# BME Design-Fall 2025 - NATHAN HANSEN Complete Notebook

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# NATHAN HANSEN

on

Dec 10, 2025 @06:20 PM CST

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NATHAN HANSEN - Sep 07, 2025, 2:37 PM CDT

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MARIAMAWIT TEFERA - Sep 19, 2025, 9:26 AM CDT

Course Number: BME 200

**Project Name:** Digital Traction with Japanese Finger Sleeves

**Short Name:** Finger Traction Device

## **Project description/problem statement:**

The project aims to design a device that enables precise digital control of the human hand using Japanese finger sleeves. The device will provide controlled and stable traction during surgeries, such as distal radius fracture treatment, to ensure proper hand positioning with minimal manual effort.

## About the client:

Mr. Pape Samb is the client for this project. He is collaborating with the team to guide design specifications, ensuring that the device meets clinical needs for surgical use.

NATHAN KLAUCK - Sep 12, 2025, 3:15 PM CDT

Title: First Client Meeting Questions
<b>Date:</b> 9/12/2025
Content by: Team
Present: Whole team and advisor
Goals: Questions for client
Content:
Questions:
What's your vision for this project?
orthopedics treatment without surgery by supporting the hand in a certain state, but might be used in surgery
no latex
compatible with MRI ->hopefully
modular
oct 29th
->How much do you want us to build/ code
->Ideal final project
Scope of project-how modular/demographic
Is email your preferred means of contact
What resources/ funding do we have access to?
How do we access these? (out of pocket, through UW, through company?)
Are there any requirements for said funding?
Clarify more on the type of surgeries you want the device to be applicable to?
What equipment/how many people, how much time they have (procedure limitations)
Should the device be autoclavable? Compatible with imaging techniques?

If any, what are the current ways you use digital traction in surgery?

Sterility? Shelf life? reusable?

What device do they currently use? From your current/previous devices, what has and hasn't worked?

What level of control and precision is required (force, angle, stability) for the device to be clinically useful?

Are there specific sleeve materials or designs we must use or avoid, or is there flexibility?

Are there safety mechanisms you'd want built in (e.g., force limits, emergency release)?

Guidelines?

Ethical concerns?

Resource limitation considerations?

NATHAN HANSEN - Sep 12, 2025, 5:46 PM CDT

Title: Client Meeting #1

**Date:** 9/12/2025

Content by: Nathan Hansen

Present: Whole team, Pape Samb, Srihari Gopalan, Momar, and Mohamed Saumah

Goals: Meet the clients and develop a better understanding of the clients ideas for the project

#### Content:

- Pape Samb (Project Leader)
- Dr. Mohamed Soumah, M.D. specializes in forensic medicine
- · Momar, Hospital Manager
- · Srihari Gopalan, UW Engineer: undergrade (biomechanics) and masters (tissue engineering) in BME
- Need a Japanese finger sleeve that the patients hand will hangs from for about 50 minutes in order to put a hard cast on a
  distal radius fracture. This devise allows for a treatment without surgery, but it can also be used during surgery while the
  patient is under.
- Patient is laying on the table with arm out to side and elbow is bent at a 90 degree angle with hand hanging from finger tip sleeves.
- In the beginning (1989) they had access to materials like the finger traps, but they have lost those materials for years.
- They get 25000 orthopedic patients every 6 months (people come from other surrounding) countries. Their Hospital is the
  most advanced in Senegal.
- · Avoid allergic materials like latex, they want a material that is elastic and strong. They do not want compression in the finger.
- They do not currently have any funding, but if we think we need something, reach out to them and they can try to get it. Should not be a big issue monetary wise, they should be able to cover it. Communicate via email when we have an estimated price. Always include Tracy with financial questions.
- They are not looking for a copy right. Like the modern tools but better and smarter (send a signal is a complication were to happen).
- We must have different sizes of sleeves in order to fit different fingers. They also like the idea of a "one size fits all" that can adapt to all finger sizes.
- The device must be compatible with MRI. It would be nice to not have metal pieces in order to prevent false readings.
- Mohamed Soumah will send more information (like the previous device they used) through email to the group.
- Would like the device to be reusable because it is not economically possible to be one time use.
- · Email is recurring every two weeks right now.
- Srihari is losing his wisc email in three days so start communicating through <a href="mailto:srihari.gopalan6@gmail.com">srihari.gopalan6@gmail.com</a>.
- Samb has a TV and radio show that he would like to have one or more of us on to talk about the project.
- Would like us to share a project schedule of the semester.

## <u>Information provided by Alassane Samb:</u>

- Enhancerface of the finger sleeve increases friction between the surgeon's finger and instruments or tissueed Grip: The su, helping prevent slipping. This is especially useful in microsurgery or when working with small, delicate anatomical structures.
- · Protection:

Finger sleeves protect the surgeon's fingers from contamination (blood, fluids) and reduce the risk of cuts or abrasions when handling sharp tools. They also protect the patient from oils and particles on the surgeon's skin.

### · Stabilization and Dexterity:

Some procedures require the surgeon to **hold multiple fingers in precise positions simultaneously**. Finger sleeves can help by providing slight compression and support, which reduces fatigue and improves fine motor control.

## • Sensitivity Maintenance:

Unlike thick gloves, these sleeves are thin enough to **preserve tactile feedback**, allowing the surgeon to feel texture, tension, or resistance in tissues—critical for accurate manipulation.

### · Potential for Innovation:

The current sleeves are simple. A new version could:

- Be ergonomically shaped to fit finger joints and improve comfort during long surgeries.
- Include adjustable tension or compression to support finger stability.
- Have smart materials that enhance grip, resist fluids, or even provide haptic feedback.
- Incorporate sensors to monitor finger pressure or movement for training or robotic-assisted surgery.



Fig. 1 Example of the Japanese finger sleeves that our client is referencing.

 Request for UW BME Student Project – Next-Generation Japanese Finger Sleeve with Smart Monitoring and MRI Compatibility

### **Project Goal:**

Design and prototype an advanced Japanese finger sleeve for surgical use that enhances **finger stabilization**, **grip**, **and dexterity**, maintains tactile sensitivity, includes **smart monitoring**, and is **MRI-compatible** for use in imaging environments.

## **Project Requirements:**

## · Functionality:

The finger sleeve should:

- Provide enhanced grip on surgical instruments and tissues.
- Offer stabilization and support for finger joints, reducing fatigue during prolonged surgeries.
- Maintain tactile sensitivity for precise manipulation of tissues and sutures.
- · Include smart monitoring sensors to measure:
  - Finger pressure and applied force (target range: 0.5–5 N for delicate manipulation).

- Finger movement and bending angles (target range: 0–90° per joint).
- Duration of use or repetitive motions.
- Integrate wireless or Bluetooth data transmission for analysis.
- Be MRI-compatible, meaning materials and embedded electronics must not interfere with magnetic imaging and remain safe in MRI environments.

### Design Specifications:

- Material: Flexible, medical-grade, biocompatible, and non-metallic material (e.g., silicone, thermoplastic elastomer) safe for MRI use.
- Elasticity: Snug fit without cutting off circulation; allow 15-25% stretch beyond relaxed finger diameter.
- **Length:** Sleeve should cover **fingertip to base of first knuckle** (~3–4 cm), with optional full-finger coverage including second knuckle (~5–6 cm).
- Size & Shape: Ergonomically conform to finger anatomy, including joints and fingertip; modular segments
  optional.
- Surface Texture: High-friction micro-pattern for better grip.
- Durability & Sterilization: Resistant to repeated use; cleanable/sterilizable per medical standards.
- Smart Features: Embedded pressure and motion sensors using MRI-safe components; optional haptic feedback for training.

### · Prototype & Testing:

- Develop 3-5 prototypes varying material, thickness, texture, length, and sensor integration.
- Test comfort, grip, stabilization, sensor accuracy, and MRI safety with simulated surgical tasks.
- Collect feedback from surgeons to refine design.

### · Deliverables:

- · CAD designs including sensor placement and sleeve dimensions.
- · Prototype samples demonstrating grip, stabilization, smart monitoring, and MRI safety.
- Report detailing material choice, elasticity, force range, sleeve length, MRI compatibility, sensor integration, and testing
  results.

### Goal of the Project:

Produce a **practical**, **ergonomic**, **MRI-compatible**, **and smart surgical finger sleeve** that improves surgeon performance, reduces fatigue, and provides real-time data for training and procedural optimization.

## Conclusions/action items:

The project will focus on creating a reusable, MRI-compatible finger sleeve made from strong, latex-free elastic materials that avoid finger compression. Both multiple sizes and an adaptable one-size-fits-all option will be explored, with emphasis on durability and sterilization. Early prototypes should test grip, comfort, and smart monitoring features such as force and motion sensing. A project schedule will be shared with the clients, and design development will move forward with input from provided reference devices.

Sam Dudek - Sep 12, 2025, 1:51 PM CDT

Title: Advisor Meeting 1

Date: 9/12/2025

Content by: Sam Dudek

Present: Ilia Mikhailenko, Nathan Hansen, Ben Willihnganz, Mariamawit Tefera, Nathan Klauck, Sam Dudek

**Goals:** To gain clarity on our syllabus and timing of deliverables. Also, to go over our progress report with our advisor and our questions for our future meeting with out client.

#### Content:

- -Started by going over some notes about our notebook. This included strict guidelines to only use our notebook for all note-taking. Anything that you would need to replicate our process needs to be in here. Your note-taking, wherever or whatever it is, should be done as you are doing it, and it should be done by Thursday night. With that, dates should match and if you have to edit we were told to make notes on the top.
- -For some notes on the syllabus and upcoming dates, we were told that all progress reports are due on Thursdays. That has to include an email to him, our client, and be posted on our website. With that, our PDS is due next Friday. Though if we want immediate feedback on our draft, we should have it in on Thursday.
- -Other note, all communication should have the team and advisor cc'd.
- -After that, we went through our questions for our meeting with our client later today, and he gave us feedback. Some important notes were that we need to figure out the client's exact vision for the project, because they could have something unique in their mind, or have nothing and we have to come up with everything. Knowing that early will be very important. With that, knowing what resources or funding we have access to is very important. The client could have a good budget, but we need to know how to access it, who is financing what, where we can get things from, etc. Dr. Williams expressed this as important because Madison recently started using a new system that nobody loves at the moment. Another important note he made was asking how it will be used and how many people will be in the room while it is being used. Not only that, but also if it needs to be sterile and if we are making a device for an area that may not have a lot of resources. Lastly, he noted to ask about any ethical and safety measures we may have to take.
- -After that, he once again noted what is due soon and the meeting was over.

**Conclusions/action items:** Go into our meeting with the client, introduce ourselves, and ask all our questions, noting them in our notebook at the same time. After that, figure out a time to meet as a team, and also talk about our roles in the coming week and what everyone must do.

Ilia Mikhailenko - Sep 22, 2025, 2:43 PM CDT

\*Edits were made to notes on 9/22/2025 at at 2:43 PM\*

Title: Advisor meeting 2

Date: 9/19/2025

Content by: Ilia

Present: Ben, Sam, Nathan H, Nathan K, Maria

Goals: Clear up misconceptions and discuss the progress we have made

#### Content:

- Matrix is due at the end of this week, and the prelim presentation is in two weeks
- The PDS looked good overall
  - o Add numbers wherever possible so results can be tied back to project goals later
  - It is fine to leave the "if statements" in place for now
  - o The project summary was solid
- . Strongest teams will be able to tell a story: client wanted us to do X within Y limits, and testing showed we achieved it
- · Imaging compatibility
  - o MRI should not be a priority this semester, but include it in discussion
  - o Ask whether CT or fluoroscopy compatibility is more relevant
  - o Nathan K suggested electronic circuits can work in MRI if designed with proper materials
  - A separate digital interface might be an option
  - Ask whether sensor readings are needed during imaging
  - o Account for size constraints if a digital interface is included
  - o Ask what imaging technologies they have available and use routinely
- Sensors
  - Force sensors are a relatively cheap and simple option worth researching
- Mechanical design
  - Clarify how the sleeves will be attached—ropes, actuators, or another method
- Presentation
  - Start with a strong introductory slide that outlines the problem clearly
  - o Aim to tell a story: client asked us to do X, we designed within Y constraints, and testing shows the design achieved the goal
- · Standards and specifications
  - $\circ\hspace{0.4cm}$  Even though the product is for Senegal, FDA requirements should be included
  - Frame the device as being at least as safe as comparable devices already on the market
- Logistics
  - o Send drafts with at least two days' notice in the future to get more targeted feedback

## Conclusions/action items:

The team should finalize the matrix this week and begin shaping a clear story for the prelim presentation that ties everything we've worked on so far together. Clarify imaging needs with the client and research practical sensor and attachment options. Make sure drafts are shared at least two days in advance and that targeted feedback is requested to ensure you receive what you're looking for.

Ilia Mikhailenko - Sep 26, 2025, 8:16 PM CDT

John Puccinelli - Nov 03, 2014, 3:20 PM CST

\*Notes cleaned up at 8:16 PM on Friday, September 26th, 2025, from earlier in the day\*

Title: Advisor Meeting 3

Date: 9/26/2025
Content by: Ilia

Present: whole team and Dr. Williams

Goals: To discuss the progress we've made and seek input on the steps we need to take moving forward

Content:

### **General Notes**

We are up first next week for presentations!

add slides to multiple presentations (indicated in Pucc's email)

If someone has videos, check beforehand

Questions for presentations

Practice as a group beforehand

Shoot for 10 minutes. 10-12.

Clarify the salient features of each design - specifically the less intuitive ones.

Make sure hat the values and scores are aligning with reality.

Nathan K research: asked about feasibility of load cell and how to find one that is a proper size. Will continue discussing this, put on to-do list.

Anything to add to the notebook this week?

• Any further research or anything applicable to the design / slideshow.

## Conclusion/Action Items:

- 1. Prepare for presentation next week. Have it uploaded in the correct locations and practice
- 2. Finalize values for the design matrices to ensure we chosen the correct
- 3. Give williams 1-2 specific slides for feedback

Sam Dudek - Oct 10, 2025, 12:28 PM CDT

Title: Advisor Meeting 4

Date: 10/10/2025

Content by: Sam Dudek

Present: All group members

Goals: Talk over our presentation, our progress, and where we are headed in terms of the schedule.

#### Content:

- -Started talking about the show and tell that is coming up, which is three weeks away. So we have to think about what we can make from now and then so that we can show others.
- -After that, we went through our presentation and received feedback on it. Overall, he said we did a good job. It was a bit long than usual. He said that some slides just took up a lot of time, but also that he could tell we practiced. One thing he saw amongst us and other groups is to quantify more. Some of the drawings were a bit hard to read with sliders. They should be standalone, getting the main idea without explaining. Also, overall, there was a lot of white space on the slides in general. He said to look at the slides from the back of the room is usually a good way to look at it.
- -He did say that overall, there is a delicate balance with that white space. Overall, a lot of the problems were small and constructive, and can be edited for later presentations. These are problems that are not going to tank our grade, but small things that affect people in the back of the room. For example, some of the notes on the figures are very small. Our prof. couldn't see from the back.
- -We talked over what we had done this week, other than the preliminary report, which wasn't much due to the length of the preliminary report.
- -We talked about possibly divvying the work up in the coming weeks.
- -Next, we talked about what we need to be fabricated by 3 weeks. First off, it was about ordering material. Whether it is nylon fabric, D hooks, the main frame, and more. We also have to talk more about how we are going to get materials from our client. We talked about possibly going to the maker space for fabrics; they have a lot of materials they use for us. Don't wait to make the first prototype, even if it is not the same size, same materials, but just by doing it you will learn so much.
- -We also talked about 8020.net and how we can use it, possibly for prototyping, it would go together very quickly.

#### Conclusions/action items:

-Overall, our goal is to start prototyping the sleeve portion and the stand. We will talk about possibly divvying up the work between two groups of three, buying things from Grainger, the maker space, 3D printing, and more.



Sam Dudek - Oct 17, 2025, 12:18 PM CDT

Title: Advisor Meeting 5

Date: 10/17/2025

Content by: Sam Dudek

Present: All group members

Goals: Talk about our current progress, our plans for the show and tell, and more logistics.

#### Content:

The first thing we did was go over our two groups. Ilia talked about the stand, and how we plan to go about it. He then mentioned that we needed to buy something, being the stand and the bed clamp. Williams said that we should just go out and get it because it is really only \$40. When we started talking about our beds, we stated how we needed to get more information on their beds. He inquired if we needed to purchase it or build it ourselves, and we think once we get information about the beds we can decide that. Also mentioned the statics.

Nathan H then talked about our sleeve group, how we went to the Makerspace, and got some different fabrics. We talked about how we want to do a preliminary survey at the show and tell with a prototype that we should make. We discussed the testing we plan to conduct. Tensile testing on the sleeve itself, slippage, and tensile testing after sanitation. Then we talked about all of our alternatives for joining the nylon and the Velcro straps.

He also noted possibly testing the raw materials and then the device when it is fully made, see the difference of tensile stretching.

He also noted some possible testing of the attachment with the sleeve and the stand. This was when we started to describe our possible testing with our stand. This was our ultimate load testing, and tipple, angle of deflection, which he came up with as important. So we should be able to do that.

### Conclusions/action items:

Make progress on our prototypes and ordering as soon as possible, because we have never had this client, and we dont want to have any late problems.

Sam Dudek - Oct 24, 2025, 12:24 PM CDT

Title: Advisor Meeting 6

Date: 10/24/2025

Content by: Sam Dudek

Present: All team (Nathan Klauk absent)

Goals: Talk about our progress and schedule for the upcoming week.

#### Content:

The first thing we talked about was our progress report. The first thing was about the email that we need to follow up on was the materials that we asked about. The mechanical team was talking about the PVC pipe they thought about using, as well as a possible 3D print, asking about the strength of the material. Overall, they do have some high-performing material there, like carbon fiber material. On top of that, 3D printing could make it more exact.

After that, the finger sleeve group started to talk about what we did this week. We talked about the laser cutter and how it sealed, and the finish came off really well. We used the CO2 laser. We then talked about how we made the sleeve and how it looked just like our design. We then talked about how we have to do a testing protocol. We then talked about its autoclavability of it. Originally, we believed that autoclaving was not possible. This is because ballistic nylon cannot get all the way up to the temperature. But, we can lower the temperature, increase the pressure, and keep it in for longer, which is a good idea. There is also an oxygen plasma chamber. Ethylene oxide gas is the fallback, very expensive, and they really dont have that in Senegal.

Tensile test for medical materials, ASTM, there should be a protocol. There is a dog bone thing to cut out, like we can just put it into CAD. So Nathan will need to talk to his professor to get those cutouts, and then we can use the machine for tensile testing.

We can also cut the dogbone in half and stich it, and then test that as well, in an autoclave and not in an autoclave.

#### Conclusions/action items:

For the sleeve team, look up some testing standards, sterilization protocols, get in the team lab (Dr. Puccinelli), and come up with a testing protocol.

For the mechanical team, put together a prototype.

Ilia Mikhailenko - Nov 12, 2025, 1:39 PM CST

\*Formatting adjustments made on 11.12.2025 at 1:38 PM\*

Title: Advisor Meeting 7

Date: 11/7/2025

Content by: Ilia M

Present: All team

Goals: Talk about our progress and schedule for the upcoming week.

Content:

May potentially meet up with Williams to pick up an autoclavable bin. Nathan Hansen will coordinate.

Can discuss prototype for the attachment between sleeves and mechanical arm. We will address this in the team meeting.

RAM - company that is world leader in these sort of bed clamp attachment mechanisms.

Email Williams about getting a RAM bed clamp. This is low priority though, but will keep it in mind.

This meeting was fairly short due to the Tong Distinguished Lecture before.

Conclusion: As stated above, this meeting was concise and to-the-point. We discussed points that are holding us up (autoclavable bin needed for testing), a bed clamp (not needed for this project currently, can get to it later), and other minor details. Nothing is due in the near future assignment-wise, so the team just needs to keep pushing with fabrication, testing, and other things for the project.

Sam Dudek - Nov 14, 2025, 12:22 PM CST

Title: Advisor Meeting 8

Date: 11/14/2025

Content by: Sam Dudek

Present: All

Goals: Talk about the upcoming schedule and things that we need to turn in

#### Content:

Williams first talked about our poster session on December 5. So we should start working on our poster in our free time, most likely. After that, we looked at what we did this week. The finger sleeve team went to the MTS lab and did 3 tensile tests on the material, so we can get a standard deviation for it. Then we explained our plan, which is to autoclave and then test again, and eventually create a final prototype with our new materials and test slippage and comfort. He said the plan was good.

The other team explained their connection prototype, which they will further refine with the water jet, most likely. After that, they can test it or get some intuition on where they want to refine the design going forward. He told us to look at SolidWorks to look at static equilibrium and stuff like for the design. This way, we can look at stress distributions for it. We also got our IV pole and showed it to him. We then talked about how we should test about the stitching and how to test that with the MTS machine. We could possibly only do one stitched dogbone we could do one and see if it deviates from our other ones.

Williams also gave us some things for the autoclave that we can use.

#### Conclusions/action items:

Just keep going on with our plans and execute. We only meet one more time!

Sam Dudek - Nov 21, 2025, 12:32 PM CST

Title: Advisor Meeting 9

Date: 11/21/2025

Content by: Sam Dudek

Present: All members

Goals: Talk over poster session details and our final plan

#### Content:

The first thing we talked about was where we were going to print our poster and when. If we set up our poster on the 5th from 10-11, there will be pizza before we start at exactly 12. Then we started asking questions about further details going forward. Other students will be coming to evaluate us, as well as Williams and Bartels. If we want a part of our poster to look at, ask him, but don't send the whole thing. Things we have to keep in mind is the correct balance of white space, words, and figures. Not too much words. The conclusion part of the testing doesn't really need to be a whole section, we can ask him if we have a good balance.

Next we talked about our progress report. First it was about testing, and talking about unpaired and paired. We had unpaired because it broke. It is a single tail because it either will be the same or weaker, not stronger. So it must be a single tail test. So our data is a little weak because it is unpaired, which we can't change, but it is single tailed, which makes it stronger.

We then talked about the elastic modulus. He said to come up with a graph, a bar graph with mean and standard deviation for control, 1 cycle, 5 cycle, and compare the differences between the 3. Bar and cluster. Find if they are statistically significant. If we have 3 bar plots that would be very good to put on our poster and would get all of the information onto that. If it isn't losing strength, then its fine. Also if everything is in the same order of magnitude then it is not a big deal. We could potentially do a curve graph. If it is linear and fits well, then you could possibly postulate and say maybe dont use it more than X times.

Then we talked about our metal water jet thing and Nathan described the stress analysis. He said how this is gaining more intuition and having pretty pictures. Then we talked about the displacement and how much it would move. We didn't have the right data right away, but we kind of talked about what may happen. If it is too much displacement, it isn't too big a problem because its not moving too much. Static movement is okay, dynamic movement is not okay.

He gave us some advice on how to test the stand. He said maybe doing it in SolidWorks again. Possibly add weight to the stand and measure the angle of deflection, could do that on KINAOBE or with a rope type of thing.

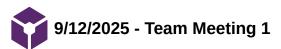
Everything kind of has to fit the story. What are our results, what to they mean for us, what does it mean for the client.

Maybe next time we want to text different geometries of the stitching to better mimic our product.

To test our beads we might need to actually put everything together.

## Conclusions/action items:

Keep working and collecting data and keep going but make decisions that would make sure that our client will have the fullest story in the end.



NATHAN HANSEN - Sep 12, 2025, 6:25 PM CDT

Title: Team Meeting #1

Date: 9/12/2025

Content by: Nathan Hansen

Present: Whole Team

Goals: Recap first client meeting, set up PDS, and plan work for the week.

#### Content:

After our virtual meeting with our client ended, we made sure that everyone was on the same page about what our client had communicated to us, as well as discuss preliminary thoughts about the project. More information from the client meeting can be found on page 9/12/2025 - Client Meeting #1.

After setting up the PDS using a template provided by UW-Madison, we divided the sections up amongst the team to be drafted:

Klauck: Function and standards & specification

Maria: Client requirements, performance requirements, safety, and accuracy & reliability

Hansen: Life in Service, Shelf Life, Operating Environment, and Ergonomics

Sam: Size, Weight, Materials, and aesthetics, appearance, & finish

Ben: Quantity and target product cost

Ilia: Standards & specifications, customer, patient-related concerns, and competition

We are planning on having a draft of all sections completed by Tuesday night so that a draft can be sent to our advisor for proof reading. This should allow time to receive feedback and edit our PDS before our advisor meeting on 9/19/2025, the same day that the document is due.

#### Conclusions/action items:

Each team member is responsible for drafting their assigned PDS sections by Tuesday night to allow time for advisor review and revisions. The compiled draft will be sent for proofreading ahead of the 9/19/2025 advisor meeting and final submission. The team will continue aligning work with the client's requirements to ensure the PDS reflects both functional needs and project goals.

Ilia Mikhailenko - Sep 22, 2025, 2:44 PM CDT

\*Edits to notes were made on 9/22 at 2:44 PM\*

Title: Team Meeting #2

Date: 9/19/2025

Content by: Ilia M

Present: Whole Team

Goals: Recap advisor meeting, discuss points of confusion, and plan work for the week.

Content:

The team discussed several miscellaneous topics to begin the meeting, including:

Why string is not a feasible option for an attachment mechanism between the finger sleeves and the mechanical portion. This discussion led to an inconclusive answer, and we concluded we would need more details from the client before making a final decision.

We discussed the location of different resources on the BME webpage

Looking at a video of how the old Japanese finger sleeve device was used to better understand our end goal

The majority of the meeting was dedicated towards developing questions we could ask the client to better understand what they are looking for in our device. Here are some of the questions we developed:

will this device be used for surgical operations / simply holding the arm for recovery purposes / both?

will the device be used for wrist scope procedures?

How much variation is needed in the positioning of the hand?

Does the elbow need to be locked into place?

Do there need to be two points of contact? Should there be an option for 1 and 2 points of contact (1 if hanging, 2 if clamped like during a procedure?)

There is a wide range of competing designs available on the market which, although expensive and incapable of providing traction to each individualized finger, do meet a fair amount of the criteria you proposed. Are you uninterested in those because of the reasons we just mentioned, or are there any other shortcomings that you believe they have which we should keep in mind when designing our prototype?

How are you guys addressing this need right now without the device which we are currently designing?

Will the device need to have force readings that are actively monitored throughout the time that the patients hand is in the finger sleeve set up, or is this more of a "set it and leave it" kind of feature?

Is it critical that the device is MRI compatible, or can it be fluoroscopy or CT compatible instead? We ask this because designing a digital traction system to be MRI compatible significantly constricts the materials and designs we can use.

Does the device need to go inside the imaging system (MR, CT, fluoroscopy, etc.)? If so, can you please provide us with the size dimensions that will need to be met for each specific machine?

Matrix: to make progress on this, each member of the team will draw two design proposals, one for a finger sleeve system and the other for the accessory mechanical part of the device.

Potential designs: using chinese finger traps.

The team also assigned slides for the preliminary presentation so that certain team members could begin working on their slides in advance of our meeting with Dr Williams this week.

- maria: pds and competing designs
- sam: intro
- ben: some methods
- Nathan k: end of design matrix and future work
- Ilia and nathan: design matrices and end of methods

## Conclusions/action items:

Each team member is responsible for having two design ideas, one for the finger sleeves and one for the other mechanical parts of the design.. The team will meet later this week to discuss the design ideas and determine the design matrix. The team will also update the PDS by including more numerical references to criteria the team is looking to meet.

Ilia Mikhailenko - Sep 23, 2025, 6:58 PM CDT

- Ben's
- Nathan hansen's
- maria

## Top 3 for mechanical

- Ilia
- Nathan hansen with Maria's comfort
- Nathan klauck's

## **Mechanical Component**

Ease of use - 25 (adaptability, accessibility, comfort

Cost - 20

Reusability - 20

Safety - 15

Versatility - 10

Imaging Compatibility - 10

## Sleeve

Cost - 25

Reusability - 25

Safety - 15 (traction)

Ease of fabrication - 15

Ease of use

Imaging Compatibility - 10

Ilia Mikhailenko - Sep 26, 2025, 8:17 PM CDT

**Title: Team Meeting 4** 

Date: 9/26/2025

Content by: Nathan Hansen

Present: Whole Team

Goals: Discuss questions to ask our client to clear up confusions about project vision.

### Content:

- · What challenges have you faced with past finger traction devices?
- · What is wrong with current designs on the market?

After asking the first two questions, show the our client our current designs as see which one aligns with what he has in mind.

- Should this be used mainly for surgery, for holding, or both?
- Will it involve a wrist scope?
- · How much variation in hand positioning is needed?
- Would you prefer one or two points of contact (or both options)?
- · How should we purchase materials?

## Slide Distribution

- maria: pds and competing designs
- sam: intro
- ben: some methods
- Nathan k: end of design matrix and future work
- Ilia and nathan: design matrices and end of methods
- Sam: intro slide, problem statement, and background material
- Maria: competing designs and PDS
- nathan h (mechanical methods)
- ilia (mechanical matrix)
- ben (sleeves methods)

- Nathan K (sleeve's design matrix and conclusion)

## **Meeting with Client**

Liked the bed clamp

Liked the wheels for portability

Wanted a hybrid design

Other questions I'm looking to ask Samb / Soumah:

- How much of a priority is digital traction
- What are the things that are wrong with those currenlty on the market

## **Notes for Presentation**

6 lines per slide, 6 words per line

As many numbers as possible

Avoid pointless figures

Add labels to figures

Don't just have one sub bullet.

## Conclusions/action items:

## Actions

We will bring these targeted questions to our client to clarify the project vision and better align our designs with their expectations. After gathering feedback, we will refine which design direction to pursue, make edits to our design matrix, and establish a clear plan for material purchasing.

Ask williams about prop

email samb about presentation time and tv show time

Nathan will redraw methods.

Other to-do's: figure out who will be getting there early to make sure everything works. Practice in the actual room, and make sure you can project.



# 10/03/2025 - Team Meeting 5 (Post Presentation)

Sam Dudek - Oct 03, 2025, 3:59 PM CDT

Title: Team Meeting 5 (Post Presentation)

Date: 10/03/2025

Content by: Sam Dudek

Present: Whole Team (excluding Nathan Hanson)

Goals: Debrief over the presentation and assign each team member to different parts of the preliminary report

**Content:** We started the meeting by walking from our presentation room to the ECB. On the way, we debriefed our presentation as well as others, talking about our slides and how we thought it went. After that, we briefly discussed the requirements for the preliminary report and decided that our responsibilities would be loosely based on what we did for the presentation. After everyone knew exactly what was being asked of them, we left and went on.

**Conclusions/action items:** Work this weekend and during next week on our preliminary report to get that in by Thursday afternoon. Possibly meet to discuss any concerns with the report and for future work. After the preliminary report, begin to fabricate our prototype.

Sam Dudek - Oct 15, 2025, 8:42 PM CDT

Title: Group Meeting

Date: 10/15/2025

Content by: Sam Dudek

Present: All group members

Goals: Talk about both of our groups progress to be ready for Friday

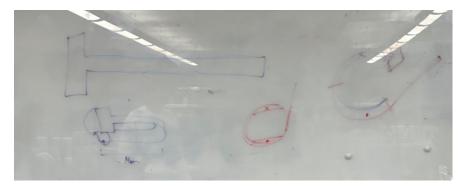
### Content:

Stand split into 3 different parts. One of them was the physics part of it, finding out the length and weight that is going to be needed to be stable at equilibrium. The other part was the part number identification. Maria was in charge of this, finding what parts they would need for the design and finding out those logistics. Ilia was in charge of the bed clamp incorporation; he made a design matrix as well.

We talked about the budget and how much the stand group needs to use in the maker space. They said as of right now they do not.

We then went over the possible ways of making our sleeve. Nathan got on the whiteboard and starting drawing the tenitive way of doing it. The picture is below.

After that Nathan talked about the statics problem, he said that he has some what of an equation for the statics problem to see the forces.



After that Ilia talked over the overall design although it is not finished, picture below:



After that he talked about the bed clamp system that he has been working on. He had 3 ideas, which are outlined in his notebook. We talked about the importance of the clamp, because the wheels will be unstable during something like a wrist arthroscopy.

After that, we talked about ordering the specific materials. Maria started to go over the things she found on 80/20 and all of the other products. Most of it was just the materials for the stand. Whether that be different collars, steel tubes, bars, sheet metal, T handle locking quicking release pin, IV pole clamp, as well as different poles.

Ben also mentioned the idea of keeping it all as one piece, and just having the clamp in the middle. The idea is that we can just roll it up to the bed and then clamp it from there.

We then talked about what we need to email Soumah.

Then we talked about testing, for sleeves, it was comfort, slippage, and durability. We think that we could do a tensile test here in the ECB. When we finally have the stand, we will try to determine a factor of safety by applying four x the amount of weight that we think we would think we need on the stand. Also, like a perfusion test, like blood flow to the finger before and after the sleeve. Nathan K could maybe ask his biomechanics proffessor about how to go about it.

Possibly looking at the angle of deflection on the on the stand for testing, we are not 100% sure how we would do that yet.

We could also test it somehow by putting our sleeve material through a sterilization process and seeing if it weakens the material.

### Conclusions/action items:

We must email Soumah to talk about the bed types they have, and if they have a standardized way of clamping onto the bed and/or operating table. Also, would the bed clamp need to be sterilized?

Also do we need to have a clamp for the bicep region.

We need to figure out the clamp by figuring out the beds, we need to email Soumah separately, so not to overload him with our progress report email.

We also need to email Samb and Soumah about the price and everything. This includes the necessary items we plan on buying, how he wants to go about reimbursement, and more.

What type of sanitation do you do on both the sleeve and the stand?



Ilia Mikhailenko - Oct 17, 2025, 1:07 PM CDT

## Things discussed:

- Where would we drill the holes? on the sleeve or on the iv pole?
- using a pvc pipe?
- using a square stock or round stock for crossbar?
- how to secure the circle stock in the pvc pipe? gluing/epoxy?

## Next steps:

- · Look at materials downstairs
- Put stuff together and see what works and what doesn't

NATHAN HANSEN - Oct 31, 2025, 1:50 PM CDT

Title: Show and Tell

Date: 10/31/2025

Content by: Whole team

Present: Whole team

Goals: Discuss current design complications with other BME design teams to gain input.

Content:

## General advice based off of presentation?

- Use of extruded aluminum (there are accessories)
- · Experiment with TPU strips for grip to the finger
- · Trampoline park socks
- Strapless bra/dress grip (silicon elastic tape)
- space
- look at the other materials used for autoclavable finger sleeves prob may be resolved already

## What other testing would be necessary for the sleeve or mechanical portion?

- · Qualitative testing of how long it takes to set up the system
- · Get specific finger weights to hang from the straps

### What methods can we use to attach the cross bar to our stand?

- Instead of using a clamp that could potentially slide down, attach it as a topper to the stand
- A pin style attachment (like a cable machine at the gym)

## How could we stabilize the stand, both attached to the bed and not? (Clamp ideas, ideas for anchoring, etc.)

- Create an attachment that is compatible with clamps they already use at the hospital (not necessarily make the clamp)
- · Low counterweight and wheel locks might be good enough for stabilization
- · Clamp that attaches to armbar of bed
- · rotating C-clamp to grab horizontal and vertical bars

## Methods of weighting/counterweighting

slideable weight to counter based on arm weight

## How to design finger attachment portion

- Could use a carabiner type clip
  - o S clip
- · Could use hooks instead of holes on the stand attachment side
- •
- · How was original design autoclavable
- gym barbell clamp
- · wrist snap-in thing for adjustability
- · ask Soumah about previous sanitation method
- Potential splint more rigid design
- Two part splint

## Conclusions/action items:

## Conclusions/action items:

To advance the design, we will order silicone elastic strips for improved finger grip and prototype a more stable, clamp-compatible stand, while also testing setup time. Next steps also include selecting autoclavable materials, refining finger attachment methods (e.g., carabiners or hooks), and confirming sterilization compatibility with hospital standards.

Ilia Mikhailenko - Dec 10, 2025, 5:13 PM CST

Title: Advisor Meeting with Srihari: Project Direction and Priorities

Date: 11/07/2025

Content by: Ilia

Present: Team

Goals: Get feedback on the project and figure out what we should focus on next

#### Content:

We met with Srihari Gopalan, a former BME student who has been checking in on our project throughout the semester. We updated him on our current work and explained the issues we've had getting photos of the hospital beds from the client, which has made it hard to design a proper bed clamp for our stand.

Srihari told us not to get stuck on the clamp and suggested we put our energy into the parts that matter most: the finger sleeves first, then the mounting plate, and the stand last. His reasoning was that the sleeves are the most unique part of our design, the mounting plate is the key connector, and the stand is something the hospital already has versions of.

His advice helped us reset our priorities and focus on thing that actually move the project forward.

## Conclusions/Action Items:

We'll start by finishing the finger sleeve design, then work on the mounting plate, and leave the bed clamp for later once we get more info from the client.

Ilia Mikhailenko - Nov 21, 2025, 8:29 AM CST

Title: Team Meeting

Date: 11/19/2025

Content by: Whole team

Present: Whole team

Goals: Discuss current design status and how we can work to effectively deliver the final deliverables

#### Content:

- · Major remaining actions
  - Final poster
    - Divvy up sections
    - Complete draft poster by Sunday, Nov 30. Send to Srihari for feedback
    - Implement feedback by Wednesday, Dec 3
    - Print on Thursday, Dec 4. Meet for practice following that
    - Feedback
      - Too many words?
      - Reference font size?
      - Conclusion for testing section
  - Final presentation practice
    - When back from break
  - Document all remaining team meetings in notebook
  - Put together a final prototype
  - Stand testing
    - Weight bearing
    - Metal bead testing (email pucc)
  - Sleeve testing
    - Slippage
    - Comfortability testing
  - Final Report
    - Divvy up sections
      - Testing
        - Stress strain for sleeve

- Draft finished by Sat, Dec 7th
- Feedback on Sun, dec 7th
- Touch up on Mon/Tues, Dec 8th/9th
- Final look over on Dec 10th. Submit
- Fabrication for sleeve
  - Print D-ring.
- Fabrication for stand
  - Initial model
  - Final waterjet model
- spreadsheet.

## Poster designations:

## Introduction

• Sam

## **Prob Statement**

• Sam

# **Competing Designs**

• Sam

## Final Design

## Ilia and Ben

- Design Criteria
- •

## Future work

• Sam

## Testing / discussion

Sleeve team: hansenStand team: klauck

## Final Report

## **Testing**

· Metal beads: maria

• FEA for sleeve-stand: nathan

· Stand deflection: ilia

# Discussion

Metal beads: maria

FEA for sleeve-stand: nathan k

• Stand deflection: ilia

· Condense all together: nathan k

Conclusions/action items: As the final stretch approaches, the team has a list of actions remaining that we need to complete to ensure we have a solid final product. This list is detailed above - major items are the final report and final poster, which are detailed above. The team has divided these up and has a plan for completing them in due time. We are almost there!



Ilia Mikhailenko - Dec 04, 2025, 8:52 PM CST

\*Edits made on 12/4 to update sequence of events/terminology\*

**Title: Team Meeting** 

Date: 11/21/2025

Content by: Nathan K, Maria, and Ilia

**Present:** Whole team

Goals: Finalize the build for the mechanical body and make small corrections

#### Content:

Since the team had just met as a group earlier in the week, a whole-team meeting was not needed.

The mechanical team went to ECB to assemble the IV pole. This took some time but the pieces were put together and the stand functioned as expected.

However there was an issue. The attachment piece, when hung from a bar on the IV pole, was quite flimsy and not stable.

Several ideas were discussed to correct this issue, including creating another attachment piece and attaching it to the IV pole as well to create a second point of contact, which would be stabilizing and limit rotation.

Another idea that was proposed was using stoppers, which could slide along the bar and wedge the attachment piece into place. This option was selected on the spot as it was deemed the most efficient to do and also would function quite effectively to achieve the desired outcome.

The team then put together a 3D printed model of the stopper after some measurement of the IV pole's diameter. This model was submitted to the Makerspace and scheduled to be printed over the course of that day.

## Conclusion:

The IV pole is assembled and in great condition, meeting the desired needs of our client. The issue of too much rotation was dealt with via a group discussion on stabilization devices and a consensus on a 3D printed stopper. This stopper was designed and submitted for printing on the spot, and awaits pick up in the near future.

## 12/4/2025 - Final Poster Presentation Practice

Ilia Mikhailenko - Dec 04, 2025, 8:34 PM CST

Title: Team meeting

Date: 12/4/2025

Content by: Whole team

Present: Whole team

Goals: Practice presentation of the final poster

### Content:

Ran over the final presentation. First run was 10:30. Points discussed following the practice run are attached below:

- Be sure to mention the advisor
- clarifications were made regarding the competing designs and the need to include them. Due to our project being tied closely to something currently available on the market, it is important to note the shortcomings of other devices based on the specific needs of our client.

Ran through the final presentation a second time. Second run was 10:15. Points discussed are attached below:

- Discuss specific statistical tests conducted.
- Mention the reasoning for the F.O.S. of four.
- Know what to discuss for the reasoning behind significant increases and decreases in the sleeve testing.

Following the second practice run, Nathan H showed us updates made to the finger sleeve regarding additional stitching to accommodate for various finger sleeve sizes.

The team then conducted a third practice run to smooth over bumps in speech and get additional practice. The team made a plan for setting up the poster tomorrow and is ready to go!

Conclusion: The team practice the presentation and made sure the overall "story" made sense. By hearing the presentation all together and listening to what each team member had to say, we can fine tune small details and ensure the poster is presented in a way that makes sense. We are ready to go for the final presentation tomorrow!

Sam Dudek - Oct 10, 2025, 4:07 PM CDT

Title: Finger Sleeve Meeting 1

Date: 10/10/2025

Content by: Sam Dudek

Present: Sam, Ben, Nathan H

Goals: Talk more about the sleeve design and our prototype

#### Content:

-Need to figure out end testing. This could be the slippage. We could do this at the show and tell. Durability, being able to withstand the force that we put into our PDS. We talked about our design and how we think we should go about it. We thought about prototyping and testing our template and if it works. We can text the fit and stuff like that with any material, but the testing with like the slippage and the durability would be with our actual materials. These materials we should ask Samb for now so we have them later.

-We went to the makerspace and looked at different different materials that we could possibly use. We found different nylon, straps, and more there. It seems like we can get our materials there for the sleeve. I also picked up some wheels that the other group can use for the stand.

### Conclusions/action items:

Continue to work on the sleeve design, find materials that we will need, and think deeply about how we go forward with our prototype.



# 10/23/2025 Initial Finger Sleeve Prototyping (Learning to Stitch)

Sam Dudek - Oct 24, 2025, 12:05 PM CDT

Title: Initial Finger Sleeve Prototyping (Learning to Stitch)

Date: 10/23/2025

Content by: Nathan Hansen

Present: Nathan, Sam, and Ben (Finger sleeve team)

Goals: Learn to stitch and construct a finger sleeve prototype to show Prof. Williams during our Friday meeting this week and begin testing on.

#### Content:

- On Tuesday (10/21/2025), the finger sleeve team laser cut some finger sleeve templates out of ballistic nylon (templates can be found under Nathan H., Ben, and Sam design ideas)
- On Thursday (10/23/2025) we went to the maker space to stich our laser cut templates together with some velcro we purchased and the pictures of our prototype are below



Conclusions/action items:

# 11/17/2025 Finger Sleeve Meeting 2-5

Sam Dudek - Nov 19, 2025, 6:38 PM CST

Title: Finger Sleeve Meeting 2-5

Date: 11/17/2025

Content by: Sam Dudek

Present: Ben W, Nathan H

Goals: Show progress of our finger sleeve design and testing

#### Content:

(10/23/2025) - Initial Finger Sleeve Prototyping, this can be found under fabrication

(10/23 - Now) - Continued Research on Materials Autoclavability and Strength, this and proposed testing protocols **can be found** in each of our individual notebooks (Ben, Sam, and Nathan H)\

(11/31/2025) - Show and Tell Feedback Discussion, **can be found** under team meetings, discussed proposed classmate ideas, and decided to purchase silicone rubber to increase the grip of the patients finger

(11/13/2025) - First MTS Tensile Testing, this was the baseline of 3 dog bones, which were not autoclaved, this **can be found** in each of our notebooks and our Testing and Results folder.

(11/17/2025) - Second MTS Testing with Stitched Dog Bones, this **can be found** under the Testing and Protocols folder. We also threw Dog Bones in the autoclave for one round that day.

#### Conclusions/action items:

We have done a lot of good work. Once we get our cable ties we will need to prototype our final design. We also have to continue testing with the autoclavability of the Dog Bones.

# 11/21/2025 Final Prototype Session 1

Sam Dudek - Nov 21, 2025, 6:39 PM CST

Title: Final Prototype Session 1

Date: 11/21/2025

Content by: Sam Dudek

Present: Ben W, Nathan H

Goals: Cut out 6 pieces of ballistic nylon and 3D print our D rings for attachment

#### Content:

Today we first 3D printed with general material our D rings. Nathan has the file in his notebook. That took a couple of hours, and we should get it Monday hopefully. After that, we cut out pieces for our nylon, 1.5 mm thick, and then had to leave because the maker space was closing.

#### Conclusions/action items:

Meet at some point the Monday before break to further create our prototypes to have ready for when we come back from break.



# 11/24/2025 Final Prototype Session 2

Sam Dudek - Nov 24, 2025, 2:24 PM CST

Title: Final Prototype Session 2

Date: 11/24/2025

Content by: Sam Dudek

Present: Nathan H, Sam D

Goals: Create our final prototype for our sleeve, use our materials from session 1

#### Content:

Nathan and I met in the Maker Space in the textiles section around noon. We started by gathering our materials, and our newly cut nylon from session 1. After that, I marked where we needed to stitch the nylon to itself and Nathan figured out the rubber silicon feature on the sewing machine. After creating that, and attempting to use it with our newly stiched nylon, we both realized that because the silicon rubber and velcro (pictures 1 and 2) were not directly attached to the nylon, it only worked as a fail safe and slipped, especially if the bottom velcro tie was not tight enough. Knowing this was a problem, we decided to overlay a piece of ballistic nylon on top of our sleeve material and stitched with equal length of our velcro strips width, effectibely creating slots we could slide the velcro ties in. That way, there would be no slippage and we could still adjust it for differing sizes of hands. The final prototype is picture 3.







Test comfortability, slippage, ease of use, and continue to perfect the final prototype.



Sam Dudek - Dec 09, 2025, 12:27 PM CST

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# 12/7/2025 Fabrication Protocol Finger Sleeve

Sam Dudek - Dec 07, 2025, 4:47 PM CST

Title: Fabrication Protocol Finger Sleeve

Date: 12/7/2025

Content by: Sam Dudek

Present: N/A

Goals: Create a fabrication protocol for the finger sleeve for easy replication by our client

Content:

## 10.5 Finger Sleeve Fabrication Protocol

## Description:

Our goal is to fabricate a reusable nylon finger sleeve that fits a range of finger sizes that aligns with our product designs specifications outlined in appendix 10.1. This means that the sleeve must be compatible with autoclave sterilization and maintain its mechanical integrity after multiple uses. It should also be able to withstand tensile stresses up to 20 MPa.

## Materials:

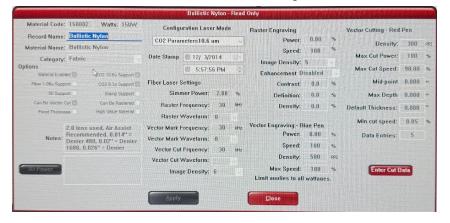
- · Ballistic nylon fabric sheet
- · Heavy duty nylon thread
- 1.5 cm D-ring
- Double sided velcro straps (12.7 x 10mm)

#### Additional Needed Items

- · Laser cutter
- · Sewing machine
- · Fabric scissors
- · Ruler or calipers
- Marking tool

#### Protocol:

- 1. Laser Cutting the Nylon Strips
  - 1. Load ballistic nylon into the laster cutter and secure it to make sure it is flat
  - 2. Program the cutter to create 5 strips measuring 44 x 1.5 cm (further settings shown below).



- 3. Remove cut our strips from the template sheet
- 2. Forming the Sleeve Loop
  - 1. Take a single 44 x 1.5 cm nylon strip
  - 2. Overlap the two ends of the strip by 8 cm
    - 1. Align edges cleanly for best stitching results
    - 2. Make sure it is untwisted
- 3. Stitching the Primary Seam
  - 1. Using the sewing machine, apply a straight stitch running over the fabric 2-3 times back and forth across the overlapped 8 cm region
  - 2. Trim any excess thread
- 4. Creating the Adjustable Slot Mechanism
  - 1. Mark 5 evenly spaced slot lines spaced 1.6 cm apart on both sides of the loop
  - 2. Stitch along the marked lines on each side, creating 5 slots on each side (10 total)
- 5. Adding the D Ring
  - 1. Pass the long end of the loop through the 1.5 cm D ring
  - 2. Pull enough of the nylon through to allow correct anchoring for the sleeve
- 6. Adding the Velcro Attachment System
  - 1. Feed the first double sided velcro strip through the bottom most slot, for the base of the finger hold
  - 2. Insert a second velcro strip through any of the remaining slots, depending on the finger length and girth
    - 1. Note: you want the second strip to go on the body of the finger
- 7. Quality Check
  - 1. Trim any extra stitching thread
  - 2. Inspect for uniform slot spacing
  - 3. Inspect for proper loop arrangement
  - 4. Manually apply tension to confirm there is no premature deformation

Finalize the fabrication protocol for the mechanical portion of the project.

NATHAN HANSEN - Dec 07, 2025, 6:34 PM CST

Title: Ballistic Nylon Dog Bone

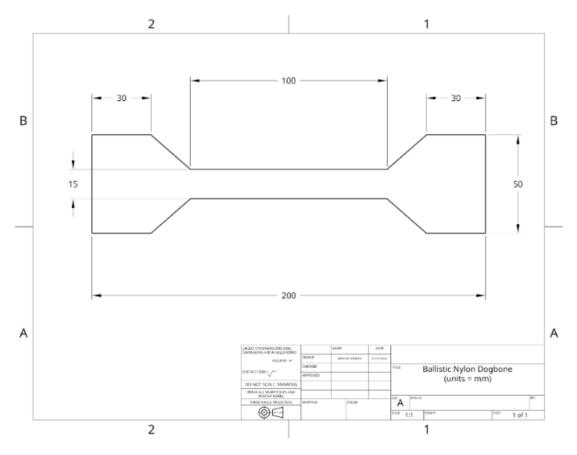
Date: 12/7/2025

Content by: Nathan Hansen

Present: N/A

Goals: Design a dog bone that complies with ASTM D882 standards for testing tensile strength of ballistic nylon.

#### Content:



#### Conclusions/action items:

This dog bone will be laser cut several times from our sheet of ballistic nylon so that we can conduct uniform tensile testing on our material before and after being autoclaved. Ideally, this shape will break in the middle where it has a uniform cross sectional area so that we get an accurate stress strain curve.

# 12/9/2025 Fabrication Protocol Mechanical Stand

NATHAN HANSEN - Dec 09, 2025, 9:24 PM CST

Title: Fabrication Protocol Mechanical Stand

Date: 12/9/2025

Content by: Nathan K

Present: N/A

Goals: To create easy to replicate protocol for creating the mechanical portion of the device

Content:

Description:

The aim is to ensure we fabricate a mechanical body that meets the stability and adjustability requirements of the traction system. The mechanical body must be stable, height-adjustable, and compatible with clinical use. All components should remain durable under repeated loading and maintain structural integrity throughout orthopedic procedures.

#### Materials:

- Standard IV pole (height-adjustable)
- · Aluminum sheet metal (for attachment platform)
- · 3D-printed stoppers
- · Bead chain segments
- D-rings

#### Additional Needed Items

- · Waterjet cutter
- · Sandpaper or deburring tool
- · Measuring tape or calipers
- · Marker for layout lines
- 3D printer + filament for stopper components

#### Protocol:

- 1. Assembling the Medline Stand IV Pole
  - 1. Unfold the base legs by spreading the four legs out from the center until the base is stable and flat on the ground. Make sure all legs are fully opened and resting evenly.
  - 2. Assemble the central pole sections. The main pole comes in several pieces that must be inserted into one another in the correct order. Push or screw them together firmly so there are no gaps or instability present.
  - 3. Once the sections are connected, loosen the collars around the central pole segments to extend the assembled body to the desired length. After you have adjusted, lock the collars on the central pole so the height is secure.
  - 4. Once the pole has been made the desired height, secure the top-piece at the apex of the assembled pole.
- 2. Preparing the IV Pole Frame
  - 1. Inspect the IV pole to ensure the height-adjustable central pole is firmly locked in place.

- 2. Remove any unnecessary parts (hooks/attachements) that interfere with mounting.
- 3. Cutting and Shaping the Mounting Plate
  - 1. Design the desired component in CAD with precise dimensions to produce a file ready for cutting
  - 2. Load the aluminum sheet into the waterjet cutter, ensuring it lies flat and is secured inside the machine.
  - 3. Program and execute the waterjet cut following the design file for the platform.
  - 4. Remove the cut piece and deburr sharp edges using sandpaper or a deburring tool.
- 4. Installing the 3D-Printed Stoppers
  - 1. Design the CAD drawing to 3-D print plate Stopper
- 5. Full Assembly Inspection
  - 1. Position the aluminum plate
  - 2. Slide the 3D-printed stoppers onto the IV pole at the intended mounting height and confirm that the stopper prevents any rotational movement.
  - 3. Connect bead-chain segments to the outer edges of the aluminum platform
  - 4. Secure each chain with a bead-chain connector
  - 5. Attach D-rings to the ends of the chains, ensuring they move freely and allow smooth traction adjustments.
- 6. Quality Check
  - 1. Verify platform stability and alignment
  - 2. Confirm that stoppers fully prevent slipping
  - 3. Ensure bead-chain attachment points are secure
  - 4. Inspect all edges for safe handling
  - 5. Test full assembly under light simulated traction

For the mechanical component of the design the team used an IV pole as the main structural frame, taking advantage of the built-in height adjustment and stability. A sheet of aluminum was selected for the attachment platform since it provides an ideal balance of strength and low weight, allowing the attachment platform to remain stable without making the IV-pole structure top-heavy. The material is easy to machine, which made waterjet cutting and shaping straightforward and efficient during fabrication.



# 10/16 - Finger Slippage Testing Protocol

NATHAN HANSEN - Oct 16, 2025, 8:14 PM CDT

Title: Finger Slippage Testing Protocol

Date: 10/16/2025

Content by: Nathan Hansen

Present: N/A

Goals: Write a testing protocol to determine how much a finger sleeve with slip on the average patient.

Content:

## **Testing Protocol For Finger Slippage**

#### Description:

A testing protocol to determine how much the finger sleeve will slip on the average finger, so that the finger sleeves can be used for 50 minute operations without the risk of the finger sleeve losing grip of the finger.

#### Materials:

- · Working prototype of finger sleeve
- · Stop watch
- Marker
- Ruler
- · 5 willing participants
- Chair
- · Stand to hang finger sleeve from

## Protocol:

- 1. Make a dot with the marker on the center of the MCP joint of the participant's middle finger
- 2. Properly secure the finger sleeve prototype to the participant's middle finger
- 3. Using the ruler, measure the distance in mm to the nearest tenth between the base of the finger sleeve prototype and the dot on the MCP joint
  - 1. Record this measurement as the initial distance
- 4. Have the participant sit in the chair and attach the finger sleeve to the stand, having the participant hang their arm from the stand with their shoulder and elbow and a 90 degree angle
  - 1. Make sure that the participants arm is not resting on the chair and that the forearm is hanging perpendicular to the floor
- 5. Once, the participant is in the proper position, start the stopwatch
- 6. Wait for the timer to reach 10 minutes, and then disconnect the finger sleeve from the stand, making sure to not apply extra tension to the finger sleeve

- 1. The participant can relax their arm at this point
- 7. Using the ruler, measure the distance in mm to the nearest tenth between the base of the finger sleeve prototype and the dot on the MCP joint
  - 1. Record this measurement as the initial distance
- 8. Calculate the change is distance (final distance initial distance)
- 9. Repeat this process for 5 participants and calculate an average change in distance

Next, I will run the slippage test with five participants to gather baseline data. Based on results, I'll determine if design changes are needed to improve grip or reduce movement during use.



# 10/16 - Durability (Finger Sleeve) Testing Protocol

NATHAN HANSEN - Oct 16, 2025, 8:42 PM CDT

Title: Durability (Finger Sleeve) Testing Protocol

Date: 10/16/2025

Content by: Nathan Hansen

Present: N/A

Goals: Write a testing protocol to determine how much tensile force can be applied to a finger sleeve prototype.

Content:

#### **Testing Protocol For Finger Sleeve Tensile Durability**

#### Description:

A testing protocol to determine how much tensile force the finger sleeve can withstand before damage to the finger sleeve and before total failure of the finger sleeve. This is important because the finger sleeve must be able to withstand 50 N of tensile force without damage.

#### Materials:

- · Working prototype of finger sleeve
- · Video camera
- · MTS Insight Model 5kN
- · 250 N load cell
- · 100 N tensile grips
- Ruler

#### Protocol:

- 1. Attach the 250 N load cell and the 100 N tensile grips to the MTS Insight Model 5kN system
- 2. Power on the TW Elite software and the MTS machine
- 3. Keep every parameter the same except change test rate to 0.10 mm/s
- 4. Right click on load and zero the signal
- 5. Unlock the hand held machine control to be able to move the crosshead up
- 6. Secure the finger sleeve prototype between the tensile grips of the system, making sure the sleeve is aligned along the axis of tension to avoid uneven loading
- 7. Set the initial grip separation to match the relaxed length of the finger sleeve (measured without tension)
  - 1. Record this starting length
- 8. Zero the load again and also click the crosshead box to zero it
- 9. Lock the hand held control
- 10. Use the video camera to document the test, focusing on the sleeve to capture the point and mode of failure

- 11. Begin running the MTS machine until it reaches a max force of 250 N or until the finger sleeve fails.
- 12. Turn off the video camera, this can be later reviewed to determine the mode of failure
- 13. Right click on the data and export the raw data to a folder
- 14. Turn off the machine, close the software, return all components to their original storage area, and clean the MTS machine

I will conduct tensile tests on multiple finger sleeve prototypes to determine the average maximum load before damage and total failure. The results will be compared to the 50 N requirement to confirm durability. If sleeves fail below this threshold, material thickness, adhesive type, or stitching methods will be revised and retested.



# 12/7 - Updated Finger Slippage Testing Protocol

NATHAN HANSEN - Dec 07, 2025, 6:30 PM CST

Title: Updated Finger Slippage Testing Protocol

Date: 12/7/2025 Content by: Ben

Present: N/A

Goals: Write a testing protocol to determine how much a finger sleeve with slip on the average patient.

Content:

## **Testing Protocol For Finger Slippage**

#### Description:

A testing protocol to determine how much the finger sleeve will slip on the average finger, so that the finger sleeves can be used for 50 minute operations without the risk of the finger sleeve losing grip of the finger.

#### Materials:

- · Prototype of finger sleeve
- · Stop watch
- Caliper
- · Willing Participants
- Wooden Board
- · Nail in which sleeve will hang
- · Permanent marker

#### Protocol:

- 1. Take the nail and hammer it into the ply board to act as a hook
- 2. Have the participant sit in the chair and attach the finger sleeve to the stand, having the participant hang their arm from the stand with their shoulder and elbow at a 90 degree angle
  - 1. Make sure that the participants arm is not resting on the chair and that the forearm is hanging perpendicular to the floor
- 3. Properly secure the finger sleeve prototype to one of the participants fingers and mark the initial pretested point
- 4. Once, the participant is in the proper position, start the stopwatch
- 5. Wait for the timer to reach 10 minutes, and then make a mark on the finger of the participant, after the dot is created the sleeve can be disconnected and the participant can relax their arm
- 6. Using the caliper, measure the distance in mm to the nearest tenth between the first mark and the second.
- 7. Repeat this process for each participants finger

#### Conclusions/action items:

Next, I will run the slippage test with five participants to gather baseline data. Based on results, I'll determine if design changes are needed to improve grip or reduce movement during use.

# 12/7 - Autoclaved Tensile Testing Protocol

NATHAN HANSEN - Dec 07, 2025, 6:27 PM CST

Title: Autoclaved Tensile Testing Protocol

**Date:** 12/7/2025

Content by: Nathan Hansen

Present: N/A

Goals: Write a testing protocol to determine how much tensile force can be applied to a finger sleeve prototype.

Content:

## **Testing Protocol For Finger Sleeve Autoclaved Tensile Durability**

#### Description:

A testing protocol to determine how much tensile force the finger sleeve can withstand before damage to the finger sleeve and before total failure of the finger sleeve. Additionally, the sleeve should maintain these strength properties after being autoclaved. This is important because the finger sleeve must be reusable and be able to withstand 20 MPa of tensile stress without damage.

#### Materials:

- · 9 ballistic nylon dog bones
- · Primus gravity autoclave
- · 2 sterilization pouches
- · MTS Insight Model 5kN
- 1 kN load cell
- 100 N tensile grips
- Ruler

## Protocol:

## Autoclaving:

- 1. Place 6 out of the 9 dog bones into a sterilization pouch and put the pouch into the Primus autoclave
  - 1. The other 3 dog bones can immediately be tensile tested
- 2. Run an hour long gravity cycle with a max temp of 251 °F (30 min sterilize, 30 min dry)
- 3. Pull the sterilization pouch out of the autoclave and allow it to reach room temperature
  - 1. Check if the sterilization strip on the sterilization pouch has changed colors, indicating that the it has been properly sterilized
- 4. Remove 3 of the autoclaved dog bones from the sterilization pouch, these can be tensile tested
- 5. Transfer the other 3 autoclaved dog bones into a new sterilization pouch and put the pouch into the Primus autoclave
- 6. Run an hour long gravity cycle with a max temp of 251 °F (30 min sterilize, 30 min dry)

- 7. Pull the sterilization pouch out of the autoclave and allow it to reach room temperature
- 8. Repeat steps 6-7 three more times in the same sterilization bag so that the set of dog bones has been autoclaved 5 times
- 9. Conduct tensile testing on the last 3 dog bones

## Tensile Testing:

- 1. Attach the 1 kN load cell and the 100 N tensile grips to the MTS Insight Model 5kN system
- 2. Power on the TW Elite software and the MTS machine
- 3. Set the machine to tensile testing and change the test rate to 0.05 mm/s
- 4. Right click on load and zero the signal
- 5. Unlock the hand held machine control to be able to move the crosshead up
- 6. Secure the finger sleeve prototype between the tensile grips of the system, making sure the sleeve is aligned along the axis of tension to avoid uneven loading (pictured below)



- 7. Set the initial grip separation to match the relaxed length of the finger sleeve (measured without tension) and record this starting length for strain calculations
- 8. Zero the load again and also click the crosshead box to zero it
- 9. Lock the hand held control
- 10. Begin running the MTS machine until it reaches a max force of 1 kN or until the material fails.
- 11. Right click on the data and export the raw data to a folder
- 12. Repeat this process for each ballistic nylon dog bone
- 13. Turn off the machine, close the software, return all components to their original storage area, and clean the MTS machine

I will conduct tensile tests on multiple finger sleeve prototypes to determine the average maximum load before damage and total failure. The results will be compared to the 20 MPa requirement to confirm durability. If sleeves fail below this threshold, material thickness, adhesive type, or stitching methods will be revised and retested.



# 12/7 - Stitched Autoclaved Tensile Testing Protocol

NATHAN HANSEN - Dec 07, 2025, 6:29 PM CST

Title: Stitched Autoclaved Tensile Testing Protocol

**Date:** 12/7/2025

Content by: Nathan Hansen

Present: N/A

Goals: Write a testing protocol to determine how much tensile force can be applied to a finger sleeve prototype.

Content:

## Testing Protocol For Finger Sleeve Stitched Autoclaved Tensile Durability

#### Description:

A testing protocol to determine how much tensile force the stitching of the finger sleeve can withstand before damage to the finger sleeve and before total failure of the finger sleeve. Additionally, the stitching should maintain these strength properties after being autoclaved. This is important because the finger sleeve must be reusable and be able to withstand 20 MPa of tensile stress without damage.

#### Materials:

- · 6 ballistic nylon dog bones
- Sewing machine
- · Medium size thread
- · Primus gravity autoclave
- · 2 sterilization pouches
- · MTS Insight Model 5kN
- · 1 kN load cell
- 100 N tensile grips
- Ruler

#### Protocol:

### Stitching:

- 1. Using a pair of scissors, cut the dog bone in half across the 15 mm wide section
- 2. Overlap the two ends of each half by 10 mm and using the sewing machine, apply a straight stitch running over the fabric 2-3 times back and forth across in the middle of the overlay
- 3. Repeat these steps for each ballistic nylon dog bone

## Autoclaving:

1. Place 3 out of the 6 stitched dog bones into a sterilization pouch and put the pouch into the Primus autoclave

- 1. The other 3 dog bones can immediately be tensile tested
- 2. Run an hour long gravity cycle with a max temp of 251 °F (30 min sterilize, 30 min dry)
- 3. Pull the sterilization pouch out of the autoclave and allow it to reach room temperature
  - 1. Check if the sterilization strip on the sterilization pouch has changed colors, indicating that the it has been properly sterilized
- 4. Conduct tensile testing on the last 3 dog bones

## Tensile Testing:

- 1. Attach the 1 kN load cell and the 100 N tensile grips to the MTS Insight Model 5kN system
- 2. Power on the TW Elite software and the MTS machine
- 3. Set the machine to tensile testing and change the test rate to 0.05 mm/s
- 4. Right click on load and zero the signal
- 5. Unlock the hand held machine control to be able to move the crosshead up
- 6. Secure the finger sleeve prototype between the tensile grips of the system, making sure the sleeve is aligned along the axis of tension to avoid uneven loading (pictured below)



- 7. Set the initial grip separation to match the relaxed length of the finger sleeve (measured without tension) and record this starting length for strain calculations
- 8. Zero the load again and also click the crosshead box to zero it
- 9. Lock the hand held control
- 10. Begin running the MTS machine until it reaches a max force of 1 kN or until the material fails.
- 11. Right click on the data and export the raw data to a folder

- 12. Repeat this process for each ballistic nylon dog bone
- 13. Turn off the machine, close the software, return all components to their original storage area, and clean the MTS machine

I will conduct tensile tests on multiple finger sleeve prototypes to determine the average maximum load before damage and total failure. The results will be compared to the 20 MPa requirement to confirm durability. If sleeves fail below this threshold, material thickness, adhesive type, or stitching methods will be revised and retested.

NATHAN HANSEN - Dec 09, 2025, 7:24 PM CST

Title: FEA Testing Protocol

Date: 12/9/2025

Content by: Nathan Klauck

Present: N/A

Goals: Design a testing protocol for the FEA testing done on the sleeve attachment piece so that it can be replicated.

Content:

Description:

A testing protocol to determine whether the mounting plate is capable of withstanding the forces outlined in the PDS without deformation.

#### Materials:

- SolidWorks FEA
- · CAD of mounting plate

#### Protocol:

- 1. Import CAD file
- 2. Specify material as Aluminum 3003 Alloy
- 3. Start new FEA study
- 4. Fix model along top supporting hole
- 5. Apply bearing loads of 36 N along each of the 5 bottom weight bearing holes (simulating 45 N total with a FOS of 4)
- 6. Run study and look for areas of high stress or areas that exceed yield stress

## Conclusions/action items:



# 11/13/2025 Baseline Ballistic Nylon MTS Tensile Testing

NATHAN HANSEN - Nov 13, 2025, 10:52 PM CST

Title: Baseline Ballistic Nylon MTS Tensile Testing

Date: 11/13/2025

Content by: Nathan Hansen

Present: N/A

Goals: Conduct tensile testing on our ballistic nylon material using the MTS machine for determining strap thickness and as a control for sterilization

testing.

Content:

raw MTS data attached below

#### Conclusions/action items:

MTS tensile testing was successful for all three control samples. Our dog bone shapes all broke in the intended area and the MTS program produced consistent curves across all three trials. The next step is to upload this raw data into MATLAB, analyze the data, and create presentable graphs. These values will be used to compare against MTS testing of autoclaved dog bones, as well as for determining the thickness of the finger sleeve straps based on maximum stress.

NATHAN HANSEN - Nov 13, 2025, 10:45 PM CST

## **Download**

DAQ-\_Crosshead\_-\_Timed\_.txt (73 kB)

NATHAN HANSEN - Nov 13, 2025, 10:46 PM CST

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#### Download

## DAQ-\_Crosshead\_-\_Timed\_1\_.txt (64.3 kB)

NATHAN HANSEN - Nov 13, 2025, 10:46 PM CST

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# **Download**

DAQ-\_Crosshead\_-\_Timed\_2\_.txt (64.7 kB)



# 11/17/2025 Stitched MTS Testing with Ballistic Nylon

Sam Dudek - Nov 17, 2025, 8:54 AM CST

Title: Stitched MTS Testing with Ballistic Nylon

Date: 11/17/2025

Content by: Sam Dudek

Present: Ben W, Nathan H

**Goals:** To test a single stitch in the same cross area spot of three dog bones on the MTS tensile testing machine. All of the dogbones were cut in half and stitched with the same technique and number of backtracks.

#### Content:

See raw data below

#### Conclusions/action items:

Our raw data shows that the stitches are strong, but not nearly as strong as the material itself. We can improve on this in many ways, stronger fabric, a different type of stitch, and/or going back and forth more times with the stitch. One thing we must take with a grain of salt is that there is not going to be a force similar to the MTS machine, pulling straight across it, so the possibility of it reaching its breaking point is slim. Next we must put this into the MATLAB to make some graphs.

NATHAN HANSEN - Nov 17, 2025, 9:30 PM CST

### **Download**

DAQ-\_Crosshead\_-\_Timed\_3\_.txt (11.9 kB)

NATHAN HANSEN - Nov 17, 2025, 9:30 PM CST

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## DAQ-\_Crosshead\_-\_Timed\_4\_.txt (10.8 kB)

NATHAN HANSEN - Nov 17, 2025, 9:30 PM CST

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# **Download**

DAQ-\_Crosshead\_-\_Timed\_5\_.txt (12.2 kB)

NATHAN HANSEN - Nov 17, 2025, 9:33 PM CST

Title: One Autoclave Cycle Ballistic Nylon MTS Tensile Testing

Date: 11/17/2025

Content by: Nathan Hansen

Present: Ben and Sam

Goals: Conduct tensile testing on our ballistic nylon material that has gone through one full autoclave cycle using the MTS machine to determine if the autoclave alters the materials properties.

#### Content:

raw MTS data attached below

#### Conclusions/action items:

MTS tensile testing was successful for all three control samples. Our dog bone shapes all broke in the intended area and the MTS program produced consistent curves across all three trials. The next step is to upload this raw data into MATLAB, analyze the data, and create presentable graphs. These values will be used to compare against MTS testing of control dog bones to determine how the materials properties have or have not changed after one full cycle in the autoclave.

NATHAN HANSEN - Nov 17, 2025, 9:33 PM CST

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### **Download**

DAQ-\_Crosshead\_-\_Timed\_6\_.txt (73.1 kB)

NATHAN HANSEN - Nov 17, 2025, 9:33 PM CST

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#### Download

# DAQ-\_Crosshead\_-\_Timed\_7\_.txt (75.2 kB)

NATHAN HANSEN - Nov 17, 2025, 9:33 PM CST

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| 1961 | 1961 | 1961 | 1981 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 |
| 1961 | 1961 | 1961 | 1981 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1985 | 1
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# **Download**

DAQ-\_Crosshead\_-\_Timed\_8\_.txt (74 kB)

# 11/17/2025 One Autoclave Cycle Stitched Ballistic Nylon MTS Tensile Testing - Copy

NATHAN HANSEN - Nov 17, 2025, 9:36 PM CST

Title: One Autoclave Cycle Stitched Ballistic Nylon MTS Tensile Testing

Date: 11/17/2025

Content by: Nathan Hansen

Present: Ben and Sam

**Goals:** Conduct tensile testing on our stitched ballistic nylon dog bones that has gone through one full autoclave cycle using the MTS machine to determine if the autoclave alters the materials properties.

#### Content:

raw MTS data attached below

#### Conclusions/action items:

MTS tensile testing was successful for all three control samples. Our dog bone shapes all broke in the intended area and the MTS program produced consistent curves across all three trials. The next step is to upload this raw data into MATLAB, analyze the data, and create presentable graphs. These values will be used to compare against MTS testing of stitched control dog bones to determine how the strength of the stitches have or have not changed after one full cycle in the autoclave.

NATHAN HANSEN - Nov 17, 2025, 9:37 PM CST

```
### 17.10 | Fig. 10 | Fig.
```

#### Download

DAQ-\_Crosshead\_-\_Timed\_9\_.txt (10.5 kB)

NATHAN HANSEN - Nov 17, 2025, 9:37 PM CST

#### Download

# DAQ-\_Crosshead\_-\_Timed\_10\_.txt (10.4 kB)

NATHAN HANSEN - Nov 17, 2025, 9:37 PM CST

# **Download**

DAQ-\_Crosshead\_-\_Timed\_11\_.txt (11 kB)

# 11/17/2025 Analysis of One Autoclave Cycle

NATHAN HANSEN - Nov 17, 2025, 9:54 PM CST

Title: Analysis of One Autoclave Cycle

Date: 11/17/2025

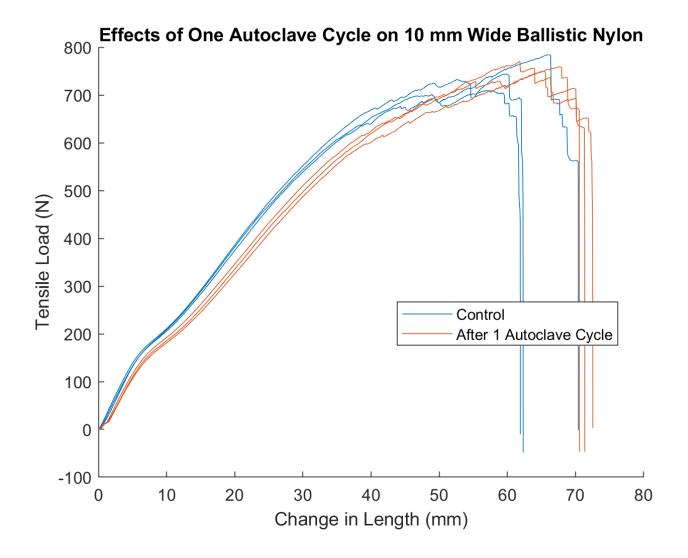
Content by: Nathan Hansen

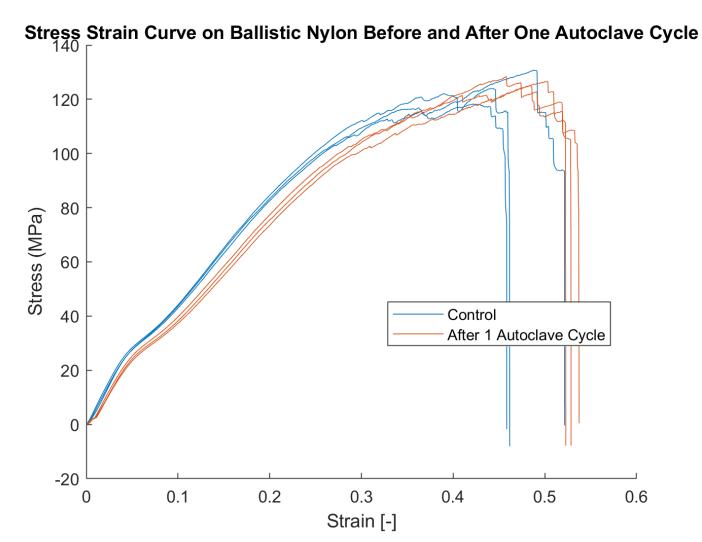
Present: N/A

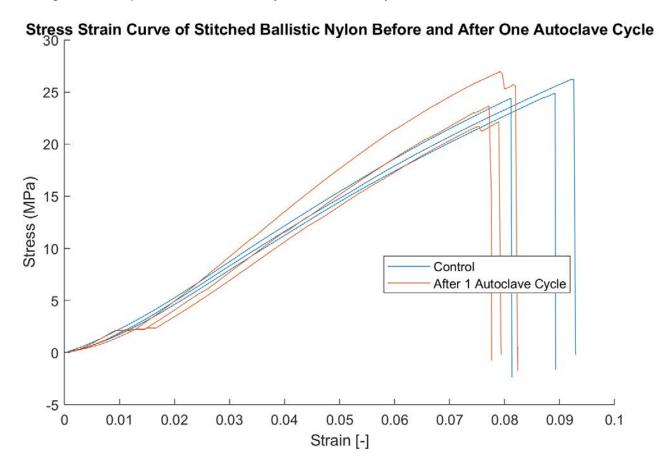
Goals: Analyze the MTS data from before and after one cycle in the autoclave by creating stress strain graphs and computing t-tests.

#### Content:

The following graphs were produced from the MTS data using MATLAB:







The following MATLAB code was used to generate these graphs and calculate t-test values for maximum force, maximum stress, strain at failure, and elastic modulus:

#### %% Import Data

```
control1 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\Control\DAQ- Crosshead, ... - (Timed) (0).txt";

control2 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\Control\DAQ- Crosshead, ... - (Timed) (1).txt";

control3 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\Control\DAQ- Crosshead, ... - (Timed) (2).txt";

stitchesC1 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\Stitches Control\DAQ- Crosshead, ... - (Timed) (3).txt";

stitchesC2 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\Stitches Control\DAQ- Crosshead, ... - (Timed) (4).txt";

stitchesC3 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\Stitches Control\DAQ- Crosshead, ... - (Timed) (5).txt";
```

C1normal2 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\1 Cycle (normal)\DAQ- Crosshead, ... - (Timed) (7).txt";

C1normal3 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\1 Cycle (normal)\DAQ- Crosshead, ... - (Timed) (8).txt";

 $c2\_crosshead = c2{:,1};$ 

```
C1stitches1 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\1 Cycle (stitches)\DAQ- Crosshead, ... - (Timed) (9).txt";
C1stitches2 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\1 Cycle (stitches)\DAQ- Crosshead, ... - (Timed) (10).txt";
C1stitches3 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\1 Cycle (stitches)\DAQ- Crosshead, ... - (Timed) (11).txt";
c1 = readtable(control1, detectImportOptions(control1, 'NumHeaderLines', 4));
c2 = readtable(control2, detectImportOptions(control2, 'NumHeaderLines', 4));
c3 = readtable(control3, detectImportOptions(control3, 'NumHeaderLines', 4));
s1 = readtable(stitchesC1, detectImportOptions(stitchesC1, 'NumHeaderLines', 4));
s2 = readtable(stitchesC2, detectImportOptions(stitchesC2, 'NumHeaderLines', 4));
s3 = readtable(stitchesC3, detectImportOptions(stitchesC3, 'NumHeaderLines', 4));
n1c1 = readtable(C1normal1, detectImportOptions(C1normal1, 'NumHeaderLines', 4));
n2c1 = readtable(C1normal2, detectImportOptions(C1normal2, 'NumHeaderLines', 4));
n3c1 = readtable(C1normal3, detectImportOptions(C1normal3, 'NumHeaderLines', 4));
s1c1 = readtable(C1stitches1, detectImportOptions(C1stitches1, 'NumHeaderLines', 4));
s2c1 = readtable(C1stitches2, detectImportOptions(C1stitches2, 'NumHeaderLines', 4));
s3c1 = readtable(C1stitches3, detectImportOptions(C1stitches3, 'NumHeaderLines', 4));
%% Extract each column
c1_crosshead = c1\{:,1\}; % mm
c1_load = c1\{:,2\}; % N
c1 time = c1{:,3}; % sec
c1_stress = c1_load ./ 6; % N/mm^2 or MPa
c1 strain = c1 crosshead ./ 135; % [-]
```

```
c2_{load} = c2{:,2};
c2_{time} = c2{:,3};
c2\_stress = c2\_load ./ 6;
c2_strain = c2_crosshead ./ 135;
c3_{crosshead} = c3{:,1};
c3_{load} = c3{:,2};
c3_{time} = c3{:,3};
c3\_stress = c3\_load ./ 6;
c3_strain = c3_crosshead ./ 135;
s1_crosshead = s1{:,1};
s1_load = s1{:,2};
s1_{time} = s1{:,3};
s1\_stress = s1\_load ./ 6;
s1_strain = s1_crosshead ./ 125;
s2\_crosshead = s2{:,1};
s2_{load} = s2{:,2};
s2_{time} = s2{:,3};
s2\_stress = s2\_load ./ 6;
s2_strain = s2_crosshead ./ 125;
s3_crosshead = s3{:,1};
s3_load = s3{:,2};
s3_{time} = s3{:,3};
s3\_stress = s3\_load ./ 6;
s3_strain = s3_crosshead ./ 125;
n1c1\_crosshead = n1c1\{:,1\};
```

```
n1c1_{load} = n1c1\{:,2\};
n1c1_{time} = n1c1{:,3};
n1c1\_stress = n1c1\_load ./ 6;
n1c1_strain = n1c1_crosshead ./ 135;
n2c1\_crosshead = n2c1\{:,1\};
n2c1_{load} = n2c1\{:,2\};
n2c1_{time} = n2c1{:,3};
n2c1\_stress = n2c1\_load ./ 6;
n2c1_strain = n2c1_crosshead ./ 135;
n3c1\_crosshead = n3c1\{:,1\};
n3c1\_load = n3c1\{:,2\};
n3c1_{time} = n3c1{:,3};
n3c1\_stress = n3c1\_load ./ 6;
n3c1_strain = n3c1_crosshead ./ 135;
s1c1_crosshead = s1c1\{:,1\};
s1c1_load = s1c1{:,2};
s1c1_{time} = s1c1{:,3};
s1c1\_stress = s1c1\_load ./ 6;
s1c1_strain = s1c1_crosshead ./ 125;
s2c1\_crosshead = s2c1{:,1};
s2c1_load = s2c1{:,2};
s2c1_{time} = s2c1{:,3};
s2c1\_stress = s2c1\_load ./ 6;
s2c1\_strain = s2c1\_crosshead ./ 125;
s3c1_crosshead = s3c1\{:,1\};
```

```
s3c1_load = s3c1\{:,2\};
s3c1_{time} = s3c1{:,3};
s3c1\_stress = s3c1\_load ./ 6;
s3c1_strain = s3c1_crosshead ./ 125;
%% Plotting Load vs. Crosshead
blue = [0\ 0.447\ 0.741];
red = [0.85 \ 0.325 \ 0.098];
figure (1)
hold on
h1 = plot(c1 crosshead, c1 load, 'Color', blue);
plot(c2_crosshead, c2_load, 'Color', blue)
plot(c3_crosshead, c3_load, 'Color', blue)
h2 = plot(n1c1_crosshead, n1c1_load, 'Color', red);
plot(n2c1_crosshead, n2c1_load, 'Color', red)
plot(n3c1_crosshead, n3c1_load, 'Color', red)
title("Effects of One Autoclave Cycle on 10 mm Wide Ballistic Nylon")
xlabel("Change in Length (mm)")
ylabel("Tensile Load (N)")
legend([h1 h2], {'Control', 'After 1 Autoclave Cycle'}, 'Location', 'best');
hold off
%% Plotting Stress vs. Strain (normal)
```

```
figure (2)
hold on
h1 = plot(c1_strain, c1_stress, 'Color', blue);
plot(c2_strain, c2_stress, 'Color', blue)
plot(c3_strain, c3_stress, 'Color', blue)
h2 = plot(n1c1_strain, n1c1_stress, 'Color', red);
plot(n2c1_strain, n2c1_stress, 'Color', red)
plot(n3c1_strain, n3c1_stress, 'Color', red)
title("Stress Strain Curve of Ballistic Nylon Before and After One Autoclave Cycle")
xlabel("Strain [-]")
ylabel("Stress (MPa)")
legend([h1 h2], {'Control', 'After 1 Autoclave Cycle'}, 'Location', 'best');
hold off
%% Plotting Stress vs. Strain (stitches)
figure (3)
hold on
h1 = plot(s1_strain, s1_stress, 'Color', blue);
plot(s2_strain, s2_stress, 'Color', blue)
plot(s3_strain, s3_stress, 'Color', blue)
h2 = plot(s1c1_strain, s1c1_stress, 'Color', red);
plot(s2c1_strain, s2c1_stress, 'Color', red)
plot(s3c1_strain, s3c1_stress, 'Color', red)
```

```
title("Stress Strain Curve of Stitched Ballistic Nylon Before and After One Autoclave Cycle")
xlabel("Strain [-]")
ylabel("Stress (MPa)")
legend([h1 h2], {'Control', 'After 1 Autoclave Cycle'}, 'Location', 'best');
hold off
%% T-test Maximum Load (1 Cycle)
control_load_max = [
  max(c1_load)
  max(c2_load)
  max(c3_load)
];
autoclave_load_max = [
  max(n1c1_load)
  max(n2c1_load)
  max(n3c1_load)
];
[h, p] = ttest2(control_load_max, autoclave_load_max) % h=0, p=0.5688
%% T-test Maximum Stress (1 Cycle)
control_stress_max = [
  max(c1_stress)
  max(c2_stress)
  max(c3_stress)
```

];

```
autoclave_stress_max = [
  max(n1c1_stress)
  max(n2c1_stress)
  max(n3c1_stress)
];
[h, p] = ttest2(control_stress_max, autoclave_stress_max) % h=0, p=0.5688
%% T-test Elastic Modulus (1 Cycle)
lower = 0.10;
upper = 0.20;
idx_c1 = c1_strain >= lower & c1_strain <= upper;
idx_c2 = c2_strain >= lower & c2_strain <= upper;
idx_c3 = c3_strain >= lower & c3_strain <= upper;
idx_n1 = n1c1_strain >= lower & n1c1_strain <= upper;
idx_n2 = n2c1_strain >= lower & n2c1_strain <= upper;
idx_n3 = n3c1_strain >= lower & n3c1_strain <= upper;
control_modulus = [
  polyfit(c1_strain(idx_c1), c1_stress(idx_c1), 1);
  polyfit(c2_strain(idx_c2), c2_stress(idx_c2), 1);
  polyfit(c3_strain(idx_c3), c3_stress(idx_c3), 1);
];
autoclave_modulus = [
```

```
polyfit(n1c1_strain(idx_n1), n1c1_stress(idx_n1), 1);
  polyfit(n2c1_strain(idx_n2), n2c1_stress(idx_n2), 1);
  polyfit(n3c1_strain(idx_n3), n3c1_stress(idx_n3), 1);
];
control_E = control_modulus(:,1);
autoclave_E = autoclave_modulus(:,1);
[h, p] = ttest2(control_E, autoclave_E) % h=1, p=0.0038
%% T-test Failure Strain (1 Cycle)
control_failure_strain = [
  max(c1_strain)
  max(c2_strain)
  max(c3_strain)
];
autoclave_failure_strain = [
  max(n1c1_strain)
  max(n2c1_strain)
  max(n3c1_strain)
];
[h, p] = ttest2(control_failure_strain, autoclave_failure_strain) % h=0, p=0.0796
%% T-test Maximum Stress (Stitches)
control_stress_max = [
  max(s1_stress)
```

```
max(s2_stress)
  max(s3_stress)
];
autoclave_stress_max = [
  max(s1c1_stress)
  max(s2c1_stress)
  max(s3c1_stress)
];
[h, p] = ttest2(control_stress_max, autoclave_stress_max) % h=0, p=0.5846
%% T-test Elastic Modulus (Stitches)
lower = 0.02;
upper = 0.05;
idx_s1 = s1_strain >= lower & s1_strain <= upper;
idx_s2 = s2_strain >= lower & s2_strain <= upper;
idx_s3 = s3_strain >= lower & s3_strain <= upper;
idx_s1c1 = s1c1_strain >= lower & s1c1_strain <= upper;
idx_s2c1 = s2c1_strain >= lower & s2c1_strain <= upper;
idx_s3c1 = s3c1_strain >= lower & s3c1_strain <= upper;
control_modulus = [
  polyfit(s1_strain(idx_s1), s1_stress(idx_s1), 1);
  polyfit(s2_strain(idx_s2), s2_stress(idx_s2), 1);
  polyfit(s3_strain(idx_s3), s3_stress(idx_s3), 1);
];
```

```
autoclave_modulus = [
  polyfit(s1c1_strain(idx_s1c1), s1c1_stress(idx_s1c1), 1);
  polyfit(s2c1_strain(idx_s2c1), s2c1_stress(idx_s2c1), 1);
  polyfit(s3c1_strain(idx_s3c1), s3c1_stress(idx_s3c1), 1);
];
control_E = control_modulus(:,1);
autoclave_E = autoclave_modulus(:,1);
[h, p] = ttest2(control_E, autoclave_E) % h=0, p=0.0698
%% T-test Failure Strain (Stitches)
control_failure_strain = [
  max(s1_strain)
  max(s2_strain)
  max(s3_strain)
];
autoclave_failure_strain = [
  max(s1c1_strain)
  max(s2c1_strain)
  max(s3c1_strain)
];
[h, p] = ttest2(control_failure_strain, autoclave_failure_strain) % h=0, p=0.0948
```

Conclusions/action items:

Across all mechanical metrics tested, most comparisons showed no statistically significant difference between ballistic nylon before and after one autoclave cycle. Maximum load and maximum stress both yielded high p-values (p = 0.5688), indicating that autoclaving did not meaningfully change the ultimate strength of the material. Strain at failure also did not differ significantly for either the normal samples (p = 0.0796) or the stitched samples (p = 0.0948). The one exception was elastic modulus in the normal (unstitched) samples, where autoclaving produced a significant decrease in stiffness (p = 0.0038). Overall, autoclaving appeared to alter the *stiffness* of ballistic nylon but did not significantly affect its failure load or failure strain under these test conditions. Going forward, we will run the same analysis against material that has been through the autoclave 5 times and see if these observations hold.

# 11/19/2025 Five Autoclave Cycles Ballistic Nylon MTS Tensile Testing - Copy - Copy

NATHAN HANSEN - Nov 19, 2025, 1:19 PM CST

Title: Five Autoclave Cycles Ballistic Nylon MTS Tensile Testing - Copy - Copy

Date: 11/19/2025

Content by: Nathan Hansen

Present: Ben and Sam

Goals: Conduct tensile testing on our ballistic nylon dog bones that has gone through five full autoclave cycles using the MTS machine to determine if the autoclave alters the materials properties.

#### Content:

raw MTS data attached below

#### Conclusions/action items:

MTS tensile testing was successful for all three control samples. Our dog bone shapes all broke in the intended area and the MTS program produced consistent curves across all three trials. The next step is to upload this raw data into MATLAB, analyze the data, and create presentable graphs. These values will be used to compare against MTS testing of control dog bones to determine how the mechanistic properties of ballistic nylon have altered.

NATHAN HANSEN - Nov 19, 2025, 1:20 PM CST

```
# 16 Dec | 17/20 | 27 Dec | 17/20 | 27 Dec | 27
```

# **Download**

DAQ- Crosshead - Timed 12 .txt (88.3 kB)

NATHAN HANSEN - Nov 19, 2025, 1:20 PM CST

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# **Download**

# DAQ-\_Crosshead\_-\_Timed\_13\_.txt (89.6 kB)

NATHAN HANSEN - Nov 19, 2025, 1:20 PM CST

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### **Download**

DAQ-\_Crosshead\_-\_Timed\_14\_.txt (84.3 kB)

# 11/19/2025 Analysis of Five Autoclave Cycles

NATHAN HANSEN - Nov 19, 2025, 1:36 PM CST

Title: Analysis of One Autoclave Cycle

Date: 11/17/2025

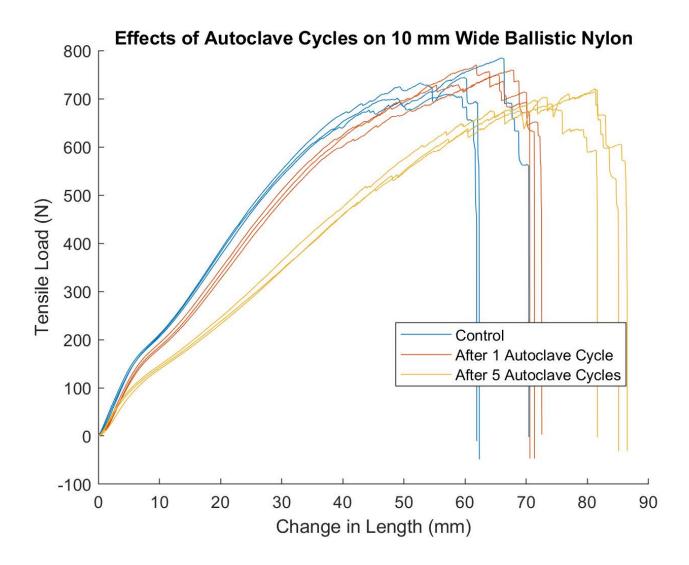
Content by: Nathan Hansen

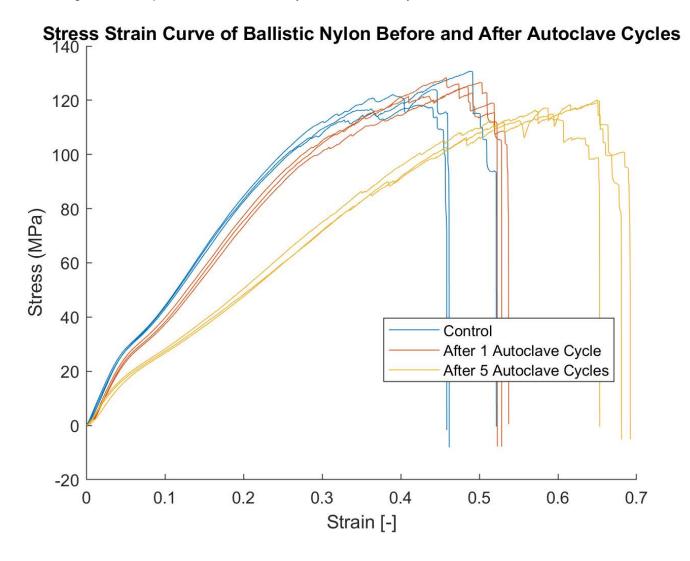
Present: N/A

Goals: Analyze the MTS data from before and after five cycles in the autoclave by creating stress strain graphs and computing t-tests.

### Content:

The following graphs were produced from the MTS data using MATLAB:





The following MATLAB code was used to generate these graphs and calculate t-test values for maximum force, maximum stress, strain at failure, and elastic modulus:

# %% Import Data

```
control1 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\Control\DAQ- Crosshead, ... - (Timed) (0).txt";

control2 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\Control\DAQ- Crosshead, ... - (Timed) (1).txt";

control3 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\Control\DAQ- Crosshead, ... - (Timed) (2).txt";

C5normal1 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\S Cycles (stitches)\DAQ- Crosshead, ... - (Timed) (12).txt";

C5normal2 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\S Cycles (stitches)\DAQ- Crosshead, ... - (Timed) (13).txt";

C5normal3 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\S Cycles (stitches)\DAQ- Crosshead, ... - (Timed) (14).txt";
```

```
c1 = readtable(control1, detectImportOptions(control1, 'NumHeaderLines', 4));
c2 = readtable(control2, detectImportOptions(control2, 'NumHeaderLines', 4));
c3 = readtable(control3, detectImportOptions(control3, 'NumHeaderLines', 4));
n1c5 = readtable(C5normal1, detectImportOptions(C5normal1, 'NumHeaderLines', 4));
n2c5 = readtable(C5normal2, detectImportOptions(C5normal2, 'NumHeaderLines', 4));
n3c5 = readtable(C5normal3, detectImportOptions(C5normal3, 'NumHeaderLines', 4));
%% Extract each column
c1_{crosshead} = c1{:,1}; % mm
c1_{load} = c1_{load} = c1_{load} = c1_{load}
c1_time = c1{:,3}; % sec
c1_stress = c1_load ./ 6; % N/mm^2 or MPa
c1_strain = c1_crosshead ./ 135; % [-]
c2_{crosshead} = c2{:,1};
c2_{load} = c2{:,2};
c2_{time} = c2{:,3};
c2\_stress = c2\_load ./ 6;
c2_strain = c2_crosshead ./ 135;
c3_crosshead = c3\{:,1\};
c3_load = c3\{:,2\};
c3_{time} = c3{:,3};
c3\_stress = c3\_load ./ 6;
c3_strain = c3_crosshead ./ 135;
```

 $n1c5_{crosshead} = n1c5{:,1};$ 

```
n1c5_{load} = n1c5{:,2};
n1c5_{time} = n1c5{:,3};
n1c5\_stress = n1c5\_load ./ 6;
n1c5_strain = n1c5_crosshead ./ 125;
n2c5\_crosshead = n2c5\{:,1\};
n2c5_{load} = n2c5{:,2};
n2c5_{time} = n2c5{:,3};
n2c5\_stress = n2c5\_load ./ 6;
n2c5_strain = n2c5_crosshead ./ 125;
n3c5_{crosshead} = n3c5{:,1};
n3c5_{load} = n3c5{:,2};
n3c5_time = n3c5\{:,3\};
n3c5\_stress = n3c5\_load ./ 6;
n3c5_strain = n3c5_crosshead ./ 125;
%% Plotting Load vs. Crosshead
blue = [0\ 0.447\ 0.741];
red = [0.85 \ 0.325 \ 0.098];
gold = [0.929 \ 0.694 \ 0.125];
figure (1)
hold on
h1 = plot(c1_crosshead, c1_load, 'Color', blue);
plot(c2_crosshead, c2_load, 'Color', blue)
plot(c3_crosshead, c3_load, 'Color', blue)
```

```
h2 = plot(n1c1_crosshead, n1c1_load, 'Color', red);
plot(n2c1_crosshead, n2c1_load, 'Color', red)
plot(n3c1_crosshead, n3c1_load, 'Color', red)
h3 = plot(n1c5_crosshead, n1c5_load, 'Color', gold);
plot(n2c5_crosshead, n2c5_load, 'Color', gold)
plot(n3c5_crosshead, n3c5_load, 'Color', gold)
title("Effects of Autoclave Cycles on 10 mm Wide Ballistic Nylon")
xlabel("Change in Length (mm)")
ylabel("Tensile Load (N)")
legend([h1 h2 h3], {'Control', 'After 1 Autoclave Cycle', 'After 5 Autoclave Cycles'}, 'Location', 'best');
hold off
%% Plotting Stress vs. Strain (normal)
figure (2)
hold on
h1 = plot(c1_strain, c1_stress, 'Color', blue);
plot(c2_strain, c2_stress, 'Color', blue)
plot(c3_strain, c3_stress, 'Color', blue)
h2 = plot(n1c1_strain, n1c1_stress, 'Color', red);
plot(n2c1_strain, n2c1_stress, 'Color', red)
plot(n3c1_strain, n3c1_stress, 'Color', red)
h3 = plot(n1c5_strain, n1c5_stress, 'Color', gold);
plot(n2c5_strain, n2c5_stress, 'Color', gold)
```

```
plot(n3c5_strain, n3c5_stress, 'Color', gold)
title("Stress Strain Curve of Ballistic Nylon Before and After Autoclave Cycles")
xlabel("Strain [-]")
ylabel("Stress (MPa)")
legend([h1 h2 h3], {'Control', 'After 1 Autoclave Cycle', 'After 5 Autoclave Cycles'}, 'Location', 'best');
hold off
%% T-test Maximum Stress (5 Cycle)
control_stress_max = [
  max(c1_stress)
  max(c2_stress)
  max(c3_stress)
];
autoclave_stress_max = [
  max(n1c5_stress)
  max(n2c5_stress)
  max(n3c5_stress)
];
[h, p] = ttest2(control_stress_max, autoclave_stress_max) % h=0, p=0.2099
%% T-test Elastic Modulus (5 Cycle)
lower = 0.10;
upper = 0.20;
```

```
idx_c1 = c1_strain >= lower & c1_strain <= upper;
idx_c2 = c2_strain >= lower & c2_strain <= upper;
idx_c3 = c3_strain >= lower & c3_strain <= upper;
idx_n1 = n1c5_strain >= lower & n1c5_strain <= upper;
idx_n2 = n2c5_strain >= lower & n2c5_strain <= upper;
idx_n3 = n3c5_strain >= lower & n3c5_strain <= upper;
control_modulus = [
  polyfit(c1_strain(idx_c1), c1_stress(idx_c1), 1);
  polyfit(c2_strain(idx_c2), c2_stress(idx_c2), 1);
  polyfit(c3_strain(idx_c3), c3_stress(idx_c3), 1);
];
autoclave_modulus = [
  polyfit(n1c5_strain(idx_n1), n1c5_stress(idx_n1), 1);
  polyfit(n2c5_strain(idx_n2), n2c5_stress(idx_n2), 1);
  polyfit(n3c5_strain(idx_n3), n3c5_stress(idx_n3), 1);
];
control_E = control_modulus(:,1);
autoclave_E = autoclave_modulus(:,1);
[h, p] = ttest2(control_E, autoclave_E) % h=1, p=2.2950e-06
%% T-test Failure Strain (5 Cycle)
control_failure_strain = [
  max(c1_strain)
  max(c2_strain)
```

```
max(c3_strain)

];

autoclave_failure_strain = [
    max(n1c5_strain)
    max(n2c5_strain)
    max(n3c5_strain)
];
```

[h, p] = ttest2(control\_failure\_strain, autoclave\_failure\_strain) % h=1, p=0.0012

#### Conclusions/action items:

Across all mechanical metrics tested, most comparisons showed no statistically significant difference between ballistic nylon before and after one autoclave cycle. Maximum load and maximum stress both yielded high p-values (p = 0.5688), indicating that autoclaving did not meaningfully change the ultimate strength of the material. Strain at failure also did not differ significantly for either the normal samples (p = 0.0796) or the stitched samples (p = 0.0948). The one exception was elastic modulus in the normal (unstitched) samples, where autoclaving produced a significant decrease in stiffness (p = 0.0038). Overall, autoclaving appeared to alter the *stiffness* of ballistic nylon but did not significantly affect its failure load or failure strain under these test conditions. Going forward, we will run the same analysis against material that has been through the autoclave 5 times and see if these observations hold.



# 12/6/2025 Analysis of Ballistic Nylon Properties

NATHAN HANSEN - Dec 06, 2025, 9:23 PM CST

Title: Analysis of Ballistic Nylon Properties

Date: 12/6/2025

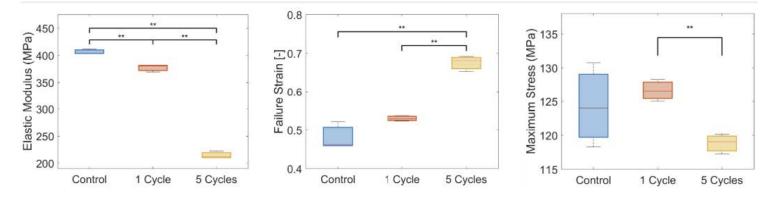
Content by: Nathan Hansen

Present: N/A

Goals: Analyze the MTS data from before and after five cycles in the autoclave by computing t-tests and creating box plots.

#### Content:

The following graphs were produced:



• change in elastic modulus and failure strain (independent two-tailed T-tests); maximum stress (independent single-tailed T-test). Brackets: \* = p <0.05, \*\* = p <0.01

The following MATLAB code was used to run the T-tests and produce the graphs:

```
%% Import Data
control1 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\Control\DAQ- Crosshead, ... - (Timed) (0).txt";
control2 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\Control\DAQ- Crosshead, ... - (Timed) (1).txt";
control3 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\Control\DAQ- Crosshead, ... - (Timed) (2).txt";
stitchesC1 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\Stitches Control\DAQ- Crosshead, ... - (Timed) (3).txt";
stitchesC2 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\Stitches Control\DAQ- Crosshead, ... - (Timed) (4).txt";
stitchesC3 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\Stitches Control\DAQ- Crosshead, ... - (Timed) (5).txt";
C1normal1 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\1 Cycle (normal)\DAQ- Crosshead, ... - (Timed) (6).txt";
C1normal2 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\1 Cycle (normal)\DAQ- Crosshead, ... - (Timed) (7).txt";
C1normal3 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\1 Cycle (normal)\DAQ- Crosshead, ... - (Timed) (8).txt";
C1stitches1 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\1 Cycle (stitches)\DAQ- Crosshead, ... - (Timed) (9).txt";
C1stitches2 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\1 Cycle (stitches)\DAQ- Crosshead, ... - (Timed) (10).txt";
C1stitches3 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\1 Cycle (stitches)\DAQ- Crosshead, ... - (Timed) (11).txt";
C5normal1 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\5 Cycles (stitches)\DAQ- Crosshead, ... - (Timed) (12).txt";
C5normal2 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\5 Cycles (stitches)\DAQ- Crosshead, ... - (Timed) (13).txt";
C5normal3 = "C:\Users\Nathan\OneDrive\Ballistic Nylon Testing\5 Cycles (stitches)\DAQ- Crosshead, ... - (Timed) (14).txt";
c1 = readtable(control1, detectImportOptions(control1, 'NumHeaderLines', 4));
c2 = readtable(control2, detectImportOptions(control2, 'NumHeaderLines', 4));
c3 = readtable(control3, detectImportOptions(control3, 'NumHeaderLines', 4));
s1 = readtable(stitchesC1, detectImportOptions(stitchesC1, 'NumHeaderLines', 4));
s2 = readtable(stitchesC2, detectImportOptions(stitchesC2, 'NumHeaderLines', 4));
s3 = readtable(stitchesC3, detectImportOptions(stitchesC3, 'NumHeaderLines', 4));
```

```
n1c1 = readtable(C1normal1, detectImportOptions(C1normal1, 'NumHeaderLines', 4));
n2c1 = readtable(C1normal2, detectImportOptions(C1normal2, 'NumHeaderLines', 4));
n3c1 = readtable(C1normal3, detectImportOptions(C1normal3, 'NumHeaderLines', 4));
s1c1 = readtable(C1stitches1, detectImportOptions(C1stitches1, 'NumHeaderLines', 4));
s2c1 = readtable(C1stitches2, detectImportOptions(C1stitches2, 'NumHeaderLines', 4));
s3c1 = readtable(C1stitches3, detectImportOptions(C1stitches3, 'NumHeaderLines', 4));
n1c5 = readtable(C5normal1, detectImportOptions(C5normal1, 'NumHeaderLines', 4));
n2c5 = readtable(C5normal2, detectImportOptions(C5normal2, 'NumHeaderLines', 4));
n3c5 = readtable(C5normal3, detectImportOptions(C5normal3, 'NumHeaderLines', 4));
%% Extract each column
c1\_crosshead = c1{:,1}; % mm
c1_load = c1{:,2}; % N
c1_time = c1{:,3}; % sec
c1_stress = c1_load ./ 6; % N/mm^2 or MPa
c1_strain = c1_crosshead ./ 135; % [-]
c2\_crosshead = c2\{:,1\};
c2_{load} = c2{:,2};
c2_time = c2{:,3};
c2\_stress = c2\_load ./ 6;
c2_strain = c2_crosshead ./ 135;
c3\_crosshead = c3{:,1};
c3_{load} = c3{:,2};
c3_time = c3{:,3};
c3\_stress = c3\_load ./ 6;
c3_strain = c3_crosshead ./ 135;
s1\_crosshead = s1{:,1};
s1_load = s1{:,2};
s1_time = s1{:,3};
s1\_stress = s1\_load ./ 6;
s1_strain = s1_crosshead ./ 125;
s2\_crosshead = s2\{:,1\};
s2_load = s2{:,2};
s2_time = s2{:,3};
s2_stress = s2_load ./ 6;
s2_strain = s2_crosshead ./ 125;
s3\_crosshead = s3{:,1};
s3_load = s3{:,2};
s3_time = s3{:,3};
s3\_stress = s3\_load ./ 6;
s3\_strain = s3\_crosshead ./ 125;
n1c1_crosshead = n1c1{:,1};
n1c1_load = n1c1{:,2};
n1c1_time = n1c1{:,3};
n1c1_stress = n1c1_load ./ 6;
n1c1_strain = n1c1_crosshead ./ 135;
n2c1\_crosshead = n2c1\{:,1\};
n2c1_load = n2c1\{:,2\};
n2c1\_time = n2c1\{:,3\};
n2c1\_stress = n2c1\_load ./ 6;
n2c1_strain = n2c1_crosshead ./ 135;
n3c1\_crosshead = n3c1\{:,1\};
n3c1_load = n3c1{:,2};
```

```
n3c1\_time = n3c1{:,3};
n3c1\_stress = n3c1\_load ./ 6;
n3c1_strain = n3c1_crosshead ./ 135;
s1c1_crosshead = s1c1{:,1};
s1c1_load = s1c1{:,2};
s1c1_time = s1c1{:,3};
s1c1_stress = s1c1_load ./ 6;
s1c1_strain = s1c1_crosshead ./ 125;
s2c1_crosshead = s2c1{:,1};
s2c1_load = s2c1{:,2};
s2c1\_time = s2c1{:,3};
s2c1\_stress = s2c1\_load ./ 6;
s2c1_strain = s2c1_crosshead ./ 125;
s3c1_crosshead = s3c1{:,1};
s3c1_load = s3c1{:,2};
s3c1_time = s3c1{:,3};
s3c1_stress = s3c1_load ./ 6;
s3c1_strain = s3c1_crosshead ./ 125;
n1c5_crosshead = n1c5{:,1};
n1c5_load = n1c5{:,2};
n1c5\_time = n1c5{:,3};
n1c5_stress = n1c5_load ./ 6;
n1c5_strain = n1c5_crosshead ./ 125;
n2c5\_crosshead = n2c5\{:,1\};
n2c5_load = n2c5{:,2};
n2c5\_time = n2c5{:,3};
n2c5\_stress = n2c5\_load ./ 6;
n2c5_strain = n2c5_crosshead ./ 125;
n3c5\_crosshead = n3c5\{:,1\};
n3c5_load = n3c5{:,2};
n3c5\_time = n3c5{:,3};
n3c5_stress = n3c5_load ./ 6;
n3c5_strain = n3c5_crosshead ./ 125;
%% Independent Single-Tailed T-test Maximum Load (Control & 1 Cycle)
control_load_max = [
max(c1_load)
max(c2_load)
max(c3_load)
];
autoclave1_load_max = [
max(n1c1_load)
max(n2c1_load)
max(n3c1_load)
];
[h_load_cto1, p_load_cto1] = ttest2(control_load_max, autoclave1_load_max, 'Tail', 'left') % h=0, p=0.2844
%% Independent Single-Tailed T-test Maximum Stress (Control & 1 Cycle)
control_stress_max = [
max(c1_stress)
max(c2_stress)
max(c3_stress)
autoclave1_stress_max = [
```

```
max(n1c1_stress)
max(n2c1_stress)
max(n3c1_stress)
];
[h_stress_cto1, p_stress_cto1] = ttest2(control_stress_max, autoclave1_stress_max, 'Tail', 'left') % h=0, p=0.2844
%% Independent 2-Tailed T-test Elastic Modulus (Control & 1 Cycle)
lower = 0.10;
upper = 0.20;
idx_c1 = c1_strain >= lower & c1_strain <= upper;
idx_c2 = c2_strain >= lower & c2_strain <= upper;
idx_c3 = c3_strain >= lower & c3_strain <= upper;</pre>
idx_n1 = n1c1_strain >= lower & n1c1_strain <= upper;</pre>
idx_n2 = n2c1_strain >= lower & n2c1_strain <= upper;</pre>
idx_n3 = n3c1_strain >= lower & n3c1_strain <= upper;</pre>
control_modulus = [
polyfit(c1_strain(idx_c1), c1_stress(idx_c1), 1);
polyfit(c2_strain(idx_c2), c2_stress(idx_c2), 1);
polyfit(c3_strain(idx_c3), c3_stress(idx_c3), 1);
];
autoclave1_modulus = [
polyfit(n1c1_strain(idx_n1), n1c1_stress(idx_n1), 1);
polyfit(n2c1_strain(idx_n2), n2c1_stress(idx_n2), 1);
polyfit(n3c1_strain(idx_n3), n3c1_stress(idx_n3), 1);
control_E = control_modulus(:,1);
autoclave1_E = autoclave1_modulus(:,1);
[h_mod_cto1, p_mod_cto1] = ttest2(control_E, autoclave1_E) % h=1, p=0.0038
%% Independent 2-Tailed T-test Failure Strain (Control & 1 Cycle)
control_failure_strain = [
max(c1_strain)
max(c2_strain)
max(c3_strain)
];
autoclave1_failure_strain = [
max(n1c1_strain)
max(n2c1_strain)
max(n3c1_strain)
];
[h_strain_cto1, p_strain_cto1] = ttest2(control_failure_strain, autoclave1_failure_strain) % h=0, p=0.0796
%% Independent Single-Tailed T-test Maximum Stress (Stitches)
control\_sti\_stress\_max = [
max(s1_stress)
max(s2_stress)
max(s3_stress)
];
autoclave_sti_stress_max = [
max(s1c1_stress)
max(s2c1_stress)
max(s3c1_stress)
```

```
];
[h_stress_sti, p_stress_sti] = ttest2(control_sti_stress_max, autoclave_sti_stress_max, 'Tail', 'right') % h=0, p=0.2923
%% Independent 2-Tailed T-test Elastic Modulus (Stitches)
lower = 0.02;
upper = 0.05;
idx_s1 = s1_strain >= lower & s1_strain <= upper;</pre>
idx_s2 = s2_strain >= lower & s2_strain <= upper;</pre>
idx_s3 = s3_strain >= lower & s3_strain <= upper;</pre>
idx_s1c1 = s1c1_strain >= lower & s1c1_strain <= upper;</pre>
idx_s2c1 = s2c1_strain >= lower & s2c1_strain <= upper;</pre>
idx_s3c1 = s3c1_strain >= lower & s3c1_strain <= upper;</pre>
control_sti_modulus = [
polyfit(s1_strain(idx_s1), s1_stress(idx_s1), 1);
polyfit(s2_strain(idx_s2), s2_stress(idx_s2), 1);
polyfit(s3_strain(idx_s3), s3_stress(idx_s3), 1);
];
autoclave_sti_modulus = [
polyfit(s1c1_strain(idx_s1c1), s1c1_stress(idx_s1c1), 1);
polyfit(s2c1_strain(idx_s2c1), s2c1_stress(idx_s2c1), 1);
polyfit(s3c1_strain(idx_s3c1), s3c1_stress(idx_s3c1), 1);
];
control_sti_E = control_sti_modulus(:,1);
autoclave_sti_E = autoclave_sti_modulus(:,1);
[h_mod_sti, p_mod_sti] = ttest2(control_sti_E, autoclave_sti_E) % h=0, p=0.0698
%% Independent 2-Tailed T-test Failure Strain (Stitches)
control_sti_failure_strain = [
max(s1_strain)
max(s2_strain)
max(s3_strain)
];
autoclave_sti_failure_strain = [
max(s1c1_strain)
max(s2c1_strain)
max(s3c1_strain)
];
[h_strain_sti, p_strain_sti] = ttest2(control_sti_failure_strain, autoclave_sti_failure_strain) % h=0, p=0.0948
%% Independent Single-Tailed T-test Maximum Stress (Control & 5 Cycle)
control\_stress\_max = [
max(c1_stress)
max(c2_stress)
max(c3_stress)
];
autoclave5_stress_max = [
max(n1c5_stress)
max(n2c5_stress)
max(n3c5_stress)
[h_stress_cto5, p_stress_cto5] = ttest2(control_stress_max, autoclave5_stress_max, 'Tail', 'right') % h=0, p=0.1049
```

```
%% Independent 2-Tailed T-test Elastic Modulus (Control & 5 Cycle)
lower = 0.10;
upper = 0.20;
idx_c1 = c1_strain >= lower & c1_strain <= upper;</pre>
idx_c2 = c2_strain >= lower & c2_strain <= upper;</pre>
idx_c3 = c3_strain >= lower & c3_strain <= upper;</pre>
idx_n1 = n1c5_strain >= lower & n1c5_strain <= upper;</pre>
idx_n2 = n2c5_strain >= lower & n2c5_strain <= upper;</pre>
idx_n3 = n3c5_strain >= lower & n3c5_strain <= upper;</pre>
control_modulus = [
polyfit(c1_strain(idx_c1), c1_stress(idx_c1), 1);
polyfit(c2_strain(idx_c2), c2_stress(idx_c2), 1);
polyfit(c3_strain(idx_c3), c3_stress(idx_c3), 1);
];
autoclave5_modulus = [
polyfit(n1c5_strain(idx_n1), n1c5_stress(idx_n1), 1);
polyfit(n2c5_strain(idx_n2), n2c5_stress(idx_n2), 1);
polyfit(n3c5_strain(idx_n3), n3c5_stress(idx_n3), 1);
];
control_E = control_modulus(:,1);
autoclave5_E = autoclave5_modulus(:,1);
[h\_mod\_cto5, \ p\_mod\_cto5] \ = \ ttest2(control\_E, \ autoclave5\_E) \ \% \ h=1, \ p=2.2950e-06
%% Independent 2-Tailed T-test Failure Strain (Control & 5 Cycle)
control_failure_strain = [
max(c1_strain)
max(c2_strain)
max(c3_strain)
];
autoclave5_failure_strain = [
max(n1c5_strain)
max(n2c5_strain)
max(n3c5_strain)
1:
[h_strain_cto5, p_strain_cto5] = ttest2(control_failure_strain, autoclave5_failure_strain) % h=1, p=0.0012
%% Independent Single-Tailed T-test Maximum Stress (1 Cycle & 5 Cycle)
autoclave1_stress_max = [
max(n1c1_stress)
max(n2c1_stress)
max(n3c1_stress)
];
autoclave5_stress_max = [
max(n1c5_stress)
max(n2c5_stress)
max(n3c5_stress)
];
[h_stress_1to5, p_stress_1to5] = ttest2(autoclave1_stress_max, autoclave5_stress_max, 'Tail', 'right') % h=1, p=0.0018
%% Independent 2-Tailed T-test Elastic Modulus (1 Cycle & 5 Cycle)
```

```
lower = 0.10:
upper = 0.20;
idx_c1 = n1c1_strain >= lower & n1c1_strain <= upper;</pre>
idx_c2 = n2c1_strain >= lower & n2c1_strain <= upper;</pre>
idx_c3 = n3c1_strain >= lower & n3c1_strain <= upper;
idx_n1 = n1c5_strain >= lower & n1c5_strain <= upper;</pre>
idx_n2 = n2c5_strain >= lower & n2c5_strain <= upper;
idx_n3 = n3c5_strain >= lower & n3c5_strain <= upper;</pre>
autoclave1_modulus = [
polyfit(n1c1_strain(idx_c1), n1c1_stress(idx_c1), 1);
polyfit(n2c1_strain(idx_c2), n2c1_stress(idx_c2), 1);
polyfit(n3c1_strain(idx_c3), n3c1_stress(idx_c3), 1);
];
autoclave5_modulus = [
polyfit(n1c5_strain(idx_n1), n1c5_stress(idx_n1), 1);
polyfit(n2c5_strain(idx_n2), n2c5_stress(idx_n2), 1);
polyfit(n3c5_strain(idx_n3), n3c5_stress(idx_n3), 1);
];
autoclave1_E = autoclave1_modulus(:,1);
autoclave5_E = autoclave5_modulus(:,1);
[h_mod_1to5, p_mod_1to5] = ttest2(autoclave1_E, autoclave5_E) % h=1, p=8.2444e-06
%% Independent 2-Tailed T-test Failure Strain (1 Cycle & 5 Cycle)
autoclave1_failure_strain = [
max(n1c1_strain)
max(n2c1_strain)
max(n3c1_strain)
1;
autoclave5_failure_strain = [
max(n1c5_strain)
max(n2c5_strain)
max(n3c5_strain)
];
[h_strain_1to5, p_strain_1to5] = ttest2(autoclave1_failure_strain, autoclave5_failure_strain) % h=1, p=0.2.9005e-04
%% Stress Box Plot
data = [control_stress_max; autoclave1_stress_max; autoclave5_stress_max];
group = [repmat("Control", length(control_stress_max),1);
repmat("1 Cycle", length(autoclave1_stress_max),1);
repmat("5 Cycles", length(autoclave5_stress_max),1)];
figure (4);
boxplot(data, group, 'Symbol', 'o');
ylabel("Maximum Stress (MPa)");
title("Comparison of Maximum Stress After Autoclave Cycles");
set(gca, 'FontSize', 12);
ylim([115 140])
hold on;
% === APPLY COLORS ===
h = findobj(gca, 'Tag', 'Box');
colors = {gold, red, blue};
% Box order returned: 5 cycles, 1 cycle, control
for i = 1:length(h)
```

```
patch(get(h(i), 'XData'), get(h(i), 'YData'), colors{i}, ...
'FaceAlpha', 0.4, 'EdgeColor', colors{i}, 'LineWidth', 1.5);
% --- Convert p-values to symbols ---
sig_cto1 = sigStar(p_stress_cto1);
sig_cto5 = sigStar(p_stress_cto5);
sig_1to5 = sigStar(p_stress_1to5);
% --- Draw brackets ---
ymax = max(data) * 0.84;
if sig_cto1 ~= ""
drawBracket(1, 2, ymax, sig_cto1);
if sig_cto5 ~= ""
drawBracket(1, 3, ymax*1.10, sig_cto5);
if sig_1to5 ~= ""
drawBracket(2, 3, ymax*1.20, sig_1to5);
hold off;
function s = sigStar(p)
if p < 0.01
s = "**";
elseif p < 0.05
else
s = "";
end
end
function drawBracket(x1, x2, y, labelText)
plot([x1 x1 x2 x2], [y y+0.02*y y+0.02*y y], 'k', 'LineWidth', 1.5);
text(mean([x1 x2]), y + 0.03*y, labelText, ...
'HorizontalAlignment', 'center', 'FontSize', 14);
%% Elastic Modulus Box Plot
data = [control_E; autoclave1_E; autoclave5_E];
group = [repmat("Control", length(control_E),1);
repmat("1 Cycle", length(autoclave1_E),1);
repmat("5 Cycles", length(autoclave5_E),1)];
figure (5);
boxplot(data, group, 'Symbol', 'o');
ylabel("Elastic Modulus (MPa)");
title("Comparison of Elastic Modulus After Autoclave Cycles");
set(gca, 'FontSize', 12);
ylim([190 475]) % adjust as needed based on your modulus values
hold on;
% === APPLY COLORS ===
h = findobj(gca, 'Tag', 'Box');
colors = {gold, red, blue}; % Box order returned: 5 cycles, 1 cycle, control
for i = 1:length(h)
patch(get(h(i), 'XData'), get(h(i), 'YData'), colors{i}, ...
'FaceAlpha', 0.4, 'EdgeColor', colors{i}, 'LineWidth', 1.5);
% --- Convert p-values to symbols ---
```

```
sig_cto1 = sigStar(p_mod_cto1);
sig_cto5 = sigStar(p_mod_cto5);
sig_1to5 = sigStar(p_mod_1to5);
% --- Draw brackets ---
ymax = max(data) * 1.02;
if sig_cto1 ~= ""
drawBracket(1, 2, ymax, sig_cto1);
end
if sig_cto5 ~= ""
drawBracket(1, 3, ymax*1.05, sig_cto5);
if sig_1to5 ~= ""
drawBracket(2, 3, ymax, sig_1to5);
hold off;
%% Failure Strain Box Plot
data = [control_failure_strain; autoclave1_failure_strain; autoclave5_failure_strain];
group = [repmat("Control", length(control_failure_strain),1);
repmat("1 Cycle", length(autoclave1_failure_strain),1);
repmat("5 Cycles", length(autoclave5_failure_strain),1)];
figure (6);
boxplot(data, group, 'Symbol', 'o');
ylabel("Failure Strain [-]");
title("Comparison of Failure Strain After Autoclave Cycles");
set(gca, 'FontSize', 12);
ylim([0.4 0.8]); % adjust based on your actual strain values
hold on;
% === APPLY COLORS ===
h = findobj(gca, 'Tag', 'Box');
colors = {gold, red, blue}; % Box order returned: 5 cycles, 1 cycle, control
for i = 1:length(h)
patch(get(h(i), 'XData'), get(h(i), 'YData'), colors{i}, ...
'FaceAlpha', 0.4, 'EdgeColor', colors{i}, 'LineWidth', 1.5);
end
% --- Convert p-values to symbols ---
sig_cto1 = sigStar(p_strain_cto1);
sig_cto5 = sigStar(p_strain_cto5);
sig_1to5 = sigStar(p_strain_1to5);
% --- Draw brackets ---
ymax = max(data) * 1.02;
if sig_cto1 ~= ""
drawBracket(1, 2, ymax, sig_cto1);
if sig_cto5 ~= ""
drawBracket(1, 3, ymax*1.05, sig_cto5);
end
if sig_1to5 ~= ""
drawBracket(2, 3, ymax, sig_1to5);
end
hold off;
%% Stress Box Plot
```

```
data = [control_stress_max; autoclave1_stress_max; autoclave5_stress_max];
group = [repmat("Control", length(control_stress_max),1);
repmat("1 Cycle", length(autoclave1_stress_max),1);
repmat("5 Cycles", length(autoclave5_stress_max),1)];
figure (4);
boxplot(data, group, 'Symbol', 'o');
ylabel("Maximum Stress (MPa)");
set(gca, 'FontSize', 18);
ylim([115 138])
hold on;
% === APPLY COLORS ===
h = findobj(gca, 'Tag', 'Box');
colors = {gold, red, blue};
% Box order returned: 5 cycles, 1 cycle, control
for i = 1:length(h)
patch(get(h(i), 'XData'), get(h(i), 'YData'), colors{i}, ...
'FaceAlpha', 0.4, 'EdgeColor', colors{i}, 'LineWidth', 1.5);
end
% --- Convert p-values to symbols ---
sig_cto1 = sigStar(p_stress_cto1);
sig_cto5 = sigStar(p_stress_cto5);
sig_1to5 = sigStar(p_stress_1to5);
% --- Draw brackets ---
ymax = max(data) * 0.84;
if sig_cto1 ~= ""
drawBracket(1, 2, ymax, sig_cto1);
if sig_cto5 ~= ""
drawBracket(1, 3, ymax*1.10, sig_cto5);
if sig_1to5 ~= ""
drawBracket(2, 3, ymax*1.20, sig_1to5);
hold off;
%% Elastic Modulus Box Plot
data = [control_E; autoclave1_E; autoclave5_E];
group = [repmat("Control", length(control_E),1);
repmat("1 Cycle", length(autoclave1_E),1);
repmat("5 Cycles", length(autoclave5_E),1)];
figure (5);
boxplot(data, group, 'Symbol', 'o');
ylabel("Elastic Modulus (MPa)");
set(gca, 'FontSize', 18);
ylim([190 475]) % adjust as needed based on your modulus values
hold on;
% === APPLY COLORS ===
h = findobj(gca, 'Tag', 'Box');
colors = {gold, red, blue}; % Box order returned: 5 cycles, 1 cycle, control
for i = 1:length(h)
patch(get(h(i), 'XData'), get(h(i), 'YData'), colors{i}, ...
'FaceAlpha', 0.4, 'EdgeColor', colors{i}, 'LineWidth', 1.5);
end
```

```
% --- Convert p-values to symbols ---
sig_cto1 = sigStar(p_mod_cto1);
sig_cto5 = sigStar(p_mod_cto5);
sig_1to5 = sigStar(p_mod_1to5);
% --- Draw brackets ---
ymax = max(data) * 1.02;
if sig_cto1 ~= ""
drawBracket(1, 2, ymax, sig_cto1);
if sig_cto5 ~= ""
drawBracket(1, 3, ymax*1.05, sig_cto5);
if sig_1to5 ~= ""
drawBracket(2, 3, ymax, sig_1to5);
hold off;
%% Failure Strain Box Plot
data = [control_failure_strain; autoclave1_failure_strain; autoclave5_failure_strain];
group = [repmat("Control", length(control_failure_strain),1);
repmat("1 Cycle", length(autoclave1_failure_strain),1);
repmat("5 Cycles", length(autoclave5_failure_strain),1)];
figure (6);
boxplot(data, group, 'Symbol', 'o');
ylabel("Failure Strain [-]");
set(gca, 'FontSize', 18);
ylim([0.4 0.8]); % adjust based on your actual strain values
hold on;
% === APPLY COLORS ===
h = findobj(gca, 'Tag', 'Box');
colors = {gold, red, blue}; % Box order returned: 5 cycles, 1 cycle, control
for i = 1:length(h)
patch(get(h(i), 'XData'), get(h(i), 'YData'), colors{i}, ...
'FaceAlpha', 0.4, 'EdgeColor', colors{i}, 'LineWidth', 1.5);
% --- Convert p-values to symbols ---
sig_cto1 = sigStar(p_strain_cto1);
sig_cto5 = sigStar(p_strain_cto5);
sig_1to5 = sigStar(p_strain_1to5);
% --- Draw brackets ---
ymax = max(data) * 1.02;
if sig_cto1 ~= ""
drawBracket(1, 2, ymax, sig_cto1);
if sig_cto5 ~= ""
drawBracket(1, 3, ymax*1.05, sig_cto5);
end
if sig_1to5 ~= ""
drawBracket(2, 3, ymax, sig_1to5);
end
hold off;
```

The Elastic Modulus and Maximum Stress both significantly decrease with an increasing number of cycles, suggesting a loss of stiffness and strength. Conversely, the Failure Strain significantly increases with more cycles, indicating the material becomes more ductile (able to deform more before failing).



Ilia Mikhailenko - Sep 18, 2025, 10:37 PM CDT



Digital Traction with Japanese Finger Sleeves Draft PDS | Sept 18, 2025 BME 200/300 Design Project

Clients: Pupe Samb and Dr. Mohamed Sommh
Advisser: Profisore Justin Williams
Team: Ilia Mikhailenko, Nathan Hancer, Nathan Klauck, Sam Dudek,
Mariananwik Tefera, and Ben Willihaganz.
Date: 09/18/2025

**Download** 

Draft\_PDS\_\_\_9.18.2025\_1\_.pdf (376 kB)



# 9.11.2025 - Nerve Lesions in Wrist Arthroscopy

Ilia Mikhailenko - Sep 11, 2025, 9:45 PM CDT

Title: Nerve Lesions in Wrist Arthroscopy

Date: 9/11/2025

Content by: Ilia

Present: N/A

Goals: Better understand some of the issues with current traction devices

Content: <a href="https://pmc.ncbi.nlm.nih.gov/articles/PMC8567779/">https://pmc.ncbi.nlm.nih.gov/articles/PMC8567779/</a>

This literature overview maps how nerves get injured during arthroscopy. The study specifically reports overall wrist arthroscopy complications as occurring around 5.1–5.98% of the time and emphasizes that excess traction and poor positioning increase stretch and compression on sensory nerves, which can lead to nerve defects ranging from transient neuropraxia to axonotmesis and even neurotmesis. By maintaining correct alignment of the joints during arthroscopic procedures, many of these nerve issues are preventable.

#### Citation:

F. Amadei, G. Basile, and M. Leigheb, "Nerve lesions during arthroscopic procedure: a literature overview," *Orthopedic Reviews (Pavia)*, vol. 13, no. 2, 2021, Art. 24441, doi: 10.52965/001c.24441. [Online]. Available: <a href="https://pmc.ncbi.nlm.nih.gov/articles/PMC8567779/">https://pmc.ncbi.nlm.nih.gov/articles/PMC8567779/</a>. [Accessed: Sep. 11, 2025].

## Conclusions/action items:

This study reveals that current traction techniques have some small amount of failure and that this could be linked to excess traction and poor positioning of the hand. I will continue looking further into how the hand is affected by traction and what the benefits of having traction individualized per digit could be.

Ilia Mikhailenko - Oct 10, 2025, 12:35 PM CDT

Title: Wrist Arthroscopy Study

Date: 10/9/2025 Content by: Ilia Present: N/A

Goals: Review large-scale complication data to identify trends related to nerve injury and procedural errors

Content: https://pmc.ncbi.nlm.nih.gov/articles/PMC5074840/

This large multicenter study reviewed data from 10,107 wrist arthroscopies to determine the prevalence and types of complications. The authors reported an overall complication rate of 5.98%, with nerve lesions accounting for 1.17% of cases. These typically involved sensory nerve irritation or transient neuropraxia. The study also found that less experienced surgeons and longer traction times correlated with higher complication rates. The authors concluded that maintaining consistent traction force and precise portal placement can significantly reduce the risk of sensory nerve injuries.

## Citation:

A. Leclercq, C. Mathoulin, "Complications of wrist arthroscopy: A multicenter study based on 10,107 arthroscopies," *Orthopaedics & Traumatology: Surgery & Research*, vol. 102, no. 8, 2016, pp. S245–S249, doi: 10.1016/j.otsr.2016.09.004. [Online]. Available: <a href="https://pmc.ncbi.nlm.nih.gov/articles/PMC5074840/">https://pmc.ncbi.nlm.nih.gov/articles/PMC5074840/</a>. [Accessed: Oct. 9, 2025].

## Conclusions/action items:

This large-scale review highlights that while wrist arthroscopy is generally safe, traction control and surgeon experience remain major factors in preventing nerve damage. Going forward, I want to focus on comparing continuous traction versus intermittent release methods and how these affect nerve perfusion during prolonged procedures.



# 10.9.2025 - Wrist Arthroscopy Complications for TFCC

Ilia Mikhailenko - Oct 09, 2025, 10:09 PM CDT

Title: Complications Following Wrist Arthroscopy for TFCC Lesions

Date: 10/9/2025 Content by: Ilia Present: N/A

Goals: Examine frequency and recovery outcomes of nerve-related complications following arthroscopic TFCC repair

Content: https://pmc.ncbi.nlm.nih.gov/articles/PMC12269757/

This prospective study followed 68 patients who underwent arthroscopic repair of triangular fibrocartilage complex (TFCC) lesions. The overall complication rate was 8.8%, and all cases were temporary sensory disturbances involving the ulnar nerve distribution. Symptoms included numbness in the ring and little fingers, all resolving spontaneously within three months. The authors did not find significant links between complication rates and operative parameters such as traction duration or hand position, but they did observe that nearly all cases occurred early in the surgeon's learning curve.

# Citation:

V. Phuong, M. I. Kusnezov, and A. M. Gonzalez, "Complications following wrist arthroscopy for TFCC lesions: a prospective study," *Orthopaedic Surgery and Traumatology*, vol. 15, no. 2, 2025, Art. e10205. [Online]. Available: <a href="https://pmc.ncbi.nlm.nih.gov/articles/PMC12269757/">https://pmc.ncbi.nlm.nih.gov/articles/PMC12269757/</a>. [Accessed: Oct. 9, 2025].

# Conclusions/action items:

This study shows that nerve irritation around the ulnar distribution is the most common complication in TFCC arthroscopy, though it is usually temporary. I will consider exploring whether traction individualized per finger could minimize localized compression, especially on the ulnar side, during wrist arthroscopy setups.



# 11.30 - Weight and Body Segment Mass in Senegal

Ilia Mikhailenko - Nov 30, 2025, 1:41 PM CST

# 11.30.2025 - Weight and Body Segment Mass

Title: Weight and Body Segment Mass Measurements

Date: 11/30/2025 Content by: Ilia Present: N/A

#### Goals:

Estimate realistic arm/forearm/hand loads for biomechanical design and clinical setup calculations.

### Content:

In this study, 13 preserved male cadavers were dissected into 14 segments and measured each segment's weight, volume, and center of mass, then derived predictive equations from anthropometric dimension

From this dataset, typical segment mass fractions are approximately: upper arm  $\approx$  3.25% of total body mass, forearm  $\approx$  1.87%, and hand  $\approx$  0.65%, giving a total for upper arm + forearm + hand of  $\sim$ 5.7% of body mass. Using those percentages, the example calculations on the page show passive arm weights of roughly:

- 50-kg person  $\rightarrow$  total arm  $\approx$  2.85 kg ( $\sim$ 28 N); forearm + hand  $\approx$  1.26 kg ( $\sim$ 12 N).
- 70-kg person  $\rightarrow$  total arm  $\approx$  4.0 kg ( $\sim$ 39 N); forearm + hand  $\approx$  1.76 kg ( $\sim$ 17 N).

These forces represent a passively hanging arm with no added muscle tension and therefore provide a useful lower-bound estimate for joint traction or support loads in neutral posture.

### Citation:

C. E. Clauser, J. T. McConville, and J. W. Young, *Weight, Volume, and Center of Mass of Segments of the Human Body*, AMRL-TR-69-70, Aerospace Medical Research Laboratory, Wright-Patterson AFB, OH, Aug. 1969. [Online]. Available: <a href="https://ntrs.nasa.gov/api/citations/19700027497/downloads/19700027497.pdf">https://ntrs.nasa.gov/api/citations/19700027497/downloads/19700027497.pdf</a> NASA Technical Reports Server

## Conclusions/action items:

For load and device calculations, we will treat a "typical" adult arm as ~5.7% of body mass and use the example force ranges from NASA as baseline design loads. When modeling Senegalese patients, I will choose total body weights that reflect accurate measurements found in that country through specific anthropometric data. I should also remember that the NASA data are derived from older male cadavers of mostly Western origin, so any precise application to Senegalese populations may require sensitivity analysis or future region-specific data.

# 9.11.2025 - Acumed Arc Wrist Tower

Ilia Mikhailenko - Dec 10, 2025, 4:57 PM CST

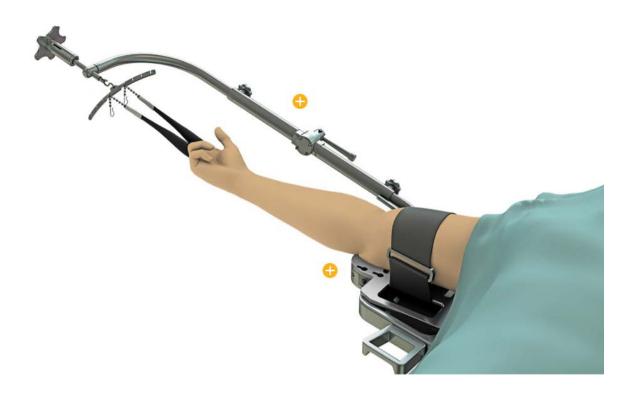
Title: Acumed Arc Wrist Tower Competing Design

Date: 9/11/2025 Content by: Ilia

Present: N/A

Goals: Learn more about pre-existing designs relevant to the prototype we are looking to build

Content: https://www.acumed.net/products/hand-wrist/arc-wrist-tower/



This model provides traction by allowing the patient's fingers to comfortably be inserted into the finger traps and for the amount of pull to then be adjusted based on the length of the arm/hand. This model also allows the hand to be lifted to the ideal position via bending at the elbow. The direction the hand faces and the flexion angle of the wrist can both be altered through rotation mechanisms in the device.

## Citation:

"Arc Wrist Tower," *Acumed*. Available: https://www.acumed.net/products/hand-wrist/arc-wrist-tower/. [Accessed: Sep. 11, 2025]

## Conclusions/action items:

This is a great example of how to implement adequate movement mechanics into our model. The plethora of rotations and hand positions that can be achieved through this design will be something our group will seek to replicate in our own prototype. I will now look further into different models to see if digital traction models currently exist for hand surgery and what the benefits of making traction digital are, compared to a model like this.



# 9.11.2025 - MPR Hand Traction System

Ilia Mikhailenko - Sep 19, 2025, 7:57 AM CDT

\*Small formatting adjustments made on 9/19 after initial entry\*

Title: MPR Hand Traction System

Date: 9/11/2025

Content by: Ilia

Present: N/A

Goals: Learn more about pre-existing designs relevant to the prototype we are looking to build

Content:

https://mprortho.com/product/mpr-hand-traction-system



Traction for the hand/upper extremity using finger traps or traction strap that can be hung from an IV pole. Includes a hand traction assembly + strap + S-hooks, though finger traps and weights are not included. Designed for flexibility in how the traction is mounted. This lets adjustments be made in height/angle depending on how the strap is hung / how assembly is positioned. Simpler than the acumed system as this one is composed of more individual pieces which makes it easier to set up and limits the systems bulkiness when it is not in use.

## Citation:

"MPR Hand Traction System," MPR Orthopedics. Available: <a href="https://mprortho.com/product/mpr-hand-traction-system/?">https://mprortho.com/product/mpr-hand-traction-system/?</a>
<a href="https://mprortho.com/product/mpr-hand-traction-system/?">https://mprortho.com/product/mpr-hand-traction-system/?</a>
<a href="https://mprortho.com/product/mpr-hand-traction-system/?">https://mprortho.com/product/mpr-hand-traction-system/?</a>
<a href="https://mprortho.com/product/mpr-hand-traction-system/?">https://mprortho.com/product/mpr-hand-traction-system/?</a>
<a href="https://mprortho.com/product/mpr-hand-traction-system/">https://mprortho.com/product/mpr-hand-traction-system/?</a>
<a href="https://mprortho.com/product/mpr-hand-traction-system/">https://mprortho.com/product/mpr-hand-traction-system/</a>
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# Conclusion

Compared to the Acumed wrist tower, this traction system is much simpler as it relies on an IV pole instead of a built-in frame and positioning system. This makes it a bit more flexible and easy to set up but offers less precision. It also has no built-in force feedback. Research needs to be done on how traction can be digitally induced and manipulated.



# 9.19.2025 - Equalizing Device with Finger Traps

Ilia Mikhailenko - Sep 19, 2025, 8:10 AM CDT

Title: Equalizing Device with Finger Traps Competing Design

Date: 9/19/2025

Content by: Ilia

Present: N/A

Goals: Learn more about pre-existing designs relevant to the prototype we are looking to build

## Content:



This model provides a simple yet effective way to apply traction digitally by adjusting tension with an equalizing bar mechanism. The bar distributes force fairly evenly across all digits, which helps balance traction and reduce localized stress on any single finger. The design is, overall, very simple, relying on gravity and weight distribution rather than powered/digital components to create traction. It is also lightweight and fairly easy to set up, making it compatible with a lot of different surgical tables or frames.

**Citation:** "Equalizing Device Shown with Finger Traps," *David Scott Company.* Available: <a href="https://www.davidscottco.com/product/equalizing-device-shown-with-finger-traps/">https://www.davidscottco.com/product/equalizing-device-shown-with-finger-traps/</a>. [Accessed: Sep. 19, 2025]

#### Conclusion/action items:

This device is a good reference point for understanding less sophisticated traction solutions whose main goal is to generate more equal force distribution across all the fingers in the hand. I will keep this design in mind as it may inspire design elements for prototypes where the focus is cost-effectiveness and ease of use. Comparing this approach with more advanced systems like the Arc Wrist Tower shows the trade offs between adjustability and mechanical reliability. I

will explore whether hybrid models can combine this device's force equalization with digital feedback for more precise real-time feedback during operations.

# 9.19.2025 - Reison Hand Traction

Ilia Mikhailenko - Dec 10, 2025, 5:35 PM CST

\*citation corrected on 12/10/2025\*

Title: Reison Hand Traction - Competing Design

Date: 9/19/2025

Content by: Ilia

Present: N/A

**Goals:** Take a look at Reison's hand fixation device, understand what it does well, where it falls short, and what we can learn from it for our own sleeve-based traction design.

### Content:

Reison's device is built to keep the hand stable during surgery when forearm traction is being used.

It's adjustable, so it can fit a range of hand sizes, and it's made from stainless steel and polycarbonate.

The setup is pretty rigid and meant to pair with other Reison traction tools, so everything stays consistent and controlled.

It's not as adjustable as our client would like it to be though, as what they use needs to fit a broad plethora of hand sizes.



# Citation:

"Hand Fixation," Reison Medical. Available: https://reison.se/produkt/hand-fixation/.

# **Conclusions / Action Items:**

This design offers solid stability and decent adjustability, but it doesn't allow for any natural finger movement and isn't especially ergonomic. Compared to what we're trying to build, it's more old-school and less comfortable. It's still a useful reference, though and it shows the level of stability we need to hit while giving us space to innovate with something lighter, more comfortable, and more dynamic.

Ilia Mikhailenko - Sep 23, 2025, 9:21 AM CDT

Title: Standing Platform Design

Date: 9/23/2025

Content by: Ilia Mikhailenko

Present: N/A

Goals: Document a design for the platform mechanism for the device that could be used in a rehabilitation setting and explain it

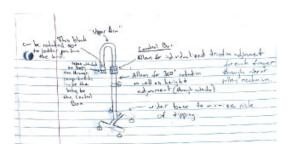
#### Content:

This is a design that could be used during rehabilitation and is intended to be stood next to the patient with their hand hung from the finger loops. The base pole would be able to accept an extender that the main "upper arm" can then be inserted into. This allows for the height and the rotation of the system to be adjusted, while keeping the length of the upper arm reasonable for it to be inserted into the Clamp-Down platform you can find in this Design Ideas folder. The upper arm would also have rotational capabilities at its end, which may prove useful for this but would be more important for the Clamp-Down Platform and intraoperative hand positioning. There are other features of this design, including materials used and the control box system (would allow for individualized finger traction), that would need to be fleshed out further if the team chooses to proceed with it.

#### Conclusion/action items:

This platform has a wide variety of features that can be considered for a final design, including a wider platform for stability, a control box to allow for adjustment and monitoring of finger traction, and a removable upper arm that can be inserted into a clamp-down design to make that feature more versatile and the device more cost-effective. For now, the next steps are to compare this design to those designed by other members of the team and establish a design matrix that will allow us to determine what the key features are for us to consider while choosing a final design.

Ilia Mikhailenko - Sep 23, 2025, 8:59 AM CDT



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# 9.23.2025 - Clamp Down Platform Design

Ilia Mikhailenko - Sep 23, 2025, 9:14 AM CDT

Title: Clamp-Down Platform Design

Date: 9/23/2025

Content by: Ilia Mikhailenko

Present: N/A

Goals: Document a design for the platform mechanism for the device that could be used during surgical operations and explain it

#### Content:

This is a design that could be used during operations and is intended to be placed on the surgical operating table. The elbow of the patient would be placed in between the gaps of the platform, and the elbow could be secured into placed with an adjustable velcro. There would be a circular projection on the side of the platform into which a curved object could be inserted to allow for rotation of the "upper arm" feature drawn in the Standing Platform Design. The upper arm itself would be inserted into this curved object, giving it versatility in its usage between the standing platform and this clamp-down platform. There are other features of this design, including materials used, that would need to be fleshed out further if the team chooses to proceed with it.

#### Conclusion/action items:

This design is an idea for what surgeons could use intraoperatively to support the patient's upper extremity. The "upper arm" of the Standing Platform Design I created is a key part of this design. and its insertion into this design would need to be explored further if the team chooses to move forward with it. For now, the next steps are to compare this design to others and create a design matrix to allow us to decide what the key features are for us to consider while choosing a final design we will move forward with.

Ilia Mikhailenko - Sep 23, 2025, 8:58 AM CDT



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# 10.16.2025 - Bed Clamp, Metallic Clamp Design

Ilia Mikhailenko - Oct 16, 2025, 10:42 PM CDT

Title: Bed Clamp, Metallic Clamp Design

Date: 10/16/2025

Content by: Ilia Mikhailenko

Present: N/A

Goals: Document a design for the bed clamp that could be used to secure the restraint arm to a surgical bed during operation

#### Content:

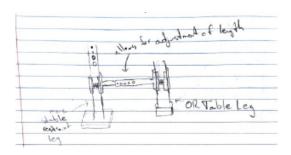
This is a design that could be used to secure the moving platform to an operating table. It would have a metallic arm with two separable parts. These could open and be positioned around the leg of our table as well as secured to the operating room table. The two pieces would be fastened together with some sort of pin or screw mechanism. Further details are yet to be finalized - see below for more details as to why.

See below for drawing.

#### Conclusion/action items:

This design is an idea for what surgeons could use in the operating room to stabilize the digital traction mount next to the bed. The feasability and usefulness of this bed clamp depends on the style of the beds found in the Senegal hospital. If they are all standing on legs that are circular, then this would be a strong design. We will reach out to our client to ask about the bed situation and understand what kinds of bed we should be accommodating this design to, and decide which design to move forward with using that information.

Ilia Mikhailenko - Oct 16, 2025, 10:37 PM CDT



**Download** 

Adobe\_Scan\_Oct\_16\_2025.pdf (81 kB)

# 10.15.2025 - Bed Clamp, Padded Claw Design

Ilia Mikhailenko - Oct 16, 2025, 10:45 PM CDT

Title: Bed Clamp, Padded Claw Design

Date: 10/16/2025

Content by: Ilia Mikhailenko

Present: N/A

Goals: Document a design for the bed clamp that could be used to secure the restraint arm to a surgical bed during operation

#### Content:

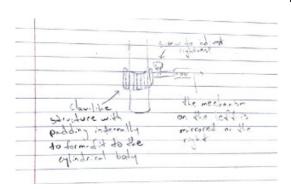
This is a design that could be used to secure the moving platform to an operating table. It would have a claw like arm with internal padded that allows it to form fit around whatever gets positioned inside it. A screw mechanism would allow the claw to open and close. These could open and be positioned around the leg of our table as well as secured to the operating room table. The distance between the two claw arms could be adjusted via an arm that has a pin system. Further details are yet to be finalized - see below for more details as to why.

See below for drawing.

#### Conclusion/action items:

This design is an idea for what surgeons could use in the operating room to stabilize the digital traction mount next to the bed. The claw mechanism distinguishes it from the metallic one by making it more complicated yet potentially more versatile in its attachment methods. Again, the usefulness of this bed clamp depends on the style of the beds found in the Senegal hospital. We will communicate with our client to ask about the bed situation and understand what kinds of bed we should be accommodating this design to, and decide which design to move forward with using that information.

Ilia Mikhailenko - Oct 16, 2025, 10:45 PM CDT



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Adobe\_Scan\_Oct\_16\_2025\_1\_.pdf (53.9 kB)



# 11.6 - Design 1 for Attachment Between Sleeves and IV Pole Arm

Ilia Mikhailenko - Nov 06, 2025, 7:47 PM CST

Title: Attachment Between Sleeves and IV Pole Arm

Date: 11/6/2025

Content by: Ilia Mikhailenko

Present: N/A

Goals: Document a design for the attachment piece described in the title

#### Content:

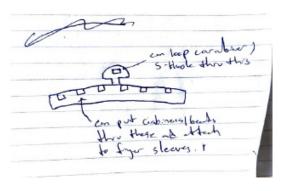
This design would hook onto the arm of the IV pole via a carabiner, S-clip, a clothes hanger type connection, or something similar. It would attach to a pad that would have several holes - one at the top which the carabiner/other hook would loop into and other holes at the bottom which would be spaced to allow physicians to position the finger sleeves at their discretion. The sleeves would loop into these holes via some thin but high durability material. Chains of metal beads are commonly found on the market and are worth exploring considering their added stability to the finger sleeves throughout surgery.

See below for drawing.

#### Conclusion/action items:

This design is an idea for what surgeons could use in the operating room to attach the finger sleeves to the IV pole. There is some room for variation that is explored in a similar design I've inputted earlier today, but this is largely what is found on the market. Our team will explore both options but, as stated in my previous entry, there is also not a need to reinvent the wheel. It is important to evaluate the benefits and drawbacks of both designs, which I will discuss a little here. For this design, it could potentially be more susceptible to tilting when weight is placed on it, as well as rotational movement. The arm will move slightly during surgery, so it's important to recognize that this design must be as stable as possible to keep the hand as steady as it can be. The team will be discussing both of these designs further when it meets, as these designs are clearly what works for other digital traction devices and it is more a matter of determining which style is best suited to our project.

Ilia Mikhailenko - Nov 06, 2025, 7:42 PM CST



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Adobe\_Scan\_Nov\_6\_2025\_1\_.pdf (80.3 kB)

Ilia Mikhailenko - Oct 29, 2025, 4:49 PM CDT

Ilia Mikhailenko - Oct 29, 2025, 4:59 PM CDT

Title: Draft Weight-Bearing Testing Protocol

Date: 10/29/2025

Content by: Ilia Mikhailenko

Present: N/A

Goals: Create a protocol for the weight-bearing testing of our IV pole and whether it can sustain an adequate factor of safety

#### Content:

Preparation: identify a weight that closely resembles X times the weight of an average arm in Senegal. This calculation was done in Ilia Mikhailenko's research notes. The logic is that if the mechanical arm is able to hold this weight, it adequately meets the weight-bearing requirements

#### Test:

- Attach the weight to the IV pole in the position that the finger sleeves would hang, while stabilizing the central pole of the IV
- -Let go of the IV pole and observe whether the IV pole remains steady.
- Do another trial where we let go and observe the angle of deflection
- Do this with progressively larger weights until we identify the weight that causes the IV pole to fall over.
- Do 5 trails of each weight.
- -Create table to compile data results

#### Conclusions/action items:

Use this protocol to create plots that clearly communicate to the team and the client the stability of the pole under different weights. use this data to decide whether the pole is stable enough to be used for the final prototype.

Ilia Mikhailenko - Sep 10, 2025, 2:10 PM CDT

Title: 9.10.2025 Lec notes

Date: 9/10/2025
Content by: Ilia

Present: N/a

Goals: learn about how to effectively utilize engineering career services

Content:

Junior year - biggest opportunity to gain experience

Summer internship - summer only experience

Co-op: fall/spring semester + adjacent summer period

Can track what you do w/ the ECS tracking sheet - see the engr career services website

Make sure you have good sources: the company's actual site, Handshake, LinkedIn.

- Do NOT use aggregator sites (dump sources into website)

Connect BEFORE you are a candidate - talk in person even though they'll just direct you to website. Follow-up necessary 2-3 weeks later

# Resume tips

- Tailor to the position. Helps you give it a look over and
- Helps you integrate key words look for this in the job description
- Show full picture of your experience -
- Design projects listed w/o years/semesters dates counted as jobs, be careful about putting dates
- · Only have December, May, and August as graduation dates

# Cover letter tips

- combine experiences and common threads across your application (leading teams, medical devices, etc.)
- Outline
  - intro: who you are, applying for, where found, and thesis: "based on my experience in A and B, I believe I would be able to make a difference in the X role at Y company.
  - paragraph all about A
  - Paragraph all about B
  - Why this employer/role + closing/next steps
- · Concision / quantity

### Career Fair Advice

- Identity your purpose it's more man just an internship look at overlap with other disciplines - biomaterials specialization have similar experiences to chemical engineering but more diversity.
- What is the "value add" that you bring you need to know this, because the employer won't give this for you.

# Career Fair

Sept. 15-18, 2025. EH Lobby, ME Lobby, ECB Lobby. Different employers each day

# Miscellaneous Questions

Objective statement: make your intentions clear for

Should you apply to internships before / after career fair. If app due before career fair, obviously apply before - but if not, go and see what they say

Skills: communication skills (work that into your experiences - don't list) not soft transferable skills, but if more technical list (excel, matlab, etc.)

Al Parsing - I don't want my materials to be scanned. decide if you want this or not

Wear something reasonably nice - use judgement skills.

tell them a little about yourself, discuss research you've done, and then give them a softball question that they can answer

After that, resond and ask if they'd be interested in looking at your resume

Conclusions/action items: there is lots of information available to bme's looking to get recruited and make sure to utilize it all in your search to get an internship/coop.



Ilia Mikhailenko - Sep 17, 2025, 3:02 PM CDT

\*inserted the notes I took into the notebook template format at 3PM on the day of lecture\*.

Title: 9.17.2025 lec notes

Date: 9.17

Content by: ilia

Present: Ilia

Goals: Understand leadership better, including the different styles and how I can improve my own

Content:

Angela Kita - Teaches interEGR 303 - leadership styles

Effective team dynamics: how can students communicate better within teams

### What is leadership?

- · What are important qualities of a leader
  - Inclusive
  - Confident
  - Transparent clear processes
  - Respectful
  - o Responsible
  - People-oriented
  - Self awareness understand strengths/weaknesses
  - Vision provide direction and purpose/goals
  - Decisive
  - Empathy connect with members

Different levels of leader - personal (goals, self-awareness, competency), interpersonal (social - recognizing and responding to others' needs, active listening, building trust, difficult convo's), team (official), organizational (ceo/president)

Different ways to assess yourself - myer's briggs, disc, clifton strengths (do, it's paid for)

## Three leadership styles

- · Power model
- Servant leadership mutual service for everyone
- · Authentic being yourself

# Power model

- · squeephahaneortakaneortani hererandituvightan melbhe ane born to lead
- · Being in control is the most important thing. Hierarchy over aall

# Servant leadership

- "it's not about me and my needs, but rather the needs of my followers."
- Being of service to other is important. sharing power is key.
- · Listening and understanding.

### <u>Authentic leadership</u>

- "by being my genuine self, I will gain and build trust."
- Emotional intelligence is big here. Understanding your own and others' emotions.

people-oriented leader: get to konw everyone. good at building trust and inclusive env

Process leader: sets pace. willing to work alongside everyone. create systems for efficiency.

thought-oriented: sees big picture and anticipate future.

impact-oriented: able to set the bar high and motivate people

## How do I want to lead:

- self assess: what do i enjoy, what am i good at, what drives me
- observe and reflect: what are tasks that give me a sense of accompllishemnt
- · seek out feedback: ask people you trust what you're good at

## Set goals:

- · What do i want to develop this semester?
  - o Decision-making.
- How will i practice that?
  - Whenever I sense the need to make a decision in our design team, I will analyze what the decisions are and think about the general pros and cons of each.
- · What would success look like?
  - Whenever I sense a big decision needs to be made, I will help the team by breaking down the options, seeing what the pros and cons are of each, and then choosing from there.

For my design team, I want it to be an example of servant leadership. i want everyone to feel open to sharing ideas and for us to do what is best for each other. As a co-leader, I can help with this by:

- being open with everyone to encourage you all to do the same
- · connecting with everyone

# Conclusions/action items:

There are a variety of different leadership styles. In order to improve one's own leadership it is key not only to understand your strengths and weaknesses but have a plan of attack for how you will change. In order to do this, it's key to think about what specifically you will work on changing and what a changed version of you will do.

Ilia Mikhailenko - Sep 24, 2025, 2:14 PM CDT

Title: 9.14.2025 lec notes

**Date:** 9.14

Content by: ilia

Present: Ilia

Goals: Understand the value of mentorship better and how I can improve my own (with the BME 200's)

Content:

What is the value of mentoring BME 200 students?

- Peers are more approachable than professors, easier for the mentees to ask questions
- · Learning how to teach, how to listen, etc
- · Share experiences since you were in their shoes not long ago

What are the values of a good mentor:

- Transparency
- · Being organized
- · Building trust
- · Psychological safety
- Transparent
- Humanizing their challenges

#### Good listening

- Get the main idea
- · Act like you're interested, even if you're not
- · React to ideas, not the person
- · Avoid hasty judgement

What do I wish I knew in BME 200

Generated a list in class and shared on white board at front of room. Paper attached below.

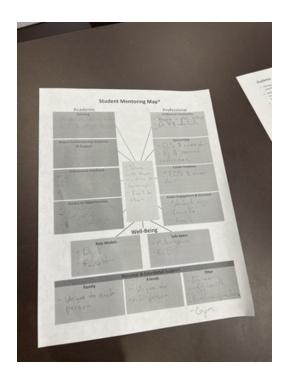
## Conclusion/action items:

There are a lot of resources available to BME's. Just because you are aware of them does not mean that others are, so do not assume the 200's are. Be very free with sharing feedback and discuss this with the BME 200's. Image of the paper we worked on in class is attached below.

### Conclusions/action items:

There are a variety of different leadership styles. In order to improve one's own leadership it is key not only to understand your strengths and weaknesses but have a plan of attack for how you will change. In order to do this, it's key to think about what specifically you will work on changing and what a changed version of you will do.

Ilia Mikhailenko - Sep 24, 2025, 2:14 PM CDT



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IMG\_0358.jpg (3.16 MB)

Ilia Mikhailenko - Oct 01, 2025, 1:57 PM CDT

Title: 10.1 lec notes

Date: 10.1

Content by: ilia

Present: Ilia

Goals: Understand the value of sustainability better and how I can improve it in our project

Content:

Carbon footprint - looking at how the raw materials used in a process create waste.

Best times for improved sustainability are where you improve sustainability and save on costs. White paper used in hospitals

Professor does research on which sustainability options are better (using a keurig and brewing your own ground coffee)

Important to consider break even points to see what options can be better/worse based on whether you need disposable vs reusable

Different anesthesia has different impacts with manufacturing and environmental impact

How do we use this knowledge (lifecycle, economical knowledge) to engineer most sustainable prototypes?

How many factors do you have to consider in life cycle? Feels like everything is interconnected at some point.

Difficult to know, and on a case-by-case basis this is determined.

#### Conclusion/action items:

Sustainability is an important thing in biomedical engineering that our team will strive to implement in our project moving forward. We will go about this by considering the materials we use the different options we have. We will also think about how the client plans to use the product - our client wants this product to be highly reusable, so we will need to consider disposable vs reusable items and the amount of energy it takes to clean something

Ilia Mikhailenko - Oct 08, 2025, 1:57 PM CDT

Title: 10.8 lec notes

**Date:** 10.8

Content by: ilia

Present: Ilia

Goals: Understand the importance of patents and how to navigating obtaining them

Content:

Copyrights - protections for creative work. A wide range of subject matter

Trademarks - prtections for names, marks, logos, etc. Required for use in commerce

Trade secrets - can be used to protect anything of value (recipe to coca-cola)

### common patent

- utility non provisional. Issued for the invention of new and useful
- patent is effective for 20 years after your file it
- often takes 2-5 issues after filing for the patent to be examined
- Typical us patent is 30K. This is for the u.s.. If you want to cover the globe, it's more like 100-200K.

#### Requirements for patenting

- 101 eligible: cannot be a product of nature, abstract idea, natural phenomenon
- 102 is it novel? must be new. never done before.
- 103 non-obvious. It cannot be simple modification. most difficult to assess
- 112 enabled and described. must provide enough detail to reproduce

WARF gets around 400 new innovation disclosures per year

- Warf has a form you can fill out to submit something
- Then you meet with warf. it's pretty straightforward. can submit final report for bme.

Licensing

- Lots of factors that play into how commercializable a medical device is

### Conclusion/action items:

A huge part of converting a project to a real commercializable product is the patent and licensing process. Understanding how this works and how to navigate this is critical to take your ideas and actually make money off of them. Not only does this allow you to see financial gain, it also protects your ideas and keeps them your own, preventing others from fabricating something similar and trying to pass it off as theirs.

Ilia Mikhailenko - Oct 15, 2025, 6:18 PM CDT

\*Edits made at 6:18 PM on the day of the lecture to clean up the notes taken in class\*

Title: 10.15 lec notes

Date: 10.15

Content by: ilia

Present: Ilia

Goals: Understand different patenting careers you can pursue and get a refresher on patents and different kinds of IP

#### Content:

- Technical advisor STEM degree (no law degree or patent bar)
- · Patent agent SD and patent bar
  - o PB tough test that, if you pass,
- · Patent examiner SD and patent bar eventually
- Patent attorney (law degree and patent bar)
- Patent litigator law degree (stem / PB optional)
  - Riding a wave all the time. Very busy when busy, but when not busy things are more chill.
- IP license attorney: similar to the WARF people

How do engineers influence law and innovation?

- Research --> determine if an innovation is truly new
- Analytic reasoning --> claim drafting / infringement analysis
- Technical writing --> pretty straightforward for engineers in law school
- Communication --> explaining tech to non-experts and patent examiners

## Who owns IP?

- University: if you use WARF, university will own the IP. Can get licensed
- Company: employer owns inventions and other IP. Employee agreements show how you can get IP
- Startup: you own all IP until you sell it.

# Timing / Publication of Patents

- If you publish before filing, you lose patent rights
- If you invent something before another person but they file before you, they claim rights to the patent

The Biomedical Start-Up Checklist

Phase A: invent something new, novel, and nonobvious

Phase B: conduct patentability search

C: file patents early

D: use NDA's

E: File trademarks/obtain domain names

Etc. see presentation for others

# Patent vs trademark vs copyright vs trade secret

- Patent: novel, nonobvious, must work, and must describe how to make/use
  - The point of the patent is to give you a monopoly on the product for 20 years. After 20 years, we want to allow society to give back
  - o Patents are critical in BME, because innovation gives you a competitive edge
  - See presentation for different parts of a patent
  - o A patent does not guarantee that your product doesn't infringe on another company's IP
- Trademark: logo, words, symbols, colors, smells, sounds. Harley davidson motor is a trademark. The smell of plato is trademarked.
- · Copyright: creative works.
  - Instruction manuals
  - music
  - o pictures
  - authorship
- · Trade secret protection
  - don't have to file anything. Just have it as long as it's kept a secret.
  - Coca-Cola their recipe. You can reverse engineer the recipe, but you wouldn't be able to sell it better than Coke so they don't really need a patent.

Lots of counterfeit exists.

### Big takeaway

• A patent is a business tool, not just a legal document.

#### Conclusion/action items:

To convert something you make into a something that can become a company, you need to understand the patenting process. This process creates lots of jobs, not only for people who look to get their ideas patented, but also for people who validate patents, help defend them, persecute them (claim infringement), and much more. Understanding the nuts and bolts behind how this works and being able to navigate this is critical to converting ideas into products that actually change lives, especially in BME where innovation is at the crux of getting a competitive edge in the business space.



Ilia Mikhailenko - Oct 27, 2025, 7:04 PM CDT

\*Edits made on 10.27.2025 to correct formatting for notebook\*

Title: 10.22 lec notes

Date: 10.27

Content by: ilia

Present: Ilia

Goals: Understand the requirements for different tracks available to BME after undergrad

Content:

Tailor personal statements for individual institutions

## Grad school options:

#### Masters

- Stepping stone / delay from entering real life. Can do this before going into industry/med school/PhD.
- o One year!
- · Resume builder
- Lets you rewrite your story: switch from bioinstrumentation to biomechanics for instance
- o If you want to fill a gap for a year before med school
- Makes you more desirable in industry. Lets you fill gaps in your resume. Teaching, mentoring, research thesi
- Make 10K more with a masters, but you're missing out on a year of work
- Masters options:
  - Research (1.5-2 years)
    - For those continuing on for a PhDBuild
    - Free tuition and you can get paid
    - Research Assistantship / Teaching Assist. / Project Assist.
    - Must have a thesis (lab PI identified and willing to support before applying)
  - Accelerated Programs
    - Funding for TA only (no tuition remission)
  - Biomedical Innovation, Design, and Entrepreneurship
    - Project based project required
    - Partnership with business school. Project management based
- PhD
  - Desire to be an independent researcher
  - Write research grants
  - Work in academia

- If research MS: List the pi who plans to support you
- If you have a 3.0, you're automatically admitted to the Master's Program

#### Master's Elsewhere

 MBA is also a valid option. Normally if companies want to move you up the corporate ladder they will pay for you to get your MBA

## PhD

- Consider the numbers when applying. If there's 1 professor you could work with you have lower odds than if there are 6 professors.
- Honors in research??
- · Look into it more if interested

#### Conclusion/action items:

There is a wide variety of options available to BME students after completing their undergrad, including but not limited to: medical school, master's programs, PhD programs, and industry work. Within each of these options, there is a plethora of suboptions that are also available. When deciding where to take my career after graduation, I will need to thoroughly consider the pros and cons of each of the choices and determine what is most attuned to me and what I'd like to pursue.

Ilia Mikhailenko - Oct 29, 2025, 1:37 PM CDT

Ilia Mikhailenko - Oct 29, 2025, 4:49 PM CDT

Title: 10.29 lec notes

Date: 10.29

Content by: ilia

Present: Ilia

Goals: Understand the regulatory affects on medical devices when taking them to market

Content:

Animal models are not very predictive of lots of human diseases

Dalkon Shield was a contraceptive marketed to women. Not very successful. Actually had 5% conception rate.

An individual who has an issue with a device cannot prevent the device from being marketed to other people. Hence, the FDA had to be formed.

There's a difference between doing audits/checks and having people send info in to the FDA. The FDA wasn't entirely sure how to do this. It was a bunch of people who were assigned to do it.

Companies don't share information between companies voluntarily.

There's not a lot of market consequence to recalls. They are not major topics in the news.

Whistleblowers move the needle. Employees and clinicians surface patterns that dashboards miss. Protection and incentives determine how much of that ever reaches regulators.

Premarket trials are often small and short. Durable implants can fail year 6; pivotal study ended at 12 months. Long tails of wear, corrosion, and biofilm rarely show up before clearance/approval.

Labeling is risk control. Clear indications, contraindications, and step-by-step IFUs reduce misuse. But labels compete with OR time pressure and muscle memory.

Companies protect information by default. Competitive secrecy + liability exposure = minimal voluntary sharing. True cross-company learning mostly happens after a public failure or through clinicians comparing notes.

#### Conclusion/action items:

Animal models and short premarket trials often fail to predict real-world device performance, pushing critical risks into the post-market phase. FDA oversight relies on imperfect reporting and audits, while companies share little by default. Recalls rarely carry meaningful market consequences. In practice, safety advances hinge on whistleblowers, clinician signal-spotting, and clear labeling that can withstand rushed workflows.

Ilia Mikhailenko - Nov 05, 2025, 2:09 PM CST

Title: 11.5 lec notes

Date: 11.5

Content by: ilia

Present: Ilia

Goals: Understand the regulatory importance of therapeutics

Content:

Different parts of fda:

- Device

- Drug: submit new drug application CDER

- Biologic: CBER

Need to go through these parts of the fda to take something from idea to marketable product

US Laws made by congress

FDA regulations made by the fda based on their interpretation of the us laws

FDA guidances are things made to help the public interpret these regulations. Not very official

351 vs 361 - important regulatory paths

Taken from patient and goes back into the patient (minimally manipulated)

361:

- Homologous use: can be done with a physician's discretion in the operating room
- Can be done in the clinic immediatlely

351

- require extensive regulation (years)

To determine if the product is 351/361, determine if the product poses some sort of risk for the patient. For example:

- Minimal manipulation in the operating room (placed in syringe or centrifuge and then put back into patient). Not minimal manipulation would be placed in a

Critical path research: ensuring minimal toxicity and safety - for drug composition, you know exactly what the drug is and are testing it in animals

Good research: everything else

Target product profile (product vision)

- When to use it
- Why to use it
- How to use it

Do people think this product fills an unmet need in the market? Do people want it? Why should development be funded?

This all makes this TPP document useful for engaging lots of different stakeholders.

## Quality importance

- Documentation is of utmost importance. If testing is not done with extremely specific documentation it is essentially worthless.

# Conclusion:

By understanding the different regulations placed on medical products, I can better understand how to take my ideas and convert them into actually marketable products. There are lots of rules that need to be followed, but there are also a lot of things that are not as important. Distinguishing these from each other is critical in maintaining focus on reaching the end goal. These also allow you to increase financial gain through understanding that phase 1 testing is essential to monetization. At this point, companies will be interested in paying a lot of money if it shows that it has some sort of efficacy and is safe.

Ilia Mikhailenko - Nov 07, 2025, 12:05 PM CST

Ilia Mikhailenko - Nov 07, 2025, 12:36 PM CST

Title: 11.5 lec notes

Date: 11.5

Content by: ilia

Present: Ilia

Goals: Hear about the Tong Lecturer's journey

Content:

Run towards the hard problems - they are the ones that change the world.

Chapter I: foundation - college. Learning skills. How to scope a project and get it done really well. Getting experience and showing what I could do.

Chapter II: combine EQ with IQ to magnify the impact. She took on a huge people leader role - managing 350 people (reporting to her) and worked under a fantastic leader. Learned more about working in teams.

You don't need to know your final destination - just follow hard problems and build skills that allow you to make an impact.

#### Quadruple aim:

- 1. Improved provider experience
- 2. Improved pateint outcomes
- 3. Lower cost of care
- 4. Improved patient experience

Despite spending a lot of money on patient care, healthcare in the US is not great per the numbers.

How to build an integral system to enable health and wellness for all. Healthcare system was never designed to work in a unified way, which is why it doesn't work well.

Primary care physician: makes half/quarter of what specialists make

Big lessons and takeaways:

Work hard and build range. Effort and range are the foundation of lots of strong qualities

Seek diverse experiences. Explore lots of different things. You don't need to center in on one.

## Conclusion:

She went to Madison with a BME degree and then got her MBA from Harvard. Makes the case that healthcare needs more engineers and shares what she would be doing. In our shoes she was focused on building skills and demonstrating her value. Some big lessons are work hard and build range. Effort and range are the foundation of lots of

strong qualities. Another is to seek diverse experiences. Explore lots of different things. You don't need to center in on one.

Ilia Mikhailenko - Nov 12, 2025, 1:55 PM CST

Title: 11.12 lec notes

**Date:** 11.12

Content by: ilia

Present: Ilia

Goals: Learn more about the inner workings of the IRB here at UW-Madison

Content:

Things not considered research:

•

QI/PE. Certain things that you may consider to be research are really not.

FDA Regulated research program can inform you when you will need IRB approval throughout the process of your study.

# De-identifying data

- •
- The three levels of data identifiability:
  - Directly identifiable: identifiers included (name/date of visit)
  - o Coded/indirectly identifiable: identifiers removed but the identity can still be determined
  - o Anonymized: all identifiers removed. Cannot trace back to the individual.

Some exemptions that have a shorter, quicker review process: links included in the slides.

Different categories of research:

- research involving benign behavioral interventions
  - must be limited in a variety of ways: duration, harm-done (none), and others
- Research with data and samples
  - allows for secondary use of information and samples. Stuff that already exists, and you haven't collected yourself.

Medical device: anything that acts on the body to diagnose, treat, or prevent a disease but is not a drug. Also might not act directly on the body

- · diagnostic software
- olive oil! used in asthma treatment
- · bandage adhesive
- MRI hardware
- prostheses

#### Conclusion:

The IRB has a plethora of logistics and verbiage related to the studies they review. There is a lot - it is described as a maze. Understanding the different facets, including how to deal with the specific scenario you looking to do research on, is useful to conducting effective studies. As I move forward in my research career, I will keep in mind what I have learned in this lecture to properly navigate the world of research.

Ilia Mikhailenko - Nov 19, 2025, 2:04 PM CST

Title: 11.19 lec notes

**Date:** 11.19

Content by: ilia

Present: Ilia

Goals: Learn more about the NPD process with medical devices

Content:

Stages of NPD (Stage-Gate Process):

Stage 0: ideation

Stage 1: exploration. What are ways we could do this?

Define probs to be solved and customer requirements

Review, refine, and screen list ideas

Once you know the right question to ask, the problem is easy to solve.

# Stage 2: concept development

Based on the designs you come up with in the earlier stages, you make a major decision here. Which one are you going to move forward with?

The designs are narrowed, and you choose one. They had a replaceable component that needed to be rebought.

Go/no-go decision made here. Should we go forward with this? How much money will we make? What are the pros/cons

# Stage 3: Design development

How do you actually make the design? Seems simple in nature, but isn't always quite the case

Stage 4: design confirmation - verification and validation. Very long.

lots of documentation and testing surrounding requirements.

Stage 5: design transfer and commercialization.

Post market surveillance: should be recording feedback from customers, especially for more advanced medical devices.

Conclusion:

The NPD (new product development) process is extensive. There are a variety of steps detailed above. You essentially have a problem that is identified by "scouts" in the market, and then engineers are given these problems and design ways to solve them. It is lengthy and has lots of nuance, but understanding the key steps and being able to utilize longitudinal planning is essential to seeing success in this space.



# 11/14/2025 - Modeling and Waterjetting of the Mounting Plate

Ilia Mikhailenko - Dec 09, 2025, 9:06 PM CST

\*CAD drawing added on December 9th. Modeling and waterjetting performed on 11/14/2025\*

Title: Modeling/Design/Waterjetting of the Mounting Plate

Date: 12/9/2025

Content by: Ilia

Goals: Create an onshape model for water jet cutting of aluminum

#### Content:

The mounting plate was made of a sheet of Aluminum alloy (3003) found in an ECB storage area.

The point of this point is for it to connect the finger sleeves to the central mechanical body

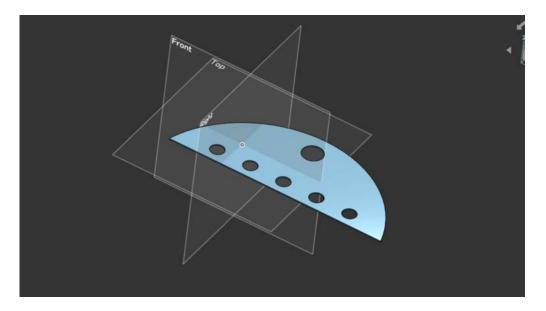
A 2D-sketch of the mounting plate design was created in OnShape

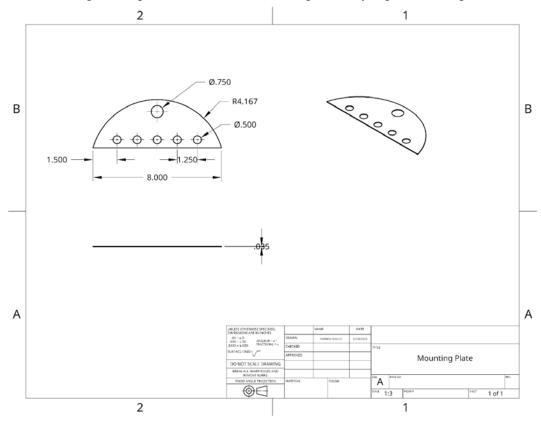
This CAD file was exported to the waterjet machine.

The aluminum sheet was then loaded into the waterjet cutter, and the waterjet sliced the mounting plate per the desired pattern.

The resulting piece had sharp edges which were dulled using a file in the MakerSpace

#### OnShape Model:





# Conclusion/Action items:

The water-jet process produced a precise aluminum mounting plate that matched the OnShape model well. Any rough edges were easy to clean up with a file, leaving the part smooth and safe to handle. Overall, the workflow was straightforward and resulted in a reliable component for the project.

# 11/14/2025 - FEA Testing of the Mounting Plate

Ilia Mikhailenko - Dec 10, 2025, 6:13 PM CST

\*Figures updated on 12/10/2025. Testing performed on 11/14/2025\*

**Title: FEA Testing of Mounting Plate** 

**Date:** 11/14/2025

Content by: Ilia

Present: Ilia, Nathan K

Goals: See if the mounting plate can sustain the load that will be placed on it during procedures at the client's hospital

#### Content:

The mounting plate was evaluated using finite element analysis (FEA)

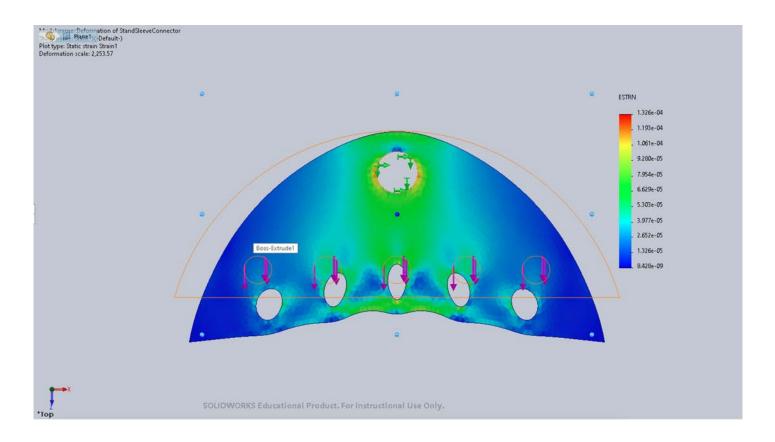
This was done to confirm that it meets the required safety factor.

All applied forces were multiplied by four to represent a factor of safety of 4 during loading.

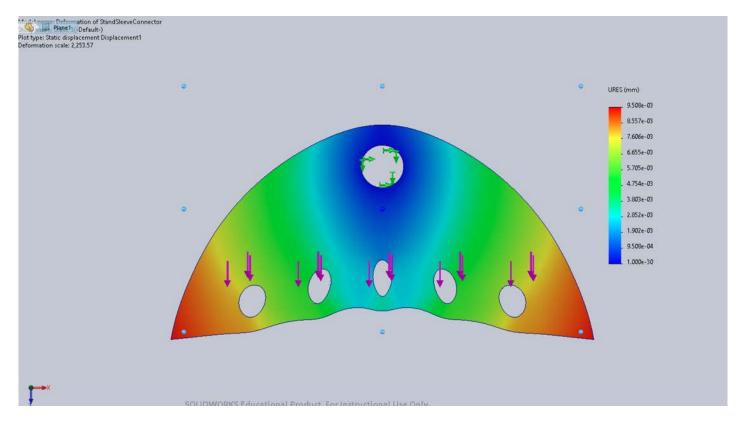
In these conditions, the model reached a maximum von Mises stress of  $5.2 \times 10^6$  N/m<sup>2</sup>, which is well below the material's yield strength of  $4.1 \times 10^7$  N/m<sup>2</sup>.

The FEA heat map, seen below, showed the highest stresses were in localized areas and did not approach the yield limit.

The testing shows part remains safely within the elastic range even under the amplified loading and meets the intended safety requirements.



# Solid Works Displacement Heat Map:



# **Conclusion:**

Overall, the analysis showed that the mounting plate easily stays within safe stress limits, even when the loads are multiplied by a factor of four. The results confirm that the design is structurally sound and meets the safety requirements for its intended use.

# 12/1/2025: Assembly of the Mechanical Stand

Ilia Mikhailenko - Dec 09, 2025, 9:04 PM CST

Ilia Mikhailenko - Dec 10, 2025, 6:14 PM CST

\*figure added on 12/10/2025. Stand assembled on 12/04/2025\*

Title: Assembly of the mechanical stand

Date: 12/10/2025

Content by: Ilia

Goals: assemble the model of the mechanical stand, putting together all existing components

#### Content:

It is worth noting that the body and base of the stand came from a Medline Stand IV Pole ordered on Amazon by the client.

The stand was assembled by unfolding the base legs and spreading them out until the base was stable

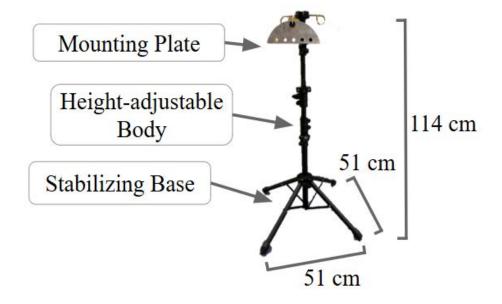
The central pole sections were then assembled by inserting them into each other in the correct order.

Next, the pole's height was adjusted to the desired length

The top-piece was secured and fastened to the apex of the assembled pole.

Finally, the mounting plate was placed onto a metal hook.

Image of assembled stand



Conclusion/Action items:

The stand came together cleanly, and all components fit as expected without any major adjustments. The final assembly is stable, height-adjustable, and ready for testing with the mounting plate in place. Next steps will focus on refining attachment points and evaluating how well the stand performs under real use conditions.



# 12/04/2025: Mounting Plate Stoppers

Ilia Mikhailenko - Dec 10, 2025, 6:14 PM CST

\*Figures added on 12/10/2025. Stopper designed on 12/04/2025\*

Title: Modeling and Printing of Mounting Plate Stopper

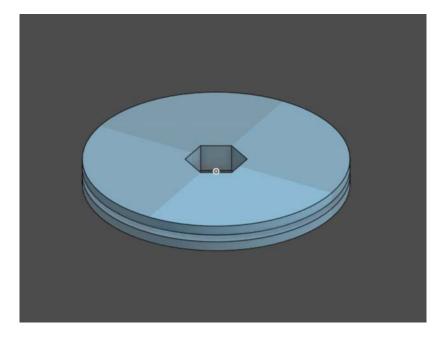
**Date:** 12/04/2025

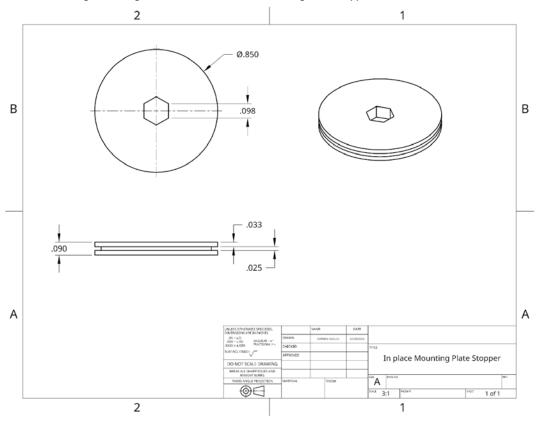
Content by: Ilia

**Goals:** create a mechanism to firmly hold the mounting plate in place and prevent it from rotating.

## Content:

The stopper modeled below will be printed with ridges to insert onto the apex of the stand (specifically the metal bar that the mounting plate currently hangs on) support it and prevent it from rotating during medical procedures. The stoppers will be printed out of TPU for flexibility. The inner hole will be hexagonal to prevent the stopper itself from slipping/roatating and giving it a firmer grip on the metal bar.





\*Note: all units listed for this CAD drawing are in inches\*

# Conclusion/Action items:

This stopper design gives the mounting plate a simple, reliable way to stay locked in place without unwanted rotation. With the TPU flexibility and hexagonal insert, it should hold firmly on the metal bar while still being easy to install and replace.

# 10/31/2025 - Pick Up of Materials from Warehouse

Ilia Mikhailenko - Dec 10, 2025, 5:04 PM CST

Title: Material Pick Up from Client

Date: 10/31/2025

Content by: Ilia

Present: Ilia

**Goals:** Obtain the IV pole and velcro cable ties from the client

Content:

I departed for the client's warehouse on

2418 Pennsylvania Ave, Madison, WI 53704

To pick up velcro cable ties and an IV pole. We had requested the client purchase them off Amazon but he offered to give us his own equipment that was stored in an affiliated warehouse. The warehouse is tied to the Wisconsin Medical Project, which sends medical equipment to under-resourced areas in Africa.

Upon arriving at the warehouse, I was met by Dr. Micke, an affiliate of our client.

Dr. Micke showed me to the warehouse but it quickly became clear that there were no IV poles or velcro cable ties in there. I called Mr. Samb to discuss this with him, and he apologized for the inconvenience and stated that he'd order the equipment we were looking for off Amazon.

My next steps are to send him the specific IV pole and cable ties that we want purchased, as well as any other equipment we would like to be ordered.

## Conclusions/action items:

The pickup didn't go as planned, but the situation was clarified quickly and the client agreed to order the needed items directly. I'll follow up by sending the exact product links to avoid any further confusion. Once the equipment arrives, we can move forward with assembly and testing.



# 11/08/2025 - Phone Discussion with Client Regarding Purchase

Ilia Mikhailenko - Dec 10, 2025, 5:07 PM CST

Title: Follow-Up Call Regarding Equipment Order

Date: 11/xx/2025

Content by: Ilia

Present: Ilia

Goals: Confirm that the IV pole and velcro cable ties had been ordered correctly by the client.

#### Content:

I called Mr. Samb to follow up on the equipment request and verify that the order had been placed.

We reviewed the specific IV pole and velcro cable ties needed for the project, and I confirmed that he had ordered the correct models from Amazon.

I also clarified a few details about expected delivery timing and confirmed that no additional items were needed at this stage.

The call ensured that we were aligned on the required equipment and prevented any further mix-ups.

# **Conclusions/Action Items:**

- Wait for shipment arrival and confirm condition of items
- Notify client once equipment is received
- Proceed with assembly as soon as materials are available



# 9/11 - Closed reduction of distal radius fractures: a systematic review and meta-analysis

NATHAN HANSEN - Sep 12, 2025, 6:36 PM CDT

#### Citation:

H. Søsborg-Würtz, S. Corap Gellert, J. Ladeby Erichsen, and B. Viberg, "Closed reduction of distal radius fractures: A systematic review and meta-analysis," EFORT open reviews, https://pmc.ncbi.nlm.nih.gov/articles/PMC5941650/ (accessed Sep. 11, 2025).

NATHAN HANSEN - Sep 12, 2025, 9:41 AM CDT

Title: Closed reduction of distal radius fractures: a systematic review and meta-analysis

Date: 9/11/2025

Content by: Nathan Hansen

Present: N/A

Goals: Conduct research on the effectiveness of current finger trap methods.

Search Term: PubMed: "finger-trap traction"

Citation:

Link: https://pmc.ncbi.nlm.nih.gov/articles/PMC5941650/

Content:

# **Abstract**

- Comparison: Manual traction (MT) vs finger-trap traction (FTT).
- · Findings:
  - · FTT better correction of radial shortening.
  - MT better correction of dorsal tilt.
  - FTT may cause less pain and fewer complications
- Suggests that traction sleeves (like Japanese sleeves) could reduce shortening and pain but need innovation for tilt correction.

#### Introduction

- · Distal radius fractures (DRFs) are common, especially in elderly.
- Closed reduction and casting is still widely used despite surgical fixation being popular.
- · MT: assistant applies counter-traction; operator manipulates fracture. Criticized since 1950s for possible soft-tissue damage.
- FTT: suspension with finger traps on radial digits; counter-traction via weights near elbow. Provides longitudinal traction automatically. Considered more gentle.
- Prior Cochrane Review (2007) found insufficient evidence to favor one method
- Aim: Compare MT vs FTT by radiographic measures + pain.
- FTT applies longitudinal traction for longer durations with consistent weights.

## Methods

- Eligibility: Adult patients, closed reduction by MT or FTT, with radiographic outcomes.
- Exclusions: Under 18, surgical fixation, non-RCTs.
- Primary outcome: Radiographic measurements (angulation, radial length).
- · Secondary outcomes: Pain during reduction, reduction difficulty, success rat

#### Results

- Total patients: 483 (240 FTT, 243 MT)
- Female predominance: 77-92%. Median age ~62-66 years.

#### Radiographic Results (Table 3)

- Earnshaw (UK, n=223):
  - Post-reduction tilt: FTT =  $-2.5^{\circ} \pm 2.0$ ; MT =  $-3.6^{\circ} \pm 2.2$ .
  - Shortening: FTT = 1.9 mm ± 1.0; MT = 2.0 mm ± 1.0.
  - · Success rate: 87% both groups.
- Holkenborg (Netherlands, n=144):
  - Tilt: FTT =  $5.3^{\circ} \pm 9.3$ ; MT =  $2.7^{\circ} \pm 9.6$ .
  - Shortening: FTT = 0.2 mm ± 2.8; MT = 0.8 mm ± 2.9.
  - Success rate: FTT = 71.2%; MT = 80.5%.
- Kongsholm (Sweden, n=116):
  - Tilt: FTT =  $-0.2^{\circ} \pm 4.3$ ; MT =  $-1.9^{\circ} \pm 3.8$ .
  - Shortening: FTT = 1.3 mm ± 2.5; MT = 2.0 mm ± 2.4.
  - Pain: FTT = significantly less than MT (VAS scale).

#### Meta-Analysis

- Dorsal tilt: MT better, mean difference = 0.43° (95% CI 0.25–0.61), p < 0.00001.
- Radial shortening: FTT better, mean difference = -0.19 mm (95% CI -0.37 to -0.01), p = 0.04

# **Complications**

- Kongsholm: FTT less painful (no anesthesia) vs MT (with local block).
  - Neurological impairment (thumb numbness): 5-week rates → FTT = 3% vs MT = 20% (p < 0.01).</li>
  - At 1 year: FTT = 6% vs MT = 15% (p < 0.05)
- Holkenborg: Quick-DASH function scores better in FTT group; complications (CRPS, carpal tunnel): FTT = 5% vs MT = 14%.
- Earnshaw: 25% required later surgery in both groups.
- · A sleeve that distributes traction evenly may reduce neurological complications and pain, as shown by FTT advantages.

#### **Discussion**

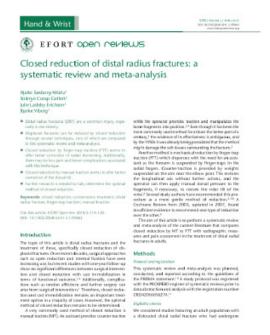
- FTT slightly better radial length correction.
- MT slightly better dorsal tilt correction.
- Differences are small (0.19 mm, 0.43°), may not be clinically significant.
- · If your sleeve allows both longitudinal traction and directed dorsal pressure, it could outperform FTT.

• Instrumentation (force sensors) could help quantify traction, ensuring consistency.

#### Conclusions/action items:

The evidence shows that finger-trap traction reduces pain and neurological complications, validating the importance of even pressure distribution in a traction sleeve. To advance this method, the design should aim for precise control of alignment, improving radial shortening within 0.2 mm and dorsal tilt within 0.5° compared to manual traction, while keeping neurological complications under 5%. Addressing FTT's weakness in dorsal pressure by integrating secondary support, along with embedding force sensors for standardized, measurable traction, would strengthen both consistency and safety.

NATHAN HANSEN - Sep 12, 2025, 9:16 AM CDT



**Download** 

eor-3-114.pdf (770 kB)



# 9/11 - Assessing the efficacy of manual reduction and novel traction techniques for distal radius fractures: A randomized controlled trial

NATHAN HANSEN - Sep 12, 2025, 6:37 PM CDT

Citation: Majidi, M., Rohani, E., Chamani, V., Rezaei, M., Roostayi, M. M., Ghaznavi, A., & Khosravi, M. "Assessing the efficacy of manual reduction and novel traction techniques for distal radius fractures: A randomized controlled trial," Health Science Reports, vol. 7, no. 7, Article e2227, Jul. 2024, doi:10.1002/hsr2.2227.

NATHAN HANSEN - Sep 12, 2025, 9:52 AM CDT

Title: Assessing the efficacy of manual reduction and novel traction techniques for distal radius fractures: A randomized controlled trial

Date: 9/11/2025

Content by: Nathan Hansen

Present: N/A

**Goals:** Conduct research on the effectiveness of current finger trap methods.

Search Term: PubMed: "traction AND distal radius fractures"

Citation:

Link: https://pmc.ncbi.nlm.nih.gov/articles/PMC11217017/

#### Content:

#### Introduction

- Distal radius fractures (Colles' fracture, Smith's fracture) are common orthopedic emergencies, especially in older adults.
- · Complications if untreated: malalignment, functional impairment.
- · Closed reduction typically involves traction and manipulation.
- UK: manual method (doctor manipulates, assistant provides counter-traction).
- US: finger-trap traction with 4.5–6.8 kg weight, considered safer with lower redislocation risk.
- · Surgical vs nonsurgical: No major differences in functional outcomes, but surgery increases tendon injury risk.
- · New traction device tested: aims to allow consistent, single-surgeon control without assistant.
- · Shows current reliance on manual vs finger trap traction and highlights the gap your digital sleeve could fill

# Methods

#### **Participants**

- 45 patients (46 hands) recruited in 2021, randomized into two groups:
  - · Manual reduction group: 25 hands.
  - · New traction device group: 21 hands.
- Mean ages: 45.5 ± 7.3 (device) vs 48 ± 5.3 (manual).
- Gender distribution: 9 males and 12 females (device), 12 males and 13 females (manual).
- Inclusion criteria: >16 years old, distal radius fracture, minimal displacement (<15° posterior rotation, <5 mm shortening).</li>

· Exclusions: severe bone/soft tissue injury, open fractures, need for surgical intervention.

#### Interventions

- · Novel device:
  - · Arm secured with brachial strap.
  - Traction via Chinese finger trap and vertical rotating component (see Fig. 1 in paper).
  - Allows single-surgeon operation with fluoroscopic guidance.
  - Provides stable, adjustable, and repeatable traction.
- Manual method:
  - Stockinet under axilla, one assistant provides counter-traction, another flexes wrist at 15°.
  - · Surgeon aligns and pins.
  - · Requires 2 or more personnel.
- · The novel device uses a finger trap-like mechanism, directly applicable to our digital sleeve project.

#### **Data Collection**

- · Radiographs taken pre-reduction, post-reduction, Week 1, Week 6.
- Parameters: volar tilt, radial angulation, shortening, inclination, dorsal angulation, ulnar variance.
- Pain measured with VAS (0-10) at same intervals.

#### Results

- · Radiographic outcomes at 6 weeks (Device vs Manual):
  - Volar tilt:  $4.19^{\circ} \pm 3.79 \text{ vs } 4.08^{\circ} \pm 3.88 \text{ (p = 0.926)}.$
  - Radial angulation: 2.18° ± 1.27 vs 2.21° ± 1.35 (p = 0.934).
  - Radial shortening: 10.52 mm ± 0.65 vs 10.56 mm ± 0.68 (p = 0.828).
  - Radial inclination: 22.52° ± 2.46 vs 22.71° ± 2.01 (p = 0.787).
  - Dorsal angulation:  $-0.33^{\circ} \pm 5.89 \text{ vs } -1.91^{\circ} \pm 5.22 \text{ (p = 1.00)}.$
  - Ulnar variance: 1.66 mm ± 0.90 vs 1.67 mm ± 0.81 (p = 0.958).
- Pain scores (VAS, 0-10):
  - Pre-reduction: 9.50 (device) vs 8.88 (manual).
  - Immediately after: 7.00 vs 6.43.
  - Week 1: 4.74 vs 4.35.
  - Week 6: 2.40 vs 2.47 (p = 0.737).
- No statistically significant difference between methods in any outcome.
- · Both methods achieve equivalent alignment accuracy and pain reduction the value of our sleeve lies in automation, sensor feedback, and single-surgeon use.

# **Discussion**

- Both methods improved all radiographic markers significantly from baseline.
- · Novel device: no better outcomes, but key advantages:
  - · Eliminates need for assistants.

- · Consistent, reproducible traction.
- Easier maneuverability (anterior, posterior, lateral).
- Prior research:
  - Earnshaw et al. (2002): No significant difference between finger trap and manual.
  - Hong (2021): Pulley and splint traction outperformed manual in stability.
  - Søsborg-Würtz et al. (2018, meta-analysis): Finger traps reduced radial shortening and pain compared to manual.

#### Conclusion

- No significant difference in outcomes between new device and manual reduction.
- · Novel device is less labor-intensive and could be more practical in clinical workflow.
- · Potential to add sensors for force standardization and safety monitoring.

#### Conclusions/action items:

This study confirms that traction-based methods, whether manual or with a device, achieve similar radiographic and pain outcomes, but the device provides greater consistency and eliminates the need for assistants. For a digital traction sleeve, the design focus should be on automating consistent longitudinal force application, integrating sensors to monitor and standardize traction in real time, and minimizing staff requirements during surgery. By combining reproducibility with measurable feedback, the sleeve could improve both safety and workflow efficiency in hand surgery.

NATHAN HANSEN - Sep 12, 2025, 9:53 AM CDT



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NATHAN HANSEN - Sep 12, 2025, 9:53 AM CDT



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# HSR2-7-e2227-g003.jpg (140 kB)

NATHAN HANSEN - Sep 12, 2025, 9:16 AM CDT



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HSR2-7-e2227.pdf (3.83 MB)



# 9/16 - Assessment of pressure pain thresholds in collisions with collaborative robots

NATHAN HANSEN - Sep 16, 2025, 9:28 PM CDT

Title: Assessment of pressure pain thresholds in collisions with collaborative robots

**Date:** 9/16/2025

Content by: Nathan Hansen

Present: N/A

Goals: Gain a better understanding of the expected ergonomics of our finger sleeves by researching pain thresholds.

Search Term: PubMed: "pain thresholds"

#### Citation:

C. G. Calfee, J. D. Sommerkamp, and R. J. Stern, "The use of finger traps in hand surgery," *The Journal of Hand Surgery*, vol. 24, no. 4, pp. 835–841, Jul. 1999. doi: 10.1053/jhsu.1999.0835.

Link: https://pmc.ncbi.nlm.nih.gov/articles/PMC6497239/

#### Content:

- Participants: 90 healthy males, aged 20–50 years (mean 28.9 years).
- BMI range: 17.6–36.4 (mean 23.8).
- Pain thresholds measured at 15 body sites using a 1.96 cm<sup>2</sup> contactor.

#### Pressure Pain Thresholds

- Lowest threshold: 65.1 +/- 22.6 N/cm² (arm nerve).
- Highest threshold: 196.1 +/- 85.8 N/cm2 (back of the hand).
- Moderate thresholds:

Forehead: 102 N/cm²

Neck muscle: 108 N/cm²

Ball of thumb: ~05 N/cm²

Shin: 128 N/cm<sup>2</sup>

- Index finger pad: 169.1 N/cm<sup>2</sup> (important for finger sleeve application).
- Palm: 97.8 N/cm2.

#### Age & BMI Effects

- Participants less than 30 years old had 33% lower pain thresholds compared to greater than 30 years.
- Example: Spinous process C7 showed 32.1% lower threshold in younger group.
- High BMI (greater than 25) generally higher thresholds at some sites (shoulder +32%, neck muscle +27%).
- Exception: Back of the hand showed 15% lower threshold for high BMI group.

## Skin Effects

- Total 4,050 site photographs analyzed.
- Mild damage only:

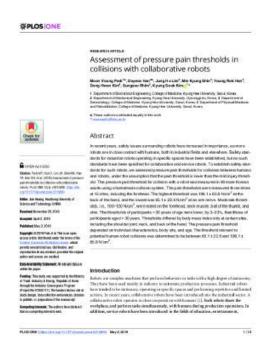
- . ...

- Erythema/redness (30.8%)
- · Edema/swelling (few cases)
- · Only 4 cases of superficial scratches.
- · No lasting damage beyond several hours.

#### Conclusions/action items:

For safe application of a traction sleeve, peak interface pressures should be kept well below 65 N/cm², with a conservative design limit of 50 N/cm². While finger pads can tolerate higher thresholds (up to 169 N/cm²), palms and nerve-rich areas are more sensitive (98 N/cm² and lower), making load distribution essential. Younger patients may have 30% lower pain thresholds, reinforcing the need for conservative safety margins. Even sub-threshold pressures can cause skin erythema or indentation, so a padded or braided contact surface is preferred.

NATHAN HANSEN - Sep 16, 2025, 9:28 PM CDT



**Download** 

pone.0215890.pdf (1.64 MB)



# 9/17 - Epidemiology of distal radius fractures: a detailed survey on a large sample of patients in a suburban area

NATHAN HANSEN - Sep 17, 2025, 4:59 PM CDT

Title: Epidemiology of distal radius fractures: a detailed survey on a large sample of patients in a suburban area

Date: 9/17/2025

Content by: Nathan Hansen

Present: N/A

Goals: Understand how common distal radius fractures are and who is most affected.

Search Term: PubMed: "DRF prevalence"

#### Citation:

V. Candela, P. Di Lucia, C. Carnevali, A. Milanese, A. Spagnoli, C. Villani, and S. Gumina, "Epidemiology of distal radius fractures: a detailed survey on a large sample of patients in a suburban area," *Journal of Orthopaedics and Traumatology*, vol. 23, no. 1, p. 43, Aug. 2022, doi: 10.1186/s10195-022-00663-6.

Link: https://pmc.ncbi.nlm.nih.gov/articles/PMC9428104/

## Content:

#### **Background**

- Distal radius fractures (DRFs) are one of the most common orthopedic injuries; account for up to 18% of all fractures in the elderly.
- Traditional reduction methods (manual traction, finger traps with weights) often vary in consistency and depend on surgeon strength or assistant availability.
- Goal of this study: assess whether ultrasound-guided reduction under hematoma block improves accuracy, safety, and clinical outcomes.

#### Methods

- Study design: prospective, 62 patients with acute DRFs.
- Patient demographics:
  - Mean age = 64.2 years (range: 23–87).
  - Female predominance = 70%.
- Anesthesia method: hematoma block with 10-20 mL of 1% lidocaine.
- Imaging: bedside ultrasound used to guide fracture reduction and confirm alignment.

#### **Outcomes**

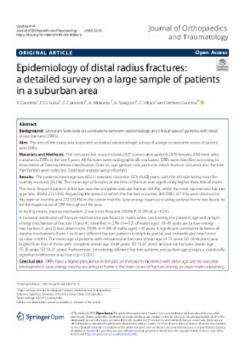
- · Reduction success rate (initial attempt):
  - Ultrasound-guided = 90.3% successful.
  - Traditional manual reduction = 74.2%.
  - Improvement of 16% absolute success rate.
- · Post-reduction alignment (measured by X-ray):
  - Mean radial shortening: 1.8 +/- 0.7 mm.

- Mean dorsal tilt: 2.1 degrees +/- 1.5 degrees.
- These are well within accepted clinical thresholds (2 mm shortening, 5 degrees tilt).
- · Pain levels:
  - Visual Analog Scale (VAS) dropped by 3.5 points on average after hematoma block.
  - · Most patients tolerated procedure without additional anesthesia.
- · Complication rate:
  - · No neurovascular injuries.
  - No cases of compartment syndrome.
  - · Minor skin irritation in 5% of patients.

#### Conclusions/action items:

Given that distal radius fractures represent about17.5% of all orthopedic cases, Idrissa Pouye General Hospital will see roughly 8,750 sleeve uses per year. To meet this demand sustainably, each finger sleeve must withstand 500 full cycles (50 minutes per cycle, 420 hours total load time) without failure. This ensures the sleeves remain functional for 1–2 years of heavy clinical use, aligning durability with the hospital's high patient throughput and limited access to replacement supplies.

NATHAN HANSEN - Sep 17, 2025, 4:59 PM CDT



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10195\_2022\_Article\_663.pdf (887 kB)



# 9/17 - In vivo friction properties of human skin

NATHAN HANSEN - Sep 17, 2025, 5:43 PM CDT

Title: In vivo friction properties of human skin

Date: 9/17/2025

Content by: Nathan Hansen

Present: N/A

Goals: Research forces of compression and friction that could cause skin damage to better understand the ergonomics of the finger

sleeves.

Search Term: PubMed: "(skin) AND (friction)"

Citation:

M. Zhang and A. F. T. Mak, "In vivo friction properties of human skin," *Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine*, vol. 213, no. 5, pp. 457–464, 1999, doi: 10.1243/0954411991535300.

Link: https://pubmed.ncbi.nlm.nih.gov/10493141/

#### Content:

## General Findings:

- Average COF of skin across all sites/materials = 0.46 +/- 0.15 (range 0.24-1.26)
- Supports your target COF range of 0.4-1.0: 0.4 gives adequate grip, 1.0 is upper safety limit.

## Anatomical Site Data:

- Palm had the highest COF: 0.62 +/- 0.22.
- Other regions (forearm, leg, dorsum of hand) lower (typically 0.3-0.5).
- · Suggests that sleeves gripping fingers/palm side must balance higher natural friction vs dorsum.

# Material Data:

• Silicone: 0.61 +/- 0.21 (highest)

• Nylon: 0.37 +/- 0.09 (lowest)

• Aluminium: .42 +/- 0.14

• Cotton sock: 0.51 +/- 0.11

• Pelite: 0.45 +/- 0.07

 For sleeve materials: nylon-like textures approach your 0.4 target, while silicone-like approaches the upper bound (risk of shear if >1.0).

#### **Environmental Conditions:**

• Tests performed at 20-24 degrees C and 55-65% relative humidity

Load Dependence:

- When normal load increased 25g -> 100g, COF decreased 9.5 +/- 6%.
- Suggests higher traction force slightly lower effective friction.

#### Safety / Skin Trauma Implications:

- Friction-induced injury occurs both with slip (abrasion) and without slip (compression/occlusion).
- COF >1.0 risks shear blistering and erythema.
- Broad, padded sleeve contact surfaces reduce localized high shear.

#### Conclusions/action items:

Friction testing of human skin shows that typical skin–material coefficients of friction (COF) range from 0.24 to 1.26, depending on anatomical site, material, and loading. Materials like nylon average around 0.37, while silicone can exceed 0.6. Since COF values above 1.0 risk shear injury, while values below 0.4 may compromise grip, setting the design goal for the inner finger sleeves at a COF of 0.4 under operating room conditions ensures reliable traction while minimizing skin damage risk.

NATHAN HANSEN - Sep 17, 2025, 5:44 PM CDT

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#### In vivo friction properties of human skin.

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# 9/17 - Ventilation of Health Care Facilities

NATHAN HANSEN - Sep 17, 2025, 6:43 PM CDT

Title: ANSI/ASHRAE/ASHE Standard 170-2017, Ventilation of Health Care Facilities

Date: 9/17/2025

Content by: Nathan Hansen

Present: N/A

Goals: Research operating room conditions to understand what our product will need to operate in.

Search Term: Google: "standard OR conditions"

#### Citation:

ASHRAE, ANSI/ASHRAE/ASHE Standard 170-2017: Ventilation of Health Care Facilities, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA, USA, 2017.

**Link:** https://www.ashrae.org/technical-resources/standards-and-guidelines/standards-addenda/ansi-ashrae-ashe-standard-170-2017-ventilation-of-health-care-facilities

#### Content:

# Operating Rooms

- · Temperature range:
  - Minimum: 68 degrees F (20 degrees C)
  - Maximum: 75 degrees F (24 degrees C)
  - Some specialized ORs allow extended ranges, but 20–24 degrees C is standard.
- Relative Humidity (RH):
  - Minimum: 20%
  - Maximum: 60%
  - Lower limit reduced from older standards (30%) to 20% to prevent microbial growth while accommodating newer HVAC systems.
- · Air changes per hour (ACH):
  - greater than 20 total ACH (air change per hour).
  - greater than 4 outdoor ACH (must be outside air).
  - Positive pressure required relative to surrounding spaces to prevent contamination.

#### Conclusions/action items:

The device must operate under OR conditions defined by ASHRAE 170-2017: 20–24 °C and 20–60% RH. Device materials and sensors must maintain function across this range and tolerate cleaning/disinfecting consistent with OR sterility standards.

NATHAN HANSEN - Sep 17, 2025, 6:44 PM CDT



# Ventilation of Health Care Facilities

Approved by ASHAA Standards Connectine on July 11, 2020; by the ASHAA Board of Directors on August 10, 2020; by the American Society for Health Care Engineering on July 28, 2020; and by the American National Standards Institute on Sentencine 1, 2020.

The addendarn was approved by a Standing Standard Project Commisse (ISPN), for which the Standards Commisse has established a decovered program for regular publication of addendar or review, including postedures for timely, decorrend, conserves activations on requestive followings can be provided to enabled. Exercise for low to submit a change can be found on the ASTMAC<sup>®</sup> website (https://www.schroscopylordine.or-en/intension).

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NATHAN HANSEN - Sep 12, 2025, 6:37 PM CDT

Title: Digital traction system

Date: 9/12/2025

Content by: Nathan Hansen

Present: N/A

Goals: Research current digital traction designs to learn what is out there and what can be improved.

Search Term: Google Patents: "digital traction"

Citation:

P. T. Donohue, "Digital traction system," U.S. Patent 5,191,903, issued Mar. 9, 1993.

Link: https://patents.google.com/patent/US5191903A/en

#### Content:

#### **Abstract**

- Describes a self-contained axial digital traction system anchored near the MCP joints using a glove-like anchoring member and hook-and-loop (Velcro) mating pads.
- Tension elements pass over rollers and connect to finger traps (Chinese-finger-trap style sleeves).
- Alternative traction plate arrangements allow individual digit treatment and increased independent MCP articulation.

## **Background**

- · Motivates self-contained traction (anchor on hand/wrist rather than external bed/frame) to preserve patient mobility.
- Notes existing self-contained devices are often heavy, complex, custom fitted patent aims for light, low-profile, low cost solution.

#### Summary of the invention

- Traction frame / plates mounted palmar side, anchored near MCP joints. Plate dimensions: inner anchor end about width of the palm, outer end wide enough to extend somewhat beyond fingertips. (Trapezoidal plate geometry described)
- Glove-like anchoring member (fingerless glove) with hook-and-loop patch on palm to engage matching pad on traction plate.

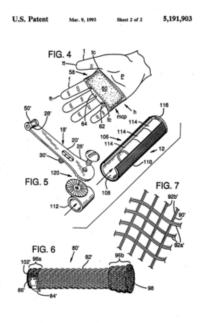
  Anchoring is localized adjacent MCP joints (not wrist), providing reaction point for traction.
- Tension members / tensors: elastic loops (elastic bands) adjustable with slide fasteners; trained over rollers (two tubular rollers on a bolt) to provide low-friction return and uniform tension. Rollers are captive between bushings; bolt with knurled head used as axle.
- Finger traps: braided sleeve that contracts under tensile load (Chinese finger trap). Sleeve made from bundles of filaments (polypropylene preferred) bundled into strands then braided. Materials called out: polypropylene, commercial braided electrical sleeving. Details of braid pattern (right/left spiral strands) are given; ends are set with adhesive to prevent unraveling.
- Modularity: full-width plate (all five digits) or narrow individual digit plates, with lateral/pivotal adjustment (adapter cylinder, rosette swivel, spacers) so individual plates can be laterally positioned and angled to deviate traction axis.

#### Conclusions/action items:

Embedding load cells and pressure sensors would enable real-time monitoring and closed-loop control of traction forces, while built-in limits ensure safe application. A braided or padded sleeve that spreads pressure evenly, combined with a secondary dorsal actuator, would address both comfort and alignment challenges. Making the anchoring sleeve disposable and the plate sterilizable supports OR sterility, while a simple UI that displays

traction forces and offers preset modes would streamline workflow. Finally, a low-profile, ergonomic plate design preserves finger motion while maintaining effective traction.

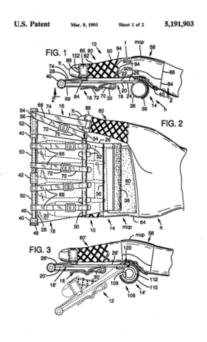
NATHAN HANSEN - Sep 12, 2025, 9:15 AM CDT



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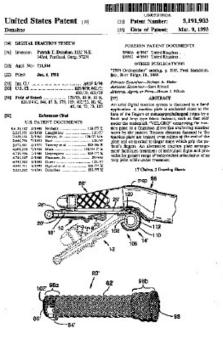
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NATHAN HANSEN - Sep 12, 2025, 9:15 AM CDT



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## US5191903-drawings-page-2.png (105 kB)



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US5191903.pdf (1.13 MB)

NATHAN HANSEN - Sep 12, 2025, 6:38 PM CDT

Title: Traction device

Date: 9/12/2025

Content by: Nathan Hansen

Present: N/A

Goals: Research current digital traction designs to learn what is out there and what can be improved.

Search Term: Google Patents: "traction device"

Citation:

D. M. Lambert, "Traction Device," U.S. Patent 6,811,541, issued Nov. 2, 2004.

Link: https://patents.google.com/patent/US6811541B2/en

## Content:

## **Background**

- Prior devices used rubber tubing for traction (risk of tearing, fatigue failure).
- Devices often required dedicated tables/frames, bulky in OR/ER.
- · Older devices lacked:
  - · Individual finger adjustment
  - · Quantitative force measurement
  - Quick release for safety
- · Needs: safe, adjustable, measurable traction in both ER and OR settings.

#### Summary of Invention

- Attach to any IV pole (portable, space-saving).
- Five finger traps distribute traction evenly.
- Ratcheting counter-traction system with an easy-to-read scale (up to 50 lbs).
- · Springs and quick-release clips:
  - Each finger can be adjusted individually.
  - Extra tension can be added by clipping unused springs together.
- · Disassemblable design fast cleaning, sterilization, repair.

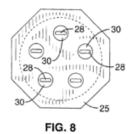
#### **Design Features**

- Finger Traps (10)
  - Woven, tapering cylinders grip tighter under load.
  - · Release when tension relieved.
  - · Prevent slippage without damaging skin.
- Springs (15) and Quick-Release Clips (20)

- · Each finger connected via its own spring independent control.
- Can add multiple springs to a single finger for extra traction force.
- o Circular pattern on swivel base (25) mimics natural hand posture.
- · Swivel Base (25)
  - · Circular arrangement of springs.
  - Allows natural hand rotation during traction.
  - Swivel attachment (35) enables 360° adjustment.
- Traction Force Measurement (45)
  - Analog/digital scale; commonly 50 lb capacity.
  - · Mounted inline between finger assembly and traction handle.
  - Provides quantitative, standardized measurement (absent in earlier patents).
- First Traction Force Generator
  - o Cable (65) + ratchet (70).
  - · Easy-grip handle (60).
  - · Allows practitioner to set traction force precisely.
- Counter-Traction System (Second Traction Force Generator)
  - Padded arm cuff (95) with quick-release clip (96).
  - · Connected to either:
    - Crank-operated windlass (105)
    - Cable and ratchet system (140, 145, 150).
  - Applies proximal force to stabilize forearm while distal traction applied.
- Finger Spacer (55)
  - Keeps fingers separated.
  - · Ensures even force distribution across digits.
- Support Attachment
  - Mounts to any IV pole or stand (80).
  - Uses adjustable clamps allows use in tight ER/OR settings.

#### Conclusions/action items:

This patent demonstrates a practical, compact traction system but relies only on analog force measurement and point-based pressure distribution. A next-generation sleeve could improve safety and consistency by adding digital force sensors, distributing load across a larger surface area, and using modular elastic zones for finger-specific adjustment. Incorporating disposable liners for sterility, maintaining portability, and adding a dorsal/volar control mechanism would further advance functionality beyond the existing design.

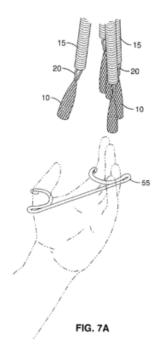




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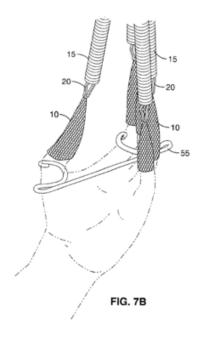
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NATHAN HANSEN - Sep 12, 2025, 9:13 AM CDT



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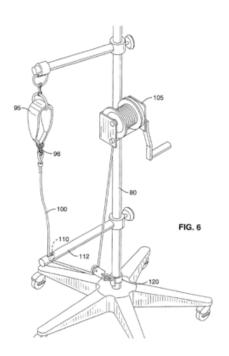
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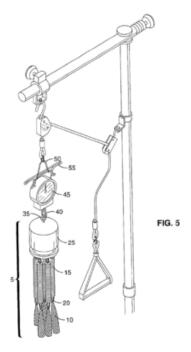
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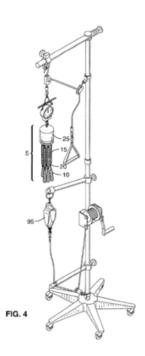
NATHAN HANSEN - Sep 12, 2025, 9:13 AM CDT



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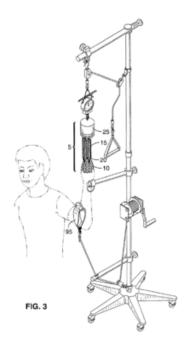
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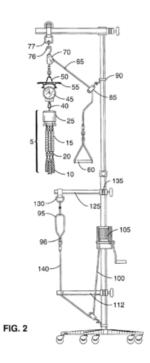
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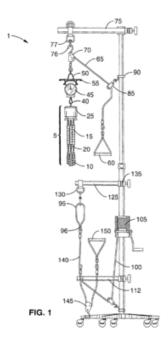
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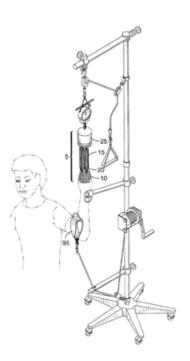
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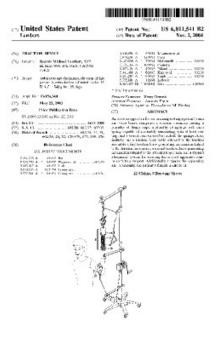
NATHAN HANSEN - Sep 12, 2025, 9:13 AM CDT



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NATHAN HANSEN - Sep 12, 2025, 9:14 AM CDT



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US6811541.pdf (893 kB)

# 10/21 - General Ballistic Nylon Information

NATHAN HANSEN - Oct 21, 2025, 4:12 PM CDT

Title: General Ballistic Nylon Information

Date: 10/21/2025

Content by: Nathan Hansen

Present: N/A

Goals: Research a general overview of the properties of ballistic nylon for use in the finger sleeve design.

Search Term: Google "ballistic nylon properties"

Citation:

TVF, "What Are Ballistic Fabrics?," TVF Inc., 2024. Accessed: Oct. 21, 2025. [Online].

Link: <a href="https://www.tvfinc.com/article/ballistic-fabrics/">https://www.tvfinc.com/article/ballistic-fabrics/</a>

#### Content:

#### What ballistic fabrics are

- Ballistic fabrics are very tough, durable materials originally designed for military use specifically to protect against shrapnel and fragments.
- Although originally created for military "flak jackets," today they're used widely in protective gear, luggage, motorcycle apparel, pet accessories, etc.

#### Construction/composition

- Typically made from nylon (nylon 6 or nylon 6,6) with a very tight "ballistic weave" (e.g., 2×2 or 3×3 basket-weave) to make the fabric dense and strong.
- Denier (thickness/weight) of the fibers is high: standard ballistic fabric is usually 840D or higher, commonly 1050D or even 1680D for heavy-duty uses.
- Often finished/coated with materials like polyurethane or PVC to improve water resistance, UV resistance, and abrasion protection.

### Key properties

- Abrasion resistance Because of the dense weave and high denier, these fabrics withstand repeated wear/abrasion better than many other fabrics.
- Tensile strength / tear resistance They have high tensile strength, resisting tearing and puncturing.
- Weather resistance With coatings, they can resist moisture and UV exposure, making them suitable for rugged outdoor or harsh-environment use.

### Comparisons / notes

- Compared with CORDURA nylon: Ballistic has a smoother, denser weave, and is preferred where very high tear/abrasion resistance is needed. Cordura has a rougher texture and is often used for outdoor gear, backpacks etc.
- The high denier and "ballistic weave" give it a thick feel and strong performance but may also mean more weight and stiffer drape compared to lighter fabrics.

## Testing / quality assurance

- · Abrasion testing (ASTM D3884) is used to evaluate how much wear the fabric can sustain before breakdown.
- Tensile strength testing (ASTM D5034) determines how resistant the fabric is to pulling forces.
- Tear strength testing (ASTM D2261) evaluates resistance to tearing, important for protective and industrial uses.
- Water repellency testing (AATCC 22) is used for coated ballistic fabrics to assess resistance to water penetration.

## Conclusions/action items:

Since the finger straps will be pretty thin strips of fabric, I think that ballistic fabric will be a good material due to its strength. Going forward, I want to look into if ballistic nylon can be used in the laser cutter or Cricut. I also want to look into the standardized testing protocol that were mentioned in this site.



# 10/21 - Tensile Strength Testing (ASTM D2261)

NATHAN HANSEN - Oct 21, 2025, 4:24 PM CDT

Title: Tensile Strength Testing (ASTM D2261)

Date: 10/21/2025

Content by: Nathan Hansen

Present: N/A

Goals: Look into the standardized protocol for testing breaking strength and elongation of textile fabrics, specifically for our ballistic

nvlon.

Search Term: Google "ASTM D5034"

Citation:

ASTM International, Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test), ASTM D5034-21, 2021. Accessed: Oct. 21, 2025.

Link: https://compass.astm.org/content-access?contentCode=ASTM%7CD5034-21%7Cen-US

#### Content:

### Purpose / What it Measures

- · Measures breaking strength and elongation at break of textile fabrics.
- Reflects effective strength, includes yarns gripped and assistance from adjacent yarns (not just yarns directly clamped).
- Used widely for acceptance testing in industry (commercial fabric quality control).

### Test Method Type

- Grab test: specimen ~100 mm wide, only the center portion is gripped.
- · Modified grab: slits cut so only center 25 mm of yarns carry load, used for high-strength woven fabrics or ones that unravel.

#### Applicability

- Works for woven, nonwoven, and felted textiles (not recommended for knits or high-stretch fabrics >11%).
- · Can be performed in conditioned (standard lab atmosphere) or wet condition.

### **Key Test Setup Parameters**

- · Uses tensile testing machine (CRE, CRL, or CRT).
- Standard gage length: 75 +/- 1 mm between clamps.
- Standard loading rate: 300 +/- 10 mm/min unless otherwise specified.
- · Records maximum force (N or lbf) and optional elongation (%).
- · Clamping quality is critical (slippage or edge breaks invalidate data).

## Output / Reporting

- · Average breaking force per fabric direction (warp & fill separately).
- · Percent elongation at break, if required.
- · Report must specify:
  - specimen type (G or MG),
  - o machine type (E, L, or T),
  - · test condition (wet or conditioned),
  - o jaw face size, grip mods, pretension, etc.

#### Why It's Used

- · Standard practice for ruggedness and load capacity evaluation.
- · Particularly important for ballistic, industrial, and technical textiles.
- · Not directly comparable across machine types, precision depends on consistency.

## Conclusions/action items:

I think that our current tensile testing protocol for the finger sleeves already cover most of the information covered in this standard. One thing that could be added to it is recording the elongation of the material before it breaks. Going forward, we should further cross reference this standard and maybe cite it within our tensile testing protocol.

NATHAN HANSEN - Oct 21, 2025, 4:26 PM CDT



**Download** 

D5034-21.pdf (340 kB)

# 10/21 - Tear Strength Testing (ASTM D2261)

NATHAN HANSEN - Oct 21, 2025, 4:35 PM CDT

Title: Tear Strength Testing (ASTM D2261)

Date: 10/21/2025

Content by: Nathan Hansen

Present: N/A

Goals: Look into the standardized protocol for testing tear strength of textile fabrics, specifically for our ballistic nylon.

Search Term: Google "ASTM D2261"

#### Citation:

ASTM International, "ASTM D2261-13(2024): Standard Test Method for Tearing Strength of Fabrics by the Tongue (Single Rip) Procedure (Constant-Rate-of-Extension Tensile Testing Machine)," ASTM International, West Conshohocken, PA, 2024. doi: 10.1520/D2261-13R24.

Link: https://compass.astm.org/content-access?contentCode=ASTM%7CD2261-13R24%7Cen-US

#### Content:

- Purpose: Measures tearing strength of fabric using *tongue tear method* with a constant-rate-of-extension (CRE) tensile testing machine.
- Applies to most fabric types: woven, knitted, non-woven, coated, treated, layered, napped, airbag fabrics, etc.
- Test concept: A slit forms two "tongues", each held in opposing tensile tester jaws. Force is applied to propagate the tear while force peaks are recorded.
- · Does NOT measure force required to initiate a tear, only force to continue tearing.
- Reported result is either the highest single peak or the average of five highest peak forces (specified by agreement).
- · Primary axis alignment matters, yarns must be aligned correctly before cutting slit.
- Specimen dimensions: 75 mm × 200 mm rectangle with a 75 mm slit.
- Specimens taken both warp (machine direction) and fill (cross direction).
- Test speed: 50 mm/min (CRE), optionally 300 mm/min (if agreed).
- Wet testing option available, specimens must be tested within 2 min of removal.
- Environment: Standard textile testing conditions (21 °C, 65% RH).
- Common failure: Force curve often irregular, multiple peaks & valleys are normal.
- Acceptance testing: Widely used in industry, standard allows for interlaboratory comparison & bias resolution process.

#### Conclusions/action items:

I do not think that this will be a great testing protocol for our finger sleeves as it does not measure the force required to initiate a tear, only the force to continue tearing. Additionally, the finger sleeves do not receive much shearing force, mainly tensile. We will be able to see any critical ripping areas during our tensile testing.

Designation: E2001 - 13 (Recaptored 2004)

Standard Test Method for Tearing Strength of Fabrics by the Tongue (Single Rip) Proceedure (Constant Handson - Decktorasion Transillo Testing Machine)

Tearing Strength of Fabrics by the Tongue (Single Rip) Proceedure (Constant - Handson - Decktorasion Termillo Testing Machine)

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D2261-13\_2024\_.pdf (579 kB)

# 10/21 - Laser Cutting Ballistic Nylon

NATHAN HANSEN - Oct 21, 2025, 4:51 PM CDT

Title: Tear Strength Testing (ASTM D2261)

Date: 10/21/2025

Content by: Nathan Hansen

Present: N/A

Goals: Look into the standardized protocol for testing tear strength of textile fabrics, specifically for our ballistic nylon.

Search Term: Google "can you laser cut ballistic nylon"

#### Citation:

MimoWork, "Laser Cutting Nylon – Professional Nylon Cutting Solutions," *MimoWork*, 2025. Accessed: Oct. 21, 2025. [Online]

Link: https://www.mimowork.com/laser-cutting-nylon/

#### Content:

#### Material & Process Overview

- Nylon (including nylon 6,6 and ripstop variants) is widely used for products like parachutes, military gear, outdoor equipment, activewear.
- Laser cutting nylon offers non-contact, precise processing with minimal mechanical distortion.
- A CO<sub>2</sub> laser (wavelength ~9.3 or 10.6 μm) is recommended because nylon absorbs this wavelength, enabling melting / clean cutting rather than ragged tearing.

## Benefits of Laser Cutting Nylon

- Produces clean, flat edges with sealed margins, reduces fraying and burrs.
- Can cut complex shapes, perforations, and fine holes in nylon sheets/fabrics.
- · Maintains material integrity because the process is force-free and avoids mechanical tool wear.
- Suitable for large format or roll material processing because of CNC driven automation and conveyor tables.

#### **Recommendations and Considerations**

- Choose proper laser power depending on thickness and type of nylon: e.g., 40–120 W typical for fabrics, higher (e.g., 150 W+) for heavy technical textiles like 1000D nylon.
- Secure the nylon fabric on the bed to avoid movement; vacuum or tape/fixture recommended.
- Perform a test cut on the same material before actual production to confirm parameters and avoid burning or distortion.
- Ensure fume extraction/ventilation is in place, cutting nylon can generate strong odors or harmful gases when melted.

#### Conclusions/action items:

Ballistic nylon should be suitable for use of the laser cutter. This will help our team produce consistent prototypes for the client and testing purposes. Additionally, the heat of the laser should melt the edges of the cut, eliminating the worry of fraying and subsequent

degradation over time. Next we need to check with the UW Makerspace to make sure that they are okay with us using ballistic nylon fabric in their laser cutter.

NATHAN HANSEN - Nov 06, 2025, 4:43 PM CST

Title: ASTM D882 Tensile Properties of Thin Film / Plastic Sheeting

Date: 11/6/2025

Content by: Nathan Hansen

Present: N/A

Goals: Look into the standardized protocol for dog bone tensile testing for the specific MTS machine in the

experimental teaching lab.

Search Term: Google "MTS tensile testing protocol"

Citation:

MTS Systems Corporation, "ASTM D882 Tensile Properties of Thin Film / Plastic Sheeting: Test Method Summary," Technical Note 100-332-870a, Eden Prairie, MN, USA, Aug. 2023.

Link: https://www.mts.com/en/applications/materials/test-standard/astm/astm-d882

### Content:

ASTM D882 is a standardized tensile test method designed for plastic films and thin sheeting with thicknesses < 1 mm (0.04 in).

#### It measures:

- Elongation (%)
- Tensile modulus (elastic modulus)
- · Tensile yield strength
- Tensile strength at break

#### Used for:

- Quality control (QC) and specification of materials
- · Material selection for packaging or design
- Testing under temperature conditions that simulate real use

## Testing Procedure

- Specimen preparation: Rectangular strips of uniform width and thickness are cut; edges must be parallel within 5% of width.
- Mounting: Specimens are gripped in a universal testing machine (UTM) and pulled until failure.
- Challenge: Avoid slippage without introducing local stresses causing tearing.

## **Equipment and Setup**

**Load Frames** 

- MTS Criterion® and MTS Exceed® Electromechanical Universal Testing Machines
- Force capacities: up to 100 kN
- Configurations: 1-column tabletop to 2-column floor models
- Dual-zone test spaces available in 30 kN and 100 kN models
- Option: MTS ReNew™ Upgrade for modernizing old systems

## Grips

- Vise & Wedge style grips: Constant clamping force; minimize slippage
- Pneumatic roller grips: Easy setup; used for QA/QC
- Flat rubber grip faces: Best for fragile thin films
- Line contact grip faces: For specific applications; may be combined with rubber-coated faces
- Grip face width: Must be wider than specimen width

Dimensions for ballistic nylon dog bone can be determined by this table:

ASTM D882 Test Specimen Requirements	
Uniformity	Test specimens shall consist of strips of uniform width and thickness at least 50 mm (2 in) longer than the grip separation used.
Width	Nominal width of the specimens shall be not less than 5.0 mm (0.20 in) or greater than 25.4 mm (1.0 in).
Width-thickness Ratio	A width-thickness ratio of at least eight shall be used. Narrow specimens magnify effects of edge strains or flaws, or both.
Undamaged Specimens	Care shall be exercised in cutting specimens to prevent nicks and tears that cause premature failures. Edges shall be parallel to within 5 % of the width over the length of the specimen between the grips.
Consistent Thickness	Test specimens shall be uniform thickness to within 10 % of the thickness over the length of the specimen between the grips for specimen thickness of 0.25 mm (0.010 in) or less, and to within 5 % in the case of specimens greater than 0.25 mm (0.010 in) in thickness.
Anistropic Material	For anisotropic materials, two sets of test specimens shall be prepared having their long axes respectively parallel with and normal to the suspected direction of anisotropy.
Tensile Modulus	For determining tensile modulus of elasticity, a specimen gage length of 250 mm (10 in) is considered standard. This length minimizes the effects of grip slippage on test results. When this length is not feasible, test sections as short as 100 mm (4 in) can be used if test results are not appreciably affected.

## Conclusions/action items:

I think that our current tensile testing protocol for the finger sleeves already cover most of the information covered in this standard. One thing that could be added to it is recording the elongation of the material before it breaks. Going forward, we should further cross reference this standard and maybe cite it within our tensile testing protocol.







## Download

100-332-870a\_PlasticsD882.pdf (326 kB)

# 11/13 Stress Calculations for Finger Sleeve

NATHAN HANSEN - Nov 13, 2025, 10:38 PM CST

Title: Stress Calculations for Finger Sleeve

Date: 11/13/2025

Content by: Nathan Hansen

Present: N/A

Goals: Compute stress calculations to determine if our finger sleeve material will be strong enough to comply with our PDS.

Content:

Stress = axial force / cross sectional area

Our material is 0.4 mm thick

We would like our rectangular finger sleeve straps to be 1.5 mm wide or thinner

Since the finger sleeve strap wraps around, the cross sectional area is double the thickness times the width

Based on previous research, we want our finger sleeves to hold an axial load of 60 N of force

Based on clinical standards, we want a safety factor of 4

At 15 mm wide:

Maximum stress = (60 N \* 4) / [(15 mm) (0.4 mm) (2)] = 20 MPa

At 10 mm wide:

Maximum stress = (60 N \* 4) / [ (10 mm) (0.4 mm) (2) ] = 30 MPa

### Conclusions/action items:

Based on the data that we receive on our MTS testing for our ballistic material, and any other potential materials, we can compare the value of maximum stress before failure to these calculation. If the material has a maximum stress of 30 MPa, we will have to test differences in comfortability and slippage to determine what width of material is best for the design. If the maximum stress is 20 MPa, then we will have to go with a 15 mm wide design because safety is a huge factor. If ballistic nylon can not withhold 20 MPa of stress, then we will have to look into new material or an even wider strap.

# 9/23 - Adjustable Velcro Finger Sleeve Design

NATHAN HANSEN - Sep 23, 2025, 9:24 PM CDT

Title: Adjustable Velcro Finger Sleeve Design

Date: 9/23/2025

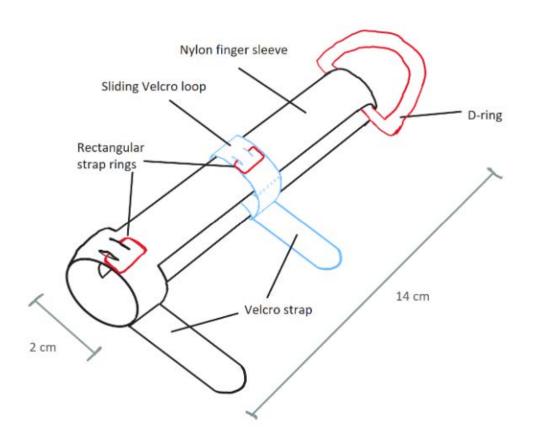
Content by: Nathan Hansen

Present: N/A

**Goals:** Develop a finger sleeve design that can attach to the traction device is adjustable to fit all sized fingers (both length and width).

## Content:

- This finger sleeve is a one size fits all
  - The sleeve is long enough to fit the large majority of fingers (14 cm long)
    - The 95th percentile for middle finger (longest finger) length is 108.17 mm
  - The base Velcro strap sits below the middle knuckle, and the sliding Velcro loop can be adjusted to sit under the top knuckle
    - The 95th percentile for thumb (widest finger) width is 18.83 mm
- The d-ring on the end of the sleeve allows for it to be attached to the mechanical component of the traction device
- One downfall of using Velcro is that it may lose function after prolonged use
- The sleeve is made out of nylon and the d-ring and rectangular strap rings could be made out of a sturdy plastic for MRI compatibility



## Conclusions/action items:

This finger sleeve design appears suitable for a wide range of users based on length and width dimensions, and its adjustability makes it versatile. However, the reliance on Velcro presents a potential durability issue, as it may lose effectiveness over time. Moving forward, it will be important to research more durable fastening alternatives to Velcro as well as identify strong, MRI-compatible plastics for the d-ring and strap components to ensure long-term reliability and user safety.



# 9/23 - Bed Clamp with Restraint Arm Traction Stand

NATHAN HANSEN - Sep 23, 2025, 9:48 PM CDT

Title: Bed Clamp with Restraint Arm Traction Stand

Date: 9/23/2025

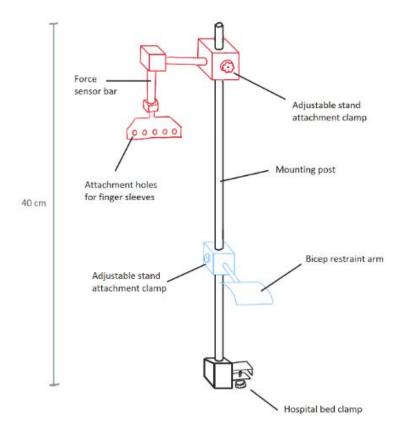
Content by: Nathan Hansen

Present: N/A

Goals: Develop a design for a stand that will attach to the hospital bed and hold the traction device.

#### Content:

- One main component of this design is that it mounts to the side of a hospital bed, which may be convenient for casting where the patient has to be in the device for 50 minutes
  - This locks the stand in place so that it does not move while the hand is being positioned and the cast is being placed
  - This may be an issue in the operating room for surgical use
  - Device will need to be cleaned between used, so take down and set up may take longer
- Another key component of this design is the bicep restraint arm, which instead of using a strap to hold the arm down, the restrain arm just prevent the arm from moving up while it is under tension
  - This could also be a safety concern: if the hand were to slip out of the finger sleeves, the arm may drop down and cause injury
- · This device is very sleek and does not take up much space
- All of the attachments on the stand are adjustable and can be moved up and down the mounting post to accommodate different sized arms
- The device is easy to operate with just one doctor



#### Conclusions/action items:

The design is sleek, adjustable, and easy to use, making it effective for casting. However, its hospital bed mounting may limit surgical use, and the bicep restraint raises safety concerns if the hand slips. Future work should address restraint safety and explore alternative mounting options.

NATHAN HANSEN - Oct 02, 2025, 8:35 PM CDT

**Title: Extension Brace** 

Date: 10/2/2025

Content by: Nathan Hansen

Present: N/A

Goals: Further develop and construct a drawing of our extension brace preliminary design for our professional presentation.

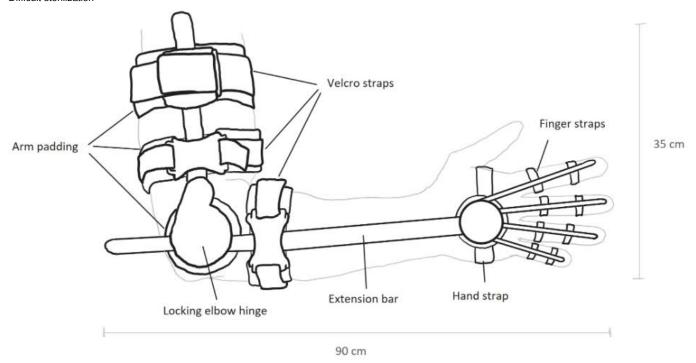
#### Content:

#### Advantages

- · Enhanced patient comfort
- · Reduced joint strain
- · Compact system

#### Disadvantages

- · Procedural adaptations required
- · Restricted accessibility
- · Difficult sterilization



### Conclusions/action items:

The extension brace shows promise in improving patient comfort, joint protection, and operating room efficiency. However, workflow adjustments, access limitations, and cleaning challenges remain considerations. For the preliminary presentation, we will finalize design drawings, highlight these advantages and limitations, and gather feedback on feasibility and potential refinements.

NATHAN HANSEN - Oct 02, 2025, 8:35 PM CDT

Title: Floor Stand

Date: 10/2/2025

Content by: Nathan Hansen

Present: N/A

Goals: Further develop and construct a drawing of our floor stand preliminary design for our professional presentation.

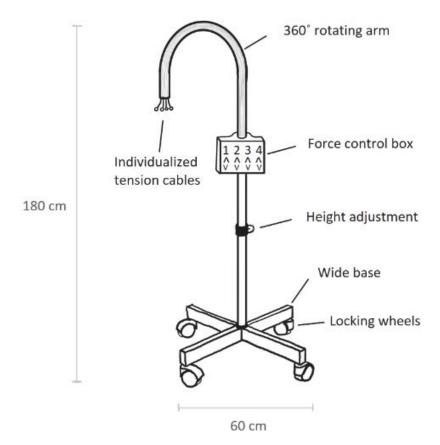
#### Content:

## Advantages

- · High mobility and adaptability
- · Individualized traction control
- · Potential digital integration

## Disadvantages

- · Higher cost of production
- · Large physical footprint
- · Stability concerns



## Conclusions/action items:

The floor stand design provides strong adaptability, individualized control, and opportunities for future digital integration. Key drawbacks include cost, footprint, and stability. For the preliminary presentation, we will complete detailed drawings, emphasize both strengths and

limitations, and identify areas where modifications could reduce bulk and improve stability.

NATHAN HANSEN - Oct 02, 2025, 8:37 PM CDT

Title: Braided Nylon Sleeve

Date: 10/2/2025

Content by: Nathan Hansen

Present: N/A

Goals: Further develop and construct a drawing of our braided nylon sleeve preliminary design for our professional presentation.

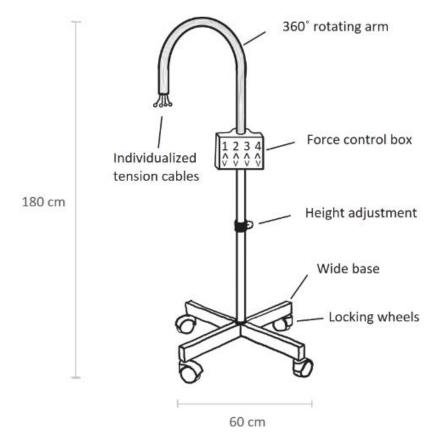
#### Content:

## Advantages

- Ease of application to finger
- · High client familiarity

## Disadvantages

- · Difficult to fabricate
- · Requires multiple sizes
- · High material cost



## Conclusions/action items:

The braided nylon sleeve offers simple application and strong patient familiarity but presents challenges in fabrication, sizing, and material cost. For the preliminary presentation, we will prepare draft drawings, highlight both usability benefits and production barriers, and evaluate whether design adjustments or alternative materials could improve feasibility.

NATHAN HANSEN - Oct 02, 2025, 8:39 PM CDT

Title: Hand Immobilizer

Date: 10/2/2025

Content by: Nathan Hansen

Present: N/A

Goals: Further develop and construct a drawing of our hand immobilizer preliminary design for our professional presentation.

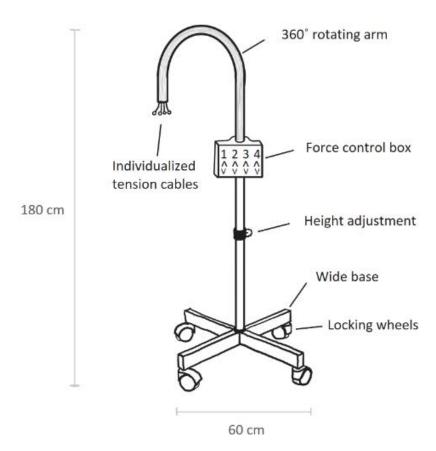
#### Content:

## Advantages

- · Complete hand immobilization
- · Sterilizability for reuse
- · Similar to current product

## Disadvantages

- · No direct finger attachment
- · Incompatible for certain surgeries



## Conclusions/action items:

The hand immobilizer provides full stabilization, reliable sterilization, and design familiarity, but lacks finger-specific support and may not suit all surgical contexts. For the preliminary presentation, we will finalize concept drawings, clearly outline benefits and limitations, and determine whether modifications could expand surgical compatibility.



# 10/9 - Hybridized Bed Clamp and Wheels Stand

NATHAN HANSEN - Oct 09, 2025, 10:51 PM CDT

Title: Hybridized Bed Clamp and Wheels Stand

**Date:** 10/9

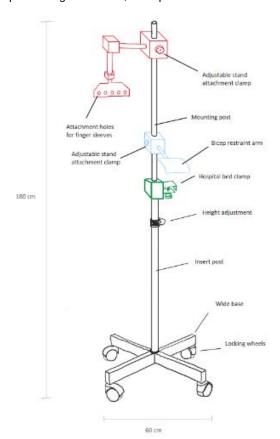
Content by: Nathan Hansen

Present: N/A

**Goals:** Construct a hybrid design between the bed clamp with restrain and the standing platform to gain the stability of the bed clamp and the versatility accompanied with a wheeled base.

#### Content:

The decision to go with a hybridized design was based on the close scoring on the mechanical design matrix. Particularly, this new design was made based on the bed clamp and restraints design's ease of use, cost, and reusability. The ease of use of this device comes from its ability to be easily clamped onto a typical patient's bed and the simplistic attachment method. Further the cost of this device sets it apart due to its simplistic design requiring very few intricate parts to manage the device. Similarly the simplicity of the design allows for the device to be more easily cleaned and designed out of parts more resistant to cleaning techniques, making it more reusable. This device struggled in terms of its versatility, but the standing platform excelled in this category due to its wheel base, allowing for increased transfer mobility and positioning. Therefore, a simple addition of a detachable wheel base was made to the bed clamp and restraint design.



### Conclusions/action items:

The hybrid design successfully integrates the stability and simplicity of the bed clamp system with the mobility and versatility of the standing platform, resulting in a device that is both cost-effective and adaptable to various clinical environments.



# 10/9 - Potential Use of Cable Ties for the Finger Sleeve

NATHAN HANSEN - Oct 09, 2025, 11:11 PM CDT

Title: Potential Use of Cable Ties for the Finger Sleeve

Date: 10/9/2025

Content by: Nathan Hansen

Present: N/A

Goals: Explore the potential for using Velcro cable ties as the straps for the strap and buckle finger sleeve design.

#### Content:

When constructing the fabrication protocol for the strap and buckle finger sleeve design, I had some difficulties figuring out how the buckle would be attached to the sleeve as well as how the Velcro strap could be sinched tight without the fibric underneath bunching up and creating potential contact sores on the finger. When looking at available Velcro strips online, I came across some strips that are designed for cable organization. The strips are double sided and have a built-in, pre-cut slot for the strip to feed through itself, allowing the strip to sinch around itself. Here is a link to one that I found on Amazon: https://www.amazon.com/VELCRO-Brand-Cable-Ties-100Pk/dp/B08BLCZDYL/ref=asc\_df\_B001E1Y5O6?tag=bingshoppinga-20&linkCode=df0&hvadid=79852084166486&hvnetw=o&hvqmt=e&hvbmt=be&hvdev=c&hvlocint=&hvlocphy=68066&hvtargid=pla-4583451663039951&th=1



Additionally, in order to attach these to the finger sleeve and allow for the sleeve to fit patients with skinnier fingers without the nylon fabric scrunching up, I think that the Velcro could be sewn at 2 points directly across from each other on the loop. This would create 2 wide slots for the nylon finger sleeve to slide through. For larger fingers, the nylon sleeve would sit in the middle of these slots created on the loop. For skinny fingers, the nylon sleeve would be pushed up against one of the stitches, and the excess loop and Velcro strip would wrap around, leaving no bunched up fabric to cause contact sores.

#### Conclusions/action items:

Velcro cable ties presents a promising solution for simplifying the strap and buckle finger sleeve design by eliminating the need for a separate buckle and reducing the risk of fabric bunching. The double-sided, self-looping feature of these ties allows for a secure, adjustable fit across various finger sizes. The next steps include prototyping the two-point sewn attachment to test comfort, adjustability, and durability under repeated use.



# 10/9 - Potential Use of Buddy Tape Finger Straps

NATHAN HANSEN - Oct 09, 2025, 11:22 PM CDT

Title: Potential Use of Buddy Tape Finger Straps

Date: 10/9/2025

Content by: Nathan Hansen

Present: N/A

Goals: Explore the possibility of implementing buddy tape finger straps for the strap and buckle finger sleeve design.

#### Content:

One major downside for the strap and buckle finger sleeve design was its potential for poor comfort. This was due to a minimalized contact surface with the finger while a fairly large tension force is being applied. The use of a simple nylon fabric could dig into the skin when a force is applied, especially with older more brittle skin. When brainstorming this complication, I remembered the time that I had broken my ring finger and, after surgery, the doctor had given me these buddy straps that had Velcroed around two fingers. The part of this design that I found novel was that the underside of the Velcro straps was a foam. This foam increased the amount of cushion and make the buddy tape very comfortable to wear all day long. After looking them up, I found out that they are also washable, which is an important feature for our reusable finger sleeves. Here is the specific pair that I had found on Amazon: https://www.amazon.com/Tygour-Washable-Reusable-Fingers-

Injured/dp/B0DSBQQ58C/ref=asc\_df\_B0DSBQQ58C?tag=bingshoppinga-

20& link Code = df0& hvadid = 80814302733256& hvnetw = o& hvqmt = e& hvbmt = be& hvdev = c& hvlocint = & hvlocphy = 68066& hvtargid = pla-4584413771949630& psc = 1& msclkid = e7e020072589196b5c8748e2ec2f601c



This product could potentially be modified to wrap around one finger and serve as the whole securing system for the buckle and strap finger sleeve design. We could also just take inspiration from this and incorporate a foam material under the nylon fabric loops already present in our current design.

### Conclusions/action items:

Integrating buddy tape—style finger straps into the strap and buckle finger sleeve design could significantly improve user comfort and skin protection by distributing pressure more evenly and providing a soft foam cushion beneath the strap. The washable and reusable nature of these straps also aligns

with the project's goals for durability and hygiene. The next steps include testing the foam-backed Velcro straps for comfort, fit, and long-term wearability under simulated loading conditions.

NATHAN HANSEN - Oct 16, 2025, 7:35 PM CDT

Title: Fabric Template #1

Date: 10/16/2025

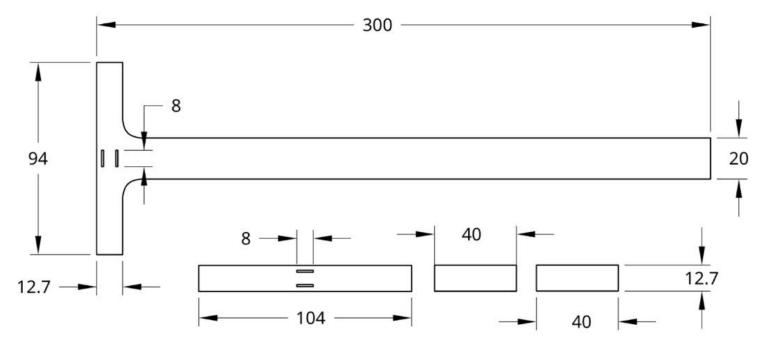
Content by: Nathan Hansen

Present: N/A

Goals: Design a template for the nylon finger sleeve to be cut out and fabricated.

#### Content:

Using a Cricut Maker 3, a template containing a long T-shape with two slits, a 104 x 12.7 mm rectangle with two slits, and two 40 x 12.7 mm rectangles, seen in figure 11, will be cut out of a nylon fabric sheet. The 104 x 12.7 mm nylon strip will be folded into a loop, overlapping the two ends by 1 cm and securing them together using fabric adhesive. The 40 x 12.7 mm strips will be attached parallel on the inside of the loop, one centered under the slits and the other centered under the overlapping ends of the loop, by placing 1 cm of fabric adhesive on each end of the strip. This creates two slots on the loop between the layers of nylon fabric. The long end of the T-shaped strip will be inserted into the slot with the two slits. The same end will then be pushed through a 20 cm D-Ring, before being inserted into the other slot on the loop. The T-shaped strip will then be folded over on itself so that the flap of the T can be butted up to each other and laid on top of the long end, making sure the outer edges are all aligned and that each flap overlaps 1 cm before securing with fabric adhesive. At this point, 12.7 mm rectangular rings can be clipped around the two fabric hooks created by the slits. Finally, 12.7 x 100 mm double sided Velcro strips can be wrapped around the two loops of the finger sleeve and secured with fabric adhesive, making sure to only glue half way around the loop starting from one end of a ring. If later testing shows that the fabric adhesive does not withstand forces to the finger sleeve stated in appendix 10.1, stitching can be added to the connections for reinforcement.



# Conclusions/action items:

In the near future I need to have a conversation with the staff at the UW Makerspace to figure out what materials can be used in the Cricut Maker. I have also put some thought into the potential of using the laser cutter. We are currently thinking about using ballistic nylon fabric, so we need to figure out if that material can be using in the Cricut or the laser cutter.

NATHAN HANSEN - Oct 16, 2025, 7:47 PM CDT

Title: Fabric Template #2

Date: 10/16/2025

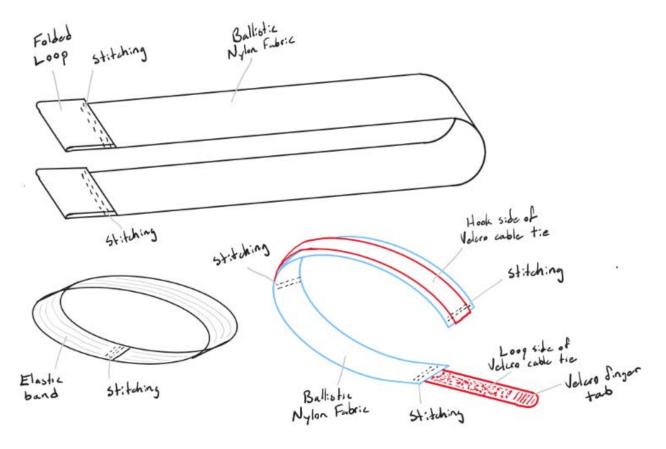
Content by: Nathan Hansen

Present: N/A

Goals: Design a finger sleeve that decreases the amount of time that it takes to apply.

### Content:

This design cuts the use of Velcro straps in half. This is important because you use your time efficiently at the hospital, and having to strap up half of the amount of Velcro. However, this design could increase the amount of slippage of the sleeve and decrease the comfort of the sleeve. Also, another key feature of this design is elastic band that replaces the Velcro loop at the base of the finger. This elastic band allows for the finger sleeve to easily slip onto the finger and hold on while the Velcro strap is being tightened.



### Conclusions/action items:

In the future, we need to start constructing prototypes of several different designs. This way, testing can be done on each prototype and compared to one another in order to decide the best construction for the project. Testing should include time to apply, durability, comfort, and slippage.

NATHAN HANSEN - Oct 30, 2025, 6:52 PM CDT

Title: Finger Sleeve D-Ring

Date: 10/30/2025

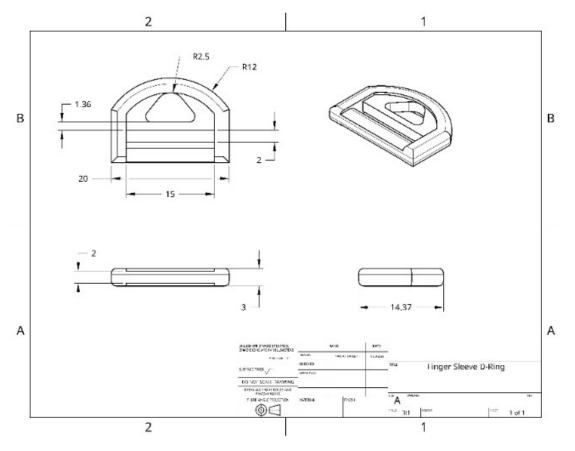
Content by: Nathan Hansen

Present: N/A

Goals: Design a D-ring with CAD to 3D-print with carbon fiber filled nylon.

### Content:

I used Onshape to design a D-ring to be printed in the Makerspace, this way we do not have to wait for a D-rings to be ordered. Additionally, by designing our own D-ring, it can fit the size of our finger sleeve perfectly. Below is a drawing of the CAD file:



# Conclusions/action items:

Going forward, I will need to download this CAD file as a .stl and print it at the UW Makerspace. We will be using carbon fiber filled nylon filament so that the D-ring can withstand the force during axial loading.

NATHAN HANSEN - Dec 06, 2025, 9:33 PM CST

Title: Stitched Loops Finger Sleeve

Date: 12/6/2025

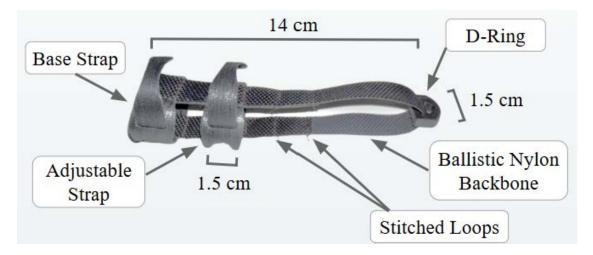
Content by: Nathan Hanse

Present: N/A

Goals: Create a new finger sleeve design that solves the problem of slippage between the middle strap and the nylon backbone.

#### Content:

The current design with a sliding middle strap has shown through testing that the middle strap grips the finger, but there is not enough friction between the strips of ballistic nylon to prevent sleeve displacement and increased stress points on the stitching. To solve this problem we could create a bunch of loops that go up the side of the nylon backbone, similar to the lop that the bottom strap currently is fed through. This design would slightly reduce the amount of variability in placement of the middle strap, but it would significantly reduce slippage and improve strength of the stitching. To make this design, a  $48 \text{ cm} \times 1.5 \text{ cm}$  strip of ballistic nylon would need to be laser cut. On both ends of the strip, 8 cm of material would be folded over on itself and a stich would be placed at the end and repeated every 1.6 cm.



### Conclusions/action items:

The proposed new design introduces stitched loops on the ballistic nylon backbone to prevent the slippage of the middle strap, which is expected to reduce strap displacement and localized stress points. The immediate action item is to test how easily this new design can be fabricated, as well as how well if fits differently sized fingers.

NATHAN HANSEN - Oct 30, 2025, 11:00 AM CDT

Title: CITI Training

Date: 10/30/2025

Content by: Nathan Hansen

Present: N/A

Goals: Learn how to test our design on users and survey individuals regarding usability.

Content:

\*Certificate and quiz scores are posted below

# Conclusions/action items:

Our team wants to conduct comfortability testing for our finger sleeve designs. This protocol would consist of surveying a wide variety of individuals after they try on the finger sleeve. This training will be useful for making sure that we are making all proper considerations when crafting the survey.

NATHAN HANSEN - Oct 30, 2025, 11:00 AM CDT



# **Download**

citiCompletionReport\_15032577\_73306100.pdf (78.6 kB)

NATHAN HANSEN - Oct 30, 2025, 11:00 AM CDT





# Download

citiCompletionCertificate\_15032577\_73306100.pdf (77.4 kB)

NATHAN HANSEN - Nov 05, 2025, 9:12 PM CST

Title: Biosafety 106: Autoclave

Date: 11/5/2025

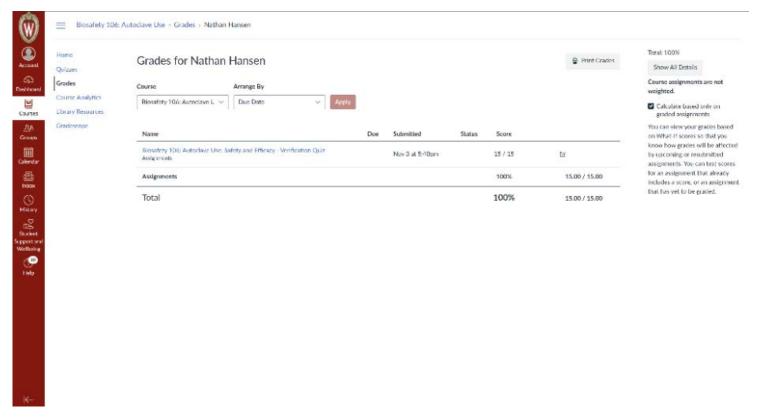
Content by: Nathan Hansen

Present: N/A

Goals: Complete training for ECB 2048, so that we can conduct autoclave testing on our finger sleeve.

Content:

Here is the grades I received on the required quizzes to complete the training:



# Conclusions/action items:

The training, along with the other two training requirements for autoclave and cryogen, will allow me to gain access to ECB 2048. Here I can run our material (dog bone shape strips) through cycles in the autoclave. This will allow our team to compare values from MTS testing on control and sterilized material, and determine if autoclaving affects durability over time.



# 11/5 - Cage Wash & Autoclave Safety

NATHAN HANSEN - Nov 05, 2025, 9:13 PM CST

Title: Cage Wash & Autoclave Safety

Date: 11/5/2025

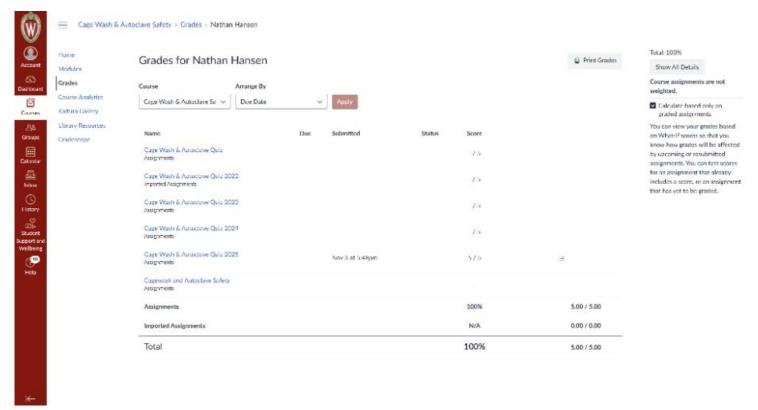
Content by: Nathan Hansen

Present: N/A

Goals: Complete training for ECB 2048, so that we can conduct autoclave testing on our finger sleeve.

Content:

Here is the grades I received on the required quizzes to complete the training:



### Conclusions/action items:

The training, along with the other two training requirements for autoclave and cryogen, will allow me to gain access to ECB 2048. Here I can run our material (dog bone shape strips) through cycles in the autoclave. This will allow our team to compare values from MTS testing on control and sterilized material, and determine if autoclaving affects durability over time.



# 11/5 - Chemical Safety: Cryogen Safety

NATHAN HANSEN - Nov 05, 2025, 9:14 PM CST

Title: Chemical Safety: Cryogen Safety

Date: 11/5/2025

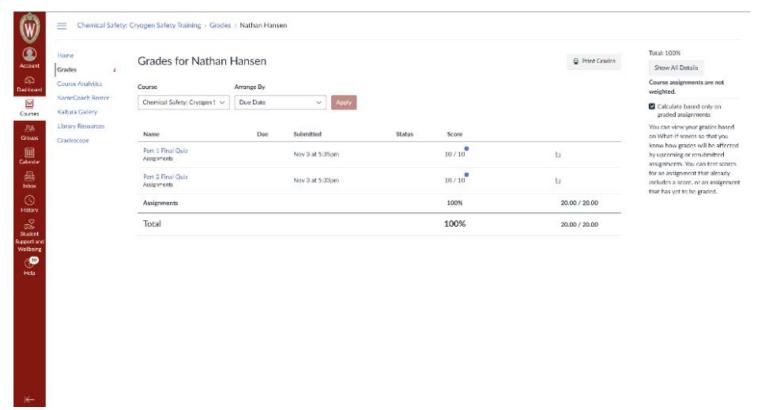
Content by: Nathan Hansen

Present: N/A

Goals: Complete training for ECB 2048, so that we can conduct autoclave testing on our finger sleeve.

Content:

Here is the grades I received on the required quizzes to complete the training:



# Conclusions/action items:

The training, along with the other two training requirements for autoclave and cryogen, will allow me to gain access to ECB 2048. Here I can run our material (dog bone shape strips) through cycles in the autoclave. This will allow our team to compare values from MTS testing on control and sterilized material, and determine if autoclaving affects durability over time.

NATHAN HANSEN - Sep 10, 2025, 2:05 PM CDT

Title: BME Career Prep

Date: 9/10/2025

Content by: Nathan Hansen

Present: N/A

Goals: Get ready for the career fair and job searching.

Content:

Speaker: Stephanie Salazar Kann, Director of Engineering Career Services

# Job Search Tips

- keep track of what you do (ECS tracking sheet available)
- connect before you are a candidate
- follow up in 2-3 weeks after you apply
- don't use aggregator sites rather use the companies website, Handshake, and LinkedIn

### Resume Tips

- tailor your resume to the position (integrate keywords)
- show a full picture of your experience (make it unique to you)
- Design projects without years or semesters (only put dates on jobs)
- only put degree date as May, December, or August
- use an objective statement for situations like a career fair, but not for a submission to a specific job
- skills should highlight technical skills not soft skills

# Cover Letter Tips

- always based on the job description and custom to each job
- demonstrate employer knowledge
- address to person

# Career Fair Advice

- identify your purpose beyond just an internship
- Biomechanics also overlaps with mechanical engineering explain why being a BME makes you a more diverse/well-rounded applicant

# Conclusions/action items:

This lecture taught me a lot of useful tips on how to search for and apply to job applications. Using some of these tips that I received during this lecture, I am going to go back to my resume, review it, and update it. After that I plan to attend the UW engineering career fair on Sept. 15-18.

NATHAN HANSEN - Sep 17, 2025, 2:05 PM CDT

**Title: Leadership Styles** 

Date: 9/17/2025

Content by: Nathan Hansen

Present: N/A

Goals: Explore my leadership style and learn how to implement them into a group.

### Content:

· Speaker: Angela Kita

• teaches InterEGR 303 - Leadership Competencies

# **Leadership**

- · Important qualities of leadership:
  - o communicative
  - inclusive
  - empathetic
  - confident
  - o decisive
  - o respectful
  - openminded
  - transparent
  - self-aware
  - having vision
- Leadership can come in levels: personal -> interpersonal -> team -> organizational

# **Styles**

- Power Model
  - · takes control of the situation
  - key words: hierarchy, authority, command
- Servant
  - being a service to followers
  - o sharing power
  - · listening and understanding
  - key words: empathetic, empowering, shared decision making
- Authentic
  - building self esteem and self-awareness
  - · emotional intelligence
  - · creating authentic relationships
  - key words: transparency, genuineness, honesty

### Define how you want to lead

- being a leader doesn't require a title
- · self-assess
- · observe and reflect
- · set out for feedback

# Goal setting

• Throughout the semester I would like to work on becoming a more vocal and confident leader.

- I can practice this skill during team meeting. I will try to speak out more during discussion, share my opinions, and prompt others to share theirs.
- · Success would look like having now withdrawn thoughts and making sure that my voice is heard.

# Conclusions/action items:

Going forward through the semester as project co-leader, I would like to implement some of the qualities that I have learned during lecture today. I think that the servant and authentic leadership style better fits my character. Some of the biggest qualities that I would like to work on is communication and confidence. Every couple of weeks I would like to recheck in on my goal and see if I am making an progress.

NATHAN HANSEN - Sep 24, 2025, 2:00 PM CDT

**Title: Near Peer Mentoring** 

Date: 9/24/2025

Content by: Nathan Hansen

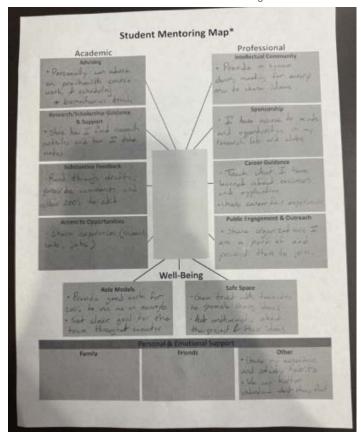
Present: N/A

Goals: Learn how to better mentor BME 200 students on my team.

### Content:

• Speaker: Dr. Tracy Puccinelli

- Why are we mentoring BME 200 students?
  - see one, do one, teach one
  - we just took the course so we know what they are going through
  - we are more approachable for the 200 students
  - we meet BME students in surrounding grades
  - share experiences
  - · build and share transferable skills:
    - leadership
    - communication
    - active listening
    - study practices
- · What does it mean to be a good mentor?
  - o communitive
    - be available
  - o approachable
    - open to help in non-BME related way
    - build trust
    - enthusiasm
  - reliable
  - o effective listener
    - get rid of distractions
    - act interested
    - make sure you get the main idea (ask questions if not)
- Make a list of topics, resources, advice, etc that you wished you knew in BME 200
  - o general schedule of deadlines
  - · how to properly use notebook throughout entirety of semester
- Mentor Map:



# Conclusions/action items:

Mentoring provides an opportunity to support BME 200 students by sharing experiences, building community, and developing transferable skills. By following the Mentoring Map throughout the semester, I will stay focused on being approachable, reliable, and effective in guiding my mentees.

NATHAN HANSEN - Oct 01, 2025, 2:02 PM CDT

Title: Sustainability in BME

Date: 10/1/2025

Content by: Nathan Hansen

Present: N/A

Goals: Learn how to make sustainable designs as a biomedical engineer.

Content:

Speaker: Andrea Hicks

- · Circular economy: how do we keep our resources in the economy (recycling)
  - glass battles take more energy to recycle than make
- · Coffee pods and coffee pot actually have about the same carbon footprint
- Sometimes environmental decisions align with economic decisions
  - These decisions can also be affected by supply restrictions
- · When something is reusable there are a lot of other costs (labor, power, PPE, etc.) involved with the cleaning/autoclaving process
- Can calculate a break even point to figure out if you should use single-use or reusable products
- · How do we use this knowledge to engineering our digital traction device?
  - A product that is has a longer life, but a higher initial price may be more economically efficient
  - It is possible that a single use finger sleeve is more efficient than a reusable product

### Conclusions/action items:

Sustainability is a very import component to consider when designing a product. Specifically for our project, I think that it is going to be very important to consider the affects of creating a single use product or a reusable product. Our client assumed that a reusable product would be more economically efficient for them, but it may be possible that a single use product is actually more economically efficient.

NATHAN HANSEN - Oct 08, 2025, 2:07 PM CDT

Title: WARF Lecture

Date: 10/8/2025

Content by: Nathan Hansen

Present: N/A

Goals: Learn how WARF could potentially support us with inventions made on campus.

#### Content:

- · There are four common types of intellectual property (IP)
  - patents
    - Three types of different U.S. patents
      - Design 15 year term (can not cover the functionality of the product, just its ornamental features)
      - Plant 20 year term
      - Utility the most common patent
        - Provisional effectively a 1 year placeholder
        - Non-provisional 20 year term
          - this often takes 2-5 year to issue after filing
          - on average, they cost \$30k (mostly attorney fees)
  - · copy rights
    - protection for creative works (music, movies, software, surveys)
  - trademarks
    - protection for names, marks, logo, dress, etc.
  - trade secrets
    - very broad, anything that has value
- · Other WARF IP
  - biomaterials
  - o technique and know how (very similar to trade secrets)
  - data (data sets, research results)
- · Requirements for patenting (big four)
  - Eligible: cannot be product of nature
  - · Novel: it must be new
  - Non-obvious: it cannot be simple modification of combination of existing concepts
  - Described: must provide enough detail to teach other how to make/use invention
- · WARF receives about an invention a day
- Marketing and Licensing
  - licensing reduces R&D cots, improves time to market, and creates an opportunity to enter new markets
  - $\circ \ \ \text{value is determined based on key selling points, technology trends, market size, competition, and industry standards}\\$
- Patents are for human concepts and authorship, so AI can not invent but it can likely assist (Pannu Factors)

### Conclusions/action items:

At the current stage of our project I do not foresee us reaching out for IP this semester. However, I believe that in future semesters, or if we have time to implement digitized individual finger traction I think that their could be a potential use for a patent for the design, or maybe even a broader technique IP for how to cost effectively produce these traction devices for global use.

NATHAN HANSEN - Oct 15, 2025, 2:10 PM CDT

**Title: Dickinson Wright** 

Date: 10/15/2025

Content by: Nathan Hansen

Present: N/A

Goals: Learn about how biomedical engineers can get involved with legal career paths.

#### Content:

- Speaker: Andrea L. Arndt (BME alumni) is really good at her job (has a corner office)
- IP protection allows research to safely transfer to products (investments, partnerships)
- · Legal Career Paths for Engineers:
  - No law degree or Patent Bar
    - Technical advisor performs prior art searches (patents, articles, company websites)
    - Tech Transfer Manager
    - Engineer work with IP lawyers to protect your invention
  - Patent Bar
    - Patent Agent you can now have conversations with the patent office (sign documents, interviews with patent clients) (optional law degree)
    - Patent Examiner
  - Law degree
    - Patent Attorney gets to council clients and choose their clients
    - Patent Litigator it's a little crazy and busy
    - IP License Attorney
- Patent examiners want the smallest fence (maintenance fees) and patent owners want the largest fence (most protection form competitors)
- How do engineers influence law and innovation?
  - engineers write efficiently (technical/logical writing is very important)
  - o biomedical engineers are creative
- IP Ownership
  - University: owned by the university, possible license
  - Company: employer owns invention if made at work or in the same field (know the scope of employee agreements)
  - · Startup: you own your own IP (document development and file early)
- Public Disclosure
  - · In the U.S. you have a 1 year grace period to file a patent
- · Steps to a start up:
  - invent something new, novel, and non-obvious
  - o conduct patentability search / FTO
  - · file patents early
  - use NDAs
  - File Trademarks / Obtain Domain Names
  - (more steps on presentation)
- · You don't need a working prototype before filing a patent application
- · Importance of IP:
  - Protects consumers from counterfeit products (quality)
  - You share your product with the world, they protect you from competitors
  - is a business tool, not just a legal document

### Conclusions/action items:

Biomedical engineers can easily transfer into the legal field by applying their technical expertise to intellectual property protection and technology transfer, helping innovations move safely from research to real-world applications. Understanding IP law, patent processes, and ownership rights empowers engineers to protect their inventions, collaborate effectively with legal professionals, and contribute to innovation through ethical and informed practices.

NATHAN HANSEN - Oct 15, 2025, 1:18 PM CDT



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NATHAN HANSEN - Oct 15, 2025, 1:18 PM CDT



**Download** 

IMG\_9198.jpeg (3.31 MB)

NATHAN HANSEN - Oct 22, 2025, 1:59 PM CDT

Title: Post Graduate Planning

Date: 10/22/2025

Content by: Nathan Hansen

Present: N/A

Goals: Think about my post graduate plan and how to get there.

### Content:

- · Use your undergraduate experience to build a story
- · Research is very important for all post-degrees
- Start to think about letter writers or references (3 strong ones)
- · Summer before the senior year start thinking about the MCAT
- · For med school you need to write your story
  - · do not give typical stories
  - o do not say that you will do anything, people want to hear what you want to do and how you can help
  - o don't regurgitate your resume (I did this, then this, ...)
  - · Start with what you want to do (thesis statement)
- · Graduate school options
  - Masters
    - Stepping stone
    - change directions (rewrite story)
    - gain depth, expand credentials (fill gap in resume for medical school of PhD program)
    - Industry focused (70% of masters students)
    - Generally one year
  - Doctoral, PhD
    - desire to be an independent researcher
    - write research grants
    - work in academia
    - lead project in industry, startups, and consulting
- BME masters programs 24 credits
  - Research (1.5-2 years)
    - For those continuing on for a PhD here
    - can be funded as RA/TA/PA (tuition remission and stipend)
    - Thesis required (Must have a lab PI identified & willing to support thesis before applying)
  - Accelerated Programs (1 year)
    - can be funded as TA (stipend only)
    - no co-op, but can internship
      - Accelerated
        - Coursework only
        - Independent study/research allowed
      - Biomedical Innovation, Design, and Entrepreneurship
        - Project based (project required)
        - Partnership with business school
  - · Applying online (pay fee and submit)
    - Statement of purpose: why you want to pursue further education in BME
    - Research MS only: list the PI who plans to support you
    - Special for UW BME BS students:
      - no letters of rec, just need to input email addresses
      - Research MS only: at least one from PI that has agreed to mentor you

- Deadline of 12/15 (apply senior year)
- Automatically admitted to master program with overall 3.0 GPA
- PhD
  - find out who is working in the area of your passion where (network)
  - o utilize your lab PI
  - Research is a must (Honors in Research)
  - Apply for NSF GRFP next year (fully funds PhD for 4 years)
  - o apply early and list names in program

### Medical School

- do I have my non-stem **com B**? (check with pre-health advising)
- shadow physicians
- research required (publications)
- patient contact time (CNA)
- · strong letters are really important
- some require microbiology

# Conclusions/action items:

I was aware of the accelerated masters program, but the research masters program is an interesting consideration, I just do not like that it is more than 1 year. Going forward I need to check with my advisor and pre-health advising to make sure all of my requirements are covered (com-B and microbiology).

NATHAN HANSEN - Oct 29, 2025, 2:09 PM CDT

Title: Regulation

Date: 10/20/2025

Content by: Nathan Hansen

Present: N/A

Goals: Learn when to regulate and when not to.

### Content:

- Speaker: Dr. Kip Ludwig, Department of Neurological Surgery
- FDA consists of 3 centers
  - o CBR
  - CDR

0

- FDA determines if a devices benefits out way the risks (not if it is safe)
- Materials are not approved by the FDA (titanium is approved for hip implants but not eye contacts)
- Higher class regulations take more testing (expenses) to achieve that approval
- Large disagreements on whether FDA should regulate more or less
- · History of medical devices
  - FDA started regulating medical devices 1976
  - Surgeons worked with engineers if they needed something
  - Patients trusted a surgeon who trusted an engineer
  - Iterations were made quickly to see what happens/works in humans (no animal testing which sometimes doesn't correlate)
  - FDA started regulating after the Dalkon Shield (contraceptive)
  - This that could help patients take years and a lot of money to test and get approved
- When you employ a device across millions of patients, very small side effects that may seem trivial can lead to deaths
- The FDA makes you go over every single possible failure mode and determine risk factors and how you can test that
- A lot of times there are supply chain and shipment issues that make a product inefficient

# Conclusions/action items:

There is a large disagreement amongst the public on whether the FDA should make more less regulations. While iterations can be made more quickly in human technology and companies can save tons of money, it seems necessary to have regulations to protect patients. As for our project, we should make sure to check what regulations and testing needs to be done on a surgical traction device.

NATHAN HANSEN - Nov 05, 2025, 2:11 PM CST

Title: Regulatory Strategy

Date: 11/5/2025

Content by: Nathan Hansen

Present: N/A

Goals: Learn about the framework the guides advanced therapeutic product development.

#### Content:

- · Three big relevant subunits in FDA
  - o Device (CDRH)
  - o Drug (CDER)
  - · Biologic (CBER)
- · Law structure:
  - · U.S. laws are made by congress
  - Regulations are made by FDA based on laws
  - FDA guidance is made by the FAD to help public interpret regulations
- In any given area, you will be following broad guidance at first, as area develops, FDA learns and provides more specific guidance
- Homologous use: taken from the patient, minimally manipulated, and put back in patient (do not require dramatic implications)(361
  products)
- · 361 products can be used in OR immediately, 351 products require years of testing
- If you produce a 351 product, the company gets 12 years of market exclusivity
- · Product development life cycle:
  - o important to be able to distinguish studies that are on the critical path vs. good research projects
  - use a target product profile (TPP) to determine product vision (basically a PDS)
    - Core information
    - Clinical development planning
    - CMC (chemistry, manufacturing, and control)
  - · Answer 4 general questions:
    - Will patients and prescribers want it?
    - Will regulators accept it?
    - Will payers reimburse for it?
    - Why should I fund development?
  - As your product moves along the critical path it gains value
- Quality management system:
  - system that documents policies, processes, internal rules, procedures, etc.
  - · every small detail needs to be tracked

### Conclusions/action items:

The best way to learn what you like and what you want to do is to go out into industry and try it out. When working for a company

NATHAN HANSEN - Nov 07, 2025, 12:34 PM CST

Title: Tong Lecture

Date: 11/7/2025

Content by: Nathan Hansen

Present: N/A

Goals: Hear from BME alumni about her journey as an engineer.

### Content:

- Speaker: Kristin Myers, BME class of 2002
- When she studies BME there was 30 students in her class
- Chapter 1: worked as an engineer at Medtronic for 5 years, got her MBA and then became an investor in healthcare startup (getting an education and experience)
- Chapter 2: took a role leading a large team at Aetna and then another large role at Unified Women's Healthcare (figuring out how to work through teams and make larger impact)
- Chapter 3: founded Hopscotch Health that focuses on primary care for rural communities and COO at Blue Shield
- "Run towards the hard problems... they are the ones that change the world"
- if you talk to a doctor that is 15 years out from residency about 50% of them would say they'd go back and do it again (a lot of your time is less and less about patient care and more about charting)
- US spends 2x more % of GDP compared to other countries, but we are last in equity (a lot of people skip healthcare visits due to too high cost)
- · Healthcare was never designed to be one system
- · What's required to build a better healthcare system:
  - seamless exchange of data across payers, providers, and patients
  - · care build around people not processes
  - · everyone needs to be rewarded for outcomes not activity
  - o integration of virtual and at home care
  - · automatic admin tasks
- · We should take on the hardest projects, classes, and experiences to show effort and build range

# Conclusions/action items:

There is a large gap between the money put into the healthcare system and the actual efficiency of the healthcare system. The future of healthcare is an integrated ecosystem of health and care. This is really an engineering problem and an area that we should try to build up with our BME education.

NATHAN HANSEN - Nov 12, 2025, 2:01 PM CST

Title: The Institutional Review Board

Date: 11/12/2025

Content by: Nathan Hansen

Present: N/A

Goals: Learn about the institutional review board and its role in conducting research.

#### Content:

- · The IRB reviews all research involving human subject
- · Research can not start until the IRB has given approval
- The common rule criteria (45 CFR 46) ways risks vs. benefits (not if the research is safe)
  - It also factors in equitable selection of subjects, informed consent, and privacy
- Quality improvement programs/PE projects do not meet the definition of human subjects research
- The FDA regulated research program can help tell you when you need IRB approval
- · De-identifying data:
  - o Directly: identifiers included with data
  - o Coded/Indirectly: identifiers removed form data but linked via study ID code
  - o Deidentified: all identifiers removed
- There are different categories for different levels of human subject research
- · Before you make any changes to the protocol, you much ask for approval before implementing change

# Conclusions/action items:

For our finger sleeve project, we plan on doing comfortability testing. This would fall under human subject surveying, so we should take into account leaving peoples data confidential.

NATHAN HANSEN - Nov 19, 2025, 2:06 PM CST

Title: New Product Development

Date: 11/19/2025

Content by: Nathan Hansen

Present: N/A

Goals: Learn how new product development works in the medical device industry.

#### Content:

- · There are many different roles on a NPD team
- Stage-Gate Process:
  - o 0) Ideation
  - 1) Exploration (bring down to 8-10 opportunities)
  - 2) Concept Development (boil down to 3-5 --> best opportunity)
    - go/no-go decision
  - o 3) Design Development (engineering development and testing)
  - 4) Design Confirmation (verification and validation)
    - design freeze
  - 5) Design Transfer and Commercialization (making sure product can be manufactured and transported)
    - launch
  - Post-Market Surveillance
- Case Study: Cardinal Health fluid management solutions for high volume cases (2007)
  - 0) found area of opportunity, customers want a machine that is easier to clean --> created a bunch of story boards and white board drawings
  - 1) reflected on and refined the real problem they were trying to solve --> maximize clinician safety and OR productivity (drew out 8 leading concepts)
  - 2) created prototypes for top 3 concepts and chose one leading concept
  - o 3) started cyclical development (prototypes --> test --> evaluate --> repeat) of how to actually make design work
  - 4) longest part of the stage-gate process --> finalized a frozen design to conducted proper testing
  - 5) built molds to manufacture the product and solved packaging/shipping problems
  - Post-Market Surveillance: Development took 3 years and by then Stryker reduced a lot of their issues and price of their consumable, so sales of the product were not great and they took the product off the market, installation price was too high

### Conclusions/action items:

The NPD in the medical device industry is highly regulated, expensive, resource intensive, and competitive. The most important thing is to develop and fine tune the question/problem that you are trying to solve. Taking time to do this will make the product development/engineering part quicker and easier.

Title: Anatomy of the Hand

Date: 09/11/2025

Content by: Nathan Klauck

Present: N/A

Goals: Learn more about the anatomy of the hand

Search Term: Anatomy of the hand

Link: https://search.library.wisc.edu/openurl?

 $\underline{sid=google\&auinit=CA\&aulast=Moran\&atitle=Anatomy+of+the+hand\&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.12.1007\&title=Physical+therapy+:+journal+of+the+And&id=doi:10.1093/ptj/69.1093/ptj/69.1093/ptj/69.1093/ptj/69.1093/ptj/69.1093/ptj/69.1093/ptj/69.1093/ptj/69.1093/ptj/69.1093/ptj/69.1093/ptj/69.1093/ptj/69.1093/ptj/69.1093/ptj/69.1093/ptj/69.1093/ptj/69.109$ 

9023

### Citation:

C. Moran, "Physical therapy: journal of the American Physical Therapy Association." 1989.

#### Content:

The hand's anatomy is complex, requiring intricate movements and controlled force production.

Injury to any structures can complicate hand function and therapeutic management.

The article emphasizes the importance of understanding hand anatomy for effective treatment of injuries.

### Joint Structures

Carpometacarpal (CMC) joints of fingers are classified as plane joints with one degree of freedom; the fifth CMC joint (the thumb) is a semisaddle joint.

Metacarpophalangeal (MCP) joints are ellipsoidal with two degrees of freedom, featuring asymmetrical condylar surfaces (bones adjacent to the wrist)

Proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints are bicondylar with one degree of freedom and exhibit obliquity in motion (further joir

# Ligaments and Joint Stability

The transverse intermetacarpal ligament (TIML) (base of fingers) is crucial for grasping activities and allows mobility between metacarpal heads.

 $Collateral\ ligaments\ provide\ stability\ to\ MCP\ joints,\ with\ radial\ ligaments\ being\ longer\ than\ ulnar\ ligaments,\ contributing\ to\ ulnar\ drift.$ 

The volar plate serves as a stabilizing structure at the MCP and PIP joints, preventing hyperextension.

### Muscle and Nerve Arrangement

Hand movements are facilitated by intrinsic and extrinsic muscles, innervated by the radial, median, and ulnar nerves.

The thenar and hypothenar muscle groups are primarily innervated by the median and ulnar nerves, respectively.

The median nerve enters the hand through the carpal tunnel, while the ulnar nerve passes through Guyon's canal.

### **Tendon Arrangement**

Flexor tendons pass through the carpal tunnel, with specific arrangements important for evaluating wrist lacerations.

Extensor tendons are organized into six compartments at the wrist, with compartment-specific tendons susceptible to conditions like de Quervain's syndro

# Skin and Sensory Innervation

The skin of the hand is highly innervated, providing tactile feedback essential for hand function.

The volar surface is innervated by the median and ulnar nerves, while the dorsal surface receives sensory input from all three major nerves.

# Conclusions/action items:

Look further into these anatomical components, ensuring our device allows for controlled motion along the degrees of freedom of the joints and for possib

NATHAN KLAUCK - Sep 12, 2025, 9:49 AM CDT



Anatomy\_of\_the\_Hand.pdf (5.91 MB)

NATHAN KLAUCK - Sep 12, 2025, 9:58 AM CDT

Title: Hand Stabilization Device

Date: 09/11/2025

Content by: Nathan Klauck

Present: N/A

Goals: Learn more about whats on the market, what has been done, and what adjacent applications might help with our own

Search Term: hand stabilization device for surgery

Link: https://expertnet.org/index.cfm?

 $\underline{fuse action = lo. details \& property ID = 12706\#; \sim: text = The \%20 hand \%2D stabilizing \%20 device \%20 consists, surface \%20 in \%20 the \%20 work \%20 area.}$ 

#### Citation:

"Support tool for hand stability in micro-surgery | florida expertnet." Accessed: Sep. 11, 2025. [Online]. Available: https://expertnet.org/index.cfm? fuseaction=lo.details&propertyID=12706#:~:text=The%20hand%2Dstabilizing%20device%20consists,surface%20in%20the%20work%20area.

### Content:

Website is a technology profile for a design of a support tool for hand stability in micro-surgery from the university of Florida

This design focuses on the stability of the surgeons arm

fatigue during long surgeries can lead to increased tremor, and tremor is more common in inexperienced surgeons

providing surfaces for surgeons to rest their hands on can decrease tremors by more than 2.5 times

device consists of a base component that extends from the wrist to the rest of the hand which has a two ringed finger grip.

### Conclusions/action items:

I mainly looked at this to see if there were any parallels we could draw between this device and our design idea, but the lack of information and pictures leaves this research largely unfruitful

NATHAN KLAUCK - Sep 12, 2025, 10:07 AM CDT

**Title: Hand Immobilizers** 

Date: 09/11/2025

Content by: Nathan Klauck

Present: N/A

Goals: Determine whats already on the market

Search Term: hand stabilization device for surgery

Link: <a href="https://expertnet.org/index.cfm?">https://expertnet.org/index.cfm?</a>

 $\underline{fuse action = lo. details \& property ID = 12706 \# : \text{-:} text = The \%20 hand \%2D stabilizing \%20 device \%20 consists, \underline{surface \%20 in \%20 the \%20 work \%20 area.}$ 

### Citation:

"Hand Immobilizers," Surgical Advantage. Accessed: Sep. 11, 2025. [Online]. Available: https://surgicaladvantage.net/product-category/hand-immobilizers/

### Content:

Appears to offer to different models, one called an Alumi-Hand and another a Dura-Hand

The costs are \$302-\$374 and \$206-\$215 respectively

# Alumi-Hand

Made of foam on the exterior

boasts a pliable aluminum interior for placement

prevents tilting of hand while in surgery

Allows use of X-ray and Fluoroscopy





### **Dura-Hand**

reusable

boasts a pliable aluminum structure for placement

allows for X-ray and Fluoroscopy

Anti-tilt design

Soft and smooth



# Conclusions/action items:

Based of prior research it seems comfort is a pretty large factor in a lot of designs, so similar considerations should be taken in our design. Additionally, being compatible with imagery techniques is a criteria that we should also consider.

NATHAN KLAUCK - Sep 17, 2025, 8:50 PM CDT

Title: ISO 13485:2016 Quality management system

Date: 09/17/2025

Content by: Nathan Klauck

Present: N/A

Goals: Understand Requirements for our device in Senegal

Search Term: -

Link: https://www.iso.org/standard/59752.html

# Citation:

ISO, ISO 13485:2016 – Medical devices – Quality management systems – Requirements for regulatory purposes. International Organization for Standardization, 2016.

# Content:

- -Internationally recognized standard
- -ensures safety and efficacy for the customer
- -ensures consistent process in design of the device
- -helps with mitigating risk while ensuring best practice for medical devices
- -ensures trust among stake holders
- ->safety and quality
- -additionally simplifies design process making it more efficient
- -allows for market access globally
- -builds credibility
- -more specifically requires documented procedures and necessity of organization
- -sets up preventative actions
- -control of non-conforming products

### Conclusions/action items:

Ensure QMS practices to align with ISO 13485:2016, specifically in relation to documentation and design control.

NATHAN KLAUCK - Sep 17, 2025, 8:59 PM CDT

Title: ISO 14971:2019 Application of risk management

Date: 09/17/2025

Content by: Nathan Klauck

Present: N/A

Goals: Understand Requirements for our device in Senegal

Search Term: -

Link: https://www.iso.org/standard/72704.html

# Citation:

ISO, *ISO* 14971:2019 – *Medical devices* – *Application of risk management to medical devices*. International Organization for Standardization, 2019.

# Content:

- -Designed to help process risk with medical devices, evaluate these, and mitigate them, and see how well these methods work
- -viable throughout the life of a product
- -covers all associated risks with medical devices, biocompatibility, data security, moving parts, electricity, usability

### Conclusions/action items:

Develop a risk management method that identifies hazards, defines control strategies, and integrates monitoring into device lifecycle processes.

NATHAN KLAUCK - Sep 17, 2025, 9:18 PM CDT

Title: ISO 10993-1:2018 - Biological evaluation of medical devices

Date: 09/17/2025

Content by: Nathan Klauck

Present: N/A

Goals: Understand Requirements for our device in Senegal

Search Term: -

Link: https://www.iso.org/standard/68936.html

# Citation:

ISO, ISO 10993-1:2018 – Biological evaluation of medical devices – Part 1: Evaluation and testing within a risk management process. International Organization for Standardization, 2018.

# Content:

- -discusses principles regarding risk assessment
- -discusses categorization of medical devices based on how they interact with the body
- -evaluation of existing data relevant to the device and gaps related to risk analysis
- -any additionally info that should be considered to for risk analysis
- -relevant to devices that directly interact with the pt body during use, or the users body if intended for protection
- -provides guidelines for assessment risks relevant to biological safety
- -consideration of device breaks that may expose the body
- -doesn't discuss pathogens

### Conclusions/action items:

Confirm biocompatibility testing strategy aligns with ISO 10993-1, ensuring material safety for intended patient contact scenarios.

NATHAN KLAUCK - Sep 17, 2025, 9:21 PM CDT

Title: ISO 15223-1:2021 - Symbols for medical device labeling

Date: 09/17/2025

Content by: Nathan Klauck

Present: N/A

Goals: Understand Requirements for our device in Senegal

Search Term: -

Link: https://www.iso.org/standard/86270.html

# Citation:

ISO, ISO 15223-1:2021 – Medical devices – Symbols to be used with information to be supplied by the manufacturer – Part 1: General requirements. International Organization for Standardization, 2021.

# Content:

- -discusses graphical symbols to be used on medical devices, packaging, and associated mediums
- -allows for universal recognition
- -improves safety
- -required form of labeling

## Conclusions/action items:

Ensure product labeling uses ISO 15223-1 standardized symbols for global consistency and regulatory compliance.

NATHAN KLAUCK - Oct 15, 2025, 4:56 PM CDT

Title: 21 CFR Part 820 - Quality System Regulation

Date: 09/17/2025

Content by: Nathan Klauck

Present: N/A

Goals: Understand Requirements for our device in Senegal

Search Term: -

Link: https://www.ecfr.gov/current/title-21/chapter-I/subchapter-H/part-820

#### Citation:

U.S. Food and Drug Administration, *21 CFR Part 820 – Quality System Regulation*. U.S. Government Publishing Office, 2023.

#### Content:

- -A General: Quality system required; exemptions; FDA inspection authority.
- -B Quality System: Management responsibility, audits, personnel training.
- -C Design Controls: For Class II/III + some Class I; design inputs/outputs, reviews, verification, validation, design history, change control.
- -D Document Controls: Approve, update, distribute documents; prevent use of obsolete versions.
- -E Purchasing: Evaluate/select suppliers; written specs; oversight of purchased products/services.
- -F Identification & Traceability: Identify product throughout; traceability required for critical devices.
- -G Production & Process Controls: SOPs, process validation, equipment maintenance, environment, software validation.
- -H Acceptance Activities: Incoming/in-process/final inspection & testing; define acceptance criteria.
- -I Nonconforming Product: Procedures for identification, segregation, evaluation, disposition, rework.
- -J CAPA: Investigate root causes, correct/prevent issues, verify effectiveness.
- -K Labeling & Packaging: Accuracy, control, prevent mix-ups, ensure packaging protects device.
- -L Handling/Storage/Distribution/Installation: Procedures to prevent damage, proper records, installation verification.
- -M Records: Maintain DMR, DHR, Quality System Record (QSR), complaint files; retention + availability for FDA.
- -N Servicing: Procedures + records; analyze service reports; treat some as complaints.

-O – Statistical Techniques: Use valid stats for sampling, process capability, product characteristics.

# Conclusions/action items:

Verify adherence with all the codes specified	
	NATHAN KLAUCK - Oct 15, 2025, 4:56 PM CDT

Upon reviewing my notes I accidentally double clicked, listed date is accurate

NATHAN KLAUCK - Sep 25, 2025, 4:37 PM CDT

**Title: Force Sensor Types** 

Date: 09/25/2025

Content by: Nathan Klauck

Present: N/A

Goals: Learn about types of force sensors

Search Term: types of force sensors

Link: https://www.dsm-messtechnik.de/en/force-sensors/

#### Citation:

"Different Types of Force Sensors and How They Work." Accessed: Sep. 25, 2025. [Online]. Available: <a href="https://www.dsm-messtechnik.de/en/force-sensors/">https://www.dsm-messtechnik.de/en/force-sensors/</a>

#### Content:

# Force Sensors/Transducers/ Load Cells

- -Measure force applied to an object
- -common in manufacturing, quality control, R&D, and safety monitoring
- -operate through the use of strain gauges that measure deformation under force and convert it to electrical signal
- -various options exist with different applications
- -accuracy class, or precision of measurement, can be found in the data-sheet defining potential maximum deviation in measurements
- -regular inspection and calibration of force sensors are necessary to ensure proper measurements
- -ideal measurement situations involve measuring the deformity in one direction without interference from lateral forces or bending moments

#### **Types**

- -Different measurement principles result in different types of force sensors:
- -> load cells
- ->ring force transducers
- ->Force measuring tabs
- ->load pins

- ->thread force sensor
- -often miniaturized to be easily added to machines
- ->tension bars, measuring rings, load cells, bending bars

Name	Measurement Principle	Suitability
Strain Gauge or Spring Body Force Sensors	Strain Gauge force sensors utilize a support plate equipped with thin metal foils. The applied force deforms the metal, leading to a measurable change in resistance.	Among the most common types of force sensors, they excel in high accuracy and good long-term stability.
Piezoelectric Force Sensors (Piezo)	Piezo force sensors incorporate crystals that generate electrical charges when subjected to force. The electric charge forms the basis for calculating the force.	Particularly suitable for measuring dynamic tension and compression forces.
Hydraulic Force Transducers	Measurement involves the compression of liquids in a chamber subjected to pressure. Evaluating the pressure increase allows for the calculation of force.	Capable of measuring various types of forces, such as lateral or compression forces. They are robust and highly reliable in difficult weather conditions or when temperature fluctuations occur.
Magnetoelastic Force Sensors	The measuring body consists of ferromagnetic material connected to a coil. The effect of force is detected through a change in induction.	Cover a wide measuring range and are suitable for mass production due to their cost-effectiveness.
Inductive Force Sensors	Inductive force sensors measure the change in distance that occurs when force is applied to two points.	Often used in laboratories due to high sensitivity.

# Multi-component force sensors

-used to measure forces along several different axes

# Conclusions/action items:

Look into the types of force sensors and determine which would be best used to measure the tension in our device.

# 9/25/2025: Piezoelectric Force Sensor

NATHAN KLAUCK - Sep 25, 2025, 4:49 PM CDT

**Title: Piezoelectric Force Sensor** 

Date: 09/25/2025

Content by: Nathan Klauck

Present: N/A

Goals: Learn about Piezoelectric Force Sensors

Search Term: Piezoelectric Force Sensor

Link: <a href="https://www.ato.com/piezoelectric-force-sensor?">https://www.ato.com/piezoelectric-force-sensor?</a>

srsltid=AfmBOorwuLB xDY4SzsSavsJVzyjTpP51XeOP58EszoWbD3MoyjxzvNq

#### Citation:

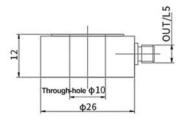
"Piezoelectric Force Sensor, 0 to 30000N," <u>ATO.com</u>. Accessed: Sep. 25, 2025. [Online]. Available: <a href="https://www.ato.com/piezoelectric-force-sensor?">https://www.ato.com/piezoelectric-force-sensor?</a> srsltid=AfmBOorwuLB xDY4SzsSavsJVzyjTpP51XeOP58EszoWbD3MoyjxzvNg

#### Content:

- -Measures forces 0-30,000N
- -\$691.19
- -used for precise measuring
- -common in industrial automation, robotics, and quality control
- -can be bought with a digital panel meter to obtain readings directly
- -customizable output between 0-5V, 0-10V, or 4-20mA

Model	ATO-SACL030LA
Charge Sensitivity (20±5°C)	≈4pC/N
Measuring Range	0~30000N
Overload Capacity	120%
Matched Transmitter	ATO-LCTR-OA (Click it to the transmitter page)
Matched Display Controller	ATO-DPM-DY800 (Click it to the controller page)
Linearity	≤1%F.S
Hysteresis	≤1%F.S
Repeatability	≤1%F.S
Capacitance	≥18pF
Insulation Resistance	>1013Ω
Resonant Frequency	≥40kHz
Operating Temperature Range	-54°C~120°C
Weight	18g
Housing Material	High-Strength Stainless Steel
Installation	Through Hole φ10
Sensitive Material	Quartz
Output Mode	Side L5 Socket
Connection Cable	2m Double-Ended L5 Low-Noise Cable

#### Dimension (Unit: mm)



- -measures force by utilizing the piezoelectric force
- ->certain materials generate an electric charge when mechanically stressed
- ->typically made from piezoelectric crystals like quartz
- -ideal for detecting small forces or short duration impacts, poor for static or slowly changing forces



# Conclusions/action items:

Look into a different type of force sensor as this seems to precise and too expensive for our applications

NATHAN KLAUCK - Sep 25, 2025, 5:06 PM CDT

**Title: Tension Force Sensor** 

Date: 09/25/2025

Content by: Nathan Klauck

Present: N/A

Goals: Learn about Tension Force Sensors

Search Term: Tension Force Sensor

Link: <a href="https://www.ato.com/tension-force-sensor-for-fiber-cable?srsltid=AfmBOop9BdazPx9md9L-6iE1x0vN1xLHUe4PuG">https://www.ato.com/tension-force-sensor-for-fiber-cable?srsltid=AfmBOop9BdazPx9md9L-6iE1x0vN1xLHUe4PuG</a> coTcLQpspgGDJv9aR

#### Citation:

"Tension Force Sensor for Fiber/Cable, 10N-500N," <u>ATO.com</u>. Accessed: Sep. 25, 2025. [Online]. Available: <a href="https://www.ato.com/tension-force-sensor-for-fiber-cable?srsltid=AfmBOop9BdazPx9md9L-6iE1x0vN1xLHUe4PuG\_coTcLQpspgGDJv9aR">https://www.ato.com/tension-force-sensor-for-fiber-cable?srsltid=AfmBOop9BdazPx9md9L-6iE1x0vN1xLHUe4PuG\_coTcLQpspgGDJv9aR</a>

#### Content:



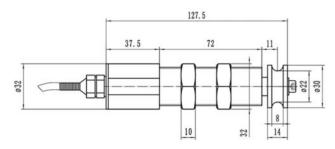
-can measure tension to a range of 10N, 20N, 30N, 50N, 100N, 200N, and 500N, with an output sensitivity of 1.0  $\pm$  0.05 mV/V

-\$192.47

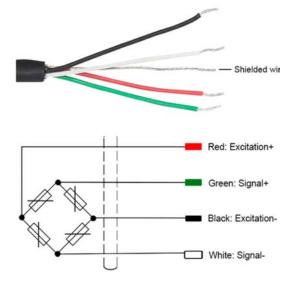
- -can purchase separate digital meter panel with sensor
- -cable pulling limit 98 N

Model	ATO-DYZHL
Measuring Range	10N-500N
Matched Transmitter	ATO-LCTR-OA (Click it to the transmitter page)
Matched Display Controller	ATO-DPM-DY800 (Click it to the controller page)
Output Sensitivity	1.0 ± 0.05 mV/V
Zero Output	±1%F.S.
Non-linearity	±0.2%F.S.
Full Scale	±0.2%F.S.
Hysteresis	±0.2%F.S.
Drift (30 min)	±0.3%F.S.
Temperature Sensitivity	0.1%F.S./10°C
Zero Temperature Drift	0.1%F.S./10°C
Response Frequency	1 kHz
Material	42CrMoA
Resistance	350 Ω
Insulation Resistance	≥5000 MΩ/100V DC
Operating Voltage	5-15 V
Working Temperature Range	-20°C to 80°C
Safety Load	≤150%R.C.
Max Load	≤300%R.C.
Cable Specifications	Ф5*3m
Cable Pulling Limit	98N
TEDS	Optional (Contact customer service)

# Dimension (unit: mm)



# Wiring Method



-response frequency of 1kHz

# Conclusions/action items:

Still very pricey for our applications, but presents a more feasible option than the piezoelectric sensor, might be worth considering some of the cheaper options mentioned on amazon

Title: Sparkfun Load Cell

Date: 09/25/2025

Content by: Nathan Klauck

Present: N/A

Goals: Find a cheap option to measure tension in our design

Search Term: Tension Load Cell

Link: <a href="https://www.digikey.com/en/products/detail/sparkfun-electronics/14727/9555601?">https://www.digikey.com/en/products/detail/sparkfun-electronics/14727/9555601?</a>
<a href="gclsrc=aw.ds&gad\_source=1&gad\_campaignid=20243136172&gbraid=0AAAAADrbLlgE4AGR5mx7d24tY5qwKR1we&gclid=Cj0KCQjw0NPGBhC">https://www.digikey.com/en/products/detail/sparkfun-electronics/14727/9555601?</a>
<a href="gclsrc=aw.ds&gad\_source=1&gad\_campaignid=20243136172&gbraid=0AAAAADrbLlgE4AGR5mx7d24tY5qwKR1we&gclid=Cj0KCQjw0NPGBhC">https://www.digikey.com/en/products/detail/sparkfun-electronics/14727/9555601?</a>
<a href="gclsrc=aw.ds&gad\_source=1&gad\_campaignid=20243136172&gbraid=0AAAAADrbLlgE4AGR5mx7d24tY5qwKR1we&gclid=Cj0KCQjw0NPGBhC">https://www.digikey.com/en/products/detail/sparkfun-electronics/14727/9555601?</a>

#### Citation:

SparkFun Electronics, "14727 Mini Load Cell 100 g Straight Bar," DigiKey, Online. Available: https://www.digikey.com/en/products/detail/sparkfun-electroni

#### Content:



-\$16.72

-only listed as MINI LOAD CELL 100G STRAIGHT BAR

-Load Cell Force Sensor 0.10kgf (0.220lbs)



#### Conclusions/action items:

Much more reasonable price range, however doesn't have enough force capabilities for our application. Might have to consider possibility of designing our

NATHAN KLAUCK - Oct 15, 2025, 5:12 PM CDT

Title: Static load test

Date: 10/15/2025

Content by: Nathan Klauck

Present: N/A

Goals: Assess the capabilities of the mechanical portion of our design

Link: https://www.osha.gov/laws-regs/standardinterpretations/2002-08-15-0

#### Citation:

Occupational Safety and Health Administration, "Rigging equipment for material handling; custom-designed accessories must be proof-tested to 125 % of rated load," 29 CFR 1926.251(a)(4), Aug. 15, 2002. [Online]. Available: <a href="https://www.osha.gov/laws-regs/standardinterpretations/2002-08-15-0">https://www.osha.gov/laws-regs/standardinterpretations/2002-08-15-0</a>

#### Content:

- §1926.251(a)(4) states rigging equipment should be designed to hold 125% of their rated load
- -> tests must be conducted to demonstrate this has been achieved
- -additional tests are not required prior to each use unless the lifting accessory undergoes change that affects the safe working load
- -> this would mean the changed design is considered a completely different design
- -only applies to a unique design, if the design is mass produced it does not require additional testing

#### Conclusions/action items:

Ensure the mechanical portion of our stand can support loads 125% the weight of what we intend to be the most heavy patient arm to be used with the device.

NATHAN KLAUCK - Oct 15, 2025, 6:41 PM CDT

Title: Ultimate load test

Date: 10/15/2025

Content by: Nathan Klauck

Present: N/A

Goals: Assess the capabilities of the mechanical portion of our design

Link: https://www.healthcaretec.com/specs

#### Citation:

Healthcare Technology Specifications, "Medical equipment mounting and support standards," HealthcareTec, 2024. [Online]. Available: <a href="https://www.healthcaretec.com/specs">https://www.healthcaretec.com/specs</a>

#### Content:

- -this paper regards surgical lights, exam lights, equipment booms, monitor equipment, and injector equipment
- -medical equipment should be assembled before they are brought to use site
- -reference ASTM:
- 1. ASTM A36 Carbon Structural Steel
- 2. ASTM A6 General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
- 3. ASTM A500 Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
- 4. ASTM A501 Hot-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
- 5. ASTM A563 Carbon and Alloy Steel Nuts
- 6. ASTM A572 High-Strength Low-Alloy Columbium-Vanadium Structural Steel
- -medical equipment support should be designed to have a maximum allowable deflection of 0.2 degrees or less
- -support systems should be designed with a minimum safety factor of 4 based on ultimate strength under full static loading conditions

#### Conclusions/action items:

Ideally ensure design can withhold weights so as to have a factor of safety of 4, and a maximum deflection of 0.2 degrees

NATHAN KLAUCK - Oct 15, 2025, 6:49 PM CDT

Title: EMG test

**Date:** 10/15/2025

Content by: Nathan Klauck

Present: N/A

Goals: Assess the capabilities of the sleeve portion of our design

Link: https://pubmed.ncbi.nlm.nih.gov/6869487/

#### Citation:

K. R. Giele and N. J. Beasley, "Assessment of digital vascularity in the hand and its clinical applications," J. Hand Surg. Br., vol. 12, no. 1, pp. 75–80, 1987. [Online]. Available: <a href="https://pubmed.ncbi.nlm.nih.gov/6869487/">https://pubmed.ncbi.nlm.nih.gov/6869487/</a>

#### Content:

- -discusses devices claimed to reduce spasticity, and if so, which are most effective.
- -The authors aimed to compare the immediate effects of various positioning devices in both normal and hemiplegic (spastic) hands using EMG measurement.
- used EMG of forearm flexor muscles (flexor carpi radialis) to analyze forearm in different positions
- -More activation observed in the use of finger spreaders
- -didnt result in a difference in spastic patients (same EMG activation regardless)
- -static positioning devices may not be the best for managing spasticity

#### Conclusions/action items:

Consider if similar methods of muscle activation using EMG is relevant

NATHAN KLAUCK - Oct 15, 2025, 6:58 PM CDT

**Title: Perfusion test** 

Date: 10/15/2025

Content by: Nathan Klauck

Present: N/A

Goals: Assess muscular effects of our design

Link: https://pmc.ncbi.nlm.nih.gov/articles/PMC11902658/

#### Citation:

R. L. Lieber and G. J. Fridén, "Functional electromyography of forearm muscles during orthosis-assisted positioning," J. Hand Surg. Am., vol. 8, no. 2, pp. 135–143, 1983. [Online]. Available: <a href="https://pmc.ncbi.nlm.nih.gov/articles/PMC11902658/">https://pmc.ncbi.nlm.nih.gov/articles/PMC11902658/</a>

# Content:

- -discussing method to assess actual wear time
- -attached pressure sensors to the finger
- -Participants performed various grip tests throughout the day with this on and recorded data
- -Sensors set up to read forces
- -can give insight into quality of wear time
- -can inform better design for finger attachment

#### Conclusions/action items:

Consider a similar method of measuring finger force pressures, possible measure perfusion as well through an spo2 monitor or via assessment of cap refill time



# 10/15/2025: Patient Bed Height During Operation

NATHAN KLAUCK - Oct 15, 2025, 7:16 PM CDT

**Title: Patient Bed Height During Operation** 

Date: 10/15/2025

Content by: Nathan Klauck

Present: N/A

Goals: Determine height of patient bed for our device

Link: https://pmc.ncbi.nlm.nih.gov/articles/PMC3655202/

Citation: H.-M. Tzeng, A. Prakash, M. Brehob, D. A. Devecsery, A. Anderson, and C.-Y. Yin, "Keeping patient beds in a low position: An exploratory descriptive study to continuously monitor the height of patient beds in an adult acute surgical inpatient care setting," Contemp Nurse, vol. 41, no. 2, pp. 184–189, Jun. 2012, doi: 10.5172/conu.2012.41.2.184.

#### Content:

- -Appropriate height for a hospital bed is between 19.5 and 21.5 inches
- -bed height ranges go from 17 to 35 inches

#### Conclusions/action items:

Use these value for your calculations

NATHAN KLAUCK - Oct 15, 2025, 7:19 PM CDT

**Title: Arm Length** 

Date: 10/15/2025

Content by: Nathan Klauck

Present: N/A

Goals: Determine length of the average forearm + hand

Link: <a href="https://ourworldindata.org/human-height">https://ourworldindata.org/human-height</a>

Citation:

#### Content:

70 % of men are between 170 and 186 cm tall

70% of women between 157 and 172 cm

# Conclusions/action items:

Use these values with anthropometry data to determine typical arm length

NATHAN KLAUCK - Oct 15, 2025, 7:20 PM CDT

**Title: Arm Weight** 

Date: 10/15/2025

Content by: Nathan Klauck

Present: N/A

Goals: Determine weight of the average forearm + hand

Link:

Citation:

#### Content:

Men weight 200 lbs

Women weight 172 lbs

# Conclusions/action items:

Use these values with anthropometry data to determine weight of forearm

NATHAN KLAUCK - Oct 27, 2025, 4:18 PM CDT

Title: PETG

Date: 10/27/2025

Content by: Nathan Klauck

Present: N/A

Goals: Determine benefits of utilizing PETG for printing parts

Link: https://www.acmeplastics.com/what-is-petg?

srsltid=AfmBOoo6HRgwPYyOK8flKLVCjPs2HE00xVOTmFJRjZo4y3SU0aui-tSQ

#### Citation:

"What is PETG Plastic? Information on PETG | Acme Plastics." Accessed: Oct. 27, 2025. [Online]. Available: <a href="https://www.acmeplastics.com/what-is-petg?">https://www.acmeplastics.com/what-is-petg?</a> srsltid=AfmBOoo6HRgwPYyOK8flKLVCjPs2HE00xVOTmFJRjZo4y3SU0aui-tSQ

#### Content:

#### **Traits**

- -Polyethylene terephthalate glycol (PETG)
- ->thermoplastic polyester
- ->chemical resistant
- ->durable
- ->good formability

has a low forming temperature so can be easily vacuumed, pressure formed, and heat-bent

-strong & cost effective compared to acrylic/polycarbonate options

#### **Additional perks**

- -Ideal for impact resistance and high strength
- -recyclable
- -food safe/FDA approved
- -commonly used in medical field as its able to survive harsh sterilization processes

# **Printing**

- -good layer adhesion
- -odorless
- -low shrinkage allows larger prints than PLA/ABS
- -Less brittle, more shock resistant, and more heat resistant than PET

# Conclusions/action items:

PETG's cost, low foot print, and easy forming make it an easy and friendly material to work with. Its chemical resistance and strength make it ideal for our applications regarding loading and cleaning with basic cleaning substances. One flaw with this material, however, is its low temperature resistance, making it not viable for autoclaving

Look into other plastics to find viable competitors, but worst case scenario this plastic will work wonderfully

NATHAN KLAUCK - Oct 27, 2025, 4:25 PM CDT

Title: ABS

Date: 10/27/2025

Content by: Nathan Klauck

Present: N/A

Goals: Determine benefits of utilizing ABS for printing parts

Link: https://www.acmeplastics.com/abs/abs-sheet?list=Search%20Listing

#### Citation:

"ABS SHEET," ACME Plastics, Inc. Accessed: Oct. 27, 2025. [Online]. Available: <a href="https://www.acmeplastics.com/abs/abs-sheet">https://www.acmeplastics.com/abs/abs-sheet</a>

#### Content:

# **Traits**

- -acrylonitrile butadiene styrene (ABS)
- ->thermoplastic
- ->easy to machine
- ->highly heat resistant (~221°F)
- ->chemical resistant

# **Additional perks**

- ->strong
- ->high scratch resistance
- ->commonly plated with metals like aluminum and magnesium
- ->used in prosthetics

### **Printing**

->low heat shrinkage

# Conclusions/action items:

Seems like a good alternative to PETG, likely more heat resistance, however not enough to make it viable for autoclave. Both PETG and ABS are used for medical applications, but PETG seems to be more widely used in the field where only the use of prosthetics is brought up with ABS.

Based of this I believe PETG is likely still the best option for our device, but ABS will work if we need it to.

NATHAN KLAUCK - Oct 27, 2025, 4:44 PM CDT

Title: PEEK

Date: 10/27/2025

Content by: Nathan Klauck

Present: N/A

Goals: Determine benefits of utilizing PEEK for printing parts

Link: <a href="https://www.acmeplastics.com/content/understanding-peek-material/?systlid=AfmBOoo4FzmFmb206VfkSMk8oH9Y1JlvXwqPkZo-C63aT\_WsGlnO1R-H">https://www.acmeplastics.com/content/understanding-peek-material/?systlid=AfmBOoo4FzmFmb206VfkSMk8oH9Y1JlvXwqPkZo-C63aT\_WsGlnO1R-H</a>

#### Citation:

A. Marla\_Acme, "Understanding PEEK Material," Acme Plastics. Accessed: Oct. 27, 2025. [Online]. Available: <a href="https://www.acmeplastics.com/content/understanding-peek-material/">https://www.acmeplastics.com/content/understanding-peek-material/</a>

#### Content:

### **Traits**

- -Polyetheretherketone (PEEK)
- -semicrystalline thermoplastic polymer
- -high thermal resistivity (250°C)
- -light weight
- -stiff
- -high mechanical strength
- -corrosion resistive
- -good resistance to X, Beta and gamma rays
- -high use in medical applications (and numerous other fields)
- -FDA food approved
- -used in implants
- -used for "autoclave components, biomedical implants, such as orthopedic devices, dental implants, and healing caps"

# **Printing**

-injection molding, extrusion, compression molding

->three different variants:

PEEK Natural: toughest

PEEK Glass Filled: reduced expansion rate, increased bending modulus

PEEK Carbon Filled: Increased rigidity and creep strength

# What are the Benefits of Glass Filled or Carbon Filled PEEK material?

- · Excellent mechanical and chemical resistance
- · Highly resistant to thermal degradation
- · Excellent strength, stiffness, and dimensional stability
- · Easy to process
- · Lightweight compared to steel, aluminum, and titanium
- · Low coefficient of friction
- · High wear resistance without lubrication

#### What are the Benefits of PEEK Natural material?

- 480° F relative thermal index temperature
- · Excellent flexural and tensile properties
- · Low moisture absorption
- · Good abrasive resistance
- · Excellent strength, rigidity and toughness, even at elevated temperatures
- · Superior electrical properties
- · Exceptional dimensional stability
- Easily machined and fabricated
- · Bearing and wear grade offers lower coefficient of friction and improved wear resistance
- · Extreme chemical resistance, good mechanical properties
- · Low toxicity when exposed to flames

Highly limited by cost

#### Conclusions/action items:

PEEK would be the ideal plastic to use for our application, but due to its cost and requirements of specialized 3D printers or other printing techniques it is most likely not viable. Its one advantage over the other plastics is its ability to be autoclaved, but assuming purely chemical sanitation methods are used (which may be more viable for a component of a stand, for which we are considering this plastic for) the other plastics are more practical. Additionally I doubt the maker space has this plastic or the ability to print it, making it further more challenging to pursue this option

NATHAN KLAUCK - Sep 24, 2025, 7:44 PM CDT

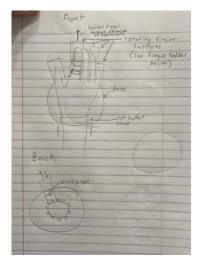
**Title: Mechanical Extension Device** 

Date: 9/24/2025

Content by: Nathan Klauck

#### Content:

This design consists of a base plate to rest the hand on and then five attached platforms for the fingers utilizing some from of strapping device as mention in my Sleeve Strap Design. These finger platforms would rotate about the main body of the platform for further control over hand position. Tension can be applied to the fingers in the device by utilizing some form of extending aspect of the finger platforms to pull on the hand from the straps. To be considered is a different location for the strap given tension need be applied elsewhere in the arm. Devices to measure the compressive force applied in the finger platforms can be used to calculate the tension applied to the hand in the device.



#### Conclusion/Action Items:

Look into devices that can be used to measure compressive force in this form of design as well as a mechanism for the rotating finger designs. Compare design with team and consider the possibility of moving on with a more unique design like this one

NATHAN KLAUCK - Sep 24, 2025, 7:46 PM CDT

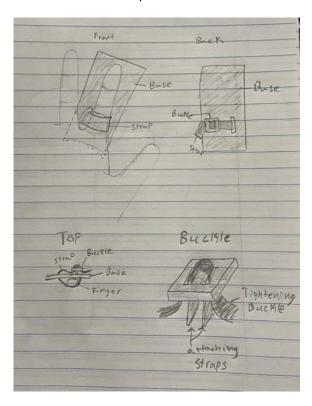
Title: Sleeve Strap Design

Date: 9/24/2025

Content by: Nathan Klauck

#### Content:

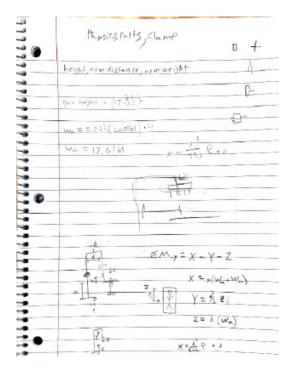
This device consists of a simple finger platform attached to the finger via a basic strap and buckle. The buckle would be on the back side of the device and the strap would wrap around the finger and travel through a slit in the platform to reach the back of the platform and the buckle.



# **Conclusion/Action Items:**

Compare design with team and consider plausibility of design.

NATHAN KLAUCK - Oct 15, 2025, 8:19 PM CDT



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Adobe\_Scan\_Oct\_15\_2025.pdf (702 kB)

NATHAN KLAUCK - Sep 10, 2025, 2:07 PM CDT

Title: Career Fair Prep

Date: 9/9/2025

Content by: Nathan Klauck

Goals: Learn how to prepare for career fair and to search for jobs

#### Content:

- Make sure to keep track of materials: who we've applied to (they have a job tracker on website)
- Quality of source matters, Handshake, LinkedIn, Company Page -> use these to reach out to company
- Process
  - o meet someone in person at career fair
    - follow up through website and reference them
- Otherwise make a contact outside of fair and go from there, including career services
- Internship is about getting experience A to apply to internship B in future
- · Things to prepare
  - o Resume- a summary, an abstract
    - show a balance- full picture
    - Flawless product ATS proofed resume is do-able
      - MS word
      - no columns, charts, colors
      - design projects, without years/semesters
      - Technical Skills and coursework
      - Jobs organization + Location, position title + date
    - ECS help still available before fair!
    - resume always under construction
    - esc.wisc.edu/students/career-fairs/
- Do not need cover letter for fair, but is important
  - o provides way to package information in a different format
  - o custom to job
  - o focus on two-three points you want to get across and support those
  - o 1-page, short and concise
    - intro
    - paragraph about point a
    - paragraph b
    - why this employer, closing, next steps

- · identify phirographicaliani
- · research employer
- develop value added statement
- argue why your focus is more relevant to the position and more rounded than typical four pillar engineers
- handshake not set up to look for specific role positions, look into adjacent fields
- abbvie
- · info on this career fair
- wisc.joinhandshake.com/career\_fairs
- plan
  - o introduce,
  - show knowledge of company (research)
  - o ask relevant question about research

### Conclusion/Action Items:

NATHAN KLAUCK - Sep 17, 2025, 2:01 PM CDT

Title: Qualities of a Leader

Date: 9/17/2025

Content by: Nathan Klauck

Goals: Learn how to be a good leader

#### Content:

- Qualities of a leader- Communication, Confidence, Inclusivity, Understanding, Organized, etc.
- Self Aware (Strengths, Weaknesses)
- Vision
- Transparency
- Communication
- · Decision Making
- Empathy
- · organizational, team, interpersonal and personal skills necessary
- · Leadership model of power
- someone has to take control, certain people born for it
- Servant leadership
- · being of service to others, sharing power
- · listening and understanding
- Authentic Leadership
- · being yourself
- · emotional intelligence
- · creating authentic relationships

What would it be like to work with someone that uses one of these styles?->

each enact a different dynamic, and I feel it would be fine to work with any of them, but I feel the servant model lacks control necessary in certain circumstances, and power lacks relatability. I also feel there are times for authentic leadership and times for a less open version, so I feel a fair mix of each is what would be ideal, otherwise its highly circumstantial

people oriented, process orientated, thought orientated, impact oriented

Goal:

serve as a good role model for the 200s as a BSAC member and inspire them to preform better.

# Personal goal:

Learn to be a better decision maker. This means less reaching out for input on certain aspect of our project and more having the confidence that I've done them well (with in reason)

# **Interpersonal Goal**

Love to organize the team into different functioning parts to focus on different aspects of the project-> this would look like splitting the group into subdivided groups where one maybe focuses on mechanics and the others on software

#### Conclusion/Action Items:

Be more aware of team leader characteristics, and try to demonstrate them in your role as a leader to the 200's in BME

NATHAN KLAUCK - Sep 24, 2025, 1:59 PM CDT

Title: How to be a better mentor

Date: 9/24/2025

Content by: Nathan Klauck

Goals:

# Content:

# Why do we mentor 200's

- -see one, do one, teach one
- -300's can answer the questions they had as 200s
- -teams made up of a variety of different skill levels
- -we are more approachable than the faculty
- -additionally instructional and emotional support
- -share our experiences
- -increases belonging
- -mutual benefits (transferrable skills)
- ->leadership
- ->communication
- ->active listening
- ->study practices
- ->self awareness
- ->interpersonal skills

Additionally factors: increased self esteem, patience, positive habits, personal growth

# What does it mean to be a good mentor?

- -building trust
- -Safe environment
- -Reliability

- -Enthusiasm
- -Be available
- -Transparent

# Listen effectively

Get rid of distractions

look at other person

ask questions

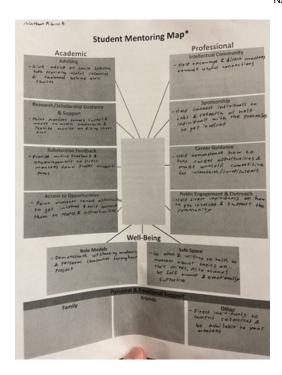
# What do you wish you knew in BME 200

- -The timeline associated with our assignments
- -how to use the notebook

# Conclusion/Action Items:

Make an effort to be a better mentee to my 200's

NATHAN KLAUCK - Sep 24, 2025, 1:58 PM CDT



**Download** 

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NATHAN KLAUCK - Oct 01, 2025, 1:57 PM CDT

Title: Sustainability in BME

**Date:** 10/01/2025

Content by: Nathan Klauck

Goals: Define and explore sustainability in BME

# Content:

- -Three paradigms in sustainability, social environmental and economic
- -idea of keeping circular structure for our resources, keeping them in the community
- -its economically favorable to recycle aluminum as it is cheaper to recycle than refine it; not the same for glass
- -Life cycle assessment-> assesses carbon footprint of different aspects of your products life
- ->answers questions without biases
- -example: paper on the table at the doctors, getting rid of it doesn't change anything but is economically favorable
- -other factors to consider in disposable vs reusable options

How do we apply this?

- -Identify where there are environmental differences between designs if they exist
- -counteract biases
- -these life cycle assessments make assumptions and set bounds for their analysis
- ->for example e-bikes, they cause someone to eat more calories but thats hard to account for

### **Conclusion/Action Items:**

Look further into sustainability for our design project and share learnings with 200s

look into sustainable materials and reusable/disposable options

NATHAN KLAUCK - Oct 08, 2025, 2:01 PM CDT

Title: WARF

Date: 10/08/2025

Content by: Nathan Klauck

Goals: Learn about patenting

Content:

Technology transfer: getting research results from campus to the market

WARF donates to campus

Four types of intellectual property (IP)

-patents (inventions)

heavily time sensitive, have to keep secret before patenting

-copyrights

protections for creative expressions (movie, music, software, surveys)

can be registered at any time

-trademarks

protection for names, marks, logos

requires use in commerce

protects consumer

-trade secrets

can be used to protect anything of value

Other warf IP:

- -biomaterials (might not qualify for patent, but still valuable to others)
- -technique and know how (akin to trade secrets)
- -data (research results)

# **Patent**

a patent is a property right granted by a governmental agency,

excludes others from making, using or selling or importing claimed invention

types:

-design(15 year, limited to ornamental features)

-plant

-utility (non provisional) patents

issued for new and useful processes

applicant gets a limited monopoly on your invention (20 years from filing)

but applicant must teach others how to make and use claimed invention

often takes 2-5 years to issue after filing (patent examination)

costs on average 30k-monthly attorneys fees

~90% of patents issued by USPTO are non provisional utility patents

Requirements for patenting

101-eligible, cant be a product of nature (have to to make it into something)

102-novel, must be tree

103-non-obvious, it cant be simple modification or combination of existing concepts

112-enabled and described, must provide enough detail to teach others how to make or use the invention

patent examiners are scientists hired and trained by the USPTO to review patent applications for these requirements

-graduating would qualify me as a patent examiner

Disclosing an innovation to warf

- -describe the innovation
- -identify its advantages and potential applications
- -name contributors
- -provide funding and public disclosure details

meeting with warf

- -discuss innovation in more detail
- -ask questions about warf and patenting processes

### -discuss next steps

IP considerations
-type of IP protection
-potential breadth and strength of IP protection
-public disclosure (past and planned)
-stage of development
broad claims are better for patent protection as it allows protection of design even with a single step changed
licensing considerations
-applications
-likelihood of identifying a commercial partner
-likely return from licensing
Market and licensing
-market status, establishing, emerging, new
-size and type, large and growing, medium and contracting etc
-potential licensees, companies in the market
license negotiation
-type and terms, exclusive and field limited, sub-licensing etc
-consideration, upfront payment, royalties, reimbursement
ongoing
-technology development, enforcement, amendment, termination

Licensing can reduce r&d cost, improved time to market, opportunity to expand, additional revenue opportunities

ΑI

Al cannot invent

Al can assist in inventing under Pannu Factors

Al must be incidental to conception and creation

Original concept by human master mind

## Conclusion/Action Items:

NATHAN KLAUCK - Oct 08, 2025, 2:08 PM CDT



**Download** 

IMG\_3090.JPG (1.84 MB)

NATHAN KLAUCK - Oct 15, 2025, 2:10 PM CDT

**Title:** Intellectual Property Considerations

Date: 10/15/2025

Content by: Nathan Klauck

Goals: Learn about IP and Dickinson Wright

- -IP is more the law side of engineering
- -IP protection allows research to safely transfer into products processes and/or systems
- --Legal paths exist without further schooling
- -technical advisor, patent examiner, Tech Transfer Manager, engineer
- --legal paths with patent bar
- -patent agent
- --paths that require law school
- -patent attorney, patent litigator, IP license Attorney
- --Skills for engineering IP
- -Research
- -Analytical Reasoning
- -Technical writing
- -Communication
- -Creativity
- -Collaboration
- -Project Management
- --Intellectual Property Ownership in the biomedical Industry
- -University: disclose before publishing, university usually owns IP, possible license opportunities

- -Company: employers typically owns inventions, trademarks, copyrights and other IP, review employee agreements
- -Startup: you own IP, file early, use NDAs, document development
- ->try for earlier patent date to avoid conflict of people stealing idea
- --timing and publication
- -disclosure internally first
- -publishing before filing and offers for sale = lost patent rights abroad and possible loss of rights in the US
- -posters or abstracts can count as public disclosure
- -first to file system (not first to invent) (file before your competitors!!!)
- -respect others IP
- -keep invention notebooks
- -understand inventorship vs authorship (authors have help with design idea, but haven't signifcantly contributed
- -maintain confidentiality agreements
- --Startup IP checklist- see attachment
- -Invent something new novel and non obvious
- -conduct patentability search/ FTO
- -file patents early
- -use NDAs
- -file trademearks.... see attachments
- --patent protection
- -novel, non-obvious, utility(has to work, but optional features dont have to), enablement (must describe on how to make and use)
- ->creates monopoly and stops others
- ->utility patents: protect how something works or how it is made
- ->design patents: protect the unique visual appearance of a product
- ->especially important in bme

components of a patent
front page, bibliographic info
drawings/figures
specifications
claims
abstract
-patentability vs FTO
trademark protects your brand name, cant have something similar or confusing to a consumer
copyright protection, source code, paper authorship, photos
trade secret protections, dont have to file for it, as long as you dont release it, requires certain procedures to keep safe
need right protections to fight counterfits
Conclusion/Action Items:
NATHAN KLAUCK - Oct 15, 2025, 1:14 PM CDT



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Intellectual\_Property\_Packet.pdf (1.24 MB)

NATHAN KLAUCK - Oct 22, 2025, 2:00 PM CDT

Title: BME Advising Session Part II: Post Grad Planning

Date: 10/22/2025

Content by: Nathan Klauck

Goals: Learn more about planning for Post Grad

- -Use undergraduate time to build an experience, get involved in research
- ->tie them together into a big picture of who you are/want to go/want to be
- ->research is important for all post-degrees and helpful in industry
- -Look into location, career development, people, disease, research, courses
- ->think about letter writers or references early 3 Strong ones
- -School: Prepare for the MCAT/GRE summer before your senior year
- -Make sure your story is clear to someone who isn't familiar with you
- -dont make story too basic, we all used to loved to build as kids, all been touched by disease.
- -I will do anything!- bad, want to specify what you can contribute
- -Start with thesis statement, what you want to do and how
- -Expand upon your personal experiences in your resume and talk about how those can contribute to what you want to do
- -Taylor your statement to the institution and individuals at the institution you be interested working with
- -Masters
- ->Stepping stone, change direction, gain depth, expand credientials for future, >med school, PhD
- ->Industry focused
- ->typical one year

- -PhD
- ->desire to be an independent researcher
- ->write research grants
- ->work in academia

### MS

- ->allows you to rewrite your story
- ->need time to prep for MCAT or apply for med school
- ->PhD: cannot find funding
- ->fills your resume
- ->higher level of skills
- ->more access to experiences
- ->older/more maturity

Three types of MS

- -Research
- 1.5-2 yrs

can be funded

thesis required

- -accelerated program
- 1 year

can get funded as a TA

->accelerated

coursework only

independent study/research is allowed

->Biomedical innovation, design, and entrepreneurship

project based, project required

partnership with business school

-Applying for BME Accelerated MS program
apply online pay fee, and submit
statement of purpose, why masters
research MS only, which PI wants to support you?
Input three different email addresses for for letters of rec
3.0 or above gets automatically admitted
you can master in other areas such as other engr degrees or MBA
PhD
-do your research
-network at BMES in october
-REU
-honors in research
-External funding NSF -GRFP
PhD
-apply early and list names of people you want to work with
-Generally >3.5 GPA and 75% Quantitative GRE
MD
Psychology 202 & sociology
Research
Volunteer
Shadow
Pt contact
Build relationships for letters
use your design experiences

requirements vary by degree

**Conclusion/Action Items:** 

NATHAN KLAUCK - Oct 29, 2025, 2:11 PM CDT

Title: FDA

Date: 10/29/2025

Content by: Nathan Klauck

Goals: Learn about regulation in the context of industry

### Content:

FDA consists of three different sectors, CBER (biologics), CDER(drugs), and one other focusing on devices

drugs- looking at receptor binding, common testing across all drugs

-FDA doesn't determine if a device is safe, its whether its benefits outweigh its risks

FDA doesn't approve materials, only applications

early feasibility study, feasibility study, and uno mas

### Three classes of devices

Class 1

Low risk (not very safe)

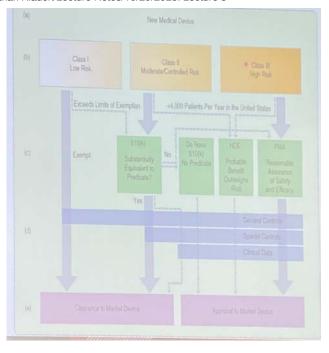
Class 2

510k(predicate), De novo 510k

HDE -probably benefits outweigh risks

Class 3

PMA (reasonable assurance of safety and efficacy



### FDA didnt regulate until 1970

pacemaker wasn't regulated, resulted in pts trusting doctor trusting engineer. Pacemakers improved overtime regulations formed due to larger problems and a specific intense event, industry pushes back saying they prevent devices that can help people

Dalkons shield was this extreme event, no news source at the time to communicate problems with the company or individuals

- ->prompted FDA
- -various examples of fraud in the industry setting
- -offloading of blame in industry setting

various trivial side effects can cause large problems went sent out to large scale consumer populations difficulty predicting failure modes in damaged devices in biologic, companies not familiar 15 years biological time study needed to discover effects of certain biologic treatments

FDA requires failure mode analysis: going through everything that could possibly go wrong and address it, its a pain **Conclusion/Action Items:** 

Research most similar device to ours that has gone through the FDA

NATHAN KLAUCK - Nov 05, 2025, 2:11 PM CST

Title: Framework Guiding Advanced Therapeutic Product Development

Date: 11/05/2025

Content by: Nathan Klauck

Goals: Learn about regulation in regards to therapeutics

### Content:

-understand regulatory processes and quality management for higher paying professions

-CDRH (Device): PMA, 510(k), IDE

-CDER (Drug): NDA(new drug application, allows for marketing), IND (investigational new drug application-for clinical trials)

-CBER (Biologics): BLA (biologics license application), IND

FD&C- FDAs control of drugs

PHS- gives FDA more pathways and manufacturing information for drugs

CURES- creates regenerative medicine advanced therapy (RMAT) framework to speed drug development

CARES- COVID response, more responsibility to FDA

**Dramatic Implications** 

-351 used for uses of human cells, tissues and tissue based products that aren't well understood

-361 used for ones that are understood

identify where research projects are on the critical path

Target Product Profile (TTP)

- -PDS/ Living document for a therapeutic
- ->indication
- ->efficacy

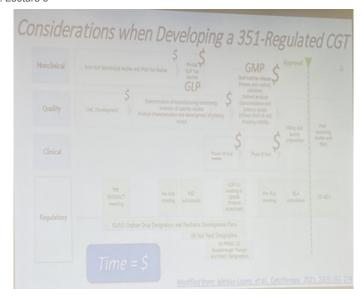
Nathan Klauck/Lecture Notes/11/05/2025: Lecture 9 303 of 419 ->safety ->dose -> route of administration ->clinical pathway/regulatory pathway ->timelines/cost/risk ->CMC important part of this -> important chemical information regarding therapeutic -> tells you if pt prescribers want it, will regulators accept it, and if payers will reimburse for it 351 regulated CGT ->nonclinical, Quality, clinical, regulatory ->Interact meeting and Pre-IND are day one considerations ->phase I trial gives you insight into a biologics efficacy, also when companies might consider buying it off you -Quality Management system -documentation of protocol and is highly specific -> required in any industry

Large number of regulatory jobs available, check slides for job areas

### Conclusion/Action Items:

Look further into the regulatory aspect of engineering and the careers available

NATHAN KLAUCK - Nov 05, 2025, 1:57 PM CST



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IMG\_3144.jpg (528 kB)

NATHAN KLAUCK - Nov 07, 2025, 12:58 PM CST

Title: Building a Career of Impact

Date: 11/07/2025

Content by: Nathan Klauck

Goals: Learn why healtcare needs more engineers

#### **Content:**

- -challenge yourself, dream
- -Abiomed-completely artificial heart
- -worked several jobs, did several internships and co-ops

don't feel like you need to know where you are going, just develop skills that make you competitive and capable later on

- -aim to improve provider experience, patient outcomes, lower cost of care, and improve patient experience
- -its become hard to be a physician in this country-> more of your time is hospital administration and less patient care
- -bad outcomes common, clinician burn out, people struggle to afford care
- ->challenges stem from misaligned incentives, fragmented financing and regulation
- ->physicians paid by client see more clients than seek out quality care
- -zipcode you are born into dictates your life expectancy and projected pay
- -better healthcare requires design and system thinking

#### 5 things

- -work on and build range: take on the hardest projects, classes, and experiences you can find. Effort and range are your foundation
- -Seek diverse exposure: explore different sectors, teams and geographies. Gain perspective and learn how systems connect, not just how parts work
- -choose your people wisely: Surround yourself with curious, driven, high-integrity people. They will shape who you become
- -Know your values and protect them: define what matters most- family/friends, health, career/impact, values and make decisions that align
- -embrace challenges and keep growing: run towards hard problems. Growth lives on the edge of discomfort where big impact starts

#### QΑ

Find a time of day when you work best

- ->take break early afternoon, and do low energy later in the night block calendar for own projects, don't always react others learn to say no
- -make time to exercise, sleep and have time with family

### Conclusion/Action Items:

Pursue challenges and development

NATHAN KLAUCK - Nov 12, 2025, 2:06 PM CST

**Title: Institutional Review Board** 

Date: 11/12/2025

Content by: Nathan Klauck

Goals: Learn about IRB

Content:

Things that require IRB review

-exempt research

-...

IRB results of historical problems with research ethics

Nuremberg Code 1974

-enforces voluntary consent

Declaration of Helsinki 1964

-focus on medical research

National Research Act 1974

- -Belmont report
- --Respect for persons/anatomy
- -Person needs to be able to represent themselves, say yes and no
- --Beneficence
- -benefits outweigh harms
- --Justice
- -who ought to receive benefits and bear burdens

**DHHS 45 CFR 46** 

-common rule

- --criteria for approving research
- --protections for vulnerable groups (prisoners, pregnant women, newborns)
- --requirements for IRB operations

Diversity of membership required in IRB

- -diversity
- -scientific expertise (MD,PhD, MPH)
- -Non scientists (community members, IRB staff)

IRB purpose-protect rights and wlfare of people in research

-research cannot begin until the IRB has reached a determination

Common rule criteria

- -no unnecessary risks
- -appropriate monitoring
- -don't need direct benefits to participants, but they should outweigh risks
- -equitable selection of subjects
- -informed consent
- -privacy and confidentiality

De-identifying Data

- -directly identifiable data
- -coded/indirectly identifiable
- -anonymized/de-identified

non-exempt studies,

-children or identified studies

Medical device

-anything that acts on a body that acts directly on the body to prevent disease
-protheses
-contact lenses
-MRI hardware/software
-diagnostic software
IRB review process
-Administrative review
After approval
-begin study
-change of protocols have to be approved before implementation
-reportable events: noncompliance, unanticipated problem/SAE, new information

# **Conclusion/Action Items:**

NATHAN KLAUCK - Nov 19, 2025, 2:04 PM CST

Title: How medical product R&D works in industry

Date: 11/19/2025

Content by: Nathan Klauck

Goals: Medical device R&D

Content:

Managing NPD: Stage-Gate Process

Ideation, exploration, concept development, design development, design confirmation, design transfer and commercialization

Stage 0: Ideation:

- -choose area of opportunity
- -review market rends and/or competitive threats
- -conduct primary and secondary market research
- -identify customer unmet needs

Stage 1: Exploration:

- -Define problem to be solved and customer requirements
- -review, refine, and screen list of ideas from stage 0 for exploration
- -create concepts for 8-10 ideas
- -develop high-level business case
- -conduct preliminary technical scouting and intellectual property landscaping

Stage 2: Concept Definition

- -Based on customer interview and use case assessments
- -Develop robust business case including market opportunity, projected expenses
- -Conduct comprehensive IP examination

Stage 3: Design Development

-move to functional prototype

-continue iterative design w/ initial testing and reviews with customers

## Stage 4: Design Conformation

- -Conduct extensive verification and validation testing
- -finalize products and component drawing/models
- -Submit regulatory documentation (FDA 510(k)
- Stage 5: Design Transfer & Commercialization
- -Complete any remain testing
- -Make final design changes
- -Build molds, assembly/test equipment
- -Create instructions for use (IFU) and user manuals
- -develop service plan and resources

### Conclusion/Action Items:

NATHAN KLAUCK - Sep 12, 2025, 12:10 PM CDT

Title: BSAC Meeting 1

Date: 9/12/2025

Content by: Nathan Klauck

**Goals: Discuss BSAC** 

- -New training curriculum (one training a year, pushing back bio/chem safety) (300's have to do human subject training)-
- > under safety and training
- ->not communicated very well
- -> makes it harder for transfers
- --> follow-up email to communicate idea
- -Communicate Biocore better to incoming students
- ->unless really interested in biology, not worth
- ->biocore course recommendation schedule with BME is not practical
- -Fall/Spring classes
- ->catches you off guard, maybe not the best communicated to new students
- -- Group Discussion
- -sorting projects by number of active proposals
- ->based on class as well
- -additional skills work shops: linked in, coding, excel
- -sending out course recommendations/ options earlier
- ->send once you passed progression

NATHAN KLAUCK - Sep 19, 2025, 11:52 AM CDT

Title: BSAC Exec 1

Date: 9/19/2025

Content by: Nathan Klauck

**Goals: Discuss BSAC** 

- -google form link to use as a request format for unlisted training (such as linked in learning)
- -redesign website, or break during project selection
- -6 hours of work outside of class should be seen in notebook
- -lecture for 200s at start of the year
- -BME project selection website??
- -3rd choice for proposal
- -scheduling a client meeting ahead of project selection

NATHAN KLAUCK - Sep 26, 2025, 11:43 AM CDT

Title: BSAC Meeting 2

**Date:** 9/26/2025

Content by: Nathan Klauck

**Goals: Discuss with faculty** 

Content:

Met with Dr. Nimunkar

- -PDS problems with client not being able to meet in the first few weeks
- -varying experiences with client expectations for lab archives
- -make sure to talk to client about expectations for lab archives
- -231 and 331 solid works classes for credit
- possible class for coding knowledge

### **Lab Archive Entries**

- -look at research as a way to learn more about the project and something to be interested about and ask more about at design meetings
- -add pictures and drawings to lab archives
- -use it more as sticky notes, record everything your thinking and what not

# Suggestion Form

-a way to suggest new trainings



NATHAN KLAUCK - Oct 03, 2025, 11:09 AM CDT

Title: BSAC Exec 2

**Date:** 10/03/2025

Content by: Nathan Klauck

Goals: Discuss Training throughout the curriculum form

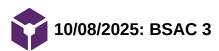
Content:

Specify explanation length

specify ideal training time

flow charts (BME & biocore)

-> make course specific, update, account for ahead or behind



NATHAN KLAUCK - Oct 10, 2025, 11:26 AM CDT

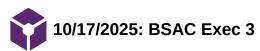
Title: BSAC 3

**Date:** 10/08/2025

Content by: Nathan Klauck

Goals:

- -concept of having a virtual bme 200 class
- -advisors choose classes
- -website is connected to DoIT, harder to change, free hosting
- -----website work through two servers?
- -training throughout the curriculum- at least 90 minutes worth of training
- -have preliminary report due by Thursday to submit with prelim report??
- ->Wednesday deadline is a little awkward
- -budget range for project suggestion



NATHAN KLAUCK - Oct 17, 2025, 11:21 AM CDT

Title: BSAC Exec 3

Date: 10/08/2025

Content by: Nathan Klauck

Goals:

- -make flow chart for course requirements between different tracks
- -provide research resources for mentees and how to get into lab info
- -Puccinelli responses
- ->client budget is submitted, not viewable to students
- ->Report deadline and FBF will stay the same
- ->Leadership talk was planned
- -> 200 and 201 will not be swapped



NATHAN KLAUCK - Nov 07, 2025, 11:29 AM CST

Title: BSAC Exec 3

Date: 11/07/2025

Content by: Nathan Klauck

Goals:

- -200 and 201 cant be swapped
- -people who are uncertain of the validity of the CITI training efficacy in 300
- -show and tell went well, one student didn't have advisors present.
- -project should be done before Thanksgiving, and poster printed at least before Wednesday the week of

NATHAN KLAUCK - Nov 14, 2025, 11:21 AM CST

Title: BSAC Exec 5

Date: 11/14/2025

Content by: Nathan Klauck

Goals:

Content:

## <u>CITI</u>

- -Teams have gotten to the point where they have submitted a project to IRB, so having CITI training helps prepare them for this
- ->CITI is directly relevant to industry

Questions for next week

- -What is team plan for rest of the semester
- -how has testing and data collection been going
- -how did enrollment go? are there any concerns
- -ready for final poster presentation
- -is project going to be continued
- -awards every semester
- -feedback from advisor on preliminary report
- -expectations for progress of the report

NATHAN KLAUCK - Nov 21, 2025, 11:39 AM CST

Title: BSAC 6

Date: 11/21/2025

Content by: Nathan Klauck

Goals: Discuss semester with faculty

- -Testing opinion mixed, some feel they don't have time
- -discussed printing poster, faculty suggested reserve 2 or more spots to guarantee time print and cancel if cant make it
- -in terms of understanding if project is done, the goal is to answer a question for the client on one aspect of the design
- ->tell a story to your client through your poster
- -try to test criteria on PDS and use statistics to see what you can say about how your design addresses them
- -feedback fruit assignment to grade other peoples posters
- -set up posters by 11 am, stand by them at 12 pm

NATHAN KLAUCK - Sep 12, 2025, 12:57 PM CDT

**Title: Advisory Meeting 1(Personal Notes)** 

Date: 9/12/2025

Content by: Nathan Klauck

Present: Whole team and advisor

Goals: To discuss our plan for the semester

- -Don't use other software or media to take notes
- -should be done by Thursday night
- -Dates should match
- -Progress reports due by thursday night
- ->sent to client, uploaded to website and sent to advisor
- -all communication should have the team and advisor cc

NATHAN KLAUCK - Sep 19, 2025, 1:19 PM CDT

**Title: Advisory Meeting 2(Personal Notes)** 

Date: 9/19/2025

Content by: Nathan Klauck

Present: Whole team and advisor

Goals: To discuss our plan for the semester

#### Content:

-include set number ranges in PDS

-look into force sensors to utilize for measuring forces

-think of how to connect the force sensors to the hand (vertically-dangle hand? tension-apply force through connection to wrist?)

-Flesh out FDA requirements for our device

# 10/02/2025: Presentation Practice Notecard

NATHAN KLAUCK - Oct 02, 2025, 5:44 PM CDT

Title: Presentation Practice Notecard

Date: 10/02/2025

Content by: Nathan Klauck

Present: Whole team

Goals: Review script and general info in preparation for presentations

#### Content:

- Thanks
- · This design highlights designs considered
- With highest priority category being
  - · Healthcare setting, shouldn't harm
  - Involves stability circulation
  - Distributed forces
- · Next two highest
  - Due to importance of meeting supply needs
  - Simplistic design and cheap materials
- · Next category
  - Rated middle as should not impede use of clinician
  - Simplistic & rapid method of attachment
- · Comfort rated lowest
  - Despite importance, functionality and supply more important
  - · Larger support for hand
- · Last is reusability
  - Important for maintaining stock, but with low production cost may not be as big of factor
  - Simplistic design easily cleanable
- · Material Choice
  - Cost
  - · Available options dimensions of available peaces
  - Reusability
- Construction
  - Mechanical Portion
  - Sleeve Portion
  - Combination
- Testing
  - Force Range
  - Slippage

id like to acknowledge these people, here are our sources, and any questions?

\_\_\_\_\_

Nathan Script: Thanks previous presenter, this is the design matrix we used to decide on a design for the holding mechanism of the hand attached to the mechanical aspect of our design, which we refer to as the finger sleeve portion of the device. In a finger sleeve the primary goal is to support the hand in a way safe for the pt, thus we ranked safety the highest. Ease of fabrication and cost were ranked next highest as a major aspect of this design is to be able to effectively produce this design so that it can easily be used to replace and supplement the current lack of this device available. Next rated was ease of use as its import for the design to not counteract the role of the care provider. Then is comfort as a current flaw in one of the existing designs is the pain it causes the pt. Finally is reusability, as although it does not play as much of a role in supplying as the second and third category, making an easily usable device aids this dilemma

NATHAN KLAUCK - Oct 03, 2025, 11:54 AM CDT

thanks ben. this is the design matrix we used to decide on our final design for the sleeve portion of our device. the category we rated the highest for this device is safety, as the nature of this product places it in a healthcare setting we want a device that is safe, specifically one that doesnt risk compromised circulation or a weak hold on a pt hand.

the next two highest rated categories are ease of fabrication and cost as supply is an important aspect of our design.

next is ease of use as we dont inhibit

comfort important, not as important as safety and supply

re



# 11/14/2025: OnShape Model and SolidWorks Analysis

Ilia Mikhailenko - Dec 10, 2025, 5:19 PM CST

Title: OnShape Model and SolidWorks Analysis

Date: 11/14/2025

Content by: Nathan Klauck

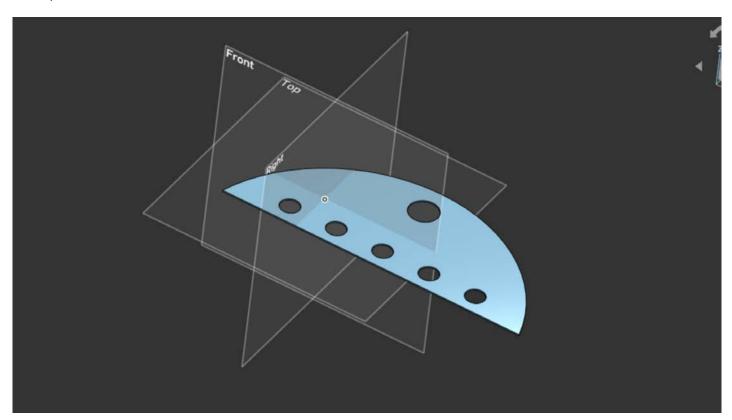
Goals: Simulate potential stress/strain on our design, create an onshape model for water jet cutting of

aluminum

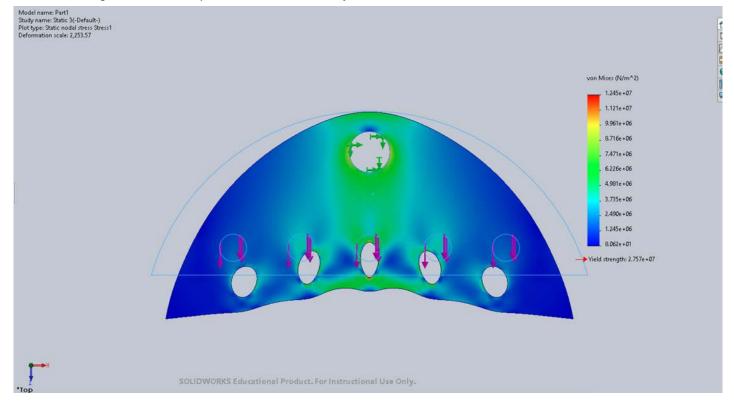
# Content:

- -Aluminum alloy 1060 (not accurate)
- -45 N of total force applied
- -no time duration specified

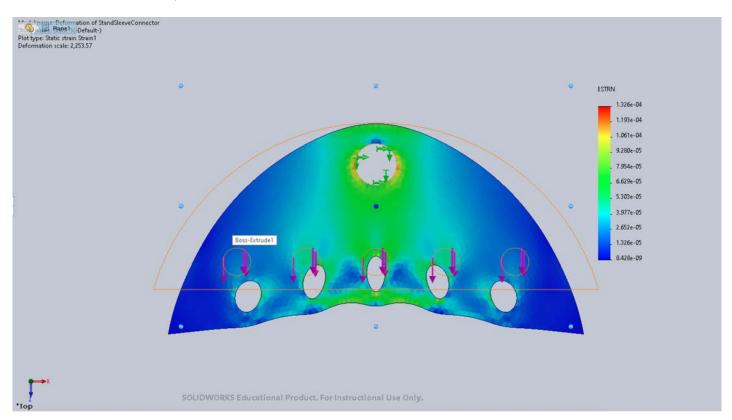
# OnShape Model:



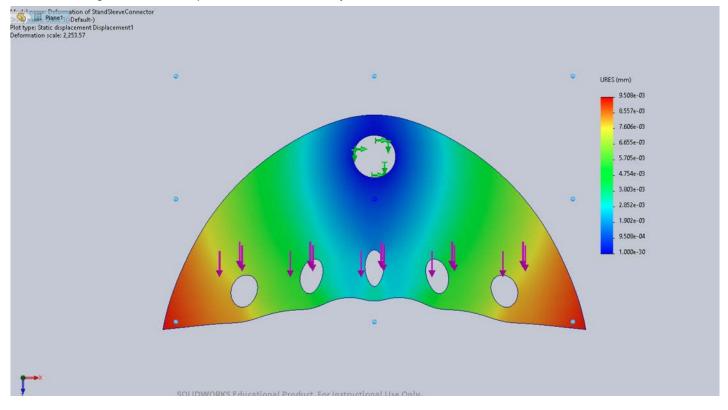
Solid Works Stress Heat Map:



# Solid Works Strain Heat Map:



Solid Works Displacement Heat Map:



NATHAN KLAUCK - Nov 14, 2025, 2:40 PM CST



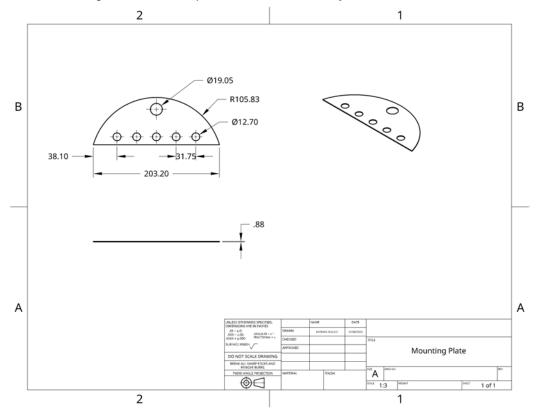
**Download** 

Part\_Studio\_1.sldprt (26.6 kB)

NATHAN KLAUCK - Nov 17, 2025, 10:10 AM CST

actual aluminum was 3003 aluminum

NATHAN KLAUCK - Dec 10, 2025, 1:54 PM CST



dimensions in mm

NATHAN KLAUCK - Dec 10, 2025, 1:57 PM CST

# Formalized Test Procedure:

# Description:

A testing protocol to determine whether the mounting plate is capable of withstanding the forces as outlined in Appendix 10.1 (Product Design Specification) without deformation.

Materials:

SolidWorks FEA

CAD of mounting plate

Protocol:

Import CAD file

Specify material as Aluminum 3003 Alloy

Start new FEA study

Fix model along top supporting hole

Apply bearing loads of 36 N along each of the 5 bottom weight bearing holes (simulating 45 N total with a FOS of 4)

Run study and look for areas of high stress or areas that exceed yield stress

Title: SolidWorks FEA

Date: 11/17/2025

Content by: Nathan Klauck

Goals: Simulate potential stress/strain on our design, create an onshape model for water jet cutting of aluminum

Content:

Procedure:

- -designate material
- -go to simulation tab and create new study
- -designate fixture as entirety of the top loop
- -set up an axes coincident with each cylindrical hole, and then apply a bearing loads to each of 9 N (for a total of 45 N)
- ->https://www.google.com/search?

<u>q=how+to+dictate+direction+of+bearing+load+solidworks&oq=how+to+dictate+direction+of+bearing+load+solidworks&gs\_lcrp=EgZjaHJvbWUyCQgAEEU`</u>
8#fpstate=ive&vld=cid:cbca723c,vid:63ndAB8wlPw,st:269

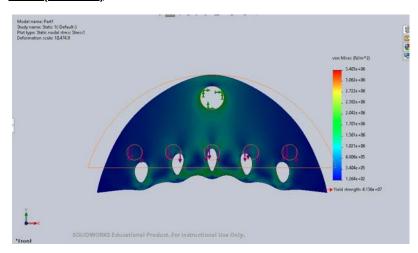
- ->[1] "- YouTube." Accessed: Nov. 17, 2025. [Online]. Available: https://www.youtube.com/watch?v=63ndAB8wIPw
- -under mesh create new mesh
- -press run

-3003 alloy used as material (our material was 3003 aluminum)

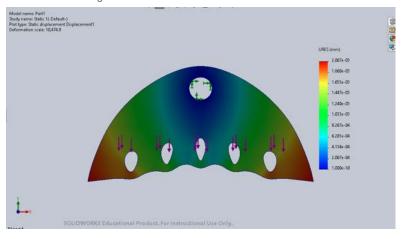
NATHAN KLAUCK - Nov 17, 2025, 2:55 PM CST

Below are the results of running the study again using this time bearing loads and the proper aluminum alloy:

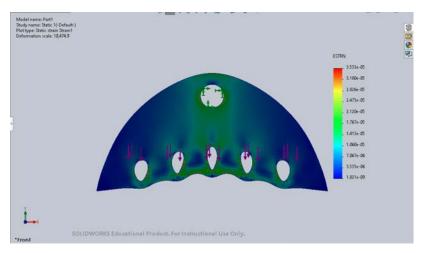
### Stress (Von-Mises):



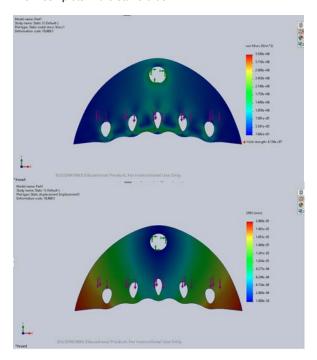
**Displacement**:

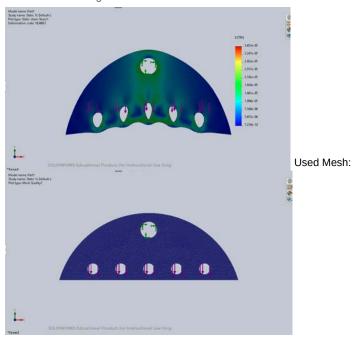


# Strain (Equivalent):



# Fine Mesh plots in the same order:

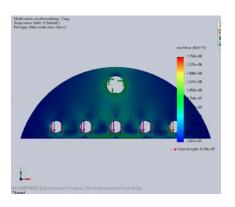




### Conclusion:

The plots indicate our utilized alloy lacks sufficient mechanical properties to support the desired load. Future work would include changing the utilized material, finding a way to indicate time in the FEA, or to conduct an analysis utilizing a factor of safety

NATHAN KLAUCK - Nov 19, 2025, 6:58 PM CST



Ilia Mikhailenko - Dec 09, 2025, 8:51 PM CST

Title: Stopper 3D model

**Date:** 12/04/2025

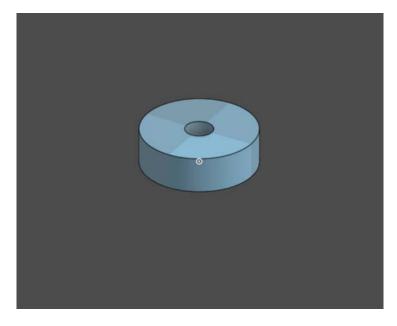
Content by: Nathan Klauck

**Goals: Design Stoppers to Hold Design in place** 

# Content:

Two plastic stoppers of the below design will be printed to secure the metal piece to the IV stand by sliding onto the IV pole supports on the top and hold the metal piece between them.

->print out of TPU for flexibility

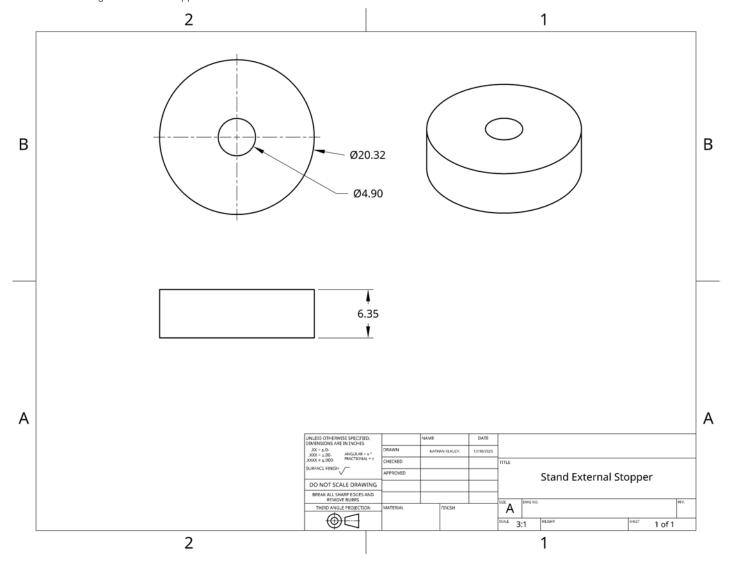


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NATHAN KLAUCK - Dec 10, 2025, 1:55 PM CST



dimensions in mm

Ilia Mikhailenko - Dec 09, 2025, 8:43 PM CST

Title: Internal Stopper

Date: 12/04/2025

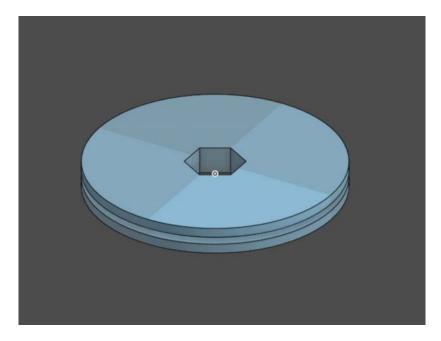
Content by: Nathan Klauck

Goals: Design Stoppers to Hold Design in place

# Content:

One plastic stopper will be printed with ridges to insert into the interior of the metal piece to support it and prevent it from moving (depicted below)

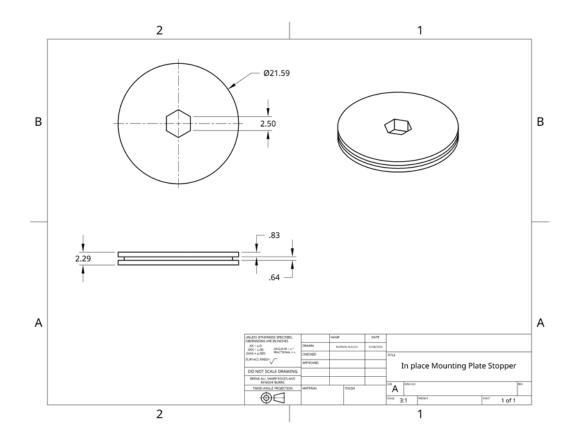
->print out of TPU for flexibility



Displayed in white below



NATHAN KLAUCK - Dec 10, 2025, 1:55 PM CST



Dimensions in mm

MARIAMAWIT TEFERA - Sep 12, 2025, 9:46 AM CDT

**Title:** Flexor Tendon Mechanism (AO Surgery Reference)

Date: 9/12/2025

Content by: Mariamawit Tefera

Present: N/A

**Goals:** To document detailed anatomy & biomechanics of the flexor tendon mechanism in the hand—tendons, sheaths, pulleys, zones of tendon injury—to inform design decisions for our digital traction device

Search Term: tendon mechanism and anatomy of pulleys zones

Citation: Garcia, A., Suarez, F. A., Berezowsky, C. A. (AO Surgery Reference). "Flexor Tendon Mechanism." AO Foundation. (Accessed September 2025)

Link: Surgery Reference

#### **Content:**

The fingers bend and straighten because of two main tendons that run along each finger. These tendons are like cords that pull on the finger joints to make them move. They slide inside protective tunnels, called sheaths, that reduce friction and keep the tendons healthy. Small blood vessels, carried by tiny tissue bands, also keep the tendons alive. To keep the tendons close to the bone, the hand has a system of "pulleys," which act like loops that stop the tendons from bowing outward when you flex your fingers. The thumb has a simpler pulley setup compared to the other fingers. Doctors divide the hand into zones based on where tendon injuries happen. Some zones, especially zone 2, are tricky because many tendons and pulleys overlap there, making healing harder if things get damaged.

### **Conclusions/action items:**

For our project, this means the traction device must avoid pressing too hard on the pulleys or tendons, since that could block smooth finger motion or cause damage. The device should support the hand and fingers while still allowing the tendons to glide naturally. Our sleeve-based design should spread out pressure evenly, let the joints bend and straighten, and avoid squeezing sensitive areas. In short, we need to match the body's natural mechanics instead of fighting against them.

MARIAMAWIT TEFERA - Sep 12, 2025, 9:35 AM CDT

Title: Existing stabilization device

**Date:** 9/11/2025

Content by: Mariamawit Tefera

Present: N/A

**Goals:** To document Reison's hand fixation product as a competing design, identify its strengths and weaknesses, and extract insights that inform our project's development of a digital, sleeve-based traction device.

Search Term: Forearm extension hand stabilization device

Citation:

Reison Medical. Hand Fixation. Reison.se. Part no. 10-394.

Link: Reison Medical

### Content:



Provides rigid stabilization of the hand during surgery with forearm traction. Adjustable to accommodate different hand sizes and shapes. Specifications:  $220 \text{ mm} \times 190 \text{ mm}$ , weight 0.7 kg, stainless steel + polycarbonate. Designed to integrate with other Reison traction devices.

### **Conclusions/action items:**

Overall, this has good stability and adjustability, but is static (no active finger motion). Heavy and potentially less ergonomic compared to a sleeve-based design. Our project could benefit from replicating the stability and adjustability while innovating with digit-level control, comfort, and reduced invasiveness.



# 9/10/2025-Traction method for active motion

MARIAMAWIT TEFERA - Sep 12, 2025, 9:34 AM CDT

Title: Interphalangeal Joints: A Method of Digital Skeletal Traction Which Permits Active Motion

Date: 9/10/2025

Content by: Mariamawit Tefera

Present: N/A

**Goals:** To describe and evaluate a method of digital skeletal traction that allows active motion of the interphalangeal joints, and analyze it see what we should incorporate in our design or can be improved.

Search Term: digital skeletal traction and motion

**Citation:** Quigley, T. B., & Urist, M. R. (1947). Interphalangeal Joints: A Method of Digital Skeletal Traction Which Permits Active Motion. The American Journal of Surgery, 0002-9610(47)90310-3.

### **Link: Science Direct**

#### Content:

Traditional skeletal traction methods for finger fractures often immobilize the joints, leading to stiffness due to the complex anatomy of the hand (tendons, ligaments, and capsules). Authors describe a novel technique placing a Kirschner wire hook into the middle phalanx, avoiding major tendinous or neurovascular structures. This allows traction while permitting active interphalangeal joint motion, which prevents adhesions and stiffness. Technique tested in >70 fingers over several weeks with no major complications reported. Case studies (gunshot wounds, crushing injuries, sports injuries) demonstrate improved motion recovery when traction is applied with fingers flexed rather than extended.

### **Conclusions/action items:**

Historical skeletal traction hook allowed active motion and reduced stiffness, but was invasive and risky (infection, tendon injury, discomfort). Our device should replicate its benefit of controlled motion while avoiding invasive methods. This design underscores the need for a modern, sleeve-based, non-invasive solution.

# 9/19/2025-Notes from Finger Trap Technique video

MARIAMAWIT TEFERA - Sep 19, 2025, 9:23 AM CDT

Title: Finger Trap Technique for Distal Radius Fracture Reduction

**Date:** 9/19/2025

Content by: Mariamawit Tefera

Present: N/A

**Goals:** Understand how finger traps are used for distal radius fracture reduction and learn correct patient positioning, application process, and plaster technique, and also to identify the benefits and safety considerations of the method

**Search Term:** N/A since it's notes from a video sent by the client

Citation: YouTube – Finger Trap Technique for Distal Radius Fracture Reduction

Link: https://youtu.be/9QFZzajwiqI

#### **Content:**

Finger traps provide a non-invasive, painless way to apply finger traction for distal radius fracture reduction. The patient lies with the shoulder and elbow at a 90° angle, completely relaxed. Finger traps are slid onto the fingers and suspended from a ceiling or stand to apply longitudinal traction. Minimum traction is 20 minutes, with a safe maximum of up to 2 hours. Plaster application requires radial and dorsal slab coverage with three-point molding, leaving the MCP joints and the thumb mobile. The method enables a single operator to apply plaster without requiring additional pain relief, while also improving patient comfort and accessibility.

### **Conclusions/action items:**

- Ensure correct patient positioning (shoulder & elbow at 90°, relaxed shoulders).
- Apply traction for at least 20 minutes before reduction.
- Maintain plaster technique requirements (radial/dorsal coverage, three-point molding, free MCP joints, thumb mobility).
- Recognize advantages: one-person operation, no analgesia needed, patient comfort maintained.

# 9/23/2025-Wrist Traction Pillow tower

MARIAMAWIT TEFERA - Sep 23, 2025, 3:22 PM CDT

Title: Combined design

**Date:** 9/23/2025

Content by: Mariamawit Tefera

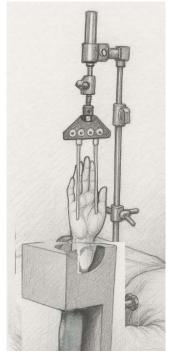
Present: N/A

### Goals:

My aim is to design a prototype that ensures we have fixed support for the sleeves, as well as making sure the patient is comfortable.

### **Content:**

My idea is to integrate the stability and traction features of a wrist traction tower with the comfort and elevation provided by a rehabilitation pillow. This combination would allow controlled and stable traction during surgeries, such as distal radius fracture treatments, with minimal manual effort from the surgical team. So far, I have reviewed existing devices like the Wrist Traction Tower and Carter Arm Elevation Pillow, and I sketched out how the key parts could come together: a table rail clamp, vertical mast, articulating arm, equalizer bar, finger tethers, and Japanese finger sleeves, all working in coordination with the elevation pillow. The device would distribute tension evenly, enable controlled wrist and forearm orientation, and ensure that the arm stays comfortably stabilized throughout the procedure.







#### **Conclusions/action items:**

The next steps include refining the sketch into an exploded view to show how each part connects, investigating options for digital tensioning mechanisms, and selecting safe and durable materials for the finger sleeve attachments. From there, I plan to move toward a prototype to test the feasibility and ergonomics of the design.

# MARIAMAWIT TEFERA - Oct 16, 2025, 10:41 PM CDT

Title: Analysis of different materials

**Date:** 10/9/2025

Content by: Mariamawit Tefera

Present: N/A

**Goals:** To see the comparison between the mechanical strength and failure modes of two tube anchoring techniques — the Chinese Finger Trap (CFT) and the Four Friction Suture (FFS)

#### **Content:**

The study aimed to determine the most secure and practical method for securing various medical tubes. Both the CFT and FFS techniques were compared across GT, JT, and TT tubes using different materials. Results showed that for GT tubes, there was no significant difference in slippage between the two methods, though the FFS technique required slightly more time to complete. For JT tubes, both methods performed similarly, but again FFS took longer to apply. For TT tubes, both methods provided reliable securement, though the CFT technique required less time overall. The study emphasized that tube material, diameter, and the applied technique influence the stability of the securement.

### **Conclusions/action items:**

The findings suggest that while both CFT and FFS techniques are effective, the Chinese Finger Trap (CFT) method is generally faster and easier to perform without sacrificing security. In clinical practice, the CFT technique may be preferred when time efficiency is important, whereas FFS may be chosen for cases where maximum stability is required

MARIAMAWIT TEFERA - Oct 16, 2025, 10:46 PM CDT

Title: Mechanical Part Material Selection

Date: 10/16/2025

Content by: Mariamawit

Present: N/A

Goals: Identify and select potential materials for the mechanical components of the digital traction device.

### Content:

The team reviewed and compiled potential materials for the mechanical section of the device, focusing on lightweight and strong options suitable for adjustable mechanisms and load-bearing structures.

Key materials and their sources included:

- Aluminum (6061 Flat Bar, Sheet Metal, and Rods) lightweight, corrosion-resistant, easily machinable.
- Plain Steel Round Tube strong structural support for adjustable rods.
- T-Handle Locking Quick-Release Pins for secure adjustable locking mechanisms.
- IV Pole Clamp (3-Prong) for attachment and support integration.
- Shaft Collars (Carbon Steel) to stabilize and limit rod movement.

All components were sourced primarily from Amazon, Home Depot, McMaster-Carr, American Hospital Supply, and Grainger, with individual prices ranging between \$12–\$36

Link to Document: Mechanical part materials - Google Docs

### Conclusions/action items:

- Purchase selected materials for initial prototyping phase.
- Begin testing the mechanical functionality of adjustable components.
- Evaluate the feasibility of aluminum vs. steel combinations for weight and strength optimization.
- Document initial testing results and update the project notebook with findings for next week's progress report.

# 11/16/2025-Protocol for mechanical part

MARIAMAWIT TEFERA - Dec 10, 2025, 4:06 PM CST

Title: -Protocol for mechanical part

Date: 11/16/2025

Content by: Mariamawit

Present: N/A

**Goals:** Draft a step-by-step description of how to set up the mechanical part of our final prototype.

Content:

Description:

The aim is to ensure we fabricate a mechanical body that meets the stability and adjustability requirements of the traction system. The mechanical body must be stable, height-adjustable, and compatible with clinical use. All components should remain durable under repeated loading and maintain structural integrity throughout orthopedic procedures.

Materials:

Standard IV pole (height-adjustable)

Aluminum sheet metal (for attachment platform)

3D-printed stoppers

Bead chain segments

**D-rings** 

Additional Needed Items

Waterjet cutter

Sandpaper or deburring tool

Measuring tape or calipers

Marker for layout lines

3D printer + filament for stopper components

Protocol:

Assembling the Medline Stand IV Pole

Unfold the base legs by spreading the four legs out from the center until the base is stable and flat on the ground. Make sure all legs are fully opened and resting evenly.

Assemble the central pole sections. The main pole comes in several pieces that must be inserted into one another in the correct order. Push or screw them together firmly so there are no gaps or instability present.

Once the sections are connected, loosen the collars around the central pole segments to extend the assembled body to the desired length. After you have adjusted, lock the collars on the central pole so the height is secure.

Once the pole has been made the desired height, secure the top-piece at the apex of the assembled pole.

Preparing the IV Pole Frame

Inspect the IV pole to ensure the height-adjustable central pole is firmly locked in place.

Remove any unnecessary parts (hooks/attachements) that interfere with mounting.

Cutting and Shaping the Mounting Plate

Design the desired component in CAD with precise dimensions to produce a file ready for cutting

Load the aluminum sheet into the waterjet cutter, ensuring it lies flat and is secured inside the machine.

Program and execute the waterjet cut following the design file for the platform.

Remove the cut piece and deburr sharp edges using sandpaper or a deburring tool.

Installing the 3D-Printed Stoppers

Design the CAD drawing to 3-D print plate stopper

**Full Assembly Inspection** 

Position the aluminum plate

Slide the 3D-printed stoppers onto the IV pole at the intended mounting height and confirm that the stopper prevents any rotational movement.

Connect bead-chain segments to the outer edges of the aluminum platform

Secure each chain with a bead-chain connector

Attach D-rings to the ends of the chains, ensuring they move freely and allow smooth traction adjustments.

Quality Check

Verify platform stability and alignment

Confirm that stoppers fully prevent slipping

Ensure bead-chain attachment points are secure

Inspect all edges for safe handling

Test full assembly under light simulated traction

Link to Document: Mechanical part materials - Google Docs

# Conclusions/action items:

•

# 12/01/2025-Mechanical part testing (copy)

MARIAMAWIT TEFERA - Dec 10, 2025, 4:17 PM CST

Title:In-place Mounting Plate Stopper CAD Drawing

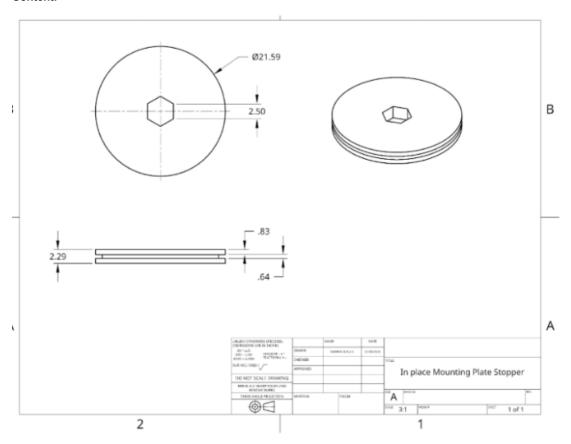
Date: 12/10/2025

Content by: Mariamawit Tefera

Present: N/A

Goals: To document the design for the 3-D printed stoppers

# Content:



We wanted 2 stoppers to prevent movement back and forth, so we used this design to make 2 of the same stoppers.



MARIAMAWIT TEFERA - Oct 31, 2025, 6:

Title: Biosafety Required Training

Date: 10/31/2025

Content by: Mariamawit Tefera

Present: N/A

Goals: Documentation for the Biosafety Required Training

Content:

# **OVCR Training Information Lookup Tool**

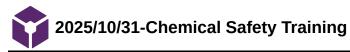
# **University of Wisconsin-Madison**



This certifies that Mariamawit Tefera has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024-2025	10/31/2025	10/31/2028
Chemical Safety: The OSHA Lab Standard	Final Quiz	10/31/2025	

Data Last Imported: 10/31/2025 05:54 PM



MARIAMAWIT TEFERA - Nov 04, 2025, 3:04 PM CST

Title: Chemical Safety: The OSHA Lab Standard

Date: 10/31/2025

Content by: Mariamawit Tefera

Present: N/A

Goals: To document my completion of the Chemical Safety: The OSHA Lab Standard

Content:







This certificate is awarded to

# Mariamawit Tefera

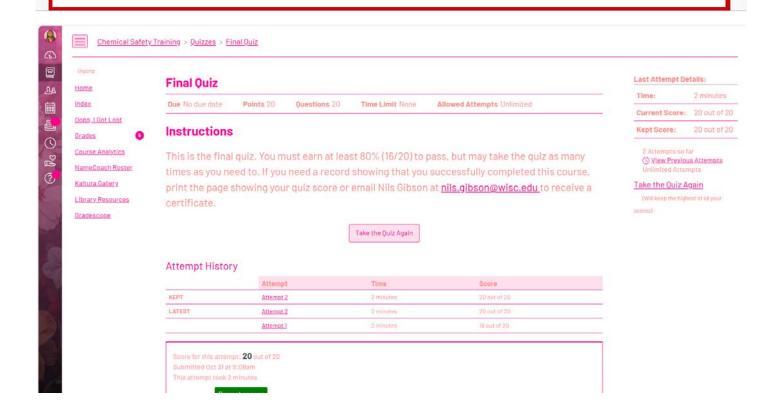
This Training Satisfies 29 CFR Part 1910.1450(f)
Employee Information Training

Mils Gibson

Safety Specialist

310ct2025

**Training Date** 





# 2025/10/31-Intro to Machining and other Desing Innovation Lab trainings

MARIAMAWIT TEFERA - Oct 31, 2025

Title: Intro to Machining

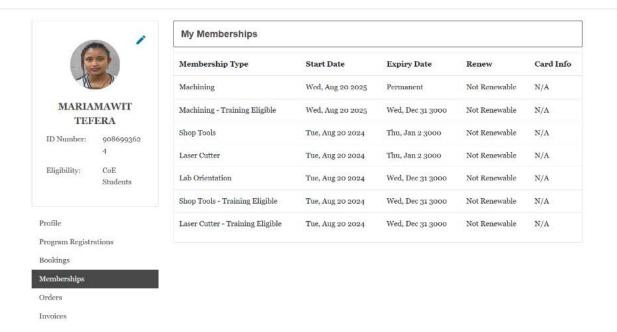
Date: 10/31/2025

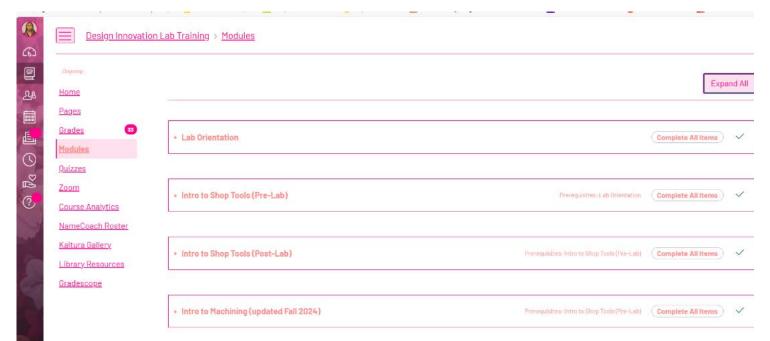
Content by: Mariamawit Tefera

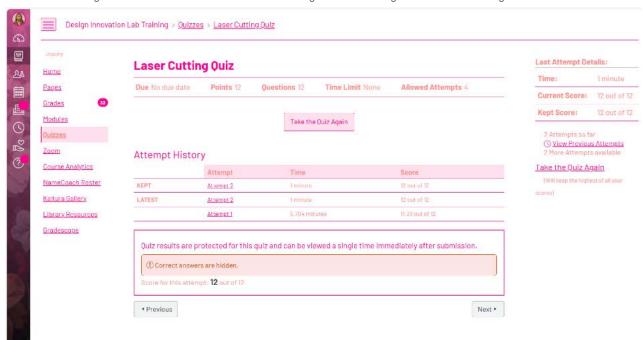
Present: N/A

Goals: To document my intro to machining training (for the lathe and mill machines) and also additional training I did in INTEREGR 170.

Content:







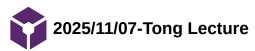
► 3D Printing: Pre-Lab

Complete All Items

► 3D Printing: Post-Lab

Prerequisites: 3D Printing: Pre-Lab

Complete All Items



MARIAMAWIT TEFERA - Nov 09, 2025, 1:20 PM CST

Title: Biosafety Required Training

Date: 11/07/2025

Content by: Mariamawit Tefera

Present: N/A

Goals: Documentation for the Tong Lecture

Content:

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MARIAMAWIT TEFERA - Dec 10, 2025, 4:10 PM CST

Title: Intro to Machining

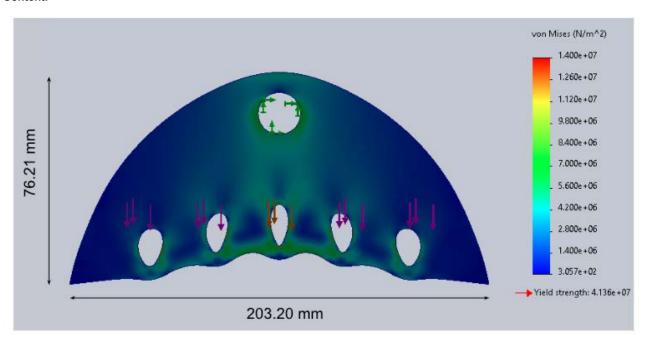
Date: 12/01/2025

Content by: Mariamawit Tefera

Present: N/A

Goals: To document the FEA testing

Content:



Overall, the part remains safely within the elastic range even under the amplified loading and meets the intended safety requirements.



# **General Orthopedic Hand Surgeries 9-9-25**

Ben Willihnganz - Sep 09, 2025, 4:22 PM CDT

Title: General Orthopedic Hand Surgeries

**Date:** 09/09/2025

Content by: Ben Willihnganz

Present: N/A

Goals: Learn about the standard procedure of a hand surgery and some of the difficulties.

Search Term: - finger traction in orthopedic hand and finger surgery

Link: - Operative Techniques: Hand and Wrist Surgery

**Citation: -** [1] M. Chung MD Kevin C., *Operative Techniques: Hand and Wrist Surgery e-Book*. Philadelphia, PA: Elsevier, 2021.

**Content:** This textbook displays important hand and finger anatomy for numerous common hand and wrist surgeries our device could be necessary in. Although I did not have access to the entire textbook, the preview I was able to engage in contained a descriptive easily understood map of the joints and nerves of the hand as well as common positions the hand could be maneuvered into during surgery. I believe understanding the hand and fingers of the human body and the goals of many common surgeries will be essential in the success of our device.

# Conclusions/action items:

All in all, understanding how our device can help to improve the ease of surgery as well as the outcome will come down to understanding the goal of common surgeries. One of, if not the most common surgical operation on the hand is for fractures, which our device is being designated specifically for. As far as what I need to understand better is the devices that are in place already to deal with traction during surgery.

# Senegalese Finger Size - 10-8-25

Ben Willihnganz - Oct 08, 2025, 7:54 PM CDT

Title: Average Finger and Hand Size in Senegal

Date: 10/8/2025

Content by: Ben Willihnganz

Present: N/A

Goals: Find an article that will allow further my understanding of a typical patient

**Search Term: - Senegal Finger Sizes** 

Link: - Hand Morphometry in Healthy Young Individuals from Different Countries

Citation: -

[1] N. E. Sahin, Rukiye Sumeyye Bakici, S. Toy, and Z. Oner, "Evaluation of Hand Morphometry in Healthy Young Individuals from Different Countries," *International Journal of Morphology*, vol. 42, no. 4, pp. 991–998, Aug. 2024, doi: https://doi.org/10.4067/s0717-95022024000400991.

### Content:

Senegal finger size:

- -8.26cm average for females not normally distributed. This is also for the middle finger, the longest finger
- 8.69cm average for males with a standard deviation of .47cm
- pinky finger lengths were 6.58cm and 6.14cm on average for females and males respectively
- this journal article does a great job highlighting very specific finger measurements which can be referenced throughout the design process

### Conclusions/action items:

In conclusion, typical Senegalese people have a much longer and skinnier finger than typical Americans. This needs to be accounted for in our design.

# **Chinese Finger Traps Design 9-9-25**

Ben Willihnganz - Sep 09, 2025, 5:05 PM CDT

**Title: Chinese Finger Traps and Similar Alternatives** 

Date: 09/09/2025

Content by: Ben Willihnganz

Present: N/A

Goals: My goal for this article is to explore designs that are already on the market and look for potential

improvements.

**Search Term: Chinese Finger Traps for Surgery** 

<u>Link: - A readily available alternative to Chinese finger traps for fracture reduction</u>

### Citation:

[1] K. Akhtar, D. Akhtar, and J. Simmons, "A readily available alternative to Chinese finger traps for fracture reduction," Royal College of Surgeons of England, https://publishing.rcseng.ac.uk/doi/full/10.1308/rcsann.2013.95.2.159 (accessed Sep. 9, 2025).

#### Content:

- This article describes Chinese Finger Traps and their drawbacks. It also describes a Jerry-rigged method
  of creating the device. The article mentions that one of the major drawbacks to the existing device, the
  Chinese Finger Traps, is that they are far from readily available in hospitals especially not during regular
  hours.
- This device uses long carrying for the fingers, like a traditional Chinese Finger Trap does, and suspends the hand allowing gravity to add tension and traction to the arm, hand, and wrist specifically for castings and fracture fixations.
- The Jerry-rigged version described in the article used tape instead of the finger sleeves to achieve a similar result.
- These designs lack sensors and adjustability like our design will be desired to have.

**Conclusions/action items:** Overall, I believe that the traditional design can be easily improved upon. I believe that the biggest fault of this design is that it requires gravity in order to function correctly. I believe that with sensors and other means this device can be utilized for other scenarios than just when the hand and arm is suspended.

Ben Willihnganz - Sep 09, 2025, 6:04 PM CDT

**Title: Alternative Design for Traction** 

Date: 09/09/2025

Content by: Ben Willihnganz

Present: N/A

Goals: My goal is to understand what current products and designs are on the market right now for traction and fixation of the hand and digitals during surgery.

Search Term: - Traction devices for hand surgery

**Link: -** <u>A Novel Approach to Open Reduction and Internal Fixation of Distal Radius Fractures Utilizing a Multi-Degree-of-Freedom Traction and Stabilization Device</u>

### Citation: -

[1] J. Oeding et al., "A Novel Approach to Open Reduction and Internal Fixation of Distal Radius Fractures Utilizing a Multi-Degree-of-Freedom Traction and Stabilization Device," ASME Digital Collection, https://asmedigitalcollection-asme-org.ezproxy.library.wisc.edu/medicaldevices/article/16/2/021006/1123007/A-Novel-Approach-to-Open-Reduction-and-Internal (accessed Sep. 9, 2025).

**Content:** This device to fixate the hand and phalanges for distal radial fractures utilizes wraps and a rachet strap to achieve the desired fixation and tension of the arm and hand. It contained a table mount and a quick release pin, both to improve functionality of the design. This design was able to effectively decrease the amount of work a surgeon would have to do in order orient their patient into the correct position. Our goal is to decrease the amount of work and people it takes to correctly align a patients arm and fingers for hand and wrist surgeries, this design achieves that, but in a different way to what our project asks for.

### Conclusions/action items:

Ultimately, this product is of great value to the brainstorming of the team. It utilizes simple mechanisms and devices to achieve its purpose. Although this device is quiet simple, I would like to move forward and use this design to start initially brainstorming ideas for our work. Generating force for our design could be difficult, but something like a rachet strap or a pully is always an option to keep in mind as well similarly to how this design utilized those mechanism.

# SchureMed Wrist Traction Tower 9-14-25 -

Ben Willihnganz - Sep 14, 2025, 9:39 PM CDT

**Title: SchureMed Wrist Traction Tower** 

Date: 09/14/2025

Content by: Ben Willihnganz

Present: N/A

**Goals:** Look into prices and more designs already on the market. Note areas of potential improvement and other ideas to keep in mind for the project.

Search Term: finger traction device for surgery with finger sleeves tower

**Link: SchureMed Wrist Traction Tower** 

# Citation:

[1] SchureMed, "Schuremed 800-0135 wrist traction tower," Universal Medical, https://www.universalmedicalinc.com/wrist-traction-tower.html (accessed Sep. 14, 2025).

## Content:

# **Price**

- The price of this entire design including finger sleeves and table came out to \$3,959.00
- Sold separately is the attachment device that allows for connection to most surgical tables which costs another \$374.00
- Sold separately finger sleeves cost \$23.00 \$27.00 per sleeve depending on size or 5 for \$101.00
- Size ranges from XS to XL

# Areas of Improvement

- I see the price of this device to be a big drawback.
- Adaptability of this device can be improved upon as well. I believe that making a device that is universal for all surgical tables and setting is important.
- -Adjustability of this device also seems like something that can be improved as well. I believe a device with more joints could be advantageous.

# Other Notes

- Remembering to keep a weight limit of the project in mind at all times. For example, this design is said to support 500 lbs.
- Making sleeves based on different finger sizes and shapes. Fingers come in all shapes and sizes. I want to make sure the device is usable for everyone.

# Conclusions/action items:

All in all, looking into this device allowed me to better understand the overall goal and ideals of our project. The world of medical sales is very expensive, and making an affordable design that competes with higher end designs while

also improving on them is important and must be achieved. I believe that making our device usable for everyone is also very important in making sure youth and elders can be supported in surgery with our device

# Aluminum - Material Research 10-7-2025

Ben Willihnganz - Nov 13, 2025, 4:13 PM CST

**Title: Aluminum Research** 

Date: 10/7/2025

Content by: Ben Willihnganz

Present: N/A

Goals: Find a strong, cheap, and lightweight metal for use in the mechanical portion of our design

Search Term: Strong lightweight metals

<u>Link: - Recent advances in cost-effective aluminum alloys with enhanced mechanical performance for high-temperature applications: A review</u>

# Citation:

[1]L. Cui, K. Liu, and X.-G. Chen, "Recent advances in cost-effective aluminum alloys with enhanced mechanical performance for high-temperature applications: A review," Materials & Design, p. 113869, Mar. 2025, doi: https://doi.org/10.1016/j.matdes.2025.113869.

### Content:

Overall Material Consideration:

- Titanium
- Titanium alloy
- Aluminum
- Aluminum alloy
- Steal or treated steal

### Content on Aluminum:

Overall, aluminum or an aluminum alloy best fit the needs of our design. They check every box as far as strength, affordability, and weight. They are durable and can withstand the weathering of the operating room and post operation sanitation. Aluminum is a better choice for this project then the other options as the other 4 options fail to meet one of the criteria. It is also important to note that the choice of metal is subject to change as different materials could be obtained for a lower cost.

## Conclusions/action items:

Aluminum is the best overall candidate for the majority of metal aspects on our design. Its affordability, relative lightweight, and strength were all extremely valuable aspects for our project and aluminum best met this. It will be

important to begin searching for aluminum available in the makers space and the design labs before we begin purchasing materials we do not need.

# **Ballistic Nylon - Material Research 10-16-2025**

Ben Willihnganz - Oct 16, 2025, 3:57 PM CDT

Title: Ballistic Nylon Research

**Date:** 10/16/2025

Content by: Ben Willihnganz

Present: N/A

Goals: Look into the use cases and other details about a material our group found in the Makerspace.

**Search Term: Ballistic Nylon Material Information** 

# Citation:

[1] "Ballistic Nylon - Canwil Textiles," *Canwil Textiles*, Mar. 24, 2025. https://www.canwiltextiles.com/synthetic-coated-fabrics/ballistic-nylon/?utm\_source(accessed Oct. 16, 2025).

### Content:

Ballistic Nylon Use Cases or other Urethane Coated Fabrics

- Backpacks
- -Luggage
- -Straps
- Motorcycle Jackets
- Watch bands
- -Etc

# **Ballistic Nylon Information**

Ballistic Nylon is a traditional nylon rope material that has been coated in an epoxy for extra strength and durability. This allows the material to undergo more tension, stress, abrasion, and penetration that traditional products. This product was developed for flack jackets used in the second World War, which goes to show its strength and another use case. Ballistic Weave, which is specifically what we are considering using is said to be some of the strongest, most durable, and tear resistant woven fabric on the market, making it a great material for us to potentially move forward with.

# Conclusions/action items:

In all, I believe that ballistic nylon would be a great material for us to prototype on. It is currently available in the Makerspace and would allow us to get going on initial prototyping of our design. Initial prototyping allows for us to move forward with testing and minor improvements in the design throughout the next 2 months.

# **Ballistic Nylon Autoclave - Material Research 10-22-2025**

Ben Willihnganz - Oct 22, 2025, 2:11 PM CDT

Title: Ballistic Nylon Autoclave Research

Date: 10/22/2025

Content by: Ben Willihnganz

Present: N/A

Goals: Look into the overall ability of autoclave on nylon fabrics

Search Term: Ballistic Fabrics Autoclave

# Citation:

"Nylon 6/6 (PA 6/6) | ECK Plastic Arts | Plastic Fabrication, Thermoforming, Assembly - Binghamton NY," Eckplastics.com, 2024. https://eckplastics.com/nylon-66-pa-66/

## Content:

Typically, autoclave reduces the tensile strength of most nylon or polyester fabrics after repeated use. For nylon 6,6 the max service air temperature is 203°F much lower than typical autoclaving temperatures. It will be required of us to finger out whether or not this fabric can withstand the changes this temperature causes it to undergo. Melting should not be an issue typical melting points for nylon 6,6 is roughly 490°F.

# Conclusions/action items:

In all, it is crucial that our finger sleeves team tests and ensures the strength of the ballistic nylon sleeves after autoclave. Our client mentioned to us that they also have a plasma sterilization device that could be sued to clean the sleeves as well. This plasma sleeve could be an alternative if autoclave damages the material to the point that the ballistic nylon becomes ineffective in digital traction.

Ben Willihnganz - Oct 30, 2025, 11:51 AM CDT

Title: Ballistic Nylon Plasma Sterilization

**Date:** 10/30/2025

Content by: Ben Willihnganz

Present: N/A

Goals: Look into how nylon behaves in a plasma sterilizer

Search Term: Nylon in Plasma Sterilization

Citation:

[2]N. V. Annapurna, N. R. Goud, and S. Nadella, "Resurgence of Plasma Sterilization: A Review," *Journal of Ophthalmology Clinics and Research*, vol. 1, no. 1, p. 9, Jul. 2021, doi: https://doi.org/10.4103/jocr.jocr\_1\_21.

# Content:

After, the team determined that temperatures in an autoclave would exceed the temperature that nylon can undergo before some plasticizing occurs and overall strength and durability could be decreased, I wanted to look into temperatures at which a plasma sterilizer runs at. It was determined based on previous research that the set temperature we should attempt to avoid exceeding is roughly 95 degrees Celsius. A typical plasma device never exceeds 60 degrees Celsius, so this could be a good potential alternative. The one thing that we would need to be weary of would be if the hydrogen peroxide has any effect on the strength of the ballistic nylon, and if damage were to occur ensuring that the damage would not exceed a threshold that could cause the product to break or malfunction.

# Conclusions/action items:

All in all, it will be critical we test the effects that autoclave and plasma sterilization have on our finger sleeves. These are the 2 sterilization methods our client uses and ensuring our product can undergo these cleaning procedures is essential for the shelf life and success of the design. When we tensile test our material using the dog bone cut out, ensuring we test the cut outs after both autoclave and plasma sterilization will allow us to determine the correct sterilization method for our client.

Ben Willihnganz - Nov 05, 2025, 9:54 PM CST

**Title: MTS Machine Procedure** 

Date: 11/5/2025

Content by: Ben Willihnganz

Present: N/A

Goals: Familiarize myself with a device we will use for testing

Search Term: ASTM D 5034 Tensile (Grab)

## Citation:

[1] "ASTM D 5034 Tensile (Grab)» SGS-IPS Testing," *Ipstesting.com*, 2015. https://ipstesting.com/find-a-test/astm-test-methods/astm-d-5034-tensile-grab (accessed Nov. 06, 2025).

### Content:

- The mts machine tests breaking strength and elongation of fabrics
- should not be used for glass or knitted fabrics
- can do inch-lb and SI units and systems must be used independently, so make sure we set SI units when testing so we don't waste fabric
- force is applied until the specimen breaks
- many different built in features can output data on the material that is beneficial for testing

## Conclusions/action items:

In conclusion, this device will most definitely allow our finger sleeve team to determine the effects that high temperature autoclaving has on our specimen. It will be extremely important that we can determine if the specimen maintain enough strength to undergo autoclave and still be used after another use. In all, this testing will determine if our group can go forward with using ballistic nylon as a fabric for multiuse situations, or if the device has to be limited to 1 use.

Ben Willihnganz - Nov 20, 2025, 10:05 AM CST

**Title: Rubber Silicon properties** 

Date: 11/20/2025

Content by: Ben Willihnganz

Present: N/A

Goals: Determine whether or not rubber silicon will be useful to the final design

**Search Term: Rubber Silicon Properties** 

Citation:

AZO Materials, "Properties: Silicone Rubber," *AZoM.com*, 2019. https://www.azom.com/properties.aspx? ArticleID=920

## Content:

When looking at max and min set point for standard rubber silicon products, I was able to determine using this data that the rubber silicon will have no issues in the OR or in the autoclave for sanitation. The maximum set temperature is roughly 226 Celsius which we will approach but never actually exceed and the minimum set temperature was roughly -70 Celsius which we will never approach given our design and goals for the project.

The overall tensile strength of standard rubber silicon is much much stronger than our stich and ballistic nylon strength. Given this, and that the rubber silicon will be placed in an area of minimal to no stress, the product should never be pushed to failure in our design again making this material very usable.

# Conclusions/action items:

In conclusion, the silicon tape we ordered should be more than usable in our final design. The autoclavability and location of the tape in our design both contribute to why this product is usable for the betterment of the sleeves. Our goal with this product is to use it to enhance the grip of our product onto the fingers to ensure safety for the patient and the doctor.



# **Economic Research of Senegal 10-8-2025**

Ben Willihnganz - Oct 08, 2025, 8:00 PM CDT

Title: Senegal Economic Research

Date: 10/8/2025

Content by: Ben Willihnganz

Present: N/A

Goals: Find a comparison in economics between the United States and Senegal to better explain the cost

component of our design

Search Term: Senegal GDP

Link: - Senegal

# Citation:

[1]The World Bank Docs, "SELECTED INDICATORS\*," 2016. Accessed: Oct. 09, 2025. [Online]. Available: https://thedocs.worldbank.org/en/doc/b3502c65235d8c72aef5f34d87ed6298-0500062021/related/data-sen.pdf

## Content:

The overall GDP of Senegal is significantly lower than that of the US. The GDP per capita is roughly 40 times lower amongst other economical differences between the two countries.

### Conclusions/action items:

In all, it will be an important factor of our design to keep our cost low for our Doctor in Senegal. It is not extremely important for the team to consider cost at the moment as we have no understanding of what our client has in mind for the budget. It will be important for us to understand that the budget could be lower than typical devices on the market.



# 11/13/2025 Tensile Testing Session 1 - Copy

Ben Willihnganz - Nov 13, 2025, 4:17 PM CST

Title: Tensile Testing Session 1

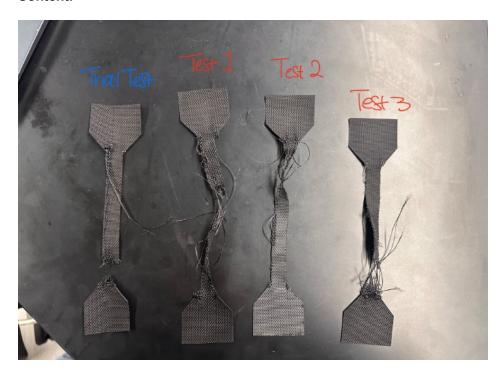
Date: 11/13/2025 (happened on the 12th)

Content by: Ben Willihnganz

Present: Nathan Hansen, Ben W

Goals: Record 3 good data points for our baseline tests

# Content:



Above is a visual representation of 4 tests we ran to tensile test our ballistic nylon dog bone. We tested the 3 real tests using a 1kN load cell and were able to test strength values of roughly 700N per dog bone. Our goal with this information is to be able to determine if autoclave will degrade our baseline material in terms fo strength. We hope that given our the strong baseline performance of the material, that even when autoclave does inevitably degrade the material slightly that it will still be able to perform very well.

# Conclusions/action items:

We hope to finish tensile testing soon through use of the autoclave after we can find a tray suitable for our dog bones.

Ben Willihnganz - Dec 07, 2025, 2:49 PM CST

Title: Slippage Testing

Date: 12/1/2025

Content by: Ben Willihnganz

Present: Sam D, Ben W, Nathan H

**Goals:** Reevaluate testing protocol for slippage and edit based on what was done.

## Content:

## **Description:**

A testing protocol to determine how much the finger sleeve will slip on the average finger, so that the finger sleeves can be used for 50 minute operations without the risk of the finger sleeve losing grip of the finger.

### Materials:

- · Prototype of finger sleeve
- · Stop watch
- Caliper
- Willing Participants
- · Wooden Board
- · Nail in which sleeve will hang
- · Permanent marker

## **Protocol:**

- 1. Take the nail and hammer it into the ply board to act as a hook
- 2. Have the participant sit in the chair and attach the finger sleeve to the stand, having the participant hang their arm from the stand with their shoulder and elbow at a 90 degree angle
  - a. Make sure that the participants arm is not resting on the chair and that the forearm is hanging perpendicular to the floor
- 3. Properly secure the finger sleeve prototype to one of the participants fingers and mark the initial pretested point for both the lower and upper connection points
- 4. Once, the participant is in the proper position, start the stopwatch
- 5. Wait for the timer to reach 10 minutes, and then make a mark on the finger of the participant, after the dot is created the sleeve can be disconnected and the participant can relax their arm
- 6. Using the caliper, measure the distance in mm to the nearest tenth between the first mark and the second.
- 7. Repeat this process for each participants finger

# Conclusions/action items:

Testing allowed us to determine the overall effectiveness and safety of the design and this protocol outlined how that was done. It was a repeatable and effective protocol and it achieved our purpose in testing.

Ben Willihnganz - Sep 21, 2025, 11:21 PM CDT

Title: Frame and Machine Design Idea

Date: 9/21/2025

Content by: Ben Willihnganz

Present: N/A

Goals: Put brainstorm idea for frame and mechanism onto paper in order for it to be considered for the final design

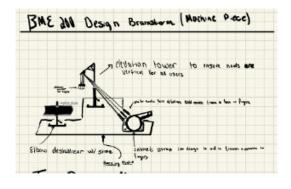
## Content:

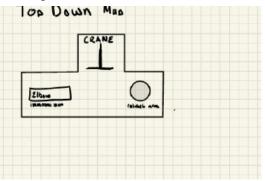
- Attached is an image of a notebook page I used to sketch my machine/ frame.
- I used a ratchet strap as an application of tension rather than gravity like most ideas we have seen
- The tension strings could be made out of steal strings, but alternatives could be explored if MRI compatibility is required
- Force detection in the manner I suggested could be potentially difficult and alternatives may have to be explored here as well
- I believe that this design could be the most versatile for both surgery and day to day stint and cast application as well
- A table on wheels could be a necessary for this design to function, but permanently fixating it to a table could remove some of the workability and mobility of the design

# Conclusions/action items:

In all, I believe that this design could solve our clients issues and do so in a unique and effective way. The rachet strap is a bit clunky, but when improved upon I believe it is a effective way of applying tension to the fingers for every applicable surgery and desired use. I know this design is quite raw, but I believe it presents some relevant ideas for traction application, like the rachet strap. I also believe that the curved elbow immobilizer could be added to other designs in our group in order to improve them.

Ben Willihnganz - Sep 21, 2025, 11:21 PM CDT





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BME\_200.pdf (3.34 MB)

Ben Willihnganz - Sep 21, 2025, 11:17 PM CDT

**Title: Finger Sleeve Design** 

Date: 9/21/2025

Content by: Ben Willihnganz

Present: N/A

**Goals:** Put brainstorm idea for finger sleeves onto paper in order for it to be considered for the final design and design matrix.

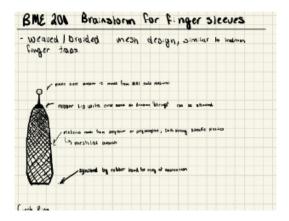
## Content:

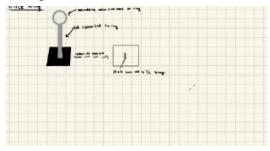
- Attached is an image of a notebook page I used to sketch my idea for the finger sleeve aspect of our design.
- Research would be required in order to finalize material choice for the sleeves.
- The circle hook would require have to be made from a metal that is not conductive to optimize MRI compatibility.
- The circle hook could also be replaced with an other type of screw, bolt, or connection device in order to adhere with other designs created by the team.
- I believe that upholding the durability of the sleeve can be increased by using the rubber piece in the tip of the sleeve, I do believe that this would change the performance of the device, just increase the finger sleeves shelf life.

# Conclusions/action items:

In conclusion, I believe that the material our finger sleeves are made out of is the most important aspect in deciding on which design is best. I believe that a strong mesh like plastic will be perfect for this job. Meshes will work best as the mesh's grid will stretch and secure the finger allowing tension to be applied to it. A rubber band could be a helpful at the bottom of the sleeve to keep the sleeve on the finger while the tension is being adjusted, especially if the client is in pain or immobile.

Ben Willihnganz - Sep 21, 2025, 11:18 PM CDT





**Download** 

BME\_200\_1\_.pdf (2.62 MB)

# 10-22-25 Finger Sleeve Cutout Template

Ben Willihnganz - Oct 22, 2025, 1:50 PM CDT

**Title: Finger Sleeve Laser Cut Template** 

Date: 10/22/2025

Content by: Ben Willihnganz

Present: N/A

Goals: Create an Onshape sketch that can be laser cut

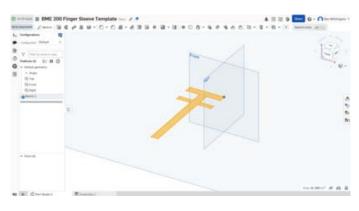
## Content:

- Attached is an image of my Onshape sketch
- The overall design consists of two wrapping portions and the main sleeve itself
- This template would require the attachment of cable ties to tighten the sleeves
- In all, the design could be potentially used, as it would require the least amount of reliance on sewing.

# Conclusions/action items:

In all, I believe that this template would create an effective finger sleeve. After cutting the ballistic nylon we purchased from the Makerspace, we have determine that the initial dimensions of this cut out were a bit small, but could easily be changed after the prototyping stage.

Ben Willihnganz - Oct 22, 2025, 1:51 PM CDT



**Download** 

Screenshot\_2025-10-22\_134457.png (199 kB)

# 12/1/2025 slippage and comfort testing ideas

Ben Willihnganz - Dec 01, 2025, 10:38 AM CST

Title: Slippage and comfort testing ideas

**Date:** 12/1/2025

Content by: Ben Willihnganz

Present: N/A

Goals: Brainstorm ideas to better our testing section for the final paper

## Content:

# slippage ideas

- find the max length of operation for a typical wrist or hand procedure and test the overall slip distance of the device in that time
- potentially look at differences with people that have sweaty palms and would potentially be prone to higher slippage
- based on the two points above, decide the max duration of the device with a certain standard of safety

# comfort testing

- look out for any major points of pain or discomfort when the hand is suspended
- test this differing amounts of fingers and decide whether that plays a role in the overall comfort of the device
- potentially look into a survey and create data with overall comfort

## Conclusions/action items:

In all, I believe that both of these tests are critical in deciding if our device achieves its purpose. The device needs to be safe and the slippage test is vastly important in determining the safety of the design. Then, for the comfort test, we have to determine of a patient would experience discomfort if they were to be awake for a casting or another procedure like that. In all, we should use these 2 tests and determine any future works for the project and decide if they are things we can do before the poster presentation.

Ben Willihnganz - Oct 31, 2025, 10:19 PM CDT

**Title: Intro to Machining Documentation of Completion** 

Date: 10/31/2025

Content by: Ben Willihnganz

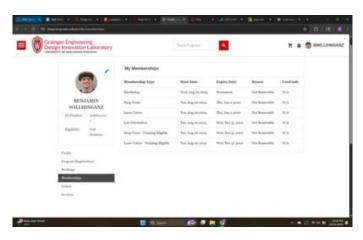
Present: N/A

Goals: Learn to use the lathe and the mill

Content:

\*Certificate of completion is attached below

Ben Willihnganz - Oct 31, 2025, 10:17 PM CDT



**Download** 

Screenshot\_2025-10-31\_221020.png (319 kB)



# 10/31 Biosafety Training Completion

Ben Willihnganz - Oct 31, 2025, 10:18 PM CDT

**Title: Biosafety Documentation of Completion** 

Date: 10/31/2025

Content by: Ben Willihnganz

Present: N/A

Goals: Educate myself in biosafety for further use in my degree and future jobs

Content:

\*Certificate of completion is attached below

Ben Willihnganz - Oct 31, 2025, 10:19 PM CDT



**Download** 

Screenshot\_2025-10-31\_220932.png (233 kB)



Ben Willihnganz - Oct 31, 2025, 10:21 PM CDT

**Title: Chemical Safety Training** 

Date: 10/31/2025

Content by: Ben Willihnganz

Present: N/A

Goals: Learn about lab standards for chemical safety provided by OSHA

Content:

\*Certificate of completion is attached below

Ben Willihnganz - Oct 31, 2025, 10:20 PM CDT



**Download** 

Screenshot\_2025-10-31\_220932.png (233 kB)



# 11/7/2025 Building a Career of Impact

Ben Willihnganz - Nov 07, 2025, 12:43 PM CST

Title: Building a Career of Impact

Date: 11/7/2025

Content by: Ben Willihnganz

Present: N/a

Goals: Learn about the importance of BME in health care

Content:

# Overview

- Kristin Myers goes over her background and experiences in BME
- The speaker recommended the following: "Run Towards the hard problems... They are the ones that change the world"

# Chapters:

- 4 internships all over the board and the midwest
- · Received a business degree from Harvard and became a venture capitalist
- took a role leading a group of OBGYN and then covid hit, 50% of workers were laid off
- · Learning towards becoming the best team worker you can be
- There is a massive shortage of rural practicians solving that issue was something the speaker worked towards
- · The US is behind in healthcare
- "Follow hard problems and take on tough issues
- · quadruple aim
  - improved provider experience
  - improved patient outcomes
  - o lower cost of care
  - improved patient experience
- It is becoming a huge difficulty to be a physician in this country

## archaic system in healthcare

- · misaligned incentives
- · fragmented financing and regulation
- data silos and legacy IT
- inequities (10-15yr gap between zip codes)

# systems are what engineers build best

- · primary doctors are not compensated for there work, people will run towards money always
- · slight issue of doctors going to the field for money

## Final notes:

- 1
- work hard and build range

- Take on the hardest projects, classes and experience you can find. Effort and range are your foundation
- look for an office job not an at home job
- 2
- seek diverse exposure
  - explore different sectors, teams and geographies
  - gain perspectives and learn how system connect, not just how parts work
- 3
- choose your people wisely
  - surround yourself with curious, driven, high integrity people
  - they will shape who you become
- 4
- know your values and protect them
  - define what matters most
    - family and friends
    - health
    - career impact
- 5
- o embrace challenge and keep growing
  - run towards hard problems
  - growth lives on the edge of discomfort
  - where big impact starts

Conclusions/action items: It is widely important to incorporate your beliefs and personality into everything you do, push yourself to do the hard and challenge yourself every single day



# 9/9/2025 Biology and Physiology Research Article 1

Sam Dudek - Sep 09, 2025, 10:54 AM CDT

Title: Biology and Physiology Research Article 1

Date: 9/9/2025

Content by: Sam Dudek

Present: N/A

**Goals:** To find information on the purpose of hand and finger fracture management and why digital traction is important to both the patient and the surgeon. Additionally, to understand why it is so important and what it means to successfully manage a hand or finger fracture, both during and after surgery.

## Content:

- -Hand fractures are the most common fractures within ortho clinics
- -There are a lot of small and irregularly shaped bones within the hand and fingers
- -"The hands long-term function is often dependent on the fractures angulation and rotation"
- -A main reason for management is to reduce any shortening of the ligament
- -Traction in particular, can restore alignment of those tiny bones
- -It can also create more space for surgery or healing
- -It stabilizes during fixation, protects soft tissue, and supports rehabilitation
- -Traction assisted surgery is good for a lot of reasons, it aligns fractures to preserve joint mobility, reduces crushing forces, allows the surgeon to see and work inside small joints, and more

# Citation:

[1 D. Haughton, D. Jordan, M. Malahias, S. Hindocha, and W. Khan, "Principles of hand fracture management," *Open Orthop J*, vol. 6, pp. 43–53, 2012, doi: 10.2174/1874325001206010043.

# Conclusions/action items:

Continue to research both the biological need for digital traction in surgery, but also start to research different strategies that are already being used in the field. On top of that look at different designs and prototypes that have already been used or designed and note that.



# 10/03/2025 Biology and Physiology Research Article 2

Sam Dudek - Oct 03, 2025, 4:08 PM CDT

Title: Biology and Physiology Research Article 2

Date: 10/03/2025

Content by: Sam Dudek

Present: N/A

Goals: To learn more about the need of digital traction systems in the Dakar region by looking at a study of common workplace injuries in the region.

## Content:

- -This study covered 5 years and 9308 work accidents that were declared to the Social Security fund in Dakar.
- -Many of the accidents had fractures, many of those involving upper limbs and hands. This means there is a demand of surgeries that may need a device like this.
- -A traction device could help reduce complications which could shorten rehab time if used correctly.
- -A system to work correctly has to see patient comfort and risk management. It also has to be easy to use.

## Citation:

[1] S. A. Dia *et al.*, "Caractéristiques des accidents du travail et devenir des victimes: à propos de 133 cas déclarés auprès de la Caisse de Sécurité Sociale de Dakar (Sénégal)," *Pan Afr Med J*, vol. 30, p. 156, June 2018, doi: 10.11604/pamj.2018.30.156.10517.

**Conclusions/action items:** Continue to work on maximizing the potential of this device, and put yourself in the shoes of the doctor and patient to try and create a device that is easy to use and adaptable for all types of procedures of the hand and wrist.

# 10/21/2025 Nylon-11 Nanofiber Research

Sam Dudek - Oct 21, 2025, 11:02 AM CDT

Title: Nylon-11 Nanofiber Research

Date: 10/21/2025

Content by: Sam Dudek

Present: N/A

Goals: To explore how nylon performs under tension and evaluate its strength and flexability

### Content:

This study measured the tensile strength of nylon-11 fibers. It showed it was a strong, flexible, and biocompatible material used for medical applications. A lot of this article talked about how adding carbon dots to the nylon enhanced its strength. Carbon dots are nano materials that go into the nylon. They do this by first creating the dots by heating up something natural, blending into a solution of nylon, and then creating it that way. This seems pretty complex. This article is still important to know though, because their baselind data demonstrates nylons abiloity to withstand a lot of tension, which directly applies to our project.

Data: "With the incorporation of F-CDs at 10 wt% into the Nylon-11 nanofiber mats, the tensile strength increases from 7.5 to 16.6 MPa, and the elongation ratio at break increases from 39% to 125%."

Citation: [1] X. Chen *et al.*, "Green Synthesis of Carbon Dots and Their Integration into Nylon-11 Nanofibers for Enhanced Mechanical Strength and Biocompatibility," *Nanomaterials (Basel)*, vol. 12, no. 19, p. 3347, Sept. 2022, doi: 10.3390/nano12193347.

### Conclusions/action items:

Possibly do some research on how different types of nylon or surface coatings are effected by moisture and apply it to common hospital rooms and their humidity levels there. We could possibly look into improving antimicrobial additives to improve saftey for all.



# 9/9/2025 Competing Designs Research Article 1

Sam Dudek - Sep 09, 2025, 10:53 AM CDT

Title: A Simple Technique for Injecting the Small Joints of the Fingers and Thumb Using Finger Traps for Traction

Date: 9/9/2025

Content by: Sam Dudek

Present: N/A

Goals: To research a specific design or way that digital traction is being used in the world of surgery, and to take inspiration from it.

## Content:

- -Although this is not a direct use of traction for surgery, it gives us a good idea of what digital traction does
- -Usually, injecting steroids into small joints is hard, so they use a Japanese finger trap to pull the finger and make it "safe and easy" to enter.
- -What this shows is that using a Japanese finger trap is a good way to pull the finger into a stretched position
- -When in the stretched position, we now have evidence that it frees up space to make it easier for a doctor to do work. Whether this is injecting something like a pain reliever or actually doing surgery, using traction to pull the finger away from the body properly aligns the figure to do work on it.

## Citation:

[1 M. Bashir and A. Arya, "A simple technique for injecting the small joints of the fingers and thumb using finger traps for traction," *Ann R Coll Surg* ] *Engl*, vol. 98, no. 5, pp. 343–344, May 2016, doi: 10.1308/rcsann.2016.0110.

## Conclusions/action items:

Continue to find other competing designs or ideas to properly align the finger and free up space within the finger to it is easier to do surgery. Not only that, but build on ideas like this to improve precise positioning and reducing manual labor.



# 9/9/2025 Competing Designs Research Article 2

Sam Dudek - Sep 09, 2025, 10:53 AM CDT

Title: Competing Designs Research Article 2

Date: 9/9/2025

Content by: Sam Dudek

Present: N/A

Goals: To look at many different competing designs and/or devices to learn from and take inspiration from when creating a future prototype.

## Content:

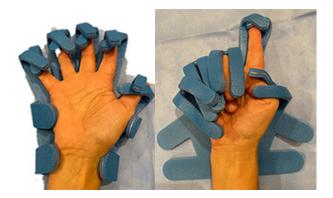
- -There are many different devices
- -Wrist traction tower:



-Equalizing Device & Horizontal Traction Tower:



-Alumi-Hand Surgical Hand Plus Immobilizer



These are just 3 of the different types, and the last one is very different from the first two. It can be used in an x ray, is disposable, and basically can secure the hand in any position possible. Whether you want something stretched or flexed, anything is possible with that. With the first two, they use Japanese finger traps to pull the fingers. One using a tower and one that is more horizontal. My assumption is that it would be easier for the surgeon if the hand was resting on a surface.

### Citation:

- [1 "Surgical Finger Traps | Non-Sterile Finger Traps | SW Med-Source." Accessed: Sep. 09, 2025. [Online]. Available:
- ] https://www.swmedsource.com/traction\_finger\_traps.htm

# Conclusions/action items:

There are a lot of different ways to go about digital traction. We need to find a way that minimizes effort for the surgeon, so a successful procedure is more likely to happen.



# 9/14/2025 Competing Desing Research Article 3

Sam Dudek - Sep 14, 2025, 8:24 PM CDT

Title: Competing Design Research Article 3

Date: 9/14/2025

Content by: Sam Dudek

Present: N/A

Goals: To research more about the type of product our client used to use, and its size, weight, materials, aesthetics and finish.

## Content:

This is a medical device that has rings as the base, an S shaped metal hook, and a Trumpf hand holder. There were a lot of metal parts used. In terms of the finish they put foam over the metal in any spots that soft tissue was going to come in contact. Overall, the aesthetics are more raw compared to a sleek look. For size, there is an adjustability aspect. They use rods that can be extended to create more traction in the fingers. It is pretty large, the base in around 336 mm length and radius on the bottom, and 250 mm rods that go all the way up.\





## Citation:

 $[1\ A.\ Zolotov,\ "Handmade\ Traction\ Wrist\ Tower,"\ \textit{J}\ \textit{Wrist}\ \textit{Surg},\ vol.\ 7,\ no.\ 5,\ pp.\ 441-444,\ Nov.\ 2018,\ doi:\ \underline{10.1055/s-0038-1649504}.$ 

# Conclusions/action items:

Review standards for medical devices, including those that come into contact with the skin and those that must be compatible with an MRI machine. After that, draft into the PDS about what I have learned.



# 9/14/2025 Standard 1 MRI Compatible Devices

Sam Dudek - Sep 14, 2025, 8:39 PM CDT

Title: Standard 1 Compatible Devices

Date: 9/14/2025

Content by: Sam Dudek

Present: N/A

Goals: To find what materials we can and cannot use due to the need of being used in an MRI machine.

## Content:

The device must fit within the sterile surgical field, and cannot interfere with any other devices. It needs to be compact enough that it wont block MRI coils or distort imaging. Heavier components risk displacement forces in the machine, lower weight improves that. There is no strict weight cut-off, you would have to test the displacement forces. The materials have to be non-ferromagnetic, non-conductive, and biocompatible. These are things like plastics, ceramics, and titanium is possible too.

## Citation:

[1] ASTM International, Standard Practice for Marking Medical Devices and Other Items for Safety in the Magnetic Resonance Environment, ASTM F2503-20, West Conshohocken, PA, USA, 2020.

Link: compass

## Conclusions/action items:

Continue to find other standards to figure out what type of materials can or cannot be used for the device.

Sam Dudek - Sep 14, 2025, 8:46 PM CDT

Title: Standard 2 Biocompatibility

Date: 9/14/2025

Content by: Sam Dudek

Present: N/A

Goals: To look into biocompatibility with materials coming into contact with the skin.

## Content:

Our materials must be tested to ensure they do not release irritating substances, causing redness, burning, itching, or swelling. Basically, we just need to make sure that none of the materials are harmful for the skin.

## Citation:

[1] International Organization for Standardization, *Biological Evaluation of Medical Devices—Part 23: Tests for Irritation*, ISO 10993-23:2021, Geneva, Switzerland. 2021.

Link: compass

## Conclusions/action items:

Continue research on materials and design, and once we get to designing, make sure to pick materials that are known to be safe for all people and all skin.



# 10/26/2025 Tensile Testing Standard (Strip Method)

Sam Dudek - Oct 26, 2025, 1:23 PM CDT

Title: Tensile Testing Standard (Strip Method)

Date: 10/26/2025

Content by: Sam Dudek

Present: N/A

Goals: Research tensile testing of woven fabrics like ballistic nylon to see procedures and how to go about it

### Content:

- -The overall message that this standard is talking about the breaking force and elongation at break of textile fabrics, which is exactly what we need to test. This applies to woven, non woven, and coated fabrics, which we may do later possibly. When you run this procedure the units for breaking force are N or lbf and per unit is usually per mm. The elongation at break is %.
- -An important thing to talk about is the conditions that they mention, which is around 70 +- 2 degrees F, with a relative humidity of around 65 +- 2%, and the conditions need to be reported, if we were publishing of course.
- -In this they use a standard UTM tensile tester called a Constant rate of extension (CRE).
- -One thing that was important is that there can be no frays, which is good because the laser cutter doesnt do that to the nylon.
- -Although it is a little hard to exactly know what all of this means, as I have never been truly investigated or used the tensile tester machine, these were the setup specifications of the procedure marked up in the standard.
- 1. Use a universal testing machine
- 2. Use flat or rubber faced grips the stop slipping
- 3. Default strip was 50mm wide (but we can change them by 6in, 75 mm gauge length
- 4. Crosshead spee3d was around 300 mm/min, can slow all the way down to 100mm/min
- 5. Conditions were 70F,65% humidity)
- 6. Test both warp and weft directions
- 7. Minimum 5 repeats per direction

Citation: [1] **ASTM International**, *ASTM D5035-11(2019): Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)*, ASTM International, West Conshohocken, PA, USA, 2019. doi:10.1520/D5035-11R19

## Conclusions/action items:

Use this knowledge to create a testing protocol to test the durability and strength of our ballistic nylon as a dog bone shape at different widths.



# 10/28/2025 Tensile Testing Standard (Grab Method)

Sam Dudek - Oct 28, 2025, 10:41 AM CDT

Title: Tensile Testing Standard (Grab Method)

Date: 10/28/2025

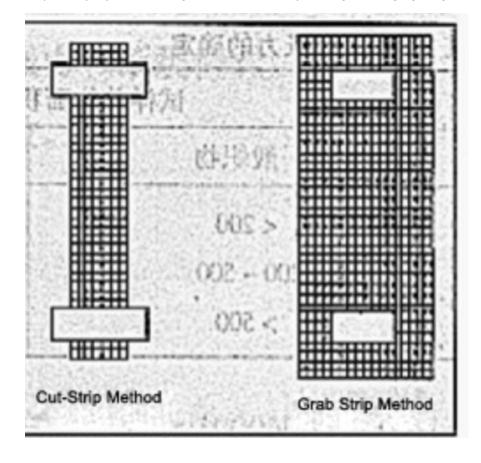
Content by: Sam Dudek

Present: N/A

Goals: Research the grab method to find differences from the strip method and see what is better for our material

## Content:

- -The difference between this method and the strip method is that this clamps basically the entire with, not just the narrow dogbone. So this method will have a much larger force needed to break the nylon, because it measures how well the nylon helps and works together. It is much more representative of the entire fabric and how it behaves when it is actually in use. This obviously sounds good, but could pose problems because it would take longer and take a lot more force to break, usually this is for not as strong of fabric. For example, SGS IPS in Appleton does it on tissues a lot, both wet and dry.
- -For a testing protocol, everything would be the same, but there would be no dogbone, just strips of different width.
- -It specifically says to cut rectangles 100mm 4 in wide by 6 in long, and set gauge length to 3in. The speed once again should be 300mm/min.





Citation: [1] ASTM D5034–21, Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test), ASTM International, West Conshohocken, PA, 2021.

# Conclusions/action items:

Talk with team and advisor about which test to do, and which will fit our project better. After that, do the test and report.



# 10/26/2025 Possible Tensile Testing Protocol

Sam Dudek - Nov 03, 2025, 6:04 PM CST

Title: Possible Tensile Testing Protocol

Date: 10/26/2025

Content by: Sam Dudek

Present: N/A

Goals: To create a tentative protocol for tensile testing of different widths of ballistic nylon

Content:

Prep Work:

-Cut 3 widths of dog bones (for us, 1.5 cm, 1.75 cm, 2.0 cm). Overall length should be 150mm. The gauge length should be 150mm.

Setup:

- -Mount the dog bone and clam the ends in the arms.
- -Set the gauge length and speed at 100 mm/min
- -Apply small pre load to get rid of slack

Test:

- -Pull fabric until it breaks
- -Record the maximum load in N and extension at break

Breaking force is the max load, strength per width is N/mm, and elongation percentage is the (extension)/(50mm) x 100%.

- -Says to do 5 times each width, but if we don't have enough nylon, 2-3 is good.
- -Create table

# Conclusions/action items:

Use protocol to create plots that are easily communicated to ourselves and the client, and use this data to decide what length the final width should be.

Sam Dudek - Nov 03, 2025, 2:55 PM CST

Title: Autoclavability of Silicone

Date: 11/03/2025

Content by: Sam Dudek

Present: N/A

Goals: To find more about any problems we may run into while trying to test our prototype and to find details about the autoclavability of our new addition material, elastic silicone.

#### Content:

Citation: [1] E. Gautriaud, K. T. Stafford, J. Adamchuk, M. W. Simon, and D. L. Ou, "Effect of Sterilization on the Mechanical Properties of Silicone Rubbers," Saint-Gobain Performance Plastics, White Paper, 2009. [Online]. Available: <a href="https://www.biopharm.saint-gobain.com/sites/hps-mac3-lifesciences-bioprocess/files/effect-of-sterilization-on-the-mechanical-properties-of-silicone-rubbers.pdf">https://www.biopharm.saint-gobain.com/sites/hps-mac3-lifesciences-bioprocess/files/effect-of-sterilization-on-the-mechanical-properties-of-silicone-rubbers.pdf</a>. [Accessed: Nov. 3, 2025].

- -This study mostly talks about three sterilization methods, gamma irradiation, electron beam irradiation, and ethylene oxide gas treatment. It does not talk much about steam sterilization, which is very common, and kind of unfortunate, considering we need to see how it acts specifically under autoclayment.
- -But with that said, there are still some things we can take away from it. One thing is that high temperatures can cause extraction of low-molecular-weight species species from silicone rubber. This means that there is a concern with the material integrity, considering our finger sleeves are small.
- -In what they actually tested, the irradiation deteriorates mechanical properties (hardness increases, tensile elongation decreases, and tensile strength and tear strength degrade). This is important because if we use silicone for our sleeve we know they shouldn't use this.
- -The next finding was that EtO gas sterilization had minimal negative effect, sometimes the tensile strength or elongation improved slightly. So this would be preferred for silicone rubber.

# Conclusions/action items:

Verify with the manufacturer's data for specific silicone information on autoclavement, but we need to know exactly what we are buying first. Also find if they have EtO method in the hospital in Senegal.

Sam Dudek - Nov 13, 2025, 8:50 AM CST

Title: Tensile Testing Session 1

Date: 11/13/2025 (happened on the 12th)

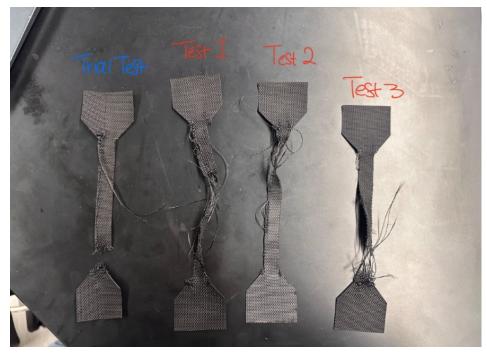
Content by: Sam Dudek

Present: Nathan Hansen, Ben W

Goals: Get 3 good data sets in for 3 control tensile tests of our ballistic nylon.

## Content:

Because Nathan had already taken 201 and had used the MTS machine in a separate class the same day, it is important to note that he was much more familiar with the machine and did a lot of the computer work associated with the MTS machine. Either way, we first clamped in our test trial into the machine, which already had a slight weakness to it as the laser cutter cut it wrong. We just wanted to make sure that we had the right program running on the computer. After that, we did 3 more tests, all with the same feed and graphing. The first one split in half, with the other two splitting near the end. We believe this is because they were set up slightly differently, but even so, our raw findings show that this is a very strong material, and even if autoclaving it decreases strength over time, this is still a good material to use. Nathan has all the raw data that he can put into MATLAB.



# Conclusions/action items:

Eventually, sterilize some pieces of ballistic nylon material and then go back to the MTS machine to test those as well.

# 11/18/2025 Autoclavability Results Research

Sam Dudek - Nov 18, 2025, 12:22 PM CST

Title: Autoclavability Results Research

Date: 11/18/2025

Content by: Sam Dudek

Present: N/A

Goals: Find some reasoning for our autoclaving results in terms of the raw data given by MTS testing before and after a round of sterilization

#### Content:

To summarize what was shown after MTS testing our ballistic nylon after one round of autoclaving, we saw that the strength was very similar. What changed was the elongation at break, which was longer. The elastic modulus also went up. So overall trend was more ductile, less stiff, similar strength.

## What I Found:

- -During autoclaving, steam is exposed to Nylon as pressurized water. Because of the high temperature and steam it increases moisture absorption by nylon. This then puts nylon in something called a highly plasticized state.
- -This happens because nylon is very hygroscopic and absorbs water easily through hydrogen bonding.
- -When water interacts with nylon it can lower stiffness, increase flexibility, and more, which is what we saw in our results.
- -One thing to note is that usually when you autoclave the absorption happens, which only is hydrogen bonding of water, it doesn't break any bonds of the material, making the strength stay similar. If the temperature were to get very high, it could break bonds and degrade the material (hydrolysis).
- -Most of the time the nylon dries in 3-4 hours, bringing it back to normal absorption, which is low. The autoclave speeds up the hydration.

Citation: [1] D. Mesyn, "Managing Moisture: The Science Behind Moisture Absorption in Nylon." Accessed: Nov. 18, 2025. [Online]. Available: <a href="https://etp.teknorapex.com/blog/moisture-absorption-in-nylon">https://etp.teknorapex.com/blog/moisture-absorption-in-nylon</a>

# Conclusions/action items:

This is very important and explains our test results, and is something we did not understand before. Continue to test our 5x autoclaved material to see if it continues to match this hyptothesis.

Ben Willihnganz - Dec 07, 2025, 2:13 PM CST

Title: Slippage Testing

Date: 12/1/2025

Content by: Sam Dudek

Present: Sam D, Ben W, Nathan H

Goals: Test average displacement on different fingers after hanging for an interval of 10 minutes

# Content:

Here is a picture of how we did it, basically, we had our arms hanging like dead weight to simulate the use. Actually our results will likely be stronger because there will be sleeves on multiple fingers, not just one. Here is a picture:



# Raw Data:

	Pointer Disp.	Middle Disp.	Ring Disp.	Pinky Disp.
Bottom Hold	1.5mm,0mm	1.2mm,0.8mm	0mm,1.3mm	2.0mm,1.5mm
Top Hold	2.2mm,2.0mm	0mm,1.5mm	1.5mm,0mm	0mm,1.1mm
Finger Length	95mm, 83mm	109mm, 98mm	98mm, 90	62mm, 60mm
Finger Girth	60mm, 52mm	65mm, 61mm	58mm, 54mm	48mm, 42mm

# Conclusions/action items:

We found that one important thing to do is to maybe switch the Velcro every couple of times. We also found that the biggest reason something would slip is because of how it was put on, so that is very important.

We added the finger lengths and girths for each test on 12/7/2025 but it was done on 12/1/2025.

Sam Dudek - Oct 31, 2025, 5:41 PM CDT

Title: Training Proof

Date: 10/31/2025

Content by: Sam Dudek

Present: N/A

Goals: To show evidence that I have completed the necessary training for BME 200

Content:



This certifies that Sam Dudek has completed training for the following course(s):

My Memberships

Membership Type

Woodshop Orientation

Laser Cutter - Training Eligible

Machining

Shop Tools

Laser Cutter

Lab Orientation

Course	Assignment	Completion	Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024-2025	10/12/2025	10/12/2030
Chemical Safety: The OSHA Lab Standard	Final Quiz	10/12/2025	

Start Date

Wed, Aug 20 2025

Wed, Feb 12 2025

Tue, Aug 20 2024

Tue, Aug 20 2024

Tue, Aug 20 2024

Tue, Aug 20 2024





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Profile

Program Registrations

Conclusions/action items: Continue to do trainings next year and heading into the future.



# 10/08/2025 Client Research for Preliminary Report

Sam Dudek - Oct 14, 2025, 10:58 AM CDT

This research was done on 10/08/2025 and edited/logged on 10/14/2025.

Sam Dudek - Oct 14, 2025, 10:58 AM CDT

Title: Client Research for Preliminary Report

Date: 10/08/2025

Content by: Sam Dudek

Present: N/A

Goals: To figure out concrete information about our client, his companies. Also, our other client and the hospital he works in.

#### Content:

Our client Mr. Pape Samb is the founder of the non profit Jamerek. What this company does is focuses on helping historically underserved communities and regions within Senegal. He has been a Software Engineer, Network Specialist, and an Electronic Engineer. He is also a founder of multiple other companies creating solutions for businesses with IT problems. He also serves on the board of Sun Prairies Media Center, is a TV and radio producer. Lastly, he is behind a STEAM program that promotes engineering and technology to BIPOC communities. Our client does a ton of cool things in this community and communities within Senegal.

Citation: [1] "Pape Samb – Jamarek." Accessed: Oct. 05, 2025. [Online]. Available: https://jamarek.org/wps-members/petter-nilsen/

## Conclusions/action items:

Our client is a very eclectic man and is very helpful. Knowing this information is not just good for the report, and for others to know, but helps us further understand the purpose of the project. Knowing this and remembering this during the harder parts of the project can propel us forward later on.

Sam Dudek - Sep 21, 2025, 9:43 PM CDT

Title: Platform Design 1

Date: 9/21/2025

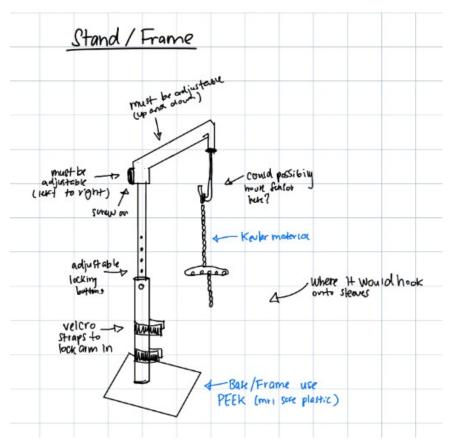
Content by: Sam Dudek

Present: N/A

Goals: Design and draw out a design for the stand mechanism for the device, and note some of the fine details that need to be noted.

## Content:

-The stand and most of it need to make out of a plastic that is strong and also MRI compatible. A good idea would be to use PEEK, which is Polyether ether ketone. At multiple places, it needs to be adjustable and needs to be able to move to fit comfortably for both the patient and the physician. There will need to be more thinking towards how to make it adjustable if we go on with this idea, because that will be an important part of it. For this device, the arm will go on the base, so we might need to put padding there. It will be strapped in by those straps and then hung by connecting the sleeves to the Kevlar chain or string.



# Conclusions/action items:

Continue to brainstorm and think about different possible designs for both the stand and the sleeve. Figure out the mechanisms to make it adjustable and confirm what materials must be used. Use the information that our client should get back to us soon with.

Sam Dudek - Sep 21, 2025, 9:57 PM CDT

Title: Sleeve Design 1

Date: 09/21/2025

Content by: Sam Dudek

Present: N/A

Goals: Design and draw out details for the Japanese finger sleeve portion of the project.

## Content:

-So this finger sleeve is basically what is on the market, and it is not much different. It is made of woven nylon which works well with people and is also MRI safe. What is good about this too is that we can buy multiple sizes. The only problem with these is that the hook is often metal which would not be compatible, so if we were to buy something we would need to take that off and make something new. Also, we could just buy the woven nylon and make our own.



## Conclusions/action items:

Continue to brainstorm once again. Once Mr. Pape Samb emails back with answers to our questions, come revisit ideas and edit and figure out if anything needs to be changed. Be prepared to talk about this with teammates and find unique solutions to different designs.



# 10/14/2025 Possible Testing for Final Sleeve Design

Sam Dudek - Oct 14, 2025, 11:16 AM CDT

Title: Possible Testing for Testing Final Sleeve Design

Date: 10/14/2025

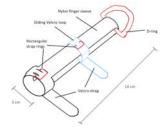
Content by: Sam Dudek

Present: N/A

Goals: Figure out possible ways to test force, slippage, and Velcro usage in the most efficient way possible for the final sleeve design.

#### Content:

For context, here is the final design for our sleeve portion of the project. This note will be split into two sections, one being the possible testing for comfort and slippage over time, as well as the durability of the Velcro straps.



For comfort testing, an idea I think that would go well is conducting a survey at the table talk. Two weeks from now, we should have a working prototype for the sleeve. If we do, due to the need for easy usage, it will be easy to put the sleeve on a finger, and test comfortability slippage on a wide range of finger types and sizes, on both men and women. We would put the sleeve on just by asking for volunteers and slipping it on. If we do not have a prototype to use for the mechanical stand, we can manually hang or use a carabiner to hang on something simple. Either would work, as the only force we need for comfort and slippage is the force of gravity, as that is the only force being used in Senegal. To measure, one group member would gather data on slippage, that is, how many out of x amount of people experience slippage of the finger sleeve. Then for extra data, we would create an online survey for scanning that asks if the people felt uncomfortable, mildly uncomfortable, mildly comfortable, and comfortable. Also, we would ask if they felt any slippage within the sleeve. One concern with this would be the need for them to do it soon, as it would be easy to forget, but we could also ask them right then and there. That would also create some problems with peer pressure, and answering not completely honest.

Now for testing of the durability of the Velcro straps, we would just measure the number of uses until failure. Failure shouldn't be a problem, as it would only be a prototype.

## Conclusions/action items:

Overall, I think that this would be a good way to test the finger sleeve and get good numbers and values in a timely matter. There will be a lot of people there thinking about the project, easily prompted to test the sleeve with us. There are obviously other options, but this would be a good way to test without using ourselves are the main testers, which would cause a lot of bias.

Sam Dudek - Oct 14, 2025, 11:43 AM CDT

Title: Joining Methods for Velcro Straps and Nylon Material

Date: 10/14/2025

Content by: Sam Dudek

Present: N/A

Goals: To talk about and find the best way to join the materials for maximum comfort and usability, ensuring reusability and the strength of the joining.

#### Content:

The first possible way to join these two would just be sewing the Velcro to the nylon. This would be a good option as the maker space has manual sewing stations as well as automatic ones. The sewing would not be as hard, as once you know the basics, you would just sew a small spot or two, as one of the Velcro straps has to be free-moving. Sewing is very strong and durable, and should last long. The possible disadvantages are possible fraying, especially because none of us group members are pro sewers. We could combat the strength by doing zig zags in the middle of the Velcro too, but with an increase of needle holes, it could weaken the fabric.

Another thing we could do is use an adhesive. We could use some sort of fabric glue to bond the two together. With this, it is very simple; there would be no holes created, and very quick for something like prototyping. A possible problem with this would be that the glue may degrade with multiple uses and sweat or water coming in contact with it. It is also not as strong as sewing. I think this would be a good option for prototyping, although using sewing for prototyping would be good practice.

The last option I think we could have is thermo-bonding using the thermoformer in the Maker Space. I am not 100% sure that this is possible with our project, but it is definitely worth asking. Thermobonding is very strong, there would be no fraying, and it is waterproof. This also is a very good option for multiple uses, as it would be a strong and seamless finish. With that being said, if this machine in Wendt could do it, we would need a lot of supervision, as we could easily overheat it and weaken the material.

# Citations:

[1] "(44) How To Sew On Velcro - Hook And Loop - YouTube." Accessed: Oct. 14, 2025. [Online]. Available: <a href="https://www.youtube.com/watch?v=aHN5PnZYNj8">https://www.youtube.com/watch?v=aHN5PnZYNj8</a>

[2] "Thermoformer," Grainger Engineering Design Innovation Lab. Accessed: Oct. 14, 2025. [Online]. Available: <a href="https://making.engr.wisc.edu/equipment/thermoformers/">https://making.engr.wisc.edu/equipment/thermoformers/</a>

#### Conclusions/action items:

Overall, there is a lot of ways we could go about it. All of them include actually going into the maker space and asking questions. I think we do this next and ask about the thermobonding and if that is a valid option. A lot of times, the workers in the maker space know a completely different way to do something that you didn't even think of, so it is a good idea to get there and ask.



# 10/19/2025 Possible Cutout and Sleeve Proposal

Sam Dudek - Oct 19, 2025, 4:09 PM CDT

Title: Possible Cutout and Sleeve Proposal Drawings and Explanation

Date: 10/19/2025

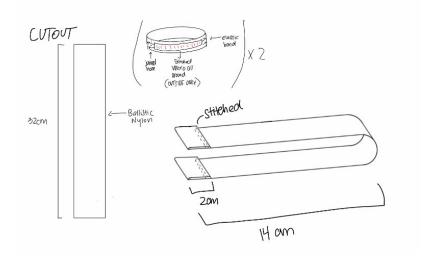
Content by: Sam Dudek

Present: N/A

Goals: To come up with an idea for a cutout of ballistic nylon that will work well with the laser cutter, and that we can shape into our sleeve.

## Content:

The idea of this is to create a cutout of ballistic nylon that is 32 cm long. Once that is cut, each end will be folded back 2 inches and stitched to create a slot that the elastic band will go through. This band will already be pretty tight where it should grasp onto the finger. To make it tighter, we can stitch the non sticky side of Velcro to the elastic band, and once it is inside the slot of the ballistic nylon, you can use the other side of the velcro to tighten it. For the other elastic band complex that goes higher on the finger, we can really just slide that around the sleeve and tighten it when need be.



#### Conclusions/action items:

We need to go to the maker space and actually make a cut with the laser cutter with the ballistic nylon. After that, we must start the joining of the band itself and the Velcro once we get those materials.

Sam Dudek - Oct 19, 2025, 4:42 PM CDT

Title: Possible Cutout OnShape File

Date: 10/19/2025

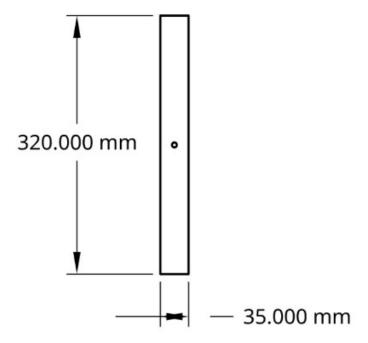
Content by: Sam Dudek

Present: N/A

Goals: Create a file on On Shape that can be used on the laser cutter for the ballistic nylon.

#### Content:

I am not sure how to put the DXF file on here, but here is a picture. It is not much, as the design is for minimum complexity.



#### Conclusions/action items:

Talk with Ben and Nathan H about our ideas, go with the best one, and use the laser cutter to make our first prototype.

Sam Dudek - Nov 06, 2025, 10:33 AM CST

Title: Attachment Design

Date: 11/6/2025

Content by: Sam Dudek

Present: N/A

Goals: Bring an attachment design to the meeting on Friday to discuss with the mechanical team, as the process has slowed for them because it's been difficult to get the parts

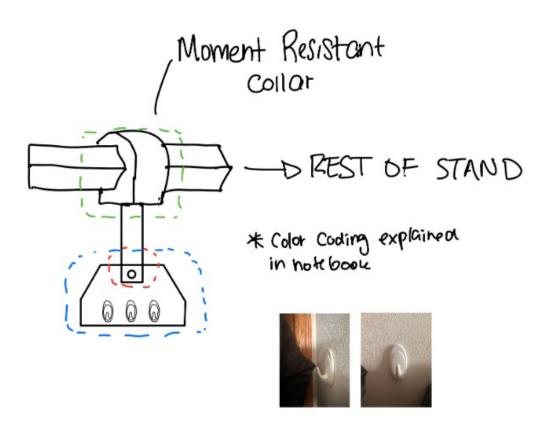
#### Content:

Overall, the design I made is very raw, but serves are a very good brainstorming idea with some smart (I think they are) ideas. This design has a moment-resistant collar, due to its shape on the L bar being rectangular on the inside, resisting any moments. That is connected to a metal bar, which is connected to the 3D printed shape with hooks that our D ring can attach to. Attachment and connectivity will be discussed further in detail.

For the green part, which can be welded to totally resist all translation along the longitudinal axis, but can also be secured with screws that can tighten it along that axis if we choose to do that. But that is not drawn. For the metal bar on the bottom, that can also be welded on, but we could also drill a hole in the collar, and thread that in there, or do both.

For the blue part, that would have to be 3D printed, most likely. It would have to be a strong material, as the hooks cannot break. We could also find a way to strengthen those with possible counterweights, but that can be brainstormed with the team.

For the red, which refers to the attachment of the 3D printed part and the metal bar, they both will have a hole at their respective top and bottom. We can line those up and use a bolt, washer, and nut to tighten it very well. We could make the bar thicker as well and make two holes to resist a moment.



#### Conclusions/action items:

Talk with the mechanical team about this idea, brainstorm the best way to attach our mechanical design and the sleeve.

Sam Dudek - Sep 26, 2025, 12:28 PM CDT

Title: BPAG Meeting

Date: 09/26/2025

Content by: Sam Dudek

**Present:** Other BPAG BME 200/300 students, Dr. Puccinelli **Goals:** To learn more about the role and what it all entails.

### Content:

- -Started with the general concept of our role.
- -The first thing that was said was to get our client to buy stuff for us, which is a lot easier. Or, we pay and then get reimbursed.
- -Either way, though, we have to have our purchases approved by our client prior to the purchase; the client has to give the okay.
- -Any purchase over \$1000 must have departmental approval as well as client approval. Make sure you don't overspend. You need to keep track of all of our purchases.
- -There are different project types. These are UW affiliations but not BME, UW affiliations with BME, and lastly, no UW affiliation (which happens to be my group).
- -Because our client is non-UW, it is fair game. We either have the client paid, or we pay which leaves us with more work because we have to get reimbursement by the end of the semester.
- -Client can pay for the materials with a funding string--we cannot order directly.
- -The next thing we did was go over the MakerSpace, design innovation lab, they have a lot of different things there that we can buy. **We have 50** dollars that we can use there no matter way. Account name: BMEDesign.
- -Design innovation lab at ECB, there is a lot of machining and woodworking, expertise, lots of good tools, screws, nuts, bolts, etc.
- -I need an intro to machining permit
- -Only the BPAG will be reimbursed when your team purchases something
- -Non-reimbursable expenses
- ----Lab archives notebook
- ----Poster
- -There is a template; the goal is to make it easy to repeat
- -Some general notes. Make sure client buys things, make sure it is approved. There are some ineligible uw vendors. Save all of the receipts.
- -If you need funding from the BME professors, let them know before 11 on Wednesday
- -BPAG expense sheet has to go at the bottom of the progress report.

## Conclusions/action items:

Start filling out the expense sheet once we start buying things. Communicate with the client about how we want to go about buying things.

Sam Dudek - Nov 07, 2025, 12:44 PM CST

Title: Build A Career of Impact

Date: 11/7/2025

Content by: Sam Dudek

Present: N/A

Goals: Learn from Kristen Myers about why healthcare needs more engineers

#### Content:

- -The first thing Dr. P did was tell us about Myers. She went to school here, got her PhD from Harvard. She now works at Blue Cross.
- -She started talking about how when she was a student, there were only 30 people in the program. BME was not more popular, and tells us the outline. The outline was her story, why healthcare needs more engineers, and what she would want us to do now.
- -"Run towards the hard problems... they are the ones that change the world."

#### Her Career Journey:

- -The Framework: She went to UW-Madison (had four internships for many different companies). She then worked at Medtronic for 5 years. Then she got her Harvard MBA. After that she was in Venture Capital for healthcare companies in California. She said that chapter one was learning how to problem solve, leading teams, filing patents, and getting good work done. This is where you run toward the problems and build. More about getting experience, showing what you can do.
- -Clime The Growth Curve: After this she worked at Aetna as a chief of staff to the CEO president. After that, she worked as the Unified Women's Healthcare as President and Chief Operating Officer. This would be combining IQ with EQ. Working on big teams.
- -Build and Transform: She was the founder and CEO of advanced primary care for rural communities. She now works for Blue Cross Blue Shield Association as COO.
- -What does great look like. Quadruple Aim for healthcare is lower cost of care, improved patient experience, improved patient outcomes, improved provider experience.
- -She stated how it is very hard to be a doctor now, that depending on your specialty, more of it is about charting, filling out paper, other burdens, and less about actual care.
- -Compared to other countries, we spend 2x more money on healthcare per person. US ranked last on equity, access, and outcomes, doctors get burnt out, people dont get healthcare becasue its so costly, etc.
- -This happens for many reasons. There are misaligned incentives, fragmented financing and regulations, data silos and legacy IT, and inequities (10-15yr gap between zip codes of life expectancy).
- -She stated what is required to build a better system of healthcare?
- --Seamless exchange of clinical, claims, and social data. Need a human centered design. We need better incentives for actual better care. Performance is transparent and noticeable to all.

Here are the things she wants us to do.

- 1. Work hard and build range. Take on the hardest projects, classes and experiences you can find. Effort and range are your foundation.
- 2. Seek diverse exposure. Explore different sectors, teams and geographies. Gain perspective and learn how systems connect, not just how parts work. Do different things.
- 3. Choose your people wisely. Surround yourself with curious, driven, high-integrity people. They will shape who you become.
- 4. Know your values and protect them. Define what matters the most -- family/friends, health, career/impact, values -- and make decisions that align.
- 5. Embrace challenge and keep growing. Run towards the hard problems. Growth lives on the edge of discomfort- where big impact starts.

# Conclusions/action items:

Take her advice and continue to work hard and build your foundation throughout my college career.

Sam Dudek - Dec 05, 2025, 9:21 AM CST

Title: Poster and Script Work

Date: 12/4/2025

Content by: Sam Dudek

Present: All

Goals: Create script and practice with the team before the poster session Friday

#### Content:

Before thanksgiving break I worked on my poster part, which happened to be writing in the problem statement, background, and competing designs. When I had finished that, I helped when I could with other parts if people needed it. Other than that, I created my script and started to practice on Tuesday. Thursday night we as a team went over to practice.

## Script:

Hello as you may know we are the digital traction device team, this is...... Our client is Mr. Pape Samb and Dr. Mohammed Soumah.

So as a group, we have been tasked with creating a digital traction device using a Japanese finger trap mechanism to basically put a patients hand, wrist, and forearm in a neutral position while holding the static load of their arm during surgery or something like a casting. Some basic important things for this project were the cost effectiveness, being adaptive, and autoclavable, which we will get into later.

For some context, Senegal, where our final prototype will be sent, has a large amount of hand injuries in the workplace. These often require surgeries, and surgeons rely heavily on traction to align small bone fragments to prevent things like neurovascular compromise.

Because existing solutions are either too expensive, hard to outsource, not easily adjustable, or not designed for multiple uses, our client currently uses a manual system in the Senegal hospital which is unhelpful for both the patient and surgeon. So once again, we have been tasked with finding a cost effective solution for Soumah and his staff in Senegal.

# Conclusions/action items:

Keep practicing in order to be polished and perfect during the presentation on Friday.

Sam Dudek - Dec 05, 2025, 5:05 PM CST

Title: Poster Session

Date: 12/5/2025

Content by: Sam Dudek

Present: All Members

Goals: Present our final poster to our advisor and then go around and talk to other posters and review them.

## Content:

I showed up to ECB after Statics, which happened to be at 11. After walking around and eating some pizza, eventually everyone for our team got there and we presented to Williams and Bartel. After that I went first to go talk to other groups. I first talked to the weight bearing group. I thought it was very interesting how strong the chips were, because you could place 220 lb if I'm not mistaken, before it broke, which should be enough for this specific project. Either way, I thought it was cool how they mitigated the breakage of the more fragile parts that needed to within the final prototype, as well at the amount of coding they probably had to do. Next, I talked the group that had to make a test dialysis mechanism in a stuffed animal. I thought it was cool they got it fit right and you could see right in there. It wasn't as science for lack of better words, but it was interesting that they actually pulled it off. After that, I went to the group that I was originally interested in as a project, which was the glucose monitoring system. What I thought was cool is that they used something that has already been made to extract the numbers and used those to color coordinate the status of glucose in the blood. That was very interesting to ask about how they actually did that coding wise, because I personally would have no idea how to do that. Overall those were the main three I talked too among others, but it was a very cool experience to also go back and talk about our project some more to others. There was this one man who must have been an undercover doctor speaking to us, because he had a lot of specific and strong opinions on our project, but was more reserved to share them.

## Conclusions/action items:

Work on our final report and notebook for next week Wednesday.

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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.

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Ilia Mikhailenko - Dec 10, 2025, 4:57 PM CST

Title:	
Date:	
Content by:	
Present:	
Goals:	
Content:	
Conclusions/action items:	

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MARIAMAWIT TEFERA - Sep 19, 2025, 9:22 AM CDT

New Page

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