finish, good for prototypes, non-mechanical uses, and low-temperature applications.
- **Tough PLA**: Matte finish, higher impact resistance, suitable for tools and functional parts, can replace ABS without warping or the need for an enclosure.
- **Shared properties**: Both have similar thermal resistance, no dangerous fumes, and no warping issues.
- **Mechanical properties**: Tough PLA is more durable than PLA, offering better impact resistance and mechanical strength, comparable to ABS and PET-G.





Conclusions/action items:

We will move forward with tough PLA as our material that we will use to 3D print our weightlifting clip. The additional strength and toughness as expressed with a higher Young's Modulus will be necessary to hold the weight on the barbell, maintaining the functionality of the weightlifting clip.

Bar Sensei

Jackson Jarrett - Sep 28, 2024, 6:58 PM CDT

Title: Bar Sensei

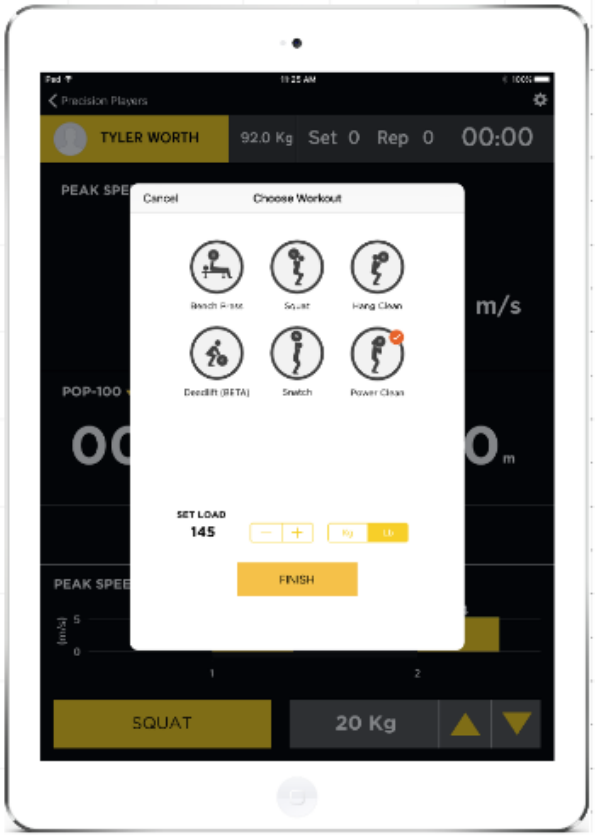
Date: 9/28/24

Content by: Jackson

Goals: To explore existing and competing technology that look to serve the same or a similar function as our future device

Content:

- **Purpose**: Provides instant feedback on barbell training to enhance performance and motivation.
- **Outputs**: Measures and displays key metrics such as power, force, bar speed, and distance directly on smart devices.
- **Technology**: Utilizes Bluetooth Smart for real-time data transmission to a mobile app, allowing athletes to view their performance after each rep.
- **Design**: Lightweight (1 ounce), portable, and easy to attach to the barbell with Velcro straps; designed to stay out of the way during workouts.
- **App Compatibility**: Works with the A2P SPORT app, which features various performance metrics and can be upgraded to A2P PRO for deeper analysis.
- **Team Training**: Streamlines data management in team environments, making it easier for coaches to track athletes' performance and adjust training programs accordingly.
- **Sensor Technology**: The A2P-FIT™ sensor module captures and analyzes movement, accommodating irregular bar paths typical in weightlifting



Conclusions/action items:

We will avoid any patents that exist with this product. This device does have an application that we will likely rival.

Citation: [1] “Bar Sensei.” Accessed: Sep. 19, 2024. [Online]. Available: http://files.assess2perform.com/barsensei.html

Move FactorX

Jackson Jarrett - Sep 28, 2024, 6:59 PM CDT

Title: Move FactorX

Date: 9/28/24

Content by: Jackson

Goals: To explore existing and competing technology that look to serve the same or a similar function as our future device

Content:

The MoveFactorX Module is a highly portable sensor designed for Velocity-Based Training (VBT) and movement tracking, offering real-time performance feedback.

- **Ultra-lightweight design**: Weighs less than 30 grams, making it easy to use for both barbell and bodyweight exercises.
- **Instant feedback**: Tracks barbell velocity and body movement, delivering real-time data to a connected iOS device via a free app.
- **Advanced VBT metrics**: Provides cutting-edge metrics like POP-100V and InversePOP-100V for detailed performance analysis, including during eccentric and concentric phases of movements.
- **Versatility**: Can be used with barbell and bodyweight exercises, including specific protocols for vertical jumps and trap bar exercises.
- **Expandable use**: Additional protocols for bodyweight movements are expected to roll out in 2024, expanding its capabilities.
- **Comprehensive kit**: Includes the sensor, a barbell sleeve, a neoprene waist belt, extra batteries, and a tool for module maintenance.

Conclusions/action items:

We will avoid any patents that exist with this product. This device does have an application that we will likely rival.

Initial Design Ideas Design Matrix

Jackson Jarrett - Oct 03, 2024, 7:51 PM CDT

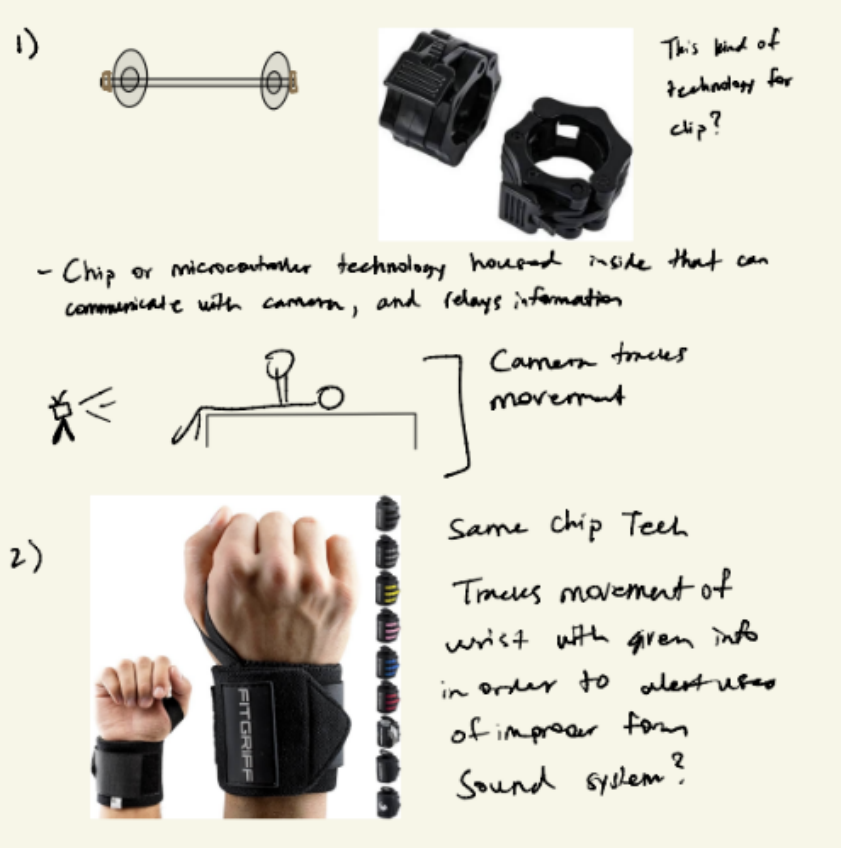
Title: Initial Design Ideas for Design Matrix

Date: 9/23/24

Content by: Jackson

Goals: To explore any possible options which we can move forward with in design.

Content:



Conclusions/action items:

We will move forward with our design matrix after brainstorming and culminating ideas.

2024/11/12 - Updated MATLAB Code

Jackson Jarrett - Nov 13, 2024, 9:57 AM CST

Title: Updated MATLAB Code to read data stored in Arduino Nano's EEPROM storage

Date: 11/12/24

Content by: Kai McClellan

Present: N/A

Goals: N/A

Content:

MATLAB Code:

```
clear;
clc;

% Define the serial port and baud rate (adjust as needed)
serialPort = 'COM6';  % Replace with your Arduino's COM port
baudRate = 115200;    % Ensure this matches the Arduino code

% Create the serial object
serialObj = serialport(serialPort, baudRate);

% Request EEPROM data
writeline(serialObj, 'R');  % Send 'R' command to Arduino

% Initialize arrays to store data
ax = [];
ay = [];
az = [];
gx = [];
gy = [];
gz = [];
counter = 1;

% Read data line-by-line until we reach the end marker
while true
    dataLine = readline(serialObj);

    if strcmp(dataLine, "End of EEPROM data")
        break;  % Stop reading when the end marker is found
    end

    % Convert string to numeric and store in the appropriate array
    value = str2double(dataLine);

    % Use counter to assign each value to the appropriate array
    switch mod(counter - 1, 6) + 1
        case 1
            ax(end + 1) = value;
        case 2
            ay(end + 1) = value;
        case 3
            az(end + 1) = value;
        case 4
            gx(end + 1) = value;
        case 5
            gy(end + 1) = value;
```

```
        case 6
            gz(end + 1) = value;
    end
    counter = counter + 1;
end

% Close the serial port
clear serialObj;

% Number of readings
numReadings = length(ax);

% Plot accelerometer and gyroscope data
figure;
subplot(2,1,1);
plot(1:numReadings, ax, 'r', 1:numReadings, ay, 'g', 1:numReadings, az, 'b');
title('Accelerometer Data');
legend('Ax', 'Ay', 'Az');

subplot(2,1,2);
plot(1:numReadings, gx, 'r', 1:numReadings, gy, 'g', 1:numReadings, gz, 'b');
title('Gyroscope Data');
legend('Gx', 'Gy', 'Gz');
```

Conclusions/action items:

The subplots will display the data of the six individual data components, so this portion might change again after successful testing to obtain 3D graphs of the sensors motion, but the individual subplots may be useful as well to show which plane had the greatest deviation.

2024/11/12 - Possible Code for MATLAB with deviation integration

Jackson Jarrett - Nov 13, 2024, 9:57 AM CST

Title: Possible Code for MATLAB with deviation integration

Date: 11/12/24

Content by: Kai McClellan

Present: N/A

Goals: N/A

Content:

```
clear;
clc;

% Define the serial port and baud rate (adjust as needed)
serialPort = 'COM6';  % Replace with your Arduino's COM port
baudRate = 115200;    % Ensure this matches the Arduino code

% Load or define the optimal trial data (replace with your actual data)
optimal_ax = [0, 10, 20, 30, 40];
optimal_ay = [0, -10, -20, -30, -40];
optimal_az = [16384, 16380, 16378, 16385, 16390];
optimal_gx = [0, 5, -5, 10, -10];
optimal_gy = [0, -5, 5, -10, 10];
optimal_gz = [0, 3, -3, 2, -2];

% Create the serial object
serialObj = serialport(serialPort, baudRate);

% Request EEPROM data
writeline(serialObj, 'R');  % Send 'R' command to Arduino

% Initialize arrays to store new trial data
ax = [];
ay = [];
az = [];
gx = [];
gy = [];
gz = [];
counter = 1;

% Read data line-by-line until we reach the end marker
while true
    dataLine = readline(serialObj);

    if strcmp(dataLine, "End of EEPROM data")
        break;  % Stop reading when the end marker is found
    end

    % Convert string to numeric and store in the appropriate array
    value = str2double(dataLine);

    % Use counter to assign each value to the appropriate array
    switch mod(counter - 1, 6) + 1
        case 1
            ax(end + 1) = value;
        case 2
            ay(end + 1) = value;
```

```
        case 3
            az(end + 1) = value;
        case 4
            gx(end + 1) = value;
        case 5
            gy(end + 1) = value;
        case 6
            gz(end + 1) = value;
    end
    counter = counter + 1;
end

% Close the serial port
clear serialObj;

% Ensure trial data and optimal data have the same length
numOptimal = length(optimal_ax);
numTrial = length(ax);

% If lengths are different, truncate or interpolate trial data
if numTrial > numOptimal
    % Truncate if trial data is longer than optimal
    ax = ax(1:numOptimal);
    ay = ay(1:numOptimal);
    az = az(1:numOptimal);
    gx = gx(1:numOptimal);
    gy = gy(1:numOptimal);
    gz = gz(1:numOptimal);
elseif numTrial < numOptimal
    % Interpolate if trial data is shorter than optimal
    xq = linspace(1, numTrial, numOptimal);
    ax = interp1(1:numTrial, ax, xq);
    ay = interp1(1:numTrial, ay, xq);
    az = interp1(1:numTrial, az, xq);
    gx = interp1(1:numTrial, gx, xq);
    gy = interp1(1:numTrial, gy, xq);
    gz = interp1(1:numTrial, gz, xq);
end

% Calculate deviations from optimal values over time
deviation_ax = abs(ax - optimal_ax);
deviation_ay = abs(ay - optimal_ay);
deviation_az = abs(az - optimal_az);
deviation_gx = abs(gx - optimal_gx);
deviation_gy = abs(gy - optimal_gy);
deviation_gz = abs(gz - optimal_gz);

% Identify the time point with the largest deviation for each axis
[max_dev_ax, time_ax] = max(deviation_ax);
[max_dev_ay, time_ay] = max(deviation_ay);
[max_dev_az, time_az] = max(deviation_az);
[max_dev_gx, time_gx] = max(deviation_gx);
[max_dev_gy, time_gy] = max(deviation_gy);
[max_dev_gz, time_gz] = max(deviation_gz);

% Display the largest deviations
disp(['Max deviation for Ax: ', num2str(max_dev_ax), ' at time ', num2str(time_ax)]);
disp(['Max deviation for Ay: ', num2str(max_dev_ay), ' at time ', num2str(time_ay)]);
disp(['Max deviation for Az: ', num2str(max_dev_az), ' at time ', num2str(time_az)]);
disp(['Max deviation for Gx: ', num2str(max_dev_gx), ' at time ', num2str(time_gx)]);
disp(['Max deviation for Gy: ', num2str(max_dev_gy), ' at time ', num2str(time_gy)]);
disp(['Max deviation for Gz: ', num2str(max_dev_gz), ' at time ', num2str(time_gz)]);

% Plot deviation data over time
numReadings = length(ax);
```

```
figure;
subplot(2,1,1);
plot(1:numReadings, deviation_ax, 'r', 1:numReadings, deviation_ay, 'g', 1:numReadings, deviation_az, 'b');
title('Deviation from Optimal Accelerometer Data');
legend('Deviation Ax', 'Deviation Ay', 'Deviation Az');

subplot(2,1,2);
plot(1:numReadings, deviation_gx, 'r', 1:numReadings, deviation_gy, 'g', 1:numReadings, deviation_gz, 'b');
title('Deviation from Optimal Gyroscope Data');
legend('Deviation Gx', 'Deviation Gy', 'Deviation Gz');
```

Conclusions/action items:

This code should be able to take a set of "optimal" data and compare it to the data recorded from each trial stored in the Arduino's EEPROM

2024/11/25 - Button to Initialize Arduino Code

Jackson Jarrett - Nov 25, 2024, 3:02 PM CST

Title: Arduino Button to Initialize Code

Date: 11/25

Content by: Jackson

Content:

```
#include <EEPROM.h>

#include "I2Cdev.h"

#include "MPU6050.h"


MPU6050 mpu;


/* OUTPUT FORMAT DEFINITION */

#define OUTPUT_READABLE_ACCELGYRO

//#define OUTPUT_BINARY_ACCELGYRO


// Pin definitions

#define BUTTON_PIN A3


int16_t rawAx, rawAy, rawAz; // Raw accelerometer data

int16_t rawGx, rawGy, rawGz; // Raw gyroscope data

float ax, ay, az;            // Processed accelerometer data

float gx, gy, gz;            // Processed gyroscope data


bool blinkState;
```

```
int eepromAddress = 0;  // To track EEPROM storage position

bool isRecording = false;   // Flag to indicate if the program is recording
bool buttonPressed = false; // Flag to detect a button press
bool lastButtonState = HIGH; // Previous button state for edge detection

float accelOffsets[3] = {0, 0, 0}; // Accelerometer offsets for calibration

void clearEEPROM() {
    for (int i = 0; i < EEPROM.length(); i++) {
        EEPROM.write(i, 0);
    }
    eepromAddress = 0;
    Serial.println("EEPROM cleared.");
}

void setup() {
    pinMode(BUTTON_PIN, INPUT_PULLUP);
    Serial.begin(115200);

    #if I2CDEV_IMPLEMENTATION == I2CDEV_ARDUINO_WIRE
        Wire.begin();
    #elif I2CDEV_IMPLEMENTATION == I2CDEV_BUILTIN_FASTWIRE
        Fastwire::setup(400, true);
```

```
    #endif

    Serial.println("Initializing MPU...");
    mpu.initialize();

    if (!mpu.testConnection()) {
        Serial.println("MPU6050 connection failed");
        while (true);
    } else {
        Serial.println("MPU6050 connection successful");
    }

    Serial.println("Calibrating accelerometer...");
    calibrateAccelerometer();
    Serial.println("Calibration complete.");

    pinMode(LED_BUILTIN, OUTPUT);
    Serial.println("System initialized. Waiting for button press to start...");
}

void handleButtonPress() {
    bool currentButtonState = digitalRead(BUTTON_PIN);
    if (lastButtonState == HIGH && currentButtonState == LOW) {
```

```
        buttonPressed = true;
    }
    lastButtonState = currentButtonState;
}

void loop() {
    handleButtonPress();

    if (buttonPressed) {
        buttonPressed = false;

        if (isRecording) {
            Serial.println("Stopping recording. Clearing EEPROM...");
            clearEEPROM();
            isRecording = false;
            Serial.println("System reset. Press the button to start recording new data.");
        } else {
            Serial.println("Starting recording...");
            isRecording = true;
        }
    }
```

```
    if (isRecording) {

        readSensorData();

        applyLowPassFilter();


        #ifdef OUTPUT_READABLE_ACCELGYRO

            Serial.print("a/g:\t");

            Serial.print(ax, 2); Serial.print("\t");

            Serial.print(ay, 2); Serial.print("\t");

            Serial.print(az, 2); Serial.print("\t");

            Serial.print(gx, 2); Serial.print("\t");

            Serial.print(gy, 2); Serial.print("\t");

            Serial.println(gz, 2);

        #endif


        storeDataInEEPROM(ax, ay, az, gx, gy, gz);


        if (isRecording) {

            blinkState = !blinkState;

            digitalWrite(LED_BUILTIN, blinkState);

        }


        delay(1000);

    }
```

```
}

void readSensorData() {
    mpu.getMotion6(&rawAx, &rawAy, &rawAz, &rawGx, &rawGy, &rawGz);

    // Subtract calibration offsets
    ax = (rawAx - accelOffsets[0]) / 16384.0; // Convert to 'g'
    ay = (rawAy - accelOffsets[1]) / 16384.0;
    az = (rawAz - accelOffsets[2]) / 16384.0;
    gx = rawGx / 131.0; // Convert to degrees/sec
    gy = rawGy / 131.0;
    gz = rawGz / 131.0;
}

void calibrateAccelerometer() {
    const int sampleSize = 100;
    long sumAx = 0, sumAy = 0, sumAz = 0;

    for (int i = 0; i < sampleSize; i++) {
        mpu.getMotion6(&rawAx, &rawAy, &rawAz, &rawGx, &rawGy, &rawGz);

        sumAx += rawAx;
        sumAy += rawAy;
```

```
        sumAz += rawAz;

        delay(10);
    }

    accelOffsets[0] = sumAx / sampleSize;
    accelOffsets[1] = sumAy / sampleSize;
    accelOffsets[2] = (sumAz / sampleSize) - 16384; // Account for gravity on Z-axis
}

void applyLowPassFilter() {
    static float prevAx = 0, prevAy = 0, prevAz = 0;
    const float alpha = 0.1; // Smoothing factor (0.0 - 1.0)

    ax = alpha * ax + (1 - alpha) * prevAx;
    ay = alpha * ay + (1 - alpha) * prevAy;
    az = alpha * az + (1 - alpha) * prevAz;

    prevAx = ax;
    prevAy = ay;
    prevAz = az;
}

void storeDataInEEPROM(float ax, float ay, float az, float gx, float gy, float gz) {
```

```
    if (eepromAddress + 12 <= EEPROM.length()) {
        EEPROM.put(eepromAddress, ax); eepromAddress += sizeof(float);
        EEPROM.put(eepromAddress, ay); eepromAddress += sizeof(float);
        EEPROM.put(eepromAddress, az); eepromAddress += sizeof(float);
        EEPROM.put(eepromAddress, gx); eepromAddress += sizeof(float);
        EEPROM.put(eepromAddress, gy); eepromAddress += sizeof(float);
        EEPROM.put(eepromAddress, gz); eepromAddress += sizeof(float);
    } else {
        Serial.println("EEPROM full, stopping recording.");
        isRecording = false;
        digitalWrite(LED_BUILTIN, LOW);
    }
}
```

Conclusions/action items:

Training Documentation

Jackson Jarrett - Oct 09, 2024, 12:21 PM CDT

Title: UW Training Documentation

Date: 10/9/24

Content by: Jackson

Content:

Jackson Jarrett

ID Number: 9084221895

Eligibility: CoE Students

My Memberships

Membership Type	Start Date	Expiry Date	Renew	Card Info
Machining	Sun, Jan 1 2023	Permanent	Not Renewable	N/A
Lab Orientation	Sun, Jan 1 2023	Tue, Dec 30 3000	Not Renewable	N/A
Laser Cutter	Sun, Jan 1 2023	Tue, Dec 30 3000	Not Renewable	N/A
Shop Tools	Sun, Jan 1 2023	Tue, Dec 30 3000	Not Renewable	N/A
Shop Tools - Training Eligible	Sun, Jan 1 2023	Tue, Dec 30 3000	Not Renewable	N/A

Conclusions/action items:

Lecture 1 9/11/2024

Jackson Jarrett - Sep 11, 2024, 2:04 PM CDT

Title: Lecture 1 Notes

Date: 9/11/2024

Content by: Jackson

Goals: To discuss preparedness and readiness for the career fair and future careers in the Biomedical Engineering sphere.

Content:

- Keep track of what you do, spreadsheet for applications with logins (esc.wisc.edu/resources)
- Application is step 1. Follow up required (2-3 weeks)
- Think beyond the title, focus on skills, industry, exposure
- With your resume, create balance. Show a full picture of your experience. Technical skills and course work, no columns, charts, colors
- Microsoft Word. ATS used, write your own resume
- Nothing in the header or footer. Not read on ATS.
- No cover letters at career fair
- Sell yourself! Don't limit yourself to BME positions, in fact do the opposite

Conclusions/action items:

In conclusion, there are several valuable resources available on the ECS website that can assist with resume building/workshop, as well as more valuable advice for the upcoming career fair. I will use my previous experience, available resources, and confidence in my self to have a very successful career fair and recruitment season.

Lecture 2 9/18/2024

Jackson Jarrett - Sep 18, 2024, 1:57 PM CDT

Title: Leadership

Date: 9/18/2024

Goals: To discuss leadership, leadership qualities, and why it is necessary and effective in the workplace.

Content:

- Anatomy of a Good Leader
- Styles of Leadership
    - Power Model
        - "Someone has to take control here, and it should be me."
        - "Great man theory" only certain people born to lead
        - Being in control the most important thing
        - Hierarchy, authority, command
    - Servant
        - "It's not about me and my needs, the needs of my followers is most important"
        - Being of service to others
        - Empathetic
        - Empowering
        - Shared decision making
    - Authentic Leadership
        - "By being my genuine self, I will gain and build trust"
        - Honesty
        - Transparency
        - Genuineness
    - People Oriented Leader
        - Glue that holds the team together
    - Process Oriented Leader
        - Sets the pace for the team, willing to work alongside everyone
    - Thought Oriented
        - Sees the big picture and anticipates the future, open to new ideas
    - Impact Oriented Leader
        - Set a high bar, push for excellence, bring people up

Conclusions/action items:

- Goal Setting:
    - Team Goal: I would like my design team to work together in harmony, and with clear expectations. I look forward to embracing my People Oriented Leadership qualities, in order to promote us being a close group that gets done what needs to be done.
    - Self Goal: I would like to continue to develop my People Oriented Leadership qualities, as well as improve on my impact and process oriented qualities. I would like to avoid some of my Servant leadership qualities for BME design specifically, because I believe that this leadership style is detrimental to group success.

Lecture 3 9/25/2024

Jackson Jarrett - Sep 25, 2024, 1:38 PM CDT

Title: BME Advising Session Part II: Fall Post Graduate Planning

Date: 9/25/204

Content by: Jackson

Goals: To explore post grad options and opportunities

Content:

- Use your undergraduate experience to "build a story". Gain experience while you can, it is much easier while in school
- Research is important for all post-degree and helpful for industry.
- Do your homework. What programs have the opportunities that you are looking for
- Writing your Story
    - General: Start with what you want to do- thesis statement
    - Narrow experiences that applies to interest
    - Personal Statement: Reasonable idea of what you have achieved, what you want to do afterwards
    - Defend your plan with experience and confidence
- Masters, MS
    - Industry focused, one year
    - expand credentials for future
    - Stepping stone for future education
        - Accelerated Masters Program (1 year)
            - Coursework Only
            - Independent study/research is allowed
            - Funding (TA only) stipend only (no tuition remission $1200/credit)
- Doctoral, PhD
    - Desire to be independent in research
    - Lead projects in industry, startups, consulting

Conclusions/action items:

Lecture 4 10/2/2024

Jackson Jarrett - Oct 03, 2024, 11:10 AM CDT

Title: Lecture 4

Date: 10/2/2024

Goals: Understanding the importance of Mentorship in the Biomedical Engineering Department

Content:

- Why do we mentor the 200s?
  - Design support
  - emotional support
  - Leadership skills
  - Communication
  - Break the ice for students who are just fully getting into BME
  - Benefits
  - mentoring boosts self-esteem and confidence and patience
  - build positive habits
  - foster personal growth
  - identify gaps in knowledge
- What makes a good mentor?
  - Building trust
  - psychological safety
  - reliability
  - support/enthusiasm
  - being available
  - transparency
  - humanizing their challenges
  - good listening
- List of topics, resources, advice, etc. that I wish I knew in BME 200
  - Don't be afraid to speak out about troubles or emotions
  - Use Zotero for citations
  - Work hard to develop strong connections with your group, they can be really great resources later on

Conclusions/action items:

The connections and relationships made in group work are extremely important, even outside of school. Character development and prosperity is a great part of going through life.

Lecture 5 10/9/2024

Jackson Jarrett - Oct 09, 2024, 1:59 PM CDT

Title: Lecture 5 - Sustainable Engineering (By: Andrea Hicks)

Date: 10/9/2024

Goals: To explore sustainability and its importance in engineering and how we can apply this to our project

Content:

- What is sustainability? Why should I care as an engineer? How do I apply this to my project?
  - Circular Economy
    - Keep things out of landfill, keep things recycled in economy going from consumer to user
    - Fix one thing, something else happens. Constant game of Whack-a-mole
    - Life Cycle Assessments - Calculation that leads to a carbon footprint
      - Resources, Processing, Manufacturing, Distribution, Use, End of Life
      - 1969, Coca-Cola did the first
  - Resilience
    - Sustainability of devices in crisis, such as COVID, improves resilience
- Sustainability in Our Team
  - Make our weightlifting clip recyclable
  - Necessary recycling of technology pieces
  - Everyone should use our product to promote being in the gym and the battle against obesity

Conclusions/action items:

Lecture 6 10/16/2024

Jackson Jarrett - Oct 16, 2024, 1:48 PM CDT

Title: Introduction to WARF, IP, Disclosing & Licensing

Date: 10/16/2024

Content by: Jackson

Goals: To learn about WARF , vision, mission and what it does

Content:

- Vision: enable UW Madison research to solve the worlds problems
- Independent supporting organization governed by a board of successful UW Madison alumni with expertise in a variety of fields
- Technology Transfer - moving research results from campus into the market. WARF works at this interface to facilitate securing IP rights and commercial licenses.
    - Intellectual property licenses
    - Industry sponsored research
    - Consulting arrangements
    - Fee for service
- Types of Intellectual Property:
    - Patents
        - Property right granted by a governmental agency
        - Country specific
            - Patent holder has right to exclude others from making, using, and selling, or importing the claimed invention
        - Design
            - 15 year term limited to ornamental features
        - Plant
            - New variety, 20 year term
        - Utility
            - 1 year placeholder (provisional)
            - 20 year placeholder (non-provisional)
    - Copyrights
        - Protection for creative works that are expressed in a tangible medium
        - Wide range of subject matter, including software code
    - Trademarks
        - Protection for names, marks, logos, dress, etc.
        - Requires use in commerce
        - Source identifying function
    - Trade Secrets
        - Can be used to protect anything of value
        - Protection is good so long as the concept is not generally known (Coca-Cola Recipe)
    - Other - Biomaterials, technique, data
- Statutory Requirements for patenting:
    - 101 - Eligible
        - Can't be a product of nature, abstract idea, or natural phenomenon
    - 102 - Novel
        - Must be new
    - 103 Non-Obvious
        - Can't be simple modification or combination of existing subjects
    - 112 - Enabled and Described
        - Must provide enough detail to teach others how to make or use the invention
- WARF
    - Receives around 400 new innovation disclosures each year
    - Disclosing:
        - Describing innovation
        - Identify advantages and potential applications
        - Name contributors
        - Provide funding and public disclosure details
    - Meeting:

        - Ask questions about WARF and patent process
        - Discuss next steps
    - IP Considerations:
        - Type of protection
        - Potential breadth and strength of IP protection
        - Public disclosure (past and planned)
        - Stage of development
    - Licensing Considerations
        - Applications
        - Likelihood of identifying commercial partner
        - Likely return from licensing

Conclusions/action items:

Lecture 7 10/23/2024

Jackson Jarrett - Oct 24, 2024, 1:36 PM CDT

Title: Basics of Human Participants Research Requirements (IRB)

Date: 10/23/24

Content by: Kai McClellan

Present: BME 300

Goals: Understand the requirements, what they mean to me, and how to learn more.

Content:

- **IRB - Institutional Review Board**
  - conducts ethical and regulatory reviews of human research
- **Infamous studies:** WWII Nazi prisoner experiments--Nuremberg Trials-- 1947 Nuremberg Code
- **Institutional Review Boards**
  - Instituted by Common Rule and FDA regulations
  - Review research studies to ensure they meet regulatory codes and standards
- **UW Madison:**
  - **Minimal Risk IRB** - Biomedical, Education, Social/Behavioral research.
    - Secondary analysis of data, survey research
  - **Health Sciences IRB** - Biomedical, interventional, any risk level
    - All FDA-regulated and VA-regulated research
- **Does my project need IRB review?**
  - Is it research under the **Common Rule?**
    - **Research** means a systematic investigation, including research development, testing, and evaluation, designed to develop or contribute to generalizable knowledge
  - Does it involve **human subjects**?
    - Obtains information or biospecimens through intervention or interaction, and uses, studies, or analyzes information or biospecimens
    - Or obtains/uses/studies/analyzes/generates identifiable private information or identifiable biospecimens
  - Is it human research under **FDA device regs**?
    - Device - intended to diagnose, treat, prevent disease, or affect structure/function of the body
    - Research
    - Sample
- **Preparing for IRB review**
  - Complete required training for researchers through CITI
  - Complete annual Outside Activities Reports
  - Develop a Research Plan
    - Identify appropriate Principal investigator and study team
    - Consider participants
    - Consult the FDA-regulated research oversight Program at UW if looking at device safety/effectiveness
    - develop a research question and steps to answer it
    - Collect preliminary data and background information
- **What IRB application will you need?**
  - UW electronic submission system **ARROW**
  - Basic types: **Protocol - based** and **Non - Protocol based**
  - **PBA components:** Protocol document, informed consent form(s), recruitment tools, screening scripts, written assessments
- Resources:
  - IRB website

Conclusions/action items:

This lecture highlighted the importance of ethical principles born from unethical research experiments in the past. The speaker explained which types of IRBs are available at UW-Madison. The characteristics for when a project needs IRB review were also established and defined. She spoke about

how to prepare for an IRB review and all of the pieces necessary to apply for IRB reviews. The review steps were also explained, detailing what could be spoken about during the meeting and any pre-review items needed.

Lecture 8 10/31/2024

Jackson Jarrett - Oct 30, 2024, 2:05 PM CDT

Title: Navigating FDA Device Requirements

Date: 10/31/2024

Content by: Jackson

Goals: To learn and explore the FDA device requirements that will be useful to navigate when fabricating final deliverables

Content:

- Medical Device: Anything intended to improve health or improve a structure of the body without chemical influence
  - As long as it is not a drug. Even mouthwash is a medical device
- Software as a Medical Device (SaMD)
  - Not a medical device if it drives or controls the hardware medical device
- Device Classification Overview
  - Class 1:
    - Low Risk
    - Regulatory Requirements
      - Exempt from premarket approval
      - Must follow certain general controls - labeling, record retention, complaint files
    - Band Aids, floss, tongue depressor, manual toothbrush
  - Class 2:
    - Moderate
    - Regulatory Requirements
      - Must follow general and special controls, which can include performance standards, post-market surveillance, specific labeling requirements
    - 510(k) showing substantial equivalence, may be exempt
    - BP cuffs, sutures, catheters
  - Class 3:
    - High Risk
    - Sustain or support life, implanted or potential for unreasonable risk
  - Regulatory Requirements:
    - General controls
    - Clinical Trials to demonstrate safety and efficacy
  - Approval Process:
    - PMA submission, which involves a comprehensive FDA review of safety and effectiveness data before marketing

Conclusions/action items:

Use this knowledge and keep this in mind when thinking about product development in the future.

Lecture 9 11/6/2024

Jackson Jarrett - Nov 08, 2024, 12:04 PM CST

Title: Framework Guiding Advanced Therapeutic Product Development - Slides by Cathy Rasmussen, delivered by Professor Murphy

Date: 11/6/2024

Content by: Jackson

Goals: Understand the overall structure of FDA, including the framework of laws, regulations, and guidance for advanced therapeutics

Content:

- **FDA Structure:**
  - **Device (CDRH)**
    - PMA - premarket approval
    - 510(k)
    - IDE - Device exemption
  - **Drug (CDER)-Center for drug engineering and research**
    - NDA - New drug application
    - IND - Investigational new drug application
  - **Biologic (CBER)-Center for biological engineering and research**
    - BLA - biologic license agreement
    - IND - Investigational new drug application
  - **Drug vs. Biologic**: Drugs are synthetic, biologics are living things or made by living things
- **FDA Framework from top to bottom**
  - **U.S. Laws made by Congress**
  - **Regulations (CFR Title 21) made by FDA based on laws**
  - **FDA Guidance made with help from public to help industry and the public to interpret regulations**
    - Guidance is helpful because it prevents companies from paying lots of money for clinical trials that aren't FDA approved and also helps speedrun clinical trial process so that researchers can get through trials before they run out of money
- **Implications for HCT/Ps** (Human cell and tissue-based products) **351 vs. 361**
  - **361 -** minimally manipulated, low regulations compared to 351
    - demineralized bone, tendons/ligaments
  - **351** - not minimally manipulated, requires more regulation.
    - taking out a gene and manipulating it to change the performance of a protein and putting it back into the body
- **Target Product Profile**
  - **Product Development Life Cycle**
    - Extremely important to be able to distinguish between studies that are "on the critical path" vs. "Good Research Products"
  - Need Patient Identification, Patient benefits, patient risks
  - **Core**
    - Indication and patients
    - efficacy
    - Safety
    - Dose and regimen
    - route of administration
    - dose form
  - **Clinical Development Planning**
    - Clinical pathway
    - regulatory pathway
    - timelines
    - cost
    - risk
  - **CMC (qTPP : Quality TPP)**
    - Product attributes
      - purity
      - degradants
      - biocompatibility
    - Storage

        - Stability
        - Container
        - Pharmaceutical compliance
- **Quality management System Implementation**
    - **Must think about:**
        - Materials/Input
        - Expansion process/output
        - Monitoring and contamination
        - System
        - Machine/hardware/software
        - Up and down stream process
        - People
- **Career Options within a regulated Environment**
    - Characterization and Analytics
    - Process Development
    - Manufacturing Process
    - Gene delivery

Conclusions/action items:

Lecture 10 11/13/2024

Jackson Jarrett - Nov 13, 2024, 1:52 PM CST

Title: Medical Device Innovation from Prototype to Commercial Clinical Use

Date: 11/13/24

Content by: Jackson

Goals: A method of getting a medical device onto the market, and looking into reimbursing, financial incentive, and sales

Content:

- FDA approval takes time. Plan for twice as long as they say.
  - Time resets if they ask a question
- Breakthrough Device Program
  - timely access to medical devices for life-threatening or irreversibly debilitating conditions
  - Just because it is accepted intro program, doesn't mean it's FDA approved
- Reimbursement or Financial Incentive
  - Value based medicine at a lower cost
- Sales
  - National Policy, Standards of Practice and Clinical Practice Guidelines
  - Health System and Provider
  - Payor
- Value Drivers to Discover
  - Economic
    - Money
    - Staff Time
    - Resources
    - Waste
    - Metrics
  - Clinical
    - Improve Outcomes
    - Reduce Risk
    - Reduce Complications
    - Shorten Length of Stay
    - Solve Issues
  - Mission Impact
    - Patient Satisfaction
    - Academic Leadership
    - Innovation in Care

Conclusions/action items:

Tong Leadership 11/15/2024

Jackson Jarrett - Nov 15, 2024, 12:44 PM CST

Title: Tong Leadership Lecture - Tasso, Inc.

Date: 11/15/24

Goals: Learn about entrepreneurship in biomedical engineering

Content:

- Blood collection in the home - following modernizing trends such as food and goods delivery
- Prototyping everything, use campus resources
- Grants - DARPA, NIH
- Defend your idea, present it well
- Make a better product, don't be afraid to "kill" existing products. Get yours
- Develop the technology for the customer, early adopter with ownership

Conclusions/action items:

Take the risk. Get yours

Lecture 11 11/20/2024

Jackson Jarrett - Nov 20, 2024, 2:07 PM CST

Date: 11/20/204

Content by: Jackson

Goals: Learning about how a new product develops and works efficiently in the medical device industry

Content:

- NPD in the medical device industry
  - High Regulated: FDA and other regulatory bodies have a significant impact
  - Expensive - Requirement for verification and validation (clinical testing) is a cost multiplier
- Selecting and Prioritizing Projects - Annual Process
  - Corporate Business Strategy - defining how a business will sustain itself over the next 3-5 years
  - Product Portfolio Review - Define product categories to develop, sustain, and eliminate
  - Project Review - Select and prioritize projects to support over the next 1-3 years
  - Budgeting and Resource Allocation - allocation of budget and resources based on project prioritization
- Managing NPD: Stage-Gate Process
  - Stage 0 - Ideation, Brainstorming - "The Cloud"
  - Stage 1 - Exploration
  - Stage 2 - Concept Development - "The Funnel"
  - Stage 3 - Design Development - engineering, how do we make this work - place projects either die or move forward
  - Stage 4 - Design Confirmation - PDS, testing - "The Tunnel"
  - Stage 5 - Design Transfer and Commercialization - market strategy
- Defining the problem is arguably the most important step of the design process
- Medical Device development is an expensive, complex, and high-collaborative effort
- Having limited resources, most business have instituted processes like Stage-Gate to reduce risk and increase probability of success

Conclusions/action items:

Overall, this is valuable information that I can look to utilize in the future steps of my career as I make my way into the medical device industry.

09/13/2024 EMG Study Regarding Muscle Activation for Deadlifts

LUKE SCHMELING - Nov 15, 2024, 6:35 PM CST

Title: EMG Study Regarding Muscle Activation for Deadlifts

Date: 9/13/2024

Content by: Isabel Martin-Fuentes, Jose M. Oliva-Lozano, Jose M. Muyor

Present: N/A

Goals:

- To learn more about the process of identifying muscle activation occurring during a compound lift so we can apply it to our own scenario.
- To learn information about muscle activation during a deadlift so I can find information in another article or whether these muscles are most likely to be injured while performing a deadlift.
- To apply the goals stated above to current project to streamline the process of identifying problem areas to work on a solution.
- To learn what an EMG is.

Content: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7046193/

Abstract

- **Findings of the article indicate erector spinae and quadriceps experienced the most activation, followed by gluteus maximus and bicep femoris (in thigh part of hamstring complex. Other hamstring muscles include semitendinosus and semimembranosus).**
- **Semitendinosus muscle activation predominates slightly over that of the biceps femoris.**

Introduction

- **sEMG- Surface electromyography**
- **^Defined as electrophysiological recording technology used for the detection of the electric potential crossing muscle fiber membranes**
- **Can be used to detect motor unit recruitment patterns in data that can be reported through the sEMG**

Conclusions/action items:

- **I believe that the specific type of deadlift the above-mentioned muscle activation is referring to is "conventional" deadlift, as later in the introduction they refer to sumo deadlift, Romanian deadlift and other variations as "less popular variants,"**
- **later on in the article they do have numbers for studies taken on a large variation of deadlifts including sumo and RDLs where they do go into detail on the muscle activation surrounding these muscle variations as well.**
- **I want to come back to this article again later to read it in detail and to find other articles like this about back squat and bench-press specifically.**

10/03/2024 How to Avoid Shoulder Impingement

LUKE SCHMELING - Oct 04, 2024, 3:33 PM CDT

Title: How to Avoid Impingement

Date: 10-03-2024

Content by: Luke Schmeling

Present: N/A

Goals: To understand how to prevent shoulder injuries from occuring in Bench Press.

Content:

- **Link to Research Article:** Frontiers | Effects of bench press technique variations on musculoskeletal shoulder loads and potential injury risk (frontiersin.org)

Takeaways

- Grip Width: The width of placement of your hands on the barbell dictates the amount of force enacting on the shoulder. Wider grip bench press tends to increase the amount of force and ergo amount of stress on the shoulder, whilst a narrower grip does the opposite.
- Scapula Position: The position of the scapula helps take stress off the shoulders and reduces chance of injury by taking partial brunt of the force the shoulder would experience.
- Mediolateral Forces: When you are lifting, minimize side-to-side movement as this would put large amounts of stress on one shoulder or the other and increases the risk of shoulder impingement and tears. Control the weight to minimize risk of injury.

Conclusions/action items:

- My conclusion from this article is that in order to minimize risk of shoulder injury, it is important to keep all these variables in mind.
- From here I plan to apply this article to my part of the presentation which will be given tomorrow.

10/04/2024 How the Shoulder Impinges

LUKE SCHMELING - Oct 04, 2024, 3:43 PM CDT

Title: How the Shoulder Impinges

Date: 10/04/2024

Content by: Luke Schmeling

Present: N/A

Goals: To better understand what is anatomically happening when a shoulder impingement occurs.

Content: Link to Article: **Shoulder Impingement & Resistance Training: What Powerlifters, Weightlifters and Barbell Strength Athletes Need to Know to Understand Shoulder Injuries (progressiverehabandstrength.com)**

Main Takeaways:

1. Shoulder impingements occur when the tendon is inflamed
2. Tendon Inflammation occurs when the subacromial space in the shoulder is impeded upon by the acromion bone or the coracoid process
3. The Acromion bone is more likely to impinge the Supraspinatus Tendon in the subacromial space
4. The Coracoid Process is more likely to inflame the long head of the Bicep tendon
5. Repeated use after inflammation occurs can lead to tears in the tendon

Conclusions/action items:

My main conclusion from this article was making a connection between improper bench press form and impingement

I can visualize in my mind how as the angle between your elbow and side of your body becomes larger during bench press, the possibility of contact between the tendon and bone is more likely.

From here I am going to continue to make lab archive notes about our presentation today as well as fact checking the problem statement given to us in the project overview.

10/04/2024 Weightlifting Injuries Per Year as Well as Revision of Problem Statement

LUKE SCHMELING - Oct 04, 2024, 4:07 PM CDT

Title: Weightlifting Injuries Per Year as Well as Revision of Problem Statement

Date: 10/04/2024

Content by: Luke Schmeling

Present: N/A

Goals: To explain how I revised the team's problem statement in advance of our presentation given today, as well as how I found errors in our project overview's description of this project.

Content: Links: https://www.nationwidechildrens.org/newsroom/news-releases/2010/03/new-national-study-examines-weight-training-related-injuries ; https://bmedesign.engr.wisc.edu/projects/f24/weight_trainer ; https://docs.google.com/document/d/10j61tLo7bnHnj4M0GujAfSFwgPjbn43QVkpFnsaiHkE/edit

Attached above is research I found regarding weightlifting injuries per year

The website that holds our project overview and what was our problem statement until last night when I made changes to it with my group's permission

Our PDS and the changes I made to our problem statement in preparation for our project presentation we had today.

- Our project overviews website talked about the number of weightlifting injuries that occur in the United States per year.
- They said the number was in the millions, but the only resource I could find on this body of information said that the number of injuries from the 90's to the mid 2010's was in the millions
- The number that occurs yearly are more realistically in the thousands.
- Our Problem Statement was also outdated to our current perspective on how we are going to tackle this issue
- Now we are less focusing on the muscles itself, and more so focusing on improving technique to prevent injury. This deviates from what the project overview and our problem statement was, so I made changes accordingly to bring our problem statement up to date

Conclusions/action items:

I feel confident about where our project and where our problem statement is at this point

I want to learn more about IMU's

I need to make an entry regarding our presentation today and my thoughts for it and the future

09/27/2024 Patents for Barbell, Weight Plate, Weight Clip

LUKE SCHMELING - Sep 27, 2024, 6:32 PM CDT

Title: Patents for Barbell, Weight Plate, Weight Clip

Date: 09/27/2024

Content by: Luke Schmeling

Present: N/A

Goals: To determine dimensions for pieces of equipment that our design will be directly attached to.

Content: Below

Links For:

- Barbell-https://patents.google.com/patent/US20150038302A1/en
- Weight Plate-https://patents.google.com/patent/US7828702B2/en ; https://www.garagegymreviews.com/olympic-weights-vs-standard#:~:text=For%20our%20comparison%2C%20we'll,350%20millimeters%2C%20or%2013.8%20inches.
- Clips-https://patents.google.com/patent/USD780860S1/en ; https://www.garage-gyms.com/olympic-collars-guide-review/#:~:text=IWF%2Dspec'd%20barbells%20have,1.976%20inches%20%E2%80%93%202.0%20inches).

Dimensions for Barbell:

- Length: 214 cm
- Sleeves of Barbell Diameter: 50 mm
- Sleeves of Barbell Length: 41.5 cm

Dimensions for Weight Plate:

- Weight Plate Diameter: 45 cm
- Weight Plate Thickness: no exact thickness for the majority of 45-pound weight plates, will update this metric later when I go to the gym and take all these measurements in the real world.

Dimensions for Weight Clip:

- Weight Clip Diameter: 50.2-50.8 mm
- Weight Clip Thickness: no exact thickness for the majority of weight clips, will update this metric later when I go to the gym and take all these measurements in the real world.

Conclusions/action items:

- Go to the gym and take all these measurements again.
- Do Research on how IMU's work
- Begin looking at Rubric for Presentation, see what I need to keep myself up to speed on.

09/13/2024 EMG Study Regarding Muscle Activation for Deadlifts - Copy

LUKE SCHMELING - Nov 15, 2024, 6:39 PM CST

Title: EMG Study Regarding Muscle Activation for Deadlifts

Date: 9/13/2024

Content by: Isabel Martin-Fuentes, Jose M. Oliva-Lozano, Jose M. Muyor

Present: N/A

Goals:

- To learn more about the process of identifying muscle activation occurring during a compound lift so we can apply it to our own scenario.
- To learn information about muscle activation during a deadlift so I can find information in another article or whether these muscles are most likely to be injured while performing a deadlift.
- To apply the goals stated above to current project to streamline the process of identifying problem areas to work on a solution.
- To learn what an EMG is.

Content: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7046193/

Abstract

- **Findings of the article indicate erector spinae and quadriceps experienced the most activation, followed by gluteus maximus and bicep femoris (in thigh part of hamstring complex. Other hamstring muscles include semitendinosus and semimembranosus).**
- **Semitendinosus muscle activation predominates slightly over that of the biceps femoris.**

Introduction

- **sEMG- Surface electromyography**
- **^Defined as electrophysiological recording technology used for the detection of the electric potential crossing muscle fiber membranes**
- **Can be used to detect motor unit recruitment patterns in data that can be reported through the sEMG**

Conclusions/action items:

- **I believe that the specific type of deadlift the above-mentioned muscle activation is referring to is "conventional" deadlift, as later in the introduction they refer to sumo deadlift, Romanian deadlift and other variations as "less popular variants,"**
- **later on in the article they do have numbers for studies taken on a large variation of deadlifts including sumo and RDLs where they do go into detail on the muscle activation surrounding these muscle variations as well.**
- **I want to come back to this article again later to read it in detail and to find other articles like this about back squat and bench-press specifically.**

10/17/2024 IMU Complementary Filters - Copy

LUKE SCHMELING - Nov 15, 2024, 6:41 PM CST

Title: IMU Complementary Filters

Date: 10/17/2024

Content by: Luke Schmeling

Present: N/A

Goals: To understand the effect that frequency has on IMU chips and how to fix the issues that occur.

Content: LINKS: **Measure inclination with IMU, Arduino and complementary filter (luisllamas.es)** ; **Bing Videos**

1. An Arduino IMU is composed of an accelerometer and a gyroscope.
2. Arduino IMU collects raw data from the accelerometer and gyroscope separately and gives two separate values or images of the object in space.
3. Arduino IMU accelerometer data is very jittery and super susceptible to changes in frequency, loud noises, changes in acceleration etc...
4. Arduino IMU gyroscope data is less jittery, however, overtime the image and data begins to drift off course from its original position.
5. A Complementary Filter takes the raw data of the accelerometer and gyroscope in an IMU and combines them in a way which makes the image and data collected superior to the two separate components of data collected.

Conclusions/action items:

1. This seems like it needs to be a necessary thing for our group to look into applying if we haven't already
2. I need to contact Kai about this and see if the code he researched includes this
3. I need to fill out the progress report with these findings
4. Meeting with the groupmates at the Makerspace at 4:30 PM

11/25/2024 Fabrication Day 1: Assembly

LUKE SCHMELING - Dec 03, 2024, 6:28 PM CST

Title: Fabrication Day 1: Assembly

Date: 11/25/2024

Content by: Luke Schmeling

Present: Kai, Jackson, Luke

Goals: To complete fabrication of the device.

Content: In the attached PDF you can see some action shots of activity the team did in order to get our project in the correct orientation to complete the project the following day. The tasks that were done are the following:

- Sodering of wires in order for a button to be used to activate the IMU's to start recording data
- Gathering of information about performing a bench press rep using a competitors device so we can compare our data we collect the following day with our project to this data
- Grinding down of the breadboards in order to fit in the boxes

Conclusions/action items:

- **After this day all we had left to do was put everything together and test the accuracy of the device**
- **We decided that we would meet at the makerspace the following day in the morning before going to final testing**
- **We decided that drilling holes for the button wires would be the least intrusive way of going about the button's installation the following day**

LUKE SCHMELING - Dec 03, 2024, 6:30 PM CST

Download

Fabrication_day_1.pdf (1.48 MB)

11/26/2024 Fabrication Day 2: Assembly and Testing

LUKE SCHMELING - Dec 03, 2024, 6:44 PM CST

Title: Fabrication Day 2: Assembly and Testing

Date: 11/26/2024

Content by: Luke Schmeling

Present: Kai, Jackson, Luke

Goals: To finish fabrication and finalize testing of accuracy of the device

Content: Pictures are attached in a PDF.

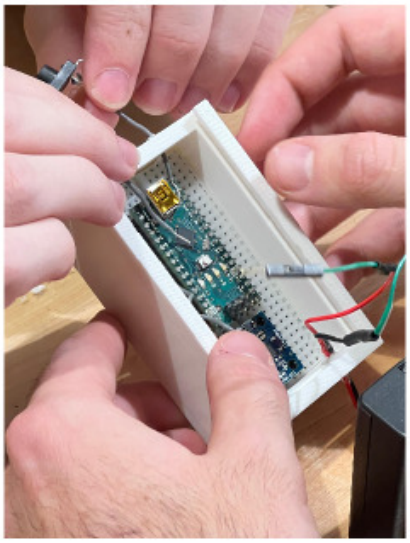
In fabrication day 2 the team finalized fabrication by drilling two holes in each box for our sodered wires connected to a button in order for the wires to attach to the breadboard and for the button to be accessed from the outside

- I was able to resoder one of the wires for the button since the initial sodering of this wire was not satisfactory, it was a great learning experience!
- After fabrication the team went to the Nickolas Davis rec center and began testing which lasted for about 2 hours where I did bench press reps with the device and it was then processed and graphed by Kai and Jackson

Conclusions/action items:

- **The device works**
- **Finish Poster Board**
- **Begin Final Report**

LUKE SCHMELING - Dec 03, 2024, 6:46 PM CST



Download

Fabrication_Day_2.pdf (1.53 MB)

10/04/2024 Coordinate Axis System

LUKE SCHMELING - Oct 04, 2024, 5:06 PM CDT

Title: Coordinate Axis System

Date: 10/04/2024

Content by: Luke Schmeling

Present: N/A

Goals: To identify ideas

Content: SEE ATTACHMENT

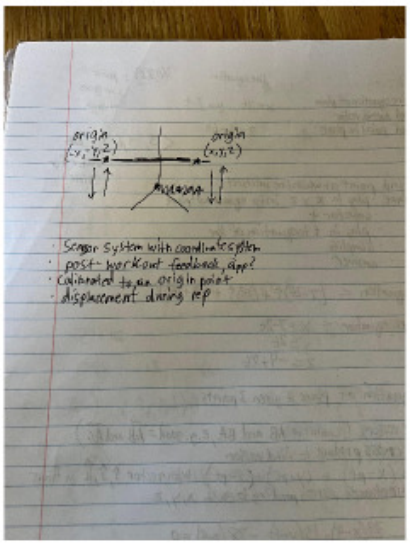
When our group met to create our design matrix, I brought up the idea of measuring our barbells distance from its starting position by using some sort of coordinate system with our barbell clips and the rack as the origin of the coordinate system and then some way or another we could record the barbells path using this technology to see how it compares to a line of best fit.

Conclusions/action items:

I just realized I didn't have dates for any of these entries in the titles so I will go do that now

I plan to learn about IMU Chips this coming week and how we can derive the position of the barbell by measuring the angular velocity which apparently is what the IMU chips tell us.

LUKE SCHMELING - Oct 04, 2024, 5:06 PM CDT



Download

Entry_For_Design_Ideas.pdf (549 kB)

10/17/2024 3D Tracking with IMU Video

LUKE SCHMELING - Oct 17, 2024, 2:08 PM CDT

Title: 3D Tracking With IMU Video

Date: 10/17/2024

Content by: Luke Schmeling

Present: N/A

Goals: I wanted to document this video because it might have valuable info for us in the future about how to record bar path using the software the video uses.

Content:

LINK:[3D Tracking with IMU - YouTube]

Conclusions/action items:

1. Probe video to find info about software used to get video up on the screen.
2. Learn more about 6DoF Animations
3. Finish Progress Report.

10/17/2024 IMU Complementary Filters

LUKE SCHMELING - Oct 17, 2024, 1:48 PM CDT

Title: IMU Complementary Filters

Date: 10/17/2024

Content by: Luke Schmeling

Present: N/A

Goals: To understand the effect that frequency has on IMU chips and how to fix the issues that occur.

Content: LINKS: **Measure inclination with IMU, Arduino and complementary filter (luisllamas.es)** ; **Bing Videos**

1. An Arduino IMU is composed of an accelerometer and a gyroscope.
2. Arduino IMU collects raw data from the accelerometer and gyroscope separately and gives two separate values or images of the object in space.
3. Arduino IMU accelerometer data is very jittery and super susceptible to changes in frequency, loud noises, changes in acceleration etc...
4. Arduino IMU gyroscope data is less jittery, however, overtime the image and data begins to drift off course from its original position.
5. A Complementary Filter takes the raw data of the accelerometer and gyroscope in an IMU and combines them in a way which makes the image and data collected superior to the two separate components of data collected.

Conclusions/action items:

1. This seems like it needs to be a necessary thing for our group to look into applying if we haven't already
2. I need to contact Kai about this and see if the code he researched includes this
3. I need to fill out the progress report with these findings
4. Meeting with the groupmates at the Makerspace at 4:30 PM

10/30/2024 Idea on Compartments for Breadboard and Batteries

LUKE SCHMELING - Oct 30, 2024, 7:17 PM CDT

Title: Idea on Compartments for Breadboard and Batteries

Date: 10/30/2024

Content by: Luke Schmeling

Present: Kai McClellan, Jackson Jarrett, Gavin Gruber, Luke Schmeling

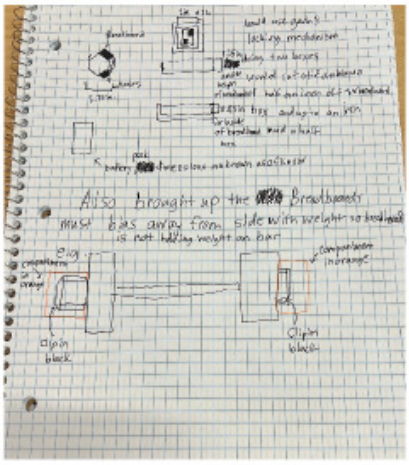
Goals: To present a new idea I had for the storage compartments since our first prototype is massive this would reduce height by incredibly considerable margins.

Content: See PDF attached

Conclusions/action items:

- Create one more entry regarding second part of PDF with idea to Bias compartments away from weight.
- Finish assignments for other classes
- Look into Onshape as it is much easier than solid works

LUKE SCHMELING - Oct 30, 2024, 7:17 PM CDT



Download

Sketched.pdf (736 kB)

10/30/2024 Breadboard Bias

LUKE SCHMELING - Oct 30, 2024, 7:19 PM CDT

Title: Breadboard Bias

Date: 10/30/2024

Content by: Luke Schmeling

Present: Kai McClellan, Jackson Jarrett, Gavin Gruber, Luke Schmeling

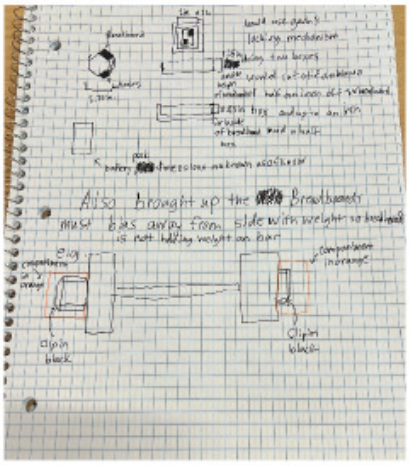
Goals: To present how I informed group of the reminder to remember we must bias breadboards away from the weight on the clip in order to make sure they are not taking the brunt of the weight on the bar.

Content: See second part of PDF attached

Conclusions/action items:

- **Finish assignments for other classes**
- **Look at Onshape**
- **Compare to Solidworks**

LUKE SCHMELING - Oct 30, 2024, 7:20 PM CDT



Download

Sketched.pdf (736 kB)

11/02/2024 Solidworks Training

LUKE SCHMELING - Nov 02, 2024, 8:26 PM CDT

Title: SolidWorks Training

Date: 11/02/2024

Content by: Luke Schmeling

Present: N/A

Goals: To gain knowledge surrounding how to do actions on SolidWorks

Content: **https://www.youtube.com/watch?v=E69EqFY2qMc**

Conclusions/action items:

This task began long before the date of this excerpt, I have been doing this for about two weeks based on YouTube videos such as the one stated above.

I have realized after talking with Gavin Gruber that Onshape is much easier and simpler to use for the purposes of this project and perhaps I should start trying to do actions on that as well.

- **To catch up on classwork for this week in order to do fabrication stuff towards the end of the week**
- **Learn about Onshape**
- **Brainstorm ideas for the shape of the compartment on the clip.**

10/04/2024 First Preliminary Design Presentation

LUKE SCHMELING - Oct 04, 2024, 4:54 PM CDT

Title: First Preliminary Design Presentation

Date: 10/04/2024

Content by: Luke Schmeling, Kai McClellan, Jackson Jarrett, Gavin Gruber

Present: Luke Schmeling, Kai McClellan, Jackson Jarrett, Gavin Gruber, Professor Murphy, 3-4 other groups presenting their projects

Goals: To present our designs and project to other BME design groups.

Content: Links: https://docs.google.com/presentation/d/1dfgmMyty9hV-_1_gEpdoHfK_Fbleg3cb/edit#slide=id.p2

I was in charge of introducing our groups project and giving background information as well as stating our Problem Statement.

Conclusions/action items:

- From this presentation and seeing where the other groups are at, I feel confident about our gameplan and design ideas going forward
- We will begin fabrication next week so I will be seeking instruction from the BME 300 members of my group as to how to do some of the stuff we need to do regarding the technology
- I realized we know very little about our client maybe reaching out to our client and speaking with him about what he does wouldn't be a bad idea if he is willing to share
- One audience member raised a good point in his question about our orientation of the barbell clips relative to each other and how that would affect our readings, I believe that is something we need to address

2024/09/22-Optimal Bench Path Research

GAVIN GRUBER - Dec 02, 2024, 7:31 PM CST

Title: Optimal Bench Path

Date: 09/22/2024

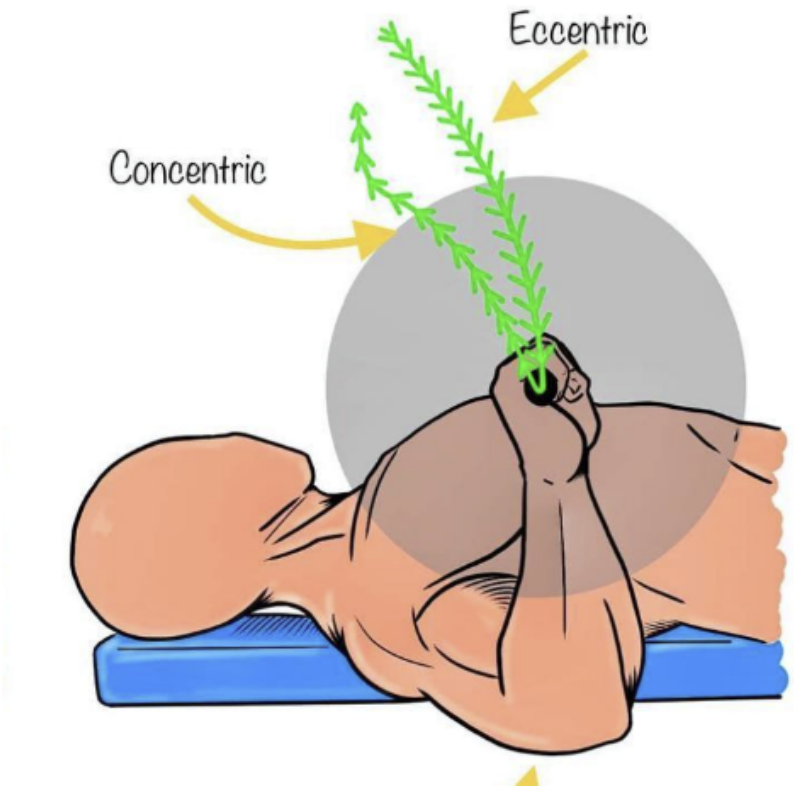
Content by: Gavin Gruber

Goals: Understand what the optimal bench path is and why.

Content:

https://www.strongerbyscience.com/bench-press-bar-path/

- The optimal bench path for the descent is a downward-facing parabola with the bar directly above your shoulders at the top, and the bath just below the nipple at the bottom. To push back up the most optimal path is pushing off your chest and moving the bar upwards and towards your shoulder, then pushing up the rest of the way with the bar finishing with your elbows locked out and the bar above your shoulders. (Shown in the image below)
- The reason for this is this path minimizes the work the front delt is doing and maximizes how much work your chest is doing. This reduces shoulder problems and the strain benching puts on the shoulders.
- The reason you go to just below your nipple is to reduce the range of motion (when you are arching your back) as well as get more power our of your chest. It puts your shoulders in a safe position and allows your chest to do a lot of work.



Conclusions/action items:

- The path of the bench press is not linear and it is better to push the bar above your shoulders, but bring it below the nipple line at the very bottom.
- The path of the barbell is also a way to track which muscles are focused and reduce injury.

2024/10/4 Proper Bench Form research

GAVIN GRUBER - Oct 04, 2024, 7:55 PM CDT

Title: Proper Bench Form

Date: 10/4/2024

Content by: Gavin Gruber

Present: NA

Goals: To Learn more about how to bench with the best form and prevent injury.

Content:

- **Grip width**: Your hands should be outside shoulder-width to ensure chest activation. A narrow grip shifts the focus to the triceps, while too wide risks shoulder strain.
- **Body setup**: Press your feet into the floor, tighten your core, and squeeze your glutes. This stabilizes your body and prevents excess movement of muscles you are not trying to focus on bench.
- **Arch your back**: A slight, controlled lower-back arch ensures the chest is targeted and shoulder safety is maintained.
- **Bar path**: Bring the bar slowly to your lower chest just below the nipple line, keeping control throughout, then push the bar to above the shoulders then push the rest of the way up.
- **Elbow positioning**: Keep elbows at between 45°-70° from your torso, this balancing chest and shoulder engagement and minimizes risks of strains.
- **Shoulder blade position**: Retract your shoulder blades before lifting to stabilize your upper back and prevent shoulder injuries.
- **Other things to keep in mind**: Avoid flaring your elbows or bouncing the bar off your chest. Both can lead to injury also, don't let your wrists bend backward; keep them straight to protect your wrist joints.

Conclusions/action items:

2024/10/4 How Bench Form Targets Different Muscles

GAVIN GRUBER - Oct 04, 2024, 8:38 PM CDT

Title: How Bench Form Targets Different Muscles

Date: 10/4/2024

Content by: Gavin

Present: NA

Goals: To learn how different forms target different musclse

Content:

- **Grip Width**:
    - **Wider Grip**: Engages pectoral muscles more
    - **Narrower Grip**: Targets triceps, enhancing arm strength.
- **Elbow Position**:
    - **Flared Elbows**: Emphasize the chest (over shoulders or anterior deltoids), but puts much more strain on the shoulders and increases risk of shoulder injury.
    - **Tucked Elbows**: Focus on the upper chest, anterior deltoids, and triceps. If your elbows are tucked too much you heavily limit the amount of force you can exert on the bar and you will not lift as much weight.
- **Back and Foot Positioning**:
    - Proper alignment enhances stability, allowing effective force transfer and minimizing injury risk.
- **Range of Motion**:
    - Full range activates more muscle fibers, improving overall effectiveness.

Conclusions/action items:

You want a grip width a little over shoulder width. You also want your elbows to be about 45-70 degrees away from your torso. This will give you ideal strength with minimal risk of injury.

https://blog.nasm.org/biomechanics-of-the-bench-press

2024/10/2 WL Analysis - bar path tracker

GAVIN GRUBER - Oct 04, 2024, 3:35 PM CDT

Title: WL Analysis Bar path tracker

Date: 10/2/2024

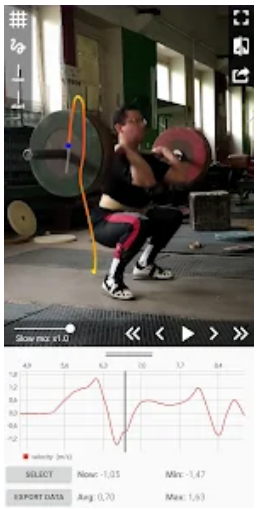
Content by: Gavin Gruber

Present: NA

Goals: To look at existing apps that track the barbell path and look at the interface to see how we could show our user what they did well or badly after their lift.

Content:

This app takes a video of your lift and tracks the barbell path, velocity, and horizontal displacement. Most of the issues with this app come with the analyzing software not recognizing the barbell and it cutting off the tracking of the barbell too early (stops when the weight reaches the bottom and doesn't record it going up). This app also doesn't check to see if the bar is lined up with your shoulders, or if the barbell is sloped towards one side.



Conclusions/action items:

This app does some things good, but it is missing some of the information collection that we hope to collect. The good things about the app are it is free, and it does a decent job of tracking the barbell. I think a similar interface would be good for our project, we will just have different information being displayed.

Citation:

https://play.google.com/store/apps/details?id=com.karolsmolak.wlanalysis&pcampaignid=pcampaignidMKT-Other-global-all-co-prtnr-py-PartBadge-Mar2515-1

2024/10/3 Flex Barbell Tracker

GAVIN GRUBER - Oct 04, 2024, 3:47 PM CDT

Title: Flex Barbell Tracker

Date: 10/3/2024

Content by: Gavin

Present: NA

Goals: To look at an existing product and see what they did well and what we can learn from them.

Content:

This product uses a laser optic system to track its position relative to the ground and its surroundings. It uses this information to track the speed, acceleration, bar path, and bar position. This device connects to an app via Bluetooth and connects to the end of a barbell through a magnet. This device does not measure the ends of the bar relative to each other to see if the barbell is parallel to the shoulders. This device is also very expensive at $495.

Conclusions/action items:

This device is very similar to what we want our product to be. For our project, we also want to look at bar alignment relative to the shoulders and making sure the bar stays level. That is the one thing we need to add. This device also uses a much more complicated and expensive way to track the barbell (laser optic system). This system is very cool but it is not very practical in the context of our project due to its price. We also want to make sure our project is much cheaper than this product.

Citation:

https://gymaware.com/product/flex-barbell-tracker/

2024/9/22- Clamp Barbell Path Tracker

GAVIN GRUBER - Sep 22, 2024, 6:03 PM CDT

Title: Clamp Barbell Path Tracker

Date: 9/22/2024

Content by: Gavin Gruber

Present: NA

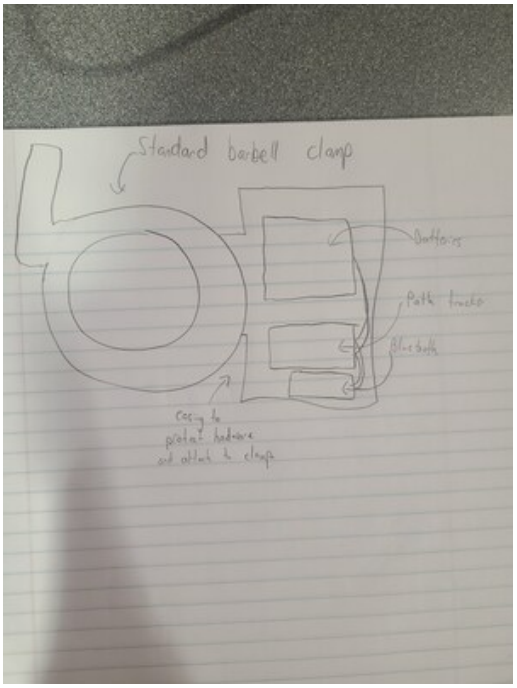
Goals: Create a rough idea for a barbell clamp that tracks the path.

Content:

This device would clamp onto the barbell and act as a clamp and a sensor. It would contain hardware that can track the path of the barbell and a Bluetooth device that could connect the sensors to an outside device (phone, laptop, or other device). It would compare the two sensors to make sure the barbell was level and not lopsided or uneven, as well as track the bar's path. This data would then be displayed on the device along with how to fix the path of the bar or tell you the bar was uneven.

Conclusions/action items:

GAVIN GRUBER - Sep 22, 2024, 6:05 PM CDT



Download

1727046344886252398405075029784 2.jpg (1.98 MB)

2024/10/10-3D Printing Barbell clamp

GAVIN GRUBER - Dec 11, 2024, 1:06 PM CST

Title: 3D Printing Barbell Clamp

Date: 10/10/2024

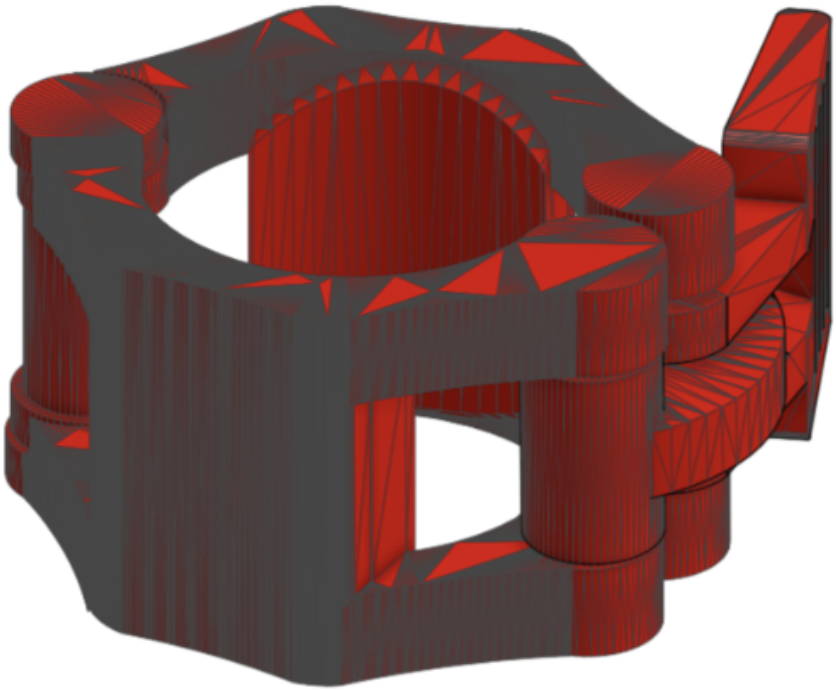
Content by: Gavin Gruber

Present:

Goals: To determine if we can 3D print our barbell clip.

Content:

3D printing our clip would be cheaper and would allow us to fully integrate our modification into the body of the clip. I have found a model of a barbell clip in the OnShape library that we could use as a base for our clip.



This is the clip that is modeled already on Onshape. It would be possible for us to directly add any modifications to this model before we print it, we could add the electronics box directly onto the print, and we wouldn't need any extra way to combine the 2. The problem with 3D printing the clip is it could pose as a safety risk. The clip is used to keep the weights in place and if it doesn't accomplish its job it could be dangerous for the users. Because of this risk, we don't want our clip to break or fail. We talked to the makerspace employees about 3D printing a barbell clip like this and they said the way this would be printed doesn't allow for the lattice structure to support the force. the forces on this clamp would come radially from the center of the clamp, and this clip would not be able to withstand the forces on it with any confidence. This risk of it breaking when put on the clip has made us decide not to 3D print the clip. This will cost a little more money and we will have to think of another way to attach our modules to the clip.

Conclusions/action items:

We have to buy barbell clips online to ensure they will not break when in use. We also have to think of a way to attach our modules to the barbell clip.

2024/10/13 3D Printed Box Designs

GAVIN GRUBER - Dec 11, 2024, 12:56 PM CST

Title: 3D Printed Box Designs

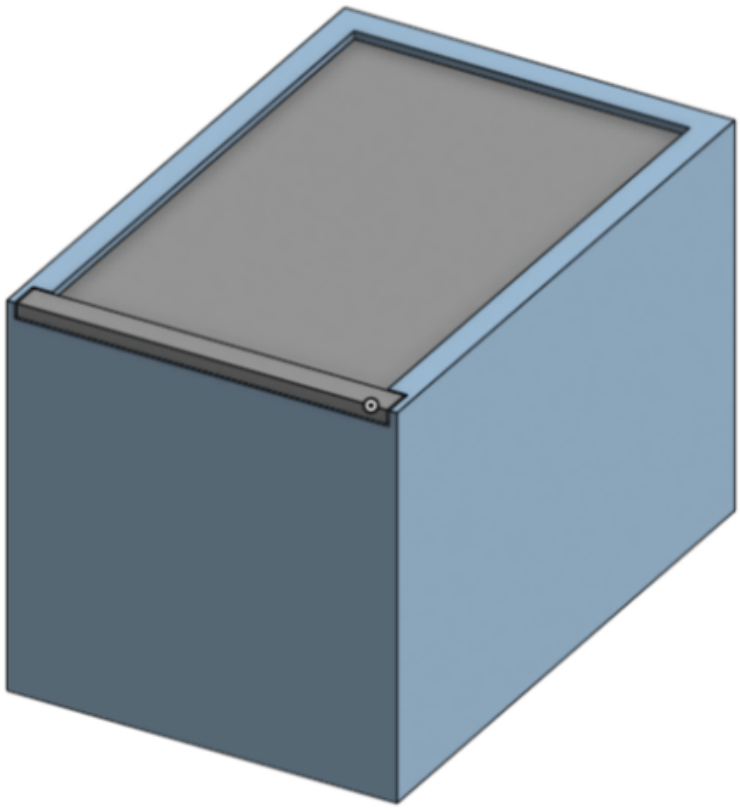
Date: 10/13/2024

Content by: Gavin Gruber

Present:

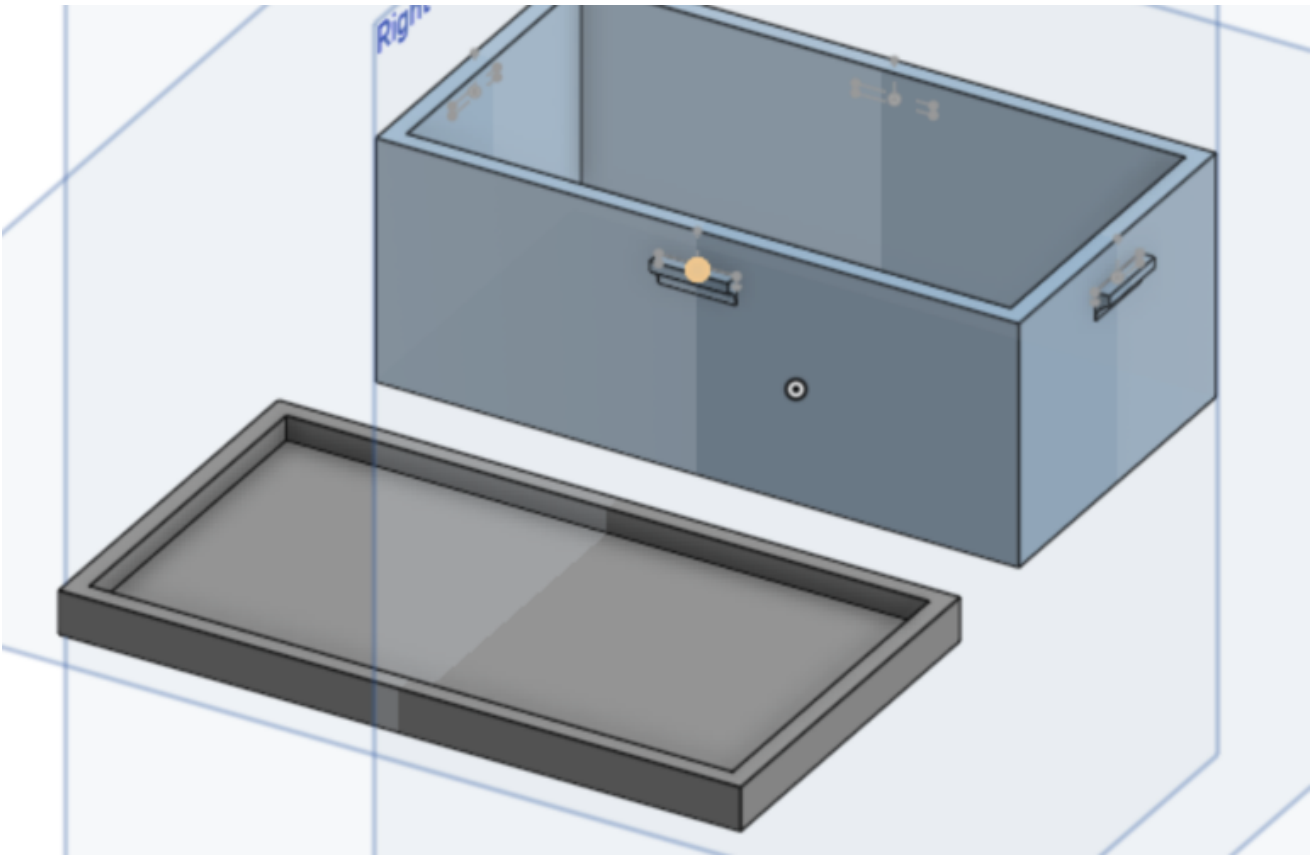
Goals: To look at existing 3D printed boxes in the OnShape library to get an idea of what is possible, so we can discuss which ideas would work for us at our next team meeting.

Content:



This box has a sliding lid and uses rails and a channel to have the lid slide on and off. The problem with this box is that there is no way to lock the lid in place so it doesn't slide off when you don't want it to.

This design has a good way to close the box with the latching mechanism on it. The problem is the hinges on 3D-printed boxes like this are very weak and prone to breaking or coming apart from very small forces. It would not adequately protect any electronics we put in, because the lid would fall of if it was dropped.



This box has a lid that latches on to attachments that are on the box. This design seems like it could work well for our product. I think the latching mechanism might be too weak to work for our design and might not adequately protect our electronics.

Conclusions/action items:

I will discuss these designs with our group in our upcoming meetings and we will figure out what we will move forward with. I think a combination of these designs will for best for our project.

2024/10/21-Latching Mechanism for 3D printed Box

GAVIN GRUBER - Dec 11, 2024, 12:19 PM CST

Title: Latching Mechanism for 3D Printed Box

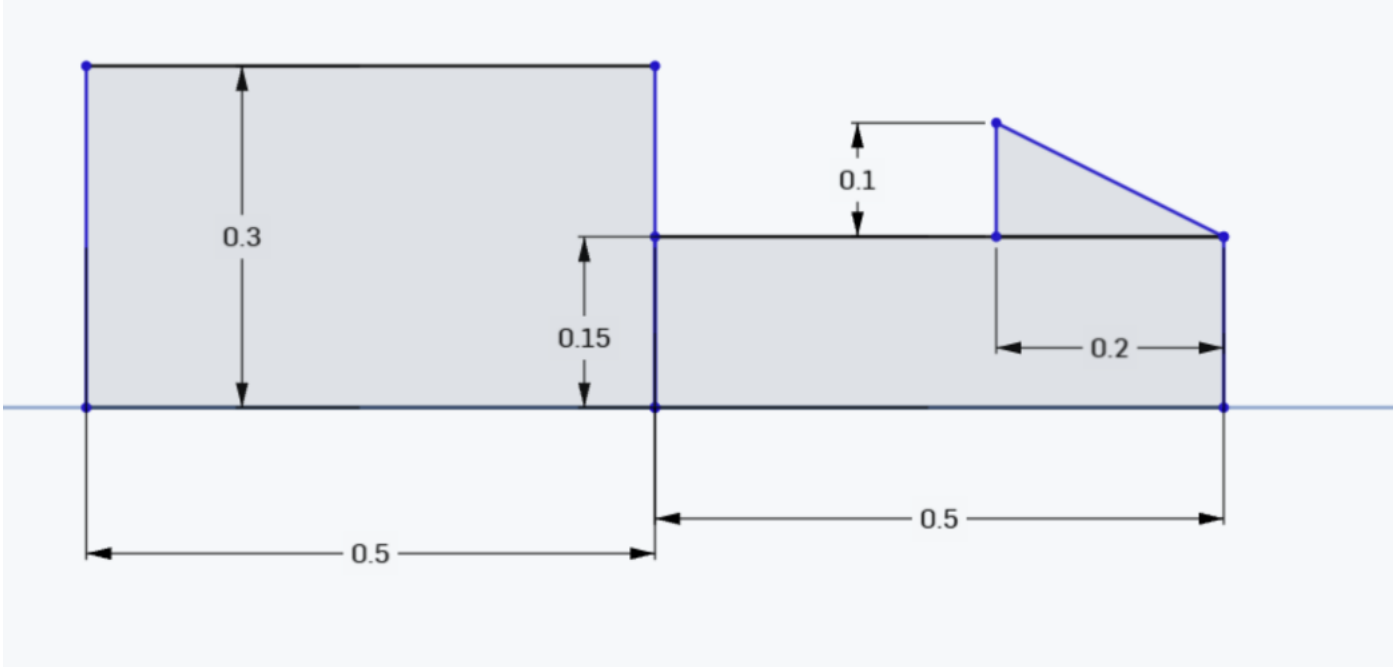
Date: 10/21/2024

Content by: Gavin Gruber

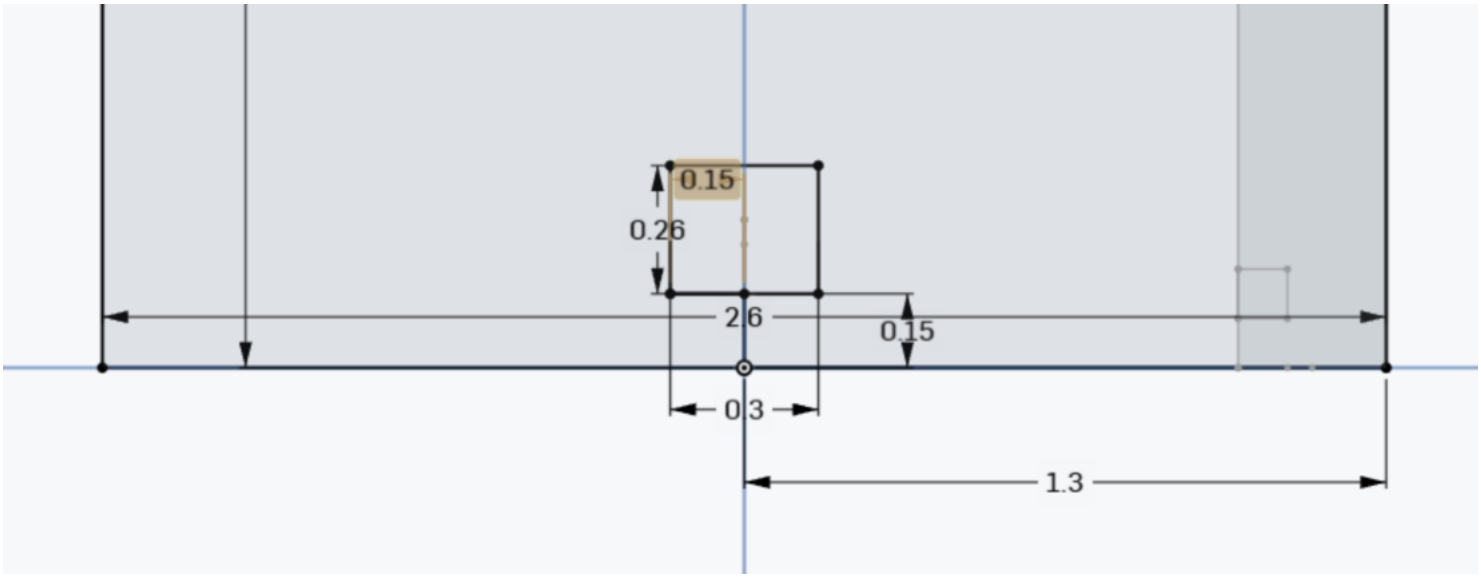
Present:

Goals: To design a working latching mechanism that will keep our 3D-printed box closed.

Content:



This is the design that will be on the end of the sliding lid, and should slide into a hole then click into place.



This is what the the sliding lid will slide into and the square in the middle of the drawing above will be the hole that the latch will slide into.

Conclusions/action items:

This design has to be fully 3D rendered and then 3D printed so we can test to see if the measurement will work and to make sure it functions as a latching mechanism.

2024/10/23- Channel Design for Sliding Lid and Box

GAVIN GRUBER - Dec 11, 2024, 12:29 PM CST

Title: Channel Design for Sliding Lid and Box

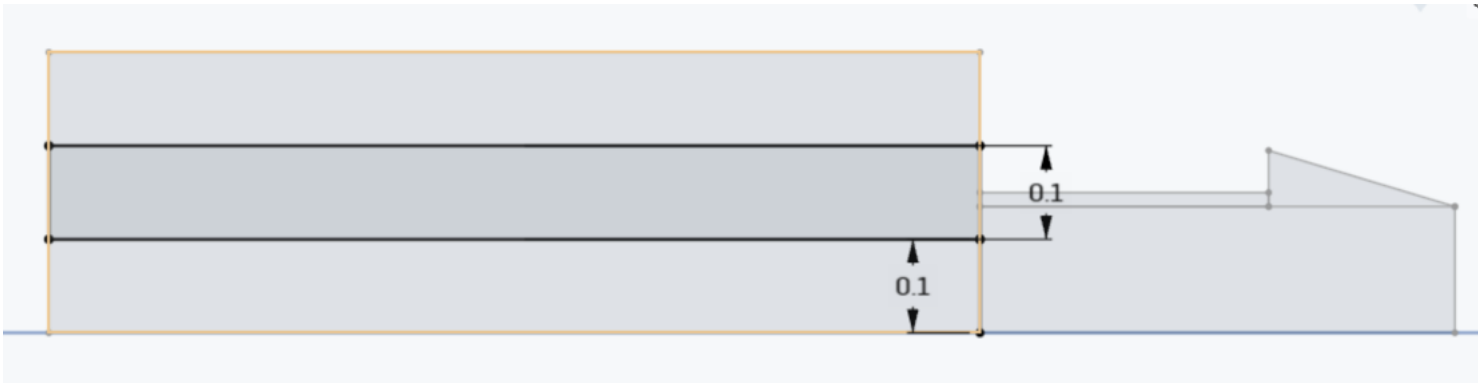
Date: 10/23/2024

Content by: Gavin gruber

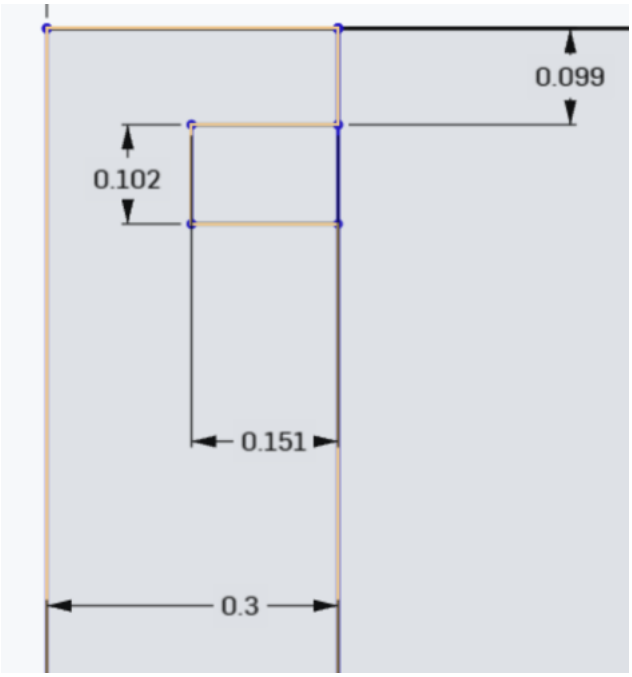
Present:

Goals: To design and get the measurements for a system of channels and rails that will be used for our sliding box.

Content:



This is the sketch that will be used to create the rails on the sliding lid for our prototype. It will be extruded .1 inches further than the rest of the sliding lid to is will stick out and act as rails that wil slide in the channels of the walls for the sliding lid.



This picture shows the measurements of the wall that will be extruded from the sketch. The rail is also shown as it will be cut out from the wall. This rail will be used to keep the lid secure and in place while the lid slides on and off the box.

Conclusions/action items:

These sketches need to be fully extruded and rendered in 3D so they can be 3D printed. They will then have to be tested to see if they fully function as intended.

2024/11/07-Reducing Prototype Box Size

GAVIN GRUBER - Dec 11, 2024, 12:43 PM CST

Title: Reducing Prototype Box Size

Date: 11/07/2024

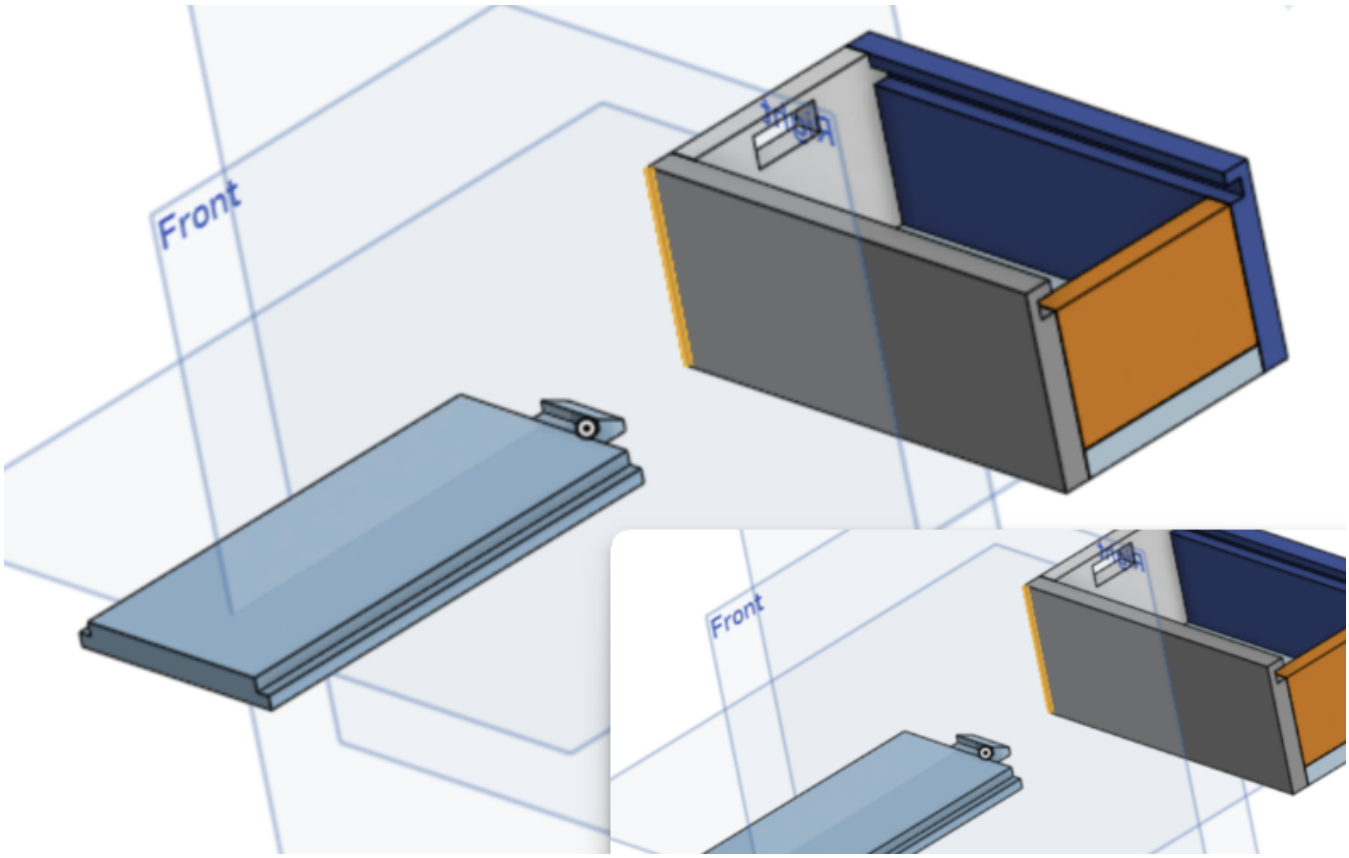
Content by: Gavin Gruber

Present:

Goals: Our team has decided we want to have a battery pack that is not contained by a 3D printed Box, and is instead attached to the barbell clip separately. My goal is to design a smaller Sliding Box.

Content:

Our original prototype box was very bulky and was too big so we are attaching the battery pack somewhere else. Our original box had interior dimensions of 3.5 in x 2 in x 2.8 in. These dimensions were made assuming we would put a battery pack inside of the box, now that we are no longer doing that we can make our box much smaller. The smallest dimension we can fit the Arduino, MPU-6050, the breadboard, and the various wires, we need is 1.5 in x 3 in x 1.2. We have also decided that .3 in thick walls were unnecessarily thick and we can reduce the walls to .2 in thick. This greatly reduces the size of our box and makes it much more practical to attach to our box.



This is the new box which is significantly smaller than our first prototype box.

Conclusions/action items:

This box still needs to be 3D printed to confirm that all the new dimensions work properly. We also need to insert all of our electrical components to make sure that is enough room inside of the box.

2014/11/03-Entry guidelines

John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity. subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.

2014/11/03-Template

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

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items: